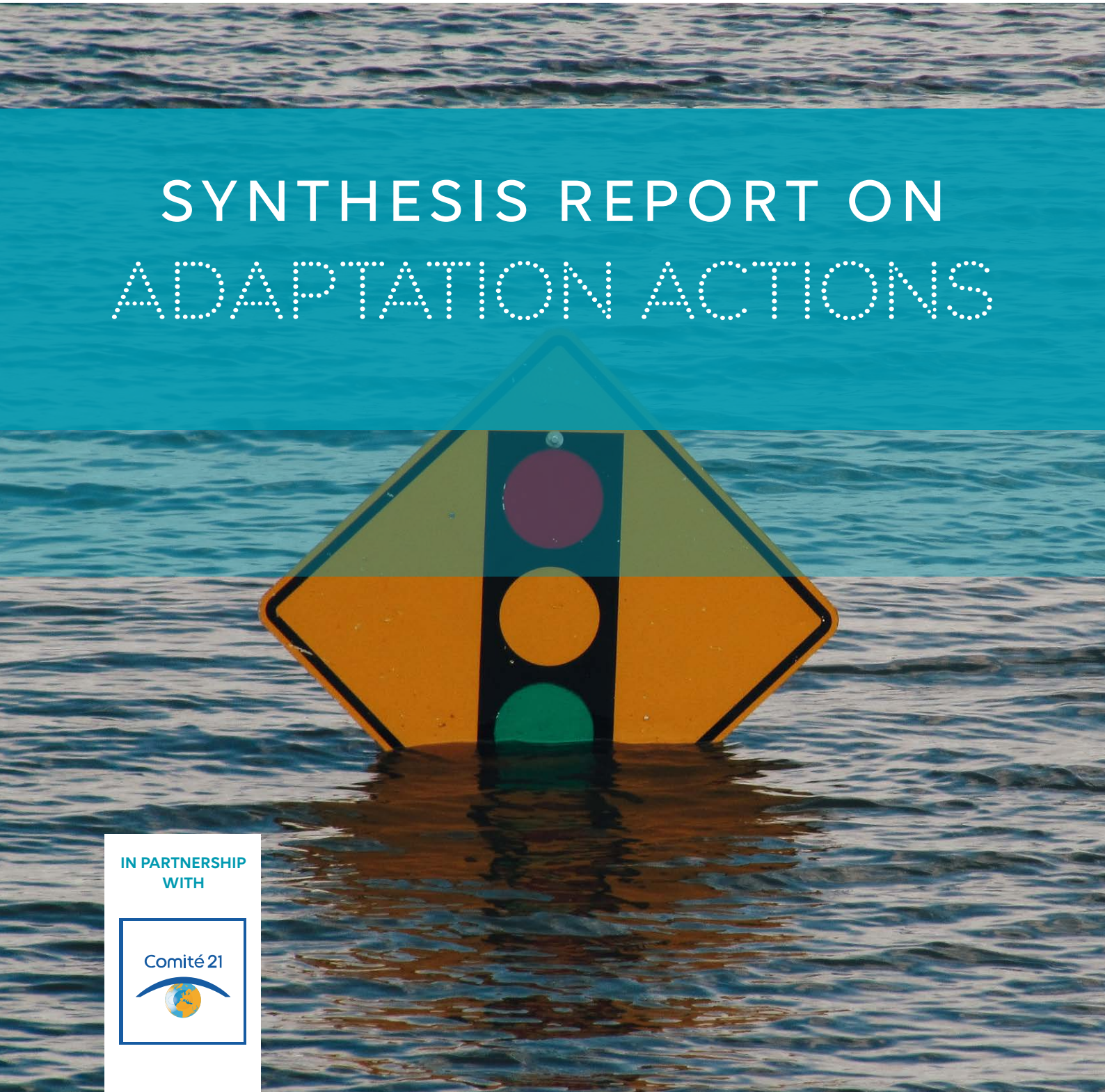
CLIMATE CHANCE 2019

GLOBAL OBSERVATORY
ON NON-STATE
CLIMATE ACTION

ADAPTATION BOOK

SYNTHESIS REPORT ON ADAPTATION ACTIONS



IN PARTNERSHIP WITH

Comité 21

PUBLISHED BY CLIMATE CHANCE ASSOCIATION AND COMITÉ 21
NOVEMBER 2019

Quote
CLIMATE CHANCE & COMITÉ 21 (2019). "ADAPTATION BOOK" SYNTHESIS REPORT 2019 ON ADAPTATION ACTION. GLOBAL OBSERVATORY ON NON-STATE CLIMATE ACTION.

PUBLICATION DIRECTORS
Ronan Dantec, *Chair of Climate Chance Association*
Bettina Laville, *Chair of Comité 21*

EDITORIAL TEAM
From Comité 21:
Bettina Laville, *Chair of Comité 21*
Virginie Hugues, *pôle Climat-Energie international, Comité 21*
Experts associés: Guillaume Simonet, consultant and independant researcher; Marc-Antoine Martin, Administrateur-Trésorier de l'Académie de l'eau; Matthieu Wemaëre, Lawyer

FROM CLIMATE CHANCE:
Amaury Parelle, *Coordinator, Observatory*
Antoine Gillod, T*ask officer, Observatory*
Associated Experts: Vanessa Laubin, *Consultant on local climate planning "Projections"*; Thibault Laconde, *Consultant "Energie-Developpement"*

We also thank the following organisations for their contributions: Ademe, AFD (Evaluation Department), CITEPA, Regions4.

GRAPHIC CREATION AND LAYOUT
Elaine Gressan-Guillemot - LATELIERDELESTUAIRE.COM
Hewan Goethals

ENGLISH TRANSLATION
Solten France Sarl

COVER
Kelly Sikkema on Unsplash

PRESENTATION

Comité 21

Created after the Earth Summit in Rio (1992), the Comite 21, a French non-profit organization for sustainable development, gathers about 400 members (businesses, local authorities, NGO, academics, citizens and media), in the spirit of the 17th SDG, embodied for about 25 years ! Anticipate, Accompany, Transform: Comite 21 contributes to transform society toward a sustainable model, relying on the 2030 Agenda and the 17 Sustainable Development Goals. Comite 21 offers regular analysis of actualities, in order to decrypt and identify trends, animates several support paths, collective intelligence methods, experimentations, and customized support and advices. Comite 21 also moderates a Prospective Committee, gathering the major components of the French society.

Climate Chance Association

Since 2015, the Climate Chance Association is participating in the mobilization against climate change. It is the only international organisation that aims to bring together all the non-state actors recognized by the UN (the 9 groups of actors: lo-cal authorities, companies, NGOs, trade unions, scientific community, agricultural, youth, indigenous peoples and women organisations), to develop common priorities and proposals and to strengthen stakeholders dynamics through networking (thematic coalitions, summits, ac-tion portal).

The "Adaptation Book"

This Book tells the political and conceptual story of adaptation in international climate negotiations (section 1), before analyzing subnational and local governments initiatives (section 2) through global reports and case studies. We then study adaptation issues raised and answers provided in six sectors of the economy (section 3), to finally conclude with an overview of financial flows and tools for adaptation (section 4).

The Climate Chance Association and its Observatory are supported by

BETTINA LAVILLE
Honorary member of
the Conseil d'État
President of Climate Chance

RONAN DANTEC
Founding President of the Comité 21

EDITORIAL

For this Synthesis Report 2019 on non-state climate action of Climate Chance Observatory, the Comité 21 is glad to co-author this Adaptation Book. First because our association has worked on this them since 2016, with the publication of the book Adapting to Climate Change. A question for our society in 2017 with the French National Centre for Scientific Research (CNRS), and since then with an awareness programme for our adherents. Second, because we identify ourselves with Climate Chance's approach, promoting civil society's role towards climate change, since we also gather local and subnational governments, NGOs, academic institutions, businesses and now citizens, our "direct" members. Now, we see how important is the awakening of civil society, especially the youth, to face climate challenges in this century, while States keep often hesitant between sovereign action of framing and direct interventions.

As a too long neglected issue, as we'll see in these pages, adaptation to climate change is the perfect illustration of the dialectic difficulties met for an efficient governance facing emerging risks, as much in international negotiations as for funding or local action. National states, local and subnational governments often tend to pass the buck to one another when disaster occur, although solution can be found in setting up an efficient work with civil society representatives and citizens. To the State falls the responsibility to build a legal framework and control it; to the State again the mission to watch risks; to local and subnational governments the mission to design measures matching risks; and upon civil society relies risk consciousness, vigilance upon consequences of extreme phenomena ahead. And to everyone, the remembrance endeavour so that all risks that are known and all disasters that were lived can be included in prevention policies.

Sometimes events are symbols on their own: as I write these lines, Venice has known a particularly violent episode of acqua alta, while the Mose plan, launched since the Italian law of 1984 is 20 years late and clearly not sufficient compared to the effects of climate change. On the other hand, Indonesia has chosen prevention when deciding to move the capital city Jakarta, into a less exposed region. In northern hemisphere as in the southern, climate change threatens our cultural and institutional grounds. Adaptation to climate change is a new central space of the consent to transformations, hence to public decisions.

This is why we want to review the international framework for adaptation to climate change, diverse experiences that local authorities are leading to protection populations and economic activities and the financial frame, still insufficient. Our message is that, from being the poor relation of climate policies, adaptation should now become one of the two pillars, all the more as consequences of adaptation works also benefit to impede temperatures from rising.

Undoubtedly, this is all about a new culture, a new collective psyche that can only work under the active content of the people.

May this Book contribute to building new democratic climate policies.

2019 Global trends and context

2019 was landmark for climate change and leaves us with one thing to be certain: our societies are already facing a change in climate conditions that is deep enough to force us to adapt our socio-economic systems to it in the medium and long term.

This July was the warmest month ever recorded in the world since weather records began. As we are writing this now, the European Copernicus programme reports that October was the warmest October on record, 1.2°C above pre-industrial temperatures (Copernicus, 2019). Published during the Climate Action Summit in New York, the latest report of the World Meteorological Organisation shows an increase of 1.1°C in the global average temperature between 2015 and 2019 compared to the averages between between 1850 and 1900 (OMM, 2019). Month after month, year after year, climate records follow one another and break records.

"Increasingly frequent extreme events are becoming the norm"

Current events confirm, if there were still a need, the physical reality of these changes.

What strikes us first is the acceleration of the occurrence of extreme climate events. While their isolated existence cannot be attributed solely to climate change, their increasingly frequent occurrence confirms the predictions: such events are becoming the norm. In California, one year after the historic Camp Fire, the region has once again been affected by 14 simultaneous fires, forcing the evacuation of over 180,000 people in 48 hours, cutting off electricity to nearly 2 million people and destroying many hectares of land and buildings. Historically, located in southern California, these fires now threaten the entire state. In northern India, in the Kerala region, floods caused 140 deaths this summer, while the region had already experienced up to 164% above normal rainfall in August 2018 (ReliefWeb, 30/09/2018). In Mozambique, the city of Beira was completely destroyed by Cyclone Idai last spring, and more than 146,000 people were displaced (OCHA, Mai 2019). In total, during the first half of 2019, 7 million people were displaced due to extreme weather events, according to calculations by the International Displacement Monitoring Centre: a new record (IDMC, September 2019). 62 million people had been impacted by such events in 2018 (OMM, March 2019).

"In terms of action, cities are still struggling to get out of the diagnostic stage and enter the planning and implementation phases."

On top of the number of human and material losses caused by these spectacular events, this year also saw the fundamental impact of climate change on socio-economic systems. Agricultural yields and sustainability are particularly vulnerable. In Europe, wine production plummeted by 15 % between 2018 and 2019. This is due to "random meteorological conditions" according to the International Organisation of Vine and Wine, which complicate wine growers' expectations (Novethic, 01/11/2019). The same case occurs in Central America, where the instability of weather conditions over the past two years in the "dry corridor" covering El Salvador, Guatemala, Honduras and Nicaragua has caused nearly 2 million farmers to lose their harvests, forcing them to sell their land, livestock and move away (Relief Web, 2019 ; The Conversation, 2019). Unpredictable weather projects uncertainty on local activities that are directly dependent on seasonal variety.

This list, which is not exhaustive, is doubly instructive. First, it is a good reminder that climate change is universal: its effects are felt in all region across the globe, and despite a persistent lack of interest in adaptation, even developed countries that are less vulnerable will have to confront and respond to it. Secondly, the effects of climate change discriminate against the most vulnerable populations.

Lastly, the diversity of manifestations of climate change observed this year and their impacts on human societies all call for the localization of adaptation strategies. Bringing public policies into line with adaptation objectives is essential to prepare living environments and economic sectors for the changes already underway. A planning effort must therefore be put in place at national and sub-national levels, in consultation with economic actors, to organise the adaptation of socio-economic systems in the medium and long term.

Some countries have been noticed for their planning efforts: Portugal presented its first national adaptation plan, France renewed its plan, Kiribati published an update of theirs and Uruguay launched an adaptation plan specific to the agricultural sector (NAP-Agro).

Nevertheless, adaptation policies "suffer from a persistent lack of recognition and legitimacy", as pointed out in France by the report of the delegation for strategic foresight of the Senate (Sénat de la République française, 2019). However, there are many benefits stemming from joint implementation of mitigation and adaptation strategies.

The first report issued by the Global Commission on Adaptation attempted to assess the cost-benefit ratios of different types of adaptation, in comparison with the costs of non-adaptation.

Outcome: 1 US$ invested in adaptation is likely to generate 2 to 10 US$ of net economic benefits (GCA, 2019). The Commission therefore calls for a triple revolution in understanding, planning and financing to boost political investment in adaptation. During the presentation of the report at the Climate Action Summit, 75 national governments, multilateral banks, civil society and private sector actors committed to eight action tracks with specific objectives: finance and investment, agriculture and food security, nature-based solutions, water, city, location of action, infrastructure and disaster prevention.

"With little support in Katowice, adaptation still does not receive the equal attention to mitigation that it has been promised since Cancún"

In this context, this Adaptation Book co-authored by Climate Chance Observatory and the Comité 21, proposes to assess the extent to which a culture of adaptation is being disseminated among non-state actors. Since adaptation must be local, it is necessary to understand the broad underlying trends that drive one's community of practice, but also to observe the extent to which adaptation is able to integrate into the daily political, social or economic choices of the actors as a whole.

Key takeaways from the "Adaptation Book"

1 With little support in Katowice, adaptation still does not receive the equal attention to mitigation that it has been promised since Cancún.

The creation of the Global Commission on Adaptation, at the start of 2019, along with the release of its first report in September of the same year, signal a desire to boost political and financial investment in adaptation among international governance bodies.

2 Although the costs of adaptation for developing countries are constantly on the rise, the international community is still lagging behind with its financial commitments:

US$ 463 billion for the climate in 2016, with only US$ 22 billion for adaptation (= 4.75 %, Climate Policy Initiative, 2017), far from the initial commitment of 100 billion/year promised by developed countries. However, according to the Global Commission on Adaptation, the cost-benefit ratio of an adaptation investment can range from 2 :1 to 10 :1.

3 All studies on climate finance, however, show a clear increase in bilateral and multilateral funding for adaptation since 2016.

Southeast Asia was the first recipient country. In particular, North-South flows benefit from the global rise in climate funding for developing countries. However, these amounts remain limited to small absolute volume, and in proportion to what mitigation receives, they are far from marking a change in the scale of adaptation financing. Bilateral institutions such as UKAid, or multilateral ones like the Green Fund, are still aiming for 50% for adaptation funding.

4 The development of markets and guarantees for green assets must make it possible to redirect private investment towards adaptation,

notably for the least developed countries (LDCs) while reducing the financial sector's exposure to the physical risks to which their assets are exposed.

5 In a context where the number of funds dedicated to adaptation is constantly growing and private investors are reluctant to take on high country-risks, clarifying criteria and consolidating monitoring tools can facilitate the financing of adaptation in the LDCs.

Lacking common metrics and standard methodology for evaluating adaptation projects, it is difficult to assess the impact of measures and monitor investments. AFD, the World Bank and Citepa have recently tried to develop universal instruments that can be adapted to local contexts.

6 Key actors in local resilience, there are more and more cities declaring their commitment to adaptation with networks and international climate initiatives.

However, all the academic studies that were produced since 2018 on cities' commitment to adaptation show that less attention is paid to adaptation in local political agendas than to mitigation actions. With no binding regulatory frameworks (requiring local adaptation plans for example), voluntary action is still very minimal.

7 Action reports by local authorities present many continental asymmetries in a trompe-l'œil way.

While European and North American local authorities are the quickest to communicate their planning approaches and actions, many "silent adaptations" elsewhere in the world are not included in the aggregated data. Not listed as such, these actions are struggling to access funding. Latin American local authorities have been very active in their adaptation reporting in recent years.

8 In terms of action, cities are still struggling to get out of the diagnostic stage and enter the planning and implementation phases.

Policies implemented by local authorities tend to be polarised in regard to some visible risks (mainly when related to water) with a preference for well-identified "grey" adaptation measures, mainly located in urban areas.

9 The local adaptation of economic actors produces direct co-benefits for the overall mitigation of the sector.

This is the case in agri-food, tourism or power generation sectors: reduction of demand and reorganisation of supply (less livestock, more proximity, decarbonation of electricity, etc.) are part of the same movement of holistic reorientation.

10 The range of adaptation strategies for certain sectors or services raises some ethical and political questions:

the use of GMOs in the agri-food sector, artificial substitutes for natural resources (synthetic grass, artificial snow, etc.) or even the construction of seawalls on fragile coasts... confirm that the adaptation of certain local areas is a matter of strategic choices and requires governance mechanisms open to all stakeholders.

SECTION I

Adapting to climate change: from science to policy

1 • Historical background: From the Rio Conference (1992) to the implementation of the Paris Agreement: twenty-three years of incipient work

The United Nations Framework Convention on Climate Change (UNFCCC), adopted at the Rio Conference in 1992, is based on the difference in obligations between developed and developing countries. The former have a constraint to reduce their greenhouse gas (GHG) emissions and must provide financial support, as well as the means to implement the Convention to ensure the least carbon-intensive development possible for developing countries. The entire structure of the Convention is based on a "response strategy", as expressed in one of the paragraphs of its preamble,[1] and thus enshrines the fight against climate change.

Adaptation, as we understand it today, is not much addressed in the text of the Convention. In its Article 2, the Convention sets itself the ultimate goals of "*stabilising greenhouse gas concentrations in the atmosphere at a level that prevents dangerous anthropogenic interference with the climate system*". Thus, Article 2 links mitigation and adaptation measures in a "natural" way, since the aim is to contain global warming. This is projected by the signatory states as a temperature increase to which ecosystems must adapt "naturally",[2] as they have adapted during known variations in past centuries. The objective then envisioned is to return to previous levels of anthropogenic emissions in the decade,[3] i.e. at the beginning of the 21st century, so that adaptation, as understood today in the Convention, would not be necessary. Article 3.3 merely establishes the general principle that precautionary measures should be taken to anticipate, prevent or mitigate the causes of climate change and limit its adverse effects. However, adaptation is provided for in Article 4.1(b) and (e) to require all Parties to establish, implement and regularly update measures to facilitate adaptation. This includes the preparation of ad hoc and targeted measures (appropriate and integrated plans for coastal zone management, water resources and agriculture and for the protection and rehabilitation of areas affected by drought and desertification), in particular in Africa, on a "cooperative" basis.

---

1 *"recognizing also that developed countries must act immediately and flexibly on the basis of clearly defined priorities,[…, such response strategies should take into account all greenhouse gases and take due account of the share of each of them in enhancing the greenhouse effect…"* https://unfccc.int/resource/ccsites/haiti/ccweb/conven/text/textcomplet.html

2 *"…This level should be reached in time for ecosystems to adapt naturally to climate change, for food production not to be threatened and for economic development to continue in a sustainable manner."* (Art.2)

3 Article 4.2(a) states that *"a return, by the end of this decade, to previous levels of anthropogenic emissions of carbon dioxide and other greenhouse gases not controlled by the Montreal Protocol would contribute to such a change."*

For adaptation financing, the Convention is clear: developed countries (Annex II) must help developing countries, which are particularly vulnerable to the adverse effects of climate change, to meet the cost of their adaptation to these effects (Article 4.4). The various funds, set up by the UNFCCC Financial Mechanism, must therefore mainly support adaptation and capacity building to integrate it.

During the conferences on climate change that followed the Rio Earth Summit in 1992, States quickly recognized the inadequacy of the Convention's objectives, especially after the second report of the Intergovernmental Panel on Climate Change (IPCC); but the "Berlin Mandate", in 1995, which opened negotiations towards a Protocol or other legal instrument to supplement the Convention, strengthening and clarifying the commitments of developed countries, did not contain any reference to adaptation.

Moreover, *the Kyoto Protocol* itself will make little mention of it in 1997. It is very focused on strengthening developed countries' mitigation efforts and merely creates, on the one hand, the Kyoto Protocol Adaptation Fund to complement the financing mechanism, with the twofold particularity of being endowed by sources from the private sector (levying a portion of carbon credit revenues - 2% on the monetization of credits - issued under the Clean Development Mechanism - CDM)[4] and, on the other hand, allowing direct access to accredited entities from developing countries (without going through implementing agencies imposed by donors).

1997-2007: an arduous decade for mainstreaming adaptation

It is only in 2001, when *the Marrakech Accords* were concluded, that adaptation was to be set out along with mitigation and that operational measures were to be taken on financing adaptation and technology transfer. In addition to the operationalization modalities of the Adaptation Fund, adaptation is addressed in "capacity building":[5] adaptation is anchored in measures for developing countries and includes the development of National Adaptation Programmes of Action (NAPAs) as part of the work programme for the least developed countries (LDCs). The latter aim to identify priority actions for adaptation on the basis of Article 4.9 of the Convention. This includes an analysis of vulnerabilities and an inventory of ways to address them. However, and due to a lack of financial resources and capacity to translate them into operational projects, they could not be effectively implemented.

But it is above all the adoption of a revised definition of adaptation, which emerged from the work of the IPCC synthesis report published in 2001, that renews thinking on the subject: *"Adaptation is a process by which societies make themselves better able to cope with an uncertain future. Adaptating to climate change entails taking the right measures to reduce the negative effects of climate change (or exploit the positive ones) by making the appropriate adjustments and changes."*Here are the key words of adaptation: it is a process wading through uncertainty.

In order to consolidate adaptation activities and initiate a process of discussion on the impacts of response measures, small steps were taken at COP10 in Buenos Aires (*Buenos Aires Programme of Work on Adaptation and Response Measures*) in 2004, and at COP11 in Montreal in 2005 with the adoption of a five-year work programme on adaptation to climate change.

---

4 The Clean Development Mechanism or CDM is one of the three so-called flexibility mechanisms established by the Kyoto Protocol to make it easier for industrialized countries to achieve their targets. Clean development mechanisms thus enable these countries to obtain carbon credits by financing projects that aim to reduce greenhouse gas emissions in developing countries, which are not required to make mandatory reductions in their emissions, but where mitigation policies generally have reduced abatement costs.

5 FCCC/CP/2001/13/Add.1, Annex "Framework for capacity-building in developing countries", Part C. Action http://unfccc.int/resource/docs/french/cop7/cp713a01f.pdf

Finally, at COP12 in 2006, the Nairobi Programme was adopted to improve understanding and assessment of the impacts of vulnerability and adaptation needs and to make informed decisions. Nevertheless, it is first and foremost a programme for exchanging and sharing good practices in adaptation.

From Bali to the Paris Agreement: towards adaptation as risk management

In Bali, the discussions paved the way for the creation of an expert group on adaptation. Adaptation was then at the heart of the G77[6] and China's demands, requiring a work programme to be finalised on this subject, as well as guarantees on financing. But China, in particular, was using the legitimate demands of the least developed countries and small island states to hide their refusal to commit to emission reduction targets. This was even truer for emerging countries and oil-producing countries.

The Bali Action Plan (COP13, 2007) emphasizes the integration of adaptation measures into sectoral and national plans and into specific projects and programmes, taking into account the "urgent and pressing" needs of developing countries, which are particularly vulnerable to the adverse effects of climate change. This plan outlines risk management and reduction strategies: risk sharing and transfer mechanisms (e.g. insurance schemes), disaster reduction strategies and ways to deal with disasters and damages related to the impacts of climate change. Adaptation then becomes a political lever in negotiations for some States, including lesser developed countries and small-island developing States.

In an attempt to respond to the Bali Action Plan and following the failure of the Copenhagen Conference (COP15, 2009), COP16 held in Cancún in 2010 adopted the "Cancún Adaptation Framework". It aims to stimulate international cooperation for enhanced action on adaptation, in particular to enable developing countries to improve the planning, prioritization and implementation of adaptation measures, but also to set up an Adaptation Committee. This Committee is a true specialized agency of the UNFCCC in this field, which was to launch a programme on National Adaptation Plans (NAPs) at the Doha Conference (COP17, 2012).

The number of NAPs is still small, as each State remains free to choose the form that its planning and the process that will suit its particular situation will take. Nevertheless, the international community has slowly spurred the process with a view to facilitating effective adaptation planning among least developed countries and other developing countries that may wish to do so. The Paris Agreement, as we will see, provides for enhanced international support to developing countries on an ongoing basis to support their planning efforts.

However, no financial amount is specified for the adaptation. Certainly, in Cancún, the Green Fund was created with the objective of seeing funding distributed equally between mitigation and adaptation. Despite African countries' request to mobilize a total of $100 billion, adaptation remained the poor relation of international financing in Doha in 2012.

6 The Group of 77 at the United Nations is a coalition of developing countries, of which 134 are currently members.

At that time, the international community was at a deadlock on adaptation. Perceived as the failure of mitigation, it is therefore implicitly prioritized in the background. Indeed, the countries of the North are less exposed to the effects of climate change, but it is generally on them that the question of adaptation financing rests (François Gemenne).

This was clearly demonstrated at the Warsaw Conference in 2013 (COP19), where adaptation remained one of the main points of disagreement in the negotiation of the implementation of the Convention. Nevertheless, COP19 allowed for the creation of the "Warsaw Mechanism" for losses and damages for the most vulnerable countries such as developing countries and small island countries, which are most exposed to the effects of climate change. Compensation for adaptation?

However, in the face of the increase in disasters, the 5th IPCC report (2014) or the UNEP report on adaptation needs in Africa[7] are making progress on the subject. For example, the IPCC refers to *"risks related to the impacts of climate change"* rather than *"vulnerability to climate change"*,[8] which makes it possible to better connect climate change adaptation and disaster risk reduction and thus move the concept towards a risk management approach.

At COP20, held in Lima in December 2014, the idea of simultaneous adaptation and mitigation policies is gaining ground. First, because the prospect of a temperature increase of more than 2°C requires that vulnerable populations be protected, and second, because synergies and leverage effects between adaptation and mitigation measures are finally recognized. These elements will ultimately be included in the Paris Agreement, in particular through the adoption of a global adaptation agreement to bring it into line with mitigation. However, these are tentative advances that still need to be operationalized and even clarified, particularly with regard to the scope of the notion of resilience that is now attached to adaptation.

Tentative progress in the Paris Agreement

Prior to COP21, several developing countries and groups of developing countries, including the African Group, suggested introducing a global adaptation target in the future as a "universal agreement applicable to all" under the Durban mandate (COP17, 2011). This strong demand had already been echoed at COP20 in Lima, which had insisted on strengthening action on adaptation. The so-called negotiating text of the Geneva Conference (ADP-8, 13 February 2015) included 13 proposals to formulate such a global goal. These combined different approaches based on the outcome to be achieved (resilience), the processes to be followed (to achieve the desired resilience), the means to be mobilized (the financing to be provided, sometimes calculated by reference to the historical emissions levels of developed countries).

COP21 helped to find a consensus to adopt the Paris Agreement, which establishes for the first time a global adaptation target as follows in Article 2(b).[9]

The preamble to the Paris Agreement recognizes that adaptation is a global challenge facing all countries, but emphasizes that the special needs of developing countries must be recognized. This objective requires a significant strengthening of national adaptation efforts, including through international support and cooperation.

---

7 Keeping Track of Adaptation Actions in Africa (2014), "Targeted Fiscal Stimulus Actions Making a Difference.

8 See for example GIZ (2017), Risk Supplement to the Vulnerability Sourcebook.

9 "This Agreement,[...] aims to strengthen the global response to the threat of climate change, in the context of sustainable development and poverty reduction, including by: (...) (b) Building capacity to adapt to the adverse effects of climate change and promoting resilience to climate change and low greenhouse gas emission development, in a manner that does not threaten food production"

Although this global objective does not set a specific outcome to be achieved, since it aims to "promote" resilience without giving it a baseline, it is clear that this objective should guide adaptive capacity building in the context of limiting global average temperature rise, the central objective of the Agreement. Implicitly, the Agreement therefore recognizes the link between the level of ambition for mitigation and adaptation needs, which puts them on an equal footing in terms of urgency to act. Although there is no explicit correlation between the two, in terms of financing, it is clear that insufficient action on mitigation will support developing countries' demand to support their adaptation efforts.

In addition, the Paris Agreement sets out guiding principles for adaptation action: Article 7 stipulates that it should follow a country-led, gender-sensitive, participatory and fully transparent approach, taking into account vulnerable groups, communities and ecosystems. Moreover, it should take into account and build on the best available scientific evidence and, as appropriate, traditional knowledge, indigenous peoples' knowledge and local knowledge systems, with a view to integrating adaptation into relevant socio-economic and environmental policies and measures, where appropriate.

With regard to planning, which is the central tool for integrating and supporting adaptation at the national and local levels, the Paris Agreement provides that each Party should, as appropriate, submit and periodically update a communication on adaptation, including its priorities, implementation and support needs, projects and actions, without imposing additional costs on developing country Parties to the Agreement. Communication on adaptation can be integrated into a national adaptation plan, into the Nationally-Determined Contributions (NDCs, Article 4 of the Paris Agreement) or into the National Communication (submitted pursuant to Article 12 of the UNFCCC) of the Contracting Parties.

Furthermore, the loss and damage mechanism is reaffirmed and clarified;[10] apart from this objective, the whole of Article 7 is drafted conditionally, and in the form of a recommendation.[11] In particular, country communications on adaptation are not mandatory. The subject of adaptation was excluded from the chorus of congratulations addressed to the negotiators of the Paris Agreement and NGOs did not fail to excoriate the timidity of the measures adopted. In particular, the issue of the Adaptation Fund, which depends on the Kyoto Protocol, was left open: the decision, adopted in Paris in December 2015, states (paragraph 60) that *"the Adaptation Fund may contribute to the implementation of the Agreement, subject to the relevant decisions of the Conference of the Parties serving as the meeting of the Parties to the Kyoto Protocol (CMP) and the Conference of the Parties serving as the meeting of the Parties to the Paris Agreement (CMA)"*. The implementation modalities and adaptation financing were therefore postponed to COP22 in Marrakech.

However, in Marrakech (COP22), the following year (2016), the Moroccan Presidency wanted to put adaptation on the table, with its "AAA" initiative, i.e. "Africa, Adaptation, Agriculture", based on the UNEP report "Adaptation Gap Report 2016".[12] The report showed that the costs of climate change adaptation in Africa could reach $350 billion per year by 2070, if temperatures rise by +3.5°C to +4°C. *"Additional funding for climate change adaptation is essential to control harms and build resilience,"* the report stressed. This was timely because adaptation was on many of COP22 agenda items, including the Nairobi Work Programme under the Convention, and the agenda on how to implement Article 7 of the Paris Agreement. The question that remained open at COP21 as to whether the Kyoto Protocol Adaptation Fund could assist the implementation of the Paris

10 Article 8 of the Paris Agreement

11 "The Parties should intensify their cooperation to improve adaptation action".

12 http://www.unep.org/adaptationgapreport/sites/unep.org.adaptationgapreport/files/documents/agr2016.pdf

Agreement, with the latter to take over from the former from 2020. In general, the aim was to try to find answers to the constant demand from developing countries to increase adaptation financing and improve access to financing, and also to discuss useful elements to be included in the Communications on adaptation provided for in the Paris Agreement. However, apart from the decision in principle to continue the Kyoto Protocol Adaptation Fund, subject to the resolution of certain legal and institutional issues, no decision has been taken, except to adopt the modalities on this subject in 2018 at COP24.

Developed countries did publish a roadmap in Marrakech detailing the mobilization of the $100 billion they have pledged to provide to developing countries by 2020, in which adaptation-related financing is expected to double by 2020 to $20 billion. Many considered this amount "inadequate", especially in view of the above-mentioned UNEP evaluations.

COP23 planned to be the COP dedicated to adaptation; it was more about resilience. The presidency, held by Fiji, had been searing in Marrakech: *"Allocating only 10% of climate finance to adaptation is both a real imbalance and a flagrant injustice,"* according to Frank Bainimarama, Prime Minister of Fiji. He added: *"It is high time to reorganize spending priorities, calling for global negotiations to focus on countries at risk."*

In Katowice, Poland (COP24, 2018), the challenge was therefore to adopt the modalities for preparing communications on adaptation, bearing in mind that this communication is optional for countries under Article 7 of the Paris Agreement, and that they can choose the vehicle that they consider most suitable for communication (NDCs, National Communication, National Adaptation Plans). COP24, once again, noted the gaps and difficulties of many countries, including the least developed countries, in developing their NAPs, and requested that the Adaptation Committee find solutions to address these gaps through its Task Force on NAPs. The Subsidiary Body for Implementation of the UNFCCC ("SBI") is responsible for assessing progress in 2021 (SBI 55, 2018)[13].

Finally, the rulebook adopted in Katowice highlights the "additional information" that countries would consider necessary to indicate in their communication. This particularly includes information on financial support for the preparation and submission of the Communication on adaptation, as well as for the implementation of the proposed actions, in accordance with the activities of the UNFCCC "constituencies" within their respective mandates (including the Adaptation Committee, Climate and Technology Centre and Network, Paris Committee on Capacity Building) and the operational entities of the UNFCCC financial mechanism (including GEF, FVC).

In Katowice, the Adaptation Committee invited the links with the systems for monitoring sustainable development goals and the Sendai Framework for Disaster Risk Reduction (2015-2030) be strengthened.

To answer the questions[14] raised by the G77/China and the African Group, the secretariat will have to report on several points:
• Strengthening the coherence of the activities of institutional mechanisms relating to adaptation;
• The modalities for recognizing the adaptation efforts of developing countries;
• Adaptation needs assessment methods to assist developing countries without imposing an excessive burden on them;

13 https://unfccc.int/sites/default/files/resource/cop24_auv_nap.pdf
14 Questions raised by § 42, 44 and 45 of Decision 1/CP 21 on adaptation.

• Methods for adopting measures to facilitate the mobilization of adaptation support in developing countries, and methods for assessing the adequacy and efficiency of adaptation and support.
• The IPCC will support the work of the Adaptation Committee to this end, but only to provide technical support.

But the most important decision included in the "Katowice Package" was that the Adaptation Fund should serve the implementation of the Paris Agreement by following its guidelines, as of 1 January 2019.[15] The link between the Treaty and adaptation financing is finally established, and this enshrines adaptation as one of the Paris Agreement's voluntary and costly actions. There is no doubt that the acceleration of climate change will (unfortunately) have the consequence of establishing adaptation as one of the pillars of climate diplomacy.

The issue of adaptation, a future technical and financial challenge

Adaptation to climate change has been neglected by the various Conferences of the Parties for very different reasons. First, adaptation has been invited in COPs beyond the 1992 Convention: we have thus been able to speak of an "adaptation deficit" (Weikmans, 2012). Secondly, the escalation of the subject of loss and damage has contributed to blurring the demands of developing countries, which has ultimately satisfied developed countries concerned primarily with mitigation. Finally, the multiplicity of adaptation funds[16] (as well as their limited nature) reflects the local anchoring of needs, which is not part of the "universal" ambition of climate negotiations. This is why adaptation financing has many other channels than the UNFCCC, such as the Framework Convention to Combat Desertification and Land Degradation (UNCCD). But it is the treatment of the crucial issue of equity that will bring adaptation back to the forefront of climate negotiations, or... the acceleration of global warming.

Nevertheless, today, the subject finally seems to be getting tackled head-on. The Global Commission on Adaptation, including for example Bill Gates and former World Bank Managing Director Kristalina Georgieva (now head of the IMF), published a report[17] two weeks before the Climate Action Summit organised by the UN Secretary-General on 23 September in New York. This report recalls that the subject is complex and goes beyond development issues[18] and aims to develop guidelines for adaptation and stimulate global action, building coalitions between governments, business and civil society. It identifies 8 areas of action: (1) finance and investment, (2) food security and agriculture, (3) nature-based solutions, (4) water, (5) resilient cities, (6) action at the local level, (7) infrastructure and (8) disaster prevention.

This report states that every US dollar spent on adaptation could result in a net economic benefit of between 2 and 10 US dollars and produce benefits for people and the environment. This statement therefore opens the reflection on the possible "profitability" of adaptation investments and, in so doing, makes it more acceptable to finance adaptation through financial instruments other than grants.

---

15 The Fund continues to be funded by CDM transactions under the Kyoto Protocol, as well as donations from developed countries, but it is expected that the Fund will exclusively serve the Paris Agreement once the share of funds raised under Article 6.4 (i.e. the Sustainable Development Mechanism) of the Paris Agreement is available, as well as various public and private voluntary sources.
https://unfccc.int/sites/default/files/resource/l11f_1.pdf

16 Over 60, see chapter 4 (Funding)

17 Global Commission on Adaptation, (2019), "Adapt now : a global call for leadership on climate resilience"

18 Although only the developing countries' nationally-determined contributions (NDCs) reported before the COP 21 in 2015, included a section dedicated to adaptation - no developed country had done the same.

2 • Theoretical context and evolution of the concept of adaptation

The most commonly accepted definition today is that of the Intergovernmental Panel on Climate Change (IPCC), which defines adaptation as "*the adjustment in ecological, economic or social systems in response to actual or expected climate stimuli and their effects or impacts. This term refers to changes in processes, practices or structures to moderate potential damage or to benefit from opportunities associated with climate change*" (IPCC, 2014).

The emergence of a definition takes into account both current climate variability (in the short-term) and future climate that can be anticipated using different forecasts (in the long-term). This definition is the result of a theoretical and semantic evolution that we propose to briefly retrace, before addressing their implementation in practice through the issue of adaptation indicators.

Accommodation before adaptation

In anthropology, the concept of adaptation is uncertain.[19] It comes from biology, which defines a static conception of adaptation, as analysed by Cuvier in particular in his History of the Natural Sciences, which describes the structural-functional findings specific to living beings allowing them to survive in a given environment; dynamic adaptation rather refers to the transformations observed in a living organism, subjected to new living conditions allowing it to respond more effectively to these new conditions; one could more accurately speak of "acclimatization". They are individuals, while species transformations occur during evolution, in the Darwinian sense of the term.

But adaptation is not only biological, it can be behavioural. This is why we speak of adaptation strategies, which are dynamic and offer interim responses to climate change. All living beings seem to have this ability to adapt, as Gilles Bœuf (2012) illustrates. Among living species, the human species is the one that has best developed this ability. The problem is to know if, in the complex, diversified and unequal societies in which Man evolves in the 21st century, he will be able, as an individual and as a social group, or even as a species, to adapt to the predicted climate changes.

If living species seem to be able to adapt in many ways, human beings have extremely well-developed cognitive possibilities for adaptation: without going into the very many theories on human capacity to adapt, Jean Piaget's theories seem particularly interesting to us when transposing from the man-child to the man confronted with climate change.

Psychologist Jean Piaget, a biologist by training, has linked the principles of adaptation in biology with the progress of knowledge. He highlighted that learning can take place through *assimilation* or *accommodation*. According to him, the construction of knowledge and learning is achieved by combining the subject's pre-existing cognitive structures (assimilation into the subject) and the distinguished objects in the environment (accommodation to things). This synthesis is called

19 See Guillaume Simonet "From adjustment to transformation: towards an expansion of adaptation", in Sustainable Development and Territories Vol. 7, No. 2 (July 2016) Adaptation under stress (2/2)

balancing (équilibration). It is a dynamic state that combines assimilation and accommodation. Sometimes there is an imbalance, because there is no cognitive structure pre-existing to what the child apprehends, he then adjusts by accommodation. He needs to modify his cognitive structure to integrate this new object (Piaget, 1974).

At the individual level, as well as at the group level, Man has an unbalanced learning about climate change. His or her abilities allow him or her to feel the changes in time mentioned above, and also to assimilate the information he or she receives about climate change, which is multiple and contradictory. However, several characteristics of this mutation allow Man to mobilise his cognitive structures to apprehend it and adapt to it:

- the speed of changes projected or observed on the scale of a human life (our cognitive structure, forged by culture, considers nature as immutable in relation to the ephemeral nature of our life);
- the extent of these climate changes (glaciers melting in less than a century, sea level rise, various disasters, in other words, the possibility of the reality of an apocalypse);
- the controversy that applies to it (climate scepticism, uncertain projections in ranges from +2°C to +6°C, catastrophism);
- and finally, collective and individual guilt (individual impossibility to break with certain habits of life, feeling of guilt in relation to future generations...).
- There is a cognitive dissonance among 21st century man in relation to the upheavals he feels and begins to experience.

The American Psychological Association has reported on the importance of psychology in the fight against climate change. The report, published in 2009, describes the physiological and psychological barriers that would prevent behavioural changes that could limit the causes and effects of climate change. This perfectly illustrates the difficulty of accommodation that we have just highlighted. And this is true all over the world. According to this report, the reason is that it is difficult to experience climate change personally and directly, and that accommodation of these phenomena is not achieved. As a result, their appropriation cannot be either. Human populations are in a great imbalance between information that is beyond their control and experience that they lack, except in the event of a disaster or climate stress.

Conceptual obstacles to adaptation

One illustration of this imbalance is precisely the refusal to work for adaptation to climate change, which has prevailed over the past 25 years in international negotiations: mitigating global warming has always been given priority over adapting to it. In ecological environments, the very word "adaptation", which is nevertheless part of the history of species, and particularly of the human species, arouses mistrust and embodies the repudiation of the "fight" against global warming.

The economist Olivier Godard strongly defended this point of view (Godard, 2010), reminding us, alongside Lewontin, that adaptation was not evolution;[20] he also demonstrates that adaptation in ecology is only a co-evolution. But, as a result, he places the supporters of adaptation, whose point of view he equates to a "great defeat", in the camp not only of the inactive who embody the "shift from the imagination to resignation", but also of the climate sceptics: "*Thus humanity would only have to adapt to the new climate situation without claiming to change its course*". This is the position defended by Henri Atlan, a medical biologist, who thus castigates the "adaptationists". The

20 "In fact, beings only begin (...) to adapt when they begin to interact with the world. As a result, adaptation does not refer to a process in which organisms encounter pre-existing problems, because organisms create these problems through their existence and change. The real problem of evolution is that organisms are constantly building their own worlds and creating the problems they then have to solve." (Godard, 2010)

latter then concedes an interest in combining mitigation and adaptation policies by distinguishing an "unavoidable" climate change with another that would not be unavoidable. For the former, *"it is better to take measures to facilitate the adaptation of the economy, society and individuals than to remain vulnerable in the name of preserving familiar ways of life and doing things"*, but for the latter, adaptation proposals would not be appropriate, because *"the problem is to build investment capacity to achieve this low-carbon economy that the climate threat and oil depletion require to be promoted in the fairly short term"*.

One can only agree with this second part of the analysis, but one may wonder whether the "repulsion" shown by Olivier Godard in 2010 (motivated in part by the disappointing results of the Copenhagen conference, which could legitimately lead to fears that adaptation would be a "safe haven" from the difficulties of serious decisions for mitigation) would be the same today when political and civil leaders made commitments in Paris in 2015. However, even after the Paris Agreement, it seems that mitigation policies continue to be more mobilizing - without prejudging the real effects of this mobilization, given the global warming boom - and that adaptation funds, although very urgent, are struggling to be raised.[21] Moreover, today adaptation is our inevitable destiny in the next twenty years, because our efforts, if they are proven, will only be significant after 2050 because of climate inertia. The acceleration of global warming and its extent mean that adaptation must therefore take on another dimension, another direction in order to satisfy the climate justice claimed (Godard, 2015).

To adapt or to transform?

It is quite interesting to note that a philosopher like Clive Hamilton, in denouncing the human community's denial in the face of the inevitable end of the world as we know it, distinguishes two stages of adaptation: technical adaptation, which would assimilate it to a solution, which is ridiculous in relation to the immensity of what needs to be done, and ontological adaptation, which would support the recognition of the momentous upheavals caused by global warming. According to his thesis (whose starting point is expressed in the first sentence of his book, *"with each advance in climatology, we are told that the situation is getting worse"), adaptation risks becoming "an endless task." Thereby assimilating global warming denial to humans' refusal to accept death, it castigates both "our confidence in our ability to adapt easily to climate change and our ability to stabilize it."* (Hamilton, 2013)

Nevertheless, as with the philosopher Jean-Pierre Dupuy, who defends that "enlightened catastrophism" is humanity's path of salvation, this desperate consciousness to make us accept reality, would be a step akin to mourning. It is on the basis of this awareness of the disappearance of the world, as man has known it for thousands of years, that we would be able to take measures against global warming, useful in any case, whether they are corrective or adaptive.

Adaptation, resilience, transition.

We can therefore see that, as biologist Lucien Cuenot said, adaptation (which he called a "frightening question") raises metaphysical and philosophical problems of the relationship between man and nature. If we were to retain two variations of adaptation, that of coping with a shock, and that of moving from one state to another, from one world to another, we better understand that it is often better understood under the terms of resilience and transition.

---

21 See chapter 4 (Funding)

Resilience is commonly defined as the ability for a subject facing significant stress to use adaptive mechanisms that allow him or her not only to "hold on" but to bounce back by taking some benefit from such a confrontation.[22] Therefore, with regard to climate change, an astrophysicist such as Vincent Boqueho (2012) considers that environmental stress, crucial in the evolution of species (in the Darwinian sense of the term) could even have contributed to driving human evolution to date and would generate major innovations in the history of our species. Resilience, a term used in the adaptation chapter of the Paris Agreement,[23] can be defined both in its original physical meaning and in that of psychology. The transition, for its part, would acknowledge that one of the components of the Anthropocene is adaptation, so that this new era does not lead to collapse, in Diamond's sense. As stated in The Age of Transition, *"where sustainable development sought to prevent distant difficulties, transition is intended to be an urgent adaptation to the ongoing and/or imminent energy decline and climate change."* (Bourg et al., 2015). This requires adapting to climate change in hard and technological sciences, but also in the human sciences, such as evolutionary psychology and neuroscience.

The neuropsychiatrist Sébastien Bohler[24] has just thereby argued that the cause of our blindness to global warming is in the striatum, a part of our brain involved in desire, addictions, motor skills and the management of anxiety and well-being. This brain structure encourages us to behave in a way that ignores the long term, reacting to immediate pleasure or danger, because we would be programmed to think only of the present...

Adaptation to climate change will also have to involve both the hard sciences and the humanities. Man can no longer assimilate to Prometheus, and adaptation, which must clearly not replace mitigation of GHG emissions, must serve as an ethical foundation for a humanity whose new history is being written. In 2013, before the 2017 "Declaration of Ethical Principles in relation to Climate Change", UNESCO had understood this well, by drafting 5 principles dedicated to adaptation:

- Avoid harming people or the environment by failing to act in response to climate change or by responding recklessly.
- Equity in the distribution of climate change management and response in an appropriate manner with particular reference to the situation of the most vulnerable populations, future generations, indigenous peoples, women and children.
- Equitable access to essential resources, medical, scientific and technological developments, as well as knowledge about climate change and measures taken to adapt to it.
- The intellectual and moral solidarity of humanity in the face of the common challenges of climate change and the consequences of climate disasters.
- Environmental sustainability, including the protection of biodiversity and the integrity of ecosystems as the very basis of life on earth.

22 In 2004, psychiatrist Boris Cyrulnik recounted the fable of the "stone breakers" often mentioned by Charles Péguy.

23 Paragraph 44 of the Decision "invites all relevant United Nations organizations and international, regional and national financial institutions, through the secretariat, to provide information to Parties on how their development assistance and climate finance programmes incorporate measures to protect against climate risks and resilience to climate change"; and Article 7.1. of the Agreement: "The Parties shall establish the global adaptation target, which shall be to enhance adaptive capacity, increase resilience to climate change and reduce vulnerability to climate change, with a view to contributing to sustainable development and ensuring an adequate adaptation response in the context of the temperature target set out in Article 2."

24 Bohler, S. (2019). The human bug, why our brains push us to destroy the planet and how to prevent it. Paris: Robert Laffont. 270 p.

3 • The pitfall of indicators and the metrics of adaptation

As much as mitigation action indicators are standardized (because they are based on the quantification of reduced or avoided emissions), adaptation indicators are confronted with a series of constraints that make this harmonization much more complex. *"Adaptation concerns both society and ecosystems. It involves capacity and governance dimensions. It cannot be measured through a single indicator"* (Ademe, 2012).

Many indicators have focused on assessing the vulnerabilities of a territory, but do not reflect the adaptive capacities of that territory or a given community. Researchers, such as Alexandre Magnan (IDDRI), have highlighted the "vulnerability trajectories" and a very large number of indicators exist, for example, for coastal areas. But it should be noted that not all are exactly adaptation indicators, but indicators of fragility, vulnerability (for example through composite indicators integrating demographic, climate data, etc.). For adaptation, they must be both process indicators and interdisciplinary and contextualized results. We therefore need to clearly separate vulnerability indicators (based on climate scenarios = external factors) from adaptation indicators (internal ecosystem factors), which remain more difficult to understand.

The use of adaptation indicators occurs at three stages in the description and selection of adaptive projects for funding: (i) to rank funding priorities and guide the actors' investments (ex ante evaluation), (ii) to estimate the results and effectiveness of the investments and projects financed, so as to possibly redirect certain actions if they prove to be ineffective or even counterproductive (ex post evaluation), (iii) to monitor funding dedicated to adaptation taking into account the political nature of the issue and the adaptation/development continuum ("tracking"). The issue of adaptation metrics in the UNFCCC process reflects this evolution over the past 20 years: since the measurement of adaptation needs, monitoring and evaluation of actions have gradually emerged with the results-based management of international funds. Finally, the assessment of collective progress, in terms of the overall impact of adaptation actions, occurred with the adoption of the Paris Agreement and as a component of the "global assessment" assessment, scheduled every five years from 2023 (Möhner, UNEP DTU 2018). At present, no common indicators are adopted within the UNFCCC.

These adaptation indicators must overcome many challenges, including:
- the interval between project completion and the occurrence of climate change impacts;
- the high level of uncertainty in climate projections and therefore the adequacy of adaptation action, particularly in regions where climate data are lacking;
- local specificities and contexts involving environmental, climatic, economic and social variables, which can sometimes be difficult to model due to a lack of robust local data;
- in developing countries, the difficulty of measuring what is "development" versus adaptation, given that many basic needs are not covered and do not provide strong adaptive capacities;
- the non-linearity of constraints, risks and levers of change, with threshold effects that are difficult to predict.

The need to stick as closely as possible to local social and environmental contexts when it comes to adaptation is a recurring conclusion amply illustrated by UNEP's collection of scientific articles in 2018.[25] This concludes that the establishment of a common assessment framework for adaptation, to enable a common approach operating at all levels of governance and in all sectors of activity, must remain flexible, open and thus strike a balance between its relevance at the local level and its standardization. In concrete terms, it is a question of integrating the use of metrics whose values cannot be aggregated. If, however, universal metrics are used, they must be accompanied by metrics more specific to the program, its objectives and context.

Ex ante evaluation

Countries' adaptation strategies and projects are recent in relation to those of mitigation. For example, France's first national climate change adaptation plan (PNACCC) dates back to 2011: the Parties to the UNFCCC agreed to develop their first National Climate Adaptation Plans (NAPs) at the Cancún Summit in 2010. Moreover, adaptation actions are established with a long term view. Their impacts will only be appraised from 2030, or even 2040. The ex ante evaluation of projects and future strategies often remains the only relevant evaluation, in order to direct funding (known as conditional in the NDCs) towards adaptation intentions (projects programmed in contributions and adaptation plans).

The methodology, which would allow this assessment against a reference scenario and through adaptive efficiency indicators, is still at the research stage (example of IDDRI publications). Several authors pointed out the difficulty of collectively agreeing on a set of reliable indicators that could be used ex ante. The Citepa[26] has developed an indicator of the universal relevance (called the adaptive fitness coefficient) of adaptive solutions to the challenges. The fitness coefficient makes it possible, on the one hand, to compare ex ante the relevance of the adaptive choices made by the 192 Parties in their NDCs (version 1), and on the other hand, to predict which climate risks and vulnerabilities would be best addressed by such adaptive action, and conversely, which would be the most relevant adaptive solutions to solve a climate challenge. It is currently being published.

The prospects for ex ante evaluation and comparability of projects, beyond the diversity and even specificity of local situations, are considerable. In the context of the 2020 update of the NDCs (in their second version), and even more so in order to develop version 3 (due in 2025), the challenge is to be able to direct, channel and mobilize development (AfDB for example), and climate (AFD, GCF) financing towards effective adaptive projects.

Ex post evaluation

Some donors have developed their own frameworks for evaluating climate change adaptation projects. The World Bank[27] uses its own evaluation method for its capacity building operations to build resilience to natural disasters. This illustrates the absence of an ex-post standardized approach to evaluation *"There is no standardized approach to evaluation. Rather, each evaluation must be tailored to meet the needs of an operation's stakeholders as well as specific contexts (geographic, socio-economic, institutional, sectoral, etc.)"* and the importance of defining first and foremost the primary objective to be evaluated. Other funds, such as the Least Developed Countries Fund or the Special Climate Change Fund, have developed the Adaptation Monitoring and Assessment Tool.

25 Christiansen, L., Martinez, G. and Naswa, P. (eds.) Adaptation metrics: perspectives on measuring, aggregating and comparing adaptation results. UNEP DTU Partnership, Copenhagen.

26 Centre Interprofessionnel Technique d'Etudes de la pollution Atmosphérique

27 World Bank (2017). Operational Guidance for Monitoring and Evaluation (M&E) in Climate and Disaster Resilience-Building Operations.

These tools are used to assess progress in the territories and to make international comparisons.

However, in order to make this commitment to compatibility made in the Paris Agreement operational, it is also necessary to harmonize the assessment of the project's impacts (ex-post). For example, in 2019, Agence Française de Développement (AFD) launched a working group on ex-post evaluation of climate projects including adaptation with two members of the International Development Finance Club (IDFC), the German Development Bank (KfW) and the South African Development Bank (DBSA).

To this end, the AFD also conducted a review of the ex-post evaluation practices of some 20 donors. Concerning adaptation, the comparison notes that many of them use methods traditionally used for development projects to evaluate projects, using the criteria of the OECD Development Assistance Committee (DAC), without including specific adaptation indicators. At the same time, few have developed impact evaluations based on so-called "experimental" methods: econometric methods to compare the results of an intervention between a beneficiary group of the intervention and a non-beneficiary control group. The report highlights various initiatives: the Green Climate Fund with the LORTA (Learning-Oriented Real-Time Real-Time impact Assessment) programme, United Nations Development Programme and GIZ, which jointly propose a guide on scientific impact assessments specific to adaptation,[28] and the International Fund for Agricultural Development (IFAD-, through the Adaptation for Smallholder Agriculture Programme (ASAP), which includes an assessment of the increase in resilience of targeted populations, by developing composite indices. A central recommendation is to *"strengthen the evaluability of projects and prepare for evaluation from the design phase of the project, by defining clear objectives, indicators and developing targeted theories of change"*.[29]

The example of Tracking Adaptation and Measuring Development (TAMD), developed by The International Institute for Environment and Development (IIED), shows that taking the context of an indicator into account does not necessarily prevent the comparison and aggregation of results, and also highlights the importance of co-creating indicators with stakeholders to strengthen their ownership of the project. The TAMD framework is an indicator methodology that identifies four categories of indicators for monitoring and evaluation (M&E):

1. Climate risk management indicators are used to assess the extent and quality of institutional processes and mechanisms for responding to climate risk;
2. Resilience indicators, which include reducing vulnerabilities and increasing adaptive capacities;
3. Human well-being and development performance indicators, measurable through indicators of the "costs" of climate change (or inaction), its effects on material goods, livelihoods, human lives or aspects of well-being, such as poverty, nutrition or health;
4. climatic indices, if possible as indexed as closely as possible to local specificities, for example using the dates of the beginning of the rainy season, the duration of dry periods during crop growth periods or maximum rainfall intensities, data that are more relevant than average temperatures or total rainfall.

The various applications of the TAMD at the local level - in decentralized climate funds (Kenya, Tanzania, Mali, Senegal), in guidelines for the formulation of local adaptation plans (Mozambique) or in the evaluation of national adaptation programmes (Ethiopia) - have shown the capacity of this method to adapt to local contexts by partially adjusting the dashboard and indicators used to the context, and especially by identifying objectives that are being monitored and evaluated

28 GIZ, UNDP (2015). Impact evaluation guidebook for CCA projects

29 AFD (2019). Extract from the TORs of the adaptation assessment currently being prepared

with programme stakeholders. Nevertheless, the TAMD allows the risk management capacities of several communities to be compared in different ways: when the geographical and/or institutional scale is strictly the same, by comparing not absolute values that are compared between two communes, but relative changes or progress towards a situation of resilience (Fisher; Anderson, UNEP UTP 2018).

Finally, methodologies proposing common bases for the evaluation of adaptation actions are also proposed by networks of actors, with the objective of securing funding allocated to adaptation projects by demonstrating their impact. This is the case of C40 with the city specific guidelines *"Measuring Progress in Urban Climate Adaptation"* which go much further than a turn-key framework by suggesting a method for formulating its own framework, as well as a matrix of commonly encountered indicators, both based on the experience of network member cities and the feedback of many others. This shows that the metric of adaptation is an essentially empirical or bottom-up tool.

Tracking

Tracking here refers to the process of identifying (or characterizing) adaptation projects. As a major example, Agence Française de Développement (AFD) has committed to dedicating 50% of its financial commitments to projects with co-benefits for climate change and to conduct their activity in a way that is 100% compatible with the Paris Agreement: each project financed by the group must therefore be part of the low-carbon and resilient development path of the country of intervention. On adaptation in particular, the agency carried out work to qualify adaptation projects based on criteria preceding project implementation (analysis of vulnerabilities, objectives targeting them and expected impacts), which in turn stemmed from the common principles for Climate Change Adaptation Finance Tracking (MDBs-IDFC). Beyond tracking tools, the long-term methodological perspective is to propose a Monitoring, Reporting and Verification (MRV) system for adaptation, similar to what exists for inventories and mitigation. This MRV (or equivalent) approach should allow comparison, secure assessment and monitoring of adaptive progress over time. It will be based on a complete information system (models and field data), specific reporting tools and a long-term evaluation process.

REFERENCES

• American Psychological Association, 2009, Psychology and Global Climate Change: Addressing a Multi-faceted Phenomenon and Set of Challenges, Report, www.apa.org

• Aykut S. C. et Dahan A., Gouverner le climat ? 20 ans de négociations internationales, SciencesPo les presses, 2015

• Boeuf G., Toussaint J.-F., Swynghedauw B. (dir.), 2012, L'Homme peut-il s'adapter à lui-même ?, Quae éditions

• Boqueho V., Les civilisations à l'épreuve du climat, Dunod 2012

• Bourg D., Kaufmann A. et Meda D., 2015, L'âge de la transition, en route pour la conversion écologique. Colloque de Cerisy, Les petits matins, 2015

• Gemenne F., 2009, De l'équité dans l'adaptation aux impacts du changement climatique in Cournil C. et Fabregoule C. Changement climatique et défis du droit. Bruxelles : Bruylant

Voir par exemple GIZ, (2017), "Risk Supplement to the Vulnerability Sourcebook"

• Godard O., 2010, Cette ambigüe adaptation au changement climatique, in Natures Sciences Sociétés 18(3):287-297

• Godard O., 2015, La justice climatique mondiale, Paris, La Découverte, coll. " Repères ",

• de Guio S., Rencki J., 2011, Le Fonds d'adaptation, laboratoire du financement du changement climatique. IDDRI Working paper n°10/11 novembre 2011 | climat http://www.iddri.org/Publications/

• Hamilton C., 2013, Requiem pour l'espèce humaine, Sciences Po Les Presses

• Laville B., 2017, " Contraindre les États et les éléments ? " : le pari de... l'Accord de Paris " et " L'entrée en vigueur de l'Accord de Paris intervient

avant la COP 22, alors que les alertes sur l'accélération du réchauffement climatique se multiplient. " In Energie Environnement Infrastructures,
• Revue mensuelle Lexisnexis Jurisclasseur, février et octobre 2017
• Laville B., 2015, Comment l'Apocalypse peut-elle nous rendre heureux ? in Nouveaux mythes, nouveaux imaginaires pour un monde durable, Éditions Les petits matins
• Piaget J., 1974, La prise de conscience, PUF. Version électronique sur le site de la Fondation Jean Piaget ; www.fondationjeanpiaget.ch
OCDE 2016 L'adaptation nationale au changement climatique, Nouvelles pratiques de suivi et d'évaluation,
• Guillaume Simonet, Le concept d'adaptation : polysémie interdisciplinaire et implication pour les changements climatique, in Natures Sciences Sociétés 2009/4 (Vol. 17), pages 392 à 401
• Guillaume Simonet De l'ajustement à la transformation : vers un essor de l'adaptation ? i Développement durable et territoires Vol. 7, n°2 (Juillet 2016) L'adaptation en tension (2/2)
• Weikmans R., 2012, Le coût de l'adaptation aux changements climatiques dans les pays en développement VertigO - la revue électronique en sciences de l'environnement, Volume 12 Numéro 1 | mai 2012 - https://vertigo.revues.org/11931

SECTION II

Adaptation actions by local authorities

1 • From diagnosis to action: available data on adaptation processes

The implementation of adaptation measures is largely the responsibility of governments and local communities. While the extent of climate change knows no borders, its effects are local and can vary greatly from one territory to another, depending on that territory's degree of vulnerability. Each system, whether urban, rural or natural, is a unique combination of interconnected geographical, physical, socio-economic, political and environmental factors. ***These parameters will determine the vulnerability* of a territory to climate change, which according to Ademe is "*a function of the nature, extent and rate of climate variation (also known as exposure) to which the system in question is exposed and the sensitivity of the system to this climate variation*"** (Ademe, 2013, p.5. Italic is ours). Quenault et al. (2011) add a third factor to this equation – the adaptive capacities of the system, defined by the IPCC as "*the ability of natural or human systems to adjust in response to climate change (including climate variability and extremes) in order to mitigate potential effects, exploit opportunities, or cope with consequences*" (Quenault et al., 2011, p. 153).

Detailed knowledge of the particular characteristics of a territory is therefore essential to prepare for the necessary long-term transformations imposed by climate change, with their share of uncertainties for the future. It is at the local level, as the OECD points out, that adaptation action is best observed, insofar as this scale makes it possible to assess the "translation of knowledge and capacities into behaviours and actions" (OECD, 2009, p. 151) into real-life conditions. More recently, the first Global Commission on Adaptation report has also stressed the importance of local knowledge, in particular that of local and indigenous communities (Global Commission on Adaptation, 2019). In particular, cities, as a system concentrating human activities, will play a central role in future adaptation efforts: half of the world's population now resides in cities, and more than two-thirds will be urban by 2050, with particularly strong growth in the south; 80% of the world's wealth is produced there; 880 million informal residents are particularly vulnerable (Chu & al., 2019).

In this section, we will review the data primarily provided by cities and regions to the main international networks, initiatives and reporting platforms (see Climate Chance, Report 2 – Assessment of territorial action, 2019), but also look at academic studies. This will help to establish a synthesis of the different **typologies in evolution of the risks and impacts diagnosed by the territories (1)**, their **degrees of commitment (2)** and their **strategies and projects in action (3).** The synthesis and analysis of these data will help to **estimate progress in the dissemination of a culture of adaptation within communities**.

Diagnosing adaptation needs: typology of risks and priorities for action by cities and regions

A territorial diagnosis of risk exposure and direct observation of impacts caused by hazards and/or long-term changing climate trends are direct triggers for territorial adaptation action. This data on the nature of the impacts facing the territories provides more information on the processes that underpin the adaptation efforts undertaken at the regional or local level.

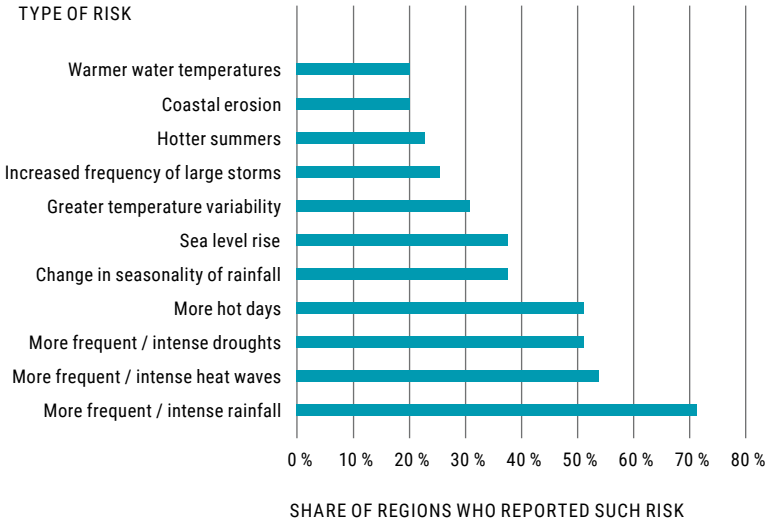
• CLIMATE HAZARDS AND CLIMATE CHANGE •

• **RegionsAdapt**: In 2018, members (n=38) of the RegionsAdapt initiative (Regions4) who reported that they had engaged in adaptation efforts reported that the three most important types of risks they faced were extreme precipitation (71% of respondents), heat events (54%) and droughts (51%), all of which were more frequent and/or intense (fig. 1). Only three regions could not respond, mainly due to a lack of information.

FIGURE 1

THE CLIMATE RISKS MOST FREQUENTLY REPORTED BY THE PARTICIPANT REGIONS

Source : RegionsAdapt, 2018



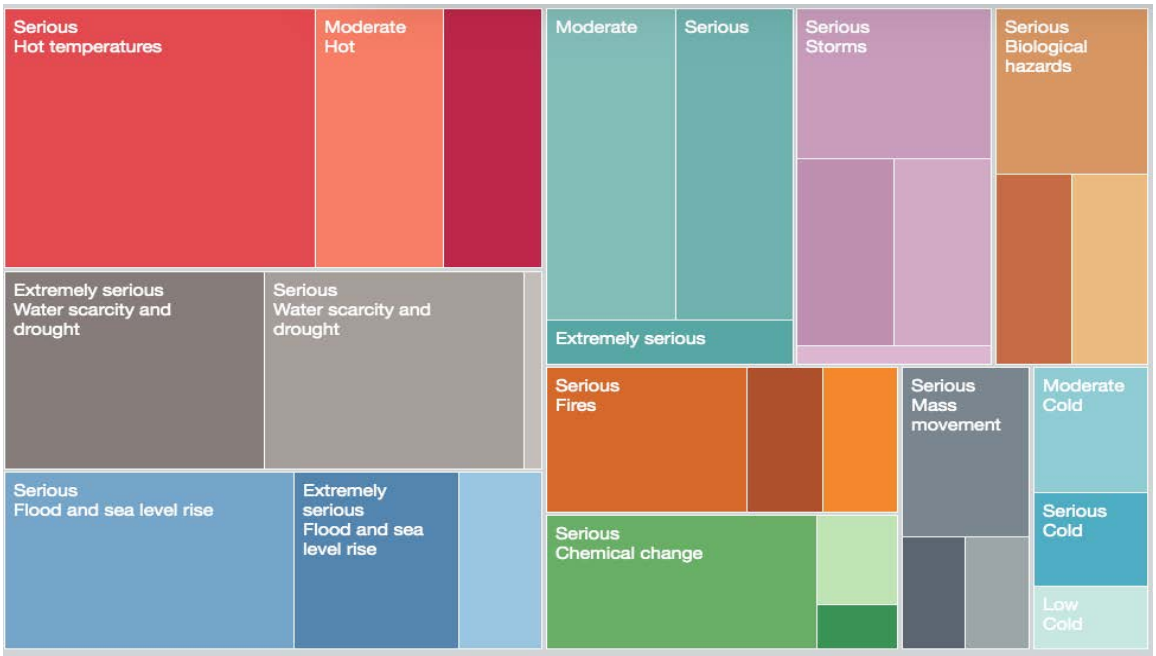
• **Global Covenant of Mayors:** In the form of an interactive graph, the GCoM presents the risks for which a panel of signatory cities (n=300) report preparing at different time horizons and intensities (moderate/serious/extremely serious) (fig. 2). The most frequently cited current risks are those related to increased water stress and droughts (13%), rising temperatures (12.6%), floods and rising water levels (8.3%) and precipitation (8%). On the other hand, in the long term, risks related to floods and rising water levels are the most frequently mentioned (10.6%), but to a lesser extent. The proportions of the results tend to converge as we look to the long term.

• **ICLEI:** Regarding the three main climate risks reported by ICLEI members (n=139) in their urban areas, responses indicate flooding and sea level rise (52%), extreme rainfall (38%) and water availability due to droughts (30%). These risks, reported by respondents as having a high probability of occurring in the near future with a high potential magnitude, could lead to serious consequences and disruptions in their operations. In addition, 79% of these respondents believe that they expect an increase in the intensity and frequency of impacts on their territory (fig. 3).

FIGURE 2

CLIMATE HAZARDS AND TRENDS CURRENTLY IDENTIFIED (WEIGHTING NUMBER OF CITIES/HAZARDS)

Source : GCOM, *2019*



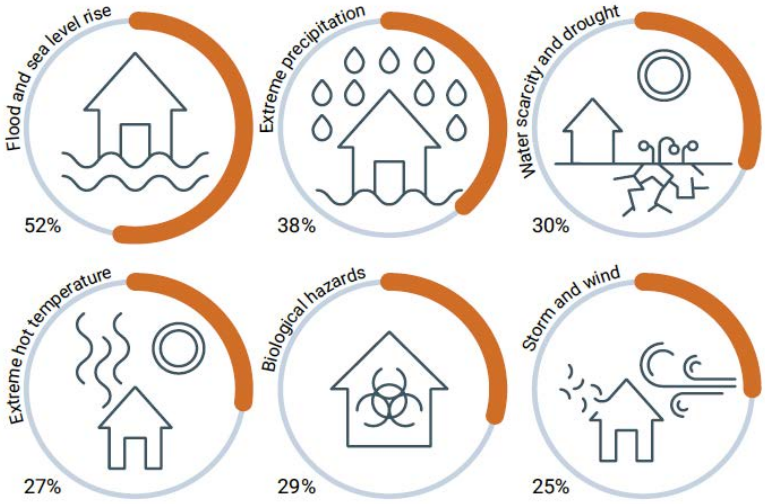
According to the data collected, the observed climate risks currently facing the world's regions and cities are converging. The increase in seasonal variability and the gap between seasons is noted, leading to severe droughts (and to some extent extreme cold) and floods leading to occasional or progressive water unavailability for both populations and economic activities. Beyond these variables, the intensity of storms, the arrival of invasive biological species and the increase in coastal erosion are among the trends that territories currently report facing and against which they expect to have to increase their adaptation efforts due to the increasing number of direct and indirect consequences. All of these risks and their developments are in line with the scientific results from successive publications of IPCC reports and studies (Aguiar et al., 2018). According to the UN Department of Economic and Social Affairs, around **three in five towns or cities across the world with a population greater than 500,000 inhabitants could have to face increased risks as the result of climate change**. This means that of the 1,146 towns and cities covered by the study, 679 are estimated to be vulnerable to cyclones, floods, droughts or mudslides. Combined, these high-risk towns and cities represent 1.4 billion people, or one fifth of the world's population (UNDESA, 2018).

By analysing the climate scenarios of 520 towns and cities around the world for up until 2050, an international group of researchers has come to the conclusion that, even under an optimistic forcing scenario, i.e. with a limited change in the concentration of CO_2 in the atmosphere, **in the future, 77% of cities will experience climate conditions close to the current climate of other cities of similar size**. This means that London could resemble Barcelona, Seattle could be like San Francisco, or Nairobi may be more similar to Beirut (Bastin et al., 2019).

FIGURE 3

THE SIX MAIN RISKS AFFECTING ICLEI MEMBERS

Source : ICLEI, 2018



However, risk exposure is not uniform and remains unevenly distributed between the southern and northern hemispheres. The IPCC Special Report on the impacts of global warming of 1.5°C notes in this regard that **despite the political leadership of northern cities, the basic social and economic activities of a large part of the population of southern countries are expected to suffer greater consequences** (IPCC, 2018). These impacts are on top of demographic, economic, environmental, social and political stress factors in southern cities. In addition, even the estimated "average" consequences of climate risks can be particularly damaging to cities in the south because of their greater sensitivity to disaster risks. These observations are regularly used as arguments to **encourage territories to increase their synergies when developing sectoral policies structuring their territorial action** (ICLEI, 2018a).

Although the situation is greatly contrasted within the continent, the regions and cities of the African continent face significant challenges in linking socio-economic issues with the impacts of climate change. The ongoing rural exodus in most countries of the continent, combined with weak planning capacities, generates large areas of informal settlements with extremely vulnerable populations. The increasingly limited availability of high-quality drinking water and increasing tensions between uses of depleted resources are worrying risks that weigh heavily on the public institutions responsible for managing them, and already have limited room for manoeuvre (Butterfield et al., 2017).

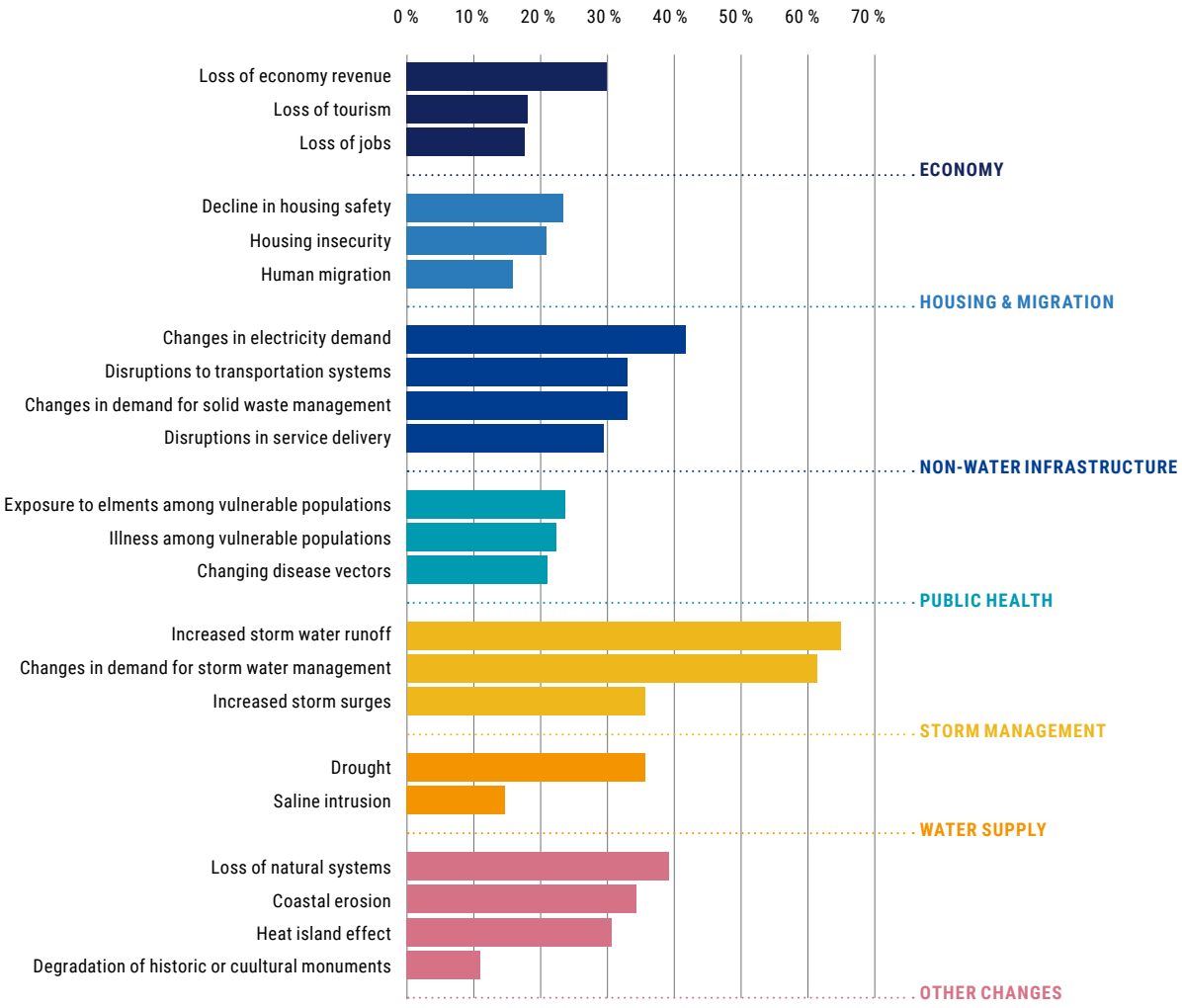
• SOCIOECONOMIC IMPACTS •

Economists have long been working to estimate the cumulative socio-economic impact of climate change on a global scale. From the first Stern Review (2006) to the High-Level Commission on Carbon Prices (2017), the "social cost of carbon" has been measured to estimate the marginal cost to society of each additional ton of CO_2 emitted into the atmosphere. This makes it possible to estimate not only the "cost of inaction" in mitigation, but also to assess the magnitude of the impacts of climate risks on society. At the end of 2018, Ricke et el. published in *Nature Climate Change* an estimate of this social cost of carbon per country, arguing that this scale of measurement makes it possible to better estimate the regional impacts of climate change and, among other things, to plan the necessary adaptation and compensation measures. **Moving down an additional level, studies have undertaken to synthesise the potential losses identified by cities and regional governments when translating these climate risks into socio-economic risks.**

FIGURE 4

ANTICIPATED RISKS CONNECTED TO CLIMATE CHANGE

Source : Carmin et al , 2012



• A first survey coordinated by MIT in 2012 among 468 ICLEI cities, representing 44% of the members at the time and a majority of US cities, Carmin et al. (2012) notes that storm water risks are the most frequently cited, including increased runoff (65%) and increased demand for storm water management (61%). Respondents also report that they expect changes in electricity demand (41%) and disruptions in transportation systems and solid waste management (fig. 4).

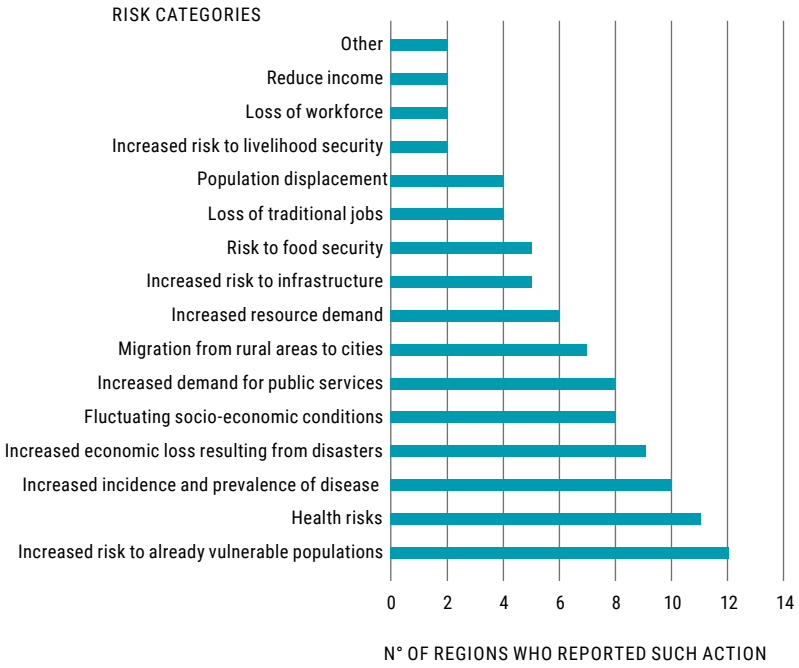
• Among the future socio-economic risks identified by the RegionsAdapt regions (n=38), the increase in risks for populations already in a vulnerable situation is most frequently cited (12) in the face of public health risks (11 + 10) or economic losses due to climate disasters (9) (fig. 5).

• **In non-urban areas, it is mainly issues related to water availability and its consequences that have triggered transformations in agricultural or livestock systems** (n=23). This means that risks are mainly associated with changes in the seasonal shift and variability of rainfall (in terms of intensity, duration and/or frequency of droughts, floods or frost), leading to a gap in agricultural water needs at key stages in the agricultural calendar. Finally, the reduction of snow cover, invasions of harmful species and increased soil salinisation are also elements that have contributed to triggering adaptation actions among farmers or agricultural cooperatives in the territories concerned (Vermuelen et al., 2018).

FIGURE 5

MOST COMMON SOCIO-ECONOMIC RISKS MENTIONED BY PARTICIPANT REGIONS

Source : RegionsAdapt, 2018



Boosting adaptation: typology of the involvement of cities and regions

• ACADEMIC CONTRIBUTIONS •

Many scientific studies allow for international comparison, sometimes based on data provided by networks and initiatives. The 2012 MIT study of 468 ICLEI member towns and villages provided information on the status of their adaptation efforts (Carmin et al., 2012), **in which 68% of respondents reported that they were engaged in activities related to adaptation planning**. The highest engagement rates were reported by cities in Latin America (95%), Canada (92%), Australia and New Zealand (86%), Europe (84%) and Africa (80%). The lowest rates were observed in Asia (67%) and in the US (59%).

Four years later, in 2016, a new study by Aaros of 401 urban areas with more than one million inhabitants worldwide used documents available online (adaptation or climate plans, and partnerships with local NGOs) in targeted cities to identify and characterise ongoing adaptation approaches. **The results are very different from the 2012 study: only 15% of cities reported operational adaptation initiatives (61) and 18% (73) planning to develop an adaptation policy**. Thirteen cities were described as very active, i.e. having implemented at least 17 adaptation actions, including two megacities (New York and London). With the exception of Cape Town and Durban in South Africa, and Semarang in Indonesia, the most active cities are located in high-income countries in North America, Europe and Oceania (Araos et al., 2016).

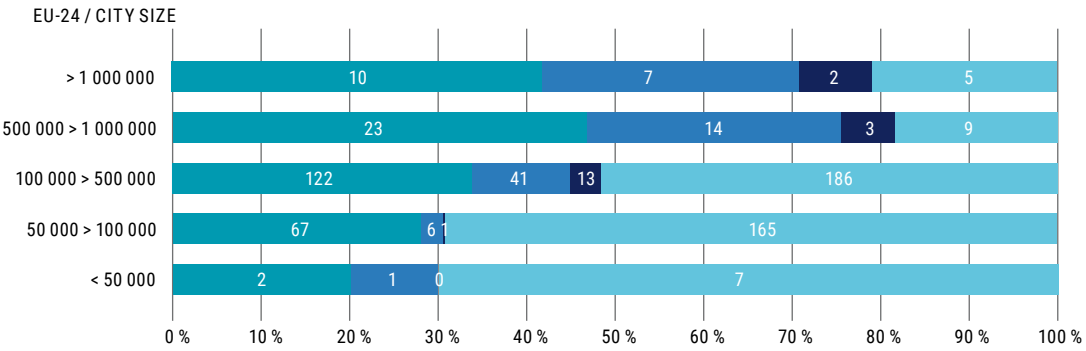
How can such a decline in results between two studies four years apart be explained? The best results for ICLEI cities can be attributed to their greater sensitivity to climate issues. However, as detailed in the following section, the typological refinement of adaptation actions from one study

to another first narrowed the scope of what can be considered an adaptation action, much broader in the analysis of ICLEI cities. It can also be assumed that in the first study, which is based on declarations, respondents may have an incorrect idea of what adaptation is, with figures rising (see Section 1 of this Report on confusions between development, adaptation and resilience); conversely, in the second study, the survey on online platforms is likely to have suffered from a lack of information if communities' online communication on their adaptation actions is incomplete, which could lower the results.

FIGURE 6

SHARE OF ADAPTATION PLANS IN CLIMATE POLICIES IMPLEMENTED IN EUROPEAN CITIES BASED ON THEIR SIZE

Source : Reckien et al , 2018



Several other studies published recently on the place of adaptation in territorial climate plans have focused on regional sample groups around the world, such as the study by Guyadeen et al. (2018) focusing on 66 cities in Canada, Woodruff (2018) on a panel of 44 cities in the United States, or the many studies focusing on European cities (Pietrapertosa, F. et al., 2019; Reckien et al., 2019). **The conclusions of all of these regional studies show that adaptation is still at the emergence stage for the majority of the cases studied and suffers from less attention in local political agendas compared to actions to reduce greenhouse gas emissions.** The study by Reckien and colleagues (2018) is probably the most successful to date. Covering 885 cities in 32 European countries, its results show that only 26% of them have developed an adaptation plan, and 16% have adaptation measures within their local climate plan (fig. 6). **In addition, the study points out that only 20% of these measures are voluntary, the rest corresponding to a response to national regulatory injunctions.**

• DATA FROM LOCAL AUTHORITIES' COOPERATION AREAS •

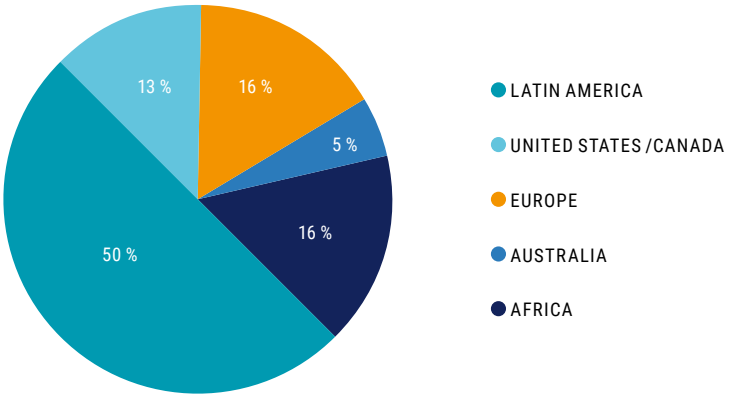
Whether specialised or more general, the networks, local authority initiatives and reporting platforms presented in Climate Chance's "Report 2 – Assessment of territorial action" aggregate the data reported by their members. These sources provide a synthetic overview of adaptation trends.

The RegionsAdapt initiative reports on the progress of member regions (or any level of intermediate government) in adapting to the objectives and milestones set by the programme. In terms of distribution, 50% of the 38 regional governments that reported their data publicly came from South America, 16% from Africa, 16% from Europe, 13% from North America and 5% from Australia (fig. 7). **Of these, 60% have engaged in the development and/or implementation of adaptation plans within the framework required by their country's national scale,** while 34 of these actors report working with local authorities in the development and/or implementation of their regional strategy. In addition,

53% of the participating regions have developed adaptation plans and 10% are currently developing their plans. A total of 165 adaptation actions were reported, mainly in the implementation or operational phase. Most of these are related to risk monitoring, community-based education and the integration of climate change into long-term planning documents (RegionsAdapt, 2018).

FIGURE 7

GEOGRAPHICAL DISTRIBUTION OF THE 38 REGIONAL GOVERNMENTS THAT REPORTED THEIR ADAPTATION DATA TO THE CDP - *Source : RegionsAdapt, 2018*



The Global Covenant of Mayors (GCoM) lists the adaptation actions undertaken by its signatory cities according to their implementation phase: the Adaptation Assessment phase, the Adaptation Goal phase and the Adaptation Plan phase[1]. Of the 9209 cities listed in its database, the GCoM reports that 1744 cities have initiated an adaptation process. Of these, 244 cities have initiated a risk assessment process, 1273 have defined adaptation objectives and 227 have adopted an adaptation plan (GCOM, 2019) (tab. 1).

TABLE 1

ADAPTATION APPROACHES UNDERTAKEN (NUMBER OF CITIES BY REGION)

	ADAPTATION PHASE		
REGIONS	**ASSESSMENT**	**GOAL**	**PLAN**
North-Africa/Middle-East	3	7	1
Sub-saharan Africa	8	0	8
North America	37	0	31
Latin America/Caraïbes	12	0	8
East Asia	13	0	13
South Asia	2	0	0
South-East Asia	2	0	0
Eastern Europe/Central Asia	15	165	18
EU and Western Europe	142	1101	140
Oceania	10	0	8

1 Each phase requires the submission and validation of a plan that must meet the GCoM requirements. Details of the requirements are available here: https://www.globalcovenantofmayors.org/our-initiatives/data4cities/common-global-reporting-framework/.

BOX 1

ADAPTATION APPROACHES IDENTIFIED OUTSIDE MAJOR URBAN AREAS

Little data is available within the International Cooperation Initiatives (ICIs) on adaptation actions implemented in non-urban areas (mountainous, coastal, etc.). However, these data are documented in several scientific articles and reports from development agencies. Given the preponderance of agrosystems and livestock farming as economic sectors for a large part of the world's population living outside urban areas, these are often data on food production. On this point, Vermuelen et al (2018) provided a review of the scientific literature on the transformations of agrosystems and livestock farming around the world as a result of climate impacts, or in order to adapt to new climate conditions in the future. This research work focused on 23 case studies (from 17 different countries over 5 continents) which have made changes to their agricultural or livestock systems in the last 25 years before 2018 as a result of changing climatic conditions and which include exploitable empirical data. Various data are aggregated for each case study, such as the type of transformation, climate risks and opportunities upstream of the transformations undertaken, empirical evidence of transformation (of the territory concerned, up to at least 33% of its surface area), changes in governance, the scale of the system concerned and the duration during which the transformations took place.

484 countries shared their **CDP** adaptation data by providing information on climate risks, adaptation actions, status and content of the action taken. In total, 640 adaptation actions were shared by 156 cities in North America (United States and Canada), 406 by 118 cities in Europe and 307 by 127 cities in Latin America. As a result of these three world regions, 39 cities in Africa and 18 cities in South-East Asia and Oceania reported 77 adaptation actions undertaken, 58 actions were shared by 16 cities in East Asia, 18 by 7 cities in South-West Asia and 11 by 3 cities in the Middle East (fig. 8). North American cities account for more than half of the 30 cities with the most adaptation actions (12 from the United States and 4 from Canada), followed by Europe (7), Latin America (2 from Brazil and 2 from Argentina), Asia (2 from Japan 1 from the Philippines) and Africa (1 from South Africa) (Fig. 9).

FIGURE 8

NUMBER OF CITIES BY REGIONS OF THE WORLD THAT HAVE SHARED ACTIONS TO ADAPT TO THE CDP

Source : CDP, 2019

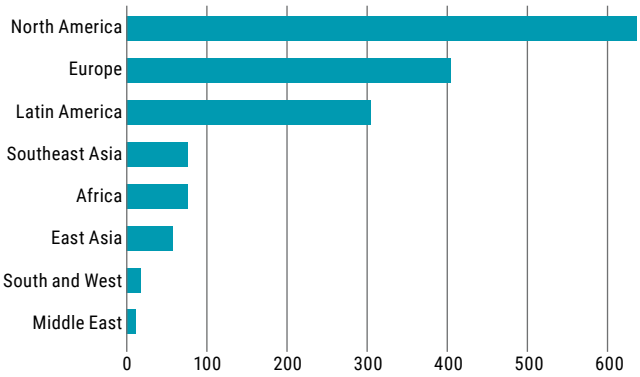
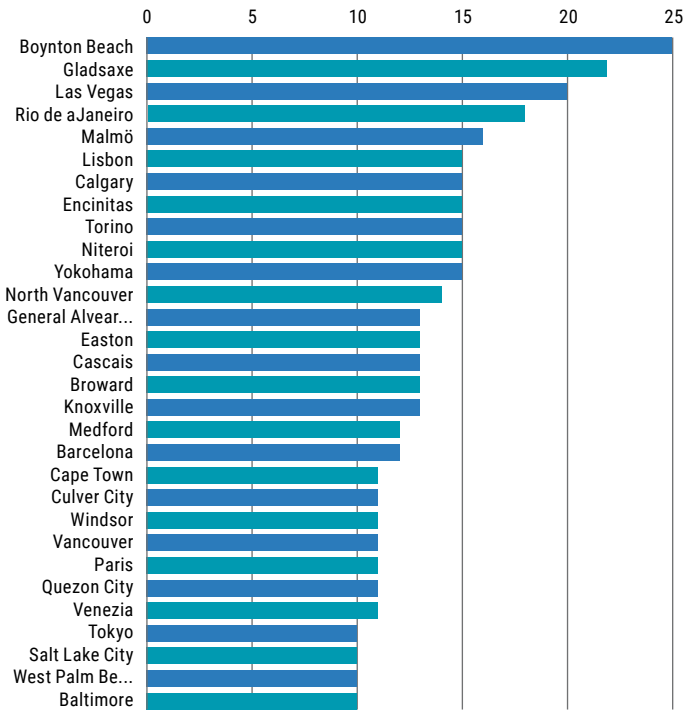


FIGURE 9

RANKING OF THE TOP 30 CITIES BY NUMBER OF ADAPTATION ACTIONS DISCLOSED TO THE CDP

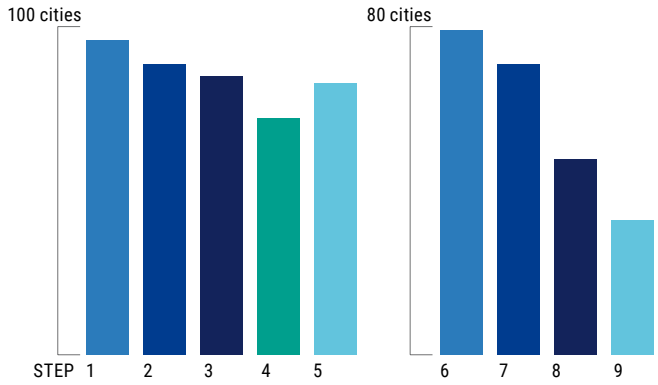
Source : CDP, *2019*



Since 2016, the carbon Climate Registry (cCR) has included in its reporting process a section dedicated to adaptation, based on the "CRAFT" (Climate Risk and Adaptation Framework and Taxonomy) tool, a specific adaptation reporting framework designed for GCoM and also used by the CDP Cities reporting platform. CRAFT offers cities the opportunity to report climate risks and impacts, assess their risks and vulnerabilities and submit their adaptation plans and actions within a common standardised framework. Reporting cities can then monitor and evaluate their progress, identify priority improvement targets and draw on examples from their peers.

FIGURE 10

PLANNING STEPS FOR URBAN ADAPTATION, FROM THE POLITICAL ENGAGEMENT PROCESS (STEPS 1 TO 5) TO PLANNING AND MONITORING (STEPS 6 TO 9) - *Source: ICLEI, Data speaks louder than words*



At the end of 2018, the ICLEI *Data Speaks Louder than Words* report listed 295 local and regional governments that had shared their adaptation data on the cCR, its reporting platform. More than half (58%) have completed or are in the process of completing a risk assessment or vulnerability analysis on climate change, while 19% have no plans to do so at the time of reporting. In total, only 21% of reporting governments have initiated or are in the process of initiating a process of political commitment to a climate change adaptation strategy covering the following five steps: identification of a vision (1), actors (2), risks and vulnerability (3), objectives (4), and finally possible options for actions (5) (fig. 5, left-hand side). In total, only 9% of them are involved in the process of planning and monitoring adaptation measures (steps 6 to 9, fig. 5, right-hand side). As a result, less than 9% of the 295 reporting entities have reached the update phase of the adaptation plan (step 9).

Implementing adaptation: increasingly diversified adaptation approaches and actions

Despite obvious connections, adaptation approaches differ from typical urban planning and sustainable development approaches (Carmin et al., 2012). The challenge for local governments is to look at all their activities through the "climate lens", to move from an **incremental adaptation logic focused on reacting to specific events to a more structural and transformative logic that anticipates future changes (Chu et al., 2019).** Adaptation approaches must therefore be systemic and intersectoral (EEA, 2016): risk management, climate scenarios, medium-term socio-economic projections must be integrated. Achieving its adaptation objectives involves not only the protection, resilience and reduction of the vulnerability of its territory (populations, activities, infrastructure) faced with present and future variations in climate conditions (beyond their natural variability), but also the transformation of its territory. Implicitly, this objective therefore also calls on the community to lead efforts to reduce domestic greenhouse gas emissions.

Several studies have tried to establish a typology of adaptation actions. The European Environment Agency defines four types of actions (EEA, 2016):

- **"Green"** adaptation actions that build on the non-human living world, often referred to as *"nature-based adaptation solutions"* (NBAS). Examples include the introduction of plant species in urban developments to limit runoff and avoid heat islands, new crop and tree varieties, or wetland restoration that allows rivers to naturally flood floodplains;
- **So-called "grey" (or "hard")** adaptation actions take shape through artificial infrastructures, of which seawalls or beach restoration to cope with coastal erosion are good examples;
- **So-called "soft"** adaptation actions are managerial, legal or political approaches that call for changes in behaviour and governance methods. Early warning systems and insurance against damage caused are examples of this category;
- **So-called "combined" actions** use several types of adaptation at the same time and make it possible to accelerate the systemic approach and the decompartmentalisation of issues but also of services, disciplines or action logics.

In 2012, Carmin et al. highlighted that the four types of adaptation activities that were most common among the 468 ICLEI members participating in the survey at the time reflected the limited experience of communities on the subject at that time: 1) meetings with local governments on adaptation; 2) research online or in the literature on adaptation information; 3) creation of commissions or working groups to plan adaptation; 4) development of partnerships with local NGOs, businesses or community groups.

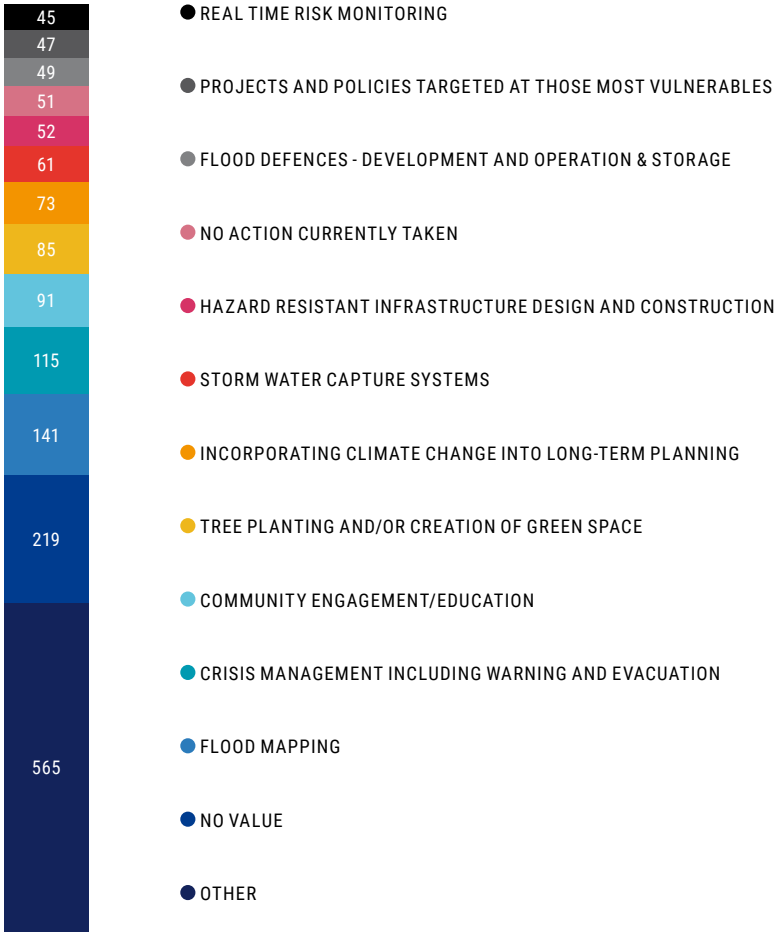
Since then, the evolution of the typologies used in the literature has revealed an increasing range of adaptation actions undertaken by communities, which may explain the gaps in commitment measures observed above. Araos et al. (2016) then classified the initiatives analysed into five types: 1) capacity building, 2) management, planning and policy, 3) practices and behaviours, 4) information and 5) funding.

The CDP database provides an overview of the categories of action most frequently reported by cities. First, 35% of the 1594 actions reported by the 484 respondents in 2018 are categorised as "other", i.e. not falling into any of the categories proposed by the CDP form. In addition, 14% of the actions do not include any description, although they are declared to be adaptation actions undertaken (fig. 11). **Smaller towns or cities have more difficulty in categorising or describing their actions**, because if we consider the population of cities that have reported actions in "others", this represents only 5% of the total population covered by these 1594 actions.

FIGURE 11

THEMATIC DISTRIBUTION OF THE 1594 ADAPTATION ACTIONS DISCLOSED TO THE CDP BY 484 CITIES

Source : CDP, 2019



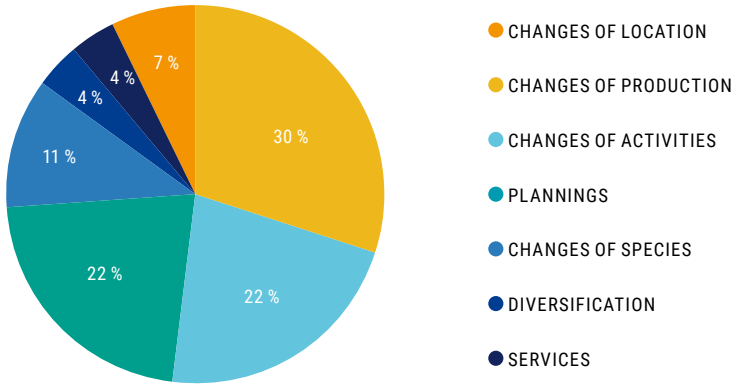
Secondary education, planning and awareness-raising activities are the most frequently mentioned among the actions reported: flood mapping (9%), crisis management (7%) and education (6%). Again, if we consider the total number of people covered by these measures, the relationships change, with crisis management measures (9%), flood defences (8%) and tree planting and creation of green spaces (7%) featuring in that order. More direct actions on spatial transformation and planning would therefore be more likely to be carried out by large cities.

Outside of urban areas, the work of Vermuelen et al. (2018) provides information on the diversity of responses in agricultural and livestock systems to climate impacts. For several case studies, this has been a question of moving production areas to other territories that had not undergone or had undergone less major climate change. For others, agricultural managers (farmers or cooperatives) have decided to modify agricultural or animal varieties to select more suitable ones for the new climate conditions. Some holdings have preferred to change their activities (from agriculture to aquaculture, ending transhumance), inquire about new technologies (climate prediction services) or modify their practices (crop rotations, changes in inputs). Other plots have been developed to reduce the impact on production (addition of irrigation, shade areas, trees). Finally, several agricultural estates have above all wished to diversify their production in order to maintain a minimum gain in the face of potential bad weather (fig. 12).

FIGURE 12

DISTRIBUTION OF ADAPTATION ACTIONS GROUPED INTO CATEGORIES (N=23 CASE STUDIES)

Source : according to Vermuelen et al , 2018



Despite the absence of common metrics on adaptation, this first section has allowed us to identify some general trends that we want to develop later in this last section:

- **Cities and urban areas communicate more** about their adaptation approaches, creating a misleading effect on the actual state and dynamics of adaptation in rural areas.
- **Regional dynamics differ from continent to continent** and are more or less polarised in the so-called "western" countries
- **The types and priorities of adaptation actions are contextualised** according to the climate risks and socio-economic issues identified locally
- **The strength of the regulatory framework influences** the level of ambition and scope of the approaches
- **Inequalities between the north and south are pronounced** in the face of common climate risks.

2 • Cooperation strengthens action and assessment of the adaptation of territories to climate change

Overview of cooperation areas for adaptation

To get an overview of the actors involved in adapting to climate change in territories, we suggest classifying the different "cooperation spaces" into a multiple entry grid, and providing a quick overview of their degree of specialisation. The concept of a cooperation area is intended to cover all entities and can be used for two types of cooperation:

- territorial cooperation between peers or multi-level cooperation
- cooperation between decision-makers and knowledge producers

Among these areas of cooperation, there are therefore organisations that are neither networks nor initiatives but which, at the local level, act to bring together research communities and communities of decision-makers, such as territorial IPCCs for example.

Last, the list is not intended to be exhaustive. At the transnational level, it covers the main initiatives of networks of cities and regions whose data have enabled us to build our analysis of global trends in territorial adaptation. At the national, local and regional levels, only outstanding examples of initiatives are proposed, either through their attention to adaptation or through the originality of their institutional design or instruments.

• HOW DOES THE GRID WORK? •

The grid we have constructed proposes a typology of the functions of cooperation areas and organisations involved in supporting the adaptation of territories to climate change. It focuses on three elements: the scale of action and the nature of the organisation on the y-axis, and the functions performed on the x-axis. We have included a variable in the latter, with a colour code to qualify the degree of speciality and specificity of the functions for each organisation. Finally, we have highlighted in bold the cooperation areas specialised in adaptation.

• SCALE OF ACTION •

Depending on their scale of action, cooperation areas are likely to emphasise some of their functions rather than others. We have therefore decided to divide the entities identified into four levels of scale that are significant for territorial action: global, regional, national and local.

• TYPE OF ORGANISATIONS •

In this list, not all the organisations listed, although they are all described as areas of cooperation, are of the same type and therefore do not claim to serve the same objectives. Depending on their institutional conception, they are more or less autonomous in the conduct of their activities and will offer different adaptation services to the territories. We distinguish five of them: cooperation initiatives; networks; reporting platforms; projects; local agencies.

• FUNCTIONS •

We want to characterise the degree of *specialisation* for each of the organisation's functions: **Light green – weak; Mid green – average; Dark green – specialist.** A fourth neutral shade **(grey) highlights the absence of an instrument in the function being considered.** This is not a value judgment that is made about the usefulness of what is implemented by the organisations, but rather it highlights the degree of specialisation and the innovative nature of the resources mobilised to support the actors. The choice of functions and associated instruments is based on the authors' expertise and is inspired by the methodologies used in functionalist-inspired academic work (Guston, 1999; Cash & al., 2003; Liese & Besheim, 2014; Dzebo, 2019; Papin, 2019). Seven of them have been designed to cover all the potential activities carried out by a cooperation area:

A) KNOWLEDGE PRODUCTION AND DISSEMINATION

1) Existence and updating of an information page / knowledge tab

2) Producing reports

3) Organising webinars and information workshops

B) OBJECTIVE PRODUCTION AND PLANNING

1) Requires both quantitative and qualitative short, medium and long-term objectives from members

2) Requires a vulnerability study of the territory

3) Requires the production of an adaptation plan

C) FUNDING

1) Assistance in the formulation of funding requests

2) Establishing contacts with funders

3) Direct funding / Allocation of funds

D) CAPACITY BUILDING

1) Workshops/training

2) Providing tools to assist in the development of public policy/ action

3) Training/Funding of a local expert specialised in adaptation within the city

E) SCIENCE-POLICY INTERFACE (FROM THE BOUNDARY ORGANISATION CONCEPT BY CASH ET AL. 2003[2])

1) Unilateral production of knowledge to decision-makers

2) Science-policy dialogue forum

3) Direct participation of the scientific community in the formulation of public policies

F) FOLLOW-UP REPORTING

1) Production of a programme evaluation report and regular communication

2) Bottom-up public reporting platform

G) EVALUATION

1) Evaluation of deliverables and achievements (outputs)

2) Evaluation of changes introduced (outcomes)

Evaluation of medium and long-term effects (impact)

2 Term invented by David H. Guston in 1999. According to Cash et al., (2003), boundary organisations on climate change are defined as institutions that act as intermediaries between scientists and decision-makers, and between these actors and the different scales that require three main prerequisites to generate action: 1) relevant, credible and legitimate information, 2) multi-directional communication between actors, and 3) efficient knowledge transfer.

			FUNCTIONS						
			Prepare the action		Assist/Implement the Action			Action follow-up	
Scale	Type	Name	Knowledge production and dissemination	Objective production and planning	Funding	Capacity building	Science-policy interface	Follow-up reporting	Evaluation
Global	Cooperation initiative	GCoM							
		RegionsAdapt							
	Reporting platform	CDP							
		Carbonn Climate Registry (cCR)							
	Network	ICLEI							
		Climate and Development Knowledge Network							
		C40							
		100 Resilient Cities							
	Project	WeAdapt							
	Database	Prevention Web							
Regional	Network	Africa Adapt							
	Cooperation initiative	The Collaborative Adaptation Research Initiative in Africa and Asia (CARIAA)							
	Database	Climate Adapt							
		PLAtform for Climate Adaptation and Risk reDuction (PLACARD)							
	Network	ACCCRN							
	Project	RESilience to cope with Climate Change in Urban arEas (RESCCUE, 2016-2020)							
National	Agency	Observatoire Territoire et Climat (France)							
Local	Agency	Ouranos (Québec)							
	IPCC territorial	New York City Panel on Climate Change							
	IPCC territorial	AcclimaTerra (Nouvelle-Aquitaine, France)							

Contributions and limitations of international adaptation initiatives

Article 7 of the Paris Agreement (2015) specifies that climate change adaptation approaches concern all levels of governance, from international to local. As such, multi-level cooperation is expected to be strengthened, as well as exchanges between state and non-state actors, with a view to sharing knowledge, strengthening action and assessing progress. The same cooperative logic governs the implementation of Agenda 2030 through SDG 17 "Partnerships for the Global Goals", the Sendai Framework for Disaster Risk Reduction 2015-2030 or the various development programmes dedicated to countries in the south (Reckien et al., 2019). The study showing that more than 350 cities will experience climatic conditions similar to those already experienced by cities of similar size reminds us that dialogue between local authorities, by disseminating appropriate measures, is essential for successful adaptation (Bastin & al., 2019).

In addition to their capacity for individual initiatives at the local level, territories have a central role in the transnational governance of climate change in three ways:

- 1)by supporting learning and exchange processes between local governments and other sub-national organisations;
- 2)by bringing together local resources and knowledge to provide complete solutions;
- 3)by strengthening the role of cities on international agendas by engaging political and private actors (Castán Broto, 2017).

This dynamism has led to the emergence of global networks of territories through which expertise, influences and capital circulate to develop and implement adaptation actions, thus transcending established geographical and political boundaries (Goh et al., 2019). However, while much research in recent years has focused on assessing the contribution of international cooperation of non-state actors to mitigation efforts (Hsu & al., 2018; UNEP, 2018), **the study of the current state of governance modes used in adaptation does not yet receive similar attention in the academic literature** (Klein et al., 2018).

BOX 2

"TO BETTER UNDERSTAND". COOPERATION NETWORKS, INITIATIVES AND ACTIONS

The various climate communities (research, international organisations, etc.) have developed precise semantics to designate the areas of cooperation of cities and regions existing on a transnational scale. Two of them and their variants appear frequently and are to be distinguished.
International Cooperation Initiatives (ICI). In the academic concepts and terminology of the United Nations Environment Programme (UNEP), the term ICI is used to characterise these transnational partnerships between any type of non-state actor (local authorities, companies, NGOs, etc.), aiming to coordinate their actions to achieve common objectives. In terms of climate, they are listed on the Climate Initiative Platform,[3] the UNFCCC's Global Climate Action portal and the Global Aggregator for Climate Action (GAFCA) of the London School of Economics (LSE) and the German Development Institute (DIE). Their leadership and the success of their objectives are based on the action of the members themselves, but they are often initiated and managed by organisations with a permanent structure.
• Examples of ICIs for adaptation: Resilient Cities (ICLEI); RegionsAdapt (Regions4); Collaborative Adaptation Research Initiative in Africa and Asia (CARIAA)...
Transnational Municipal Networks **(TMN)**. While ICIs cover all non-state actors, TMNs refer more specifically to city networks as new spaces for coordination and cooperation to participate in global governance. Theoretically, a network is a structure in its own right, an organisation that has its own existence and interests, as well as a capacity for action independent of that of its members. In use, the term TMN refers to any form of cooperation space led by and/or for cities.
• Examples of TMNs for adaptation: CDKN, Prevention Web, 100 Resilient Cities, Asian Cities Climate Resilient Network...

Despite this shared observation, many networks of cities and regions, cooperation initiatives, international organisations and international or regional reporting platforms exist and are developing programmes dedicated to capacity building for adaptation objectives and other purposes. The deciphering of these reported data provides a relevant indicator to illustrate underlying trends on a global scale: the plurality of actors involved, the diversity of actions carried out at the local level and the extent to which practices are disseminated.

However, there are a number of methodological limitations to assessing the dissemination of a culture of adaptation among communities based on the data proposed by these cooperation areas:
• A rigorous analysis of global action trends, whether in adaptation or mitigation, is all the more difficult to achieve as the sample expands as one becomes more interested at the local level. In addition, there are large regional disparities in access to data or the technical means to produce them, nor do all communities around the world share the same culture of participation in transnational cooperation.
• The voluntary nature of reporting hides the most invisible ones, and the identification of actions by preferred keywords in databases restricts examples. This means that actions that improve the resilience of a territory or reduce the vulnerability of a population are not systematically identified as adaptation actions.
• Similarly, the various actions implemented to address local social, economic or environmental issues are not always considered in the adaptation register, even though their benefits in terms of climate impacts may be considerable. Such actions sometimes fall under headings corresponding

3 Created by the Nordic Council of Ministers and hosted by the UNEP since 2016. Information on the initiatives was compiled by Ecofys, the Institute for Sustainability Leadership at Cambridge University, and the Word Resource Institute.

to local political priorities. They are then diluted in planning tools, sectoral policies (urban planning, sustainable development) or territorial climate plans[4] (Simonet and Leseur, 2019).

It is therefore difficult to exhaustively and clearly list these many "silent adaptations", i.e. all the reorganisations implemented in a given local context without any apparent link with climate change but which nevertheless have significant benefits in terms of their direct or indirect impacts. This aspect once again reveals the difficulty of distinguishing between actions qualified as adaptation and mitigation at the local level, and the obstacles to adopting a systemic and intersectoral approach when considering the transformation of a territory in a climate change context (Fisher and Norton, 2019; Simonet, 2018 ; EEA, 2016).

Attention to international cooperation on adaptation is still marginal compared to mitigation. However, it should be noted that the **International Environmental Agreement: Politics, Law and Economics report dedicated its October 2019 issue (vol. 19 issue 4-5) to transnational governance issues of climate change adaptation**. Several of the articles published examine the contribution of transnational networks and initiatives of cities and non-state actors to this global governance of adaptation. Here are some examples:

• Sander Chan (DIE) and Wanja Amling seek to discover whether the Global Climate Action Agenda (GCAA) – the UN framework for transnational action by NSAs – has actually succeeded, as it had announced, in mobilising and prioritising adaptation actions at the same level as mitigation. Reviewing about 100 climate cooperation actions, the study draws a double conclusion: **a decline in adaptation actions in the GCCA, and the persistence of geographical disparities to the disadvantage of low-income countries, the most vulnerable to the impacts of climate change.** (Chan, S. & Amling, W., 2019)

• Adis Dzebo (Stockholm Environment Institute) analyses the capacity of forty "transnational adaptation initiatives" to achieve the objectives they set for themselves in terms of the activities, results and impacts they produce. The sample includes networks and initiatives from cities such as ICLEI, C40, Covenant of Mayors and ACCCRN. These initiatives are not limited to local authorities and include all non-state actors more broadly. However, it should be noted that the author reveals **several recurring factors of effectiveness of these initiatives: the support of a global actor such as an IO or an NGO, a clear mandate and decision-making structure, a secretariat and a team dedicated to the initiative, and active participation in international adaptation regimes** (UNFCCC, Sendai framework, etc.). (Dzebo, A., 2019)

• In examining the case of 100 Resilient Cities (100RC), Marielle Papin (Université Laval, Quebec) proposes an assessment of the innovative capacity of transnational city networks (TCNs) in terms of adaptation governance vis-à-vis traditional international actors (States and international organisations). Its conclusions tend to show that there is still a certain rigidity in governance, with mandatory selection processes and objectives that contrast with the flexibility that is generally characteristic of these networks. Nevertheless, it appears that the networks are inspired by each other, by developing innovative tools such as the appointment in each of the 100RC member cities of a Chief Resilience Officer paid by the network, close to, but different from, the City Adviser of the C40 (Papin, M., 2019).

4 For example, the city of Annecy is mentioned in the GCoM database as not having initiated an adaptation process, while its Climate Plan includes an adaptation component that includes six adaptation actions.

However, whether it is a one-off case study or evolutionary data (which makes it possible to analyse dynamics over time), several precautions must be taken before drawing action trends for territories:

• **The difference in the reference framework on adaptation between initiatives or territories makes it difficult to compare and aggregate data:** not all actors share the same definition of adaptation - particularly with regard to the concepts of resilience and development (see Section 1), the time horizon and the types of actions covered (plans, public policies, commitments, projects, etc.).

• **The most widely disseminated data concern the vast majority of urban areas.** Little data is available for low-urbanised areas (rural areas, mountains, etc. – see Box 1).

• **The reports and databases are based on voluntary statements from members.** Although subject to national requirements or the reporting platform, the data collected do not reflect all the actions implemented[5] or the local dynamism in terms of adaptation (Araos et al., 2016), avoiding in particular the coherence of all public policies. Therefore, some unshared actions may also counterbalance the effectiveness of the actions communicated.

• **It is also difficult to distinguish voluntary initiatives from actions arising from regulatory obligations** imposed by higher levels of governance, limiting the possibility of assessing the share of action driven by regional and local governments.

Beyond these limits, public and large-scale communication of its actions and demonstration of progress is becoming an increasingly important issue for communities. This can come either from an obligation or commitment by the entities to provide a progress report, or from a "territorial marketing" perspective: call for investors, financing conditional on greater transparency, search for notoriety and good image, advertising for tourism. Reporting platforms are also using this increased willingness to communicate to encourage local authorities to report information, such as the carbon Climate Registry in its User Manual (2017): "*By reporting to the cCR, you will join the ranks of cities, towns, and regions demonstrating good governance by sharing transparent, accountable and credible information*".

5 For example, the Data Speak Louder Than Words report (ICLEI, 2018) states that "the information contained in this publication is based on self-reported largely non-verified data which has undergone a basic quality check".

3 • Analytical observations on the commitment of territories to adaptation

The categorisation of cooperation areas and a brief analysis of the contribution of international initiatives and actors to adaptation make it possible to see the limits of cooperation areas on too large a scale, their limited capacity to report on the adaptation efforts of territories. This is why we suggest going a little further in the analysis of the drivers and modes of action of local and regional authorities by identifying a series of local and national factors to explain the apparent disparities between territories in the world, and by distinguishing project logics from public policy logics.

Understanding the apparent disparities in commitments around the world

As for mitigation (see Climate Chance – Territorial Report 2019), all the data collected above show a greater mobilisation of European and North American cities, both in terms of the number of actions undertaken and the number of reporting cities.

There are many factors that explain this preponderance, the first being the financial and jurisdictional power of cities. The presence of megacities and capitals is strong in the panel of cities that have declared their commitments in terms of adaptation. Conversely, cities in the south often lack the institutional capacity and expert, human and financial resources that can be allocated to these challenges (Araos et al., 2016). Nevertheless, researchers highlight many examples of local governments taking adaptation initiatives regardless of wealth levels and institutional barriers, as local governments can find an incentive to carry forward their approaches and actions to gain more international funding.

The weight of the national institutional system on the ability of local and national governments to cooperate is also highlighted. An OECD report[6] shows in the 10 countries observed by the study that integration and support for local and regional authorities is particularly strong in federal countries where they have adaptation-related skills, with, for example, commissions or working groups on adaptation bringing together all levels of governance in Germany or Australia. Within RegionsAdapt, the presence of European (Basque Country, Catalonia, Lombardy, Brittany, Wales) and Canadian (Quebec and Alberta) regions with broad autonomy in terms of (jurisdictional) governance of their territory and strong identity specificities, regularly highlighted in order to distinguish themselves from other regions more limited by administrative than cultural borders. Integrating this platform could thus enhance the value of a region in need of international recognition and capitalise on a strong cultural brand to promote its proactivity in adapting to climate change.

Western regions and cities are more subject to injunctions (transnational, national, regional) for adaptation to climate change, with technical frameworks providing greater incentives for cities to plan their adaptation (Reckien et al., 2018). In Europe, for example, the EU strategy on adaptation

6 Bauer, A., Feichtinger, J., & Steurer, R. (2012). The Governance of Climate Change Adaptation in 10 OECD Countries: Challenges and Approaches. Journal of Environmental Policy & Planning, 14(3), 279–304. doi:10.1080/1523908x.2012.707406

to climate change adopted by the Commission in April 2013 builds on the Covenant of Mayors to encourage cities to voluntarily engage in an adaptation approach, and also promotes their access to information through the Climate-ADAPT platform (EC, 2013). At the national level, national climate governance in each Member State influences the development and implementation of climate plans at lower administrative levels (Heidrich et al., 2016). All EU Member States except Latvia, Bulgaria and Croatia (entered in 2014) have so far adopted a National Adaptation Strategy. Of these, 15 have also adopted a National Adaptation Plan (EEA, 2018).

However, the quality of planning is no guarantee of effectiveness in the field. These are, for example, the lessons learned from the *Information Report on France's Adaptation to Climate Disruption* submitted by French Senators Ronan Dantec and Jean-Yves Roux to the French Government. While France, among the European leaders in adaptation planning, had just produced its second national adaptation plan, the report is alarmed that adaptation policies *"suffer from a persistent lack of recognition and legitimacy"* (Senate of the French Republic, 2019).

Conversely, the gross observation of the data available by voluntary platforms overshadows the content of national planning processes. For example, in the Philippines, legislation requires 1,700 local governments to implement a Local Climate Chance Action Plan, which requires them to identify risks and vulnerabilities to climate change and develop a long-term strategy for reducing these risks. In 2019, over 1000 communities had met their obligations (Climate Change Commission, 2019), but these efforts have not been reported in international platforms. Similarly, China, South Korea and Japan provide cities with their own national platforms or methods that limit their willingness to report to the World Covenant of Mayors or the CDP.

Western public decision-makers also benefit from greater awareness (training, support, available tools) of climate issues than their non-Western counterparts (Anguelovski et al., 2014). And although many climate laws have been passed in other parts of the world in recent years, as is the case in many African countries[7], their implementation through field actions is not reflected in the available data, for the reasons given for their low participation in networks.

Similarly, western regions are facing greater political and social pressure when it comes to climate change. Although the activities of environmental NGOs and citizen movements, ranging from simple demonstrations to civil disobedience (Fridays for Future, Sunrise Movement, Extinction Rebellion), now operate on all continents, their influence is greater in western countries to encourage governments to act and be transparent. In other parts of the world, these movements are focusing more on raising community awareness of climate change and its impact on local lifestyles, but remain overshadowed by development issues on the local territorial agenda. However, many international organisations are showing interest in testing adaptation programmes in cities in the south through technical assistance and are increasingly contacting local governments to do so (Anguelovski et al., 2014).

Finally, cities and regions on all continents do not have the same presence or dynamism within international networks and initiatives. The low representation of some continents in initiatives and networks can be explained by the young people of the latter and in particular their regional chapters, as noted by Carmin et al. in the case of ICLEI. However, we have observed a growing internationalisation of climate initiatives and networks in recent years (see Climate Chance – Territorial Report 2019). For example, cities and regions in Latin America showed particular dynamism in 2019: regions

7 Law on the integration of climate change passed in June 2018 in Benin, integration of the fight against climate change into the new constitution in Burkina Faso, etc.

account for half of the members of RegionsAdapt (while there is an absence of Asian countries), while Latin American and Caribbean cities have the highest increase in signatories among the ten GCoM regions (more than 100 additional cities in this region have joined the regional convention, bringing the total in 2019 to 353 cities representing 158 million people).

Understanding the disparities in the ways local governments operate

We want to expose some trends in action, no longer identifying the best ways to implement adaptation in the territories, but to illustrate the diversity of modes of action according to the institutional configuration, and the involvement of the private sector and citizens. However, we identify two logics: that of public policy promoted by multi-level governance, and a project logic based more on multi-stakeholder cooperation and responding to specific needs.

• PUBLIC POLICY FOR ADAPTATION, AN INSTITUTIONAL CHANNEL OF ACTION BOOSTED BY MULTI-LEVEL COOPERATION •

Several studies show that national climate policies transposed into legislation contribute to the increasing importance of developing local adaptation strategies (Aguiar et al., 2018). However, **the main challenge of collaborations between the national and sub-national levels is to ensure that the national framework developed is applicable at the territorial level** and in local contexts. The same is true for **regional plans, which should be able to reflect local realities**, which is required by the need for multi-stakeholder collaboration (RegionsAdapt). Local authorities play a key role thanks to their regulatory competences (land use, emergency planning) and their ability to engage in dialogue with stakeholders in the territory. In addition, the proximity of stakeholders and local communities allows communities to access more detailed knowledge on the vulnerability of their territory, enabling them to develop approaches that are more tailored to identified needs (Aguiar et al., 2018).

Collaboration formats differ according to the profile of the stakeholders involved, the autonomy and jurisdictional power of the levels of governance involved, and the temporality of the collaboration (specific projects of limited duration for example). These collaborations are coordinated at the national level by a ministry or dedicated body, and actions can be established through cooperation frameworks, multi-stakeholder working groups composed of representatives from various levels of government or the development of common methodologies and guides to good practice (Box 3). The presence of influencers (leaders, elected officials, influence groups, local notoriety) convinced of the need to take steps to adapt to climate change remains an important condition for its operationalisation (Simonet and Leseur, 2019). By using the vague outlines of the various reference frameworks for adaptation, as described in the introduction, the arguments are developed in these cases in order to promote local priority interests above all and benefit from both political and financial support (Simonet and Salles, 2014).

BOX 3

NATIONAL AND SUB-NATIONAL COLLABORATIONS AROUND THE WORLD

The Canadian provinces (Alberta, British Columbia, Prince Edward Island and Quebec) collaborate with the federal level through the Pan Canadian Framework on Clean Growth and Climate Change, which includes support for projects that increase the resilience of infrastructure and community support. The exchange platform provides a forum where experts and decision-makers can share resources and collaborate on adaptation priorities. In Australia, a national working group on adaptation, composed of national, state and local governments, is responsible for sharing information and collaborating on specific activities. The Spanish national government and regional representatives of the Basque Country and Catalonia have also set up a working group to define the policies and actions of the Plan nacional de adaptación through exchanges and sharing feedback. Nigeria participates in meetings coordinated by the Federal Ministry of Environment with other regional stakeholders to discuss adaptation strategies. In Mexico, the State of Jalisco has adopted adaptation measures in collaboration with the federal government based on social measures, nature-based adaptation solutions (NBAS) and actions targeting strategic infrastructure and production systems. The objective is to achieve at least a 50% increase in adaptive capacity for the most vulnerable municipalities, particularly in social terms. The establishment of alerts, risk management at all levels of governance and halting deforestation are among the main orientations. In Brazil, good practice guides are being developed in collaboration between the Brazilian Climate Change Forum, the Ministry of the Environment, the Monitoring and Adaptation Working Group and the Brazilian Association of State Environmental Entities, which bring together a plurality of regional and local actors. Although Wales must comply with the National Adaptation Programme due to the political and legal jurisdiction of the United Kingdom, its regional government works with the national level to share common themes and ensure that the implementation of measures is consistent with Welsh territorial realities (RegionsAdapt).

In order to ensure optimal local implementation of nationally defined adaptation frameworks (national plan, regulation, guidance), Dazé et al. (2016) have identified several elements to be considered for optimal vertical integration in terms of institutional arrangements, information sharing and capacity building (fig. 13):

- decentralisation, i.e. the transfer of skills, responsibilities and resources to sub-national levels, helps to ensure the continuity and extent of the commitment needed for effective implementation at the local level;
- the sharing of information, whether by taking into account local needs, the transmission of scientific, technical and indigenous knowledge in formats accessible to all stakeholders or the strengthening of mechanisms for dialogue and the exchange of experience on a regular basis, remain essential keys;
- a monitoring and evaluation (M&E) system, supported by the different levels and integrating data and information from each level of governance, supports learning and the integration of adaptation approaches into local planning.

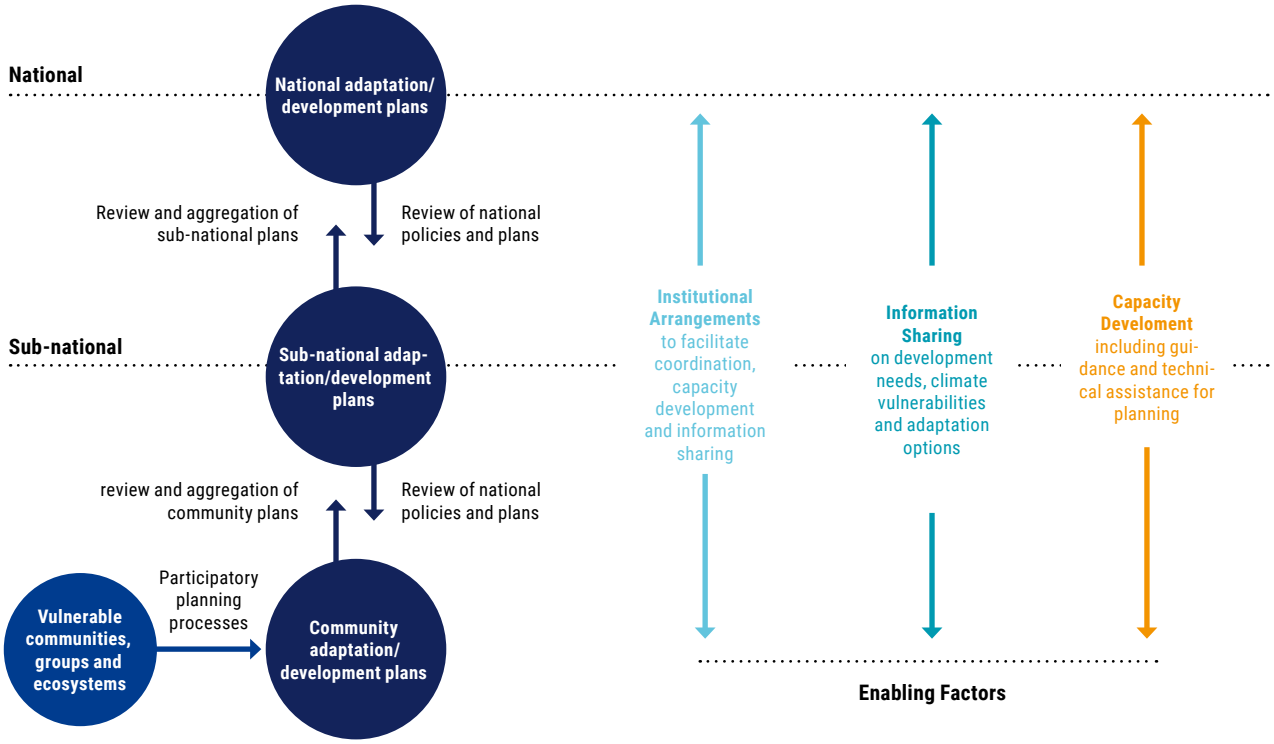
The strengthening of links between the national and sub-national levels is also at the heart of the lessons learned in a working paper prepared by Butterfield et al. 2017 as part of the Future Resilience for African Cities and Lands (FRACTAL) project. The study attempts to identify, from the experience of 45 case studies of local adaptation to climate change in Europe, the factors for optimal implementation of adaptation approaches in the context of African cities and urban areas.

Their analysis underlines that **regulations at national and sub-national levels are necessary to ensure the long-term security and sustainability of projects.** Other lessons learned include **building trust between the stakeholders involved in order to gain their support and increase the chances of sustainability of projects** and to establish partnerships between sectors of activity in order to benefit from new perspectives through the transdisciplinarity created. **The participation of women and young people, vital forces with often untapped potential**, as well as the consideration of the **knowledge, capacities and natural resources of local communities**, are also highlighted. Finally, the sharing of lessons and knowledge concerning risks, challenges and opportunities with similar projects to create synergies complements these key points.

FIGURE 13

VERTICAL INTEGRATION IN THE MONITORING AND EVALUATION OF ADAPTATION APPROACHES

Source : Dazé et al., 2016



• OPERATIONALISING ADAPTATION: COMMUNITY PROJECTS •

The project, as a mode of punctual cooperation between actors on operational mechanisms, offers the possibility of associating local authorities at different levels of governance and private sector actors, in order to promote a more effective reorganisation of their activities on which their economy is dependent in the face of climate impacts (Resilient Cities, 2018). In the specific case of tourism, for example, the dependence of local communities on tourism requires all levels of government to protect attractive resources (preservation of coastlines, biodiversity or exceptional landscapes) without, however, driving out the economic actors who drive it. A high level of consultation is therefore required to enable ambitious regulatory decisions to be applied uniformly to all territories and industry players, who sometimes risk simply losing their capital (Resilient Cities, 2018).

There are many examples that show that it is collaboration between intermediate and local levels of governance that is most relevant:

• In Ecuador, the Santa Elena regional government targets local authorities through the development of agro-ecology projects and forest management companies, while in Morona Santiago, the authorities collaborate with local authorities to develop methodologies for building drainage channels in agricultural areas, monitoring natural resources and developing environmental education programmes.

• The Québec action plan on climate change 2013-2020 developed by the Government of Québec (Canada) provides for two types of actions towards local communities: technical support in the form of training, guides and support tools for the municipal sector and financial support for conducting risk and opportunity assessments, as well as for integrating adaptation solutions into municipal planning and actions.

• The responsibility for achieving Catalonia's (Spain) adaptation objectives, enshrined in the Climate Change Act 16/2017, is shared by the regional government, local authorities, production sectors, territorial socio-economic actors and citizens. To this end, the Catalan Office for Climate Change provides financial support to municipalities for the development of actions to adapt and reduce local vulnerability to climate impacts (RegionsAdapt, 2019).

• Faced with land loss due to sea level rise and the movement of the Mississippi Delta, the Louisiana Office of Community Development – Disaster Recovery Unit (OCD-DRU) is planning a dignified relocation of homes in risk areas. With $92.6 million in assistance from the US Department of Housing and Urban Development, OCD-DRU is implementing two projects: Louisiana's strategic adaptation and the Jean Charles Resettlement Project, the first climate change-induced resettlement project in the history of the United States. In order to ensure the sustainability of the actions undertaken, both projects focus on a participatory approach that includes open meetings and consultation with local communities (Resilient Cities, 2018).

Collaborations between the public and private sectors and citizens exist, but are still in an emerging state (Box 4).

BOX 4

COLLABORATIONS BETWEEN THE PRIVATE SECTOR, CITIZENS AND THE PUBLIC SECTOR ARE STILL WEAK

Collaborations between the private sector, citizens and the still weak public sector are encouraged to develop, particularly in urban areas. This is revealed by the study by Klein et al., 2018, based on a database of 997 adaptation initiatives across 402 cities around the world developed by Araos et al., 2016. The results show that the more advanced a city is in its climate change adaptation initiatives, the more likely it is to increase the participation of the private sector and its citizens in this area. With regard to local governance for adaptation, the researchers show that the regulatory tool is not the most widely used mode of governance. Concerning links with citizens, the development of awareness-raising actions is the most common measure used by local authorities, reflecting a top-down approach since it requires citizens to use this information to implement actions at the individual level according to their capacities. Shi et al. (2016) show that a minority of municipalities collaborate with local communities in adaptation planning and that, in cases where citizens are involved, it is generally a question of developing vulnerability assessments and not of designing action plans. Researchers suggest that these modes of governance reflect the early implementation stage of adaptation, implying that more complex instruments may follow as adaptation governance becomes mature. The use of soft governance modes (partnerships, awareness-raising) can also be seen as a sign of the transfer of public responsibilities to the private sector in order to share the costs and implications of

the adaptation actions to be implemented. However, researchers point out that such a transfer could exacerbate inequalities, create vulnerabilities contrary to the initial objectives and not be effective in changing the behaviour of private actors. In the private sector, partnerships and participation in joint programmes remain the preferred route for public authorities, leaving companies to influence urban development.

More and more studies point out that local cultural and natural heritage can also be a vehicle for sustainable and resilient solutions to climate change (Fatorić and Seekamp, 2017). Local cultural, urban and natural heritages represent legacies from the past and those by which local communities define themselves and depend on them, while being economically, socially and ecologically beneficial to them (Box 5). It is on the basis of these arguments that Guimarães (Portugal) became the European Union's Capital of Culture in 2012, the European City of Sport in 2013 and the most sustainable city in Portugal in 2017. Guimarães attributes its success to its citizens, who are proud of their city, culture and heritage.

BOX 5

COMMUNITY AND ECOSYSTEM-BASED APPROACHES

Community and ecosystem-based approaches are regularly cited as a complementary, if not essential, dimension for optimal implementation of adaptation approaches. Defined as a local adaptation approach led by and at the community level, community-based adaptation focuses on empowering and promoting the adaptive capacity of local organisations. This is an approach that uses the context, culture, knowledge and preferences of the populations directly concerned by climate issues as its assets (IPCC, 2014). This approach is often more affordable, easier to maintain and more sustainable. It can transform people's views of their environment and their own potential capacities by making them aware of the opportunities and benefits of sustainable use of their resources and explaining the role they can play in this regard. Ecosystem-based adaptation is defined as the use of biodiversity and ecosystem services (or nature-based adaptation solutions; NBAS) as part of a territory-wide adaptation strategy. This approach uses the range of opportunities for sustainable ecosystem management, conservation and restoration to provide services that enable people to address climate challenges. Thanks to its systemic and intersectoral considerations that promote transversality and interaction between various local issues, it is easily integrated into sectoral and development policies (CBD, 2009).

REFERENCES

REPORTS

• Carmin, J., Nadkarni, N. and Rhie, C. (2012). Progress and Challenges in Urban Climate Adaptation Planning: Results of a Global Survey. Cambridge, MA: MIT.

• European Environment Agency (2016). Urban adaptation to climate change in Europe – Transforming cities in a changing climate.

• IPCC (2018). Global Warming of 1.5°C. An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty. World Meteorological Organization, Geneva, Switzerland, 32 pp.

• ICLEI, C40 (2018a). Data speak louder than words. ICLEI: Bonn, Germany

• ICLEI (2018b). Multilevel climate action: the path to 1.5 degrees. ICLEI: Bonn, Germany.

• Regions4, CDP (2019). RegionsAdapt 2018 Brief Report – Multi-Level Governance in Climate Change Adaptation.

• United Nations, Department of Economic and Social Affairs, Population Division (2018). The World's Cities in 2018—Data Booklet

ACADEMIC LITERATURE

• Araos, M., Berrang-Ford, L., Ford, J. D., Austin, S. E., Biesbroek, R., & Lesnikowski, A. (2016). Climate change adaptation planning in large cities: A systematic global assessment. Environmental Science & Policy, 66, 375-382.

• Anguelovski, I., Chu, E., & Carmin, J. (2014). Variations in approaches to urban climate adaptation: Experiences and experimentation from the global South. Global Environmental Change, 27, 156-167.

• Aguiar et al. (2018). Adaptation to climate change at local level in Europe: An overview. Environmental Science and Policy: 86 (38-63).

• Bastin, J.F. & al. (2019). Understanding climate change from a global analysis of city analogues. PLoS ONE 14(7)

• Butterfield, R.E., Coll Besa, M., Burmeister, H., Blair, K., Kavonic, J., Bharwani, S., Cullis, J., Spires, M. and Mwalukanga, B. (2017). Inspiring Climate Action in African Cities: Practical Options for Resilient Pathways. FRACTAL Working Paper 4. Stockholm Environment Institute, Oxford Centre: Oxford, UK.

• Castán Broto, V. (2017). Urban governance and the politics of climate change. World Dev. 93, 1e15.

• Dazé, A., Price-Kelly, H. and Rass, N., 2016. Vertical Integration in National Adaptation Plan (NAP) Processes: A guidance note for linking national and sub-national adaptation processes. International Institute for Sustainable Development : Winnipeg, Canada.

• Fatorić, S., & Seekamp, E. (2017). Are cultural heritage and resources threatened by climate change? A systematic literature review. Climatic Change, 142(1-2), 227-254.

• Fisher, S. et Norton, A. (2019). Adapting to climate change in Europe : building a systemic and urgent vision. [Blog post] Climate KIC. Retrieved from: climate-kic.org/opinion

• Goh, K. (2019). Flows in formation: The global-urban networks of climate change adaptation. Urban Studies

• Guyadeen D, Thistlethwaite J, Henstra D. (2018). Evaluating the quality of municipal climate change plans in Canada. Clim Change, 1–23.

• Heidrich, O. & al. (2016). National climate policies across Europe and their impacts on cities strategies. Journal of Environment Management, 168, 36-45.

• Hsu, A. & al. (2018). A research roadmap for quantifying non-state and subnational climate mitigation action. Nature Climate Change 9, 11-17

• Klein, J., Araos, M., Karimo, A., Heikkinen, M., Ylä-Anttila, T., & Juhola, S. (2018). The role of the private sector and citizens in urban climate change adaptation: Evidence from a global assessment of large cities. Global environmental change, 53, 127-136.

• Pietrapertosa, F., Salvia, M., Hurtado, S. D. G., d'Alonzo, V., Church, J. M., Geneletti, D. et al. (2019). Urban climate change mitigation and adaptation planning: are Italian cities ready?. Cities, 91, 93-105.

• Reckien, D., Salvia, M., Pietrapertosa, F., Simoes, S. G., Olazabal, M., Hurtado, S. D. G., et al., (2019). Dedicated versus mainstreaming approaches in local climate plans in Europe. Renewable and Sustainable Energy Reviews, 112:948-959.

• Reckien, D., et al. (2018). How are cities planning to respond to climate change? Assessment of local climate plans from 885 cities in the EU-28. Journal of Cleaner Production 191: 207-219.

• Shi, L., Chu, E., Anguelovski, I., Aylett, A., Debats, J., Goh, K., Schenk, T., Seto, K.C., Dodman, D., Roberts, D., Roberts, J.T., VanDeveer, S.D., (2016). Roadmap towards justice in urban climate adaptation research. Nature Climate Change, 6, 131–137.

• Simonet, G. et Salles, D. (2014). Eau et changement climatique en Garonne moyenne : L'adaptation en négociation. Sud-Ouest Européen, vol. 37.

• Simonet, G. (2018). L'adaptation, un concept systémique pour mieux panser les changements climatiques. Norois, 245, 113-125.

• Simonet G. and Leseur A. (2019). Barriers and drivers to adaptation to climate change—a field study of ten French local authorities. Climatic Change, 1-17. https://doi.org/10.1007/s10584-019-02484-9

• Vermeulen S.J., Dinesh D., Howden SM., Cramer L. and Thornton P.K. (2018). Transformation in Practice: A Review of Empirical Cases of Transformational Adaptation in Agriculture Under Climate Change. Frontiers in Sustainable Food Systems: 2(65).
• Woodruff S.C. (2018). City membership in climate change adaptation networks. Environmental Science & Policy, 84:60–8
Other
• carbon Climate Registry (2017). carbon Climate Registry User Manual.

SECTION II

Territorial adaptation case study

1 CASE STUDY BY CONTINENT

EUROPE

Croatia • Šibenik-Knin

NORTH AMERICA

Nevada • Las Vegas

CENTRAL ASIA

Tajikistan • Aksu

OCEANIA

Philippines • Guiuan

CENTRAL AMERICA

Nicaragua

AFRICA

Mauritania • Nouakchott

AFRICA

Mauritania • Nouakchott

Context

Nouakchott is the capital of Mauritania, located on the Atlantic coast and in the sub-Saharan region covering 204 km^2 with 958,399 inhabitants (27.1% of the country's population). The climate is hot and dry all year round with light and very irregular rainfall during the summer and dry winds causing silting up. The city's coastline is surrounded by a dune barrier. The main economic activities are agriculture, livestock farming and fishing.

Stakeholders

The AREDDUN project (Support for Environmental Resilience and Sustainable Development in Nouakchott), funded by the European Union, was implemented by the Nouakchott Region. It is based on several expert studies with the objective of developing a Sustainable Energy Access / Climate Action Plan. The participatory approach used aims to inspire the preparation of Mauritania's country programme for the Green Climate Fund (GCF) and Mauritania's National Adaptation Plan (NAP) under the Paris Agreement. Nouakchott's strategic vision for adapting to climate change is also part of the National Strategy for Accelerated Growth and Shared Prosperity (SCAPP) for 2030, which focuses on major transformations in the Mauritanian economy.

Methodology

Several expert studies (vulnerability diagnosis, energy audit of public institutions, carbon footprint) have been carried out since 2018 by design offices in the 9 municipalities of the Nouakchott Region. In order to feed into the vulnerability diagnosis, a consultation process designed and led by a consulting firm was also implemented by the Region. Three groups of actors were targeted: government departments, elected officials and civil society. The process included a first consultation workshop to develop a common vision on resilience and adaptation to climate change in Nouakchott. In a second step, the groups meet to analyse the results and contribute to the development of the action plan.

VULNERABILITIES

ANTHROPOGENIC PRESSURES: large-scale rural exodus and population boom (+755,481 people between 2000 and 2013); uncontrolled urban development; anthropogenic fragility (illegal sand exploitation, 4x4 passage, overgrazing) and climate (reduced rainfall, disappearance of vegetation) of the dune cordon.

VULNERABLE SECTORS: water and sanitation, agriculture, livestock and fisheries; coastal, spatial and urban planning and public networks and services (transport, energy, waste)

MARINE INTRUSIONS, COASTAL EROSION AND FLOODING: acceleration of dune erosion by increasing extreme storms and marine incursions; reinforcement of shoreline retreat by increasing sea level; possibility of major flooding (1/3 of the urban perimeter would be located in a floodplain); formation of permanent pools (sub-surface groundwater)

SILTING: increase in exposure to silting (wind movement of dune cordons); exacerbation of silting already aggravated by dry winds; probable increase in droughts, heat waves and decrease in rainfall;

URBAN HEAT ISLAND: exacerbation of heat islands.

ADAPTATION ACTIONS

FOUR STRATEGIC DIRECTIONS HAVE BEEN DEFINED:

• Improvement of the city's resilience against maritime intrusions and floods;

• Conservation and management of natural resources and the environment;

• Promotion of a diversified economy and the establishment of socio-economic shock absorbers;

• Governance and capacity building.

MEASURES

Two types of measures have been established: structural measures of strategic scope and whose implementation requires the involvement of the Mauritanian State and measures that fall within the competence of the Region and can be implemented for the short and medium term. More specifically, priority activities involve:

• Developing the Coastal Planning Directive (Region)

• Securing and restoring the dune cordon (Region)

• The development and tourist enhancement of the coastal façade (Region)

• Support for the relocation of Nouakchott's populations at risk (Region)

• The major programme for the water/sanitation/urban agriculture sector with:

- A pilot project of a "sponge district" against floods (Region, municipalities and Ministry of Hydraulics)

- Vegetation project: Nourishing and making Nouakchott green (Region, municipalities, local associations)

- Local sanitation throughout the city (Region and municipalities)

• The Integrated Solid Waste Management Plan (ISWMP) (Region)

• Updating climate change adaptation planning documents (Region)

STRENGTHS OF THE APPROACH

• Participation of stakeholders in the workshops of the consultation process and complementary results

• Awareness of the groups of actors involved in the city's vulnerabilities

• Overall intersectoral and complementary approach with those of the levels of governance (State, Region)

LIMITS OF THE APPROACH

• Dependence on external resources (financial, material) for the implementation of actions

• Significant socio-economic and demographic issues not sufficiently integrated into the process

• Strong differences in the results of the participatory approach between administrators and citizens.

SOURCES

• Acterra (2019). La région de Nouakchott face au changement climatique – étude de la vulnérabilité et Plan d'adaptation – projet AREDDUN

• En Haut ! (2018). Construire une vision partagée de la vulnérabilité et de l'adaptation aux changements climatiques – Démarche participative autour des enjeux du changement climatique – projet AREDDUN

• Picture: Areddun Project "Rapport et analyse des résultats des ateliers des 24 & 25 avril et des 19 & 20 septembre 2018."

NORTH AMERICA

Nevada • Las Vegas

Context

Covering approximately 650 km² with approximately 650,000 inhabitants, Las Vegas is located in a vast desert valley in the far south of Nevada, surrounded by mountains rising to 3000 metres and drawing 90% of its water from the Colorado River. The city is part of an extended urban area that covers two counties making up a territory of 67,487 km² with 2 million inhabitants. The hot desert climate offers a dry and very hot summer season and a short winter season. Due to its geographical location, population and activity needs, the water supply that depends on Lake Mead is increasingly difficult. Las Vegas is one of the three cities that reported the most adaptation actions to the CDP.

Stakeholders

The Southern Nevada Water Authority (SNWA) is an agency that was created in 1991 to manage the water needs of southern Nevada. Comprising seven water agencies, SNWA is responsible for the treatment, distribution and management of water resources in the short and long term for southern Nevada. As a member of the Environmental Protection Agency's (EPA) Creating Resilient Water Utilities programme, SNWA conducted a vulnerability analysis of Las Vegas to the climate impacts of two selected scenarios (2035 and 2060) on which its Water Resource Plan published in 2018 is based. Several levels of government help Las Vegas with water supply: at the county level, the Clark County Multi-Jurisdictional Hazard Mitigation Plan, the Nevada State Drought Plan and Enhanced Hazard Mitigation Plan, and the Department of the Interior's WaterSMART programme.

Methodology

The approach used has been to highlight the solutions proposed by the institutional actors responsible for water management and their technical partners. The vulnerability analysis conducted by the SNWA identified more than 60 potential actions to address the impacts of climate change, while assessing the availability of the resource in relation to its future demand. The methodology used for this analysis was inspired by several tools made available by the EPA, namely the Climate Resilience Assessment and Awareness Tool (CREAT), the Adaptation Strategies Guide and the Hydrologic and Water Quality System modelling platform.

VULNERABILITIES

ANTHROPOGENIC PRESSURES: water demand greater than river supply (Lake Mead); additional pressure from tourism demand; continuous urban development.

WATER RESOURCES: drinking water shortages; dependence on the Colorado River; declining water quality; increased algae; increased droughts; flash floods.

ADAPTATION ACTIONS

ENERGY MANAGEMENT: modernisation of energy-intensive municipal buildings and construction of new LEED-compliant facilities; incentives to improve building efficiency in the face of high temperatures; renewable energies and smart grids to guarantee and manage energy consumption during peak periods (summer cooling) on the hottest days;

AWARENESS: awareness campaigns for residents and motorists to avoid flooded areas and reduce water consumption and watering; development of the WET (Water Saving Technologies) programme for residential and commercial customers to help them reduce indoor water consumption;

SUPPLY AND DEMAND MANAGEMENT: water use restrictions based on low supply times and days; construction of a third intake at Mead Lake; study of groundwater development and flow from eastern Nevada to Las Vegas (project under study for over a decade while groundwater rights have been acquired);

RISK MANAGEMENT: long-term flood control master plan through the construction of retention basins and flash flood mitigation infrastructure; emergency plans for flash floods and rescues by local public safety actors (fire, police and first responders); establishment of flood zone mapping (insurance sector requirements);

PLANNING: specific green buildings to mitigate the urban heat island effect; restriction of landscaping for new residential and commercial construction; incentives to replace existing turf with low-water landscaping (cactus); residential and commercial sheds to help reduce outdoor water consumption; incentives to replace turf with synthetic (Cash for Grass programme); a programme to plant trees and green spaces in downtown Las Vegas; zoning the Las Vegas Valley floodplain against urban development; designation of national monuments, federal lands and protected spaces to restrict development; integration of shade, green and ventilated spaces into the Las Vegas Downtown Masterplan;

OTHERS: integration of adaptation measures into the City's 2050 Master Plan; provision of air-conditioned commercial areas during hot days.

STRENGTHS OF THE APPROACH

- Strengthens awareness and measures already in place for water resource saving;

- Many options presented at the consumer level;

- Informing local public decision-making on climate change adaptation.

LIMITS OF THE APPROACH

- Lack of a participatory approach and integration of populations in the search for solutions;

- Significant placement of engineering and technical solutions in the options presented;

- Few options for radical transformations of the existing water distribution system.

SOURCES

• CDP data (2019)

• US EPA (n.d.). Southern Nevada Water Authority Assesses Vulnerability To Climate Change

• Water Utility Climate Alliance (2018). Strategic Plan and Publications

• Southern Nevada Water Authority (2018). 2018 Water Resource Plan

• Division of Emergency Management – Homeland Security (2018). The State of Nevada Enhanced Hazard Mitigation Plan

• ArcGIS. Extreme Weather Adaptation in Las Vegas, Nevada

• Photo: Nathan Roser

CENTRAL AMERICA

Nicaragua

Context

In Nicaragua, the agricultural sector accounts for about 20% of GDP, 30% of employment and 25% of export revenues are linked to coffee growing, with the vast majority of the 30,000 producers owning lots of less than 5 hectares. The ideal area for Nicaraguan coffee trees is between 700 and 1700 metres, but the local increase in temperature and reduced rainfall over the last century are changing the contours of the area, accentuating the invasion of coffee rust, which is already having a major impact on production and lowering bean quality. The coffee zone includes several departments supported to implement better agricultural practices and a conversion of coffee plantations to cocoa production in order to avoid a drop in production and projected national economic losses that could reach around $75 million in 2050 (81% drop in production).

Stakeholders

The NICADAPTA project (2014-2019) is a project co-financed by the International Fund for Agricultural Development (IFAD, a specialised agency of the United Nations), the Adaptation for Smallholder Agriculture Programme (ASAP) and the Central American Bank for Economic Integration. There are 100,000 small producers involved in the project, which focuses on three areas: (i) convert coffee plantations into cocoa production and/or implement reorganisations to ensure production, (ii) strengthen institutions to support small producers and (iii) build capacity in project management, monitoring and evaluation. The regional authorities are involved, as well as the Association of Cooperatives of Small Coffee Producers (CAFENICA), which brings together 12 cooperatives at the national level.

Methodology

The project has involved several research institutes (Nicaraguan Institute of Territorial Studies (INETER), Nicaraguan Institute of Agricultural Technology (INTA), Institute of Agricultural Protection and Health (IPSA)), which made it possible to work on climate services on a regional scale and provide strategic information on climate projections related to coffee and cocoa production. An alert system (SAT) has also been installed. A Project Management Unit (PMU), composed of several stakeholder leaders involved in the project, was mandated to monitor and evaluate progress in the field.

VULNERABILITIES

CLIMATE IMPACTS:

• Increase in the propagation area of coffee rust;

• Increased droughts, especially during El Niño periods;

• Loss of canopy (and biodiversity) and shaded areas essential for coffee trees.

ECONOMIC IMPACTS:

• Decreased production and quality of coffee beans;

• Dependence on market price volatility;

• Impacts on the national economy dependent on agriculture and therefore on climate variability;

• Loss of controlled origin certifications.

SOCIAL IMPACTS:

• Impacts on food security and income of small producers;

• The drop in coffee prices between 2000 and 2003 led to a 10% increase in poverty;

• Risks of increased social protest and destabilisation of the country.

ADAPTATION ACTIONS

Small coffee producers can adapt by 1) changing their practices, 2) diversifying their production or 3) migrating their production (to altitude or other areas). A large part of the area currently used for coffee trees can be converted into other agricultural production, including cocoa production. Although also exposed to climate impacts, cocoa plantations are more resilient and the market value of these products is high. For the rest of the territory that cannot be converted, options for non-agricultural economic diversification are being considered rather than high-altitude migration that would have negative impacts on forests, biodiversity or the water cycle.

Various actions have been taken to ensure agricultural income for small coffee producers:

• Diversification of production to ensure alternative incomes;

• Incentive to produce in a cooperative in order to benefit from the solidarity of the structure:

- Loans and financial assistance

- Exchanges of good practices

- Support in providing workers and materials

Other strategies aim to better contain the impacts of the market and exports:

• Strengthening long-term collaboration of supply and export chain actors;

• Establishing collective and shared strategic investments in production;

• Creating eco-labels (organic, fair trade) to increase the added value of products;

• Enhancing competitiveness in the global market.

Finally, several practice changes, where possible, are implemented:

• Use of varieties that are more resistant to heat and drought;

• Development of (micro)irrigation systems and vegetation cover (shade);

• Use of optimised climate services, particularly on the development of agricultural pests;

• Optimisation of agronomic and marketing practices.

Strengths of the approach

- Strong support for small producers in the process of adapting their productions;

- Support is provided in a consistent manner with other regions and on a national scale;

- Long-term and generalisable management and project practices throughout Central America.

Limits of the approach

- Production conversions require a long-term period before they are profitable (10-15 years);

- Changes in agricultural practices take several years (habits, vegetation cover);

- The current coffee supply chain is not sufficiently structured and prepared for reorganisation.

SOURCES

• Läderach J. H. et al. (2010). Mesoamrican Coffee: Building a Climate Change Adaptation Strategy

• IFAD (2014). Adapting to Markets and Climate Change Project (NICADAPTA)

• IFAD (2018). Nicaragua Supervision Report

• Photo : Neil Palmer (CIAT)

OCEANIA

Philippines • Guiuan

Context

Guiuan is located in the south of the province of East Samar and is the second largest city in the province (52,991 inhabitants in 2015). The municipality is a peninsula surrounded by the Pacific Ocean and covers 175 km^2 and several islands, forming part of an important marine reserve. Fishery resources are the heart of the local economy, complemented by coconut, root vegetable and some mining resources (bauxite, nickel). On 8 November 2013, the city was struck by Typhoon Haiyan, leaving behind many human and material damages, including the Catholic Church founded in 1595, a national cultural treasure and a UNESCO World Heritage nomination. It should be noted that the city hosts one of the stations of the national meteorological services.

Stakeholders

In collaboration with local stakeholders and government officials, the Municipality of Guiuan has developed an adaptation strategy to increase the resilience, protection and enhancement of local economic sectors, communities, natural resources and ecosystems to climate impacts. In particular, it is about protecting the health of the two ecosystems of the territory on which the local economy depends: the inland lands that support forests and agriculture and the coastal areas that support marine resources.

Methodology

Following the damage caused by the category 5 hurricane Haiyan, the Guiuan Recovery and Rehabilitation Group (GRRG) was created to oversee the reconstruction efforts. In 2018, the group became the Guiuan Recovery and Sustainable Development Group for Resilience (GRSDGR). Comprising representatives of civil society, regional government bodies, the private sector and scientists, GRSDGR is now a multi-stakeholder cooperation platform that coordinates the implementation of most of the actions of the adaptation plan through shared intersectoral responsibility. Adaptation to climate change thus serves as a development framework for mobilising resources and stakeholders at the territorial level.

VULNERABILITIES

Due to its geography, the territory is highly exposed to hurricanes, storm surges, floods and rising sea levels. The damage caused by Haiyan highlighted the lack of enforcement of regulations and planning tools in land use planning and natural resource and waste management practices.

WATER RESOURCES: poor drinking water quality, declining groundwater levels, siltation and salinisation.

AGRICULTURAL AND FOREST RESOURCES: poor practices, salinisation and soil erosion, landslide risks, invasion of new species and diseases, reduced agricultural yields, loss of forest cover.

FISHERY RESOURCES: decrease in catches and corals, illegal practices, shortening of the fishing season.

SOCIO-ECONOMIC IMPACTS: migration of populations, illegal habitats, network flooding (transport, communication), reduced income from resource exploitation (agriculture and fisheries).

HEALTH: health risks and waterborne diseases, increased health costs.

ADAPTATION ACTIONS

In addition to vulnerabilities, the developed climate change adaptation framework highlights the opportunities created by climate change and highlights the dependence between the socio-economic and health security of local populations and the health of their ecosystems (forest areas, coastal areas and marine resources). The action strategy targets several sectoral outcomes: improving social services, achieving a sustainable economy, protecting ecosystems, increasing resilience and strengthening institutional capacities and resource management tools. To do this, it is structured around two main objectives:

OBJECTIVE 1: ACHIEVE FOOD SECURITY THROUGH SOUND ECOSYSTEM MANAGEMENT.

In collaboration with regional government authorities:

• Creation of a protected forest production that includes agroforestry projects;

• Training of teams in the application of regulations and laws;

• Wetland studies and delimitation;

• Revision of planning tools and creation of new ones (environmental code).

In collaboration with regional scientists:

• Soil analysis at the municipal level;

• Coastal erosion control.

In collaboration with all partners:

• Creation of a research centre on climate and root vegetables;

• Creation of a root vegetable production area using appropriate methods;

• Relocation of coastal dwellings;

• Installation of defence infrastructure (seawall) and road elevation.

Collaboration with regional authorities and the private sector

• Research programme on the analysis of pollutants in water resources;

• Implementation of an integrated management policy for coastal and marine resources;

• Rehabilitation of mangrove forests;

• Monitoring of local fisheries;

• Increased law enforcement.

OBJECTIVE 2: SECURE WATER RESOURCES - IMPROVE CAPACITY MANAGEMENT AND SUPPLY SYSTEMS AT THE MUNICIPAL LEVEL.

Collaboration with municipal departments and/or regional authorities

• Creation of a catchment area management body;

• Creation of a financial system that values ecosystem services;

• Optimisation of drinking water supplies and rainwater recovery;

• Improvement of solid waste management;

• Creation of a desalination plant;

• Development of regulatory zoning maps;

• Development of a local sustainable sanitation plan;

• Improvement of the drainage system;

• Management of rainwater and runoff use.

STRENGTHS OF THE APPROACH

• A pioneer in the development of its climate change adaptation framework as a tool for mobilising local resources and stakeholders;

• The local adaptation plan includes many interrelated actions (systemic and intersectoral approach);

• The approach aims at social and economic security by strengthening the health of the ecosystems constituting the territory (ecosystem and community-based adaptation).

LIMITS OF THE APPROACH

• Many regulatory (top-down) actions that may come up against realities on the ground during their application (lack of awareness, bad habits, illegal practices);

• Due to its small population, the adaptation framework developed is difficult to apply to more populated areas;

• Poor consideration of the share of the influence of causes outside the territory in local impacts.

SOURCES

•Municipality of Guiuan (2018). Climate Change Adaptation Framework.

•Photo : "Bantay Dagat (Sea Patrol) members in Guiuan, Eastern Samar build a floating guard house powered by solar energy, supported by Cordaid and the Institute for Climate and Sustainable Cities. (c) AC Dimatatac/ICSC".

CENTRAL ASIA

Tajikistan • Aksu

Context

The Aksu River catchment area (1,156 km^2) is located between the Sughd region of Tajikistan (25%) and the southwestern part of Kyrgyzstan (75%). In its Tajik part, it covers an area of 284 km^2 with 34,412 inhabitants. Grazing, forestry and agriculture constitute the majority of the region's economic activities. The local climate varies from subtropical and arid in the lower zone to semi-wet in the upper zone. A national water reform project plans to move from an administrative water management approach to an integrated catchment area management approach. The objective is to create a River Basin Organisation responsible for the sustainable use of water and natural resources at the watershed level.

Stakeholders

The "National Water Resources Management" project is led by an international consortium composed of the NGO ACTED, HELVETAS Swiss Intercooperation (HSI) and the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ-IS), and funded by the Swiss Agency for Development and Cooperation (SDC). The Tajik and Kyrgyz local governments are key components of the project with which ACTED has led the implementation of practices aimed at reducing the impacts of water-related disasters in the Aksu basin with local communities in both countries. The objective of the project is to (i) strengthen water resources and irrigation management in river basins; (ii) reduce water-related risks; and (iii) improve livelihoods and socio-economic indicators in rural areas of the Aksu basin.

Methodology

The process aims to facilitate cross-border meetings between stakeholders from Kyrgyzstan and Tajikistan to initiate a cross-border dialogue between neighbouring communities in the Aksu catchment area. In addition to bringing together relevant ministries, community organisations, rescue teams and local community leaders met to share knowledge, expertise and experience in developing river basin management plans and disaster risk reduction strategies. The signing of a cooperation protocol between the local communities of the two countries should make it possible in the future to better prevent disasters, evacuations and exchanges of information.

VULNERABILITIES

ANTHROPOGENIC PRESSURES: deforestation, overgrazing, poor water resource management and inappropriate agricultural practices that bruise soils and increase the risk of landslides and mudslides in the event of heavy rains;

CLIMATE HAZARDS: regular mudflows, landslides and avalanches, especially in spring due to rising temperatures, melting snow and heavy and sudden rains;

NATURAL RESOURCES: destruction of agrosystems and houses by mudflows from large quantities of water flowing downstream; severe soil erosion.

ADAPTATION ACTIONS

In response to the major climate risks and hazards, several actions have been implemented:

• Early warning system linking Tajikistan and Kyrgyzstan by telephone and software to alert authorities and individuals concerned, the population, community leaders and community relief teams in the event of a disaster;

• Installation of light structures to slow down sludge flows.

Several actions concern the protection of local natural resources (wood, energy):

• Passive reforestation (stopping deforestation by regulation) and active reforestation (mass planting);

• Awareness of the links between deforestation, poor resource and water management and natural disasters among local communities;

• Implementation of sustainable grazing management to reduce pressure on resources and water (construction of light livestock drainage infrastructure, sowing of grasses);

• Changes in agricultural practices (variety changes, end of irrigation, creation of secondary products);

• Technical assistance and training in the installation of insulation in homes and in improving the energy efficiency of heating systems (stove).

STRENGTHS OF THE APPROACH

• Integration of local populations into the participatory process and active participation of community leaders;

• Increased awareness of local issues and climate change;

• Application of the systemic approach at the scale of the catchment area (taking into account the interrelationships between the problem and social and economic activities).

LIMITS OF THE APPROACH

• Exclusion of local communities from decision-making and management once the participatory process of the project is completed;

• Slow changes in behaviour and habits, particularly for wood cutting, which remains a free and reliable source of energy since the energy crises resulting from the fall of the USSR;

• Difficulty in mobilising actors to initiate the work sites of the actions to be implemented.

SOURCES

• Swiss Agency for Development and Cooperation (2019). Managing disaster risks and water under climate change in Central Asia and Caucasus

• ACTED. Cross-border cooperation strategies: Tajiks and Kyrgyz people work together to reduce disaster risk

• IWSM (2014). Integrated watershed management in Tajikistan

• ACTED (2018). Integrated Natural Resources Management in Tajikistan Aksu watershed - Good practices on Disaster Risks Reduction

EUROPE

Croatia • Šibenik-Knin

Context

Covering 2994 km² of land and 2676 km² of sea, Šibenik-Knin comitat has 960 km of coastline and a marine area of 285 islands and rocks. Its coastal area includes seven municipalities and three cities with a population of 110,000 inhabitants, and Šibenik is the administrative centre. Highly urbanised (over 70% of coastal residences), the coastal zone of the county is characterised by a concentration of economic activities (tourism, metallurgical industry, shipbuilding, maritime transport and vineyards).

Stakeholders

The Coastal Plan of the Šibenik-Knin County focuses on the impacts of climate change in coastal areas. This was prepared and supported by the Split RAC / PAP (Priority Action Programme / Regional Activity Centre) and the Blue Plan, two components of the UNEP Action Programme entitled "Integration of Climate Variability and Change into National Implementation Strategies for the Protocol on Integrated Coastal Zone Management (ICZM) in the Mediterranean". Its objectives include raising awareness of climate variability and change and promoting ICZM as an adaptation tool.

Methodology

The process has used the DIVA (Dynamic Integrated Vulnerability Assessment) method for vulnerability analysis, the participatory and prospective Climagine approach and interviews with stakeholders to assess climate variability and observed and expected changes in coastal areas. The preparation of the Coastal Plan began in 2013 and was finalised in 2015. Adopted in 2016, it is not binding but falls within the framework of Article 18(3) of the ICZM Protocol in the Mediterranean in which Croatia is a stakeholder, which stipulates the preparation of a Coastal Plan "at an appropriate territorial scale". The Plan therefore aims to inform national, regional processes and stakeholder decisions through its recommendations.

VULNERABILITIES

ANTHROPOGENIC PRESSURES: overcrowding, uncoordinated urbanisation, poor water resource and flood management

COASTAL PROTECTION: flooding of historic cities; coastal erosion

WATER RESOURCES: reduction (summer, autumn) and increase (winter) of precipitation; shortage of fresh drinking water (groundwater and springs) and for activities (tourism, agriculture, energy production).

AGRICULTURE AND FISHERIES: impact on agricultural (reduced soil moisture, increased evapotranspiration, reduced rainfall) and marine (shellfish) production; invasion of harmful species.

CONSERVATION: increase in invasive species; change in aquatic ecosystems; increase in forest fires.

TOURISM: risk of reduced tourism; summer water shortages in urban areas and islands; landscape changes.

OTHER: impact on the insurance and banking sector; impact on energy consumption and production (hydroelectric power plants); impact on maritime transport and shipbuilding.

ADAPTATION ACTIONS

Several actions have been taken to protect water resources and strengthen infrastructure:

• Rational use measures for drinking water and irrigation; reduction of waste; river management (flow regulation, storage infrastructure); storm water management (urban drainage); giving rivers more space;

• Protection against coastal flooding and rising sea levels; integration of these elements into future infrastructure planning to provide more space for the sea.

Other strategies aim to better contain regional development, in particular through improved planning and tools for governance and resource management:

• Re-balancing urban and rural development to reduce pressure in coastal areas; strategic improvement of tourism supply (seasonal extension) and activities (mariculture, agriculture, port management).

• Optimisation of planning through the integration of landscape protection, marine spatial planning, more sustainable management of marine activities and improved prevention through land use planning and forest fire warning systems;

• Establishment of an ICZM coordination body at regional level; strengthening community participation, awareness and local capacity.

STRENGTHS OF THE APPROACH

• Active participation of stakeholders in the prospective process;

• The Coastal Plan establishes links with existing plans, respects current development policies and has collected a wealth of information and data on the coastal zone;

• Winner of the 2019 Mediterranean Climate Change Adaptation Awards.

LIMITS OF THE APPROACH

• Ambiguity between the legal basis of the approach and the adequacy with national legislation;

• The coastal zone is not a priority in existing planning tools;

• Climate change is a new issue for the population and local decision-makers and access to relevant information is difficult.

SOURCES

• ADEME (2018), County of Šibenik-Knin – design of a coastal plan integrating climate change variability, https://www.medadapt-awards.com/wp-content/uploads/2019/06/Fiche3-Croatie-HR.pdf

• Priority Actions Programme/Regional Activity Centre (PAP/RAC). The Coastal management center : https://pap-thecoastcentre.org/pdfs/ClimVar_Plan%20Sibenik_lessons.pdf ; http://iczmplatform.org//storage/documents/njPooVmOxYugcciOcYOX1FmphgsLYqeH3w9juFCe.pdf

SECTION III

Adaptation of economic sectors

1 • Agroecosystems and production and food supply chains

Introduction

The food production sector is one of the main socio-economic pillars of a country and contributes to the enhancement of its cultural, landscape and culinary heritage. In addition to agricultural, wine-growing, fisheries and livestock production, the food sector also includes the processing, transport and distribution of products. This means that from the managed land to the consumer's plate, all the actors of the production and food supply chains are concerned by the impacts of climate change – both current and future – by the agro-ecosystems that are at their heart.

Ever-expanding global food production

Current food production, which feeds the world's population, remains the livelihood of around 200 million people (IPCC, 2019)[1]. Between 1961 and 2013, per capita food intake increased by 30%, accompanied by an increase of 800% for the use of nitrogen fertilizers and 100% for irrigation. Over the same period, world trade in plant and animal products multiplied by five (FAO, 2019)[2]. According to 2016 FAO data (2016), agriculture accounts for 4% of global GDP, occupies 37% of the world's surface area and represents more than $2.3 trillion in global production. The UNEP (2016)[3] estimates that around 120 million people rely on activities connected to fisheries. However, the average annual increase in temperatures observed on land is about twice the average annual global warming observed at the surface of the globe and has reached 1.53°C (Fig. 1). With the nature and quality of soils, crop production is particularly sensitive to climate variability and extreme events. These events have a direct impact on the productivity and distribution of activities in different territories: maize, wheat and soy yields decreased by 4.1%, 1.8% and 4.5% respectively between 1981-2010 due to climate change (IPCC, 2019). These impacts are the result of real changes in landscapes, biodiversity and yields, as well as impacts on the health and socio-economic life of local populations. Livestock production is also sensitive to climate hazards and extreme conditions, such as pastoralism and small-scale farms, as well as labour associated with open-air or confined work (Ouranos, 2015)[4]. Impacts on industrial farms are less direct. These are related to the availability, quality and cost of inputs (fodder crops, water or fuel), the destruction of infrastructure by extreme events or the volatility of prices of food. Despite multiple observed impacts on global food production systems, climate change exacerbates human pressures on agro-ecosystems and accelerates the degradation and depletion of natural resources currently observed in the world in a number of regions (Box 1).

---

1 Agroecosystems and production and food supply chains
IPCC, 2019. Special report on Climate Change, Desertification, Land, Degradation, Sustainable Land Management, Food Security, and Greenhouse gas fluxes in Terrestrial Ecosystems and Land. Draft version of 07 august 2019.

2 FAO, 2019. Food and Agriculture Organization Corporate Statistical Database (FAOSTAT). [en ligne]

3 UNEP (2016). Food Systems and Natural Resources. A Report of the Working Group on Food Systems of the International Resource Panel. Westhoek, H, Ingram J., Van Berkum, S., Özay, L., and Hajer M. [en ligne]

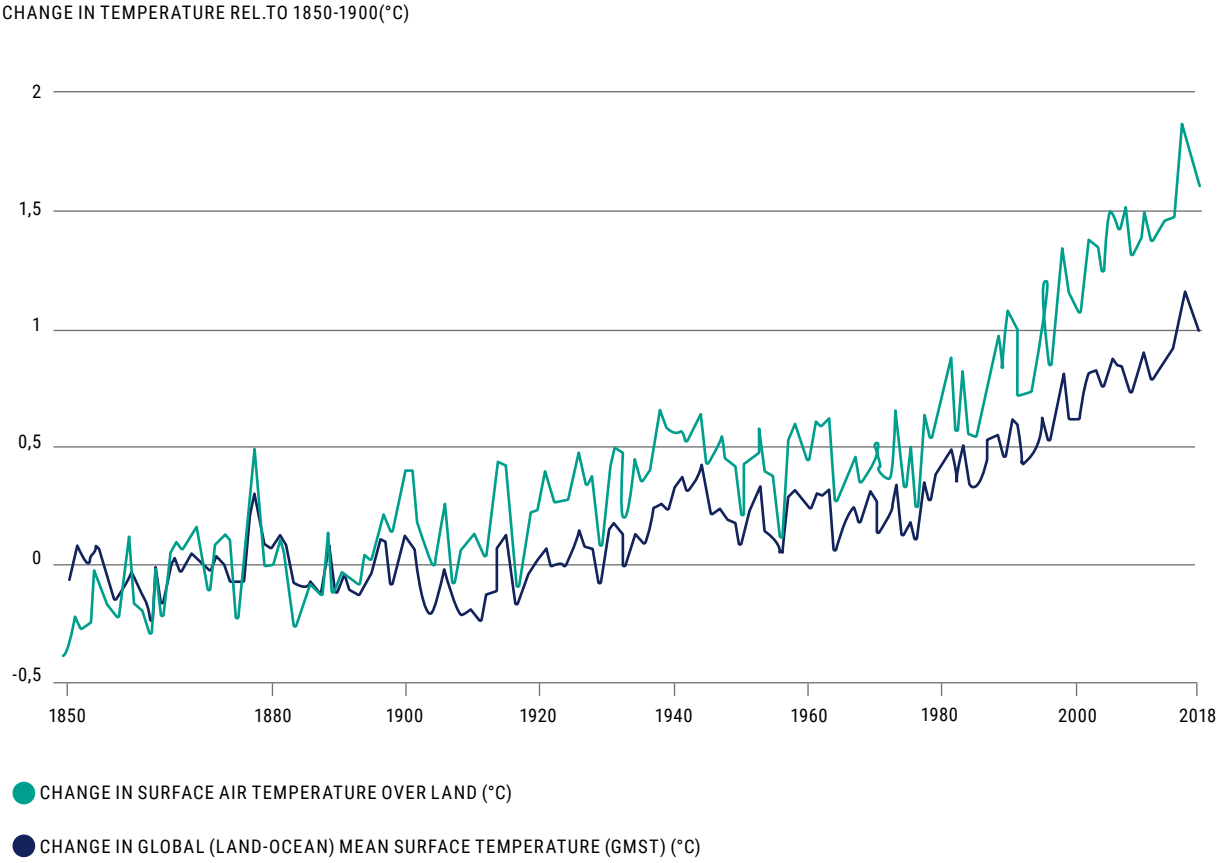
4 Ouranos (2015). Vers l'adaptation. Synthèse des connaissances sur les changements climatiques au Québec. Partie 2 : Vulnérabilités, impacts et adaptation aux changements climatiques. Édition 2015. Montréal, Québec : Ouranos, 234 p.

The juxtaposition of these two pressures threatens the pillars of global food security (availability, access, utilisation and stability) (IPCC, 2019).

FIGURE 1

TEMPERATURE CHANGE OBSERVED BETWEEN 2006 AND 2015 RELATIVE TO THE PERIOD 1850-1900

Source: IPCC, 2019b[5]



• AGROECOSYSTEM ACTORS •

The actors involved in food production and supply chains make up the largest group of natural resource managers in the world. Micro farms, often operated on family scales, dominate the landscape of developing countries and account for 56% of global agricultural production. By contrast, large specialised farms, spread over huge areas, are the preserve of developed countries (UNEP, 2016). Downstream of this sector, agri-food industries are the main players in industrial activities. These transform food production into products mainly intended for human consumption, following various agri-food processing steps (pasteurisation, refining, assembly and even packaging). Upstream of food production, the agro-industrial sector supplies products intended to increase yields (machinery, chemistry, genetic engineering, artificial intelligence). The main groups in this sector have significant financial power and the top 10 come from Western countries.

5 IPCC, 2019b. Special report on Climate Change, Desertification, Land, Degradation, Sustainable Land Management, Food Security, and Greenhouse gas fluxes in Terrestrial Ecosystems and Land – Summary for Policymakers – Approved Draft - version of 07 august 2019

BOX 1

AGROECOSYSTEMS UNDER ANTHROPIC PRESSURES

Many direct and statistical observations reveal the unsustainable and/or inefficient level of agricultural production practices in place in the vast majority of countries. These practices need to be restructured to also take into account current and future climate change. It should be considered that:

- 33% of soils are moderately to severely degraded due to erosion, nutrient depletion, acidification, salinisation, compaction and chemical pollution;
- 61% of commercial fish populations are fished to their full potential and 29% of them are over-fished at a biologically unsustainable level;
- 70% of the world's drinking water resources are used for agriculture;
- 25-30% of global food production is lost or wasted;
- Projected global urban growth is expected to be between 1.8% and 2.4% of agricultural land in 2030 and about 5% in 2050;
- At least 20% of the world's aquifers are overexploited, including in important production areas, such as the Upper Ganges (India) and California (United States);
- The expansion of agriculture in the tropical forest basins of South America and Africa has led to profound landscape changes due to deforestation and the loss of rich and unique biodiversity;
- 60% of global biodiversity loss on land is related to food production, while ecosystem services, which support food production, are often put under pressure.

Sources: IPCC, 2019; UNEP, 2016

Agroecosystems facing climate change

• A CHANGE IN YIELDS THAT CHANGES WITH THAT OF CLIMATE FACTORS •

Data show changes in the categories of climate factors related to the production and availability of foodstuffs: seasonal changes (prolongation of the growing season, extreme events, pests) and atmospheric conditions (CO_2 concentrations, pollutants and dust). The significant lengthening of crops' growing seasons has been widely observed on a global scale and climate projections believe that this will be even more the case by 2050. Faced with these new conditions, crops react differently. While this lengthening of seasons favours the yields of certain agricultural territories, such as the United Kingdom and the North-East of China, other territories, such as Nigeria or Bolivia, suffer from climate stresses that weaken or even diminish their yield (Porter et al., 2014; IPCC, 2019).

The loss of agricultural production grown without biological or chemical protection due to insect pests is estimated to be 16%, while losses caused by weeds amount to 34% (Porter et al., 2014). Changes in seasonality favour migrations, particularly towards the north, of insect pests, weeds and pathologies, the impacts of which have already been recorded (IPCC, 2019). In Eastern Africa, coffee production has already been affect by beetles because of the increase in average annual local temperatures. Brazil could also see its coffee production drop due to the proliferation of roundworms (Dasgupta et al., 2014). In the United States, at least 13 pests or diseases are steadily increasing their spread as a result of climate change and could also appear in Canada (Ouranos, 2015).

The consequences also affect the synchronicity between the life cycles of harmful species and those of their predators, leading producers to increase their means of chemical or biological control. In addition, the effectiveness of certain herbicides could decline when weed root systems increase as a result of CO_2 enrichment of the atmosphere, even though this enrichment would have

an overall positive effect on crop yields (Porter et al., 2014). According to the IPCC (IPCC, 2019), the effects on pollinators, on which 35% of global agricultural production and many ecosystem services depend, are certain. Zoonotic disease vectors (transmission of diseases and infections from animals to humans) are expected to increase and affect the health of populations living in rural areas and/or in contact with plant or animal production (Arent et al., 2014)[6].

• ECONOMIC CONSEQUENCES AND PRICE VOLATILITY THREATENING PRACTICES •

The most significant known economic impacts of climate change are related to the agricultural sector, due to its international importance and direct sensitivity to climatic conditions (Dasgupta et al., 2014)[7]. Impacts include operational and financial risks, land value and the competitiveness of the sectors in the face of changes in competitive positions. Volatile yields will affect input costs for food and beverage manufacturers or bioenergy producers. (Ouranos, 2015). The continued decline in food prices during the 20th century is likely to be reversed. Recently, several sudden increases in food prices have already been linked to extreme weather events affecting large crops. Generally speaking, lower yield developments have an impact on yields, livelihoods and the well-being of people who depend on them, particularly those who suffer from chronic food insecurity in developing countries and final consumers, via food prices, putting low incomes at risk (IPCC, 2019). The increase in biofuel production in response to climate change is also an element that affects the global demand for certain crops (Porter et al., 2014)[8]. Without a clear link to climate change, several epidemics (swine fever, avian influenza) have decimated local livestock, contributing to higher prices.

Land and water scarcity – contributing to future large-scale use conflicts?

The increasing scarcity of water or land suitable for food production activities exacerbates and fuels tensions between users. The latter are often already at work due to poor resource management, socio-political consequences and population growth (IPCC, 2019). In this sense, climate change is a real threat to stability and peace in many parts of the world (FAO, 2017)[9]. Conflicts over use can lead to dangers for vulnerable populations and migration, which in turn will fuel tensions. For example, several studies converge on the causal links between climate change, drought, impacts on agricultural production, livelihoods and civil unrest in Syria from 2007-2010, but fail to attribute a weighting to the role of each cause in subsequent migration (IPCC, 2019). The populations affected by conflicts related to the use of agroecosystems obviously include the plant and animal populations of the non-human living world, which are evolving and/or dependent on ecosystems or depleting resources. Each year, they provide ecosystem services essential to humankind, economically valued at the equivalent of global GDP (IPCC, 2019). In many cases, these conflicts of use extend to deforestation or the eradication of rare living species. Water availability is also a central point of focus in the future of food production. High anthropogenic pressure on groundwater and rivers,

---

6 Arent, D.J., R.S.J. Tol, E. Faust, J.P. Hella, S. Kumar, K.M. Strzepek, F.L. Tóth, and D. Yan, 2014: Key economic sectors and services. In: Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Field, C.B., V.R. Barros, D.J. Dokken, K.J. Mach, M.D. Mastrandrea, T.E. Bilir, M. Chatterjee, K.L. Ebi, Y.O. Estrada, R.C. Genova, B. Girma, E.S. Kissel, A.N. Levy, S. MacCracken, P.R. Mastrandrea, and L.L. White (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, pp. 659-708.

7 Dasgupta, P., J.F. Morton, D. Dodman, B. Karapinar, F. Meza, M.G. Rivera-Ferre, A. Toure Sarr, and K.E. Vincent, 2014: Rural areas. In: Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Field, C.B., V.R. Barros, D.J. Dokken, K.J. Mach, M.D. Mastrandrea, T.E. Bilir, M. Chatterjee, K.L. Ebi, Y.O. Estrada, R.C. Genova, B. Girma, E.S. Kissel, A.N. Levy, S. MacCracken, P.R. Mastrandrea, and L.L. White (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, pp. 613-657.

8 Porter, J.R., L. Xie, A.J. Challinor, K. Cochrane, S.M. Howden, M.M. Iqbal, D.B. Lobell, and M.I. Travasso, 2014: Food security and food production systems. In: Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Field, C.B., V.R. Barros, D.J. Dokken, K.J. Mach, M.D. Mastrandrea, T.E. Bilir, M. Chatterjee, K.L. Ebi, Y.O. Estrada, R.C. Genova, B. Girma, E.S. Kissel, A.N. Levy, S. MacCracken, P.R. Mastrandrea, and L.L. White (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, pp. 485-533.

9 FAO, IFAD, UNICEF, WFP, and WHO, 2017: The State of Food Security and Nutrition in the World 23 2017. Building resilience for peace and food security. Rome, Italy, 132 pp. 24. [en ligne]

combined with competition for drinking and livestock water supplies, could put farms dependent on irrigation at risk (Simonet and Salles, 2014)[10]. Changes in seasonality and variability of precipitation (in terms of intensity, duration and/or frequency) lead to shifts in the water requirements of crops. Increased and severe droughts, floods or freeze/thaw periods could be fatal for early crop species. Finally, the reduction of the snow cover leading to a spring water supply, and the increase in soil salinisation are also elements that contribute to triggering adaptation actions on the part of many farms around the world (Vermuelen et al., 2018)[11].

Agroecosystem adaptation in the face of climate change challenges

The regular management of climate variability in agri-food activities has enabled professionals in the sector to gain confidence in adapting to new current and future climate conditions (Dasgupta et al., 2014). For this reason, agriculture is one of the socio-economic sectors that has shown significant dynamism over the decades, with its actors constantly on the lookout for climate hazards, market or technological developments, as well as other external factors of a political or social nature, or relating to the personal sitation of their actors (Ouranos, 2015). In many cases, producers can rely on the various levels of government, research institutions and organisations or private sector stakeholders, even if, in the end, the decision on implementation rests with them. When it comes to cities, studies show that urban and peri-urban agriculture can contribute to improving local food security, reducing greenhouse gas emissions and protecting against major climate hazards (IPCC, 2019). Nevertheless, the issues related to climate change require some rethinking when it comes to existing practices and the abandonment of others considered obsolete in the face of the technical and chemical contributions that characterise the current global evolution of land and livestock management. They also try to stay aware of any new opportunities to reduce the vulnerability of the territories and populations that depend on them. Finally, the preferred approach to climate change adaptation strategies now includes other issues (biodiversity, soil erosion, water availability) and must target the entire supply chain through actions that address both supply and demand.

• THE CHANGING FOOD PRODUCTION SUPPLY •

Examples of how food production practices have been adapted to climate impacts vary deepening on the exact situation, as well as between developed and developing countries. For example, climate data and projections show that South America is one of the regions of the world with the greatest potential for increasing crop and livestock production in the coming decades, unlike many densely populated regions of the world in Asia, Europe or Africa (IPCC, 2019). It is estimated that a production system that has put in place effective adaptation strategies limits its yield losses by 15 to 20% compared to a system that has not implemented them. Reorganisation is also more effective at higher latitudes (for maize, wheat and rice) than in tropical regions (Dasgupta et al., 2014).

Actions relating to the supply of food production take different forms. On this point, Vermuelen et al (2018) provide a review of the scientific literature on the diversity of transformations that have occurred in the world's agroecosystems and livestock over the past 25 years, either as a result of climate impacts or in order to adapt to new climate conditions in the future. This research work focused on 23 case studies from 17 different countries spread over 5 continents. It presents a panel of adaptation options that have been implemented. For several case studies, adaptation is based on the displacement of production areas to other territories that had not undergone or had undergone

10 Simonet, G. et Salles, D. (2014). Eau et changement climatique en Garonne moyenne : L'adaptation en négociation, in Adaptation aux changements environnementaux et territoires, numéro thématique, vol. 37. [en ligne]

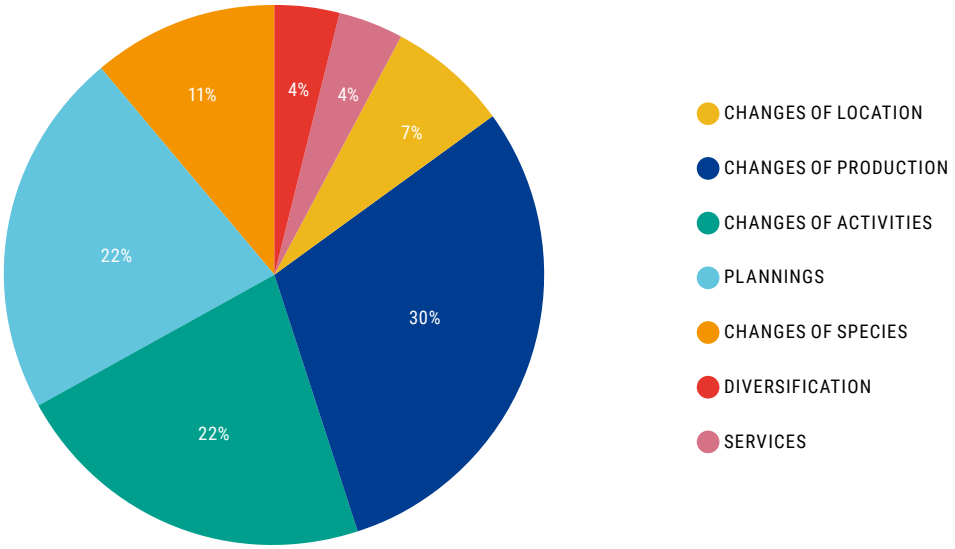
11 Vermeulen SJ, Dinesh D, Howden SM, Cramer L and Thornton PK (2018) Transformation in Practice: A Review of Empirical Cases of Transformational Adaptation in Agriculture Under Climate Change. Frontiers in Sustainable Food Systems: 2(65).

less major climate change, including transboundary migration. For others, producers (farmers, herders or cooperatives) have decided to modify agricultural or animal varieties to select more suitable ones for the new climate conditions. For example, in Pakistan, quinoa is better adapted to saline soils and offers a better yield than other species of the crop. In contrast, in Nepal, local farmers prefer to choose local bean species or millet because of their tolerance to water stress and extreme periods of cold (IPCC, 2019). Some holdings have preferred to change their activities (from agriculture to aquaculture, ending transhumance), inquire about new technologies (climate prediction services) or modify their practices (crop rotations, changes in inputs). Food storage through processing also includes options to reduce dependency in difficult years. Other plots have been developed to reduce the impact on production (addition of irrigation, shade areas, trees). Finally, several studies show that the diversification of crops or livestock makes production systems more resilient, ensures a minimum income for the farmer and reduces dependence on climate risks, compared to specialised farms. Managing pastures and nutrient and water requirements, as well as using more resistant hybrid species, are among the many options for livestock production (Fig. 2).

FIGURE 2

DISTRIBUTION OF ADAPTATION ACTIONS GROUPED INTO CATEGORIES (N=23 CASE STUDIES)

Source: according to Vermuelen et al., 2018



Local and indigenous knowledge can provide solutions to rapidly changing climate conditions and is increasingly recognised as an effective solution (IPCC, 2019; Porter et al., 2014). Among these options, agro-ecology is a form of production that diversifies crops, protects ecological processes and preserves local biodiversity. It also promotes the value of ecosystem services and involves, strengthens and recognises the role and knowledge of indigenous and local communities. Locally developed seeds can help protect local biodiversity as they may be more resistant to the climate than generic commercial varieties. They also contribute to better micronutrient intakes and, at the same time, to community food sovereignty. Some regions of Nepal preserve local plant species because of their higher levels of calcium, iron and zinc, which are higher than maize or rice, while other plants have locally recognised or religiously or culturally significant medicinal properties.

BOX 2

MAJOR AGRI-FOOD GROUPS ADAPT TO CHANGES

Large private agri-food groups are implementing reorganisation to better match their supply to growing global demand, while taking into account climate impact. The use of biotechnology, for example genetically modified organisms, is a controversial issue, but it is a real and well-argued strategy because of the need to increase food productivity to feed a growing population. On this point, Brazil and Argentina are the second and third largest producers of biotechnology crops after the United States. These crops are growing rapidly in their production supply (Dasgupta et al., 2019). In the processing stages of agricultural and livestock products, several studies have shown that the use of new processes is effective in countering the proliferation of bacteria and food deterioration associated with rising temperatures. Among these is the use of smoking or lysozyme-based coating techniques for meat preservation. In addition, the use of High Hydrostatic Pressure (HHP), which inactivates pathogenic microorganisms, spoilage agents and enzymes, without significant effects on the nutritional and sensory quality of the food (IPCC, 2019). The purchase and leasing of agricultural land in regions of other countries, in order to provide food production that can supplement and/or meet growing local demand, is also part of strategies that anticipate lower domestic yields. At this level, major Chinese agri-food groups have undertaken to lease or buy land in Ukraine, Zimbabwe or Brazil, with a significant impact on tensions with local actors. Some food giants (Bright Food, Yili and Pengxin) have even bought dozens of New Zealand dairy farms and dairies, the high production of which is very well known in China (LePoint, 2018)[12].

• REORGANISATION OF DEMAND AND CHANGING CONSUMPTION PATTERNS •

Actions addressing the demand for food consumption are also important, to enable food production systems to put in place good practices. They also aim to achieve substantial gains in public health costs related to malnutrition and a reduction in greenhouse gas emissions from production systems. Consumer demand sends strong signals that are reflected, for example, in the reorganisation of production supply practices through markets or consumption patterns. Overall, the categories of food demand change relate to consumption practices, diets and the reduction of losses and waste (IPCC, 2019). The implementation of awareness-raising or incentive campaigns by local governments, companies or consumer associations may influence diets and consumption patterns. In recent years, meat consumption has been particularly targeted because of its impact on production systems and public health – if the average meat consumption per person were adopted by every person on the planet, 178% of the Earth's surface would have to be converted into food production systems. In addition, high-earners have more varied diets, generally richer in meat and other types of food that require more resources for their production (IPCC, 2019). Food diversity in diets is advocated as it enhances nutrient intakes, as well as the consumption of fresh, local and less processed foods. Changes in consumption patterns are also associated with food transitions, which accompany income growth, urbanisation, market development and trade liberalisation, which also determine the rate and nature of food demand growth and nutritional consumption levels (Porter et al., 2014).

12 Le Point, 2018. La Chine a la conquête des terres agricoles. [en ligne]

BOX 3

VITICULTURE UNDER PRESSURE

Viticulture is of social, economic and cultural importance, particularly in Europe, a region that accounts for around 70% of global production, mainly in France, Italy and Spain (Malheiro et al., 2010)[13]. Global consumption has been stable at 245 million hectolitres since 2008. Nevertheless, demand is increasing in the United States and China, while there is a decline in Europe. As a result, the wine trade is growing every year both in volume and value. However, the climatic conditions that determine the yield, quality and geographical distribution of vines are disrupting the sector: early harvest, faster ripening of the fruit, higher sugar content and alcohol content, modification of flavours, acceleration of new diseases and migration of distribution areas towards the north are among the many climate impacts referenced in studies on the subject (Dasgupta et al., 2014). As a result, while traditional productions located in Mediterranean region are undergoing a great deal of reorganisation in their sectors, other countries (the United Kingdom, Sweden, Canada, Russia) have enjoyed record wine production almost every year for over a decade. Major investments have even been made by renowned champagne houses in England in order to anticipate these future volumes. Faced with these climate-related and commercial threats, the players in the sector are reorganising themselves and are sometimes helped by scientists to find better adapted grape varieties, optimise water and fertiliser supplies, find de-alcoholisation techniques and even act on consumer demand, with the aim of promoting new aromas and styles of wine (Le temps, 2018)[14].

13 Malheiro, A.C., Santos, J.A., Fraga, H. and Pinto, J.G. 2010. Climate change scenarios applied to viticultural zoning in Europe. Climet Research, vol. 43:163-177.
14 Le Temps, 2018. Réchauffement climatique oblige, le vin sera de plus en plus alcoolisé.

2 • Power system

Introduction

For at least half a century, and with the exception of the two years of crisis in 2008 and 2009, global electricity production has increased every year. This continuous growth reflects the role of this type of energy in the global economy and its development. The functioning of a modern society would be inconceivable without access to electricity and the services it provides: telecommunications, cooling, health systems, sanitation, etc. However, the vulnerability of electricity systems to weather hazards, almost certainly linked to climate change, has been widely demonstrated in recent years: the destruction of Puerto Rico's power grid by hurricanes Irma and Maria in 2017 (Kwasinski, 2019)[15], damage to the Oroville dams in the United States (The Weather Channel, 2018)[16] or Toddbrook Reservoir in the UK (New York Times, 2019)[17], nuclear reactor shutdowns during the European heat wave of July 2019 (Reuters, 2019)[18], bankruptcy of the California power company PG&E after its involvement in the most serious fire in the history of the state (Bloomberg, 2019)[19], etc.

Context

The power system includes various distinct activities. First, electricity production consists of transforming primary energy (coal, gas, nuclear) or a renewable flow (water, wind) into electricity. Worldwide, electricity production is dominated by coal (38.3% in 2017 according to the International Energy Agency), followed by gas (22.9%), followed by hydropower (16.3%) and nuclear (10.2%). Despite rapid growth, wind (4.4%) and solar (1.8%) still account for just a small share of global electricity production. Since local electricity production can deviate significantly from this average mix and each sector has its own vulnerabilities, exposure to climate change and the nature of the risks vary from one region to another.

The electricity produced must then be delivered to consumers via the electricity grid. A distinction is generally made between the transmission network (high voltage and long distance) and the distribution network (low voltage) that serves consumers at the level of a city or neighbourhood. These networks are made up of power lines and transformer installations to modify the voltage. In regions where electrification has been completed, these infrastructures, which are usually located outdoors, cover entire territories. They are therefore exposed to all possible climate phenomena.

The proper functioning of the power system depends on the continuous balance between production and consumption. To avoid imbalances, the effects of climate change on consumption must therefore also be anticipated.

15 Kwasinski & al. 2019. Hurricane Maria Effects on Puerto Rico Electric Power Infrastructure. IEEE Power and Energy Technology Systems Journal, vol. 6, no. 1, pp. 85-94. [en ligne]

16 The Weather Channel, 2018. Climate Change Contributed to Oroville Spillway Collapse, Study Says. [en ligne]

17 New York Times, 2019. U.K. Town Evacuated as Dam Wall Crumbles Under Heavy Rain. [en ligne]

18 Reuters, 2019. Hot weather cuts French, German nuclear power output. [en ligne]

19 Bloomberg, 2019. PG&E May Be the Business World's Biggest Climate-Change Casualty Yet. [en ligne]

TABLE 1

VULNERABILITIES IN THE ELECTRICITY SYSTEM (SCHAEFFER, 2011)[20].

Activity	Climate variables	Vulnerabilities
Thermal energy production (coal, gas, nuclear)	Air and water temperature	Quantity and quality of cooling water
	Temperature, wind, humidity	Cooling efficiency, turbine yield
	Extreme climate events	Impact on fuel production (erosion of surface mines, the end of off-shore facilities, etc.)
Hydropower production	Air temperature, precipitation	Evolution of water resources and seasonality Long droughts, long-term decline in production Evaporation of retained water Changes in water quality and sediment quantity Development of flood risks (extreme rainfall, outbursts of glacial lakes, etc.) Changes in the distribution of protected species, spread of floating algae
	Extreme climate events	Degradation of facilities (debris obstruction, erosion, etc.)
Wind energy production	Wind, extreme climate events	Changes in wind resources (intensity and duration) Wind shear, damage caused by high winds and rapid direction changes
Solar energy production	Air temperature, humidity, precipitation	Change to levels of sunshine (cloud cover) Decreased yield, linked to increase in temperatures
Biomass production	Air temperature, humidity, precipitation, CO_2 concentrations	Availability and division of usable area Desertification Crop yield
Transport and distribution	Air temperature	Reduction of the maximum permissible current with the temperature Increased risk of incidents
	Wind, extreme climate events	Degradation during exceptional climate events
Consumption	Air temperature, precipitation	Increase of consumption, linked to cooling systems, decline in demand for heating Increase in consumption linked to irrigation

Thermal power stations

Both fossil and nuclear thermal power plants are based on the same principle, whereby a turbine and an alternator convert heat into motion and then into electricity. They therefore share the same vulnerabilities. To be operated, turbines need access to a "heat sink", usually water. Their efficiency is based on the temperature of this heat sink. For example, for a nuclear power plant, the efficiency decreases by about 0.5% per additional degree of water temperature (Linnerud, 2011)[21].

The temperature of water discharged from power plants or the temperature of downstream rivers is generally regulated, in order to preserve fauna and flora (Callendar, 2019)[22]. In the event of a heatwave, these regulatory limits are reached more quickly, sometimes requiring power plants to reduce or shut down production. Finally, if the heat sink is a river, the decrease in flow during periods of drought can limit electricity production. Droughts can also disrupt the supply of fuel to coal-fired power plants when it passes along waterways.

The unavailability of thermal power plants for climate-related reasons has become frequent since the 2000s. In the summer of 2018, Swedish and Finnish power plants even encountered difficulties due to the heat Reuters, 2018)[23]. The design of thermal power plants can be adapted to all

20 Schaeffer & al. 2011. Energy sector vulnerability to climate change: A review. Energy 38 (2012) 1-12.

21 Linnerud & al. 2011. The Impact of Climate Change on Nuclear Power Supply. The Energy Journal, Vol. 32, No.

22 Callendar, 2019. Réglementation des rejets thermiques pour le parc nucléaire français. [en ligne]

23 Reuters, 2018. In hot water: How summer heat has hit Nordic nuclear plants. [en ligne]

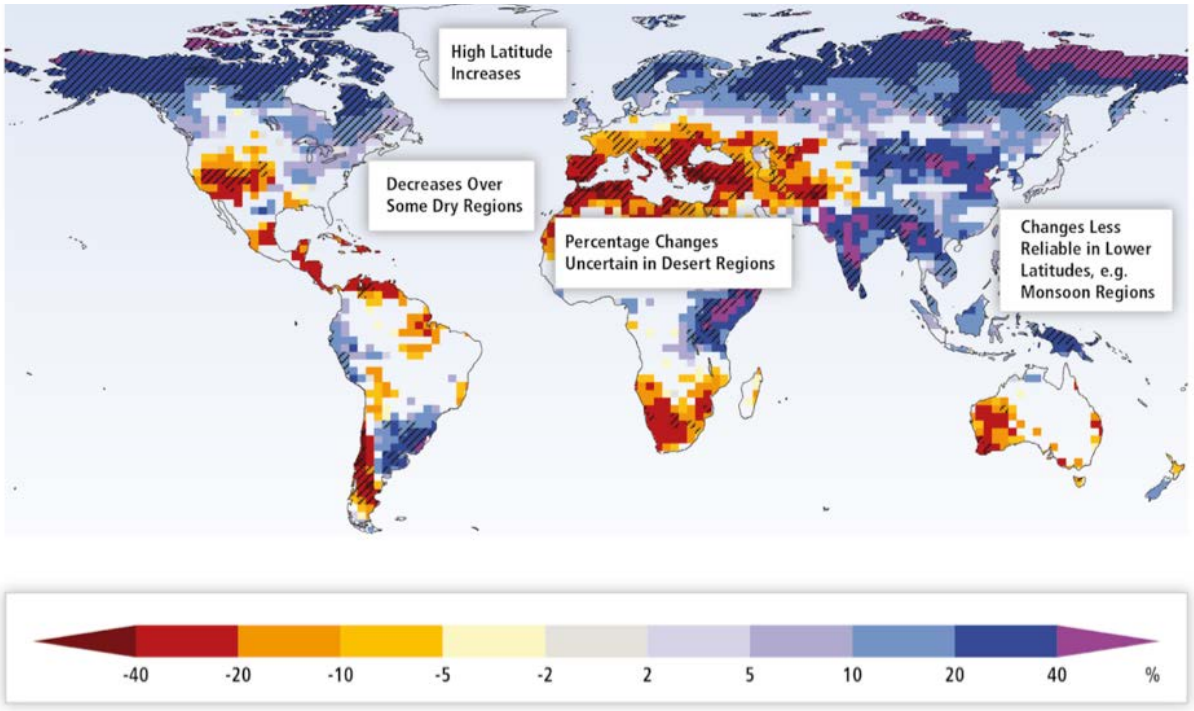
climates. For example, the Barakah nuclear power plant in the United Arab Emirates was modified for the climate of the Persian Gulf based on a South Korean model (World Nuclear Association, 2017)[24]. However, for existing power plants, the possibilities for adaptation are limited and mainly focus on the reinforcement of heat exchangers and water management at the level of the catchment area (Energie et Développement, 2019)[25].

Hydropower

According to the IPCC Special Report on Renewable Energy Sources (IPCC, 2011)[26], water resources are expected to develop differently from region to region. Divergent local developments are possible at the scale of catchment areas or even rivers. These variations may call into question the viability of hydropower facilities designed on the basis of historical observations.

FIGURE 1

DEVELOPMENTS IN RUNOFF WATER RESOURCES IN % BETWEEN 1980-1989 AND 2090-2099 UNDER A PESSIMISTIC EMISSIONS SCENARIO (A1B). THE HATCHED AREAS INDICATE REGIONS WHERE 90% OF THE MODELS CONVERGE IN THE DIRECTION OF DEVELOPMENT; AREAS WHERE LESS THAN 66% OF THE MODELS CONVERGE HAVE BEEN LEFT COLOURLESS (IPCC, 2011)



Beyond the average resource availability, variability must also be taken into account, particularly for run-of-river installations or those with small reservoirs. An increase in inter-annual variability leads to an increased risk of a sustainable electricity shortage. These long periods of drought, such as the East African drought of the 2000s, have serious economic consequences in countries dependent on hydropower and can have a lasting impact on energy choices (see Kenya country profile). Greater intra-annual variability can increase the risk of flooding and therefore production

24 World Nuclear Association, 2017. Barakah Nuclear Energy Plant Plant Cooling Water System Development. World Nuclear Performance Report 2017 Case Study. [en ligne]

25 Energie et Développement, 2019. Comment EDF se prépare aux effets du changement climatique pour le secteur électrique. [en ligne]

26 IPCC, 2011. Renewable Energy Sources and Climate Change Mitigation.

losses and damage to installations. The International Hydropower Association (2019)[27] has recently published a practical guide for its members to assess and reduce these risks.

Beyond their own activity, hydropower dam operators play a central role in two areas: in regulating the electricity system (since highly flexible hydraulic generation is often used to ensure grid balance and facilitate the integration of variable renewable generation) and in regulating water resources for downstream activities (thermal power plants, agriculture, drinking water, etc.). For example, the Hoover Dam's difficulties could deprive Los Angeles of one of its main sources of electricity and threaten Las Vegas' drinking water supply (Gober, 2010)[28]. Some researchers go so far as to consider the emergence of "failed cities" in this case (Muller, 2007)[29].

Other renewable productions

Like hydropower, wind power exploits a resource directly linked to the functioning of the climate system and is likely to vary significantly with climate change. For example, in China, the world's largest wind energy producer, production potential has already declined by around 15% since 1979 in the north of the country due to milder winters (Sherman, 2017)[30]. Wind power is also sensitive to extreme winds, especially in the event of rapid changes in direction: several Asian off-shore wind farms have been damaged by typhoons (Xiao, 2016)[31] and models suggest that even recent standards are insufficient to be able to cope with the most violent hurricanes (Worsnop, 2017)[32]. However, wind farms have the advantage of a relatively short lifespan – around 30 years compared to 40 to 60 years for a thermal power plant, and up to a century for a hydropower dam – which reduces the extent of the changes they could face.

Solar production yield decreases with temperature. For photovoltaics, this decrease is about 0.3% for each additional degree. Thermodynamic solar energy, on the other hand, uses turbines comparable to those of fossil or nuclear power plants and is subject to the same risks. In addition, climate disruption could affect available sunshine by changing cloud cover. This means that solar production is expected to vary slightly overall (Crook, 2011)[33]. Solar installations are also sensitive to extreme weather events (strong winds, hail, etc.). Feedback on these risks has been provided to improve the resilience of projects, particularly after the damage caused by the 2017 hurricane season (Burgess, 2018)[34].

Isolated studies indicate that biomass resources (Wilbanks, 2008)[35] and marine energy potential (Harrison, 2005)[36] may also change significantly with climate.

---

27 International Hydropower Association (mai 2019). Hydropower Sector Climate Resilience Guide.

28 Gober, 2010. Desert urbanization and the challenges of water sustainability. Current Opinion in Environmental Sustainability 2(3):144-150.

29 Muller & al. 2007. Adapting to climate change: water management for urban resilience. Environment and Urbanization, 19(1), 99–113.

30 Sherman & al. 2017. Wind-generated Electricity in China: Decreasing Potential, Inter-annual Variability and Association with Changing Climate. Scientific Reports volume 7. [en ligne]

31 Xiao & al. 2016. Structural integrity of wind turbines impacted by tropical cyclones: A case study from China. Journal of Physics: Conference Series, Volume 753. [en ligne]

32 Worsnop & al. 2017. Gusts and shear within hurricane eyewalls can exceed offshore wind turbine design standards. Geophysical Research Letters Volume44, Issue12. [en ligne]

33 Crook & al. 2011. Climate change impacts on future photovoltaic and concentrated solar power energy output. Energy & Environmental Sciences,4, 3101-3109.

34 Burgess & al. 2018. Solar under storm - Select best practices for resilient ground-mount pv systems with hurricane exposure. Rocky Mountain Institute. [en ligne]

35 Wilbanks & al. 2008. Effects of Climate Change on Energy Production and Use in the United States. US Department of Energy Publications. [en ligne]

36 Harrison & al. octobre 2005. Climate sensitivity of marine energy. Renewable Energy, Volume 30, Issue 12 [en ligne]

Transport and distribution networks

The maximum current that a power line or transformer can safely withstand decreases with temperature. At constant consumption, current networks could therefore become undersized. For example, in California, the heat waves expected at the end of the century would require power line capacity to be increased by 7 to 8% compared to current levels and transformer installations by 1 to 3.6% (Sathaye, 2013)[37].

Abnormal periods of heat are also associated with an increase in the number of incidents on both overhead and underground power grids. During the 2003 heatwave, the number of short circuits caused by contact with vegetation doubled on the French transmission network (RTE, 2004)[38], while distribution network failures caused outages for 240,000 households in the Île-de-France region (Létard, 2004)[39]. These risks can be limited by maintenance operations (e.g. cutting trees) and preventive maintenance.

Electricity grids are also sensitive to other meteorological hazards – wind, frost – the distribution, frequency and intensity of which can be affected by climate change, as well as to their indirect consequences – flooding, tree falls, landslides. According to the reinsurer Swiss Re (2017)[40], the insured damage caused by power cuts caused by floods, hurricanes or extreme temperatures amounted to between 20 and 55 billion dollars for the year 2015 in the United States. Some risks, such as fires and high winds, will also increase.

Consumption

Increased temperatures have had a short-term effect on electricity consumption. In the summer period in France, an additional degree leads to an increase in demand of 400 to 500 MW (RTE, 2019)[41]. Combined with the decrease in the availability of thermal generation and the reduction in system capacity, this increase can be problematic. This heat sensitivity of the demand depends in particular on the amount of air conditioning equipment. It could therefore increase if households equip themselves to cope with more frequent heat waves.

The electricity system is based on heavy infrastructure with a very long lifespan. Most existing power plants or lines will still be in operation by the middle of the century, while those currently under construction will probably see the 22nd century. This creates two distinct problems; on the one hand, adapting existing installations to a climate different from that for which they were designed, and, on the other hand, integrating long-term climate projections into the design of new projects. The sector, which is already being shaken up by a wave of technical and economic innovation that has not been seen since the beginning of electrification, is currently struggling to integrate these new dimensions. However, there are initiatives that reflect growing awareness, such as the ECEM and Climate4Energy projects, which bring together research centres (CEA, U.K. Met Office, Swedish Meteorological and Hydrological Institute, etc.) and operators (EDF, Shell, Statkraft, etc.) to provide climate data and methodologies tested in hydropower.

37 Sathaye & al. 2013. Estimating impacts of warming temperatures on California's electricity system. Global Environmental Change, Volume 23, Issue 2, Pages 499-511.

38

39 Létard & al. 2004. La France et les Français face à la canicule : les leçons d'une crise. Rapport d'information n°195 (2003-2004), mission commune d'information, Sénat. [en ligne]

40 Swiss Re, 2017. Lights out: The risks of climate and natural disaster.

41 RTE, 2019. L'équilibre offre-demande d'électricité pour l'été 2019. [en ligne]

3 • Buildings and housing

Introduction

The majority of the property stock and housing built over the last century have been designed by integrating past climate statistics and risks considered to be representative of future climate conditions. Ongoing climate change challenges this approach and raises issues of building safety and efficiency, especially in the long term. The real estate and construction sectors are increasingly aware of climate issues, but the requirements needed to adapt are on top of the requirements for new residential infrastructure due to socio-economic developments and the rehabilitation required due to their ageing. Thus, the risks of collapse, deterioration and loss of value are likely to increase in the face of changing extreme weather events (damage due to snow or water infiltration, deterioration of the indoor climate, reduction in the life span of buildings). Faced with these potential risks, the sector must continue to organise itself and involve architects, property lessors and managers, as well as the entire property construction sector.

Skyrocketing property stock prices

With a global urban population estimated at 54% (expected to grow significantly by 2030), urban and residential buildings present significant challenges, while globally, the number of extreme weather events increased by 250% between 1980 and 2013 (ULI, 2019). Direct and indirect human losses resulting from these events may be considerable, especially in vulnerable territories, to which health costs, forced displacements or even damage to local heritage also need to be taken into account. In 2017, hurricanes Harvey and Maria hit the United States and storms shook northern and central Europe. Insurers paid a record US$ 135 billion worldwide for damage caused by storms and natural disasters. In 2018, natural disasters cost the United States $92 billion in property damage, including 14 extreme weather events, each reaching $1 billion. Three events (Hurricane Michael, forest fires in the west and Hurricane Florence) exceeded US$ 24 billion in material damage, while in the 1980s, less than US$3 billion in disasters struck the United States each year, amounting to a total of US$17 billion in annual damage (JCHS, 2019)[42]. Faced with these trends, which depreciate the real estate market and increase the risk of loss for both residents and assets, new policies, standards and planning tools are being put in place.

Increasing impacts at all levels of the real estate sector

Climate impacts and conditions affect the construction sector in several ways – construction delays and costs, changes in the length of seasons favourable to construction (e.g. in the Nordic countries). Rainfall also affects the cost of construction – temporary flood protection structures (boxes), slope stabilisation management and foundation drying. Buildings, exterior components (windows, roofs, cladding) and building materials are designed and selected to withstand a particular range of weather conditions. These are developing and leading to changes in design standards to avoid increased failures (window seals, roof material leaks, reduced life span of wood or glass cladding materials). Air circulation systems need to be reviewed in order to anticipate an increase in humidity and indoor temperatures and ensure indoor air quality, with priority given

42 Joint Center for Housing Studies, 2019. The State of the Nation's Housing.

to strategic installations (hospitals, schools). All renovations may involve significant costs. Finally, climate impacts affect the real estate sector, through the demand for reconstruction and repair as disaster damage occurs, specific to specific geographical contexts (Arent et al., 2014;[43] GABC, 2016)[44].

Beyond the consequences relating to buildings, climate impacts also have financial consequences for property owners and operators, such as higher insurance premiums, capital expenditures and operating costs, as well as a decrease in the liquidity and value of buildings (Table 1). Transitory risks, focused on the social, economic and political responses to climate change, can make places or landscapes, or even entire metropolitan areas, less attractive due to past or recurrent climatic events, to the extent that real estate assets become obsolete (ULI, 2019)[45].

TABLE 1

TYPES OF CLIMATE RISKS AND THEIR POTENTIAL IMPACTS ON REAL ESTATE MANAGEMENT

Source: ULI, 2019 Climate Risk and Real Estate Investment Decision-Making

Category		Potential impacts
PHYSICAL RISKS	Catastrophic events Extreme climate events (hurricanes, forest fires, flooding, heatwaves); event intensification.	• Repair or replacement costs of damaged or destroyed property, impairment; • Unavailability of assets and disruption of operations; • Possibility of increased insurance costs, reduction and/or disappearance of coverage
	Development of climate trends Gradual changes (intensity, duration, frequency) in temperature and precipitation; rising sea levels.	• Increased wear and tear or damage to buildings, resulting in increased maintenance costs; • Increased operating costs due to the need for additional resources (or energy) to operate a building; • Cost of investments in adaptation actions, such as raising buildings or incorporating additional cooling methods; • Potential for increased damage resulting from catastrophic events; • Possibility of increased insurance costs, reduction and/or disappearance of coverage
TRANSITORY RISKS	Market Potential for markets vulnerable to climate change to become less desirable over time. Increased investment costs for the construction and maintenance of infrastructure to manage climate risks.	• Reduced economic activity in vulnerable markets; • Reduced occupant demand for properties; • Reduced asset value; • Potential for property tax increases.
	Policy and regulation Regulations to combat climate change (disclosure of climate-related risks, strengthening building standards, carbon pricing, emission caps, subsidy changes), as well as changes in infrastructure financing or reconstruction policies following major events.	• Increased cost of doing business due to new information requirements and compliance measures; • Increased taxes, both those resulting from public policies such as carbon taxes and those aimed at financing new and better adapted infrastructure; • Loss of grants or other funding opportunities; • Additional capital investments to comply with stricter regulations.
	Availability of resources Changes in availability of key resources such as energy and water	• Increased costs and reductions reduction in net operating income due to higher prices; • Additional capital expenditure to adapt buildings to operate with reduced/alternative resources.
	Reputation and market positioning Increasing preference of stakeholders to work with companies that integrate climate risk into their investment decisions and consumer preference for real estate products that integrate climate risk and issues.	• Risk to the brand and reputation of the company if no action is taken; • Decrease in the liquidity and/or attractiveness of assets that have not integrated climate risk and issues.

43 Arent, D.J., R.S.J. Tol, E. Faust, J.P. Hella, S. Kumar, K.M. Strzepek, F.L. Tóth, and D. Yan, 2014: Key economic sectors and services. In: Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Field, C.B., V.R. Barros, D.J. Dokken, K.J. Mach, M.D. Mastrandrea, T.E. Bilir, M. Chatterjee, K.L. Ebi, Y.O. Estrada, R.C. Genova, B. Girma, E.S. Kissel, A.N. Levy, S. MacCracken, P.R. Mastrandrea, and L.L. White (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, pp. 659-708.

44 Global Alliance for Buildings and Construction, 2016. Towards Low-GHG and Resilient Buildings.

45 Urban Land Institute, 2019. Climate Risk and Real Estate Investment Decision-Making

BOX 1

BUILT CULTURAL HERITAGE – LONG OVERLOOKED

Built cultural heritage plays an important role in the leisure and tourism industries, in particular by supporting the local economy. It contributes to education and cultural learning of populations, shapes socio-cultural capital through the identity, traditions and sense of place of local communities and contributes to the conservation of the environment. Climate change poses a serious threat to the protection, preservation and transmission of this non-renewable heritage to future generations, particularly with rising sea levels (floods and coastal erosion), sudden changes in air and sea temperatures and humidity levels, extreme weather events, and changing soil and sediment conditions. However, despite growing interest in these issues (symbolic, tourist and economic importance), few studies are being conducted on the potential severity of current and future climate impacts on built cultural heritage. Few documents (despite the call for more studies combining a number of different disciplines and sectors: tourism, archaeology, history, economics, sociology) deal with actions or reorganisation to be undertaken in order to compensate for possible future damage. The work of Fatorić and Seekamp (2017) addresses several obstacles identified by professionals working in heritage sites: lack of processes and guidelines for planning and implementing adaptation measures to ensure site preservation, insufficient funding and limited knowledge of the interactions between climate impacts and built cultural heritage, etc. Experts believe that the main needs to overcome these obstacles should include more scientific research and closer collaboration between stakeholders in the heritage real estate sector.

Sources: Fatorić and Seekamp, 2017[46]

Reorganisation taking place amongst property management investors

There are now more and more real estate players who invest in areas with potential climate risks who are seeing an increase in insurance premiums or a reduction in coverage, while still considering the price and risk acceptable. While insurance covers most damage resulting from weather events, it does not protect against a reduction in the liquidity of a real estate asset or a loss in its value. As a result, many investors and investment managers recognise that the use of insurance as the primary protection for the value of real estate assets is not an effective solution to mitigate the risk of devaluation. Indeed, premiums are currently largely based on historical analysis and are not likely to consider future losses. Therefore, while insurance can provide short-term protection, more and more investors and investment managers are exploring new approaches to find better tools and common standards to help the real estate industry better assess future climate risks (ULI, 2019). Among these are:

- Development of physical risk maps for current real estate portfolios and potential acquisitions;
- Integration of climate risks into due diligence and other decision-making processes in real estate investment;
- Integration of additional physical adaptation actions for real estate assets at risk;
- Identification of various strategies to mitigate risks, including portfolio diversification and direct investment in adaptation options for specific assets;
- Engaging with policy makers on resilience strategies at city level and supporting municipal investments to mitigate the risks of all assets under their jurisdiction.
- Reorganisation required at each stage of real estate construction

46 Fatorić, S. and Seekamp, E. 2017. Are cultural heritage and resources threatened by climate change ? A systematic literature review.

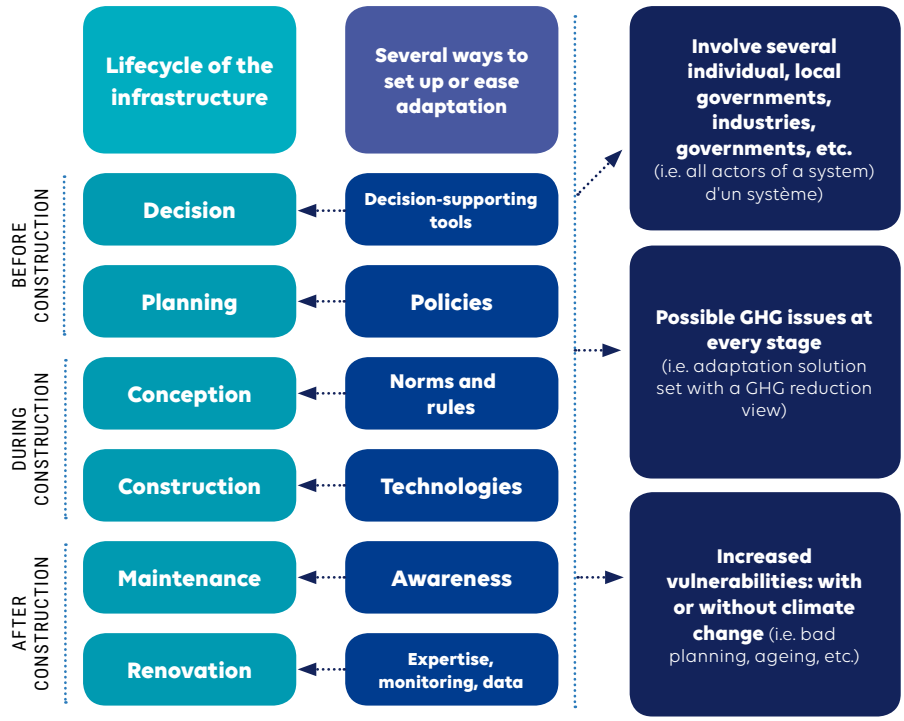
Any climate change adaptation strategy should seek to improve the resilience of the system under consideration, as is the case for building construction and housing. The life cycle of an infrastructure must be considered; therefore, at each stage of its construction (before, during, after), there are several ways to implement or facilitate adaptation, which involve many stakeholders in the context under consideration (Fig. 1). In its Climate Change Strategy 2014-2019,[47] UN-Habitat recommends strengthening adaptation to climate impacts through several actions:

1. Promoting applied research into the risks associated with climate impacts and other hazards;
2. Encouraging and supporting the assessment of vulnerability to climate change at a local level;
3. Mapping hazards (including those that may develop over time);
4. Planning human settlements, regulating land use and providing essential infrastructure and services, taking into account risk information and building resilience;
5. Prioritising actions that strengthen the resilience of vulnerable and marginalised populations and improve slums and informal settlements;
6. Promoting the restoration of ecosystems and natural buffer zones;
7. Providing regional planning that protects ecosystems and protects against "maladaptation".

FIGURE 1

DIAGRAM OF DIFFERENT TYPES OF ADAPTATION SOLUTIONS IN THE CONTEXT OF THE LIFE CYCLE OF A BUILDING CONSTRUCTION.

Source: Bourque et Simonet, 2005[48]



47 ONU-Habitat Climate Change Strategy 2014-2019. Nairobi: UN-Habitat.

48 Bourque, A. et G. Simonet. « Québec », dans Vivre avec les changements climatiques au Canada : édition 2007, D.S. Lemmen, F.J.Warren, J. Lacroix et E. Bush (éditeurs), Gouvernement du Canada, Ottawa (Ontario), 2008, pp. 171-226.

BOX 2

CITYRAP AND CRPT – PLANNING TOOLS FOR A RESILIENT HABITAT

Climate impacts significantly affect countries and communities that live in insecure housing and/or in locations highly exposed to weather hazards. These are combined with a high level of poverty, a lack of infrastructure that reduces risks or even tense social and/or political situations. Some cities and communities remain particularly vulnerable. The 2019 report of the World Commission on Adaptation estimates that 880 million people live in informal settlements that are extremely vulnerable to climate change. This is particularly the case in many urban areas of Africa with high population growth. Since 2010, UN-Habitat has been supporting African cities in reorganising their response to climate impacts, particularly floods, droughts and hurricanes. To support these communities, UN-Habitat and the Technical Centre for Disaster Risk Management, Sustainability and Urban Resilience (DiMSUR) have developed the City Resilience Action Planning (CityRAP) tool to facilitate city-level resilience planning. CityRAP is a participatory planning process that allows city managers and municipal technicians in small and medium-sized cities to develop actions to reduce risks and build resilience. To date, 25 cities in 10 African countries have implemented CityRAP and identified their resilience needs, which include strengthening drainage systems, restoring ecosystems, improving solid waste management and establishing early warning systems and shelters. In 2019, CityRAP is being implemented in Ethiopia (Arada, Dire Dawa and Adama), Malawi (Lilongwe), Mozambique (Dondo), Comoros (Fomboni), Zambia (Lusaka and Chipata) and Zimbabwe (Mutare). CityRAP is only a first step – once planning has been defined and approved, the challenge is to implement it by working with governments and regional administrations, donors, investors, local communities and policies that will better protect cities from climate risks. Similarly, the City Resilience Profiling Tool (CRPT), developed by UN-Habitat, is a method for strengthening the resilience of urban areas to climate impacts. The analysis of the urban system targeted by the CRPT is intended to be as comprehensive as possible, in particular through a holistic approach that combines climate risk analysis with cross-sector analysis of the physical, organisational, functional and social environment. The CRPT thus makes it possible to identify trends in vulnerability, as well as synergies and interconnections between sectors at the scale of the urban system. Using this tool, the built environment (commercial buildings, residential buildings and habitats) is taken into consideration by multiple indicators, such as the age of the building, the nature of the soil, urban forms and the characteristics of the habitats. Beyond the morphology of buildings, several indicators integrate the processes specific to the physical functioning of buildings and the lives of their inhabitants, such as supply flows (water, heating, electricity) and logistics (access to transport, fire hydrants). The adaptation of a set of indicators makes it possible to estimate the vulnerable aspects of local climate change.

Sources: UN Habitat 2019,[49] UN-Habitat, 2018[50]

49 ONU-Habitat, 2019. The new climate reality: protecting african cities from disaster.

50 ONU-Habitat, 2018. City Resilience Profiling Programme. Climate Action Enhancer.

Reorganising property stock through a range of options

Improving the sustainability and resilience of property stock begins with upgrading the most critical infrastructure, such as buildings of significant strategic social and economic interest (hospitals, emergency centres, schools, power plants, production and storage centres for hazardous products), particularly in the event of disasters. To this end, the stricter application of urban planning rules, incorporating a risk approach (risk zoning), can prevent or reduce the exposure of these key infrastructures to climate risks and indirect impacts that can lead to dysfunctions (rescue, rehabilitation) (GABC, 2016).

Vegetation is one of the most common options on the table when the adaptation of buildings and habitats to climate change is discussed. Green roofs, green walls or water collection and drainage systems (using plant species to capture rainwater before it can flood the sewer system) are among the options referred to as nature-based adaptation solutions. These are applied to buildings and their surroundings and have the dual benefit of mitigating climate risks or extreme weather events and promoting biodiversity.

Faced with climate change, engineering is coming up against new challenges. The sector often faces uncertainties associated with climate projections that arise from assumptions about future weather conditions, population growth and human behaviour. In addition, there is a duty to face cost and longevity constraints from the outset of projects. In order to overcome these obstacles, more and more professionals are advocating a phased capacity expansion strategy, which allows technical projects to modify the design as conditions or knowledge evolve. This approach facilitates the construction of projects through incremental change and reduces the burden of initial financing, as is the case with London's work on the Thames or the multiple measures taken by communities in the Netherlands to manage increasing floods (Noble et al., 2014)[51].

More and more cities are implementing adaptation measures for their property stock through a revision of standards that integrate the uncertainty related to future climate impacts. In Bangkok, actions include urban redevelopment to cope with floods, such as building raised basements, moving power boxes upstairs and building spaces to store enough food, water, fuel and other supplies for 72 hours. Regulatory changes, aimed at strengthening land use restrictions in floodplains and high-risk sites, as well as revisions to building safety and fire codes, are among the options being considered by many other cities (Cape Town, Boston, Melbourne, New York) (Revi et al., 2014)[52].

Labels and technical standards are also a way to accelerate the integration of climate risks in the real estate construction sector. The advantage is that these risks are coupled with objectives for greenhouse gas reduction, sustainability, thermal comfort and environmental efficiency (drainage, water supply, greening, energy flow, reduction of resources used, new materials). Many existing labels are starting to offer specific modules related to climate risks and reflect the progress of the subject in the sector: CERQUAL and NF Habitat, GRESB Resilience Module, BREEAM, LEED, REli, Green Star (Construction 21, 2018)[53].

---

51 Noble, I.R., S. Huq, Y.A. Anokhin, J. Carmin, D. Goudou, F.P. Lansigan, B. Osman-Elasha, and A. Villamizar, 2014: Adaptation needs and options. In: Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Field, C.B., V.R. Barros, D.J. Dokken, K.J. Mach, M.D. Mastrandrea, T.E. Bilir, M. Chatterjee, K.L. Ebi, Y.O. Estrada, R.C. Genova, B. Girma, E.S. Kissel, A.N. Levy, S. MacCracken, P.R. Mastrandrea, and L.L. White (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, pp. 833-868.
P.R. Mastrandrea, and L.L. White (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, pp. 535-612.

52 Revi, A., D.E. Satterthwaite, F. Aragón-Durand, J. Corfee-Morlot, R.B.R. Kiunsi, M. Pelling, D.C. Roberts, and W. Solecki, 2014: Urban areas. In: Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Field, C.B., V.R. Barros, D.J. Dokken, K.J. Mach, M.D. Mastrandrea, T.E. Bilir, M. Chatterjee, K.L. Ebi, Y.O. Estrada, R.C. Genova, B. Girma, E.S. Kissel, A.N. Levy, S. MacCracken, P.R. Mastrandrea, and L.L. White (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, pp. 535-612.

53 Construction 21, 2018. Adaptation au changement climatique dans l'immobilier: pourquoi et comment anticiper le risque physique lié aux vagues de chaleur ? [en ligne]

4 • Recreational tourism activities

Introduction

Recreational activities, whether seasonal or outdoor, are divided into different 'playgrounds' (mountains, sea) and heritage (natural, cultural) that make them more or less dependent on climatic conditions. These influence demand, supply, structures, operating costs and net income (Ouranos, 2015)[54]. Many tourist destinations are also developed according to their landscape, cultural or meteorological appeal. In the face of climate change, players in the sector must reorganise themselves, while taking into account the load capacity of their offer, in the face of changes in visitors, increased competitiveness between destinations and changes in tourist consumption patterns.

Context

The recreational and tourism sector is an important pillar of the global economy and accounts for about 9% of global GDP and employs more than 255 million people, making the provision of tourism services a dominant activity in many regional economies. Some are entirely dependent on it, such as some Small Island States (Arent et al., 2014). In 2017, 1326 million arrivals were recorded worldwide, an increase of 7% compared to 2016, with France, Spain and the United States being the top three countries visited. International tourism represents 1186 billion euros of revenue (DGE, 2018)[55]. Various studies into climate impacts on the recreational tourism sector and its reorganisation focus on tourist behaviour (demand) and on the local tourism supply. The first International Conference on Climate Change and Tourism took place, at the invitation of the Government of Tunisia and under the sponsorship of the World Tourism Organization (UNWTO), in Djerba, Tunisia, from 9 to 11 April 2003. It brought together many private, state and non-state actors linked to the sector. This initiative was repeated in Davos in 2007, before succeeding the International Conference on Sustainable Tourism (the 9th edition of which is scheduled for 2020 in the United Kingdom) and the International Conference on Sustainable Tourism Management (the 3rd edition of which took place in 2019 in Hungary).

54 Ouranos (2015). Vers l'adaptation. Synthèse des connaissances sur les changements climatiques au Québec. Partie 2 : Vulnérabilités, impacts et adaptation aux changements climatiques. Édition 2015. Montréal, Québec : Ouranos, 234 p.

55 Direction générale des entreprises (DGE), 2018. Chiffres clés du tourisme – études économiques.

Actors and types of activities in the recreational tourism sector

Tourism stakeholders include tour operators, local managers, recreational tourism service managers, and organisations, guides and major companies that own multiple hotels around the world. Natural, regional or national parks may manage the territories for which they are responsible. Ski resorts may be owned by private funds or local authorities, or by multiple local associations or companies that offer activities in public areas. Several key destinations target the historic centres of many cities, as in Europe. The sector covers everything from the tourist agency to service providers working for large hotel complexes. The activities offered may be supported by campaigns led by regional governments or structural funds aimed at attracting visitors, renovating infrastructure, enhancing historic buildings or rehabilitating natural heritage.

Climate impacts that primarily affect outdoor activities

Weather conditions influence demand (customer behaviour and flows), the supply of certain products, the administrative and operational structure, the company's image and reputation, operating costs and net revenues. The transformation of the supply chain, as well as financial aspects (increased insurance premiums, access to capital, credit, long-term financial returns, liquidity), environmental aspects (sensitive ecosystems with high tourism value), legal, political and regulatory aspects are also potential risks to be considered (Ouranos, 2015). Observed and future climate impacts include rising sea levels and ocean acidification, which threaten tourism infrastructure and coastal natural attractions, particularly when combined with anthropogenic pressures from overcrowding (Box 1). Rising temperatures shorten winter sports seasons to the point of threatening the viability of several ski resorts, particularly in the mid-mountain regions (Spandre, 2019)[56]. The ongoing collapse of biodiversity, northern species migration and invasion of harmful species are affecting outstanding sites and ecotourism. Changing precipitation affects water availability and the recreational tourism activities that depend on it (Cambridge, 2014)[57]. Many other impacts are related to the increasing severity of climate hazards (heatwaves, floods, hurricanes) or events (forest fires). Indirect impacts are related to increased insurance spending, tensions with other users of natural resources (farmers, herders, drinking water, hydroelectric production). Finally, the sector will be increasingly affected by future restrictions and standards on greenhouse gas emissions from the transportation sector, whose activities depend on it (air travel, cruise ships, use of combustion engines as recreational vehicles).

Some opportunities, however limited, are emerging as a result of climate change, such as the discovery of new territories offering better climate conditions for the development of activities (swimming, golf, hiking), as is already the case in Canada, the United Kingdom and as is expected in Alaska, Northern Europe and even Antarctica. The melting of the Arctic also provides an opportunity for cruises to move a little further north.

56 Spandre, P., François, H., Verfaillie, D., Lafaysse, M., Déqué, M., Eckert, N., Georges, E. and Morin, S. 2019. Climate controls on snow reliability in French Alps ski resorts. Scientific reports, 9(1), 8043. [en ligne]

57 University of Cambridge, 2014. Climate Change: implications for tourism. Key findings from the IPCC 5th assessement report.

BOX 1

RESTRICTING MASS TOURISM TO FACILITATE THE ADAPTATION OF NATURAL AND CULTURAL HERITAGE

Climate change is exacerbating already significant tourist pressures on the territories visited. Many nature parks have already put in place strategies to regulate mass tourism that affects their outstanding landscapes and local biodiversity. Koh Phi Phi National Park in Thailand is home to the island that served as the setting for the film The Beach (2000) – a world film success. It is faced with tourist traffic that reaches up to 4000 visitors per day and is associated with increasing impacts (plastic waste, encroachment, waste water). In addition, there are the climate impacts on corals and the fragile tropical island ecosystem. In April 2018, the authorities responsible for its management decided to close it for 4 months to allow the ecosystem to regenerate. They are considering several options to combine the economic benefits of tourist visits, ecosystem health and climate change (La Libre, 2018)[58]. This decision follows the example of several similar local decisions, such as in the Philippines on the island of Boracay or the Tayrona National Nature Park in Colombia. The latter is closed for one month of the year. Officials explain that it is a period of rest and silence for protected areas (better regeneration of ecological processes and opportunity for indigenous peoples to carry out their activities) (Le Figaro, 2017)[59]. The management of large-scale tourism, associated with climate change, also concerns cultural heritage, often located in urban areas, as is the case in the Mediterranean (Venice, Santorini, Barcelona). For example, in the Catalan capital of Barcelona, the local population is demanding the containment of a tourist population that is 20 times higher, while the Venetian home of the Doges has decided to introduce a tax and is considering banning cruise ships in its bay, in order to stop the denaturation of the living environment (RFI, 2019)[60].

Ongoing initiatives and supply-side adaptation options

Adaptation actions in the recreational tourism sector are lagging behind other economic sectors (agriculture, forestry). The sector has focused on reducing greenhouse gas emissions, in particular to reduce the energy bill related to their activities (Ouranos, 2015). Diversification of activities is one of the options commonly used by tourism infrastructures that offer specific activities (Box 2). This is why medium mountain ski resorts are developing other marketing strategies based around wellness (spas, relaxation treatments) or other less developed activities (snowshoes, sled dogs). Technology is also part of the strategy mix, but without having indirect consequences. There are increased tensions when it comes to water resources and users when artificial snow guns are put into operation. For coastal areas, the protection of seaside resorts requires more solutions linked to important infrastructures (dikes, groins, rockfill), when relocation is not possible. Some studies show that the view of such infrastructures does not reassure tourists who come to relax and thus has the disadvantage of potentially reducing the number of visitors (Njoroge, 2015)[61]. Desalination plants are emerging in Small Island States to address shortages of drinking water resources and changes in rainfall patterns.

Planning tourist seasons allows managers to spread out visitor flows and anticipate periods when climate hazards and peaks in demand (water, energy) are combined. For example, several

58 La Libre, 2018. L'enfer du tourisme de masse: «Il n'y a pas un endroit de la plage sans quelqu'un en train de prendre des photos» [en ligne]

59 Le Figaro, 2017. Ces perles de la Méditerranée asphyxiées par le tourisme de masse. [en ligne]

60 RFI Europe, 2019. Barcelone, Venise… ces villes européennes en guerre contre le tourisme de masse. [en ligne]

61 Njoroge, 2015. Climate change and tourism adaptation: literature review. Tourism and hospitality management, 21(1):95-108.

communities in the Costa Brava (Spain) add value to the off-season months (April-May and September-October) for their customers (University of Cambridge, 2014). In addition to the seasons, planning tools are emerging to link climate projections with planned projects (Table 1) (Paquin et al., 2016). Similarly, decision-makers in the public and private tourism sectors are called upon to work closely together to better plan structural investments for the future (Ouranos, 2015). Six elements have been identified as essential upstream of decision-making when it comes to reorganisation to address climate issues (Ouranos, 2015):

• Comparison with international and local case studies;
• Gathering of quantified information from economic studies (e.g. cost-benefit analysis of adaptation measures or other methods);
• Partnership (connection) between companies and regions (e.g. hotel packages/flexible attractions for customers depending on the weather situation);
• Adaptation and transformation of existing mechanisms (e.g. business or management models);
• Applied tools for users (complexity of daily risk management);
• Mobilisation and training on climate change in companies, within the public service of sectoral and local economic development associations.

TABLE 1

PLANNING SCHEDULES RELEVANT TO RISK ASSESSMENTS

Source: Paquin, D. et al., 2016[62]

Planning (years)	Actors	Interest for the recreational tourism sector
0-5	Election cycles	Risk management; business strategies; market development; image marketing; innovation and technology; insurance and financial products
5-10	Profit and loss Agriculture	Small and medium-sized tourism entreprises Cruise ship itineraries
10-20	The improvement of plants Forest lease	Development and planning of major tourism projects; maintenance of recreational infrastructure; regulations and tourism policy
20-40	New irrigation projects Coastal infrastructures	Structural investments (road access, marinas, accommodation); development of natural park strategies; tourism habits and travel patterns; insurance needs; territorial planning; landscapes, natural resource supply and services (water, ecosystems, biodiversity)
40-60	Tree planting Long-term biodiversity	Airport design Site location selection; territorial planning and policy
50+	Intergenerational equity Coastal defences Large dams Civil infrastructures Urban planning	Conservation (biodiversity); planning for new protected areas.

Tourism demand is also changing

Climate impacts affect the decisions of clients and consumers of recreational tourism activities. Although some trips are planned months in advance, many consumers wait for weather forecasts before they choose their holiday destination. For some, the fact that a destination is experiencing or has experienced climate change or extreme weather events is a more important criterion when it comes to their travel choice. For example, one study found that the decline of corals in the Red Sea discourages customers from coming to dive, preferring to choose other sites (Njoroge, 2015). Ski resorts experiencing a period of low natural snowfall are also deserted in favour of other resorts with more snow, such as high-mountain or higher latitude resorts. This leads to competition between

62 Paquin, D., de Elia, R., Beau, S., Charron, I., Logan, T et Biner S. (2016). A multiple timescales approach to assess urgency in adaptation to climate change with an application to the tourism industry. Environmental Science and Policy, 63:143-150.

establishments, as consumers prefer natural snow to artificial snow (Njoroge, 2015; Ouranos, 2015). Climate change is changing the global travel market and creating winners and losers. Nevertheless, to the extent that consumers are considered more flexible in relation to destinations and tourism operators, it is likely that tourism industry players will continue to work on reorganisation to meet changing market demands (Njoroge, 2015).

BOX 2

THE QUEBEC SKI INDUSTRY IS RALLYING

In the Canadian province of Quebec, downhill skiing is the most innovative winter activity in the province of Quebec to address climate issues (a decrease in snow quality and quantity during a seasonal period), putting local ski resorts at risk. Among the reorganisation actions carried out, there has been an increase in alliances and partnerships between resorts and other private or regional public entities to diversify the activities offered, renew technologies, infrastructures and hosting buildings or even rely on innovative marketing campaigns. New periods (in the year, or even during the day) are open to receive customers – the Bromont ski resort welcomes its customers in the evening, by fitting out adapted lighting. However, in the face of more competitive markets, regular infrastructure renewal and rate increases (artificial snowmaking costs, electricity, property taxes), many ski resort operators believe that the best adaptation strategy is to better understand future climate phenomena, to better plan their investments and satisfy an increasingly demanding and selective clientele. Benefiting from constant technical progress, the ski industry is demonstrating in this way its ability to adapt to new consumption habits, competition and new social phenomena, such as excessive and rapid consumption, changes in family situations or instant access to information on climate forecasts (which should play an increasingly important role). Finally, several local and regional strategies are based on a portfolio of complementary products, based on the biophysical and structural specificities of the territories. As a result, companies that can integrate climate risk and climate change adaptation into their major investment decisions and over the long term will benefit from greater economic resilience and be in a better position than their competitors.

Source: Ouranos, 2015; Bourque and Simonet, 2008[63]

63 Bourque, A. et Simonet G. (2008). Chapitre « Québec », dans Vivre avec les changements climatiques au Canada : édition 2007, D.S. Lemmen, F.J.Warren, J. Lacroix et E. Bush (éditeurs), Gouvernement du Canada, Ottawa (Ontario), pp. 171-226.

5 • Water resources

Introduction

Water resources remain the guiding principle of key national and international climate ambitions and commitments and are reflected in nationally determined contributions: national adaptation plans, sustainable development objectives, the Sendai Framework for Action for Disaster Risk Reduction, and national development plans (GWP, 2019)[64]. Water is a resource that supports biodiversity, food production and the well-being of human populations, and is also essential for economic activities. Today, freshwater resources are under greater human pressure than ever before (Box 1), which, combined with climate change, could lead to an alarming level of water shortages in some parts of the world (UNESCO, 2019)[65]. As the main vector through which climate impacts affect societies and ecosystems, water must be at the heart of future reorganisation actions (PFP, 2015)[66].

Context

Of the 1.4 billion km^3 of water on the planet's surface, freshwater represents 2.8%, divided into polar ice (2.15%), groundwater (0.63%), surface water (0.02%) and atmospheric water (0.001%) (SPGE, 2019)[67]. World food production (agriculture, irrigation, livestock and aquaculture) accounts for 69% of the quantity available for human activities, industry 19% (Table 1) and domestic consumption 12%. Since 1980, water use has increased by 1% per year and global demand is expected to continue to grow, even though more than 2 billion people live in countries with high water stress and 4 billion experience severe water shortages at least one month of the year (UNESCO, 2019). Ensuring urban water supply is crucial as the number of urban dwellers facing seasonal water shortages is expected to increase from 500 million people in 2000 to 1.9 billion in 2050 (World Bank, 2018)[68]. On the other hand, future global water consumption for food production is expected to increase by 19% by 2050. In this tense context, climate impacts already at work are creating many challenges at a regional level. These are intensified in view of the disparity in the distribution of water resources, but also the economic resources needed to support the reorganisation needed to ensure an adequate supply of quality water (World Bank, 2016)[69].

64 Global Water Partnership, 2019. Addressing water in national adaptations plans.

65 WWAP (UNESCO World Water Assessment Programme). 2019. The United NationsWorld Water Development Report 2019: Leaving No One Behind. Paris, UNESCO.

66 Partenariat Français pour l'eau et l'Agence Française de Développement, 2015. Adaptation au changement climatique dans le domaine de l'eau : Typologie & recommandations pour l'action

67 Société publique de gestion de l'eau, 2019. L'eau dans le monde. [en ligne]

68 World Bank. 2018. Water Scarce Cities: Thriving in a Finite World—Full Report. World Bank, Washington, DC.

69 World Bank. 2016. "High and Dry: Climate Change, Water, and the Economy." World Bank, Washington, DC.

BOX 1

WATER UNDER ANTHROPOGENIC PRESSURE AND A SOURCE OF REGIONAL CONFLICTS

Growing populations and incomes, as well as the expansion of cities, are the main factors behind the exponential increase in water demand, while supply is becoming more erratic and uncertain, particularly due to changes in rainfall patterns and the water cycle. Reduced freshwater availability and competition from other uses, such as energy and agriculture, could reduce urban water availability by up to two thirds by 2050 compared to 2015 levels. Moreover, since water is the necessary vector for food production, industrial sectors and the vital needs of human populations and biodiversity, tensions surrounding use are becoming more and more acute. Many regional conflicts are partly due to disputed water resource management and many organisations fear that new conflicts will emerge in the coming decades to the point of destabilising the state of peace.

The main anthropogenic pressures on water resources currently having an effect are:

population growth, especially in regions where water is scarce;

major demographic changes resulting from the rural-to-urban migration;

higher requirements for food security and socio-economic well-being;

increased competition between users and uses;

pollution from industrial, municipal and agricultural sources.

Sources: WWAP, 2019,[70] World Bank, 2016.

70 WWAP (UNESCO World Water Assessment Programme). 2019. The United NationsWorld Water Development Report 2019: Leaving No One Behind. Paris, UNESCO.

Impact of industrial activities on water resources

TABLE 1

WATER USES AND IMPACTS OF DIFFERENT INDUSTRIAL SECTORS ON THE RESOURCE

Source: CDP Global Water Report, 2018 Treading Water – Corporate Responses to Rising Water Challenges

Sector	Uses	Impact on resources
Textile industry	Irrigation (cotton, fibres) and leather (livestock) Dyeing, bleaching, cooling, cleaning, etc.	Use of thousands of chemicals Released microplastics (washing of synthetic products)
Biotechnology, pharmaceutical industry and health care services	Used as a reagent, solvent and cleaner Plant cooling systems	Requirements for clean, high quality water Pharmaceutical compounds released into discharged water
Food production	Crop and livestock farming Washing, packaging and transport Beverage production	Contamination of fertilisers and pesticides Groundwater withdrawals
Fossil fuel resources	Exploration, production and refining Drilling, pumping, treatment and cooling Hydraulic fracturing (oil sands)	Water consumption for power generation x2 by 2035 (coal = 50%) Risk of spills, contamination of aquifers and surface waters, leaks in networks and oil spills
Hotels	Through food produce sold Customer use, swimming pools, cleaning	Affected by local pollution and availability High consumption (10% of average hotel bills) Located in areas of water stress
Infrastructure	Cement and material production (cooling, purification)	Climate disasters and supply problems on production sites and public or private networks
Material production (chemical, automotive and electrical equipment and components, plastics, pulp, ceramics, glass)	Used ultra pure as raw material, cooling systems, cleaning, transport, solvent, coating, paints, washing, boiling, etc.	Risk of spills Heavy metal pollution and hazardous waste Requires large quantities of water Acidification of watercourses Suspended matter and hot water discharges
Mining industry	Extraction, processes (cooling, transport, cleaning), hydropower, uses for employees in remote areas	Heavy metal pollution from aquifers and watercourses Requires a lot of energy (hydropower)
Energy	Cooling (nuclear and thermal power plants), hydropower	Doubling water withdrawals through carbon capture and storage Hot water discharges Land immersion and watercourse changes

Climate trends and impacts on the water cycle

Precipitation patterns and potential evaporation are the main climate factors that have an impact on freshwater resources. Although climate modelling on the future behaviour of precipitation patterns and the water cycle remains uncertain, several trends are observed (Cisneros et al., 2014)[71]:

Surface temperature, which affects water vapour, snow and precipitation, increases 1.5 times more on land than on sea;

- Maximum warming in the Arctic (changes in snowmelt and glacier melt);
- A decrease in snowfall and snow cover in extent and duration;
- Wet seasons that become wetter and dry seasons that become drier;

An increase in global average precipitation with significant regional variations: decrease in subtropical areas (Mediterranean, Mexico, Central America and Australia);

71 Jiménez Cisneros, B.E., T. Oki, N.W. Arnell, G. Benito, J.G. Cogley, P. Döll, T. Jiang, and S.S. Mwakalila, 2014: Freshwater resources. In: Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Field, C.B., V.R. Barros, D.J. Dokken, K.J. Mach, M.D. Mastrandrea, T.E. Bilir, M. Chatterjee, K.L. Ebi, Y.O. Estrada, R.C. Genova, B. Girma, E.S. Kissel, A.N. Levy, S. MacCracken, P.R. Mastrandrea, and L.L. White (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, pp. 229-269.

• A moderate increase in evaporation, especially at the highest northern latitudes;
• A decrease in soil moisture on a global scale;
• An increase in intense rainfall and an intensification of droughts (Mediterranean, Central Europe, South Africa and North America).
• These trends translate into direct and indirect impacts:
• Lack of water (quantity) and increased droughts affecting multiple socio-economic sectors;
• Increased floods and coastal flooding that can cause human and material damage;
• Quality degradation and restricted access for uses and biodiversity;
• Damage and modification of ecosystems (wetlands, rivers) (PFP, 2015).
• Adaptation of actors in water in the face of climate change challenges

Water is the most frequently cited resource in the declarations of countries suffering from climate impacts. It is also the preferred sector through which regional governments seek to strengthen the resilience of their economies, the livelihoods of their populations and their natural ecosystems (GWP, 2019). For industrial sectors, risk assessments and vulnerability analyses of activities to tackle climate challenges are emerging at different rates. As a result, while the infrastructure construction sector comes out on top with 73% of industries having undertaken such an approach, the hotel and tourism sector is lagging behind with only 25% of entities (CDP, 2018)[72]. In this context, reorganisation, driven by regional and local, public and private actors to address climate impacts, must integrate the anthropogenic activities and pressures already underway on water resources and act on both supply and demand from a sustainable management perspective (GWP, 2019).

Adaptation strategies for water management concern so-called "hard" (protective infrastructure) and "soft" (changes in ways of doing things) actions and combine the following: institutional reorganisation actions (regulation, capacity building, awareness raising, collaborative reviews), nature-based solutions (soil protection, wetland use, river renaturation, de-watering, water treatment) and technical actions (defence infrastructure, retention basins, irrigation and drainage optimisation) (PFP, 2015; Cisneros et al., 2014).

Reorganisation of practices by management

Watershed management continues to be a promising instrument for maintaining a balance of uses on a territory and ensuring sufficient and qualitative supply and sanitation to cope with climate impacts (Cisneros et al., 2014). Many examples of watershed-based water management institutions exist throughout the world, including communities, environmental protection and recreational user associations (fishing, sports), private providers and sectoral corporate groups (farmers, local industries). The regional structures created, which support water management, are often the result of a partnership with the actors involved. They make it possible to obtain political support and public funds, mobilise other local actors and undertake investments, by extending its action to several territorial jurisdictions. Within this governance framework, obstacles to optimal management include a lack of human and institutional capacity and a lack of financial resources, awareness and communication. Due to the uncertainty of climate models, many researchers recommend that water managers move from the traditional "predict and provide" approach to adaptive water management, which takes into account current issues and regional socio-economic trends to implement so-called "no regrets" or "win-win" actions. These measures bring with them benefits to the whole sector and are to be favoured in order to avoid maladjustments or actions with consequences that may harm other sectors.

72 CDP Global Water Report, 2018. Treading Water – Corporate Responses to Rising Water Challenges.

BOX 2

EXAMPLES IN URBAN AREAS

While the experience and context of each territory is unique, lessons can be learned from many experiences around the world.

The city of Zaragoza manages supply and sanitation services, and in doing so has succeeded in reducing the drinking water consumption of its 700,000 inhabitants by 30% in 20 years. First, collaboration with a local association and several private and public partners made it possible to carry out awareness campaigns as part of a European LIFE project. Water systems are regularly renovated and optimised. An electronic charging system for actual (and unestimated) charges has been introduced, penalising large consumers and promoting bill reduction efforts. A cluster (ZINNAE), bringing together the main local economic actors, is dedicated to the rational use of water and collaborates with regional technical and research institutes. Commission 21 brings together all local actors (associations, private and public) and takes part in decisions related to urban water resource management.

Windhoek (Namibia) has successfully implemented a long-term water supply strategy. There are many lessons that can be drawn from the last five decades of management. Overall, approaches that support a multi-year strategic water supply may be more cost-effective than those that provide a constant supply. This case shows that long-term strategies should include several key considerations: a) regular reviews and interventions at strategic moments, rather than massive and sudden investments; b) a regional perspective that includes key sectors and actors; c) long-term planning and phased implementation that integrates some emergency interventions; d) a systemic approach to optimise costs, reliability and quality; e) demand management and a water reuse programme; f) consideration of joint uses of surface and groundwater;g) groundwater storage, to cope with conditions of extreme variability (since the response time of these sources to stress is different and this storage reduces evaporation losses).

Cross-border regional cooperation in the Niger basin has made it possible to mobilise several tools for drought risk and water management. For example, the Regional Centre for Agrometeorology, Hydrology and Meteorology (AGRHYMET), established in 1974, is a specialised agency of the Permanent Inter-State Committee against Drought in the Sahel (CILSS), which includes 16 countries. Its role is to focus on monitoring and building local capacity (decision-makers, private actors) to address water-related risks and regional food security. The Niger Basin Authority, another inter-state entity, is responsible for transboundary cooperation in terms of water management, notably through the Niger Basin Observatory. This observatory is responsible for a hydrometric monitoring network in the basin and ensures that participating actors share hydrological, environmental and socio-economic data. This enables it to appropriately collect, compile, analyse and disseminate water and climate data, as well as to disseminate reliable information to regional governments and other stakeholders. Key services provided by the Observatory, which contribute to resilience-building actions, include flow forecasting, water abstraction analysis, exploitation of hydrological and socio-economic data (to inform water management issues related to riparian dialogue), assessment of basin-wide trade-offs and preparation of future investment plans in the basin.

Sources: World Bank, 2018.

Reorganisation of water supply practices

Water supply management is based on several actions deployed through technical or institutional tools. For the former, increasing the capacity of storage facilities (dams, reservoirs, wetland development, soil retention) is one of the most discussed options, while concentrating points of tension between the various users of the resource, particularly between defenders of local biodiversity, the energy sector and farmers (Simonet and Salles, 2014)[73]. Several developments also make up climate change adaptation strategies: inter-basin water transfer and enhanced or artificial aquifer recharge projects, soil protection and restoration of the local water cycle through infiltration, soil greening, rainwater harvesting, reuse of treated wastewater or desalination of brackish or sea water. Remuneration for water-related ecosystem services (taxes, bonuses) is more of an institutional tool, as is the tightening of standards and regulatory frameworks. Several nature-based solutions can improve water quality, such as restoring the purification capacities and drainage systems of ecosystems (marshes, filter strips, bank reforestation) or strengthening natural barriers (dunes, mangroves) (PFP, 2015, Cisneros et al., 2014).

Reorganisation of water demand practices

Several actions are deployed to manage demand and reduce water consumption, which require technical, institutional or nature-based resources. Concerning technical actions, we identify the improvement of domestic, industrial and agricultural water efficiency processes during transfer and its uses, the reduction of leaks in supply networks, the optimisation of industrial sectors to obtain processes that consume less water, as well as for agriculture, the use of crops that are more water efficient and micro-irrigation. The institutional actions identified are the implementation of meters, economic instruments to limit water waste (quotas, taxes, levies, pricing), the animation of awareness campaigns aimed at changing habits (food, hygiene) and needs (individuals, farmers and industrialists) and finally the implementation of control tools (water policy). These institutional actions can extend to periods of water restrictions, such as in Cape Town (South Africa), Las Vegas (United States), or in many localities around the world that experience it.

73 Simonet, G. et Salles, D. (2014). Eau et changement climatique en Garonne moyenne : L'adaptation en négociation, in Adaptation aux changements environnementaux et territoires, numéro thématique, vol. 37. [en ligne]

6 • Financial actors

Introduction

Climate change poses new challenges for financial institutions, investors and creditors. In 2019, extreme weather events, natural disasters and failed climate policies are among the three most feared risks in terms of their likely occurrence by financial actors. These three risks are also among the five most feared in terms of future impacts (WEF, 2019)[74]. These results confirm a growing awareness in the financial sector of the costs of damage due to climate impacts and the costs of inaction in the face of accelerating global climate change. Faced with this situation, many sub-sectors are seeking to guide investors' choices through new approaches to take these new realities into account. However, even if the scale of the situation is beginning to be integrated, there are still several misunderstandings about how to assess, manage and reduce climate risks across all financial activities (CISL, 2019a)[75].

Context

Climate change has implications for financial institutions, which can affect both local and regional actors and the global economy as a whole. In 2017, Hurricane Harvey caused $125 billion in damage to US soil according to the US National Oceanic and Atmospheric Administration. These costs do not include impacts beyond the country's borders (I4CE, 2018a)[76]. Climate impacts on the activities of financial institutions worldwide could reach 17% of its value (or $24.2 trillion) with a global warming scenario of +2.5°C by 2100 (Dietz et al., 2016)[77]. Direct climate impacts can therefore influence the interest of investors and creditors, primarily in infrastructure, whose global investment needs could exceed $90 trillion by 2030. These threats also affect property assets, as well as future residential and commercial building stock, which is expected to increase by 13% by 2026 (CISL, 2019a). In developing countries, some studies estimate that the annual cost of adaptation could be between $140 billion and $300 billion by 2030 and between $280 billion and $500 billion by 2050 (UNEP 2016). Beyond physical facilities, climate impacts can affect the performance, value chain and macroeconomic conditions of many financial actors (I4CE, 2018b)[78]. Potential financial losses and defaults could then lead to asset devaluation and lower financial returns. Among financial institutions, the insurance sub-sector may be able to play an important role in helping investors and creditors manage these risks. Nevertheless, to be effective, all financial actors must themselves have the capacity to better understand the complexity of climate issues and develop methods to protect themselves against these.

74 World Economic Forum, 2019. The Global Risks Report 2019, 14th edition.

75 Cambridge Institute for Sustainability Leadership (CISL), 2019a. Physical risk framework: Understanding the impacts of climate change on real estate lending and investment portfolios: the Cambridge Institute for Sustainability Leadership.

76 I4CE, 2018a. La finance n'a pas encore pris la mesure des impacts climatiques.

77 Dietz et al., 2016. 'Climate value at risk' of global financial assets. [en ligne]

78 I4CE, 2018b. Getting started on physical climate risk analysis in finance – available approaches and the way forward.

Actors

The complex landscape of climate finance includes public and private organisations, which allocate funds through various financial mechanisms, including concessional and non-concessional loans, guarantees, equity capital and grants (SEI, 2019)[79]. The financing dedicated to adaptation is detailed in Section 4 of this "Adaptation Report". The sector also includes investors of all kinds, as well as the insurance sub-sector. Each actor is concerned by the climate issue according to their own interests (investments, concessions, shareholding) or those to which they are linked through projects, conventions or strategic partnerships.

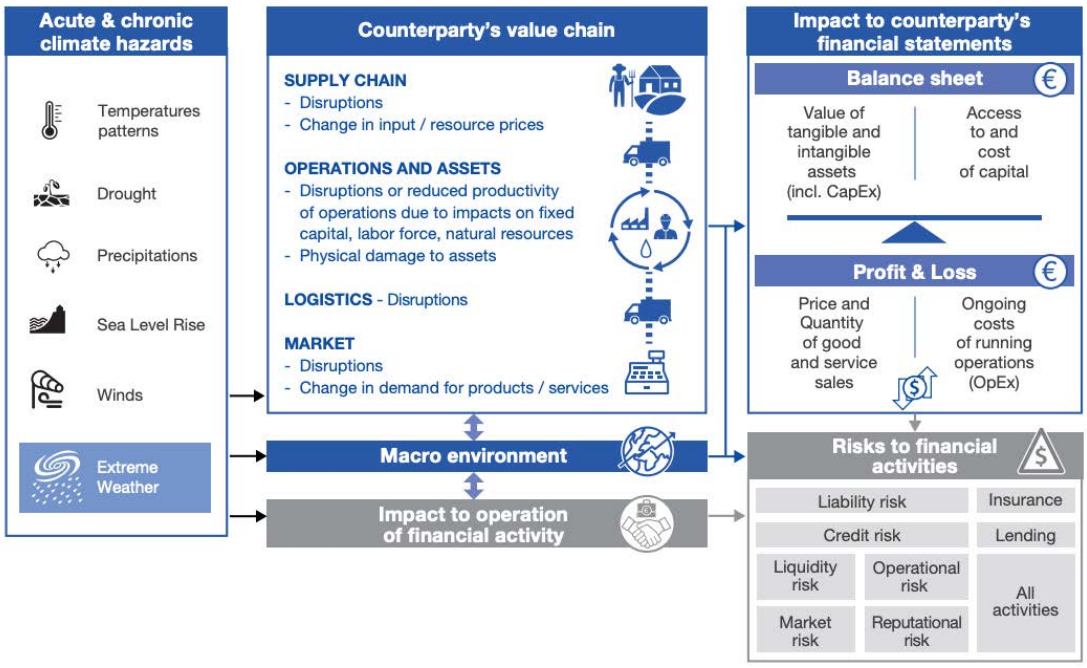
Climate impacts on the financial institutions

Climate impacts on the economy and companies may spread to the activities of financial institutions through different channels. Financial institutions may first be affected by direct climate impacts: on facilities exposed to extreme hazards and/or climate trends, on the operating sites of funded entities or on networks of partners that contribute to the functioning of activities (suppliers, consumers), both in developing and industrialized countries (I4CE, 2018a). However, financial institutions' exposure to climate risk comes mainly from the portfolios of the many entities they finance, from investment to lending. They may be companies and individuals, but also governments, communities or infrastructure, on which climate impacts may be reflected through their ability to repay their loans or seek compensation. Many institutions also finance these entities with funds allocated by their clients and climate impacts can have consequences through complex mechanisms and connections between financial institutions themselves (fig.1).

FIGURE 1

PROPAGATION CHAINS OF CLIMATE IMPACTS ON FINANCED COMPANIES AND FINANCIAL ACTIVITIES

Source: I4CE, 2018a, according to CICERO, 2017 Shades of Climate Risks



79 Stockholm Environment Institute, 2019. Climate change adaptation finance: are the most vulnerable nations prioritised ?

Gradual onset of awareness regarding climate issues

As climate events (and their associated costs), international climate negotiations, publications of IPCC reports and national standard-setting mechanisms take place, awareness of climate issues is gaining ground within the financial sphere. At least 18 regulators and central banks in Europe, North America and Asia, including the Bank of England, De Nederlandsche Bank and Banque de France, have recently drawn attention to the direct risks that climate change poses to investors, as well as the potential for contagion to other sectors. In its very first report on climate change, the Prudential Regulation Authority of the United Kingdom noted that "increasing levels of physical risks could present difficulties, both for market-based risk transfer mechanisms and for the assumptions underlying general insurance economic models" (CISL, 2019a). The Financial Stability Board has launched a Task Force on Climate-related Financial Disclosures (TCFD). It recommends that climate risks be taken into account in the organisations' annual documents, through a voluntary reporting framework that has become the benchmark in this area (I4CE, 2018a). Its action is supported by the European Commission through its Action Plan to finance sustainable growth. Despite these efforts, the Asset Owner Disclosure Project estimates that 13% of the assets in its portfolio are subject to physical climate risk analysis among the 100 largest pension funds in the world. This example is representative of the road ahead for financial actors, whether they are institutional investors or insurance companies (I4CE, 2019a).

Taking ownership of climate issues to better integrate them into decision-making processes

One of the main challenges for financial institutions is to understand the complexity of climate issues, a necessary step towards their integration into decision-making processes. However, for the time being, the lack of data, analysis and even monitoring methodologies does not fully meet the needs of institutions (I4CE, 2018a). In addition, scientific concepts and knowledge on the content of climate impacts (carbon footprint, climate model results) do not correspond well to financial activities, in terms of languages, outlooks (temporal, geographical) and indicators (de Bruin et al., 2019). In order to overcome these deficiencies, several frameworks (monitoring methodologies (see Section I) and reporting mechanisms) are gradually being deployed at an international level. Through these tools, financial institutions must first and foremost take ownership of the various facets of climate issues and become transparent on how to deal with them and manage them. The objectives are to gradually integrate climate impacts into the decisions of financial institutions and to mobilise all actors involved in the production and use of information and analytical methods (I4CE, 2018a). In this context, three countries are currently acting as precursors: France, through its Energy Transition and Green Growth Act (2015), Norway with the organisation of the national financial sector Finance Norway, as well as the Netherlands and the Dutch Central Bank (de Bruin et al., 2019)[80].

To achieve these objectives, investors and creditors may use tools currently available or under development, such as natural disaster modelling tools and their indicators. These have been improved by the insurance industry over the decades to better assess, report and reduce their exposure to physical climate risks. The Geneva Association, the leading international think tank on insurance, now recommends using climate projections in natural disaster models to obtain better estimates. In this way, the models currently used by the insurance industry are powerful tools that investors and creditors can incorporate into their analyses to quantify physical climate risks, while taking

80 Bruin, K. de, R. Hubert, J. Evain, C. Clapp, M. Stackpole Dahl, and J. Bolt (2019). Physical climate risk. Investor needs and information gaps. CICERO Climate Finance – ClimINVEST project.

into account the uncertainty inherent in the future impact of immediate decisions (CISL, 2019). The use of models is one of several currently available climate risk analysis methods, but the number of methods is limited (fig. 2).

FIGURE 2

SUPPLIERS AND APPROACHES TO INTEGRATING CLIMATE RISKS INTO FINANCIAL ACTIVITIES

Source: I4CE, 2018a, according to CICERO, 2017 Shades of Climate Risks

Target use	Target user	Service provider (approach)
Pre-screening before financing	Project officers and risk managers - more suitable for development banks	Acclimatise *(Aware for Projects)*
Exploratory approach*	Risk managers - All financial institutions	Moody's Investors Service *(Physical Effects of Climate Change on Sovereign Issuers)*
Analysis of a portfolio exposure to climate hazards	Non defined - All financial institutions	WRI (*Aqueduct Water Risk Atlas)*
Analysis of physical climate risk	Non defined - All financial institutions	Carbon Delta *(Climate VaR)* Carbone 4 *(CRIS)* Ecolab, Trucost et Microsoft *(Water risk Monetizer)* Four Twenty Seven *(427 Cliate Risk Scores)* Mercer *(TRIP framework)*

**Moody's approach is explorotory in the sense thot it does not constitute a new product to investors and it is based on illustrative data.*

It is noted that reliance on the work of external service providers remains the most common method. This reflects a low level of ownership of the theme within the financial institutions' own departments (I4CE, 2018a). Financial institutions can also, as recommended by the TCFD, encourage financed entities to use quantified indicators related to their financial documents (ledgers, balance sheets), so that they can become aware of their vulnerabilities and generate increased dialogue with creditors. Nevertheless, given the level of accuracy of the data, it is necessary to include information on the chain of actors involved upstream and downstream of the activities, the contextual elements (geographical, political), the facilities involved, as well as the specific characteristics of the functioning of the funded entities (such as their negotiating capacities or the nature of the activities and facilities). One of the obstacles to these requirements is the difficulty for service providers (or the services of financial institutions) in acquiring data and information that is exhaustive, detailed and specific to the entities financed, which some are trying to circumvent by using big data (geolocalisation, network profiles) (I4CE, 2018a). Finally, public investors are called upon to play a leading role in financing adaptation actions to climate impacts through several forms: the mobilisation of their financial resources, the promotion and encouragement of good practices and innovations or even via the ability to attract private investors. As a result, year after year, many investors, shareholders and regulators are gradually integrating climate change risks and opportunities into future financial planning; they aim to mitigate future risks to the global economy and ensure robust investment strategies for companies and governments (CISL, 2019b)[81].

81 Cambridge Institute for Sustainability Leadership (CISL), 2019b. Transition risk framework: Managing the impacts of the low carbon transition on infrastructure investments UK: the Cambridge Institute for Sustainability Leadership.

SECTION IV

Financing for climate change adaptation

United Nations Framework Convention on Climate Change (UNFCCC), adopted at the Earth Summit in Rio in 1992, defines climate finance as local, national or transnational financing – drawn from public, private and alternative sources of financing – that seeks to support mitigation and adaptation actions that will address climate change, either directly or indirectly. For several years, actors involved in international negotiations have seized the need to increase the sums allocated to the fight against climate change, as well as more and more to the adaptation to these disturbances. As set out in the Stern Review (2006), the cost of inaction is higher than the cost of action. It is therefore essential to invest in developing cleaner energies, more energy-efficient mobility, rethinking the ways we handle housing, food, etc. Adaptation cannot remain second to investment. According to United Nations Environment Programme (UNEP) estimates, adaptation costs in developing countries could reach US$ 140 to 300 billion a year by 2025/2030 and between US$ 280 and 500 billion by 2050. Forecasts are on the rise, and that is even if the rise in temperatures is limited to 2°C. The FAO (Food and Agriculture Organization of the United Nations, 2015) sets economic damages connected to climate events at US$ 1.5 trillion between 2003 and 2013.[1] Faced with these colossal financial requirements, in 2016 US$ 463 billion were put towards climate projects, including a tiny portion (US$ 22 billion) for adaptation.[2] This is compared to the US$ 825 billion invested in fossil fuels in 2016, so there is clearly significant disparity when in comes to financing.[3]

In addition, a recent study by Expertise France, in the framework of the GCCA+ programme in West Africa, also shows that there needs to be a revolution to demonstrate and value the shared benefits of investments in adaptation for the future, achievement of the Sustainable Development Goals, and thus direct the national budgets themselves towards this overall goal of adaptation of societies. The costs expressed by the 17 west African States[4] to be able to implement the actions included in their NDCs amount to US$ 337 billion by 2030. According to these NDCs, most of these costs should be provided by international climate financing contributions (up to 80%). The remaining amount, assumed by the African States of the study, remains minimal, although the fight against climate change is still often considered as an additional cost, which runs counter to the basic development needs of developing countries.[5] Developing countries and LDCs in particular are faced with a decisive choice between allocating (already limited) funds to their development or to climate change adaptation.

Developing countries are not the only ones subject to significant costs in terms of their adaptation. While the consequences may be more severe for developing countries, OECD countries are also confronted with this issue, as illustrated in the report by senators Ronan Dantec and Jean-Yves Roux on France's adaptation to climate change. The report mentions the lack of a "financial ciphering element" and "methodological guidance"[6] to make accurate estimates of adaptation needs. There is also no independent verification system or methods in place for reporting results. This is a real barrier, getting in the way of financial means being made available for adaptation.[7] When these are budgeted, they are not always effectively allocated. In fact, the European Regional Development Fund (ERDF) anticipated dedicating €295 million to France over 7 years (2014-2020)

1 FAO (2015). The impact of natural hazards and disasters on agriculture, food security and nutrition

2 Climate Finance Landscape, CPI

3 Antonio Guterres, during COP23.

4 Benin, Burkina Faso, Cape Verde, Chad, Côte d'Ivoire, Gambia, Ghana, Guinea, Guinea Bissau, Liberia, Mali, Mauritania, Niger, Nigeria, Senegal, Sierra Leone and Togo.

5 Vanessa Laubin, Camille André, "The implementation of the Climate Paris Agreement in West Africa ; Situation Analysis of Nationally Determined Contributions (NDC) and capacity building needs"

6 Dantec R., Roux J-Y. (2019). "Adapter la France aux dérèglements climatiques à l'horizon 2050 : urgence déclarée"

7 Ibid.

for climate change adaptation. At the end of 2018, only 107 million had been programmed.[8]

Beyond the quantitative objectives of climate finance, dealt with within the UNFCCC, there are **many forums for discussion** outside of these international negotiations to address the issue and to mobilise more resources, in particular for adaptation. This great number of spaces for the mobilisation of climate finance contributes, to a certain extent, to a weakening of the multilateral UN space for negotiations on the subject. During COP22 in Marrakech in 2016, the metrics of adaptation were widely discussed in relation to the challenges it presents. Other initiatives have been launched under the Global Climate Action Agenda, such as the Initiative, to which France contributes, on early warning systems for climate risks (CREWS: Climate Risk and Early Warning Systems), which is an essential challenge when it comes to adaptation. As part of the One Planet Summit, commitments have been made on adaptation. For example, during the 2017 edition, the French Development Agency launched the "Climate and Biodiversity in the Pacific" initiative to promote "the adaptation of these territories to climate change".[9]

1 • Situation analysis of global financing of climate change adaptation in recent years

A marked deficit on the part of adaptation, but recent progress

In Article 7 of the Paris Agreement, it is clearly recognises the significance of the adaptation to climate change and presents it as a global challenge for which all countries must formulate national objectives, requirements, plans, etc. It also aims to achieve a balance between financial resources allocated to mitigation and to adaptation.[10] It appears that the amounts allocated to the fight against global warming are increasing, but in an unbalanced way because too little funding is reserved for adaptation, while the accounting rules for the financial flows of adaptation are not homogeneous throughout the world and across different institutions.[11]

Many actors[12] are involved in the financial effort of adaptation to climate change: **private financing** (foundations, financial institutions), **multilateral public institutions** (financial mechanisms of the UNFCCC and the Paris Agreement: Adaptation Fund, Least Developed Countries Fund, Green Climate Fund, Pilot Program for Climate Resilience, Adaptation for Smallholder Agriculture Programme, etc.), **bilateral public institutions** ((UK International Climate Fund, German International Climate Initiative), **public financing of developed countries** (national budgets, state-owned enterprises,

8 ONERC, La lettre aux élus, December 2018

9 One Planet Summit, Commitments, Responding to extreme events in Island States

10 French Senate website, Draft budget law for 2019: Official development assistance

11 Understanding and Increasing Finance for Climate Adaptation in Developing Countries, Valerio Micale, Bella Tonkonogy and Federico Mazza, Published: December, 2018

12 Climate Finance Regional Briefing: Adaptation Finance Alice Caravani, Charlene Watson, ODI and Liane Schalatek, HBS, November 2016, 4 pages.

investment instruments), **development finance institutions**, multilateral (World Bank) and bilateral development banks (French Development Agency, etc.) and **other** mechanisms (Food and Agriculture Organization of the United Nations, United Nations Development Programme, United Nations Environment Programme, International Union for the Conservation of Nature, etc.), and finally **national and regional insurance** and **funding channels** (Indonesia Climate Change Trust Fund, Bangladesh Climate Change Resilience Fund, Benin National Environment and Climate Fund, etc.).

The States present at COP16 pledged to mobilise US$ 100 billion per year by 2020 from private and public funds to developing countries for actions to combat climate change (mitigation and adaptation).

According to the latest OECD report[13] on climate finance, **developed countries** have increased climate financing to developing countries, including for **adaptation** from 7.8 billion in 2013 to **12.9 billion in 2017**. It values **bilateral financing** from developed countries intended for adaptation at 4.7 billion in 2013 to **5.6 billion in 2017**, representing 21% of bilateral financing. **Multilateral financing for adaptation** (attributed to developed countries) increased from 20% in 2013 to **27% in 2017**. These figures do not include the category of transversal projects, which both relate to adaptation and mitigation, and which would therefore slightly increase the amount for adaptation.

Among the financing recorded, **multilateral banks** contributed **US$ 7.4 billion to adaptation** in 2017.[14] The International Development Finance Club (IDFC), which takes into account a wider scope than that of the OECD when it comes to climate finance flows, traced US$ 196 billion of financial flows relating to climate finance for the year 2017 (an increase of US$ 46 billion), of which only 10 billion was allocated to adaptation by members of the IDFC network.[15] However, this still represents double the financing allocated to adaptation compared to 2016.

Many significant commitments to adaptation are to be noted, for example, as part of its Action Plan on Climate Change Adaptation and Resilience, the **World Bank Group** plans to provide financial support of US$ 50 billion directly to adaptation, for a period from 30 June 2021 to 1 July 2025 (more than double the amount for the 2015-2018 period). One of its objectives is also to increase the mobilisation of private financing for adaptation. During the Climate Summit in New York in September 2019, the global year of action to accelerate climate change adaptation was launched. This year, action is built on the first report of the Global Commission on Adaptation (GCA), published in September 2019,[16] which one again highlights the urgency of the action, including from an economic point of view.

The table above[17] shows that the amounts allocated to adaptation by bilateral climate actors and multilateral development banks have increased, unlike multilateral climate funds.

Many actors underline the relative increase in funding for adaptation and at the same time their real inadequacy. According to reports from the NGO OXFAM, in previous years US$ 9.5 billion of public climate finance related to adaptation in the period 2015-2016 (20% of all climate financing, with 9% of the financing being mixed between mitigation and adaptation), which represents a very slight increase of one percentage point compared to the period 2013-2014[18] (19% of the total).

13 OECD (2018). Climate finance from developed to developing countries: 2013-17 public flows, OECD Publishing

14 The Adaptation Gap Report (2018). Chapter 4: STATUS AND TRENDS: THE ADAPTATION FINANCE GAP, 4.2 THE COSTS OF ADAPTATION, and The World Bank

15 IDFC (December 2018). "IDFC Green Finance Mapping Report 2018"

16 Global Commission on Adaptation (2019). "Adapt now : a global call for leadership on climate resilience"

17 Ibid.

18 OXFAM (2018). Climate Finance Shadow Report

A complex galaxy of public funding sources for adaptation while volumes are tight

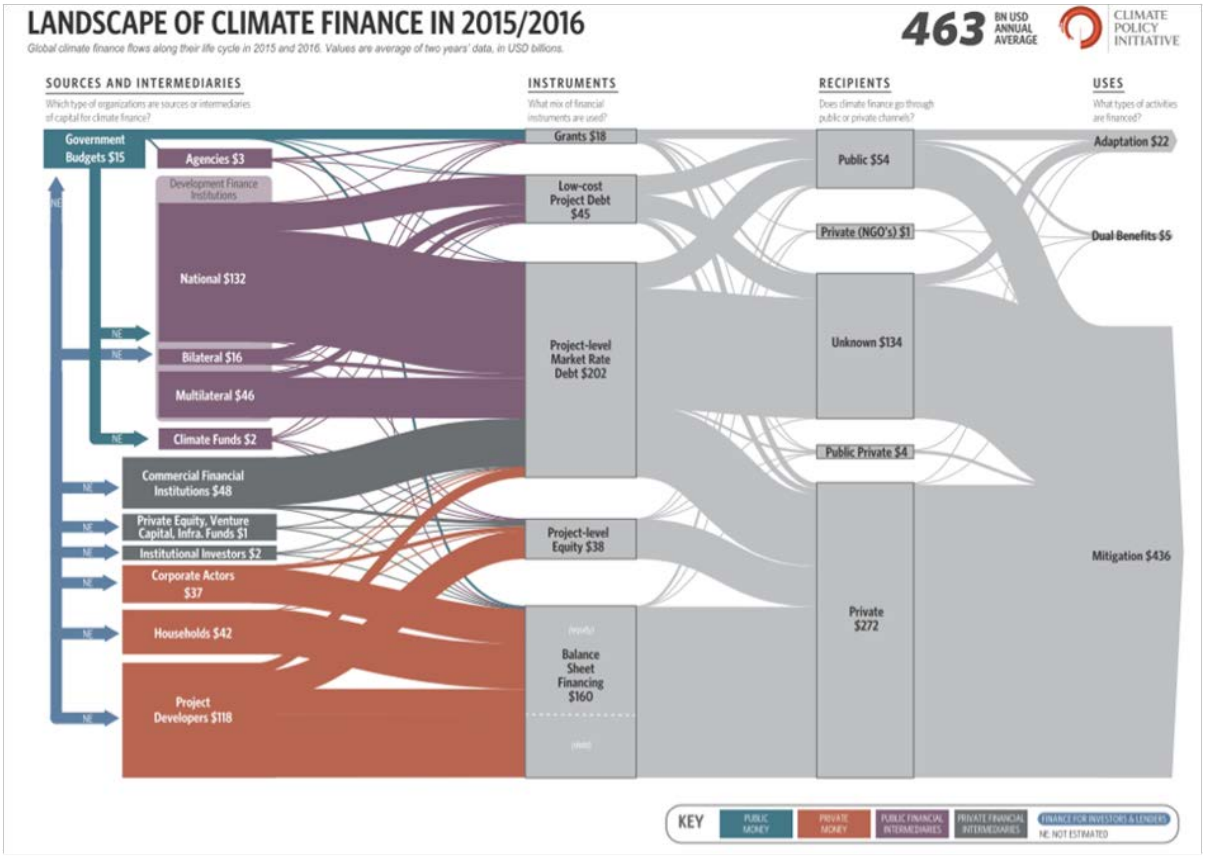
In recent decades, many funds have been developed to finance climate-related actions. Some focus on adaptation, while others fund cross-cutting, adaptation and mitigation projects and work at different levels (local, national and international). In addition, these funds work in various different ways, whether in terms of access mode (direct access vs. access via entities or international organisations)[19], type of financing tools (grants, loans, capital, guarantees technical assistance) or priority areas of intervention. It goes without saying that each financing body has its own project submission process, each time requiring specific project engineering within the organisations bringing these initiatives forward. In summary, 25 funds identified by the UNFCCC are now funding adaptation, each with their own rules and thematic priorities.

This graphic shows the complexity of the climate finance landscape and highlights the significant imbalance between funding for mitigation and that dedicated to climate change adaptation. Funding for climate change adaptation only makes up US$ 22 billion out of the US$ 463 billion for climate projects. We also note that most of the adaptation is financed by state funds, with the private sector still making up a very small minority in these areas.

However, despite relatively small amounts (compared to mitigation), the adaptation finance landscape is very fragmented, making it difficult for less technically equipped countries to access.

FIGURE 1

LANDSCAPE OF CLIMATE FINANCE IN 2015/2016 - *Source : Climate Policy Initiative*



19 Adaptation Fund: medium-term strategy 2018-2022

• MULTILATERAL MECHANISMS ESTABLISHED UNDER THE UNFCC •

Adaptation Fund: created under the Kyoto Protocol, the Adaptation Fund finances projects and programmes in developing countries that are Parties to the Protocol. It focuses on the most vulnerable communities in these countries. The importance given to direct access to the fund's resources by national entities, and the strong mobilisation of civil society in the processes of construction and implementation of the projects are key factors of the Fund. US$ 460 million have already been allocated to 70 projects and programmes in 57 countries (including 12 Island States and 18 countries among the least developed). In 2017, there were 54 new project proposals, with financing requests amounting to US$ 350 million from developing countries. New projects received US$ 104 million in 2017.[20]

The Green Climate Fund has been operating since 2015 and is the largest multilateral climate fund. It aims to invest in developing countries, particularly the Least Developed Countries, Small Island Developing States and African States, to support their efforts in adaptation to the effects of climate change. It wants to achieve a balance of funding between adaptation and mitigation (50% for adaptation, 50% of which for the Least Developed Countries, Small Island Developing States and African Countries). It may also allocate developing countries a single allocation of US$ 3 million for the formulation of their national adaptation plans. As of 30 August 2018, 74 projects had been approved by the Green Climate Fund. Of the US$ 3.5 billion represented by these projects (excluding co-financing), 32% of the projects were related to adaptation, 22% to adaptation and mitigation, and the remaining 46% to mitigation projects.[21] According to the Thematic Briefing of the Climate Fund Update on the Green Climate Fund, allocations after the 21st meeting of the Fund's Board will be divided as follows: 38% (US$ 816 million) for mitigation, 62% (US$ 1.3 billion) for adaptation and 19% (US$ 408 million) for transversal projects. This amounts to 74 active and approved projects. However, the total portfolio of 93 projects (US$ 4,605 million) represents a different nominal allocations: 39% for mitigation, 25% for adaptation and 36% for transversal projects.[22]

• MULTILATERAL FINANCING INSTITUTIONS •

Multilateral development financing institutions are the highest contributors to climate change adaptation funding.

Financing of the fight against climate change (adaptation and mitigation) by **multilateral banks** reached a record amount in **2017**, when **US$ 35.2 billion were allocated to climate finance** by the six largest multilateral banks, representing an increase of 28% compared to 2016. In a joint report published in 2017, the seven banks studied[23] provided funding of **US$ 7,352 billion** for adaptation projects.

20 Adaptation Fund: medium-term strategy 2018-2022

21 DRAFT BUDGET LAW FOR 2019 OFFICIAL DEVELOPMENT ASSISTANCE MISSION

22 Climate Fund Update, the Green Climate Fund, Liane Schalatek, HBS, and Charlene Watson, ODI, NOVEMBER 2018, 12 pages.

23 The MDBs that report jointly are African Development Bank (AfDB), the Asian Development Bank (ADB), the European Bank for Reconstruction and Development (EBRD), the European Investment Bank (EIB), the InterAmerican Development Bank Group (IDBG), the Islamic Development Bank and the World Bank Group (WBG).

This amount is divided into the following areas:

35 %	Water and wastewater systems
26 %	Energy, transport and other built environment and infrastructure
12 %	Other agricultural and ecological resources
11 %	Crop and food production
8 %	Institutional capacity support or technical assistance
5 %	Cross-cutting sectors
1 %	Coastal and riverine infrastructure
1 %	Information and communications technology
1 %	Financial services
0.1 %	Industry, manufacturing and trade

Source: author[24]

In a joint statement by the multilateral development banks in Paris during COP21,[25] six of the banks made commitments to climate action. For example, for 2020 the Asian Development Bank wishes to reach a financing amount of US$ 6 billion, including 2 billion for adaptation. The European Investment Bank has committed €16.2 billion to climate finance, including €1.1 billion for adaptation in 2018. While the amounts allocated to adaptation by development banks are smaller than the amounts they allocate to mitigation projects, these structures show a real commitment to adaptation.

• BILATERAL FINANCING INSTITUTIONS •

In May 2017, the French Development Agency (AFD) launched the "**Adapt'action**" facility, provided with **€30 million over four years**, with no specific country breakdown, but providing technical support tailored to requirements. It will support thirteen countries and two international organisations, which are particularly exposed and vulnerable to the effects of climate change (particularly Africa, LDCs and Island States), in the implementation of their contributions, through technical assistance and capacity-building. The first four funding operations relate to **Niger** (for a transition to more drought-adapted farming practices), **Comoros**, **Tunisia** (reuse of treated wastewater to adapt to the scarcity of water resources) and the **Republic of Mauritius** (to be able to better anticipate floods and cyclones).[26] In **2017**, the total climate budget of the AFD was €4 billion (3.6 billion in 2016), including **854 million for adaptation (21% of climate finance and an increase of 41% compared with 2016**) and it is committed to increasing this amount to €1.5 billion a year from 2020. This objective was achieved in 2018 (1.6 billion for adaptation, including €750 billion for the African continent). This is an increase of 50% compared with 2017. The AFD is also contributing €1 million to the triple A initiative to adapt African agriculture to climate change while increasing agricultural production, and € 30 million to the Land Degradation Neutrality (LDN) fund, which aims to fight against land degradation.[27]

The public development assistance in the UK (UK Aid) has committed to spending 50% of its climate finance on adaptation.[28] In addition, UK Aid is spearheading several initiatives to support climate change adaptation in developing countries: "Building Resilience and Adaptation to Climate Extremes and Disasters" (BRACED), for countries in the African Sahel, Sub-Saharan Africa and Southeast Asia, and "Strengthening Adaptation and Resilience to Climate Change in Kenya Plus" (stARK+).

24 according to "Key figures from the 2017 joint report on multilateral development banks' climate finance"

25 "Joint Statement by the Multilateral Development Banks in Paris, COP21"

26 AFD, Adapt'action

27 Concepcion Alvarez, 12 December 2017, "The main development banks, including AFD, align their financial flows with the Paris Agreement", Novethic

28 https://publications.parliament.uk/pa/cm201719/cmselect/cmintdev/1432/1432.pdf

The German International Climate Initiative (IKI),[29] which depends on the Federal Ministry for the Environment, Nature Conservation and Nuclear Security, mobilised €226 million for adaptation in 2016 (out of € 869 million in climate finance). This amount is distributed as follows (in millions of €): 136 for multi-zone projects, 50 in South Africa, 23 in Southeast Asia/Asia-Pacific, and 13 in Sub-Saharan Africa. As it is also heavily invested in nature-based adaptation solutions, IKI has invested €125 million in these types of projects.

• DOMESTIC CLIMATE FUNDS •

There is an increasing number of domestic funds.[30] Countries such as Bangladesh, Benin, Brazil, Cambodia, Ethiopia, Guyana, Indonesia, the Maldives, Mexico, the Philippines, Rwanda and South Africa have national climate funds.[31]

This growth comes in response to insufficient international aid and allows developing countries in particular to mobilise funds to finance climate-related projects. It reflects the desire of these countries to set themselves ambitious goals for the coming decades.

For example, the Rwanda Green Fund, FONERWA, has mobilised US$ 176 million from British international aid, the Green Climate Fund, the World Bank, the African Development Bank and the Rwandan government.

However, this has not been without consequence. Their field of application remains limited as these structures heavily rely on the regularity of payments from States and international organisations.

The difficult reorientation of private flows towards projects geared to adaptation

Private financing is essential to be able to face the challenges of climate change. Nevertheless, private investment for adaptation in developing countries remains low. One of the factors that explains this may be the low interest of private structures in risky investments, especially in countries where legal, political and economic frameworks are rather unstable. Public authorities thus have an incentivising role to play when it comes to investment to overcome the short-term logic of private investors. They must also help to make adaptation projects more "attractive" and provide quantitative results that allow private organisations to see the extent and impact of their actions in real terms. In fact, the reluctance of private structures to finance adaptation projects in countries where the governance system or social structure is different from what they know, will be less significant if public investments are more substantial. Therefore, by 2030, climate investment could represent US$ 23 trillion in investment opportunities in emerging countries.[32] The first report of the Global Commission on Adaptation highlights the economic benefit of investing in adaptation: "*Adapting now is in our strong economic self-interest. The Commission found that the overall rate of return on investments in improved resilience is very high, with benefit-cost ratios ranging from 2:1 to 10:1.*" The Commission also estimates that "*investing US$1.8 trillion globally in five areas [early warning systems, climate-resilient infrastructure, improved dryland agriculture, global mangrove protection, and investments in making water resources more resilient] from 2020 to 2030 could generate US$7.1 trillion in total net benefits*". A clear message is therefore sent to economic actors to encourage

29 Federal Ministry for the Environment, Nature Conservation and Nuclear Safety, Review of Activities 2015 to 2016, "Achieving aims together"

30 NDC Partnership, (3 April 2019), "National climate funds – a catalyst for country-driven NDC implementation"

31 Climate Finance and Adaptation. Adaptation Fund. Situation and issues analysis. PFE and Académie de l'Eau. By MA. Martin. May 2019.

32 International Finance Institution, World Bank Group, "Climate Investment Opportunities Total $23 Trillion in Emerging Markets by 2030, Says Report", report published 7 November 2016

them to invest in adaptation through an approach based on future earnings. While this bias is not without posing a number of ideological questions,[33] there is indeed a change of discourse that takes place, making adaptation a potentially profitable sector, provided that a number of precautions are taken when making investment decisions (a change in thinking when it comes to the understanding of phenomena and their analysis) and that public policies and planning provide a favourable environment for private investment in adaptation, in order to reduce its risks.

However, adaptation finance should not focus solely on areas where territories are the most profitable, leaving out those most vulnerable. Indeed, a 2018 study showed that the **vulnerability of States to climate change had a direct effect on the conditions of access to borrowing**.[34] Extreme climatic shocks can lead to slower economic growth, unforeseen expenses for reconstruction,and increased expenditure, especially in terms of insurance to compensate for losses and damages. However, in addition to the additional reactive costs for these countries,[35] they also suffer from unfavourable loan conditions, making their sovereign debt "more expensive" compared to less vulnerable countries. When it comes to the V20[36] countries, for every US$ 10 paid in interest rates, an additional dollar is added to them because of their major climate vulnerability.

However, private finance flows are now difficult to assess because little data is available, and these structures are not required to share their data on climate finance.

In addition, the private sector is very diverse and includes companies (national and international, from all sectors), private finance institutions and insurance companies, pension funds, household spending, etc. (UNEP, 2016)37. Nevertheless, some initiatives exist, such as the FISP-Climat (Facility for Climate Innovation for the Private Sector), created by the French Fund for the Global Environment (FFEM), which encourages private investment for financing projects. adaptation in developing countries (Sub-Saharan Africa, the Mediterranean region and in other developing countries). The fifth FISP-Climat call for projects, published in 2018, allows companies or groups made up of at least one private company to obtain a subsidy or a repayable advance (for a maximum of €500,000), for a project focused on adaptation or one that is transversal and carried out with local partners.

Green bonds are among the most interesting tools for mobilising private finance for adaptation. These finance projects that have been selected based on extra-financial criteria. In reality, risk and profitability are not the only criteria for investors. Socially responsible investment takes into account social and environmental aspects, and green bonds become relevant tools to finance climate action and adaptation. The first sovereign green bond was launched in France on 24 January 2017 with a value of €7 billion. According to the French Ministry of Ecology, "France's green bond will target spending from the state budget and the investment programme for the future for the fight against climate change, adaptation to climate change, protection of biodiversity, and the fight against pollution".38 For example, in 2017, 25% of Treasury equivalent government bond (OAT) expenditures financed climate change adaptation projects, representing **€2.4 billion out of a total of €9.7 billion**. [39]

---

33 Vivian DEPOUES, I4CE, (26 September 2019), "Année de l'adaptation : la voie à suivre?"

34 Gerhard Klinga, Yuen C Loa, Victor Murindea, and Ulrich Volza (2018), Climate Vulnerability and the Cost of Debt

35 For example, between 1997 and 2016, the Philippines, Bangladesh and Vietnam have lost on average $2,893.41, $2,311.07 and $2,029.80 respectively each year due to climate events that have affected them.

36 The Vulnerable Twenty (V20) is a group of the 20 countries most vulnerable to climate change. These are Afghanistan, Bangladesh, Barbados, Bhutan, Costa Rica, Ethiopia, Ghana, Kenya, Kiribati, Madagascar, Maldives, Nepal, Philippines, Rwanda, Saint Lucia, Tanzania, Timor-Leste, Tuvalu, Vanuatu and Vietnam.

37 Adaptation Gap Report 2018

38 MTES, Green Bonds, 7 February 2019

39 What have green bonds done in France? 20 June 2018, Journal de l'environnement

At a European level the study "The Green bond market in Europe 2018" shows that green bonds are developing and that both private and public actors are emerging when it comes to energy, building, transport, water, waste and even industrial projects. Adaptations is recorded as a category in its own right, which represents only 2% of the portfolio (9% if water is included). The use of green bonds is growing, but remains very marginal.

This trend is similar at the level of OECD countries. Of the €19 billion of green bonds issued in these countries, 59% are intended for mitigation, 21% for adaptation and 13% for the preservation of biodiversity.

Nevertheless, green bonds remain widely used in developed countries and still represent only a tiny proportion of climate finance.

2 • Situation analysis of global financing of climate change adaptation in recent years: recipients

Nakhoda et al. noted in 2014[40] that the countries most vulnerable to climate change receive the largest share of international public funding for adaptation, largely from OECD countries. The three countries receiving the most are Niger, Bangladesh and Nepal. In 2017, Climate Funds Update showed that adaptation financing was less concentrated than mitigation financing. The top 20 countries receiving financing for adaptation receive 48% of the total amount. For mitigation, the top 20 countries receive 75% of the total amount.

According to the ND Gain index – Notre Dame Global Adaptation Initiative (which measures a country's vulnerability in relation to its ability to cope with climate change), LDCs are the most likely to suffer the effects of climate change and therefore need to increase their funding for their own adaptation. According to Joyce Coffee, Managing Director of ND-GAIN, its objective is to "help businesses and the public sector better prioritise investments for a more efficient response to the immediate global challenges ahead".[41]

According to the Climate Policy Initiative (Oliver et al. 2018.),[42] the areas that receive the most funding for their adaptation are Eastern Asia and the Asia-Pacific with US$ 9 billion, followed by Latin America/the Caribbean with US$ 4 billion and Sub-Saharan Africa with US$ 3 billion. The rest of the regions in the world receives 1 billion or less. The sectors that receive this funding are infrastructure (33%), warning systems and disaster risk management (17%), and water management (12%).[43]

40 Mathy, S. (2015). Creating a poverty, adaptation and mitigation funding window in the Green Climate Fund. Natures Sciences Sociétés.

41 Anyadike O., (2016), "Which countries are most at risk from climate change and how can we help?", The New Humanitarian

42 Climate Policy Initiative, Understanding and Increasing Finance for Climate Adaptation in Developing Countries, Valerio Micale, Bella Tonkonogy and Federico Mazza, Published: December 2018, p.10

43 Mathy, S. (2015). Creating a poverty, adaptation and mitigation funding window in the Green Climate Fund. Natures Sciences Sociétés.

3 • The challenge of metrics for measuring adaptation finance flows

Although adaptation costs are constantly being revised upwards, in the latest UNEP Adaptation Gap Report it remains difficult to accurately quantify the financial implications of the challenge of climate change adaptation.

The very **definition** of adaptation complicates the **classification of projects and consequently their accounting**. The categorisations performed by the funders are generally different. The boundaries between adaptation, development aid and climate resilience are very fine. Accounting for climate change adaptation projects therefore includes the costs of development projects that have adaptation shares. For example, an agricultural development project that uses new practices or seeds to combat extreme and more frequent climate events involves both development and adaptation. Some countries report adaptation finance as Official Development Assistance (ODA), while others view it as additional to this assistance; clarification on this point is needed. For precise accounting of what adaptation represents, it is necessary to determine the "extra cost" related to the adaptation of the development part.[44] Nevertheless, some actors have taken up this issue of harmonisation of methods to disseminate clearer information: multilateral banks and the IDFC have developed "The Common Principles for Climate Change Adaptation Finance Tracking" (AfDB, 2015). [45]

The "Monitoring, Reporting and Verification" (MRV) mechanisms also group together a set of rules and procedures for flow accounting methods. The use of indicators is necessary to evaluate financing and its impacts in terms of adaptation, but these are often too wide-reaching and not easy to handle.

Silent adaptation, which includes all adaptation actions that are not recognised as such, is not quantified and it is difficult to evaluate the adaptation "part" in some projects. The same applies for "remittances", which are financial funds sent by emigrated populations to their country of origin. Once again, we can arrive at an estimate of these amounts, but without really knowing their destination, whereas these funds, taking into account their participation in the improvement of the local living conditions, participate in the development and sometimes in the adaptation to climate change.

In addition, not all countries use the **same methods to assess these costs**, which makes comparisons on a global scale difficult. While it is possible to fairly accurately assess the amounts of public financing for adaptation (financial institutions for development and international investments), this accounting runs into difficulties when it comes to traceability of private flows (businesses, households, etc.) and national budgets.[46] Finally, the objective of transparency set out in the Paris Agreement (Article 13) is very much linked to the issue of climate change adaptation financing. It is difficult to increase transparency without working on the harmonisation of costing methods.

44 Observatoire géopolitique de la durabilité: Finance et climat, quels enjeux ? By Alice Pauthier, March 2016

45 AfDB, 2015, in Climate Policy Initiative (December 2018), Understanding and Increasing Finance for Climate Adaptation in Developing Countries, Valerio Micale Bella Tonkonogy Federico Mazza

46 CPI, Climate Finance Landscape, "A clearer picture of climate finance can better inform decision makers and investors"

The importance of reliably assessing needs and costs, to strengthen the consideration of issues and the need to increase funding for adaptation should also be noted. There are still significant gaps in this assessment, which provides extremely wide ranges, but which also serves as a basis for international negotiations.[47]

Nevertheless, several scenarios and estimates are being considered, as the amounts required for climate change adaptation depend on how climate change itself develops in the coming years and the costs and efforts that will be provided to mitigate greenhouse gas emissions in particular[48]. This **context of uncertainty** should not slow down action but does present real limitations when it comes to achieving meaningful adaptation.[49] Adding to this uncertainty is an essential governance issue, as the availability of funds cannot guarantee that they are used properly. Funding allocated to adaptation must make it possible to improve the adaptive capacity of territories and countries, and not increase their vulnerability, as may be the case with maladaptation (the result of poor coordination between local and regional actors or poor prioritisation of the objectives to be achieved).

Funding is largely insufficient and still too dispersed to meet the needs of countries to adapt to climate change. The comparison of costs to reach the adaptation target and the financial amounts available to achieve it refers to the concept of a **finance gap**. However, the UNEP[50] warns that even if funding is available, there is no guarantee that money will be allocated effectively to efficiently deal with the adaptation challenge. The concept of **an adaptation gap** refers to the gap between the adaptation projects actually implemented (level of adaptation) and the adaptation objective of the country or region.

Faced with these growing needs, many funds have been created in recent decades. Each fund created has attempted to meet a current need in terms of sector and project. This has resulted in a **complex global system and a multitude of funds**,[51] which reduces their effectiveness. These must be reformed in terms of their architecture and how they operate (some will even merge or close in the years to come)[52].

Some funds have **procedures for obtaining complex financing**, in the face of which some actors lack the skills to carry out financing applications. The complex landscape of available funds also translates as a **visibility issue** for them.

47 Weikmans, 2012

48 Olhoff, A., Bee, S., & Puig, D. (2015). The adaptation finance gap update: with insights from the INDCs. United Nations Environment Programme.

49 Climate Policy Initiative (December 2018), Understanding and Increasing Finance for Climate Adaptation in Developing Countries, Valerio Micale Bella Tonkonogy Federico Mazz

50 Olhoff, A., Bee, S., & Puig, D. (2015). The adaptation finance gap update: with insights from the INDCs. United Nations Environment Programme.

51 World Resources Institute, Niranjali Manel Amerasinghe, Joe Thwaites, Gaia Larsen and Athena Ballesteros, (2017), Future of the Funds: Exploring the Architecture of Multilateral Climate Finance, 100 pages

52 Ibid.

WWW.CLIMATE-CHANCE.ORG