World Science Day for Peace and Development 2021

How can we build climate-resilient societies?

Climate change is upon us

Climate change is upon us. The past few years have been littered with tragic illustrations of this trend. Examples are the wildfires that swept across Greece and Turkey in 2021, New South Wales (Australia) and California (USA) in 2019 and 2020, fuelled by years of intense drought, (USA). One could also mention the heat dome that hovered over parts of Canada and the USA for weeks in 2021, the exceptionally strong hurricanes that brought extensive flooding to parts of Southern Africa and the Caribbean in 2019, exceptional flooding in China and Germany in 2021 or the locust swarms which devastated East African agriculture in 2020, a phenomenon exacerbated by an extra breeding season thanks to warmer temperatures.

Earlier in the year, the Intergovernmental Panel on Climate Change (IPCC) issued a very strong warning on the looming potential catastrophe from anthropogenic global warming whrough its its Sixth Assessment Report, entitled: "Climate Change 2021: The Physical Science Basis". The report indicated that: *Human-induced climate change is already affecting many weather and climate extremes in every region across the globe. Evidence of observed changes in extremes such as heatwaves, heavy precipitation, droughts, and tropical cyclones, and, in particular, their attribution to human influence, has strengthened since the Fifth Assessment Report".* The UN Secretary-General António Guterres said the report was: "*A code red for humanity. The alarm bells are deafening, and the evidence is irrefutable".*

It has never been so urgent to ensure that communities can weather the storm of the climate change to come – for this is just the beginning. Things are not going to get better. We must be prepared (see Annex I for more information).

The UNESCO Science Report (2021) provides insights into several key challenges and related solutions needed to adapt to and mitigate the effects of climate change and build climate-ready communities for today and the future.

According to an original UNESCO study (see box in Annex I), low-income countries more than doubled their share of academic output on climate-ready crops between 2011 and 2019 and tripled their share of output on new technologies to protect from climate-related hazards. On the latter topic, lower middle-income countries boosted their global share from 8.3% to 19.3%.

From these trends, we can see that climate change mitigation and adaptation is a priority concern for developing countries. An open approach to science (**open science**) and innovation (**open innovation**) can help these countries to narrow the knowledge gap by enabling researchers and inventors to share their information, data and methodologies for more climate-ready designs. Open science practices include open access to scientific publications. Whereas most of the scientific publications related to COVID-19 are readily available to the scientific community and the public, only about 30% of publications related to climate change are not locked behind paywalls. Efforts to reverse this situation will be critical in fighting the impact of climate change globally.

Climate change is here

- Climate change is causing more frequent and more extreme weather events. Examples are:
  - the wildfires which swept across Greece and Turkey in 2021, New South Wales (Australia) and California (USA) in 2019 and 2020, fuelled by years of intense drought, (USA);
  - the heat dome that hovered over parts of Canada and the USA for weeks in 2021;
  - the exceptionally strong hurricanes that brought extensive flooding to parts of Southern Africa and the Caribbean in 2019 and exceptional flooding in China and Germany in 2021;
- It has never been so urgent to ensure that communities can weather the storm of the climate change to come – for this is just the beginning. Things are not going to get better. We must be prepared.
- The increasing frequency and severity of tropical storms, tornados and hurricanes are wreaking havoc with the economy of many developing countries. These extreme events have been occurring beyond the tropics, such as up the northeast coast of the USA.
- This is forcing countries to develop climate-resilient infrastructure. For instance, Mozambique has built more than 1 000 climate-resilient classrooms since 2017 on firm subsoil, above ground level, with enforced roofs. This tempered the damage inflicted by Cyclone Idai in 2019 (Source: *UNESCO Science Report*, 2021).

Building codes will need to evolve with climate change

- Infrastructure is often designed and built to specific codes and standards which assume that climate is stationary. This is no longer the case.
- This is why the engineering community has adopted a protocol for assessing climate risk, the *Public Infrastructure Engineering Vulnerability Committee Protocol for Infrastructure Climate Risk Assessment*. Once engineers have completed these assessments, they will be able to elaborate new standards for the construction of water and wastewater systems, bridges, dams, airports, ports, highways, electrical transmission and distribution networks, hospitals etc. (Source: *Engineering for Sustainable Development*, UNESCO, 2021).

Reducing the heat island effect

- Cities have been described as 'concrete jungles'. Megacities that are home to 20 million inhabitants or more are trapping so much heat in their concrete footpaths, asphalt roads and brick buildings that the streets remain warm long after sunset.
- This phenomenon is known as the urban heat island and it is causing some of the world's cities to warm as much in a few decades as they have over an entire century. Global warming will make life very difficult in these megacities.
- There are ways of mitigating the heat island effect, such as by creating green parks, roof gardens and tree-lined streets.
- Many modern buildings are made of concrete and glass, which absorb heat rather than reflecting it. Scientists have designed new types of glass that can prevent heat from passing through it or that can be controlled to adjust to the temperature outside.

- UNESCO's Intergovernmental Hydrological Programme (IHP) is part of the Megacities, Freshwater and Climate Alliance established at COP21 in 2015. This alliance provides an international forum where all stakeholders in the water sector – policy-makers, civil society, urban planners, service providers, etc. – can learn from one another's experiences and share best practices.

Coping with too much, or too little, water

- One of the most emblematic signs of climate change is the retreat of glaciers. Glacier melt in mountainous regions is exacerbating geological hazards such as landslides, rock slides and glacier lake outburst floods. The latter occur after freshwater from a melting glacier accumulates in a high-altitude lake to the point where the lake bursts its banks, sending an avalanche of water cascading down the mountainside, where it may flood human settlements.
- Since 2018, a project implemented jointly by UNESCO and the International Geoscience Programme has been using remote sensing to identify glaciers and glacier lakes in the Himalayas which are evolving rapidly. Geologists are developing standardized techniques for identifying hazard 'hotspots' which will be disseminated to local communities to enable them to monitor these hazards themselves over time.
- Storms and floods may disrupt the water supply and sewage treatment plants by damaging infrastructure and transporting sediments and nutrients to affected areas. Satellites can be used to monitor these trends. UNESCO's Intergovernmental Hydrological Programme (IHP) is supporting a project which uses Earth observation satellites to monitor water quality in the Lake Chad Basin, for instance.
- In urban areas, it makes economic sense to avoid building in floodplains in the first place, rather than to invest in reconstruction and recovery after each flood event. Researchers can conduct assessments to inform decision-making on land zoning and other measures to protect residents from exposure to recurrent flooding.
- Local communities can help us to learn from past adaptation to climate change. For example, the residents of the island of Majuli in India have been living with changing water levels for centuries. They use portable building techniques to move monasteries in response to annual flooding.[1]
- One project is developing an early warning system for floods for 11 countries in the Niger and Volta River basins, namely Benin, Burkina Faso, Cameroon, Chad, Côte d'Ivoire, Ghana, Guinea, Mali, Niger, Nigeria and Togo. UNESCO's Intergovernmental Hydrological Programme (IHP) is participating in this project, as a partner in the International Flood Initiative.[2]
- Systems equipped with artificial intelligence can be used to track storms and monitor flood conditions, making it possible to ready the population for these impending disasters hours or even days in advance.
- Coastal reservoirs built at, or near, the mouth of a river can provide cities with water storage facilities. Equipped with a system of gates, these reservoirs can also retain floodwaters after heavy rains and help to ensure a steady supply of water during a drought. Many coastal cities are using coastal reservoirs for their water supply, including Hong Kong, Shanghai and

[1] See: https://www.eesi.org/articles/view/cultural-heritage-is-a-necessary-component-of-climate-solutions

[2] This partnership also involves the World Meteorological Organization, the Institute for Catastrophic Loss Reduction, United Nations University, International Strategy for Disaster Reduction, International Association of Hydrological Sciences and the International Association for Hydro-Environment Engineering and Research.

Singapore. Coastal reservoirs built in areas with strong tides can also generate renewable energy. (Source: *Water and Climate Change* (2020[1]) UNESCO, UN-Water).

- Solutions need not be sophisticated. Communities can use low-tech, low-cost technologies to harvest water, such as guttering on roofs to capture rainwater and tanks to store it, or wells from which to recover groundwater.
- Local water information centres and water museums can help communities to share knowledge of low-tech systems that were often present in the past. These low-tech systems are being promoted through the IHP Global Water Museums Network (WAMU-NET).
- UNESCO is helping to ensure that groundwater is managed responsibly at both the national and international levels – many underground aquifers span more than one country – via multi-partner initiatives like the Global Groundwater Governance programme.
- In the Middle East, fresh water in underground aquifers dates from a time thousands of years ago when the region had a wetter climate. This 'fossil water' is not being replenished by rainfall, so it will run out one day. Consequently, many Middle Eastern countries have become heavily reliant on desalinated water.
- The growing use of desalinated water in the Middle East, in particular, presents some challenges. Desalination is an energy-intensive process. Moreover, when water reclaimed from the sea is used for irrigation, it can lead to saltwater intrusion into aquifers and agricultural soil. In parts of Israel where desalinated water is the only source of drinking water, the lack of magnesium in the daily diet is making heart disease more prevalent.

Low-carbon energy solutions

- Centralized wastewater treatment plants can capture most of the methane that develops in wastewater, in order to turn waste into energy (Source: *Water and Climate*, 2020).
- As the global population rises, demand for affordable energy will climb. Since the energy provided must be as low-carbon as possible, a growing number of countries are investing in renewable sources of energy such as wind, solar and geothermal. Kenya and Turkey, for instance, are each exploiting the heat generated by the Earth's hot interior (Source: *UNESCO Science Report*, 2021).
- As temperatures rise in many parts of the world, the use of air-conditioning is growing. It alone can account for 10-20% of domestic energy use in temperate climates and up to 60-70% in hot climates. Refrigerants like air-conditioning systems potentially contribute to global warming about 2000 times more than carbon dioxide. By limiting the use of air conditioning systems – such as by using windows and doors to create draughts and closing shutters during the hottest part of the day – communities can limit their contribution to global warming. [3]

[1] United Nations World Water Development Report 2020: Water and Climate Change, a report produced by the UNESCO World Water Assessment Programme on behalf of UN-Water. See: https://en.unesco.org/themes/water-security/wwap/wwdr/2020UNESCO

[3] See: https://academic.oup.com/bioscience/article/66/9/763/1753956

Climate-ready crops

- Researchers are developing crops like "scuba rice" that can survive for long periods underwater, or which can resist extreme heat, drought, disease or saline soils caused by rising sea levels.
- Seed banks can store seeds to preserve crop diversity and support research on drought-, salt- and disease-resistant food crops. For instance, the Pacific Community maintains the Pacific Centre for Crops and Trees, which stores over 2 000 seed samples.

Species migrating or extending their range

- Climate change will drive some species to migrate, both in the ocean and on land. This could wreak havoc for communities reliant on a single species for their livelihood. The Norwegian economy relies heavily on a single fish species, for instance, the Barents Sea cod (*Gadus morhua*). If the waters become too warm, this species will migrate out of the Norwegian economic zone.[4]
- Global warming will make it easier for invasive species to extend their range. This includes vector-transmitted pathogens like the West Nile Virus. It is carried by *Culex pipiens*, a mosquito that thrives in hot, dry climates in Africa, the Middle East, India and Europe. The West Nile Virus is now also of concern in the USA.
- Even slight increases in moisture and temperature as a result of climate change can stimulate bacteria, fungi, viruses and the insects that are vectors of infectious disease. There have been disease outbreaks sensitive to climate in corals and oysters and, on land, in plants, animals, birds and humans.
- Deforestation is exacerbating the impact of climate change by removing a vital 'carbon sink' – forests absorb carbon from the atmosphere – and reducing biodiversity. By converting forests to accommodate agriculture or urbanization, we may be reducing the ability of these natural systems to buffer disease. This is because, as we lose biodiversity, we lose alternative hosts to humans and livestock for insect vectors to bite. This is why communities need to support the preservation of forests for their benefit.

Natural barriers

- The United Nations Environment Programme has estimated[5] that adaptation to climate change by developing nations may cost US$ 500 billion per year by 2050. Protecting ecosystems can lower the cost of both climate adaptation and environmental management. For instance, living coral reefs and mangroves can block 90% or more of the wave energy approaching a coast, protecting the shoreline. Restoration and protection of wetlands is the most cost-effective method for shoreline and coastal resilience.[6]
- Natural ecosystems along waterways are not only resilient to flooding. They also help to retain soil and attenuate the strength of waves to reduce the impact of flooding. Examples of these natural 'seawalls' include mangroves, marshes and coral reefs. Artificial barriers, on the other hand, can harm biodiversity. For instance, artificial seawalls host 45% fewer living organisms than natural shorelines.

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[4] See UNESCO's magazine, A World of Science: https://unesdoc.unesco.org/ark:/48223/pf0000187515.page=17
[5] See: https://wedocs.unep.org/bitstream/handle/20.500.11822/32865/agr2016.pdf
[6] See: https://www.cbd.int/doc/publications/cbd-ts-85-en.pdf

- Technology like artificial seawalls can provide short-term relief from sea-level rise but it will become inevitable, in the longer term, to build farther from the coast. This can be a hard reality
- to accept, as it will mean abandoning existing properties. For instance, sea-level rise and erosion are threatening the coastline of Braunton Burrows–North Devon's Biosphere Reserve in the UK. Climate modelling in North Devon to predict how the coastline will evolve over the next 100 years has led scientists to recommend abandoning the mouth of the estuary to the sea.[7]
- A 2020 study used machine-learning to predict human migration patterns resulting from sea level rise in the USA, where 13 million people could be forced to relocate by 2100.[8]

Carbon capture and storage: a costly solution

- Human activities are producing more greenhouse gas emissions than natural carbon sinks such as the ocean and forests can absorb.
- This is why all of the pathways defined by the Intergovernmental Panel on Climate Change for limiting global warming to 1.5°C rely on technological advances in removing carbon dioxide (CO_2) from the atmosphere to complement natural carbon sinks.[9]
- However, the high-tech industry of carbon capture and storage is still in its infancy. The technology is complex and costly. For instance, the Orca plant which opened in Iceland in September 2021 cost US$ 10–15 million to build. It has the potential to capture 4 000 tonnes of CO_2 each year, equivalent to the emissions from about 870 cars, according to the US Environmental Protection Agency.
- Geo-engineering solutions like carbon capture and storage tackle the symptom, rather than the cause, of climate change. There are concerns that techniques to remove carbon from the atmosphere and store it underground may be seen as a pretext by some governments to avoid tackling rising carbon emissions.

Open science and open innovation can facilitate climate-ready solutions

- According to an original UNESCO study (see box), low-income countries more than doubled their share of academic output on climate-ready crops between 2011 and 2019 and tripled their share of output on new technologies to protect from climate-related hazards. On the latter topic, lower middle-income countries boosted their global share from 8.3% to 19.3%.
- From these trends, we can see that climate change mitigation and adaptation is a priority for developing countries. An open approach to science (open science) and innovation (open innovation) can help these countries to narrow the knowledge gap by enabling researchers and inventors to share their information, data and methodologies for more climate-ready designs.
- Open science practices include open access to scientific publications. Whereas most of the scientific publications related to COVID-19 are readily available to the scientific community and the public, only about 30% of publications related to climate change are not locked behind paywalls. Efforts to reverse this situation will be critical in fighting the impact of climate change globally.

[7] See: https://unesdoc.unesco.org/ark:/48223/pf0000184441.page=20
[8] See Robinson *et al*, 2020 : http://dx.doi.org/10.1371/journal.pone.0227436
[9] See: http://www.ipcc.ch/report/sr15

- Open science also means extending the practice of science beyond the traditional scientific community. Greater engagement with citizens, volunteers and local and indigenous knowledge holders can potentially expand the boundaries of knowledge and provide solutions specifically tailored to solving local problems with and for the community. Such inclusive and participatory approaches are particularly relevant when it comes to climate change mitigation and adaptation. For instance, to facilitate gender-responsive solutions, the World Water Assessment Programme hosted by UNESCO has developed a Toolkit on Sex-disaggregated Water Data (second edition, 2019) to provide a global standard through a unique set of gender-responsive indicators.

Box: To what extent are scientists prioritizing climate-readiness?

According to an original study by UNESCO which analysed scientific publishing trends over 2012–2019, sustainability science is not yet mainstream at the global level. The following are a selection of the 56 research topics analysed.

Sustainable withdrawal and supply of freshwater accounted for 0.06% of academic output. Low-income countries contributed to just 3% of global output on this topic in 2019. Global output on this topic grew by 57% over over 2012–2019.

Water harvesting accounted for 0.02% of academic research, with output on this topic growing by 55% over 2012–2019. Low-income countries' contribution to this topic stagnated at 9%.

Desalination accounted for 0.18% of scientific publications, with output on this topic growing by 26% over 2012–2019.

Climate-ready crops accounted for just 0.02% of all academic publications, despite an 87% surge in output on this topic over 2012–2019. Of note is that the share of research on this topic being conducted in low-income countries surged from 4.5% to 11.4%.

Tackling invasive alien species accounted for 0.13% of academic research between 2012 and 2019 and grew by just 28% over this period.

Carbon capture and storage is a topic that accounted for 0.09% of academic research and grew by just 6% over 2012–2019, with a mere 2 501 publications on this topic produced around the world in 2019.

Disaster risk reduction: the topic of local strategies to mitigate climate-related disaster risk accounted for just 0.005% of global research between 2012 and 2019. Of note, is that low-income countries raised their global share of output on new technologies to protect from climate-related hazards from 1.7% to 6.8% and lower middle-income countries from 8.3% to 19.3%.

Source: *UNESCO Science Report* (2021)