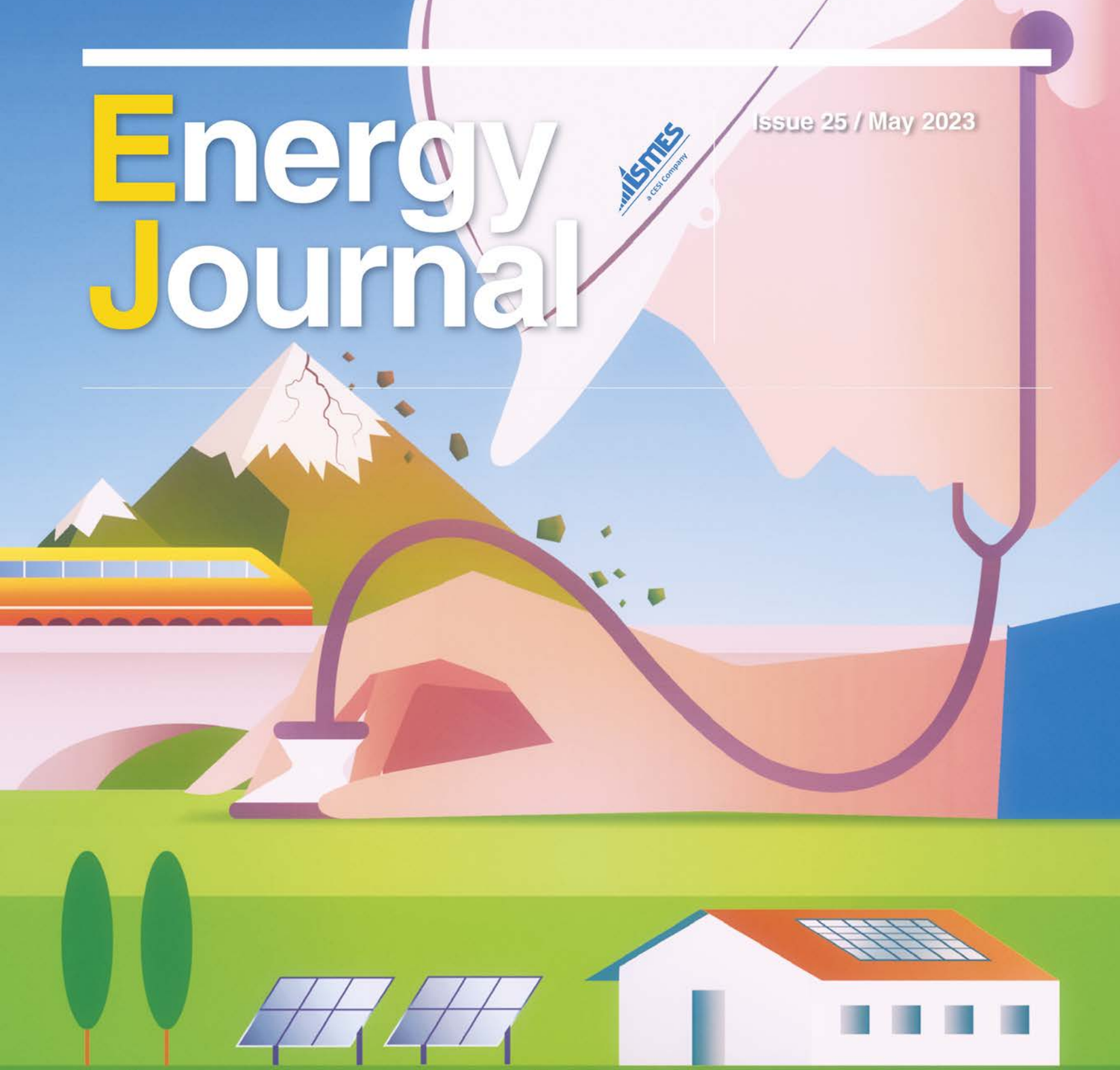
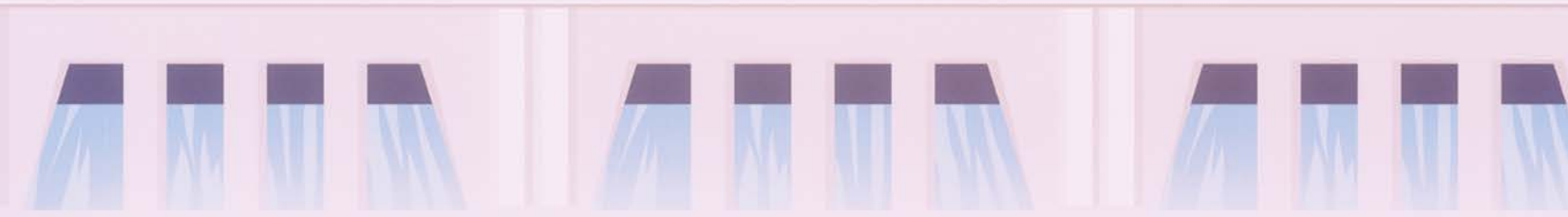
Energy Journal

Issue 25 / May 2023



Infrastructure and Environment: Are We Investing in Prevention?



A magazine about energy and more by CESI

Energy Journal
CESI's house organ
Editorial coordination
Paolo Chighine / CESI
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Project, design and translations
Cultur-e
www.cultur-e.it

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Editorial

A Larger Investment in Prevention Is Necessary to Safeguard Infrastructure and the Environment

Guido Bortoni
Chairman, CESI

Domenico VIllani
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In this issue, we will turn our attention to concerns that also affect other sectors, along with those that are of primary interest to the energy sector. This is fundamental, and we are certain it will appeal to our readers. Our Group has plenty of experience when it comes to hydrogeological instability and the solutions that can be implemented to prevent it.

We know that Italy is a wonderful, yet fragile, country due to its unique geological layout. It is exposed to risk by its very nature. Moreover, also taking into consideration its urban sprawl, developed without the necessary planning, the effects generated by extreme climatic phenomena is inevitable. In fact, in recent years, many areas have been affected by disastrous landslides and floods.

Land consumption and instability, the reduction of water resources, and desertification are just a few of the many risk factors that interest the Mediterranean basin, and these issues are further compounded by cyclones, storm surges, tornados, and what were once considered atypical temperatures. This mix of elements will continue to produce serious consequences, unless a new model of sustainable development is rapidly adopted to reduce its impact and strengthen environmental resilience.

According to the Italian Institute for Environmental Protection and Research (ISPRA), 94% of Italian municipalities are at risk of hydrogeological instability. And notwithstanding this, many local authorities have approved works that weaken natural environmental defenses, further adding to this critical situation. Therefore, in this new issue of Energy Journal, we concentrate on understanding how existing infrastructure may best be managed to make it more resilient to climate impact, both in terms of mitigation and as a consequence of adaptation strategy. We begin by analyzing how climate change acts as a risk factor for buildings, urban centers, and other works.

Reviewing the data provided by the "Risk Analysis: Climate Change in Italy" Report published by the Euro-Mediterranean Center for Climate Change (CMCC), the "Scenario" article (P. 10) draws attention to the fact that, along with the reduction of climate-altering gas emissions, it is urgent to adapt infrastructure to climate change. This can be accomplished with the help of climatic engineering and the adoption of a range of strategies to manage different environmental systems. In addition, these activities must be accompanied by scientific research and technological development to help us better comprehend the climate system and its changes, as well as to adopt more efficient mitigation and adaptation strategies.

Therefore, if on the one hand, the assessment and analysis of hydrogeological risk is essential for all infrastructure, then on the other, experts are pondering how to face this issue in terms of resilience. The answer is unanimous. The third millennium requires us to design infrastructure with greater attention and to assess any type of climatic danger that could affect it during its lifecycle. This, in turn, requires the exploitation of state of the art knowledge on new risk factors to carefully evaluate climactic dangers. In short, statistical analyses of extreme annual values, which are only valid if the climate remains unchanged, are no longer efficient.

In this context, the "Top Story" emphasizes the fundamental role that will be played by satellite data collection and so-called "climatic intelligence." The information that we gather from the observation and monitoring of the planet are indispensable to prevent and manage hydrogeological and seismic events. In Europe, a key role is played by Copernicus, the EU's Earth Observation and Monitoring Program.

This technology can be employed to monitor the situation on all continents and support the prevention and maintenance activity implemented by national authorities. In the "Industries and Countries" section (P.24), we analyze how extreme events caused by climate change are affecting the environment and infrastructure around the world.

Moreover, in order to better understand the current context and what can be done to safeguard the environment, we have interviewed two experts. Stefano Laporta, President of ISPRA and SNPA, explains how climate change is affecting hydrogeological instability in Italy and what solutions have been fielded over the past decade. Giuseppe Spilotro, a Professor of Applied Geology and Hydrogeological Risk Expert, illustrates the economic and social implications of hydrogeological instability and how the phenomenon can be addressed in terms of climate change.

The articles in this issue clearly point to the fact that the management of hydrogeological risk is a priority that must be addressed in an integrated manner. It is fundamental to understand these phenomena in order to develop well-structured preventive measures, such as the ones adopted by ISMES, the CESI Group company dedicated to civil engineering and infrastructure. Thanks to a group of 70 professionals, including engineers and geologists, ISMES provides concrete solutions for the prevention and mitigation of the effects of hydrogeological instability, both in Italy and worldwide.

Enjoy the reading.

Guido Bortoni
Chairman, CESI

Domenico Villani
CEO, CESI

Energy Journal can be browsed and downloaded at www.cesi.it

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Contents

"Environmental and hydrogeological protection is our friend. It safeguards lives and defends the future of our communities."

***Sergio Mattarella**, Italian President*

News

Latest from CESI

ISMES: Francesco Carnevale is the New DG

As of May 3, 2023, Francesco Carnevale is the new Director General of ISMES, a CESI Group Company – dedicated to Civil Engineering and Infrastructure – that provides its clients with consulting, services, and testing. Dr. Carnevale earned a degree in Civil Engineering, with a focus on Structures, and presented a thesis on Geotechnical Engineering at the University of Brescia.

From 2005 to 2016, he worked on various projects. As a geotechnical designer, he collaborated on the MoSE Project to safeguard Venice from high-tide flooding. In 2011, he completed a Ph.D in Geotechnical Engineering at the University of Parma. Then, from 2016 to 2018, he worked in the Technical Direction Department of Salini Impregilo (now Webuild). Dr. Carnevale joined CESI in 2018 as Project Manager and Senior Geotechnical Engineer. In 2020, he became Director of "Civil & Structural Engineering" in the "Infrastructure Engineering" Business Unit of CESI's Consulting Division. In January 2022, he was nominated Technical Director of ISMES and, as of May 2023, he is ISMES Director General.

"Great skills for great projects."

Progress on the Black Sea Submarine Cable Project

At the beginning of April, there was a meeting in Tbilisi on the strategic partnership for the development and transmission of green energy amongst the governments of Azerbaijan, Georgia, Romania, and Hungary. The meeting addressed the Black Sea Submarine Cable, a project in which CESI was selected by the Georgian Electricity Transmission System Operator to carry out the feasibility study.

The 1200-kilometer cable (1100 underwater) aims to connect the South Caucasus region with South-Eastern Europe, contributing to the development of the renewable energy sector and bolstering supply security. Stefano Malgarotti, CESI Engineering Consulting Director, explained that "CESI has already selected the route and the location of the converter stations. In the future, environmental and social impact assessment and geophysical and geotechnical studies will also be conducted on the bed of the Black Sea."

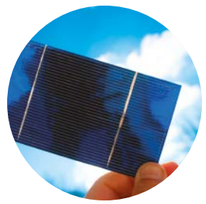
"A connection between the Caucus and Europe."

Consulting for Off-shore Wind in Bangladesh

In partnership with Blix (the Netherlands), local consultants Synotech Engineering, and SS Solutions (Bangladesh), CESI has been assigned a contract for conducting the pre-feasibility and feasibility studies for an offshore wind farm in Bangladesh, entirely funded by the Asian Development Bank. Besides identifying the most appropriate site in the Gulf of Bengal for the installation of the offshore wind facilities, CESI will produce an economic-financial assessment of the infrastructure, defining the impact on the transmission network and all necessary changes to the Bangladesh National Grid Code.

In terms of offshore wind, CESI supports its clients throughout project development: from the execution of grid impact and grid code compliance studies to the electrical, civil, and environmental engineering services required to properly connect the generators to the national grid, both for the terrestrial and marine components.

"From impact studies to engineering services."



CESI Collaborates with ASI on the Space Factory Project

CESI has been selected by the Italian Space Agency (ASI) to participate in the development of the Space Factory, which aims to generate future investments for the production of small satellites and increase the competitiveness of Italian component suppliers. Thanks to PNRR funds managed by ASI, CESI will increase its production capacity of solar cells for space applications, also through state-of-the-art machinery and a digitization process of production in line with the Industry 4.0 paradigm.

With more than 30 years of experience in research and development, CESI produces high-efficiency solar cells for space applications via a proprietary technological process. As one of the world's leading suppliers of multi-junction cells based on GaAs (Gallium Arsenide) and InGaP (Indium Gallium Phosphide), CESI has produced over 200,000 solar cells that power more than 70 civilian satellites for 25 different countries.

"«High-efficiency solar cells for space applications."

Scenario

Climate Change and Hydrogeological Risk: A Dangerous Relation

How are land consumption, uncontrolled urban development, and deforestation compounding hydrogeological instability? The impact of extreme events (landslides, floods, and coastal erosion) and infrastructural resilience.

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Climate change has become the daily protagonist of increasingly frequent and critical extreme climate phenomena. It is happening at all latitudes, and it is happening now.

The devastation and damage caused by heat waves, droughts, storms, cloudbursts, floods, and hurricanes, are expressed by statistics with far too many numbers. According to the most recent **report published by Munich Re** on climactic and natural disasters, in the first semester of 2022, catastrophes have claimed 4,300 victims and caused US$65 billion in damage.

We have seen another red flag waved by the United Nations' Intergovernmental Panel on Climate Change (IPCC). The **IPCC Report** published in 2022 clearly sounds an alarm on the **systemic challenges**

that climate change has caused and the negative domino effect it could trigger, destabilizing entire ecosystems. The report describes melting glaciers in Greenland and the Antarctic, the ecological issues faced by the Amazon basin, and the retreating Siberian permafrost. A rapid succession of climactic events could affect eastern Brazil, Southeast Asia, the Mediterranean, Central China, and its coastal zones, all areas that have been interested by extreme phenomena such as droughts, heat waves, hurricanes, fires, and floods. Now that global temperatures have increased by 1.1C over pre-industrial levels, a level that has already created severe consequences on our lives, scientists fear the "perfect storm." The United Nations' IPCC has warned that prolonged global warming in excess of 1.5 C could produce "progressively severe conditions that will persist for centuries and, in some cases, prove irreversible."

The Relation between Climate Change and Hydrogeological Instability

However, addressing climate change alone is insufficient to fully understand the risk in areas characterized by widespread **hydrogeological instability**, a phenomenon that endangers the surface of our planet and everything that rests upon it, including buildings, urban centers, and all infrastructure. There is a term that perfectly describes the relation between climate change and hydrogeological risk. It is **amplification**. In the Mediterranean basin, for example, instability and land consumption, the reduction in water resources, and desertification are hydrogeological risk factors that are compounded by **ongoing climate change, which acts as an amplifier**. This combination of factors may lead to severe consequences in the coming decades unless a **new model of sustainable development aiming to reduce their impact and bolstering resilience** is implemented timely.

As the current climate emergency compounds the **issue of hydrogeological instability** – understood as the set of morphological processes altering the earth's surface, from land consumption to landslides and floods – it is fundamental to focus on **areas that are naturally exposed because of their morphology**. A further element must be added to this scenario: **anthropic activity** is the main element that compounds hydrogeological instability. Uncontrolled urban development waterproofs land, limiting its vast potential to absorb water. Deforestation removes natural barriers to landslides. Illegal construction activity in areas that are not suitable for building due to potential landslides and the presence of watercourses constitutes a further issue.

Hydrogeological Instability in Italy and Forecast Climate Change

These issues are a foremost concern in Italy as indicated by the most recent report published by the "Istituto Superiore per la Protezione Ambientale" (ISPRA) on **"Hydrogeological Instability in Italy: Dangers and Risk Indicators."** The study states that **94% of Italian municipalities is at risk of landslides, floods, and coastal erosion**. Nearly 8 million Italian citizens live in dangerous areas. The highest risk areas include Emilia Romagna (3 million residents), Tuscany (more than one million), Campania (800,000), Veneto (ca. 575,000), and Liguria (ca. 366,000). Nearly 565,000 buildings have been erected in areas at high risk of landslides (3.9% out of over 14 million) and 1.5 million (10.7%) in areas at high risk of flooding. Industry fares no better: 84,000 plants are located in high landslide risk areas.

This issue is further compounded by land consumption, as disclosed by the 2022 edition National System for Environmental Protection (SNPA) Report entitled **"Soil Erosion, Local Dynamics and Ecosystemic Services."** The highest rate of land consumption in the last ten years was registered in 2021 when 70 km2 were developed in just one year, an average of 19 hectares per day, at a speed in excess of 2 square meters per second. In other words, this means that Italy is covered by 21,500 square kilometers of cement, an area practically as vast as the Liguria Region. Analyzing a timeline of land consumption, between 2006 and 2021, Italy lost 1153 sq. kilometers of land, mostly to urban expansion. In practice, this means that 2 square meters of land are developed every second. So, what are the consequences? Development "waterproofs" land, increasing the likelihood of floods and heat waves. The loss of countryside, biodiversity and ecosystemic services amounts to nearly **€8 million in damage every year**.

This complex situation requires a careful analysis of the climactic impact forecast for Italy. Indeed, climate change will continue to amplify all issues related to hydrogeological risk. Italy has been exposed to rising temperatures, an altered precipitation regime, and longer lasting extreme phenomena, in general. The question, is how significant will these changes be? In its report on **"Risk Analysis. Climate Change in Italy,"** the **Euro-Mediterranean Center for Climate Change (CMCC)** describes a

general increase in annual warm and dry days and a decrease in rainfall (although with greater intensity and significant geographical differences).

The report indicates that maximum attention is required by **Italian cities** that are particularly exposed to heavy rainfall and flooding, especially in the **South**, where resilience to disaster is particularly low.

In the **Alpine and Apennine areas**, the expected rise in temperatures is driving the melting of snow, ice, and permafrost, while increasingly frequent, intense precipitation increases hydraulic risk for smaller basins (which flood before larger basins) and a greater risk of landslides in distinctly permeable areas.

In terms of the consequences of climate change on **water resources**, prolonged periods of drought are detrimental both to the quality and quantity of water available. The increase in average temperatures and the consequent issue of evaporation, in conjunction with the decrease in precipitation, will determine a marked reduction in waterflow over the coming decades, which has been estimated at 40% less in 2080.

Infrastructural Resilience

The strategy necessary to efficiently address this explosive blend of extreme events and hydrogeological instability must address a balanced combination of mitigation and adaptation activity to increase resilience, defined as the ability to innovate, and be ready

to prevent and manage change. In order to obtain the best results, these two activities must be implemented simultaneously. Mitigation is necessary to stem the emission of climate-altering greenhouse gasses and prevent their potential increase; adaptation must prepare society and its infrastructure for climate change. In particular, adaptation entails the fundamental support of geo- or climate engineering to correctly manage geographical areas.

A third fundamental activity includes scientific research and technological development, which improve our understanding of the climate system and its changes, allowing us to implement more efficient mitigation and adaptation measures. Therefore, the evaluation and analysis of hydrogeological risk, which determines risk by evaluating the interaction between its three components – danger, vulnerability, and exposition – is necessary for all infrastructure.

These actions focus – for a more efficient management of the climate crisis – on the issue of **resilient infrastructure**, which is of strategic importance to reduce the impact that extreme climactic phenomena can wreak in areas that are already exposed to hydrogeological instability. Infrastructure is crucial to support the economic and social development of urban areas, and although profoundly varied, it must be viewed as interacting and interconnected. Besides energy system infrastructure – dams, plants, electric networks, photovoltaic plants, and wind farms – roads, highways, bridges, tunnels, and ports are also particularly exposed to climate risk.

In a more detailed analysis addressing **transport infrastructure**, roads, highways, bridges, and tunnels are particularly exposed to potential damage by extreme climactic phenomena. **Roads** are particularly vulnerable to flooding, landslides, and windstorms. High summer temperatures and prolonged heat waves deform road surfaces, producing potholes and cracks. **Subterranean infrastructure**, such as **tunnels, galleries, and underpasses**, require even more attention due to the high risk of flooding in case of intense precipitation. The issue is particularly severe for certain works, such as road underpasses and **metropolitan train lines**, which in case of storms and flooding can be transformed into dangerous basins and canals for water discharge. Tunnels are also exposed to the danger of fires that increase with higher temperatures. **Bridges** are particularly exposed to the damage caused by extreme occurrences. They are subject to flooding, which can cause structural damage, windstorms, which can also damage the structure, and landslides that can destroy their pillars.

A range of different actions is required to prevent such damage. This includes appropriate design and maintenance of works, such as drainage water management, substitution of traditional road surfaces with porous asphalt that is also resistant to high temperatures, protection of coastal roads from sediment build-up, operations to stabilize land underneath railway infrastructure, and the adaptation of track spacing on railway bridges and roads over rivers

with a variable waterflow. Furthermore, such action must be accompanied by technological activity: real-time monitoring of climactic phenomena (weather stations, pluviometers, thermometers, hygrometers, anemometers), real-time structural monitoring of works (digital twin), and environmental monitoring.

In view of the long lifecycle of such infrastructure, operation and maintenance activity should be revised periodically (every 5-10 years), integrating all new data into climate resilience processes and project cycle management. Indeed, this line of action satisfies the recommendations described by the European Commission in the "Technical guidance on the climate-proofing of Infrastructure in the period 2021-2027" notice, which emphasizes the importance of the tools employed to analyze the vulnerability of existing infrastructure to climactic phenomena and dynamic updates.

Dams are especially susceptible to structural stress caused by climactic change. These enormous works are essential to contain extreme events that interest rivers by collecting water and subsequently releasing it during periods of drought. Dams are called to fight climactic change by producing renewable hydroelectric energy. They are fundamental both to ensure the integrity and reliability of the electric system and to provide water for various uses (drinking water, irrigation). However, dam gates and spillovers can be damaged by extreme events, impairing their ability to correctly manage heavy precipitation. In fact, dams are often rather old and require renovation and digitalization operations. Structural monitoring, remote operation, and continuous data evaluation services are particularly efficient in this context. Testing activity now includes the use of drones to verify the internal and external state of dams, increasing the general security of plants and optimizing maintenance processes.

The Impact of Extreme Events on Energy Infrastructure

A 436-page **ministerial report** entitled **"Climate Change, Infrastructure and Mobility"** examines all the **effects that extreme events can have on energy infrastructure**.

High temperatures have a significant impact on the availability of energy, as they influence both the processes and the operation of plants and systems. In fact, if air or water temperatures are not low enough to guarantee cooling, the operation and efficiency of both fossil fuel and electric plants may be compromised. Moreover, increased temperatures also have an impact on transmission and distribution systems, reducing the available supply of energy. And as heat waves may determine a reduction in wind energy generation, an increase in the temperature of river and sea waters can lead to the interruption of energy produced by plants that discharge water into these basins, due to regulatory limits.

Low temperatures and snowstorms lead to the formation of snow and ice deposits on transmission and distribution lines, which can cause their structural collapse; moreover, low temperatures also alter the efficiency of photovoltaic cells and reduce CPV system generation in solar plants.

Arid and warm climates favor the insurgence and propagation of fires, and high temperatures and flames damage infrastructure, while both **river and coastal floods** may damage generation plants and energy storage systems (often located near coasts to facilitate the transportation of fuel and the availability of water for cooling systems).

Finally, **windstorms** may also cause structural damage either via direct wind pressure or following the impact of debris on energy generation and distribution infrastructure. Moreover, power lines oscillate in heavy winds and may cause a short circuit if they come into contact, reducing system operativity.

How can these issues by addressed in terms of resilience? We must **develop energy infrastructure that takes the climactic risk** experienced over an entire lifecycle into account. Therefore, updated knowledge on risk factors must be included in all climate risk analyses. Clearly, statistical analyses of extreme annual values based on stationary climate data are no longer sufficient.

However, resilience mainly concerns existing infrastructure, which was built to standards that largely overlooked the effects of climate change. This infrastructure is subject to different impacts depending both on climactic phenomena and the specific type infrastructure. The importance of this issue is emphasized by the PNRR that requires "operations to ensure the climactic resilience of networks" and has allocated €500 million to improve the resilience of at least 4000 kilometers of the electric grid against extreme weather, as well as to reduce the probability of prolonged electric supply blackouts and limit the negative social and economic consequences in the affected areas.

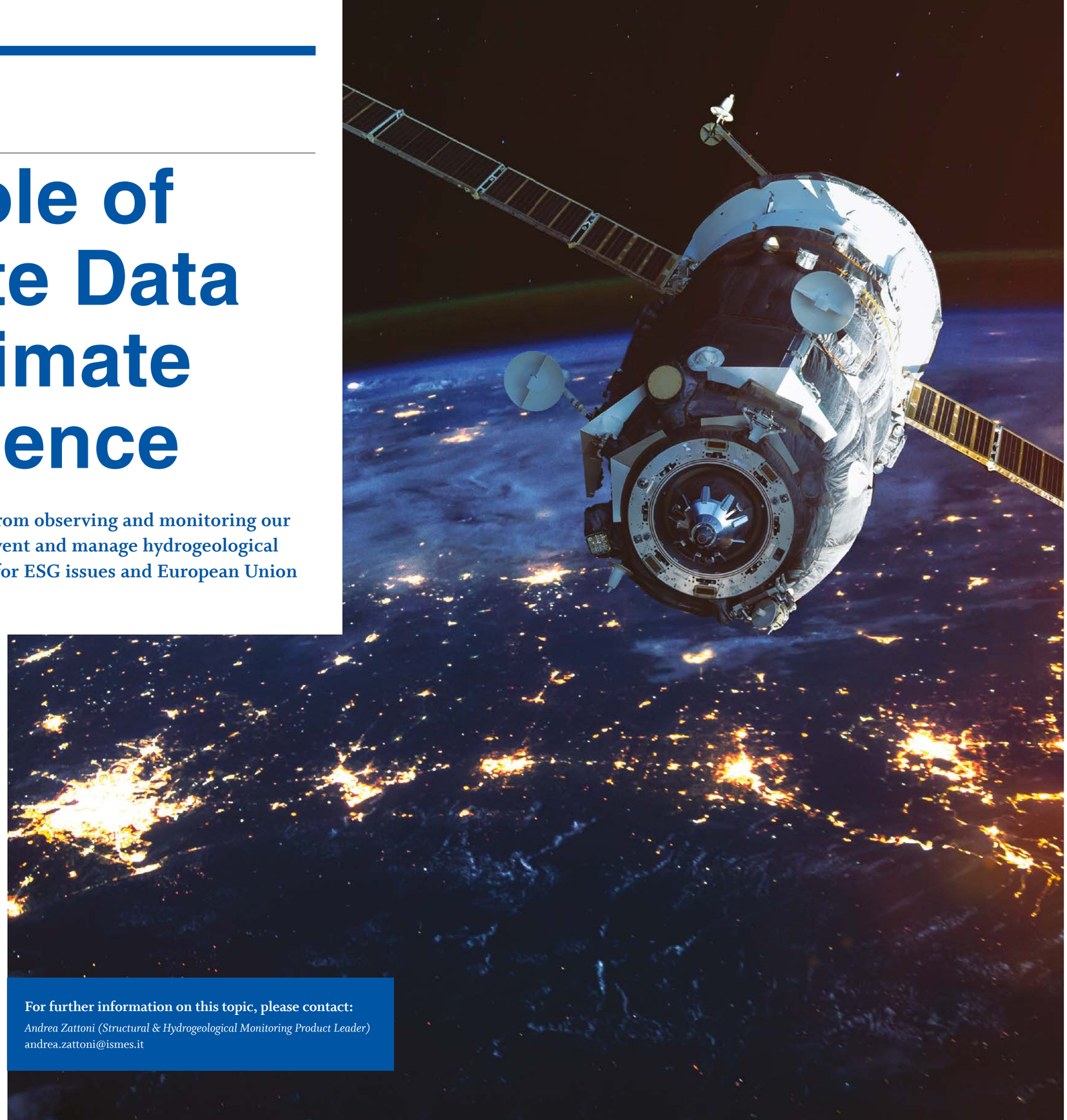
Top Story

The Role of Satellite Data and Climate Intelligence

The information we collect from observing and monitoring our planet is fundamental to prevent and manage hydrogeological and seismic events. Support for ESG issues and European Union Programmes.

Climate change is one of the main challenges that civilization will have to face in the 21st century. Satellite data has become a fundamental tool for monitoring the effects of global warming on Earth as it allows variables to be observed at a global level in real-time. If we look back, Earth observation satellites have played a crucial role in climate research, ever since the launch of the first meteorological satellite, Vanguard 2, in 1959. Today, so-called "climate intelligence" – that has emerged as a fundamental element on the financial panorama, too – is proving to be a valuable ally of companies and institutions. Using large sets of historical data, climate intelligence generates advanced forecast models that can be used to mitigate the impact of extreme phenomena and provide support to planning and managing activities.

In 2016, according to a study published by Nature Climate Change, 16.9% of global financial activities, corresponding to a value of ca. US$24.2 trillion, were considered at risk due to ongoing climate change. And, as of the same date, 76% of CEOs worldwide admitted to not being adequately prepared to face climate change. Based on the data released in 2020 by the United Nations, climate-related disasters have increased by 83% over the past two decades. Although the United Nations have provided information on climate-related risks since the beginning of the new millennium, many people have still not fully understood its possible impact. Immediate action is required to face the risks posed by climate change. However, the first step is to measure risk, and this requires credible climate data.



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Larry Fink, CEO of BlackRock (one of the largest investment companies worldwide), was one of the first to request that funded companies "divulge climate-related risk, in line with the recommendations of the Taskforce on Climate-related Financial Disclosures (TCFD)." The United Kingdom also published a roadmap defining similar requirements about the same time. These are clear signals that climate change is increasingly influencing corporate action and supply chains.

Support for ESG Issues

Technological progress, especially on the reduction front, has paved the road to previously unimaginable satellites. An example is CubeSat, a square satellite that measures just 10 cm per side. Its relatively low-cost, ease of management, and the greater availability of vectors to set satellites into orbit (especially low earth orbit: 160 – 1,000 kilometers from Earth) have ushered in a new space race, on account of the many possible applications of these satellites. Elon Musk's SpaceX is implementing Starlink, a network of thousands of satellites to extend Internet connectivity, while Kuiper Systems LLC, an Amazon subsidiary, aims to manage over 3,200 satellites. In addition, hundreds of start-ups are planning to launch their own satellites or are already testing them.

So, what about the climate? Currently, 50% of essential climate variables – key indicators of climate change on Earth – can only be monitored via satellite. Thanks to unprecedented technological progress, our tools for precisely monitoring climate risk now include open systems, edge processing, space-based systems, cloud computing and artificial intelligence. In this scenario, satellites are on the frontline to inexpensively and continuously collect large quantities of data. Besides supporting the development of predictive models, satellites can track extreme climate phenomena such as floods, fires, droughts, heat waves, and glacier

melting. Moreover, they also compensate for the lack of traditional monitoring tools (such as IoT sensors and forest rangers) which in certain contexts are more expensive and less convenient and efficient.

Over the course of a few years, satellites have provided information on the consequences of anthropic activity on the environment, also contributing to revealing a widening ozone hole. Today (in response to stakeholder pressure), enterprises are beginning to understand that climate intelligence is a fundamental resource to identify risk, especially in terms of ESG issues (Environment, Social, Governance). If it aids financial authorities in developing metrics and standards for climate information, then climate intelligence generates business opportunities. In fact, the climate crisis has led to an increasing demand for low-emission products and services, driving a market for sustainable innovation in the green economy.

We know that for companies pursuing social and environmental responsibility policies, lack of data represents a common obstacle. Therefore, climate intelligence plays a fundamental role in bridging this gap, providing information on company vulnerability to climate change, and on how to reduce carbon emissions. Indeed, satellites are also capable of measuring the quantity of carbon dioxide in the atmosphere and identifying the activities that produce it, such as the pollution caused by steelworks that can be identified by satellites through infrared sensors that quantify the heat released by steel production processes.

Satellites are also used to monitor the loss of methane from pipelines and oil wells. However, there is no single process to monitor greenhouse gasses. Their measurement requires a cross-analysis of various different data sources. Climate Trace, a non-profit that employs artificial intelligence to share the information collected by 300 satellites and 11,000 sensors around the world, has identified nearly 80,000 polluters, including oil wells whose emissions are three times the declared values. Measuring greenhouse gasses is therefore crucial, and this will require the extension and diversification of the satellite fleet monitoring these emissions.

Measurements in Europe

In Europe, a fundamental role is played by Copernicus, the Earth observation component of the European Union Space Program. The EU has established ambitious objectives for 2030: reducing greenhouse gas emissions by no less than 40%, increasing energy efficiency and the use of renewables, as well as committing to allocating at least 20% of the EU budget to climate action. The Copernicus Program supports these priorities, monitoring climate change and helping us to counter its effects. Thanks to a vast range of technology – from space satellites to terrestrial, marine, and airborne monitoring systems – Copernicus provides operative data and information services for a wide range of application areas, including action and adaptation to global phenomena such as climate change, land management, atmospheric pollution, and the state of oceans (including global rising sea levels).

According to Copernicus January 2023 data, 2022 was characterized by extreme climate phenomena ranging from extreme temperatures to an increase in greenhouse gas concentrations. Last summer was the hottest ever recorded in Europe and every boreal summer month was at least the third hottest globally. Overall, 2022 was the second hottest year recorded in Europe, while globally it was the fifth hottest. Over twelve months, there were the highest estimated emissions in 15 years in Europe and the UK due to forest fires (June-August). France,

Spain, Germany, and Slovenia registered the highest summer emissions due to fires in the last 20 years.

Copernicus also determined that, in July 2022, the extension of Antarctic sea ice covered an average area of 15.3 million sq. km., 1.1 million, or 7%, less than the average recorded for the same month over the previous three decades (1991-2020). Over the 44 years during which these measurements have been recorded, the value has never been so low during the month of July. Moreover, the report also addresses the prolonged heat waves that involved Pakistan and Northern India in the spring and central and eastern China during the summer, the extensive flooding caused by extreme precipitation in Pakistan during the month of August, and the relatively low temperatures and extreme precipitation in eastern Australia.

Satellite data is also fundamental to identify hydrogeological risk in Italy and prevent disasters. The Italian peninsula is exposed to seismic, volcanic, and hydrogeological risk (nearly 94% of all Italian municipalities are at risk). Eurostat reveals that damage due to hydrogeological instability amount to €2 billion per year. In February 2023, the government announced a "structural prevention" bill for seismic risk and hydrogeological instability that in addition to providing tools to simplify and accelerate procedures, will also seat a taskforce to coordinate and monitor the situation. In 2026, thanks to the PNRR, Italy will be able to exploit the Iride Satellite Constellation System to monitor geographical issues through constant monitoring in high resolution imagery. This will allow risk areas to be kept under control and contribute to the prevention of disasters. Moreover, the new Meteosat Third Generation Imager-1 (or Mtg-I) satellite is capable of providing fundamental information for the early identification of violent storms, as well as providing weather forecasts and climate monitoring. This data will improve forecasts from minutes to hours, allowing the situation to be determined nearly in real-time.

New Professional Profiles

In terms of employment, the focus on climate change and the importance of satellite data analysis to better understand the effects of climate change, have led to the creation of new professional profiles.

- **Satellite Climate Data Experts**: professionals who analyze data collected by satellites to provide information on the climate, including long-term changes, climate trends and extreme meteorological events.
- **Climate Modelling Specialists**: professionals who collect, analyze, and archive data from satellites and other sources to create climate models to forecast future conditions and better understand the effects of climate change.
- **Environmental Impact Analysts**: professionals who analyze the effects of climate change on communities and the environment, as well as developing strategies to mitigate negative effects.
- **Climate Engineers**: professionals who employ innovative technology to mitigate the effects of climate change, i.e., developing solutions based on renewables, water depuration systems, and energy conservation technology.
- **Climate Resilience Managers**: professionals who develop climate resilience plans for communities, including emergency plans for extreme climate phenomena and strategies for the reduction of greenhouse gas emissions.
- **Climate Communication Experts**: professionals who communicate the results of climate analyses and satellite data to the public, organizations, and governments in order to increase our awareness of climate change and necessary action.

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Industries & Countries

Climate Change: A Global Problem Demanding Innovative Solutions

A journey around the world to understand how extreme events caused by climate change affect different geographical areas and how strategies and policies are implemented to counter the climate crisis.

It is self-evident around the globe. Climate change interests every region on the planet, at every latitude. No country is immune from the consequences of climate change. As the polar ice caps melt and sea levels rise, some countries are affected by increasingly intense precipitation, while others suffer extreme drought and heat waves. Recent studies, reports, and environmental news reveal that climate change is affecting fragile territories in areas all around the world. The most dramatic consequence is that **3.3 billion people are highly vulnerable to climate change**, and the probability of death due to extreme climate phenomena has increased fifteenfold.

We must therefore strive to understand what is happening and how climate change is affecting different areas. In 2022, there were aproximately 29 major catastrophic climate-related events that claimed thousands of victims and caused billions of dollars in economic damage. These include 14 extreme weather phenomena (storms, hailstorms, and tornados), 6 floods, 5 droughts, 3 tropical cyclones, and a severe windstorm in Europe. The economic damage caused by these extreme events has been estimated at US$ 227 billion. Let's analyze this in greater detail.

Europe: Drought, Extratropical Cyclones, and Melting Glaciers

We begin our overview in Europe, which suffered two bouts of extreme heat and drought last summer, during June and July. The World Meteorological Organization has certified that **2022 was the hottest year on record since 1800 in Italy** with over 3.5 degrees above the pre-industrial average. Drought has exacerbated the **water crisis of the Po River** in northern Italy, a situation that began in December 2020, and has affected both agriculture and agribusiness in the Po Valley. Indeed, the Po River District Basin Authority is not only concerned by the water crisis of the longest river in Italy per se, but also for connected security issues. Concentrated, intense precipitation following long periods of drought can determine a condition of **water stress that affects security structures such as river embankments**. And forecasts for the summer of 2023 are even more alarming. The Regions of Lombardy and Piedmont experienced little snow and even less rain during the autumn and the winter. So, the Po River water level is already below last year's level.

Drought, which has significantly reduced available water, is further compounded by the poor conditions of the **water distribution system** in countries like Italy. According to a 2021 study conducted by ISTAT, Italy loses 42% of the water it introduces into its distribution infrastructure: 3.5 billion cu. m. of water are lost on a total of 8.2 billion cu. m. This means that only 4.7 billion cu. m. of water are effectively used. The issue is especially extreme in southern Italy, where the situation is critical in various cities. Catania ranks last with 54.7% of water loss, followed by Bari (51.2%), Cagliari (48.4%), Palermo (45.7%), Reggio Calabria (46.6%) and Messina (46.6%). The situation is better in the north, which has the lowest water loss percentages: Milan (18.7%), Bologna (28.3%), and Turin (32.6%). Rome fares worst amongst large cities with 45.1%.

Various activities can be implemented to stem this issue, including the **analysis of water loss in the distribution infrastructure**, the definition of **mitigation measures** to improve system efficiency, and the use of i**nnovative digital technology to monitor infrastructure and improve resilience**.

As water is the most important natural resource on our planet, and its availability is threatened by climate change, European agreements – from the National Strategy for Sustainable Development to the National Adaptation to Climate Change Plan – are focusing on water loss as a top priority. In fact, many tenders and contracts are planned to modernize and streamline the water distribution system in order to curb water loss, especially in southern Italy. The Italian Ministry of Infrastructure and Sustainable Mobility is funding works to remedy water loss in five southern regions: Basilicata, Calabria, Campania, Puglia, and Sicily.

The rest of Europe also suffered drought and extreme heat waves. Last July, **Portugal registered a new national record temperature, 47° C**. For the first time, the United Kingdom experienced temperatures above 40° C. In Norway, temperatures reached 44° C in various areas, while Tromsø, the third largest city in the Arctic Polar Circle, experienced a temperature of 30° C. According to the European Drought Observatory, by mid-August, half of the **European continent was affected by a heat wave**. The economic damage caused by this extreme phenomenon is estimated at billions of US dollars, primarily in the agricultural sector, infrastructure, and buildings, and especially in Spain, Italy, France, and Hungary. Moreover, the drought caused a **threefold increase in fires (compared to a sixteen-year average)** which devastated over 400,000 hectares of fields and forests, an area roughly equivalent to the Valle d'Aosta Region.

Climate change is also to blame for the **rapid melting of Alpine glaciers**, a further element with serious consequences on the environment and local communities due to the increased risk of landslides and avalanches. Indeed, on July 3, 2022, an enormous serac from the **Marmolada** detached from the glacier. On the day of the natural disaster, the temperature on the glacier was **10° C**, which allowed water to melt and erode the glacier, making it increasingly unstable.

While climate change causes heat waves and drought, it is also responsible for **floods**. In February 2022, **extra-tropical cyclone Eunice** ravaged northern and central Europe with strong winds and storms. This devastating weather front caused the death of 16 people and US$4.3 billion in economic damage in Belgium, Germany, Ireland, the Netherlands, Poland, and the United Kingdom. Amongst many other consequences, thousands of people were left **without electricity**, while flights, ferries, and rail services were disrupted both in the United Kingdom and Germany. And this was not an isolated case. According to a study published by Iop Science, in addition to North America, Europe is also now experiencing extra-tropical cyclones with intense precipitation. This phenomenon is expected to increase threefold by the end of the century unless greenhouse gasses are contained. And the forecast is particularly alarming in view of the fact that cyclones are responsible for large-scale flooding causing serious damage to infrastructure and significant economic loss.

Climate action is at the heart of the **European Green Deal**, the package of measures that aims to reduce greenhouse gasses and achieve "Net Zero" by 2050, as well as drive investment in research and innovation, and safeguard the natural environments of Europe. Climate policy is fundamental to pursue concrete action. In 2021, Europe's new **Climate Law** mandated climate neutrality and the 2050 "Net Zero" objective throughout the European Union, also establishing an intermediate goal for the reduction of emissions, 55% by 2030.

Europe is one of the most advanced global regions in terms of **cross-border cooperation for adaptation to climate change**, especially when it comes to transnational river basins. It is a global leader in the supply of **rapid and efficient alert systems, which protect nearly 75% of its residents**. And various European countries have already adopted action plans to contrast the effects of extreme heat on human health.

Moreover, the entire **Mediterranean area** is under special surveillance. It has been defined a **climatic hotspot** by the International Panel on Climate Change as it is one of the most vulnerable global regions in terms of meteorological impact. The key element of the Mediterranean, an area that will grow increasingly hot and dry, is its sea, which is turning into the **fastest warming sea, globally**. The main issue is the exposition and **vulnerability of Mediterranean basin cities**. According to a recent MedECC (Mediterranean Experts on Climate and Environmental Change) Report, the Mediterranean area, which is home to 500 million people, is the second area most impacted by climate change, globally, after the Arctic. The understanding of the impact of extreme climatic phenomena on Mediterranean cities has driven **Euro-partnership policies**

to define new actions to reinforce interregional and international cooperation with the aim of mitigating global warming and promoting the development of a sustainable economy, digital transformation, and the civil protection of settlements.

North America: The Devastating Impact of Hurricanes

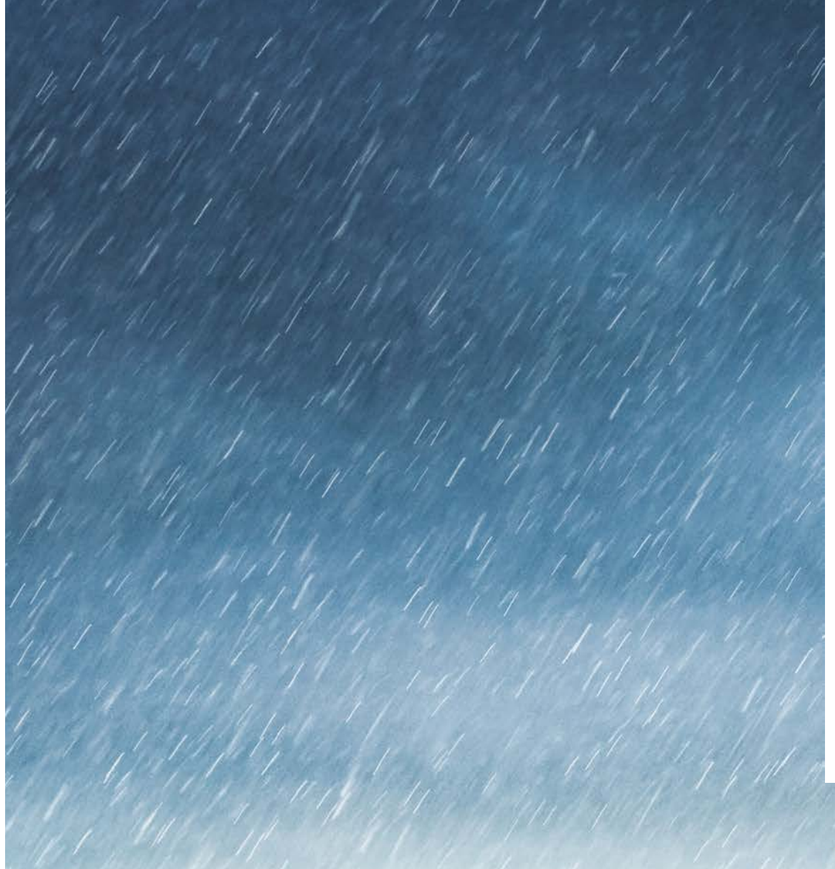
The most devastating climatic phenomenon in the United States, in 2022, was Ian, a **hurricane** that struck the southwest with winds exceeding 240 km/hour and caused vast flooding in Florida. However, there also were **stifling heatwaves** in the Midwest, **rising ocean temperatures** along the Northeast coast, and **fires** in the West. In 2021, the United States Government had already monitored 20 disasters related to extreme events caused by climate change that cost the country US$145 billion in damage. Unfortunately, these events are increasingly frequent and harmful. Over the past four decades, the United States has suffered on average US$7.7 billion in yearly damages. However, the situation has precipitated over the past five years, with the average count of extreme events climbing to 18 events a year.

The alert launched in the last report published by the United States Global Change Research Program (USGCRP) lists various critical elements. Since 1970, temperatures have risen by 2.5° F above the global average (except Alaska), sea levels have risen sharply, more than anywhere else around the world, and violent precipitation has increased along with extreme temperatures and serious floods.

These changes pose **a risk to the availability of drinking water**. Indeed, as sea levels rise, salty water seeps into aquifers, and not only. The study also measured how the frequency of climatic disasters causing billions of dollars in damage has increased, surging from once every four months in the 1980s to once every three weeks, at present.

According to the 2021 Report by the United Nations Department of Economic and Social Affairs, forest fires in the United States have increased by 40% over the past 30 years, and the phenomenon is forecast to escalate even further due to rising temperatures.

The **Inflation Reduction Act**, the most important climate bill ever approved in the United States, was ratified last summer to fight climate change. Its objective is to **decrease emissions by 40% by 2030**. Moreover, it allocated over **US$300 billion** for investments in the energy and climate transition. In particular, the bill also includes US$60 billion towards investments in renewable energy infrastructure, especially the production of solar panels and wind turbines. Tax credits will also be provided to incentivize the purchase of electric vehicles and building energy performance certification.



South America: Drought and Floods

Torrential downpours struck various areas of Peru in January 2022, including its capital, Lima, while **droughts** in Brazil, in 2021 and 2022, caused a drop in **water reserves**, especially in the Amazon basin. In fact, many cities were forced to introduce restrictions on the use of water. The same is true in central Argentina which, in the last three months of 2022, experienced the lowest amount of precipitation in over 150 years. And this was further compounded by heat waves.

During periods with scant precipitation, drought alerts resound in regions that depend on **melting glaciers** for water, as regularly occurs in the Andes. However, many smaller glaciers in Bolivia, Ecuador, and Peru are expected to disappear completely over the coming decades, and this will pose a serious issue to both natural ecosystems and urban settlements. Furthermore, the rapid melting of glaciers can also cause water basins to overflow and cause serious flooding.

Changing precipitation models has an impact on food security, the production of hydropower, and the management of water resources. However, South American countries are finally introducing mitigation measures. In Brazil, the government headed by Lula da Silva – re-elected President on January 1, 2023 – immediately focused on fighting climate change, making it a fundamental priority to ensure the future of the country. The first measures to be implemented address the reintroduction of protected areas in the Amazon rainforest. Good news also arrives from Colombia, where, following the 2022 election, Gustavo Pedro's government announced the intention to free the Columbian economy from fossil fuels.

Asia: Catastrophic Floods in Pakistan and China

Asia is an enormous continent that is experiencing increasingly frequent climatic catastrophes and vast damage. Between June and September 2022, **Pakistan** suffered the worst climatic disaster of the year, defined a **biblical flood** by Prime Ministers Shehbaz Sharif. The floods, which led to the death of 1700 individuals, left more

than 7 million people homeless, and caused US$30 billion in damage due to intense rain, with precipitation increasing by over 37% compared to the average monsoon season. In the same period, between June and September 2022, various **Chinese regions** also suffered **violent flooding** that caused ca. US$12.3 billion in damage. According to a study published on scientific journal "Advancing Earth and Space Science," China is at the greatest risk of violent flooding globally, although such phenomena also affected Nepal and Bangladesh in 2017.

In **India**, between March and May 2022, Delhi suffered five **heat waves** with record temperatures reaching 49.2° C. Another alert signal was delivered by the 2021 Report from the United Nations Environment Agency that highlighted how **sea levels** in southern Asia have risen by 5 mm/year in the last few decades, a rate double the global average, a situation which poses a concrete risk for all sea-level settlements, such as Bangkok in Thailand.

Good news in the fight against climate change comes from China which, in only seven years, has reduced atmospheric pollution almost as much as the United States have over the last three decades, according to a study Energy Policy Institute at the University of Chicago, contributing to lowering average global smog levels from 2013 to 2020. In order to shed the contradiction of being the greatest global polluter, but also the greatest producer of green energy, **China has officialized its intention of achieving carbon neutrality by 2060**.

More, in general, Asia's interest in the ecological transition is clear. Renewable energy represents 40% of global energy investments to 2025, and Asia is a frontrunner in this sector. Its **installed renewable capacity is 45%**, against 25% in Europe and 16% in North America. The International Energy Agency forecasts a **strong growth of the green energy sector** in the coming years, with Asia expected to provide 64% of new renewable energy supplies by 2040.

Africa: A Lack of Resources for Climatic Adaptation

According to IPCC, from the pre-industrial era to date, Africa has played a very minor part in the emission of greenhouse gases. Nonetheless, the African continent is one of the most affected by the climate crisis in terms of reduced food production, decreased economic growth, lack of water, and the loss of biodiversity and human lives. An example is provided by the **violent flooding** that affected **South Africa** on April 8-15, 2022, which led to the death of 459 individuals, left 40,000 homeless, and caused US$3 billion in damage. Southeastern Africa experienced **tropical cyclones** that devastated **Madagascar**. Between 2019 and 2022, Eastern Africa faced one of the worst **droughts** of the last decades, which was especially severe in **Kenya**, **Ethiopia**, and **Somalia**, while, in 2020, floods in Western Africa were caused by **torrential downpours** that paralyzed **Niger**, **Nigeria**, and **Senegal**. In 2019, **Mozambique** counted one thousand dead and thousands of homeless in the wake of **Cyclone Idai**.

The outlook is not positive for Africa. Every tenth of a degree above the 1.5° C threshold set for global warming will lead to increasingly violent repercussions on African society and ecosystems. At the regional level, rapid urbanization, the lack of infrastructure, and population growth are factors that increase climate risk for people, goods, and what infrastructure there is. The phenomenon is particularly serious in low-lying coastal areas that will be exposed to rising sea levels over the next 50 years. **By 2030, over 110 million people will be affected by rising sea levels**, a figure that will rise to 190-245 million by 2060.

The IPCC has reviewed the main **obstacles to climate change adaptation in Africa, which are especially of a technological, institutional, and financial nature**.

Adaptation is expensive and billions of dollars are still missing from the funds that the global community promised Africa. Even climate research lacks data, funds, and organization in Africa. Public and private funding must be immediately increased to drive development projects for adaptation and planning, addressing social welfare, public works, and healthcare.

Oceania: Flooding Threatens Low-Lying Islands

Between February 23 and the early days of April 2022, **violent flooding** affected many areas in Eastern Australia, leading to 27 deaths and US$7.5 billion in damage. In Queensland and New South Wales, in just one week in March, it **rained** as much as it normally does in one month. And, at the beginning of April, Sydney also experienced torrential downpours.

Forecasts indicate that without a significant reduction in carbon emissions, by the end of the century, these events could become 80% more likely throughout Australia. Indeed, the increase in temperatures sparked off by climate change is causing **rising sea levels and ocean acidification**. According to the United Nations, the sea level has risen by ca. 3.7 mm/year in the past decades, three times the global average. And in some areas of Oceania, this process is already threatening low-lying islands, infrastructure, and coastal communities.

What policies have been implemented to combat climate change? At the end of October 2021, for the first time, Australia declared that it would join the drive to achieve **complete decarbonization by 2050**, investing in technological mitigation solutions such as carbon dioxide capture and solar geo-engineering systems. The latter shoots reflecting particles into the stratosphere to increase the ability of clouds to reflect solar radiation, thereby lowering the temperature of the planet.

In conclusion, it is evident that climate change is a complex and transversal phenomenon that concerns the entire planet and all types of human activities. It cannot be countered with ordinary tools. Scientists and policy makers seem to agree on one point: **extreme climatic events require innovative tools, policies, and investments** to guarantee the fundamental conditions for humanity and life on Earth.

Future & Technology

Engineering and Climate Change: Addressing Hydrogeological Instability

ISMES (a CESI Group Company) employs monitoring systems and ad hoc design solutions, also based on deep learning and artificial intelligence, to manage critical infrastructure and geological issues.

Although the Italian Institute for Environmental Protection and Research (ISPRA) regularly publishes detailed maps for all risk areas with specific danger levels for landslides, floods, and earthquakes, 94% of Italian municipalities are at risk of hydrogeological instability and this data is not always correctly interpreted. Notwithstanding the available information, new works that **eliminate natural defenses, promote hydrogeological instability, and worsen critical conditions** continue to be erected. Many areas in Italy – from Sarno to the Cinque Terre, from Senigallia to Ischia – have suffered disastrous landslides and floods. The Italian peninsula is naturally at **high risk of landslides** (accounting for more than a quarter of the European total), as well as **floods, earthquakes, and volcanic eruptions**. And these natural issues are further compounded by real estate speculation.

Hydrogeological instability is a chronic national emergency that is being intensified by climate change. In addition, the data that emerges from the recently published **6th IPCC Report** (Intergovernmental Panel on Climate Change, United Nations, February 2023) underlines the growing danger posed by climate change with consequences that occur more rapidly than we can adapt to them. Adaptation policy was also addressed by a 2022 report produced by the **"Climate Change, Infrastructure, and Sustainable Mobility Commission"** of the Italian Ministry of Infrastructure and Transport. Based on analyses of climate evolution – pointing to a substantial increase in the frequency and intensity of extreme climate phenomena in Italy – ministry experts cautiously estimated that the direct economic impact on infrastructure caused by extreme climactic events (heat and cold waves, drought, fires, river and coastal floods, and windstorms) would cause damage for 2 billion euro a year in 2030 and **ca. 5 billion euro a year by 2050**. This is a twelvefold increase over current climactic damage (and this figure doubles if we take into account the systemic impact of infrastructural damage).

In order to optimally manage existing infrastructure and make it more resilient to climate change, the authors of the study indicate various types of adaptation that can be implemented in parallel to mitigation activity. These include, so-called hard measures – **structural and technological activities** – based on physical operations and construction work to make infrastructure exposed to extreme events more resilient. Then, there are green measures or **nature-based actions that exploit the many benefits provided by ecosystems to improve resilience and adaptation**. Another typology addresses soft adaptation activity, which includes monitoring (data, models, forecasts), and political, legal, social, management, and financial measures, that help **governance to increase awareness** of issues related to climate change.

The majority of transport infrastructure in Italy was developed in the wake of the second world war and currently requires thorough **monitoring and assessment, especially for bridges, viaducts, and galleries**, to guarantee its safety and soundness. Although, the understanding that maintenance is fundamental to prolong the lifespan of bridges, until 2020, there was no official classification and management of risk system for public infrastructure. This changed following the tragic collapse of the Morandi Bridge in Genoa. The Ministry of Transport and Infrastructure introduced more severe and demanding regulations to guarantee

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the safety of bridges. Since then, new guidelines based on six assessment levels have been adopted to guarantee uniform inspection methods. So, while Italy has the know-how, as well as new funds, to address this type of risk, monitoring activity must still be optimally scheduled. In this context, **technology and monitoring systems play a key role**, especially in a country with such a peculiar geographical conformation.

Engineering for Risk Assessment

In order to contrast hydrogeological instability in Italy – and provide operative and reliable solutions to the critical issues described above – the **CESI Group has decided to focus on the skillset of its subsidiary, ISMES**, a company entirely dedicated to civil and infrastructural engineering, headquartered in Seriate, in the Province of Bergamo. Thanks to its integration with Istedil, a laboratory for construction material certified, **ISMES activities embrace the entire lifecycle of complex infrastructure and geographical management**. "Our strength," explains ISMES Director General Francesco Carnevale, "is being a company with a dedicated group of 70 professionals, including engineers, geologists, and technicians, capable of defining the area to be monitored, designing and developing monitoring systems, and providing all the engineering support required to analyze and interpret the collected data. Moreover, our portfolio is based on services for land protection. ISMES ranges from the **design and installation of sophisticated systems for monitoring hydrogeological phenomena** (such as landslides and other common geological issues) to **remote assistance and the interpretation of collected data** to timely identify any anomalies, provide early warnings, and activate community evacuation procedures."

ISMES bases its engineering solutions on solid and transparent design activities to consolidate and improve land protection, safeguard the environment and the morphology of water courses, and recommend action for the consolidation and safety of large infrastructural works, such as viaducts, dams, and the railway network. In this context, **ISMES has designed and developed monitoring systems for two dams in Chile**. Monitoring of the **Rapel Dam** – a double curvature arch dam with a maximum height of 112 meters, a crown length of 350 meters, and a production capacity of 377 megawatts – required the installation of new tools to monitor dam body movement and measure the drainage network, the dam reservoir level, and the main meteorological parameters. For the **Pangue Dam** – a structure in rolled compacted concrete (RCC) with a maximum height of 121 meters, a crown length of 450 meters, and a production capacity of 467 megawatts – ISMES designed and installed an automated monitoring system composed of two data acquisition units connected both via fiber optic and wireless systems. Both are integrated into a data management system that **allows engineers to assess the behavior of each dam in real time**.

With regard to plants producing electric energy from renewables, ISMES designed and developed a system to monitor the meteorological parameters (temperature, wind, and exposure to solar radiation) along the perimeter of the **Ituverava Solar Plant**, in the state of Bahia (Brazil), a plant with a surface of 579 hectares, equivalent to 700 football fields, and 850,000 solar panels capable of producing 550 GWh of energy. "The aim of the system," explain the technicians, "is to assess the possible influence of the plant on local climactic conditions, in terms of residents, flora, and fauna. Besides installing the automated monitoring system, composed of six stations located in the vicinity of the main residential areas, we also developed a **model of the temperature and wind trends**, and subsequently used this data to calibrate the model and analyze the microclimate."

Structural Analysis of Major Infrastructure

The structural analysis of major works is fundamental to guarantee the safety and resistance of its weight-bearing structures. The main objective is to **define the geometric dimensioning and the most suitable construction materials to develop a weight-bearing structure**, thereby guaranteeing the load resistance to which the structure will be exposed throughout its lifecycle. This analysis addresses both existing infrastructure and works under development. "Structural analysis," explains ISMES Director of Business Development Matteo Biello, "consists in identifying the mechanical resistance of the materials used for the structure, evaluating the loads that weigh on the structure (both anthropic and natural), defining a land-structure interaction model, and developing structural reinforcement measures. Analyses are both static and dynamic in order

to guarantee the development of structural elements that will resist and contrast any source of stress."

In terms of existing infrastructure, the aim is to improve its overall performance, **guaranteeing infrastructural security and prolonging its lifecycle**. For new works, instead, structural analysis allows us to define the dimensioning of elements to optimize the cost/benefit ratio, **guaranteeing maximum efficiency and structural security**. ISMES acted as owner's engineer for the development of the **Horizonte Solar Park**, one of the largest in Brazil, with an installed capacity of 103Mw and an annual productive capacity of 220 GWh. This entailed providing support to the client for the **evaluation, certification, and approval of all electric engineering projects** (both low and medium voltage), as well as for civil and environmental engineering. "Moreover," Biello explains, "we certified the solar park's substation project, including the evaluation of the SCADA management system for the entire plant. Besides project certification activities, we also **provided support for the environmental licensing phase**, acting as consultants for all requests made by the Bahia Bureau for the Environment."

In Brazil, ISMES was also involved in developing the project for **upgrading the Paranapanema dam scour**. The operation became necessary following high-intensity rainfall. The resulting overflow marked the urgency to adapt the dam outlets to the changing climactic conditions. The dam safety operation was conducted to increase the overall safety level of the dam.

Analysis of Seismic Risk

ISMES also conducts environmental and infrastructural seismic risk analyses to **reduce the vulnerability of existing structures and to design new earthquake-resistant ones**. "All of Italy," explains Carnevale, "is considered at seismic risk. All existing and planned infrastructure must be able to resist earthquakes without suffering significant damage. Seismic risk assessment is conducted by considering the interaction of three components: **danger, vulnerability, and exposition**. The adopted approach calls for the evaluation and quantification of these three components to define the risk." In particular, procedures include the examination of a site, the definition of seismic action, the geometric survey of the work, its structural analysis, the definition of the degree of vulnerability, and the identification of mitigation action that can reduce its degree of vulnerability. "ISMES uses the same approach – analyzing the interaction of danger, vulnerability, and exposition – to assess and define **hydrogeological risk and reduce the vulnerability of strategic structures and infrastructure** (highways, bridges, and overhead power lines). Assessment studies also provide a basis for the design of new and resilient works that can resist hydrogeological risk," explains Carnevale.

Monitoring and Prevention

With regard to innovative tools to improve prevention in this sector, ISMES is also at the forefront in the design and management of a series of digital systems that simplify the correct **interpretation of phenomena over time** (the behavior of a dam or monument or the effects of a meteorological event). Such systems are integrated with **Early Warning Systems** that automatically analyze the measurements collected by monitoring systems and employ algorithms to provide real-time assessments on the phenomena under observation. Used as tools to address climate change and reduce the risk of climate-related catastrophic events, these systems are based on the integration of efficient communication and the involvement of given communities to promote understanding of risk and guarantee constant preparation. Early warning systems are common in Europe, where they are employed to determine **risk related to heavy rain, floods, storms, forest fires, heat waves, and drought**. To operate efficiently, these systems require monitoring, modelling, and accurate forecasting of climactic variables.

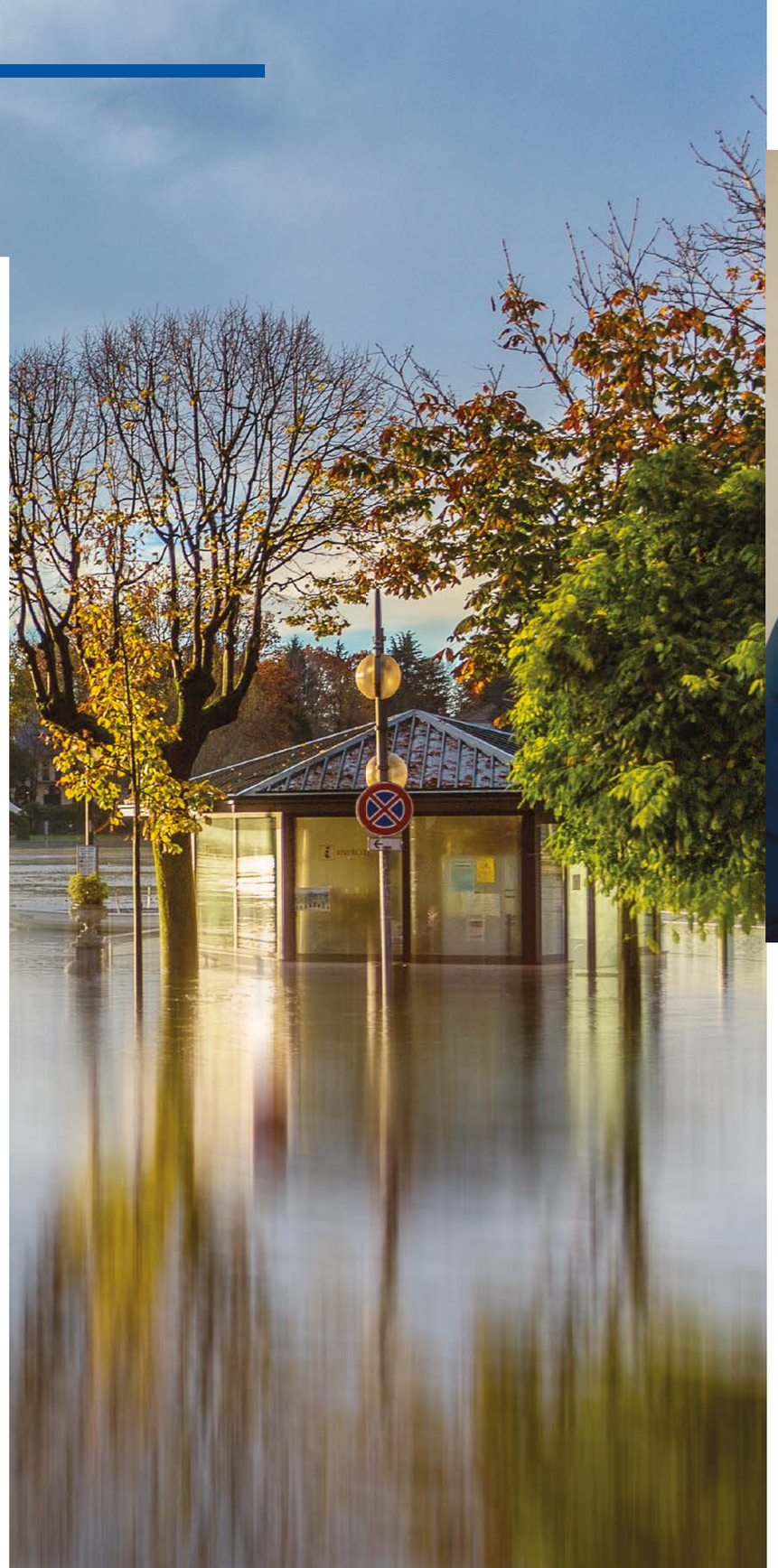
"The management of hydrogeological risk," points out the ISMES Director General, "is a priority that cannot be addressed in an unorganized manner. **It is fundamental to forecast the trends of phenomena to study and design all necessary actions.** Constant monitoring of our environment, using all available information, helps to define the correct priorities. In fact, the full enjoyment of our country is based on the mitigation of risk and the allocation of investments to these issues."

Opinions

Preventing Emergencies Is Better than Managing Them

With over 620,000 landslides surveyed, we are the European country that is most affected by hydrogeological instability. Every year – mainly due to irregular climactic phenomena and the development of urban areas – approximately one thousand landslides are initiated (or reactivated). And of these, a few hundred directly impact the population, urban centers, and the road and railway networks. While Stefano Laporta, ISPRA President, explains that nearly 2.5 billion euro from the PNRR will be allocated to manage flooding risk and reduce hydrogeological instability, Professor Giuseppe Spilotro, a geology expert, emphasizes the importance of structural operations and efficient governance, as well as correct maintenance and the use of innovative technology.

The opinions expressed in the interviews are exclusively attributable to the responsibility of the interviewees and do not necessarily reflect the position of CESI.



Stefano Laporta

President, ISPRA and SNPA

Stefano Laporta has been the President of the Italian Institute for Environmental Protection and Research (ISPRA) since September 2017, after having served as Director General of the same Institute since 2010. As President, Mr. Laporta chairs the National System for Environmental Protection (SNPA), which brings together the 21 Italian regional environmental protection agencies as well as ISPRA. He is also a member of the National Civil Protection Operative Committee. Since November 2019, Mr. Laporta has chaired the Council of Presidents of the National Public Research Agencies (CONPER). Additionally, since 2017, he has coordinated the Advisory Committee of the National Inspectorate for Nuclear Safety and Radioprotection (ISIN), after having been Director of the Italian Nuclear Safety Authority from June 2011 to 2016.

1 What is the situation of hydrogeological risk in Italy?

With over 620,000 landslides surveyed, we are the European country that is most affected by this phenomenon. Out of the 1,000 landslides that are initiated or reactivated every year, a few hundred impact the population, urban centers, and the road and railway networks. According to the ISPRA 2021 "Hydrogeological Instability in Italy" Report, which is published every three years, nearly 94% of Italian municipalities are at risk from landslides, floods, and coastal erosion. Moreover, 18.4% of the national territory is classified as highly dangerous in terms of landslides and floods. This means that 1.3 million inhabitants, residing in the greatest risk areas (very high and high), are at risk of landslides, while 6.8 million are at risk of flooding in medium hydraulic hazard scenarios with a return period estimated at 100 to 200 years. Last but not least, over 560,000 buildings are at risk due to landslides and 1,500,000 due to flooding.

2 How does climate change affect our country's hydrogeological instability?

Climate change undoubtably has a significant effect on phenomena related to instability. As emerges from the IPCC Reports, Italy is located in the so-called "Mediterranean hot spot," an area that has been identified as particularly vulnerable to climate change. Indeed, climate change is driving an increase in the frequency of heavy rains and flash floods, which are extremely dangerous and destructive phenomena due to the rapidity of the event and the short alert time. Furthermore, the increase in temperatures at high altitudes is reducing permafrost, the perennially frozen layer of soil, with a consequent increase in slope instability and the deterioration of the soil and its capacity to store carbon.

3 What are the economic and social implications of hydrogeological risk and climate change? How can they be addressed?

The issue of hydrogeological instability is particularly significant in Italy due to its impact on the population, environment, cultural heritage, linear communication infrastructures, and the economic and business system. In the last 50 years, landslides and floods have caused over 1,600 deaths with an estimated damage of €1-3 billion/year. The National Plan for Adaptation to Climate Change, published by the Ministry of the Environment and Energy Security (MASE) last December, supports national, regional, and local authorities in identifying and choosing the most effective action and promoting the integration of adaptation criteria into planning processes and tools. Moreover, in collaboration with ISPRA, MASE has also developed the National Platform for Adaptation to Climate Change, a portal that provides information and raises the awareness of citizens and stakeholders on the issue of adaptation, as well as delivering data and tools to support authorities in decision-making processes. I am convinced that any plan, any decision, no matter how strategic, will never lead to concrete results without the active involvement of citizens. And this is why ISPRA has implemented the IdroGEO Platform that allows anyone to easily view, download, and share maps and indicators on landslides and floods, even from smartphones, thereby contributing to raising the awareness of risk in local areas and the resilience of society.

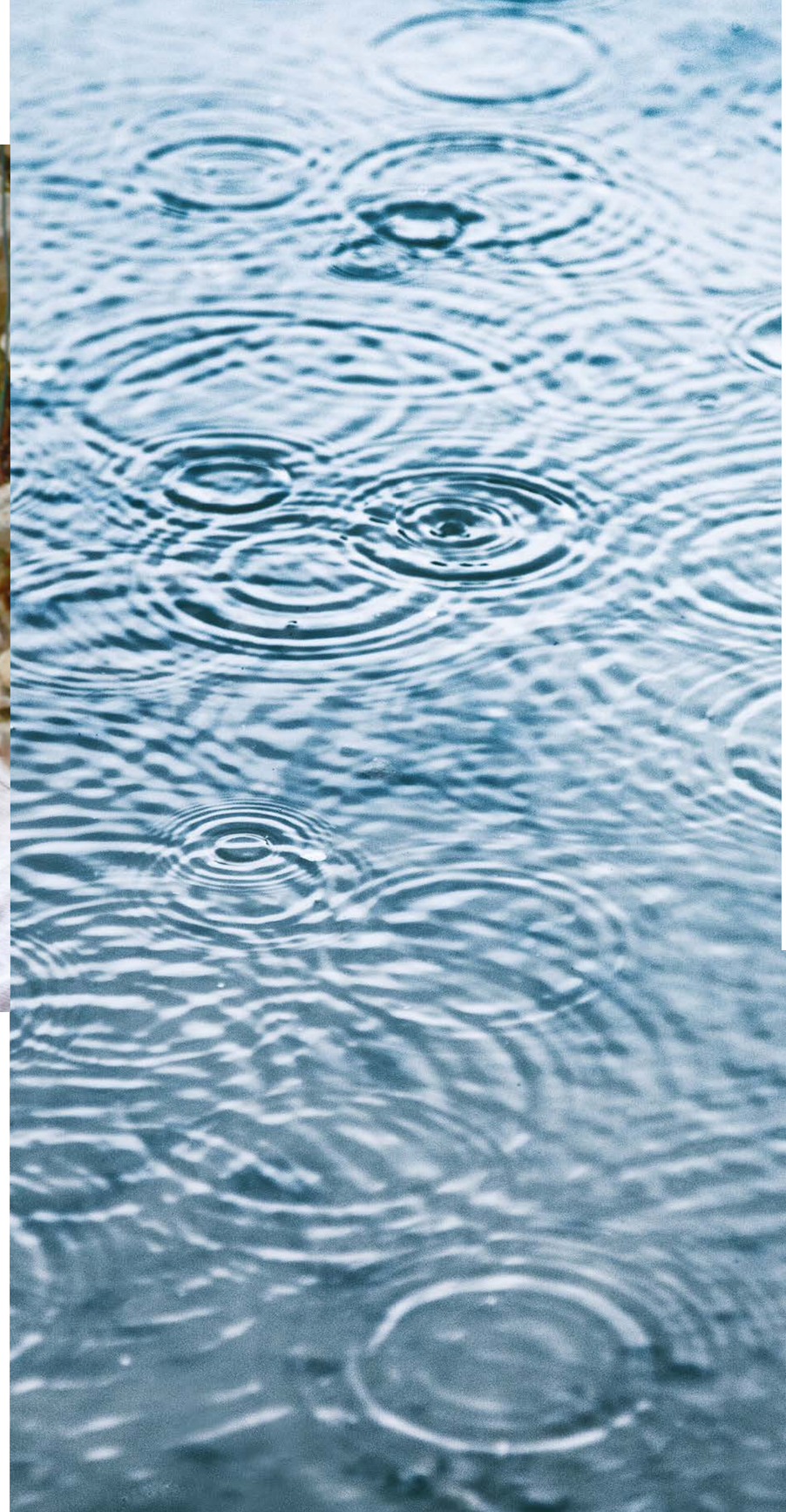
4 Has Italy implemented adequate solutions over the past ten years? If not, what is wrong?

If we analyze the data collected by the ISPRA Platform on the National Directory of Soil Defense Operations (ReNDiS), nearly 11,000 operations have been financed for over €10 billion by the Ministry of the Environment (from 1999 to today) and by the Department for Internal and Territorial Affairs (DAIT) of the Ministry of Homeland Affairs (from 2019). With regard to the implementation time of these actions – including the design, procurement, and construction phases – the average duration is almost 5 years. The PNRR has allocated €2487 billion to "Measures for the management of flood risk and for the reduction of hydrogeological risk," of which ca. €1.2 billion will be used for prevention by the Ministry of the Environment and Energy Security and another €1.2 billion will be managed by the Civil Protection Department to address risk situations and guarantee local territorial resilience to natural disasters. In terms of landslide monitoring, a few thousand events are currently being monitored with on-site instrumentation. As part of the PNRR, ISPRA, in collaboration with Italian regional authorities and those of the autonomous provinces, together with ARPA, has presented a technical proposal to monitor the most critical landslides affecting inhabited centers or linear communication infrastructures through the use of both surface and underground sensors. The aim is to assess ongoing trends, supporting the design of stabilization works, correct territorial planning, and the activation of population alert systems. Satellite data also provides a significant contribution to the analysis and monitoring of slow-moving landslides (i.e., those with an annual cumulative displacement of less than one meter). Tuscany, the Valle d'Aosta and Veneto have already launched a regional monitoring service using data collected by ESA's Sentinel 1 satellite constellation. The PNRR also calls for the implementation of the IRIDE Earth Observation Satellite Program, which will provide operational services for monitoring land and infrastructure deformation caused by landslides, earthquakes, volcanic eruptions, and other natural or anthropic causes. I therefore believe that we are working well, both at a technical-scientific level and in terms for funding for prevention and management works. However, we certainly need to ramp up this effort and aim to make operations structural and inspired by a logic of prevention, rather than the management of emergencies.

Giuseppe Spilotro

Professor of Hydrogeological Risk

Giuseppe Spilotro taught at the Faculty of Engineering at the University of Bari and was a Professor of Applied Geology at the University of Basilicata. Moreover, he served as National Coordinator and Operative Unit Director for a research project of relevant national interest (PRIN) on "Advanced Methodologies for the Assessment and Mitigation of Landslide Risk: Identification of Precursors, Forecast Models, and Cartography." Prof. Spilotro is currently an Associate Professor at the National Research Council (CNR) Institute for Environmental Electromagnetic Monitoring (IREA) in Bari.



1 *What is the current situation of hydrogeological risk in Italy?*

Before answering this question, we need to better understand the concept of hydrogeological instability. The term was officially introduced by the De Marchi Commission in 1974 to refer to "any disorder or situation of disequilibrium produced by water on or underneath the ground." The term eventually embraced all phenomena related to ground mass or particle imbalance, usually in conjunction with the action of water: erosion, landslides, floods, and sinkholes. Moreover, it is commonly extended to include coastal instability. A further premise is required. Namely, all hydrogeological instability phenomena are a part of complex systems and, with few exceptions, natural phenomena. They are all perfectly entropic phenomena, which means that a natural, dynamic, or complex system will evolve based on its sequential levels of energy. In other words, for example, a beach is an environmental system with sediment that has inferior potential energy to that of mountain or hill rock. Erosion and landslides that do not pose any danger or risk should not be contrasted as the production of sediment is essential to the life of lower beach systems. This leads to a further consideration; as part of a system of environments with different energy levels, hydrogeological risk and associated events must be carefully monitored in terms of time and dimension. Any operation on a basin or river course will have delayed effects on the coast, even years after its implementation. Given these premises, the state of hydrogeological risk in Italy, in its various components, is addressed by the biennial report published by the Italian Institute for Environmental Protection and Research (ISPRA). While detailed information is available on the Idrogeo Portal managed by ISPRA, in 2021, 90% of Italian municipalities were identified as exposed to risk. Moreover, 18.4% of the national surface (302,000 sq. km.) is in the highest landslide and flood risk category (55, 600 sq. km.), while 18% of low-lying coastline is undergoing erosion. ISPRA data also informs us that, from 1998 to 2018, Italy spent approximately €20 billion on damage caused by hydrogeological instability, while €5.6 billion were invested in projects and prevention works (ca. €300 million/year).

2 *What are the economic and social implications of hydrogeological risk and climate change? How can they be addressed?*

A premise is necessary in this case too. Our environmental system is already under pressure due to hydrogeological instability, independently of any climactic variation. Since 1970, legislators have ratified many different measures. Unfortunately, not all the available funding has been employed. In view of this, and the fact that on account of its nature and extension, hydrogeological risk cannot be totally eliminated,

preventive, and reparatory maintenance must concentrate solely where instability – even only potential – generates risk and danger. In practice, this requires feeding the biennial ISPRA summary reports into a single Dynamic Digital Twin (DDT, a dynamic and geo-referenced database of risk) that is updated through a constant real-time monitoring network. This would allow danger alerts to be circulated to citizens (i.e., via smartphone) and reference agencies (based on an operative unit model). In terms of technology, satellites, and low-cost sensors can be efficiently used to manage the danger generated by hydrogeological risk.

3 *Has Italy implemented adequate solutions over the past ten years? If not, what is wrong?*

This undoubtedly complex issue is managed by three ministries, regions with at least twice as many councilors and agencies, district authorities (recently extended from interregional to district basins), and a civil protection authority that is segmented amongst national, regional, and municipal authorities. This increasing disorder of highly evolved social systems (referred to as "entropology") has various consequences. The quick reconstruction of the Morandi Bridge was made possible by a technological miracle (in that case, we were prepared), as well as the cancellation of all possible counterarguments by the many involved parties. Indeed, the resistance of multiple parties often increases the energy necessary to complete an objective, also indefinitely delaying work completion. Moreover, danger may also be increased by inconsiderate anthropic activity. In Puglia, for example, the practice of removing rocks from the soil (and this includes boundary drystone walls) has also destroyed the soil's micro-endoreic ability to slow down surface runoff and improve aquifer replenishment. In short, we have associated hydrogeological instability and its management to two entropic processes, as the solution is based on this association. Energy loss can be remedied by restoring the initial state of energy, through external activity, to avoid a crisis. In terms of the environment, priority activity entails ongoing environmental maintenance to counter entropic decay. Railways and road networks call for constant ordinary maintenance to markedly reduce the need for extraordinary works. In the past, this system was based on a widespread network of rail and road maintenance stations with personnel in charge of daily monitoring the state of infrastructure and the surrounding environment. Today, sadly, maintenance is only implemented when degenerative processes become evident, and the state of danger has exceeded a certain degree of acceptable risk. This means the day before a landslide if everything goes to plan; unfortunately, more often it is the day after according to past experience. This situation is clearly unacceptable, especially in view of the act that environmental monitoring can now take advantage of well-established technology, such as LIDAR, laser, and satellite monitoring. Moreover, the latter can even exploit archives that extend fifteen years or more into the past. In terms of the second entropic process, the social one, the solution is even simpler. This basically requires the implementation of good management practices and culture. Critical issues must be correctly predicted and transferred to the pertinent responsible authority. Often, the process breaks down at this point. It is therefore necessary to transfer information to citizens so that, while they cannot move their houses, they can move themselves to safer places. The objective is not complicated; information must automatically and timely sent out to citizens that are potentially at risk via smartphone notifications: geo-referenced applications can alert citizens through green, yellow, and red-level alerts.

Conclusions

Climactic irregularity and urban development increase danger and risk, which must be mitigated through pertinent structural operations. Nonetheless, the priority is to remove bottlenecks and improve governance, which can be done with minimal cost. Maintenance, daily work, and technology complete the solution.

News & Events

Upcoming Energy Events

Hot Summers, Cold Winters

June 7 (11:00 am)

Paris (France)

www.iea.org

During the 8th AIE Global Conference (June 6-8) on energy efficiency, which will address the current global energy crisis and urgent climatic issues, there will be a conference dedicated to "Hot Summers, Cold Winters: Keeping People Comfortable" on June 7 at 11:00 am.

SVE36

June 11-14

Sacramento, California (USA)

www.evs36.com

The acceleration towards electric mobility is at the core of this event that brings together global electric vehicle producers to present innovation and revolutionary technology for electric transport.

Intersolar Europe 2023

June 14-16

Munich (Germany)

www.intersolar.de

This event, which focuses on photovoltaic markets, technology, and project funding, will analyze the photovoltaic trend in Europe and on single markets. A special focus will be dedicated to large-scale photovoltaic plants, especially in terms of Agri-PV and Floating PV.

European Sustainable Energy Week 2023

June 20-22

Brussels (Belgium)

www.interactive.eusew.eu

EUSEW is the largest annual event dedicated to renewables and the efficient use of energy in Europe. This edition will address "Accelerating the clean energy transition – towards lower bills and greater skills."

RE+ Renewing what's possible

September 11-14

Las Vegas (USA)

www.re-plus.com

RE+ is a rapidly growing energy event in North America. This year, it will address new technology and innovation in the renewables sector, including solar, wind, and storage solutions.

Zeroemission Mediterranean 2023

October 10-12

Rome (Italy)

www.zeroemission.show

This event brings together the main national and international stakeholders interested by the development of technology for the production of energy (solar, wind, and other renewables), electric storage, energy management, and distribution, electric grids, electric vehicles, charging stations, sustainable mobility, and relative infrastructure.

Shaping a Better Energy Future

CESI is a world-leading technical consulting and engineering company in the field of technology and innovation for the electric power sector. In particular, through its Division KEMA Labs, CESI is the world leader for the independent Testing, Inspections and Certification activities in the electricity industry. With a legacy of more than 60 years of experience, CESI operates in 40 countries around the world and supports its global clients in meeting the energy transition challenges. CESI also provides civil and environmental engineering services.

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