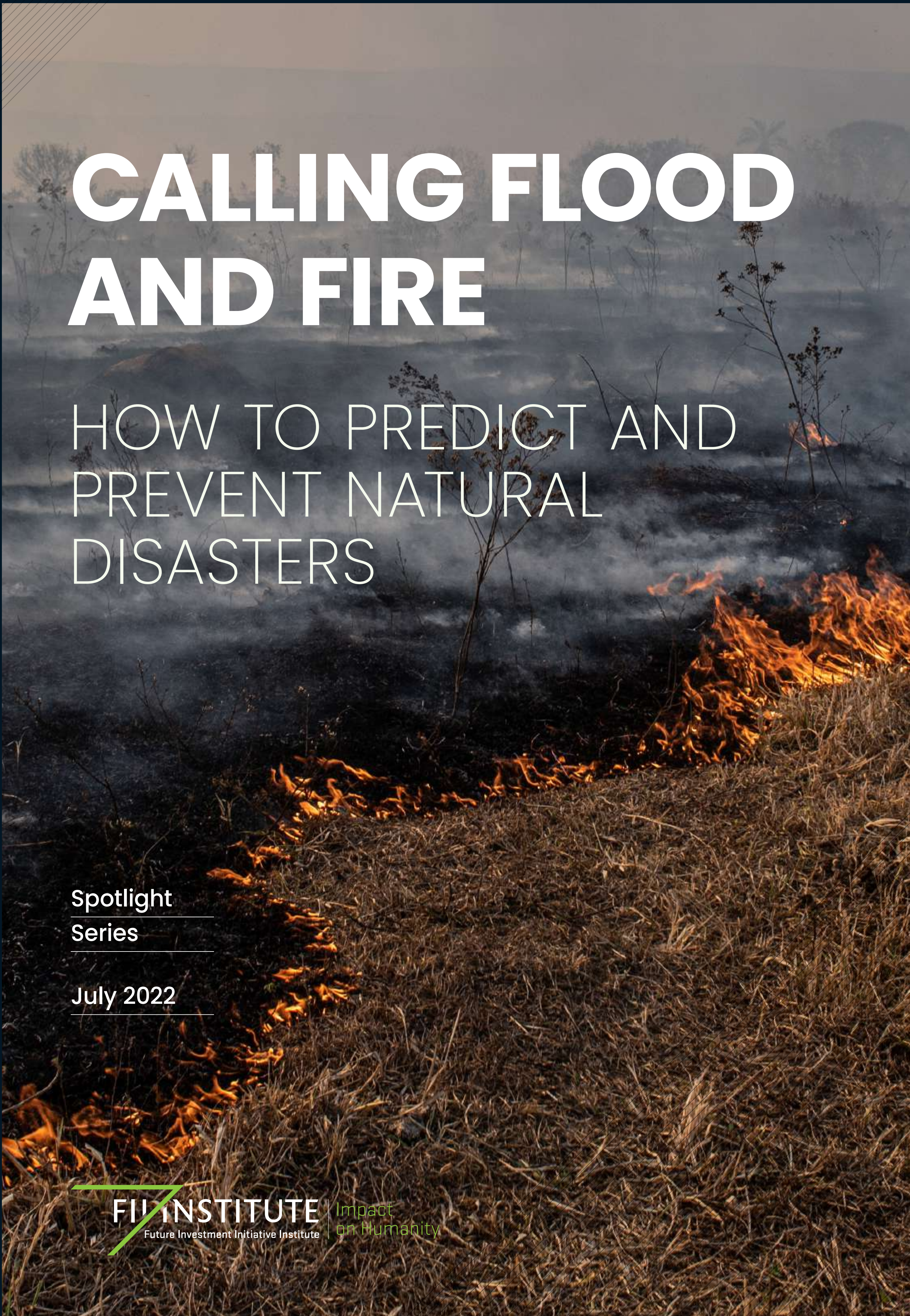
CALLING FLOOD AND FIRE

HOW TO PREDICT AND PREVENT NATURAL DISASTERS



Spotlight Series

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FII INSTITUTE
Future Investment Initiative Institute
Impact on Humanity

CALLING FLOOD AND FIRE

HOW TO PREDICT AND PREVENT NATURAL DISASTERS

There is a critical need for better understanding of the behavior of wildfires and the causes of floods – to prevent, if not the disaster itself, at least the loss of lives. To get there, we need a combination of data and science-based monitoring systems with indigenous knowledge, as well as stronger regional and international cooperation.

EXTREME WEATHER

The threat of death and destruction from wildfires and flooding is on the increase, and becoming far too close for comfort for many of those living near danger zones or within them.

Preventing fire and flood disasters is now one of the major challenges for scientists, environmentalists, governments, and civil societies. A recent UN report warned that "catastrophic wildfire events" could become 30% more common by 2050, and 50% more common by the end of the century, as a result of global warming and land-use change. The authors called for a "radical change" to the way governments tackle wildfires, with more focus on prevention and preparedness.[1]

"Current government responses to wildfires are often putting money in the wrong place. Those emergency service workers and firefighters on the frontlines who are risking their lives to fight forest wildfires need to be supported," said Inger Andersen, UNEP Executive Director.[2] "We have to minimize the risk of extreme wildfires by being better prepared: invest more in fire risk reduction, work with local communities, and strengthen global commitment to fight climate change."

The latest available data from global maps of areas where people and forests coexist show that an estimated 1.6 billion people live within 5 kilometers of a forest, with 64.5% located in tropical countries.[3]

Wildfires and floods are hardly new phenomena. Noah purportedly built his ark some 5,000 years ago for protection against a world-engulfing flood, while fire has been a dynamic ecological force for millennia, with the earliest recorded wildfire smoldering approximately 419 million years ago.[4]

So, what can be done to prevent such catastrophes in the future?

PREDICT. PREVENT. PROTECT: TECHNOLOGY ON THE DISASTER FRONT LINE

Wildfires and floods do not occur completely out of the blue, and better prediction tools are the most efficient short-term measures to reduce damage and, more importantly, human fatalities. When it comes to a flash flood, even a short warning time can avert disaster; and with wildfires, every minute sooner the source of a fire is detected increases the efficiency of firefighting, thus allowing more time for evacuation.

The latest developments in sensoring, imaging, and prediction technology (see graphic page 5) have certainly increased the chances to detect severe fires (and flooding) earlier, thus giving responders a fighting chance of, if not preventing a disaster altogether, at least of mitigating the damage.

Today, early fire detection in remote areas is typically done by satellite, but this can be hindered by cloud cover. What's more, even the most advanced satellite systems only detect fires once the burning area covers several square kilometers.[5]

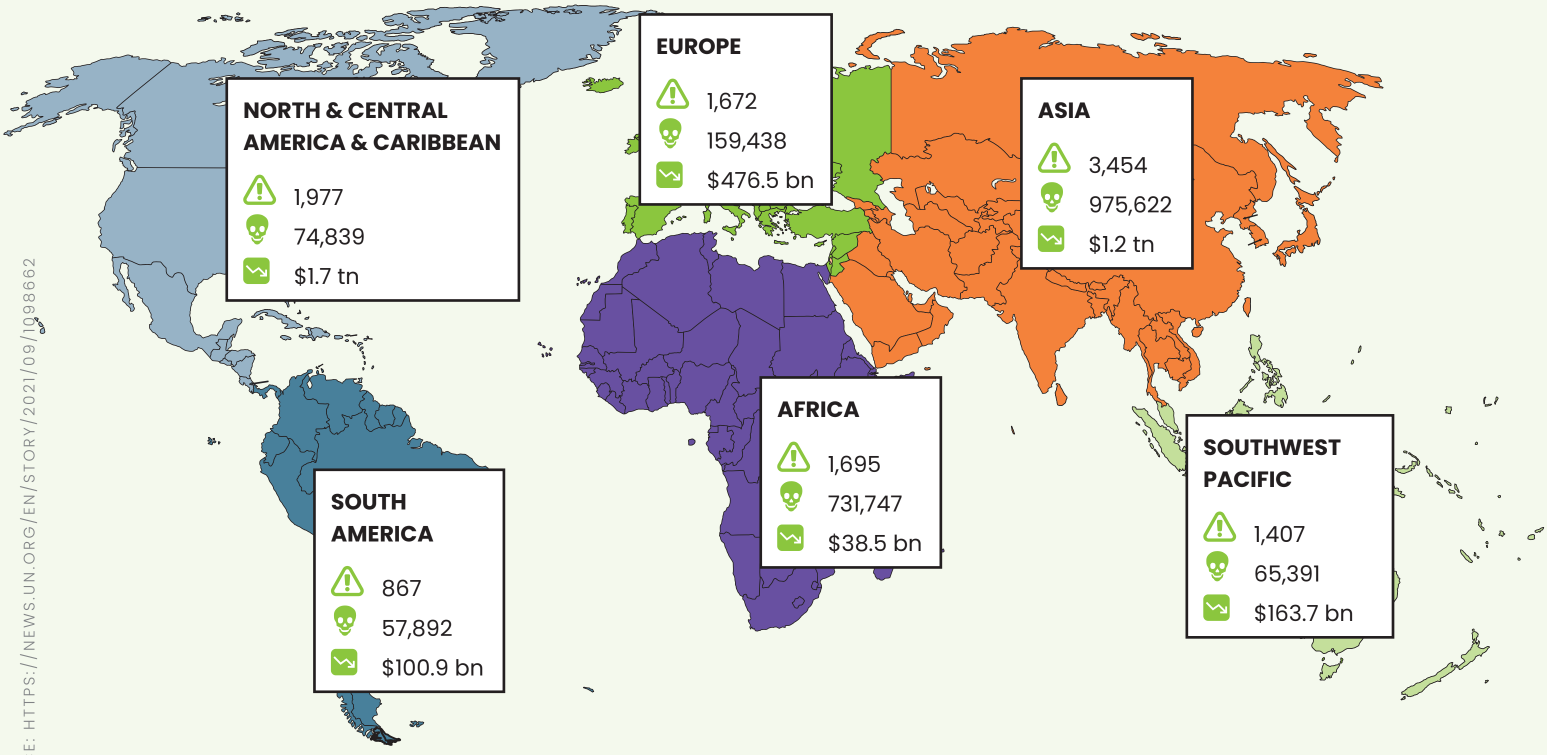
EARLY DETECTION

AI software can be used to detect budding blazes, as it can scour images from weather satellites delivered every ten minutes in search of signs such as smoke or shifts in thermal infrared data that could mean a fire has broken out. Algorithms that each look for different →

COUNTING THE COST: NATURAL DISASTERS

50 YEARS OF EXTREME WEATHER

Climate change and increasingly extreme weather events have caused a surge in natural disasters over the past 50 years, disproportionately impacting poorer countries, according to the World Meteorological Organization (WMO) and UN Office for Disaster Risk Reduction (UNDRR).



SOURCE: HTTPS://NEWS.UN.ORG/EN/STORY/2021/09/1098662

→ properties of a wildfire are run to determine if a fire is present. Should the algorithms reach consensus, the system sends a text alert to an authority's fire managers, providing the longitude and latitude the blaze and how to get there.

PREDICTIVE MAPPING

FireMap, an artificial intelligence-based platform developed by WIFIRE Lab, can in just minutes create a predictive map of a fire's expected trajectory. The system builds on deep learning techniques to crunch real-time data about weather, topography, and the dryness of vegetation with further data from satellites, on-the-ground sensors, utility cameras, and, more recently, a fixed-wing aircraft outfitted with infrared radars.

DRONES

Airplanes and helicopters used to survey wildfires and drop retardants can't fly after dark or in smoky conditions, or in too cramped a space. Flying over raging fires also puts pilots and crew at risk. Drones equipped with thermal imaging cameras can fly through the smoke, capturing high-resolution footage and other real-time data that can assist responders and their suppression efforts.

Australian scientists are now developing the country's first satellite designed to predict where bushfires are likely to start. This follows the country's catastrophic 2019-20 bushfire season that became known as "Black Summer."[6]

During Black Summer, an algorithm developed by the Royal Melbourne Institute of Technology (RMIT) used photos from a Japanese weather satellite, Himawari 8, to detect new fires. The detection system turned out to be "blindingly quick," say scientists.

Himawari 8 data centered on the North Coast IBRA region of New South Wales. It took the system only about 60 seconds to process the satellite photos and sound an alert, said Simon Jones, a professor at RMIT's Remote Sensing Research Group, who→

ILLUSTRATION: CHOKKICX /GETTYIMAGES; FLATICON helped develop the algorithm.

However, the total detection time still turned out longer, because Himawari 8 only takes one photo every ten minutes and the data initially has to travel through the Japanese meteorological service. Ultimately, there's a minimum half-hour delay built into the system.

Also, fires smaller than a few football fields might not get detected, because the resolution of the weather satellite photo is only about 500 meters per pixel. But the consensus was that RMIT's algorithm was often quicker than the traditional methods for detecting fires.

Another new solution for detecting wildfires earlier is to incorporate Internet of Things (IoT) sensors and a fleet of drones, or unmanned aerial vehicles (UAVs), which have proved able to detect fires of just 2.5 square kilometers with near-perfect accuracy.

SO WHAT CAN BE DONE TO PREEMPT FLOODING?

Flooding is viewed as the world's most costly type of natural disaster in terms of both property damage and human causalities.

Almost 2.4 billion people (about 40% of the global population) live within 100 kilometers of the coast, and over 600 million people (about 10%) live in coastal areas that are less than 10 meters above sea level.[7] Only 10% of the global population lives further than 10 kilometers away from a surface body of freshwater.[8] We can't live without water – but we have to protect ourselves against its evil moments. All those years ago, Noah could not prevent the Great Flood. Forewarned by a message from God, he set about protecting himself and his loved ones by building his ark.

Today, flood information is needed as quickly and in as much detail as possible to provide an overview of the situation that will improve crisis management and response activities.

ACCURATE FORECASTING

Since 2014, the European Space Agency has been operating a satellite constellation named Sentinel-1, with C-band synthetic-aperture radar (SAR) instruments. SAR imagery is useful for identifying inundation regardless of weather conditions and clouds.[9] Based on this data set, scientists correlate historical water level measurements with historical inundations, allowing them to identify consistent corrections to hydraulic models.

A critical step in creating an accurate flood forecasting system is to develop inundation

PHOTO: ANDREW MERRY /GETTYIMAGES, ANAND PUROHIT /GETTYIMAGES

ANATOMY OF **A WILDFIRE**

There are three components of a wildfire: **oxygen, fuel, and heat.**

Fuel, weather, and topography are the three main factors that determine how and why a wildfire behaves the way it does.

Ground fires burn up to a few feet underground in soils rich in wood fiber, and can smolder for weeks or months until conditions are favorable before emerging to the surface.

Surface fires are the main drivers behind wildfire behavior, burning up available fuel sources on the forest floor. In more severe conditions, surface fires can create heat and flame lengths significant enough to climb the ladder of branches and create crown fires burning along the forest's canopy.

Crown fires burn trees up their entire length to the top. These are the most intense and dangerous wildfires.

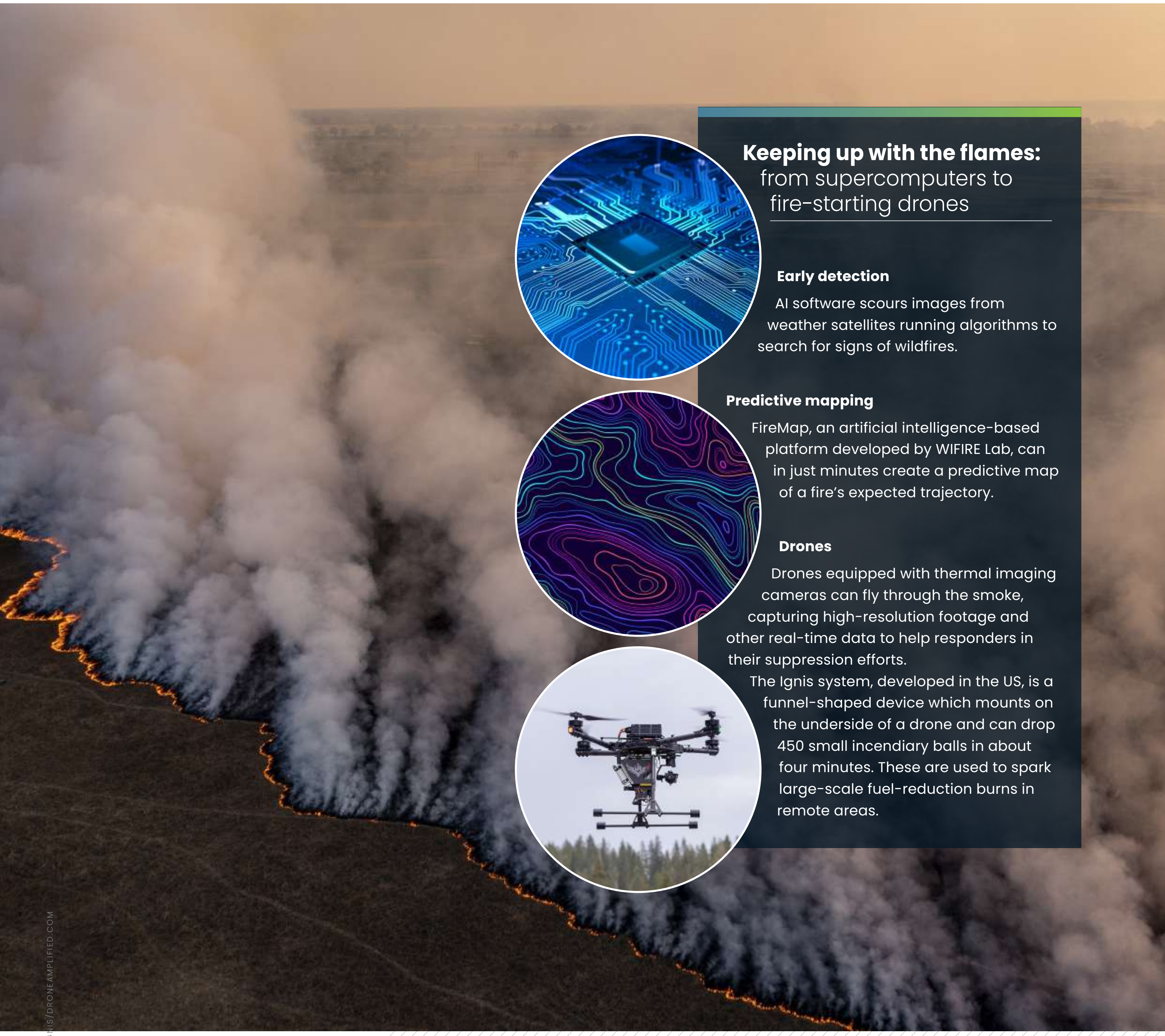
The spark

As a heat source moves toward a piece of wood, the fuel will eventually hit a temperature of 248.889–301.667°C. The molecules then begin to break off the main body, a thermal decomposition process called pyrolysis. As a result, a stew of gas made up of broken-off sub-molecules reacts with oxygen, producing carbon dioxide, water, heat, and light.

Once a flame is born, there are three primary variables that decide how it will act: fuel, weather, and topography.

Wind is the biggest driver of wildfires, but there are other weather factors, including precipitation and humidity. Not only does wind help supply a fire with more oxygen, enabling the faster combustion of fuels, it also drives flames in one direction, pressing the fire closer to the ground and enhancing the speed with which heat is being transmitted to different fuel sources on the forest floor.

Another contributing factor in determining a wildfire's behavior is the topography in which it is burning, and the most important variable in the landscape is the slope.



Keeping up with the flames: from supercomputers to fire-starting drones

Early detection

AI software scours images from weather satellites running algorithms to search for signs of wildfires.

Predictive mapping

FireMap, an artificial intelligence-based platform developed by WIFIRE Lab, can in just minutes create a predictive map of a fire's expected trajectory.

Drones

Drones equipped with thermal imaging cameras can fly through the smoke, capturing high-resolution footage and other real-time data to help responders in their suppression efforts.

The Ignis system, developed in the US, is a funnel-shaped device which mounts on the underside of a drone and can drop 450 small incendiary balls in about four minutes. These are used to spark large-scale fuel-reduction burns in remote areas.

PHOTOS: MARTIN HARVEY / GETTYIMAGES, YUICHIRO CHINO /GETTYIMAGES, FILO /GETTYIMAGES, IGNIS/DRONEAMPLIFIED.COM

→ models,[10] which use either a measurement or a forecast of the water level in a river as an input, and simulate the water behavior across the floodplain.

This method allows scientists to translate current or future river conditions into risk maps of high spatial accuracy that can predict which areas will be flooded and which will be safe. Inundation models depend on four major components, each of which has its own challenges and innovations:

Real-time water level measurements measure water levels and aggregate the data to produce forecasts based on upstream measurements.

Once scientists have inputs - the riverine measurements and forecasts, a high-resolution elevation model (collected from satellite images) of a specific area – they begin modeling using two main components:

1. A physics-based hydraulic model, which updates the location and velocity of the water through time based on (an approximated) computation of the laws of physics.
2. Machine learning, or AI, to create larger 2D grids over a wider terrain to predict flooding.

As well as inundation models, near-real-time (NRT) flood detection has been available to scientists for some years and uses SAR imaging to help scientists and weather-watchers detect the likelihood of floods.

Because of their almost all-weather day-night capabilities, ensuring data-gathering on every overpass, satellite SAR sensors are optimally suited for providing reliable→

ANATOMY OF **A FLOOD**

Floods annually cause more than $40 billion in damage worldwide, according to the Organization for Economic Cooperation and Development, and are among Earth's most common – and most destructive – natural hazards.

Causes

Rising sea levels – stronger storms: Warmer air holds more moisture and the Earth's air is about 4% more humid than it was 30 years ago.

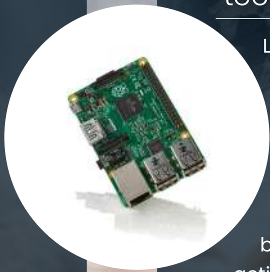
Effects

Too much water in the wrong place. Surges cause tides to rise during a tropical storm or monsoon, and sudden downpours cause rivers to burst their banks or oceans to breach their defenses.

Solutions

"Room for Water" is a Dutch strategy whereby the water is allowed to take over some land to protect the wider environment. With rivers, the Dutch make "room for the river" by ensuring rivers have plenty of bends – straight rivers can run too fast, eroding dikes quickly and leaving less time to react to floods. The Dutch also create two dikes around key waterways: an inner dike for normal water levels and an outer dike in case water floods over the inner dike. Another Dutch strategy is a massive series of barriers that close off channels if water levels rise too high.

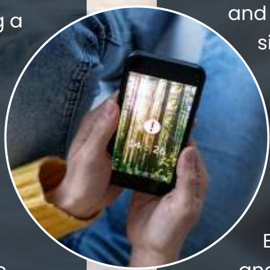
Flood prevention: technology



Low-cost monitoring systems can be developed using cheap micro-computers such as the Raspberry Pi.

Dissemination and communication

To be effective, warnings need to be accessible, easily understood, and actionable by those who receive them.



Examples of tools that can be useful for dissemination are mobile telephones (via text and voice messages), radio, television, sirens and loudspeakers (static and portable), trained volunteers going door to door, weather boards, and color-coded flags or lights.

Response capability

Everyone from government officials and emergency responders to individuals living in flood-prone communities needs to know what their responsibility is in the event of a flood, and what action each of them must take.

information on extensive floods, which usually occur during periods of long-lasting precipitation and cloud cover.

In the case of NRT disaster management, where the collection of ground truth information is not feasible due to time constraints, a simple thresholding algorithm can be used in most cases to distinguish between the classes "flood" and "non-flood" in a high-resolution SAR image to detect the largest part of an inundation area.

But even with the latest technology, things can still go wrong. A so-called smart flood prevention system was in place in the central Chinese city of Zhengzhou when rainstorms caused, according to a BBC report, at least 302 deaths in July 2021. In just three days, Zhengzhou experienced 600 mm of rain – almost equivalent to an average year's rainfall – which flooded metro stations and a cross-city tunnel.

The platform, from Aerospace Zhengzhou Smart System Technology Company, promised to allow authorities to monitor water levels in real time through sensors and intelligent analysis. It also had access to meteorological and hydrological data. But such systems only work effectively in tandem with other emergency planning operations.

China's highest government body, the state council, reviewed an investigation into the disaster, and determined that local and provincial officials and authorities were "guilty of negligence and dereliction of duty, especially considering the casualties in the subway and the tunnel that were not supposed to take place."

Local officials were accused of "seriously lacking risk awareness" and having "paralysed thinking" in the face of advance warnings of abnormally heavy rainfall.[11]

Many large cities already have access to metrological data that can accurately predict rainfall levels, and there has been a lot of energy and investment going into smart technology to help cities mitigate and adapt to climate change, but governments at the national and local levels need to combine the technology with better emergency planning systems to properly safeguard property and lives.

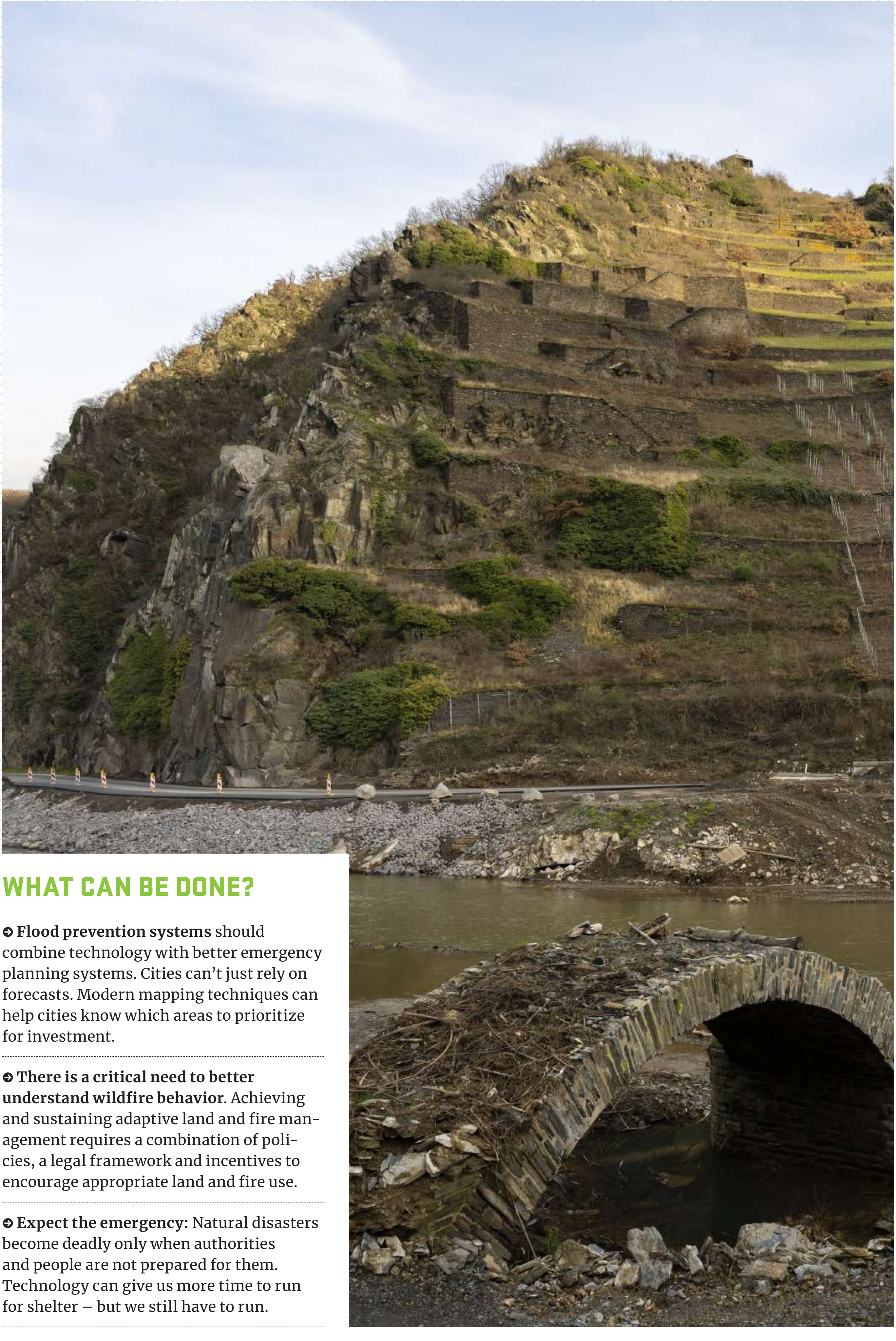


PHOTO: MISCHA KEIJSER /GETTYIMAGES

WHAT CAN BE DONE?

➲ **Flood prevention systems** should combine technology with better emergency planning systems. Cities can't just rely on forecasts. Modern mapping techniques can help cities know which areas to prioritize for investment.

➲ **There is a critical need to better understand wildfire behavior.** Achieving and sustaining adaptive land and fire management requires a combination of policies, a legal framework and incentives to encourage appropriate land and fire use.

➲ **Expect the emergency:** Natural disasters become deadly only when authorities and people are not prepared for them. Technology can give us more time to run for shelter – but we still have to run.

ABOUT FII INSTITUTE

THE FUTURE INVESTMENT INITIATIVE (FII) INSTITUTE is a new global nonprofit foundation with an investment arm and one agenda: Impact on Humanity.

Global, inclusive and committed to Environmental, Social and Governance (ESG) principles, we foster great minds from around the world and turn ideas into real-world solutions in five critical areas: Artificial Intelligence (AI) and Robotics, Education, Healthcare and Sustainability. We are in the right place at the right time: when decision-makers, investors and an engaged generation of youth come together in aspiration, energized and ready for change.

We harness that energy into three pillars: THINK, XCHANGE, ACT. Our THINK pillar empowers the world's brightest minds to identify technological solutions to the most pressing issues facing humanity. Our XCHANGE pillar builds inclusive platforms for international dialogue, knowledge-sharing and partnership. Our ACT pillar curates and invests directly in the technologies of the future to secure sustainable real-world solutions. Join us to own, co-create and actualize a brighter, more sustainable future for humanity.

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Contact

FII Institute:
THINK
think@fii-institute.org

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Anatomy of a flood

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