CLIMATE CHANGE COULD DOUBLE GLOBAL THREAT OF EXTREME DROUGHT

Global warming has serious consequences for water availability across the world. New research shows that extreme droughts could hit twice as many people and twice as much land by the end of the century. **Yadu Pokhrel** and **Farshid Felfelani** report

Modelling by a US-led team of scientists suggests that climate change could more than double both the land area and the number of people facing extreme drought by the end of the century.

The Michigan State University-led research project suggests that the global land and population facing ever more water stress will increase to 7-8 per cent by 2100, from 3 per cent in 1976-2005, if global warming continues at the medium to high level.

No previous study has examined how climate change will impact storage of land-water globally. Our research, a collaboration with over 20 scientists from Europe, China and Japan, projects a large reduction in land-water storage in two-thirds of the world, due to climate change.

Land-water storage is the accumulation of water in snow and ice, rivers, lakes and reservoirs, wetlands, soil and groundwater. That accumulation is critical to the world's water and energy supply; terrestrial water storage modulates flows within the hydrological cycle, shaping availability and scarcity of water.

Freshwater mass accounts for only 3 per cent of total water on Earth. It is conserved globally under natural equilibrium, but its spatial and temporal distribution is critical.

Climate change – driven by Earth's warming – is expected to redistribute freshwater availability across the globe and to bring profound water-related challenges that societies have never seen before. In many places, the direct impacts of climate change will reduce the number of meteorologically normal years, bringing an increase in intense drought and/or flood events.

Some places in the mid-to-high latitudes will benefit from a longer growing season, increased water resources and food production. However, other regions are being adversely affected by changes in Earth's climate.

These disastrous consequences could be exacerbated by socioeconomic developments such as population growth, land use and land-cover change, deforestation, dam construction, irrigation expansion, industrial developments, and so forth.

These general facts and principles about climate-change impacts have been long-studied and understood by using hydrological measurements and computer modeling. However, what might happen in the future is less known and uncertain.

Our research asks how freshwater availability on land might change under the influence of global warming by the end of the century and what the changes mean for future droughts?

Answering that question requires computer models. We used recent advances in process-based hydrological modelling, combined with future projections of climate under wide-ranging scenarios of greenhouse-gas emissions and socioeconomic changes, to analyse future water availability and droughts.

Our research brings together 27 global climate-hydrological model simulations spanning the years 1976-2100, under global modelling project, the Inter-Sectoral Impact Model Intercomparison Project (ISIMIP).

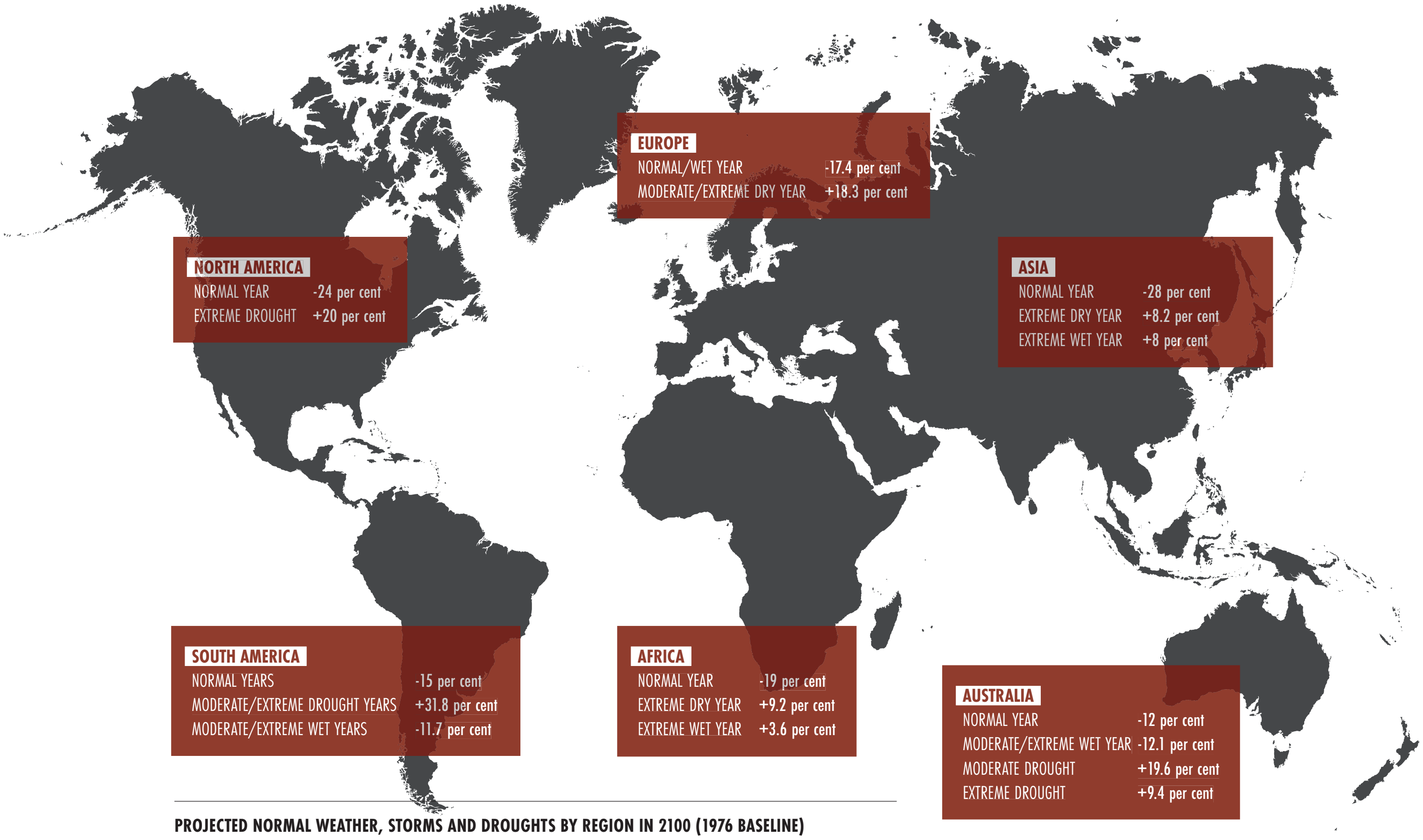
A NEW APPROACH

Drought is a general term that has different concentrations across disciplines. Atmospheric science focuses on meteorological droughts caused by lack of precipitation. However, agriculture and natural resources defines drought based on soil-water deficit and hydrology characterises drought as a lack of water in rivers and aquifers.

We presented a new perspective on drought by looking at total terrestrial water storage – the water stored in soils, groundwater, snowpack, forest canopies, wetlands, rivers, lakes and reservoirs. It is the first study of its kind to investigate future projection of drought based on the entire landscape of terrestrial water storage.

Drought severity is then defined according to total freshwater availability, grouped into five major categories of drought and wet conditions; extreme drought, moderate drought, normal condition, moderate wet, and extreme wet.

We found that total water storage over two-thirds of land on Earth is on course



PROJECTED NORMAL WEATHER, STORMS AND DROUGHTS BY REGION IN 2100 (1976 BASELINE)

to decline by the late twenty-first century. That means the global land area and population hit by extreme drought could more than double, each increasing from 3 per cent during recent decades to 7 per cent and 8 per cent, respectively.

We then looked at how drought severity varies across continents.

AFRICA: the probability of normal years occurring is projected to reduce by 19 per cent by the end of the century compared with recent decades. The probability of an extreme dry year and an extreme wet year increases by 9.2 per cent and by 3.6 per cent, respectively. However, the modelling indicates that climate change could reduce total water storage in West Africa, but increase it in eastern Africa.

ASIA: is likely to experience the largest reduction in normal years by 28 per cent and to increase extreme dry and extreme wet years by 8.2 per cent and by 8 per cent, respectively. The number of moderate wet years could also increase by 15.1 per cent by century's end. The northern high latitudes in Asia and in southern India are among the few regions that would benefit from climate warming by having more rain in future.

AUSTRALIA: we expect the frequency of normal and moderate-to-extreme wet conditions is to decline substantially, by 12 per cent and 12.1 per cent, respectively. This will increase levels of drought, ranging from moderate by 19.6 per cent to extreme, by 9.4 per cent). The modelling indicates that southern Australia will be worst hit by drought by century's end.

EUROPE: Like Australia, Europe is also on track for a 17.4 per cent drop in normal/wet conditions and an increase in dry years of 18.3 per cent. The largest decline in total water storage is expected in south Europe/Mediterranean.

NORTH AMERICA: we expect the largest rise, up 20 per cent, in probability of an extreme dry year in North America. The continent is also likely to see a 24 per cent reduction in frequency of normal years by the late twenty-first century.

SOUTH AMERICA: Modelling indicates a 31.8 per cent increase in moderate to extreme drought years, an 11.7 per cent decrease in moderate to extreme wet years and a 15 per cent decline in normal years. All of this makes South America a climate hotspot, whose water availability is shrinking especially across the Amazon River basin. These results for the Amazon region corroborate the widely discussed drying and lengthening of the dry season that increases heat and moisture stress and raises the threat of forest fires. Robust findings for this region add to the long-standing fears about the fate of the Amazonian rainforest in a warmer, drier future.

What this shows is that the impacts of climate-related drought will have a disproportionate impact on the southern hemisphere, which already suffers water scarcity. We predict that this increase in water scarcity might affect food security and escalate human migration and conflict.

And that means that more and more people could suffer from extreme drought if global warming continues at a medium to high level, and if we continue to manage our water in the way we are managing it now.

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