Brazil is in water crisis – it needs a drought plan

To avoid crop failures and soaring power costs, diversify sources, monitor soil moisture, model local hydroclimate dynamics and treat water as a national security priority.

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Brazil has the most fresh water in the world. Two thirds of what flows in the Amazon River alone could supply the world's domestic demand. Yet much of the nation now faces drought.

The worst in over 90 years. In a nation dependent on agriculture for almost a quarter of its GDP[3].

This fall, between March and May, in Brazil's South-central region there was a 267km^3 water deficit compared with the seasonal average for the past twenty years (see Figure 1). The result? Many major reservoirs are at less than 20% capacity. Farming and energy generation have been hit. Since July, coffee prices have risen 30% -- Brazil accounts for one third of global exports. By May, **soybean prices rose 67% in a year**– this crop makes up 70% of the global demand of animal feed. And electricity bills have soared 130%. Many cities face imminent water rationing.

How has this happened? And what needs to be done?

Worldwide climate change is making droughts more intense and more frequent. Deforestation in the Amazon is a contributor locally and globally. The hydroclimate in the south-central region -- engine of 60% of Brazil's GDP -- is partly controlled by moisture transfer from the rainforest. Atmospheric fluxes caused by tree transpiration – also known as 'flying rivers' – can contribute as much water per day in rainfall as the Amazon River itself carries. Cutting down these trees reduces precipitation over those areas, as well as eroding a crucial global carbon sink.

There has been a political failure to recognize the severity of the drought as a matter of national and international security. Brazil's water crisis is a world crisis. What's needed is a coordinated nationwide Drought Mitigation Plan crafted by researchers, policymakers, the public and private sectors and the public. Here below are some key points that such a plan should address; these points are supported by XXX<put number] Brazilian and international water and climate scientists (see list of co-signatories attached).

Vast reserves

About 20% of all global inland water flowing to the oceans is generated in Brazilian territory[1]. This source fuels the country's welfare and economic growth. About 85% of the nation's fresh water needs are supplied by surface waters – rivers and lakes[2]. In the US, that figure is 75%; in India, it is 60%.

Brazil has the world's second largest installed hydropower capacity at 107.4GW; it produces 65% of the country's electricity. Half of this is generated on the Parana River basin side, where reservoirs have fallen to their lowest levels in 91 years. The country has had to revert to burning fossil and biofuel, and passing the higher costs onto consumers. Thermal power produced 13.2% of the nation's electricity in July 2021, the highest in history.

Lucrative crops such as soy, coffee and sugar cane, and livestock use much of the water. Irrigation feeds about 13% of the cultivated surface[3], drawing down 66% of total water consumption -- some 6.4 billion liters daily[2].

But water is not equally available across the country, nor over time.

Different droughts

Water crises can originate from many types of droughts: meteorological, hydrological, agricultural, and socioeconomic.

Meteorological droughts are dry weather patterns due to periods of little rainfall or high heat, which increase evaporation rates. These can cause hydrological droughts, water shortages on land surfaces, such as rivers and lakes.

Agricultural droughts -- a decline in soil moisture levels – may result. These can jeopardize crop yield and increase food insecurity. Shortages to the domestic and industrial supply – socioeconomic drought – can also follow. This may lead to rationing, disease, conflict and migration. It may also bring water-intensive processes such as concrete and steel production to a halt.

These different processes can interact in complex and non-linear ways. Hydrological droughts, for example, are intensified when prolonged periods of low soil moisture begin to dry out shallow aquifers. This can drop their levels below riverbed elevations, interrupting river-groundwater connectivity. Depleted rivers or lakes can then have a knock-on effect on reservoir levels, triggering a socioeconomic drought.

Human fingerprint

The 2021 IPCC report highlighted that unabated regional landcover change and global warming are cascading recurrent dry conditions around the globe[4]. Decades-long deforestation of the Amazon has led to vast knock-on effects. Cutting down trees, as well as slashing the amount of moisture transported from the rainforest towards central-southern Brazil[6], is the main driver of fire[7]. The particulate matter released into the upper air alters the formation of rain clouds[8].

And improper land use can worsen droughts, and even cause rivers to run dry. Intensive cattle farming leads to unvegetated land and compacted soils. As well as decreasing the amount of moisture given off by plants it limits the soil's capacity to retain water and recharge aquifers.

But droughts alone don't explain the recurrence of water crises in Brazil. Successive governments inability to recognize water as an essential national resource has led to a long history of mismanagement. And recent federal policies have driven increasingly erratic land occupation by agribusiness and mining interests, increasing deforestation and wildfires and undermining climate mitigation.

As the country plunged into a severe shortages in 2014, the Brazilian Academy of Sciences upbraided state authorities for failure to take swift bold actions and for a lack of transparency about the gravity of the situation[9]. Now, it is even harder now for scientists to bust the national myth that there is unlimited water when denialism is promoted at the highest levels by Brazil's president Jair Bolsonaro[12].

Seven years have passed, and too little has changed. This time around, the country's economy is recovering to pre-pandemic levels, following a 4.1% drop in GDP in 2020 – the worst for 39 years. Economic growth requires extra energy to power production. With the current hydropower situation, this demand may have to be met by burning bio or fossil fuel.

Research priorities

The nation's groundwater and meteorological monitoring is sparse and insufficient to properly track water variability and availability across the country. Brazil monitors groundwater at 394 sites nationwide[27]; to put into perspective, the North American and Indian networks have over 16,000 and 22,000 sites, respectively. There are no nationwide systems in place to track soil moisture, and water use monitoring is patchy.

Governance of these networks must be strengthened, and more effective guidance on how to respond to future crises is needed. They are currently operated across different national agencies and departments, leading to duplicated efforts and inefficient data access. Drought monitoring initiatives through international partnerships, such as the *Monitor de Secas* (http://monitordesecas.ana.gov.br/), have been emerging in recent years. However, delayed data availability, low accuracy, and inaccessibility to end-users, such as farmers and local water departments, still limit their usefulness.

High quality, readily available data and computing power are key ingredients for multidisciplinary drought research, and need more investment. Tupã - Brazil's most powerful supercomputer is nearing the end of its lifecycle at the Brazilian Institute for Space Research (*Instituto Nacional de Pesquisas Espaciais; INPE).* UN funds have provided temporary access to alternative computers, but these are not powerful enough to perform hydrometeorological forecasts and climate predictions. Federal funds should be put aside for a new supercomputer. INPE suggests that the acquisition of an equivalent supercomputer would cost $40 million. Instead, the Science and Technology Ministry's budget for 2022 has been reduced by 87%[10].

Many processes which impact south-central's Brazil's water availability are not well understood. These need more research to best inform policy. They include:

Climate feedbacks: Deforestation, land use, biomass burning, and global warming interact to determine water availability. New approaches should exploit emerging knowledge and computational tools to better incorporate small-scale and fast processes, such as landcover changes or clouds and aerosol feedback effects in climate models. This will need higher-resolution simulations, more computational power and reliable *in situ* and satellite-based observations.

Compound events: Hazards such as droughts, heatwaves, and fires can have devastating impacts beyond those related to an isolated event. Risk assessment approaches should consider the co-occurrence of multiple and dependent hazards. Climate, health and social scientists, as well as engineers and modelers, should work to improve the estimation of the impacts.

Groundwater. Intensive pumping, especially combined with droughts, has led to severe depletion in regions such as such as western and central U.S., northwestern India and the Middle East[11]. More research, along with groundwater and soil moisture monitoring, is needed to understand how Brazilian aquifers respond to climate variability and change, and pumping.

Migration. Climate change can intensify migration from the Northeast, Brazil's driest and poorest region, to the Southeast. Other movements of people could be triggered across the country as longer, more frequent, and severe droughts arise. Massive climate migrations could result in an increase of water insecurity, as well as unemployment and poverty in major Brazilian cities. Social, political, and economic scientists should work to identify the drivers of climate migration to guide policy making.

Diversify sources

Stable, long-term investment is needed to upgrade the nation's water and power system. Hydropower has a very small carbon footprint once installed, despite its initial high environmental and social impacts. When there isn't enough water to generate electricity, however, expensive and more polluting *biofuel-based* thermal power currently pick up the slack.

Instead, Brazil should diversify by building wind and solar capacity. This could be supported by a system of contract auctions, providing a mechanism to gather funds for clean energy. The success of such a mechanism is demonstrated by recent major investments totaling nearly 8 billion dollars over the past five years, mostly from the private sector. An estimated 300GW could be generated from these sources by 2050 – four times the nation's current demand[14].

The Brazilian territory lies on major aquifers - valuable and underused resources. The agricultural sector should build climate resilience by using this groundwater, especially during extreme hydrological drought. This needs to be done sustainably, to avoid the depletion experienced by other countries[11]. A clear picture of the spatial distribution and temporal variability of aquifers could guide farmers towards appropriate locations and rates of extraction.

This month Brazil promised to end illegal deforestation and cut emissions from 2005 levels by 50% by 2030 at the 2021 United Nations Climate Change Conference (COP26). Such measures would bring the country in line with green policies, such as the European Green Deal and the U.S. Green New Deal. Brazil should also implement a nationwide zero native vegetation conversion agreement[13] to prevent future agricultural- and cattle-farming-driven deforestation.

There may be short-term economic harm from stemming deforestation, especially amongst farmers and landowners. But the costs of doing nothing are too extreme to ignore. Here again behavioral, social, political, and economic scientists must work to identify the most effective ways to shift prevailing narratives that imperil the planet. The World Economic Forum have classed water crises as a top global risk, due to their impact on food production, human health, conflict, ecosystem function, and extreme weather[15].

Brazil has the expertise, motivation and governmental tools to mitigate this risk. The research community must work with governments to craft laws, policies and investments that enforce optimal water practice -- preventative and adaptive. With political willpower, funding, and infrastructure to match, the country could become a world leader in hydroclimate resilience.

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