

Explainer

A plain language explainer for decision-makers about research from the Climate Science for Service Partnership (CSSP) Brazil

The increasing number of drought events poses a higher risk to food crops

Drought events were recorded in all Brazilian territories from 2011 to 2019 and have increased in frequency and severity over this time, particularly in the semi-arid North-East region. This has major consequences for rain-fed crop production, such as soybeans and maize, which are essential for socio-economic development in Brazil. Significant reductions of these crop yields lead to food insecurity and significant economic losses, especially in rural and poorer areas. Developing improved warnings of upcoming drought events will help to better mitigate these risks.

Importance

Water stress at different growing stages can lead to poor yields or, in extreme cases, entirely failed crops. The North-East region of Brazil is one of the most densely populated semi-arid regions in the world, which also has the most people living in poverty in Brazil. The farming of soya beans and maize is essential, both regionally and nationally.

Drought is typically a slow onset hazard. The effects may take many months before deficiency of rainfall can be detected, by which time it may be too late to mitigate.

Approach

Zeri et al (2022) highlighted the importance of including soil moisture in drought monitoring over the Brazilian semi-arid region. Soil moisture is important in identifying drought events and it correlates with the Vegetation Health Index (VHI) which is used to assess the overall health of vegetation.

Traditional drought monitoring systems rely primarily on rainfall data (Standardised Precipitation Index) but soil moisture is a more useful indicator, as this indicates the amount of water available for rain-fed crops.

Using multiple drought indices, including soil moisture anomaly and the standardised precipitation index, could enable a 1 - 1.5-month early warning of potential agricultural yield losses.

Gallear et al. (2024), applied machine learning to forecast agricultural drought impacts for large scale sub-seasonal



drought monitoring in Brazil to predict drought impacts on vegetation health across the country.

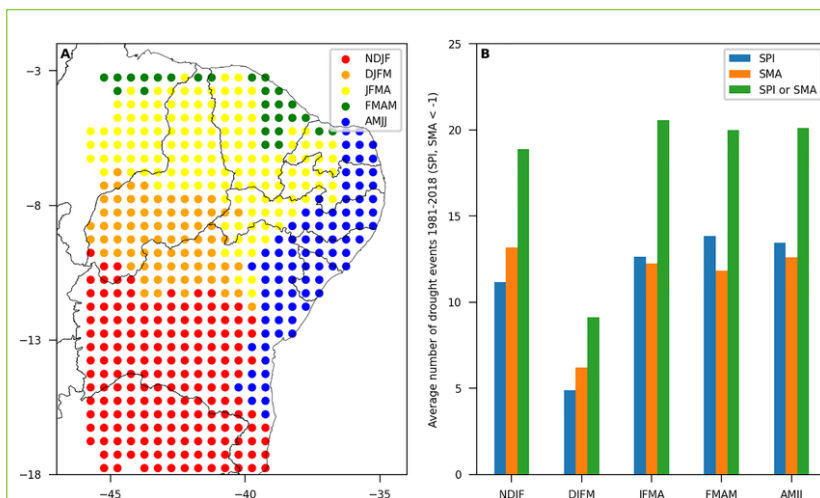
Focusing on major agricultural regions in Brazil with broad climate regimes, from hot semi-arid regions to humid sub-tropical climates, the study offers a first look at the potential of machine learning to produce monthly Vegetation Health Index forecasts.

The study showed that machine learning methods can forecast monthly drought impacts on the VHI and can also identify wider drought trends across a very large scale containing multiple and distinct biomes up to 3 months in advance.

Early warning systems would further reduce the vulnerability of people at risk from drought and help farmers make more informed decisions.

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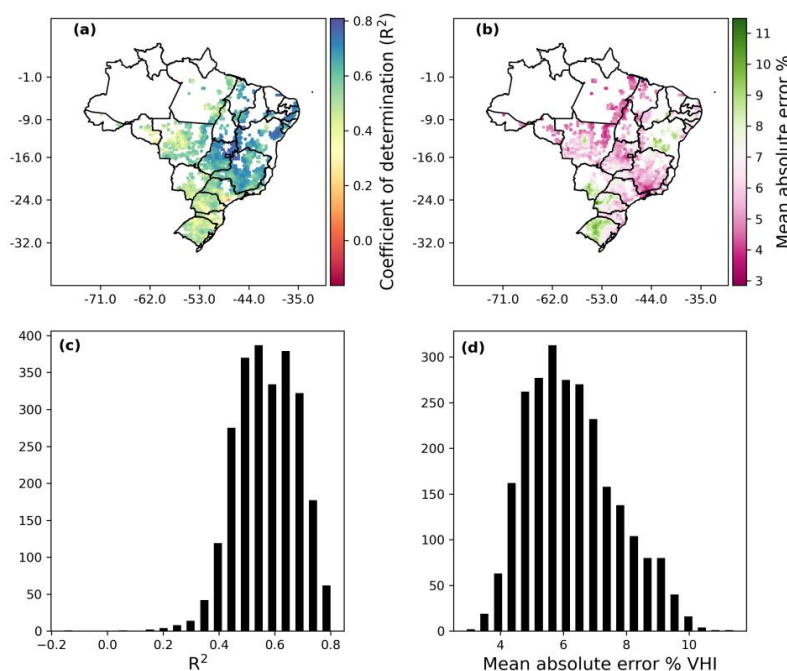
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Soil moisture is an essential indicator for monitoring agricultural drought as it directly impacts crop growth and water availability. Integrating soil moisture data into drought monitoring systems can improve the accuracy of early warnings.

Figure (A) Grid points coloured according to the 4-monthly rainy period (Nov, Dec, Jan, Feb etc.).

Figure (B) Average number of drought events during the first 2 months of the rainy period according to Standardized Precipitation Index, Standardized Soil Moisture Anomaly between 1981-2019.



Machine Learning models, such as Gradient Boosting, show promise in forecasting vegetation health and drought impacts, especially in the North-East region. These models can provide early warnings for crop yield losses and support decision-making for drought preparedness.

The plots to the left show the Vegetation Health Index (VHI) forecasting performance for the best model across the spatial domain in Brazil, showing the R^2 score and mean absolute error for each grid cell location.

Figures (a) (c) R^2 shows the "goodness of fit" of the model, the plots shows that the model performed well in most areas.

Figures (b) (d) shows the model is performing well in terms of errors, in most areas.

Combining multiple drought indices improves the accuracy of drought monitoring and early warning systems. This integrated approach captures the spatial and temporal variability of drought impacts across different regions with different ecosystems and climatic conditions.

References

Zeri, M., et al., (2022). Importance of including soil moisture in drought monitoring over the Brazilian semiarid region: An evaluation using the JULES model, in situ observations, and remote sensing. *Climate Resilience and Sustainability*, DOI: 10.1002/cli2.7 |

Gallea, J. W., Valadares Galdos, M., Zeri, M., & Hartley, A. (2024). Application of machine learning to forecast agricultural drought impacts for large scale sub-seasonal drought monitoring in Brazil. *Natural Hazards and Earth System Sciences*. DOI: 10.5194/nhess-2024-60