Drought-induced migration in Brazil: a quantitative analysis of internal displacement from the Northeast region due to water scarcity using survey microdata and gridded meteorological data

Guilherme M. Dutra[1*]; Marianne B. P. Brum[2*]

[*]Both authors contributed equally to this research.

Keywords: internal migration; water stress; microdata; gridded meteorological data; PNAD; drought index

Extended Abstract

Seasonal internal migration from the Northeast to the Southeast region of Brazil has been extensively described in literature in different fields, especially in the environmental and social sciences. During the past two centuries, various circumstances were suggested as key factors for those migration flows, such as economic stagnation in a large part of the Northeast region due to periodic drought and the economic opportunities that industrialization in other regions of the country provided. However, the connection between environmental factors and internal displacement in Brazil remains poorly understood.

The role that water scarcity and stress play in migration flows is receiving increasing attention by academic research and multilateral bodies, especially in the context of climate change. However, mostly due to data limitations, critical geographic gaps remain, especially in

[1] Postgraduate Specialization candidate, Data Science and Big Data at PUC Minas, dutra.guilherme@gmail.com
Postgraduate Specialization candidate in Data Science and Big Data at PUC Minas and holder of a Master's degree jointly awarded by LUISS Guido Carli Rome, Universidad Complutense de Madrid and IALS-University of London funded by the Erasmus+ Programme of the European Union, having defended the thesis "Do Parliaments matter to development: A global cross-sectional analysis of parliamentary strength and income levels.". Guilherme also holds a Law degree from the Federal University of Rio Grande do Sul (UFRGS). He has experience carrying out research and supporting humanitarian projects in Latin America, Europe and Asia and is currently based in Cox's Bazar, Bangladesh.

[2] MSc Hydroinformatics and Water Management, marianne.brum@gmail.com
Holds a Master degree in Hydroinformatics and Water Management jointly awarded by the Polytechnical University of Nice-Sophia Antipolis, Brandenburg University of Technology at Cottbus, Warsaw University of Technology, Newcastle University, and Technical University of Catalonia and funded by the Erasmus+ Programme of the European Union , with the thesis "Temporal Evolution of Forecast Performance of Numerical Weather Predictions and Derived Hydrological Forecasts in Application to Water Resources Systems". Marianne also has a Civil Engineering degree from the Federal University of Rio Grande do Sul (UFRGS). She has experience in water quality model development and meteorological big data management and is currently based in Aachen, Germany.

South America, as demonstrated by a 2018 study commissioned by the Food and Agriculture Organization (FAO).[3] To address this issue, our research uses a multidisciplinary approach and couples big data from geosciences with microdata from statistical surveying methodologies to breach the gap regarding quantitative evaluation of forced internal climate migration in Brazil.

The research employs microdata from the PNAD (Pesquisa Nacional por Amostra de Domicílios/National Household Sample Survey) from 2000 to 2015. The PNAD was a national household survey carried out annually in Brazil that included general characteristics of the population, education, labor, income and housing according to the information needs for the country[4]. The focus of this research will be analysing answers to the Section 5 of the questionnaire (Migration characteristics of household residents). Microdata from PNAD offers a valuable source for migration analysis[5], with variables that allow us to identify respondents who are migrants and their federal government unit of origin and residence. For simplification purposes, the definition of migrant that will be adopted encompasses individuals who have declared to be originally from federal governments units in the Northeastern region and living in the Southeast region at the time of the survey. PNAD data will be preprocessed and a database on migration in Brazil will be built using custom Python and R scripts.

To characterize drought, this paper uses the The Global Precipitation Climatology Centre Drought Index (GPCC_DI) from the Global Precipitation Center of the German Meteorological Office (Deutscher Wetterdienst, DWD)[6]. The dataset, which is gridded, has global coverage at 1° spatial resolution and is monthly aggregated. The selected data coverage is the same as the PNAD, thus allowing for a long-term time series analysis to be conducted.

The DI is defined as the mean of the Standard Precipitation Index (SPI) and the Standardized Precipitation Evapotranspiration Index (SPEI), two commonly used indexes of drought intensity. Indeed, the SPI is the criterion currently employed as a criterion for national water stress monitoring by the Center for Weather Predictions and Climate Studies (CPTEC/Centro de Previsão de Tempo e Estudos Climáticos)[7] and the National Agency of Water and Sanitation (ANA/Agência Nacional de Águas e Saneamento Básico)[8]. Nonetheless, the GPCC_DI is selected because it is easily available, and because it is arguably a better predictor of water scarcity in arid and semi-arid regions[9] such as the Northeast region of Brazil.

---

[3] Wrathall, D., Hoek, J., Walters, A., Devenish, A. (2018)

[4] Instituto Brasileiro de Geografia e Estatística (IBGE). Description: National Household Sample Survey - PNAD Instituto Brasileiro de Geografia e Estatística. Description: National Household Sample Survey - PNAD.

[5] On opportunities, gaps and methodological challenges for the use of microdata from PNAD on migration analysis, see Cunha, J. (2002). An example of the use of PNAD for understanding internal migration can be seen in the study by Ferreira-Filho, J., Horridge, M. (2016).

[6] Deutscher Wetterdienst (2011)

[7] Instituto Nacional de Pesquisas Espaciais (INPE). (2020)

[8] Agencia Nacional de Aguas e Saneamento Básico (ANA). (2020)

[9] Pietzsch and Bissolli (2011) and Vicente-Serrano, Begueria, and López-Moreno (2010)

Indeed, though rainfall variability is certainly the main driver of water availability[10], temperature is also crucial in determining drought intensity, as it influences evaporation, transpiration and soil water retention[11]. In that context, the DI evaluates both precipitation patterns and temperature variability[12] to calculate a drought score, or the anomaly of water availability. This approach is supported by the Food and Agriculture Organization of the United States (FAO)[13] in its review of current studies on water scarcity and migration, where it notes that temperature might be a stressing factor for forced migration due to water scarcity.

To better connect the meteorological and social datasets, the drought and temperature data are spatially accumulated at the state level, which means the climatological parameters are aggregated across each federal government unit. A statistical analysis of the relation between migration numbers (at origin and at destination) and climatological anomalies is then performed, namely average and maximum regional water stress. Variables of interest for the investigation are: number of months above a certain dryness threshold per year (including moderately dry, severely dry and extremely dry); and duration of drought.

A correlation between drought intensity and migration levels is expected, as seen in the literature for similar case studies and empirically understood. However, it is unclear from the available literature the strength of said correlation, particularly in the Brazilian context. Moreover, the proposed analysis allows us to draw further insights from the available data and propose other possible explanatory variables for climate forced internal migration in Brazil. Furthermore, understanding the current climate-dependent migration patterns may be extremely relevant as a starting point for simulations of the social impact of climate change in Brazil.

References

Agencia Nacional de Aguas e Saneamento Básico (ANA). (2020) Retrieved from: http://monitordesecas.ana.gov.br/o-monitor-de-secas.

Cunha, J. (2002) O uso das PNAD´s na análise do fenômeno migratório: possibilidades, lacunas e desafios metodológicos. Retrieved from http://repositorio.ipea.gov.br/handle/11058/2110.

Deutscher Wetterdienst (2011) GPCC Drought Index. Retrieved from https://opendata.dwd.de/climate_environment/GPCC/html/gpcc_firstguess_doi_download.html.

---

[10] Pietzsch, S., Bissolli, P. (2011)
[11] Vicente-Serrano, S., Begueria, S., López-Moreno, J. (2010)
[12] Ziese, M. *et al.* (2014).
[13] Food and Agriculture Organization (FAO), Wrathall, D., Hoek, J., Walters, A., Devenish, A. (2018)

Food and Agriculture Organization (FAO), ssWrathall, D., Hoek, J., Walters, A., Devenish, A. (2018). Water stress and human migration: a global, georeferenced review of empirical research. p. 9 Retrieved from http://www.fao.org/3/I8867EN/i8867en.pdf

Ferreira-Filho, J., Horridge, M. (2016). "Climate change impacts on agriculture and internal migrations in Brazil," Centre of Policy Studies/IMPACT Centre Working Papers g-262, Victoria University, Centre of Policy Studies/IMPACT Centre. Available at: https://ideas.repec.org/p/cop/wpaper/g-262.html

Instituto Brasileiro de Geografia e Estatística (IBGE). Description: National Household Sample Survey - PNAD Instituto Brasileiro de Geografia e Estatística. Description: National Household Sample Survey - PNAD. Retrieved at https://www.ibge.gov.br/en/statistics/social/social-protection/20293-supplements-pnad4.html?=&t=o-que-e

Instituto Nacional de Pesquisas Espaciais (INPE) (2020). Índice de Precipitação Padronizado (SPI). Retrieved from http://clima1.cptec.inpe.br/spi/pt

Pietzsch, S., Bissolli, P. (2011) "A modified drought index for WMO RA VI", Adv. Sci. Res., 6, pp. 275–279. Available at: https://asr.copernicus.org/articles/6/275/2011/asr-6-275-2011.pdf

Vicente-Serrano, S. (2010) A Multiscalar Drought Index Sensitive to Global Warming: The Standardized Precipitation Evapotranspiration Index. Retrieved from https://journals.ametsoc.org/jcli/article/23/7/1696/33033/A-Multiscalar-Drought-Index-Sensitive-to-Global

Ziese, M., Schneider, U., Meyer-Christoffer, A. , Schamm, K. , Vido, J., Finger, P., Bissolli, P., Pietzsch, S., Becker, A. (2014) "The GPCC Drought Index − a new, combined and gridded global drought index", Earth Syst. Sci. Data, 6, pp. 285–295. Available at: https://essd.copernicus.org/articles/6/285/2014/essd-6-285-2014.pdf