Multi-criteria modelling of drought: a study of Brandenburg Federal State, Germany
Global picture
People affected (2000-2019)

Total number of people affected by disaster type (2000-2019)

- Flood: 1.65 billion (41%)
- Drought: 1.43 billion (35%)
- Storm: 727 million (18%)
- Earthquake: 118 million (3%)
- Extreme temperature: 109 million (3%)

Source: CRED & UNDRR (2020)
Drought in Germany

According to the measurements of the German Institute for Drought Monitoring (Helmholtz Centre for Environmental Research), Germany was affected by a historic drought event in 2018.

Model the incidence of the 2018 drought in Brandenburg, Germany.

Research Objectives

- Model the spatial variation of drought prevalence during the year 2018.
- Examine the intensity of the drought on agricultural land and food security.
- Suggest possible solution to improve drought monitoring and management.
Brandenburg Federal State, Germany

- Located at the North-East Germany.
- Borders Germany’s capital (Berlin).
- Occupies an area of 29,478sqkm.
- One of the warmest region in Germany - 14 degree Celsius.
- Mean Annual temperature is 10.9 Degree.
- Precipitation of less than 600mm.
- 45% of its area comprise of Agricultural Land.
- 77% Cropland and 23% Permanent grassland.

Source: German Weather Service, World Data 2021 and Troegel and Schulz 2018.
Droughts are characterized by complex interrelationships and therefore, like nature, can only be treated in a modelling fashion.

**PLAN Model**

- Rainfall Intensity
- Land Surface Temperature
- Normalized Difference Vegetation Index

Drought Prevalence Map

Source: Ihinegbu, C., Ogunwumi, T (2021)
Diagrammatical presentation Workflow

1. **LANDSAT 8**
   - Band 10
   - Conversion of DN value to TOA Radiance
   - Conversion of Radiance to Brightness Temperature (BT) in Kelvin
   - Conversion of Kelvin to Degree Celsius
   - Band 10 (BT)
   - NDVI
   - Land Surface Emissivity (LSE)
   - Land Surface Temperature

2. **Rainfall Data**
   - IDW
   - Rainfall Intensity

3. **Landsat 8**
   - Extract Study Area
   - Band Calculation:
     - Near Infrared
     - Near-Infrared + Red
   - NDVI

4. **Reclassification (Natural Breaks)**
   - Land Surface Temp
   - Rainfall Intensity
   - Normalized Difference Vegetation Index

5. **Weight Overlay**

6. **Drought Map**

Source: Author
Rainfall Intensity

- Average annual rainfall recorded from **55 Weather Stations** in Brandenburg.
- Rainfall difference for the year 2018 compare to previous year (2016)

|       | 2016          | 2018          |
|-------|---------------|---------------|
|       | 373mm – 633mm | 288mm – 455mm |

**Source:** Deutscher Wetterdienst 2020

- Decline in Rainfall intensity for year 2018

**Precipitation distribution in Brandenburg for 2018**
Land Surface Temperature

- Mapped using **Landsat 8 Satellite Imagery.** (Measure big areas quick and cheap)
- LST generated from **Thermal band (Band 10)** of Landsat 8.
- Its estimation depends on the **albedo, vegetation cover and soil moisture of the object.**
- Highest LS-temperatures were recorded in the **Southern parts of Brandenburg.**
Normalized Difference Vegetation Index

• Mapped using Landsat 8 Satellite Imagery.

• The NDVI values range from $-1$ to $+1$. The negative limit value is highly likely water, while the positive limit value indicates high vegetation health (dense green leaf).

• Diseased plants have less green leaf mass and thus lead to a lower NDVI.

• The NDVI value for Brandenburg ranges from $-1.02$ to $0.67$
Weighting Process

Rainfall Intensity

Land Surface Temperature

Normalized Difference Vegetation Index

Drought Prevalence Map
### Drought Prevalence in Brandenburg in 2018

| Drought Prevalence       | Area (SqKm) | Percentage |
|--------------------------|-------------|------------|
| Extreme Drought          | 0.19        | 1          |
| **High Drought**         | 27,093.05   | 91         |
| Moderate Drought         | 2384        | 8          |
| **Total**                | 29,478      | 100%       |

Source: Author’s Analysis
Land Use and Land Cover

- **Landsat 8** Satellite Imagery was used.
- Interactive **Supervised Classification**.

- **Agricultural Area**
  - Heavy Vegetation
  - Light Vegetation

- **Non Agricultural Area**
  - Waterbody
  - Urban
  - Bareland

Reclassified LULC

| Reclassified LULC                  | Area (SqKm) | Percentage |
|-----------------------------------|-------------|------------|
| Agricultural area (vegetation)    | 21.60837    | 73%        |
| Non-agricultural area             | 7869.63     | 27%        |
| Total                             | 29,478      | 100%       |
The **extent of agricultural lands** (including forests) impacted by the **2018 drought** in the region (as the region is predominantly agrarian) was examined.

| Total Agricultural lands (Sqkm) | 21,608.37 |
| Agricultural lands impacted by high drought (SqKm) | 16,756.06 |
| Percentage | 77% |
| **Total** | **29,478** |
Recommendation

- As highlighted in the relationship between drought and agricultural land use in our analysis.

- Drought relief funds should be disbursed using **Drought impact maps** for a better representation of those (farmers) severely affected by the 2018 drought.

- Proactive **Drought early warning system** using **Earth Observation dataset** should be encouraged. This would ensure people get *prepared and take preventing measures before drought strikes*.

- We strongly recommend that **‘PLAN’ model** is adopted in future drought studies while integrating a multi-criteria approach.
‘The next pandemic’: drought is a hidden global crisis, UN says

Countries urged to take urgent action on managing water and land and tackling the climate emergency

Over half of the world’s population will live in water-stressed regions by 2050
THANK YOU!