How Long Can You Go?

Sayali Pawar

Supervisory team: Dr Miriam Glendell , Dr Sarah Halliday ,Dr Paola Ovando Pol , Dr Lisa Avery

Using Drought Indices To Future-Proof Scotland's Water

Sayali Pawar

Supervisory team: Dr Miriam Glendell , Dr Sarah Halliday ,Dr Paola Ovando Pol , Dr Lisa Avery

Water Situation

- 2 billion people living with risk of reduced access to drinking water (WHO,2022)

Water Situation

- 2 billion people living with risk of reduced access to drinking water (WHO,2022)
- UKCP 18 states Scotland's climate will become warmer, with drier summers, and an increased occurrence of drought events

Water Situation

- 2 billion people living with risk of reduced access to drinking water (WHO,2022)
- UKCP 18 states Scotland's climate will become warmer, with drier summers, and an increased occurrence of drought events
- Water quality and water quantity remain concerns to ensure water security during drought (UN,2013)

Drought: A Harsh Reality of Climate Change in UK

Drought in Scotland

- Drought in Scotland goes back to as early as 1765-1769

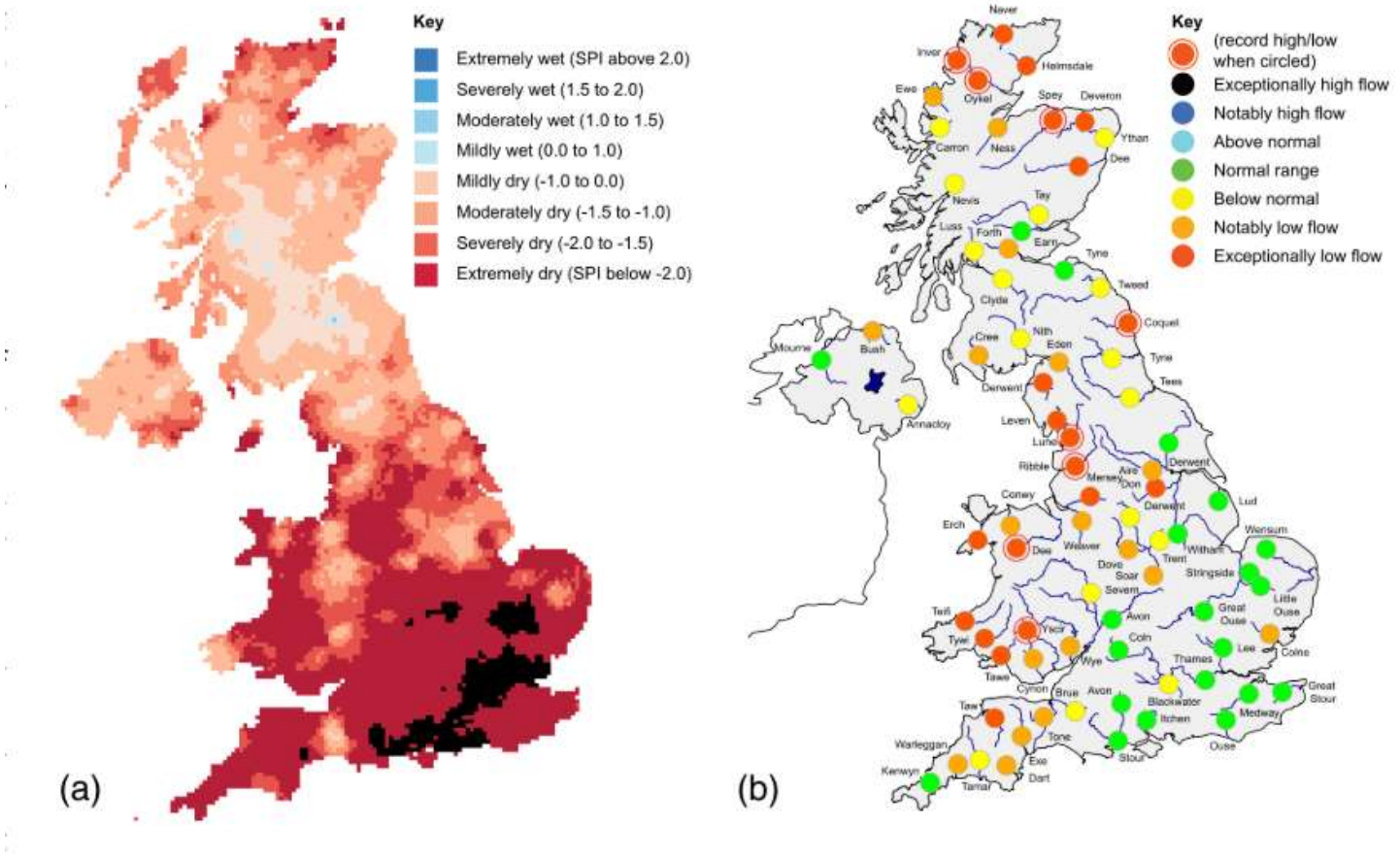


Figure 1 (a) Distribution of Standardised Precipitation Index (SPI) across the UK for June 2018 (b) Mean river flow indicators across the UK for June-July 2018, (Turner et al., 2021)

Drought in Scotland

- Drought in Scotland goes back to as early as 1765-1769
- June 2018 SPI showed unusually dry conditions

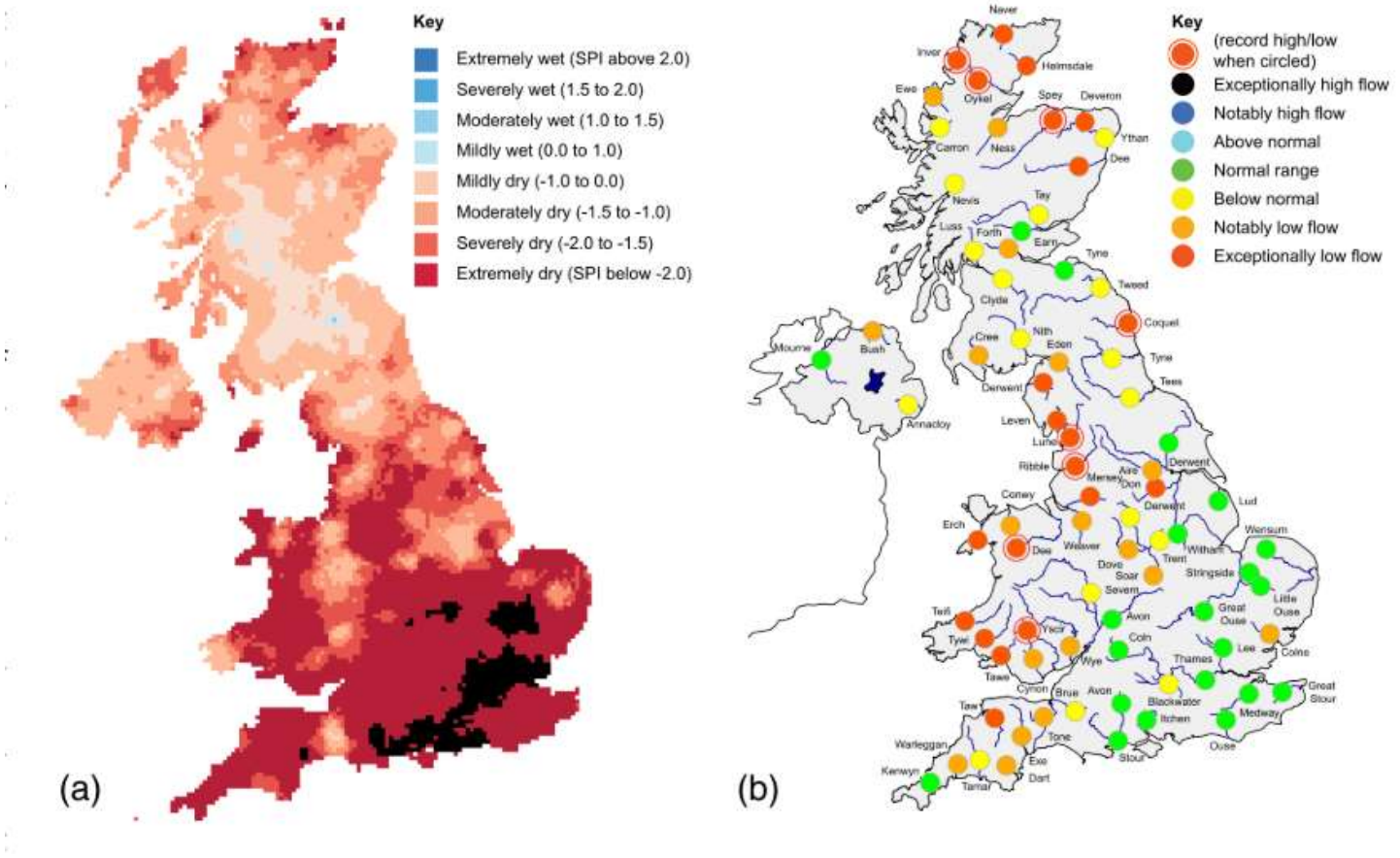


Figure 1 (a) Distribution of Standardised Precipitation Index (SPI) across the UK for June 2018 (b) Mean river flow indicators across the UK for June-July 2018, (Turner et al., 2021)

Drought in Scotland

- Drought in Scotland goes back to as early as 1765-1769
- June 2018 SPI showed unusually dry conditions
- River flows for June and July were averaged numerous catchments saw record low flows in Scotland

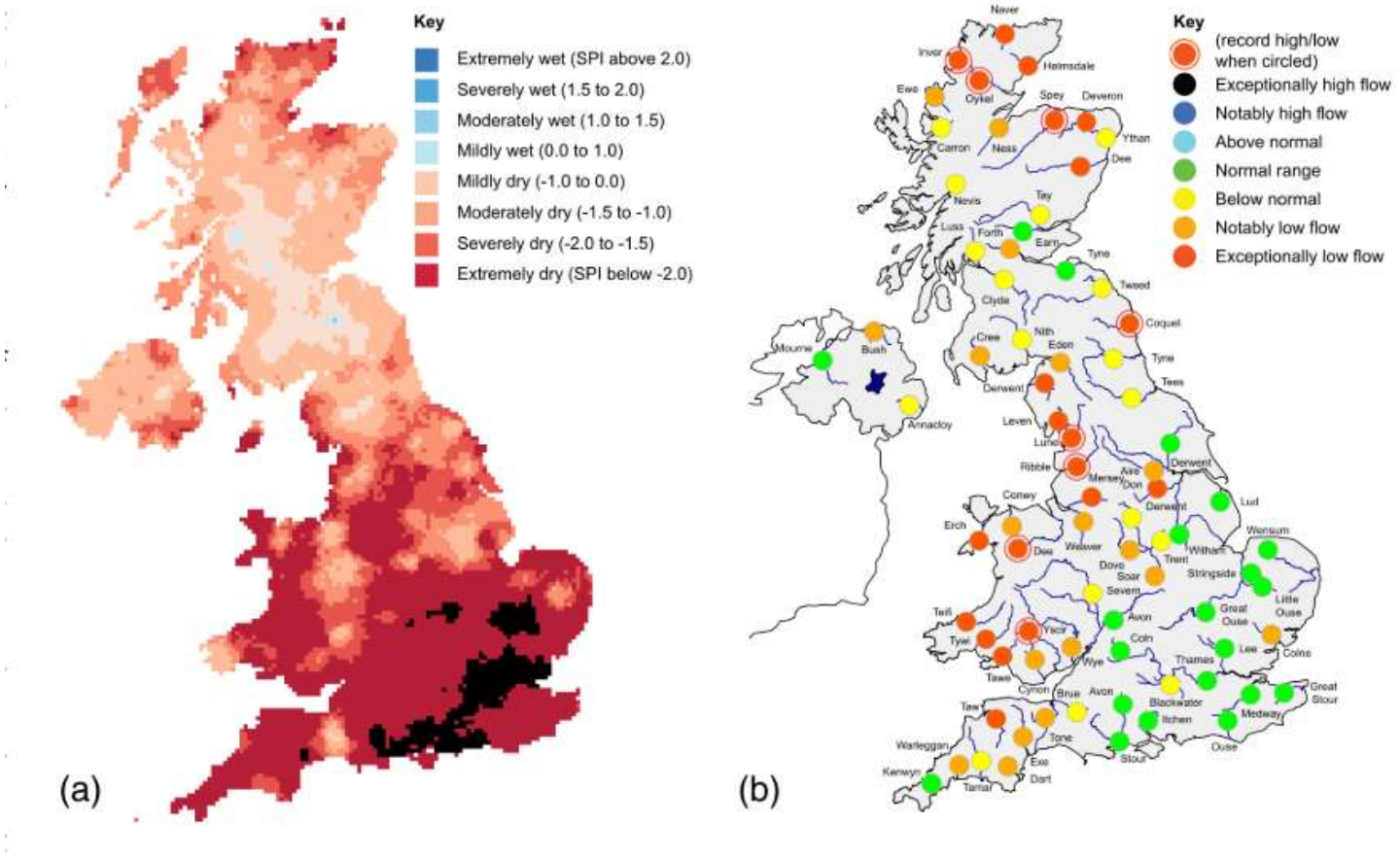


Figure 1 (a) Distribution of Standardised Precipitation Index (SPI) across the UK for June 2018 (b) Mean river flow indicators across the UK for June-July 2018, (Turner et al., 2021)

Drought affecting Scotland's Private Water Supplies

- About half of Scotland's private water supplies are estimated to be within areas of increased vulnerability between now and 2050

Drought affecting Scotland's Private Water Supplies

- About half of Scotland's private water supplies are estimated to be within areas of increased vulnerability between now and 2050
- Around 220,000 people, could have their drinking water supply impacted in the coming decades.

Drought affecting Scotland's Private Water Supplies

- About half of Scotland's private water supplies are estimated to be within areas of increased vulnerability between now and 2050
- Around 220,000 people, could have their drinking water supply impacted in the coming decades.
- North east Scotland is forecast to experience the largest increase in water shortages, which is home to the highest density of private water supplies.

What are Private Water Supplies?

- Decentralised rural water supplies or Private Water Supplies (PWS) are water supplies that are not operated by the mains or Scottish Water

Private Water Supply in Scotland (CREW)

What are Private Water Supplies?

- Decentralised rural water supplies or Private Water Supplies (PWS) are water supplies that are not operated by the mains or Scottish Water
- There are two main forms of PWS in Scotland

- Type A - Regulated water supplies having larger storage capacities; and

- Type B - Exempt water supplies which are commonly used for household purposes

Private Water Supply in Scotland (CREW)

What are Private Water Supplies?

- Decentralised rural water supplies or Private Water Supplies (PWS) are water supplies that are not operated by the mains or Scottish Water
- There are two main forms of PWS in Scotland

- Type A - Regulated water supplies having larger storage capacities; and

- Type B - Exempt water supplies which are commonly used for household purposes

- The majority of the sources for PWS are mostly shallow surface waters like springs or burns which are vulnerable to prolonged dry spells


Private Water Supply in Scotland (CREW)

Aims and objectives

1. What is the likelihood of extreme drought events in Scotland between 2041-2080 and which areas are at high risk of experiencing drought?
2. How does drought impact water quality in PWS?
3. What are the different socio-economic and environmental factors driving drought impacts on PWS water quality and how do they impact our mitigation and adaptation strategies?

Aims and objectives

1. What is the likelihood of extreme drought events in Scotland between 2041-2080 and which areas are at high risk of experiencing drought?
2. How does drought impact water quality in PWS?
3. What are the different socio-economic and environmental factors driving drought impacts on PWS water quality and how do they impact our mitigation and adaptation strategies?

i. Calculate the frequency and duration of drought events for the longer term (2041-2080) in comparison with the baseline period 1981-2020.

ii. Relate droughts identified in the baseline period to observed water quality in drinking water supply catchments (pH, turbidity, nitrates, coliforms, phosphates)

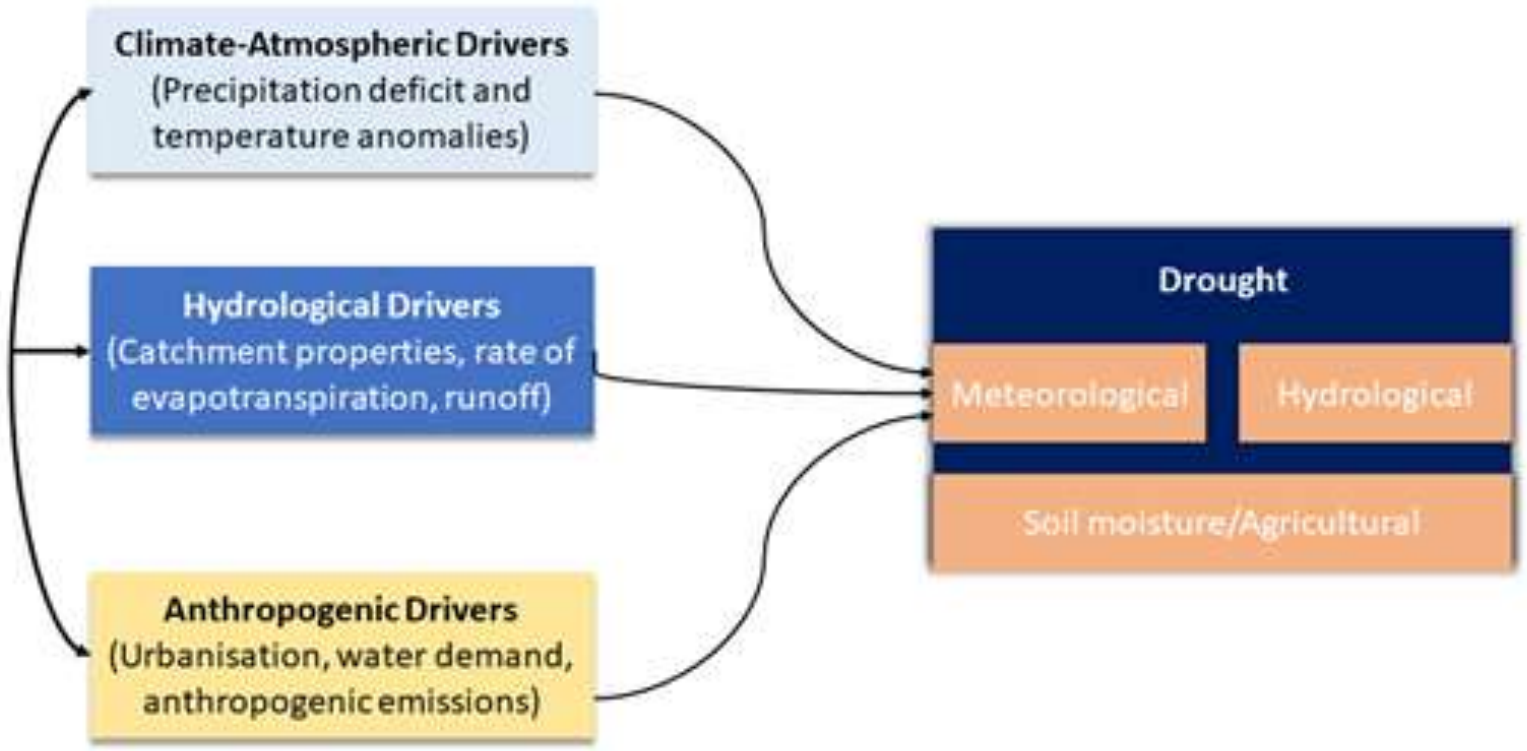
iii. Develop a national-scale risk-based decision support tool using Bayesian Belief Networks to evaluate the vulnerability of PWS to drought impacts.

Drivers of Drought

Drought is the period of a shift from standard precipitation occurrence in a region at a certain time scale rather than an estimated water supply that governs and control water scarcity impacts It is one of the most complex and least studied of all hydrological phenomenon occurring at a global scale across various climatic zones

Drivers of Drought

Drought is the period of a shift from standard precipitation occurrence in a region at a certain time scale rather than an estimated water supply that governs and control water scarcity impacts It is one of the most complex and least studied of all hydrological phenomenon occurring at a global scale across various climatic zones



Drought Indices

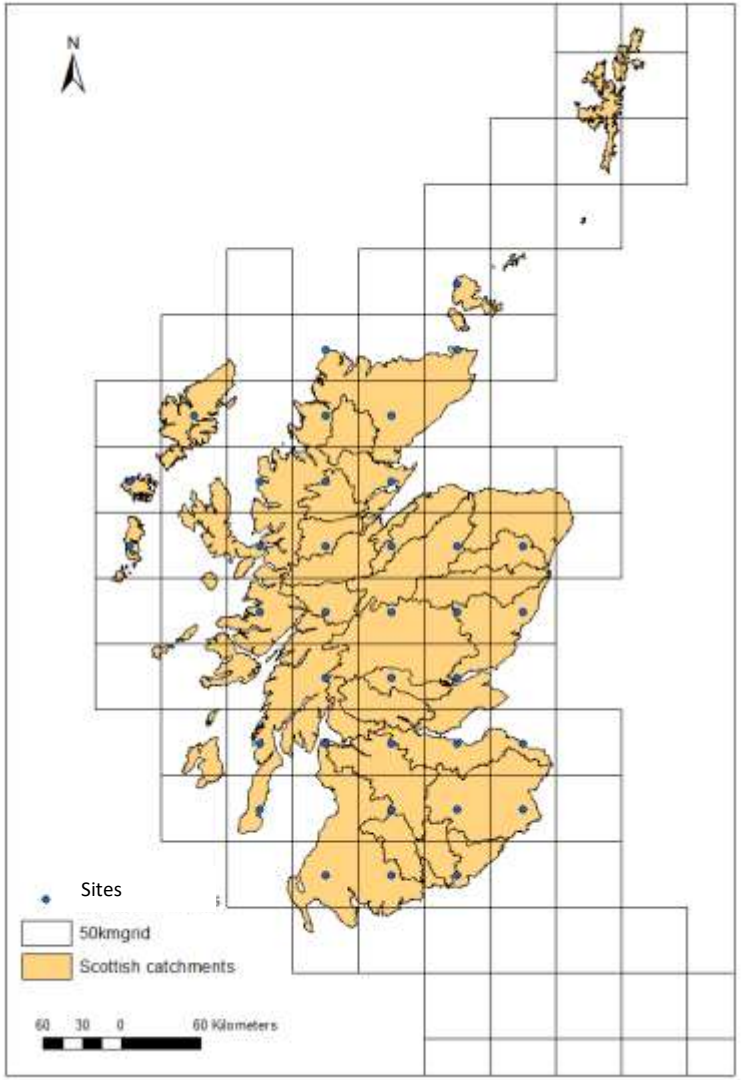
- Drought indices are developed to calculate the qualitative state of the drought in a particular region for a given period
- Types;
  - SPI- Standardised Precipitation Index
  - SPEI- Standardised Precipitation and Evapotranspiration Index
  - PDSI- Palmer Drought Severity Index
  - NFI- Normalised Flow Index

Drought Indices

- Drought indices are developed to calculate the qualitative state of the drought in a particular region for a given period
- Types- SPI, SPEI, PDSI, NFI
- SPEI incorporates changes in evapotranspiration as it includes both precipitation and temperature as input data for calculation.
- Hence, SPEI makes a good choice for projecting future changes in a warming world and allows us to see the impact of climate change in inducing drought

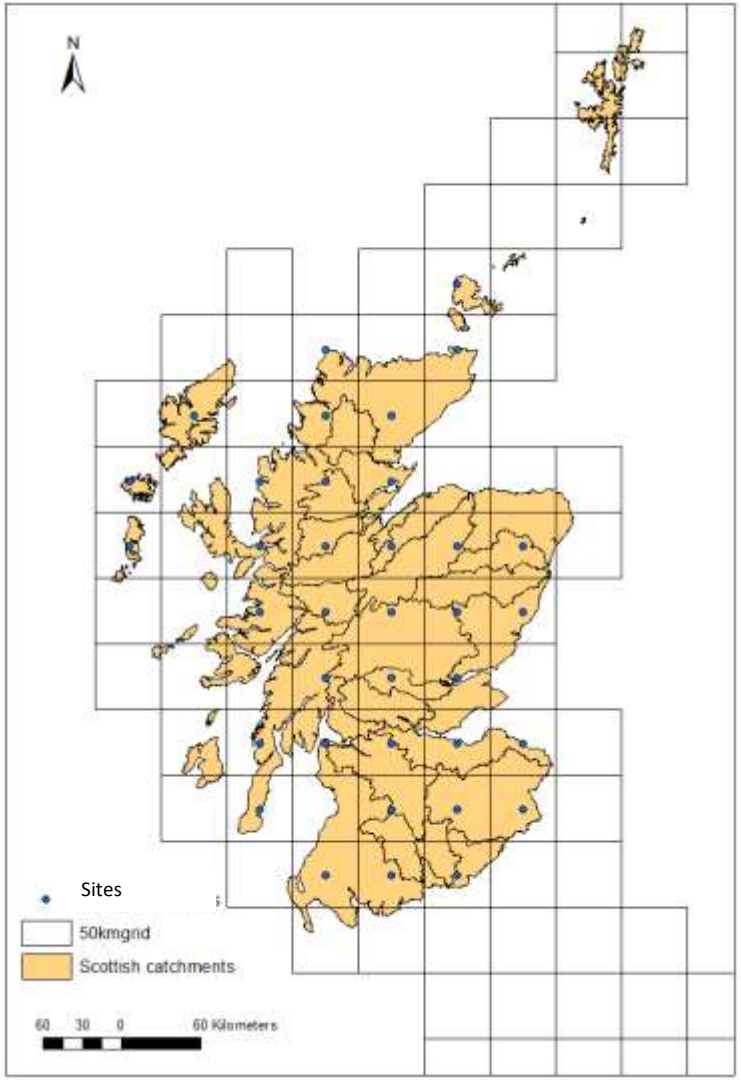
Regional Analysis

- 36 sites located used as part of our pilot case study to test the use of SPEI to project future drought scenarios for the long term (2041-2080)



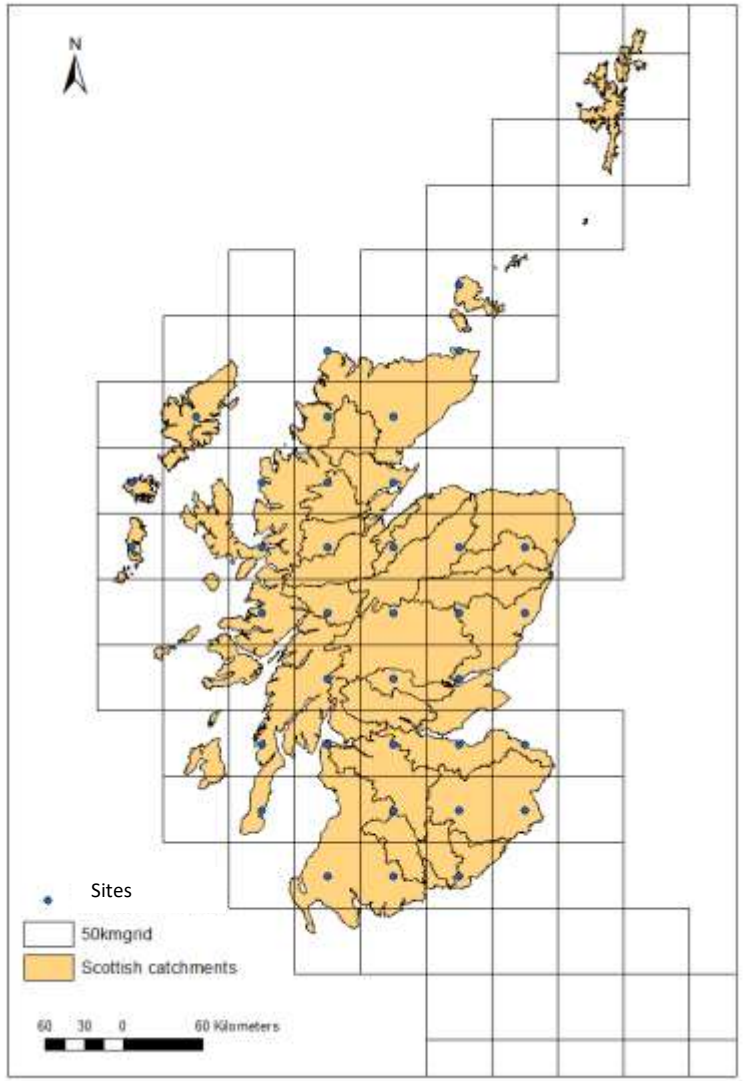
Regional Analysis

- 36 sites located used as part of our pilot case study to test the use of SPEI to project future drought scenarios for the long term (2041-2080)
- The bias-corrected UKCP18 regional data for 1981-2020 (baseline) and 2041-2080 (future) was made available by Dr Mike Rivington from the James Hutton Institute for our research



Regional Analysis

- 36 sites located used as part of our pilot case study to test the use of SPEI to project future drought scenarios for the long term (2041-2080)
- The bias-corrected UKCP18 regional data for 1981-2020 (baseline) and 2041-2080 (future) was made available by Dr Mike Rivington from the James Hutton Institute for our research
- SPEI was calculated for all 36 sites; extreme drought months calculated for 36 sites where SPEI ≤ -2 for any month classified as extreme drought month



Results and Discussion

1. Observed Baseline and Future droughts

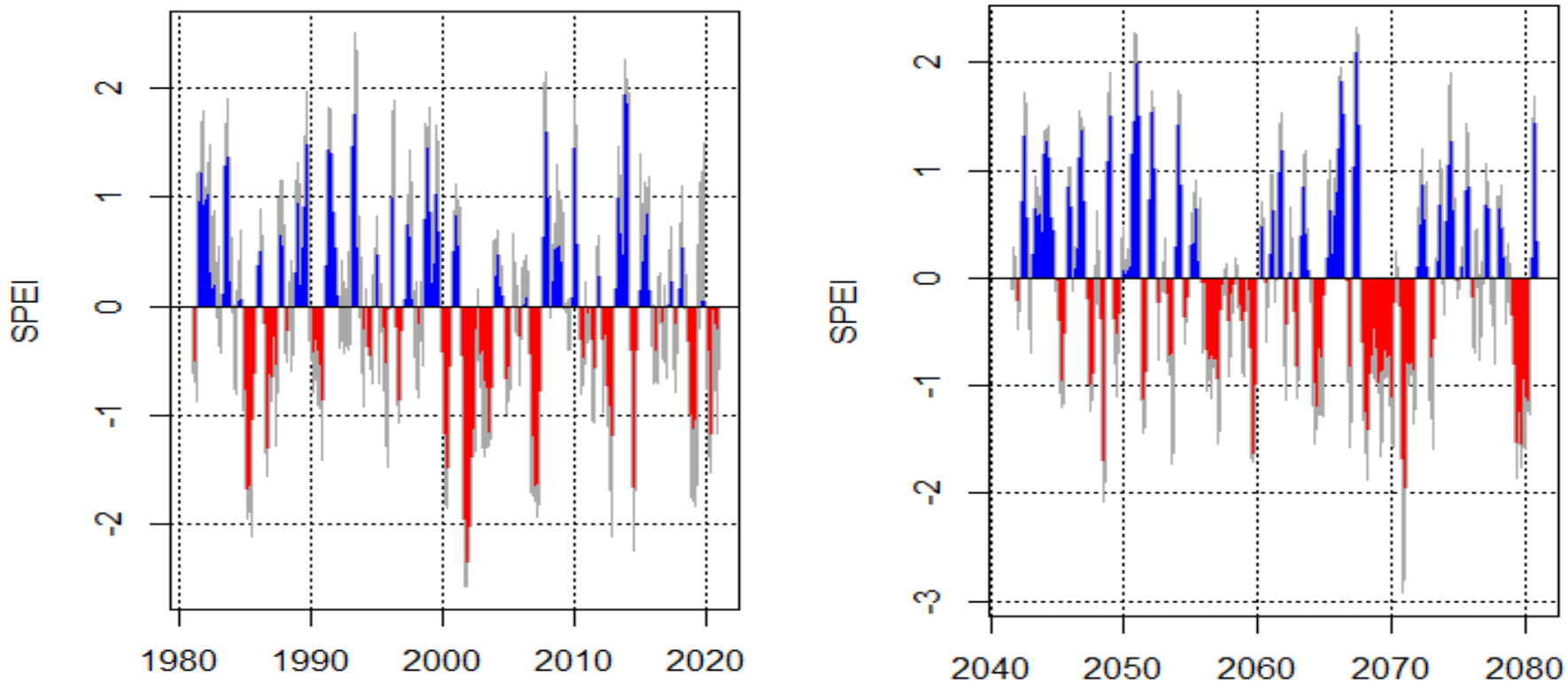
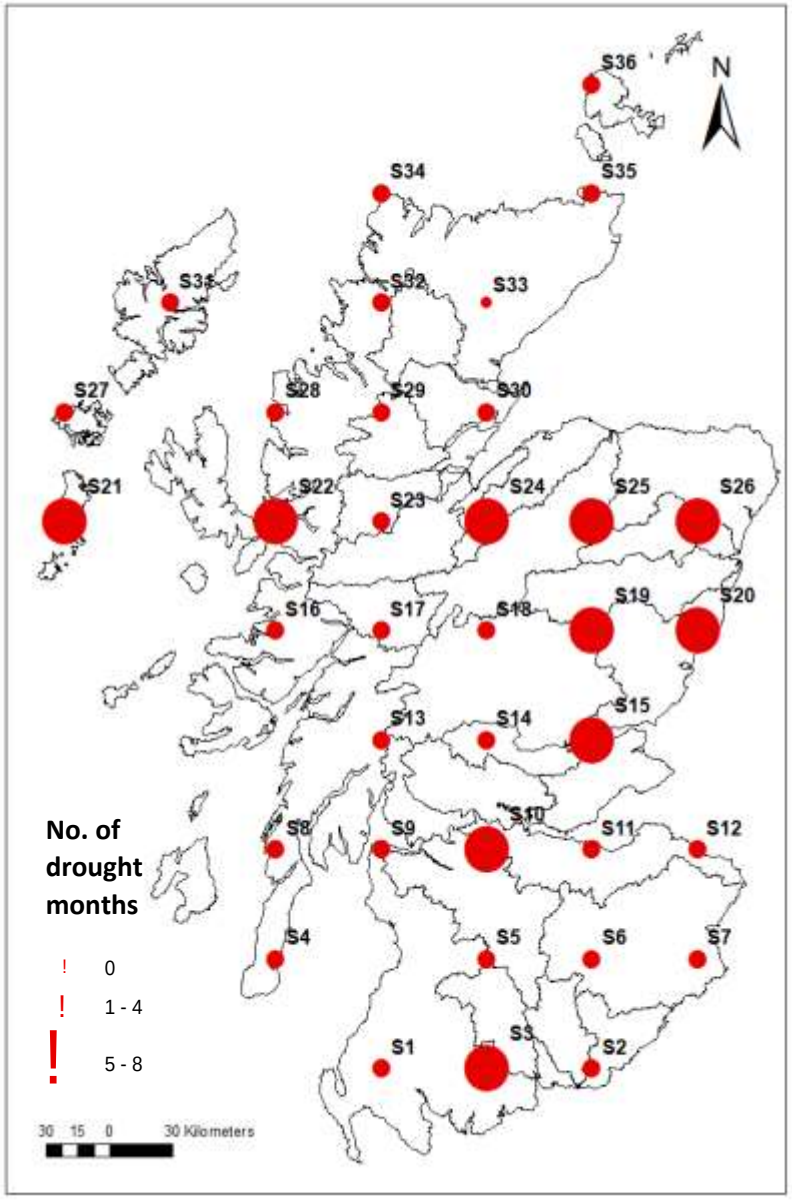


Figure: Example graph of the SPEI index a) SPEI for baseline period (1981-2020); b) SPEI Future periods (2041-2080), computed at a 6-month timestep for ensemble model member at a site near Balhalgardy, Aberdeenshire. SPEI values below -2 (in red) are identified as extreme drought events

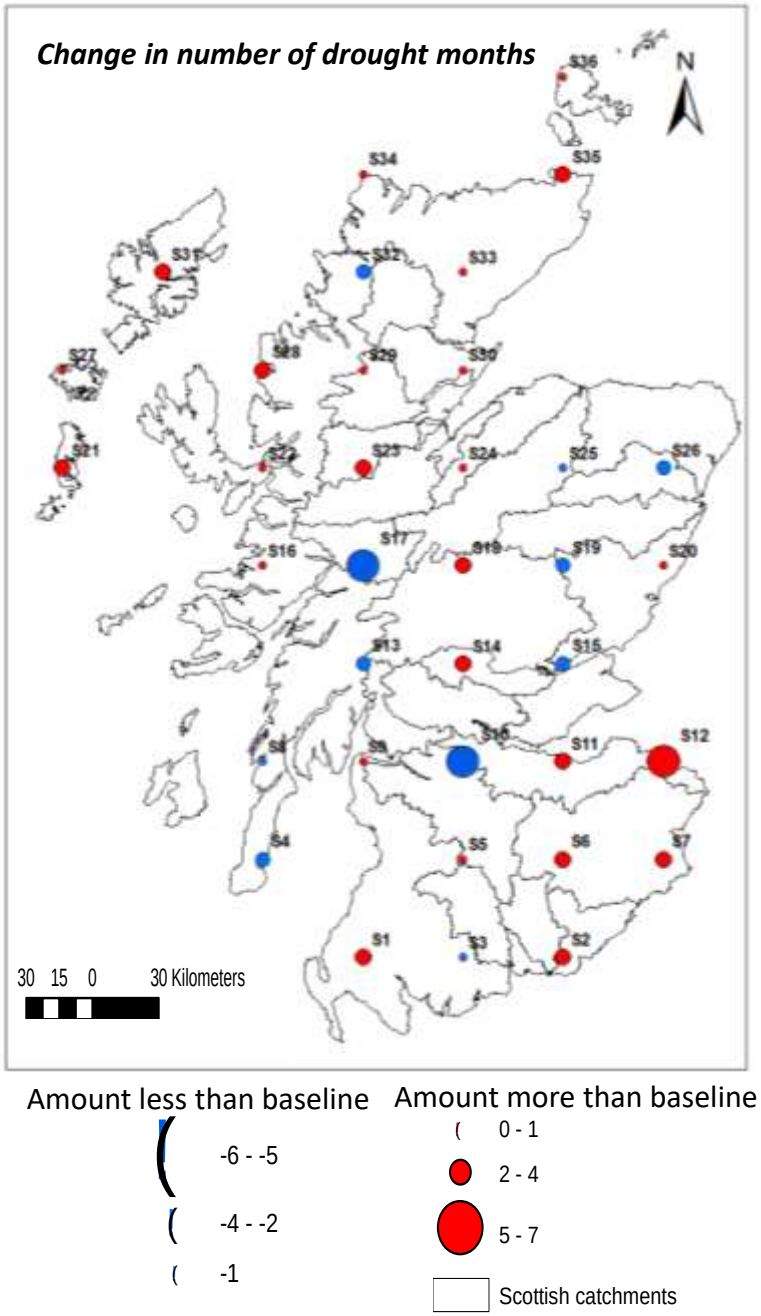


2. Extreme drought months in the future

- Increased occurrences of drought months were simulated in the south and northeast of Scotland for the future period (2041-2080)
- Site 26 and Site 15, both located on the east coast of Scotland showed the highest number of extreme drought months compared to other locations in Scotland
- All other sites showed between 1-8 number of extreme drought months for the future period 2041-2080

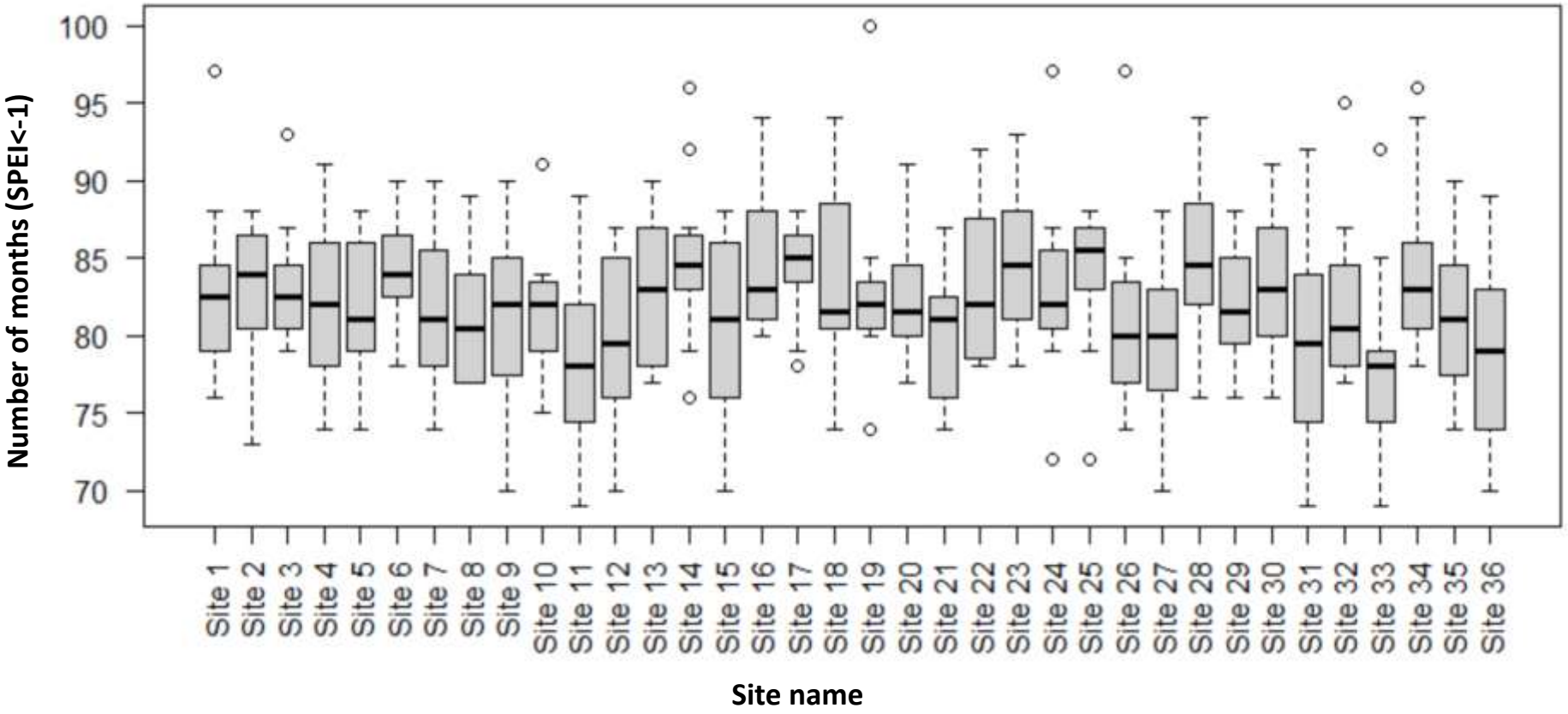
3. Absolute Change from Baseline Period

- Out of 36 sites, 25 sites showed an increase in the number of drought months from the baseline period
- The highest increase was observed in Site 12, where the number of extreme drought months increase by 7 months from the baseline period
- 11 sites showed no change or decrease in the number of extreme drought months for the future period. Site 10 located in central Scotland showed a decrease in drought months by 6
- Initial work has highlight that there is an increasing trend of extreme drought occurrences in the long-term future period from 2041-2080.



4. Site Comparison

Distribution of SPEI data showing the number of months where SPEI <-1 from 2040-2080



An outlook

Data Collation	• Water quality database • Spatial database (landuse, population)
Stakeholder engagement	• Network building and communication • Workshop and perception surveys
Decision based support tool	• Using Bayesian Belief Networks • Conceptual model using the Genie software will be created

Takeaway points

- Scotland and mainly its northeast counterparts are experiencing situations of water scarcity and affecting water quality in the areas
- Water scarcity situations are projected to be increasing in the coming decades which will be exacerbated due to a warming climate.
- Early warning systems to monitor future drought events necessary to mitigate impacts of water-related issues risking PWS.
- Strong historical pieces of evidence and stakeholder management in PWS will play an important role in drought management.

Thank You