

Understanding the social factors influencing resilience to drought exposure in Scotland

Systematic literature
review



Understanding the social factors influencing resilience to drought exposure in Scotland

Systematic literature review

Kerri McClymont and Lindsay Beevers



THE UNIVERSITY
of EDINBURGH

HERIOT
WATT
UNIVERSITY



Hydro Nation
International
Centre



The James
Hutton
Institute



Scottish Government
Riaghaltas na h-Alba
gov.scot

Published by CREW – Scotland’s Centre of Expertise for Waters. CREW connects research and policy, delivering objective and robust research and expert opinion to support the development and implementation of water policy in Scotland. CREW is a partnership between the James Hutton Institute and all Scottish Higher Education Institutes supported by MASTS. The Centre is funded by the Scottish Government.

Authors:

Kerri McClymont¹ and Lindsay Beevers²

¹EGIS, Heriot-Watt University, Edinburgh, EH14 4AS

²Institute of Infrastructure and Environment, Kings Buildings, University of Edinburgh, EH9 3FG

CREW Project Management: Katya Dimitrova-Petrova and Pauline Lang (2019-2021).

Please reference this report as follows:

McClymont, K. and Beevers, L. (2022). Understanding the social factors influencing resilience to drought exposure in Scotland: CREW Policy systematic review. CRW2020_19 CREW Policy Fellowships Programme: Scotland’s Centre of Expertise for Waters (CREW).

Available with Policy Note online at: <https://www.crew.ac.uk/publications>

ISBN number: 978-1-911706-02-1

Dissemination status: Unrestricted

Copyright: All rights reserved. No part of this publication may be reproduced, modified or stored in a retrieval system without the prior written permission of CREW management. Whilst every effort is made to ensure that the information given here is accurate, no legal responsibility is accepted for any errors, omissions, or misleading statements. All statements, views, and opinions expressed in this policy brief is attributable to the author(s) who contribute to the activities of CREW and do not necessarily represent those of the host institutions or funders.

Acknowledgements: The authors thank all stakeholders involved for their valuable contributions to the project. The authors also acknowledge the guidance of the project managers and steering group of the CREW Policy Fellowship Programme, Pauline Lang, Katya Dimitrova-Petrova, Bob Ferrier (CREW), with support from Anne Marte Bergseng (ClimateXChange).

Cover photographs courtesy of:

Carol Taylor, The James Hutton Institute. Julian Scot and CREW Stock images.

Glossary

Term	Definition
Adaptive governance	<i>"measures the degree to which the existing system has inbuilt mechanisms for adaptive flexibility (change within existing limits of practice) and adaptive reform (a timely changing of the limits)"¹ (pg. 138).</i>
Conversion factors	Different factors which can either enable or limit the way in which a drought hazard is converted into impacts on well-being ² .
Conversion factors	Environmental relate to the nature of the hazard, as well as the environmental setting which can enhance exposure to droughts.
Conversion factors	Institutional relate to the institutional and policy context which can impact the response to drought.
Conversion factors	Personal relate to the individual characteristics that can make people more or less susceptible to the impact of droughts.
Conversion factors	Social relate to the social context that influence people's adaptive capacity when preparing for or responding to droughts.
Disaster risk reduction	<i>"deals with the identification of hazards, analysis of hazard impacts and causes, and the removal or reduction of vulnerabilities"³ (pg.23).</i>
Drought	<i>"an extreme event brought about by a lack of rainfall and may be made worse by high temperatures. It is a natural phenomenon exacerbated by climate change"⁴ (pg.6).</i>
Exposure	<i>"the inventory of elements in an area in which hazard events may occur"⁵ (pg. 69).</i>
Hazard	<i>"the possible future occurrence of natural or human-induced physical events that may have adverse effects on vulnerable and exposed elements"⁵ (pg. 69).</i>
Resilience	<i>"deals with the transformation of people's capacity to cope, overcome, and recover from disaster effects"³ (pg.23).</i>
Risk	<i>"the possibility of adverse effects in the future"⁵ (pg. 69).</i>
Vulnerability	<i>"the propensity of exposed elements such as human beings, their livelihoods, and assets to suffer adverse effects when impacted by hazard events"⁵ (pg. 69).</i>
Water scarcity	<i>"the lack of sufficient available water to meet the demands of water usage. Water scarcity may be made worse by drought but can be minimised by wise water management"⁴ (pg.6).</i>

Contents

Glossary	v
Executive Summary	1
1.0 Introduction	3
1.1 Drought hazards in Scotland	
1.2 Project aims	3
2.0 Approach	3
2.1 Systematic literature review	
2.1.1 Capability approach framework	3
2.2 Limitations	4
3.0 Objective 1: Social factors which influence drought vulnerability	
3.1 Location of studies	5
3.2 Personal conversion factors	5
3.2.1 Age	5
3.2.2 Health	6
3.2.3 Income	6
3.2.4 Application in a Scottish context	6
3.3 Environmental conversion factors	6
3.3.1 Nature of the hazard	6
3.3.2 Environmental setting of the hazard	7
3.3.3 Experience of the hazard	7
3.3.4 Application in a Scottish context	7
3.4 Social factors	8
3.4.1 Social capital	
3.4.2 Ownership of land	9
3.4.3. Diversification of livelihoods	9
3.4.4 Application in a Scottish context	9
3.5 Institutional factors	9
3.5.1 Early warning systems	10
3.5.2 Bottom-up and top-down knowledge integration	10
3.5.3 Access to information	10
3.5.4 Public and institutional training	10
3.5.5 Application in a Scottish context	10
3.6 Interaction between conversion factors	11
4.0 Objective 2: Drought communication in Scotland to improve resilience	12
4.1 Drought forecasting	12
4.2 Drought preparedness	12
4.3 Drought response	13
5.0 Objective 3: Policy implications for Scotland	14
5.1 Policy recommendations	14
5.2 Future research	14
6.0 References	15

Executive summary

Research Aims

1. To undertake a systematic international literature review on the personal, social, environmental, and institutional conversion factors that interact to either enhance or reduce vulnerability to drought.
2. To map these onto three areas of drought communication: drought forecasting, drought preparedness, and drought response to improve resilience for people on PWS in Scotland.
3. To identify key policy implications for drought resilience in Scotland.

Background

Climate change poses an increasing risk of drought hazards in Scotland, with those on Private Water Supply (PWS) particularly exposed to water scarcity. Underlying social circumstances need to be acknowledged in drought management and resilience policy. These can help tailor communication for those on PWS to enable people to become more resilient to drought exposure. Public perception is important for drought preparedness and response. A key challenge for Scotland is the national messaging around climate change impacts to water resources, and future increasing water scarcity.

Research undertaken

A systematic literature review was undertaken to review the personal, social, environmental, and institutional conversion factors that interact to either enhance or reduce vulnerability to drought. These results were mapped onto three areas of drought communication: drought forecasting, drought preparedness and drought response and presented to key stakeholders to discuss potential policy implications for Scotland.

Key findings from literature

Personal conversion factors that can make people more susceptible to the impacts of droughts include age, health and income. In Scotland, low-income PWS users may be less likely to engage with their local authority for support and advice about maintaining their supply because they are more likely to fear unexpected costs they cannot afford. Elderly users or those with pre-existing health issues may be more susceptible to the impacts of water scarcity and/or poor water quality on PWS.

Environmental conversion factors relate to the nature of the hazard, the environmental setting of the hazard, and hazard experience which can enhance exposure to drought. Policy responses need to be tailored for environmental conversion factors (e.g. between urban and rural contexts) as these factors can influence different policy support. This is particularly important in Scotland, as PWS are more prevalent in rural contexts. Experience of water scarcity will also vary between urban and rural settings – and for those on PWS and on public water supply – leading to differing levels of awareness and water efficiency levels. The slow-onset nature of drought may convolute risk perception if there are storms or heavy rainfall at the same time as early drought warning communication.

Social conversion factors that influence people's adaptive capacity when preparing for or responding to droughts were social capital, tenure and diversification of livelihoods. Social capital is strong amongst rural communities in Scotland, which can be tapped into for people on PWS to establish community action groups. Such groups can help tackle some of the barriers around resilient water management and increase communication and engagement between water organisations and communities on PWS. In Scotland, some users do not have a clear understanding of the process of responsibility for a PWS which can be more complex between landowners and tenants. PWS play an important role in the resilience of rural economies. Tourism can help diversify the rural economy, but also puts a strain on water demand for PWS. There is therefore opportunity to raise awareness of water scarcity issues in Scotland through tourism campaigns.

Institutional conversion factors relate to the institutional and policy context which can impact the response to drought. These were early warning systems, bottom-up and top-down knowledge integration, access to information, and public and institutional training. An effective early warning system should: 1) disseminate information effectively; 2) be accessible to those who need it; 3) accommodate for a community's preferred source of information; and 4) include a drought action plan so people know how to respond to the drought warning. In Scotland, there is considerable opportunities for response to drought to be 'co-produced' through integration of bottom-up and top-down knowledge through improved information access.

Key findings for drought communication in Scotland

Improving communication around drought risk can help mitigate the impact these factors have on vulnerability. To identify key policy implications for Scotland, relevant conversion factors were selected around communication, focusing on drought forecasting, drought preparedness and drought response.

Key conversion factors around drought forecasting communication in Scotland include:

- Ability to understand weather and/or drought forecasts
- Access to information
- The timing of the forecast
- The perceived accuracy of information
- Translation of information into adaptation strategies

For drought preparedness, the key conversion factors include:

- Reducing uncertainty around what to prepare for
- Education on risk
- Integrating bottom-up and top-down knowledge
- Access to funding opportunities for water supply maintenance or adaptation strategies

For drought response, the conversion factors include:

- Experience with drought or water scarcity
- Public perception to drought
- Policy response to drought
- Stakeholder engagement with communities

Policy recommendations

In response to the conversion factors that can help better target communication around drought, the study identified the following policy recommendations:

- An integrated database of PWS that can be accessed by all stakeholders to allow a more targeted approach to drought preparedness and response.
- There is a need to understand the linkages between land-use planning and drought planning policy, and where these policies can ensure longer-term resilience to drought. The integrated database could help inform this.
- An improved early drought warning system which is informed by the integrated database as well as bottom-up knowledge.
- Tailored support about adaptation and resilience beyond what is currently offered by local authorities for those on PWS. There is a need to better understand the nature of households that are served by PWS to target support. A potential avenue could be a dedicated community water officer to liaise with communities and stakeholders to advise them on how to make their supplies more resilient.
- Support for both formal and informal resilience groups to create local action plans for those on PWS, including where to get information on how to be more resilient.
- Awareness raising through public communication on water efficiency throughout Scotland in the context of climate change.
- A potential avenue for raising awareness of water efficiency could be through tourism campaigns that raise awareness of water scarcity and asks visitors to use water wisely.

1.0 Introduction

1.1 Drought hazards in Scotland

Drought hazards are increasing under climate change in Scotland. Scotland experienced water scarcity in [2018](#), [2020](#) and [2021](#). Research has shown that the River Tay and the River Spey could see a two- or three-fold increase in the frequency of drought under climate change⁶. Exposure will vary between urban and rural areas in Scotland, particularly as 3% of the population are relying on Private Water Supplies (PWS) often in very remote parts of the country⁷. In the regulatory landscape of Scotland local authorities oversee PWS and often provide advice and support. Scottish Water manage public water supply and provide consumers with advice on how to save water to help keep more water in the natural environment. SEPA monitor the natural water resources. Whilst everyone who uses water is vulnerable to the impacts of drought and water scarcity, those on PWS are particularly vulnerable.

Scotland's first [National Water Scarcity Plan](#) was released in 2015. This plan focuses on how regulators will work with licensed water users and key organisations to manage resources before and during prolonged dry weather, and what action is required during periods of water scarcity. The phased approach aims to provide information early to allow them to prepare for the dry period. However, there is no policy document that explicitly explores the social impacts around drought exposure.

There is a need for policy to target communication around improving people's resilience to water scarcity. As well as varying hazard exposure between urban and rural areas, social circumstances also vary. Research has shown that rural communities tend to have stronger social connections compared to more urban communities⁹. Additionally, social capital is important for resilience to environmental hazards¹⁰. Exposure to the same hazard can result in different outcomes for people based on personal, environmental, social, and institutional conversion factors (see [Glossary](#))². Pre-existing inequalities are often not hazard-specific but can be made worse because of the hazard². For that, it is important to acknowledge the underlying social circumstances that create vulnerability and how this influences resilience. Doing so enables policy changes that can target communication strategically to reach a diverse audience, with the purpose of increasing resilience.

1.2 Project aims

This project reviews the evidence from the international literature to identify the factors which influence social vulnerability to drought. This informed knowledge-exchange with stakeholders to discuss the factors that might improve communication for people on PWS around drought forecasting, drought preparedness and drought response in a Scottish context. The specific objectives of the project were:

1. To undertake a systematic international literature review on the personal, social, environmental, and institutional conversion factors that interact to either enhance or reduce vulnerability to drought.
2. To map these onto three areas of drought communication: drought forecasting, drought preparedness, and drought response to improve resilience for people on PWS in Scotland.
3. To identify key policy implications for drought resilience in Scotland.

2.0 Approach

A systematic literature review was undertaken to review the personal, social, environmental, and institutional conversion factors that interact to either enhance or reduce vulnerability to drought. These results were mapped onto three areas of drought communication: drought forecasting, drought preparedness and drought response and presented to key stakeholders to discuss potential policy implications for Scotland.

2.1 Systematic literature review

The search terms in Figure 1 were used in Scopus in December 2021 to identify relevant academic literature to include in the study. Agriculture was excluded to focus the study on the social impacts and to exclude economic or industry impacts, or mitigation strategies that focused on agricultural crops. A predefined inclusion/exclusion criteria (Table 1) was used to screen the abstracts to further refine the studies to be included. The first 15 abstracts were screened individually by the two authors to identify any potential bias and to refine the inclusion/exclusion criteria as appropriate. Subsequently, the first 100 abstracts (~10%) were screened by both authors together to check for consistency in agreement. The lead author then screened the remaining abstracts, and the selected abstracts were checked by both authors for relevance. After screening the full texts, additional articles were removed if they were not within the scope of the study. Grey literature was included in the review to contextualise the results for PWS in Scotland. This included five additional documents.

2.1.1 Capability approach framework

The capability approach¹¹ is a wellbeing framework that acknowledges that people differ in their ability to turn resources into opportunities for wellbeing. Conversion factors in the capability approach are essential to inequality analysis, as they make explicit the factors which enhance or hinder people's use of resources for wellbeing. In disaster risk reduction, risk can be a consequence of

deprivation which results from “a shortage not only of resources, but of enabling conversion factors” (p 11)¹². Resilience strategies and policy needs to consider that not everyone can make use of the same resources to ‘bounce forward’ after a hazard event¹³.

The articles from the systematic review were analysed by applying the framework developed in Lindley et al. 2011² to identify conversion factors that influence people’s exposure, sensitivity and adaptive capacity to drought which contribute to vulnerability – all of which influence a person’s resilience. These conversion factors were then used to understand how communication needs to be tailored in Scotland to account for different levels of vulnerability.

2.2 Limitations

This was a short-term project to highlight broader gaps in knowledge around drought communication in Scotland. As such, the quality assessment of the included studies was based on peer-review only. Full texts were screened to identify the relevant personal, social, environmental, and institutional conversion factors. 14 papers could not be accessed due to subscription charges. The results from the review highlight areas where more research is required to provide more in-depth evidence for drought vulnerability in Scotland. Studies were marked ‘amber’ if they were not explicitly within the inclusion criteria but could be relevant for further analysis on this topic.

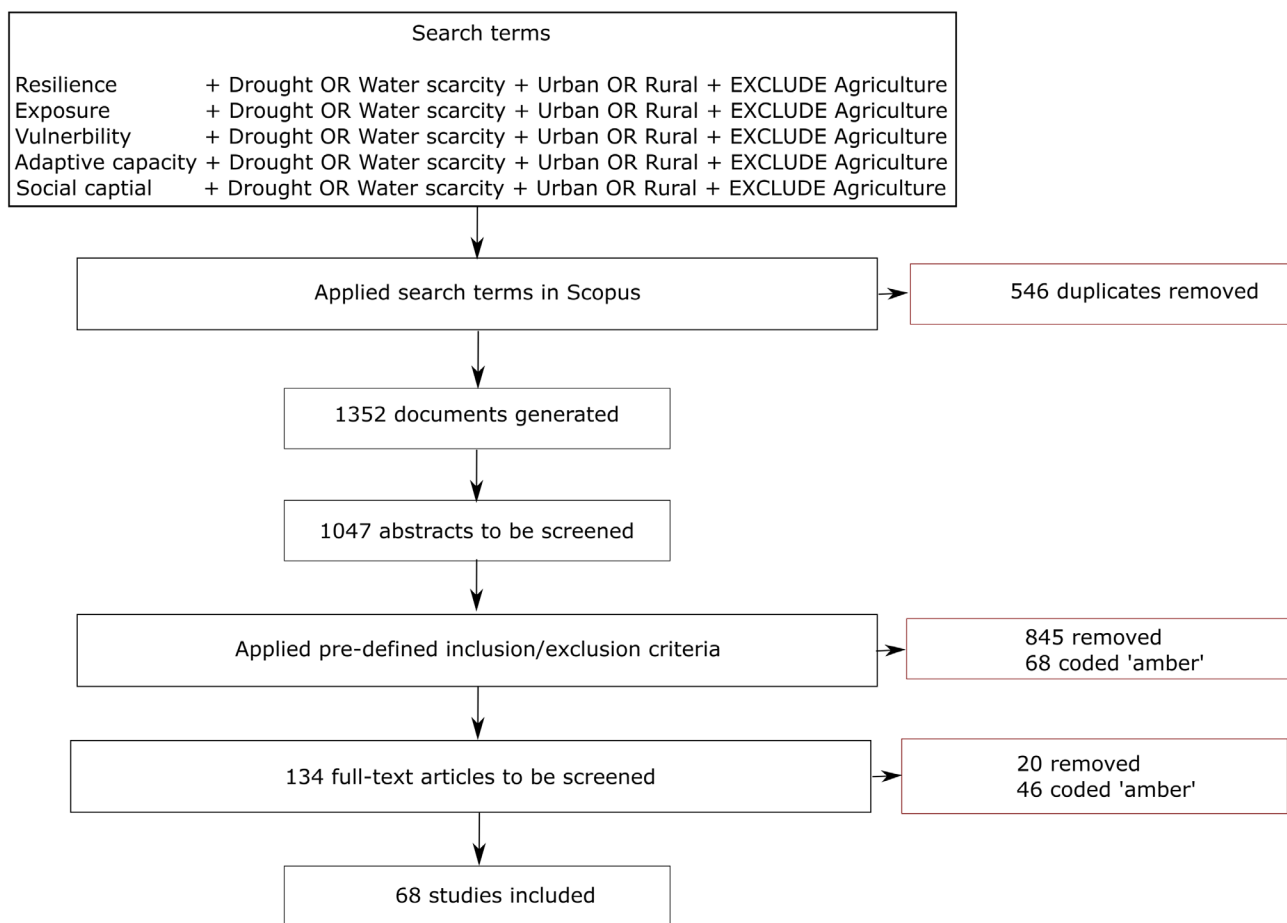


Figure 1 Systematic literature review approach. Studies marked ‘amber’ are potential studies to include in further reviews on this topic.

Table 1 Pre-defined inclusion/exclusion criteria- for abstract screening as part of the literature review	
Include	Exclude
Studies which outline social factors that impact drought exposure, vulnerability, resilience or adaptive capacity (for people).	Report characteristics: non-English, books, erratum, letters.
Studies which outline environmental factors that impact drought exposure, vulnerability, resilience, or adaptive capacity (for people).	Study characteristics: Focus of the study is exclusively on farming, food production or agricultural impacts.
Differences between urban and rural settings which have the capacity to enhance or mitigate the impact of drought exposure (for people).	Study characteristics: Study mentions droughts listed amongst other hazards, but it is not the focus of the analysis.

3.0 Objective 1: Social factors which influence drought vulnerability

3.1 Location of studies

Figure 2 illustrates the countries covered by the 68 studies included. The majority of the studies were in rural areas and predominately in Australia, with the least number of studies in Europe.

that can make people more susceptible to the impacts of other hazards (such as flooding) and include:

- Age^{3, 14-16}
- Health^{15, 17, 18}
- Income¹⁶⁻²⁹.

3.2 Personal conversion factors

Personal conversion factors are individual characteristics that can make people susceptible to the impacts of droughts (see [Glossary](#)). These were similar to the factors

3.2.1 Age

The literature review found evidence that elderly or very young people had enhanced vulnerability to droughts^{15, 16, 30}. This is because children need support and elderly



Figure 2 Geographical location of the 68 studies included in the systematic review. Note that 'Multiple' are studies that covered more than one country in their analysis. Note that Egypt is transcontinental.

people are more likely to have reduced mobility and/or poor health, increasing their need to be assisted¹⁵. For example, a systematic review on the relationship between resilience to droughts and people's wellbeing in Southern Africa found that elderly-headed households were less resilient to droughts than other households³. They noted that adaptation required labour-intensive agricultural activities which older people were unable to provide. The study also found that elderly people experienced weak socio-political empowerment which limited their capacity to respond in an effective way to droughts. This highlights the interaction between personal factors (such as age) and broader social factors (such as community empowerment) in the context of droughts.

3.2.2 Health

Poor health can make people more susceptible to the impacts of a drought and is therefore a personal conversion factor for drought vulnerability¹⁸. Droughts can also cause longer-term indirect health impacts, such as impacts from food insecurity due to water shortages, impacts on livelihoods, mental health, and waterborne diseases¹⁸. Better access to health services reduces vulnerability^{15, 29, 31}. Studies have explored the interaction between drought and mental health and wellbeing^{26, 30, 32-34}.

3.2.3 Income

Income was identified as an important conversion factor for drought resilience. Studies highlighted that low income and poverty can make people more vulnerable to drought impacts. This is because low-income households may have less financial capital to adopt adaptation strategies³⁵. For example, a study in Nigeria highlighted that low income limits household capacity to acquire alternative water supply sources²¹. Moreover, a lack of funding opportunities was found to be a barrier to drought preparedness³. Austin et al. (2020)³⁶ highlight the importance of funding and programmes to support rural communities that have been impacted by droughts.

3.2.4 Application in a Scottish context

Income, age and health personal conversion factors are relevant in a Scottish context.

- **Age** – Very young or older populations can be more susceptible to climate hazards such as flooding or heat-related stress in Scotland² and the literature has highlighted that age is also an important factor in drought contexts. Elderly populations may require additional support for implementing adaptation measures for PWS to reduce the impact of drought.

A study by Teedon et al. (2020)³⁷ found that age and the physicality of maintaining PWS was a reason for wanting to connect to a mains water supply. Moreover, older people are less likely to use the internet in Scotland – only 58% of those ages 75 or above used the internet in Scotland in 2020³⁸. This can have an impact on communication messaging which help communities prepare for droughts.

- **Health** – Pre-existing illnesses can make people more susceptible to health-related outcomes of climate hazards in Scotland². This is relevant in the context of PWS and drought in Scotland, as water scarcity for those on PWS can cause health consequences that result from lack of water access for washing and cleaning⁷. Moreover, the quality of drinking water sources in PWS can be highly variable causing potential health risks³⁹. Ash (2021)⁷ state that improving water quality may be a more immediate concern for people on PWS which means that – without additional funding and support – they are less able to prepare for climate change in a way that would increase their resilience⁷.
- **Income** – Low income can reduce people's ability to adapt in response to drought risk in Scotland. For example, research has shown that low-income private water owners are least likely to engage with their local authority for support and advice because they are more likely to fear unexpected costs they cannot afford⁷.

3.3 Environmental conversion factors

Environmental conversion factors relate to the nature of the hazard, as well as the environmental setting where the hazard occurs, which can enhance exposure to droughts. The environmental factors identified from the literature review include:

- Slow onset of drought^{18, 40-42}
- Changes to land use^{1, 15, 23, 24, 43}
- Rural or urban contexts^{18, 21, 31, 33, 44-47}.

3.3.1 Nature of the hazard

Droughts are a slow-onset hazard. The longer lead time allows for a proactive response to take action to minimise the impacts of a drought^{41, 42}. However, the slow-onset can make the impacts difficult to establish, such as indirect health impacts¹⁸, which can make response more complex. Indirect health impacts influence exposure and vulnerability, and subsequently risk, and should be understood when designing multi-sector measures in response to droughts¹⁸.

3.3.2 Environmental setting of the hazard

Land use can influence drought exposure. To reduce drought risk, land use and urban planning should consider hazard and vulnerability to drought¹. This can be done through government regulations that require the consideration of water supply in future land use planning and construction of new infrastructure¹. For example, Scott et al. (2021)⁴⁸ highlight that water management strategies when combined with land use regulations (e.g. subsidies for green infrastructure and rain water harvesting) can support urban growth whilst reducing water demand.

Exposure to drought will also vary between urban and rural contexts¹⁸. Rural communities tend to be more exposed to drought impacts compared to urban areas as they are more connected to the land for both social and economic activities^{18, 31, 44, 45}. A study in Australia found the different lifestyle demands influenced the severity of drought impact, as rural people experiencing 'constant and recent long drought' pattern tended to be more distressed than urban people living in the same conditions⁴⁴. The authors noted that rural communities are more sensitive to droughts, as the relative impact of droughts on their livelihoods is larger than for urban communities. Whilst urban residents were not insensitive to drought impacts, the better weather may mean more opportunities for recreational activities outdoors⁴⁴. Another study in Nigeria noted that most of the published research information on water scarcity is for rural areas because rural communities are seen to be more visibly involved in activities that directly depend upon water supplies²¹. However, in the Nigerian context due to the large human concentrations they support, the authors argue that urban areas are comparatively more susceptible to water scarcity challenge compared to rural areas²¹. The study suggests infrastructure which was originally designed to supply less people may be insufficient in large and rapidly expanding cities under climate change.

How a community prepares for and responds to a hazard event depends on the relationship with its environment⁴⁹, and this relationship is likely to vary between urban and rural contexts⁴⁵. A study in the USA by Jedd et al. (2018)⁴⁹ outlines these differences by explaining how rural communities are both at risk from and resilient to drought. Risk factors include livelihoods that are often based on natural capital, which can lead to limited economic diversity during periods of water scarcity. Demographic characteristics can also have an impact on the labour force (such as an ageing population). Resilience factors include an abundance of natural resources that can be an asset to attract tourism because it can diversify rural economies. Rural communities are also rich in social capital with tightly connected networks and local experts which can help them respond effectively to drought.

Environmental context can also influence different policy support. A study in Canada found that rural communities tend to support policies that protect existing water right holders, whereas urban communities tend to support policies relying on government regulation⁴⁶. This highlights the need for policy response to be tailored for environmental conversion factors. However, the study suggests that support for pro-environmental policies may be the result of the distribution of demographics between rural and urban areas, as opposed to place of residence per se. It provides evidence from previous studies which found higher levels of income and higher education to be strong predictors of pro-environmental values which were more prevalent in urban areas. It suggests that both environmental setting as well as socio-demographic variables (regardless of place of residence) influence environmental values and hence policy preferences.

3.3.3 Experience of the hazard

It is likely that the differences between urban and rural community attitudes about drought and water scarcity relate not only to connection with the land but also direct experience of water scarcity⁴⁷. Lindsay et al. (2017)⁴⁷ state that "in parts of rural Australia, residents expect, and respond to, variations in water availability. The experience of drought can alter how water is viewed, from an unlimited resource, to something that needs to be carefully managed" (pg. 576). Transferable lessons from rural communities to be encouraged in urban areas include knowledge of water variability, sustainable water use, and action to conserve water when needed⁴⁷. Bjornlund et al. (2013)⁴⁶ found that the level of water scarcity has an impact on policy acceptance. For example, people experiencing high water scarcity were significantly more likely to disagree with any policy that results in a reduction in water allocated to irrigation, whereas people experiencing the least amount of water scarcity were significantly more likely to support policies that secure water for the environment.

3.3.4 Application in a Scottish context

The environmental conversion factors that influence how drought hazards impact resilience are important in a Scottish context.

- **Nature of drought hazard** – The literature highlighted that the slow-onset of drought hazards provide a longer lead time to take action to prepare for a drought to mitigate its impacts. However, Scotland is perceived as a wet country which may convolute risk perception if there are storms or heavy rainfall at the same time as early drought warning communication.

- **Environmental setting of the hazard** – Urban and rural contexts are likely to have an influence on drought vulnerability in Scotland. PWS are vulnerable to the impacts of climate change⁸. They are more prevalent in rural areas, with 31% of the population reliant on PWS in Argyll and Bute, compared to 0.1% of the population in Aberdeen City⁷. Rural communities in Scotland on PWS may therefore experience enhanced exposure to droughts compared to urban areas. Moreover, tourism in Argyll and Bute accounts for almost 25% of private sector employment³⁷. A study by Teedon et al. (2020)³⁷ found that PWS can be a unique selling point for tourism because it adds to the 'wildscape' of the scenery. However, the study also noted that tourists can be unaware of their water use as well as creating greater demand for water. It also found that the labour costs of PWS and their maintenance can undermine labour investment in other business activities. Underlying socio-demographics, drought perception, and rural livelihoods need to be considered in drought management in Scotland. Tourism can be a potential route to raising awareness on the impact of water use for drought resilience.
- **Drought experience** – Experience of water scarcity will vary between urban and rural settings in Scotland due to PWS being predominately in rural areas. For example, in 2018 500 PWS dried up and required emergency assistance from the bottled water scheme provided by the Scottish Government⁷. As a result, there may be more increased awareness of water scarcity for people on PWS compared to people on public water supply. Moreover, each person in Scotland uses about 165 litres of water each day, and increasing water use, population growth and climate change will increasingly affect future water resources⁵⁰. With climate change, the attitude of all water consumers needs to change (with governments having to inform and guide this change).

3.4 Social factors

Social factors relate to the social context that influence people's adaptive capacity when preparing for or responding to droughts. The social factors identified from the literature review include:

- Social capital^{3, 19, 20, 25, 49, 51} – particularly community engagement⁵², networks^{20, 26, 30, 53}, and trust^{49, 54-56}
- Ownership of land^{51, 53}
- Diversification of livelihoods^{3, 17, 19, 28, 57}.

3.4.1 Social capital

Social capital refers to the connections and bonds

within communities as well as the bonds which bridge connections across communities and organisations⁹. This literature review found that access to social networks reduces vulnerability, helps adaptation and enables resilience in the context of droughts. A study by Oriangi et al. (2020)²⁵ in Uganda found that tight social networks (with relatives) are a very important source of resilience and have a positive effect on household capacity to prepare and recover from a drought. To the contrary, looser networks (with friends) did not appear to affect resilience in the study. It also found that connections across communities and organisations had a significant positive effect on the capacity to adapt to droughts (in this case with NGOs as opposed to government). Social networks within communities as well as with external organisations can act as first responders during a hazard event and can enhance resilience²⁵. They also help pool resources to ensure access to available water for everyone^{24, 58, 59}. A lack of social networks can make people more vulnerable to drought impacts. For example, Murtinho (2016)²³ found that Water User Associations could be isolated from government support if they had a lack of social networks and political connections, which could perpetuate their vulnerability to drought.

Greater engagement in water-related issues and stronger policy support is associated with higher levels of social capital⁴⁷. It helps build trust between local people and government organisations⁵⁴. It is also important from a top-down perspective. When water organisations cultivate trust and a relationship with the public, it can 'prime' people to be better prepared to respond to drought, as well as giving water organisations greater flexibility to act if and when they need to implement specific drought measures⁵⁵. Moreover, without public trust and cooperation, public measures to reduce water consumption may be seen as unnecessary and inconvenient⁴⁹. On the other hand, public measures which focus on supply solutions can diminish perception about future water scarcity⁴⁷. Community engagement can therefore foster sustainable practices⁴⁷ to target public perceptions for a balance between supply- and demand-based drought management. A lack of trust was identified as a key theme in relation to vulnerability, resilience and adaptive capacity in a study in rural Australia⁵⁶.

Social capital can be an important factor for migration decisions in response to drought⁵³. Two studies in Canada highlighted the nexus between social capital, rural migration and drought exposure. Gilbert and McLeman (2010)⁵⁹ found that strong social networks increased the potential for rural households to stay, whilst those without social capital had a greater sense of isolation and loneliness which influenced migration decisions. Wittrock et al. (2011)¹⁷ highlighted that communities already vulnerable in a socio-economic context will face reduced social capital during extreme events, as people with

options may leave the community leaving people who stay more vulnerable because of further reduced social capital.

Whilst social capital is an important conversion factor for drought vulnerability, drought can also impact social capital itself. For example, a study in rural Australia stated that prolonged drought can erode social and economic resources and deplete social capital, which can impact mental health³⁰. However, a study in rural USA that applied lessons learned from Australia stated that women may be less likely to suffer from mental health impacts during drought due to having larger and denser social networks, as well as increased likelihood of having non-agricultural jobs²⁶. Another study in rural India found that droughts can lead to prolonged scarcity and resource competition, with negative consequences for social capital in the short-term⁴⁰.

3.4.2 Ownership of land

Land ownership was identified as a conversion factor for drought vulnerability in the literature. Segnestam (2017)⁵¹ found that land ownership gives people more autonomy over land adaptation decisions, enables people to be more invested in the care and management of the land, and enables more financial capital as land is considered collateral for accessing credit. Lack of property rights can influence resource availability through reduced ability to access capital and increase vulnerability to droughts^{17, 53}.

3.4.3. Diversification of livelihoods

Droughts can threaten long-term livelihoods⁴⁰. Water scarcity can decrease agricultural productivity, which can impact livelihoods and food production, and force people to migrate⁶⁰. This can be more profound in rural communities⁴⁹. Diversification of livelihoods is therefore important for access to resources during droughts and for enabling resilience^{3, 19, 24, 28}. For example, Kamara et al. (2018)³ highlighted that collective action within the community enabled government intervention to mitigate drought effects by providing more drought-tolerant crop breeds to increase productivity. Diversification of livelihood strategies helps people to choose adaptation strategies in response to droughts¹⁹.

3.4.4 Application in a Scottish context

These social factors are relevant in Scotland.

- **Social capital** - In Scotland, social capital is measured by four inter-related aspects: social networks; community cohesion; social participation; and community empowerment, all of which contribute to people's wellbeing⁹. A report by the Scottish

Government found that rural communities in Scotland tend to be richer in social capital compared to urban communities⁹. This social capital can be tapped into in rural areas for people on PWS. Community water schemes can help communities tackle the complexities of water management through pooling of resources and developing of resilience strategies⁷. Engagement between organisations and communities on PWS should consider the community's current understanding, perceptions and attitudes towards supply issues to provide locally specific solutions³⁹.

- **Tenure** - A previous study by CREW³⁹ found issues relating to property ownership and responsibility with PWS. There was uncertainty around location of sources and infrastructure, particularly for new residents. Moreover, there were concerns about local knowledge being lost when long-term residents left, potentially increasing community vulnerability. The situation was more complex when landlords did not know who was using the water resources on their land. Moreover, the study found that it was not always clear whether the landlord or tenant could apply for grant schemes to maintain their PWS.
- **Diversification of livelihoods** – Another CREW study also highlighted that PWS play an important role in the resilience of rural economies, with local economies in remote rural areas particularly vulnerable to variations in private water supply³⁷. It found that the vulnerability amongst these businesses can be exacerbated by a lack of knowledge and associated skills in remote rural areas that can limit a community's adaptive capacity. Both businesses (e.g. tourism, dairy farming, and forestry) and private households in rural areas rely on PWS. The policy output of the study recommended that greater resilience planning over the longer-term should be implemented to reduce business exposure and improve community resilience. In this review of the academic literature, tourism was found to support rural resilience as it provides more diversified livelihoods. As the tourism sector expands in Scotland there may be increased demand on PWS. However, this may also be a potential avenue to increase public awareness about water scarcity issues in Scotland.

3.5 Institutional factors

Institutional conversion factors relate to the institutional and policy context which can impact the response to drought. Institutional factors from the literature included:

- Early warning systems^{15, 17, 28, 61}
- Bottom-up and top-down knowledge integration^{3, 17, 23, 31, 59, 62-65}

- Access to information^{1, 15-17, 19, 28, 29, 49, 55, 63, 64}
- Public and institutional training^{1, 3, 21, 51, 65}.

3.5.1 Early warning systems

Early warning systems have been identified as an important conversion factor for resilience in the literature. A lack of early warning system can reduce the ability to prepare for droughts as they do not have enough time to assess the implication of the forecast and make an informed decision on how to respond^{58, 61, 64}. A study by Grey (2019)⁶⁴ in Zimbabwe found that weather forecasts exacerbated vulnerability if they are perceived as inaccurate, therefore the translation of the forecast into digestible information is important. Ahmed et al. (2014)³¹ argued that early warning systems should be the core of future adaptation policies to reduce the vulnerability of an area. A good early warning system should:

1. disseminate information on risk and response to risk managers, at risk groups, and care providers¹
2. be accessible to end users who need it⁵⁸
3. accommodate for a community's preferred source of information⁶⁴
4. include a drought action plan so people know how to respond to the drought warning⁵⁸.

3.5.2 Bottom-up and top-down knowledge integration

Knowledge is an important conversion factor that can influence drought vulnerability. Communities with rich indigenous and local knowledge had good resilience outcomes³. For example, indigenous knowledge of seasons and early warnings, as well as traditional practices such as the use of early maturing seeds and mixed cropping, enabled the community to adapt to droughts in South Africa³. However, Fatehpanah et al. (2020)⁶² noted that using local knowledge without scientific considerations could not guarantee people's health throughout the drought period. Whilst Kamara et al. (2018)³ noted that traditional institutions and knowledge were slowly being eroded by western-modelled education and external assistance. The literature therefore highlighted the importance of blending top-down and bottom-up knowledge in the context of droughts. Doing so will increase understanding and acceptance of drought communication amongst different communities³. Knowledge sharing is important for drought preparedness and can feed into early warning system by documenting local knowledge around weather forecasting and drought prediction through official channels^{3, 64}.

3.5.3 Access to information

Information access is an important conversion factor for drought vulnerability. Institutions can influence resource availability through producing and distributing information around drought risk^{17, 63}. Widespread and targeted dissemination of information can educate the public on drought risk, as well as influence the diverse range of social, financial, ecological, cultural, and institutional activities affected¹. It is important to have access to information that is considered alongside the socio-economic and governance context, so that the information is useable and can be translated into resilience strategies⁶⁴.

3.5.4 Public and institutional training

Training around drought risk is a conversion factor that can influence drought vulnerability and resilience. Zaidi and Pelling (2014)¹ highlight that both community and private sector training is important for drought preparedness, and the absence of training can limit adaptive governance to technical solutions which manage water supply and exclude managing water demand. Moreover, a study in southern Africa identified that a lack of training and timely warning information was as a key barrier to resilience building by the government³.

3.5.5 Application in a Scottish context

These institutional conversion factors can be translated for a Scottish context.

- Early warning systems – Early warning systems are provided by SEPA in Scotland in the form of a weekly water scarcity report. Moreover, there has been research published on early warning systems for PWS in Scotland⁸. A new database that integrates the current PWS database with information on drought risk is required along with an understanding of the social context to ensure communication can be tailored for end users to improve resilience (e.g., by communicating a drought action plan for communities to tailor to their needs).
- Bottom-up and top-down knowledge integration –In Scotland, CREW research has found that communities have detailed awareness of the problems associated with effective supply through PWS but knowledge varies about infrastructure; appropriate maintenance; testing regimes; managerial responsibility; health risks and associated support services, with a desire to improve this knowledge³⁹. The study found that there are considerable opportunities for solutions to be 'co-produced' by agencies and communities. A key recommendation from the [CREW report](#) is the development of an 'Information Hub' as a credible and authoritative information source for all who use PWS. This might

include information on rights and responsibilities of landowners and tenants to maintain and ensure PWS provision³⁹. This could be extended to include information around climate change and drought resilience.

- Public and institutional training – The 'Information Hub' could also be a useful resource for stakeholders to collaborate and share information amongst both organisations and end users to improve training on drought resilience for PWS.

3.6 Interaction between conversion factors

The interaction of these personal, social, environmental and institutional conversion factors influenced people's perception around drought preparedness and response.

Figure 3 highlights the interactions between and across different personal, social, environmental, and institutional factors. Interactions between personal and social factors is exemplified by the social determinants of health that can be related to health vulnerability to drought, and how exposure to drought impacts may exacerbate this interaction¹⁸. A study in rural Brazil by Menezes et al. (2021)¹⁸ modelled health vulnerability (modulated by

social determinants, rural characteristics, and access to water) to identify spatial patterns in vulnerabilities. Results showed a clear distinction between municipalities with the higher human welfare and those municipalities with the worst living conditions and health status. The authors argue that health promotion policies should focus on reducing social inequality in the context of droughts.

There are also clear interactions and feedbacks between environmental, social and institutional factors. In particular, between social capital and bottom-up and top-down knowledge integration. Bridging social connections between communities and organisations is important for co-production of knowledge. It also builds trust, which alters public perception around both drought risk and how it is managed, giving water organisations more flexibility to implement drought management strategies if and when they are required. Co-production of knowledge can also make early warning systems more effective for drought preparedness, as it allows for information use to be better targeted to local communities and how they can implement resilience strategies based on this information. Moreover, establishing networks between communities and organisations enables people to be more informed in how to seek funding support for PWS grants, which will target personal conversion factors around low income.

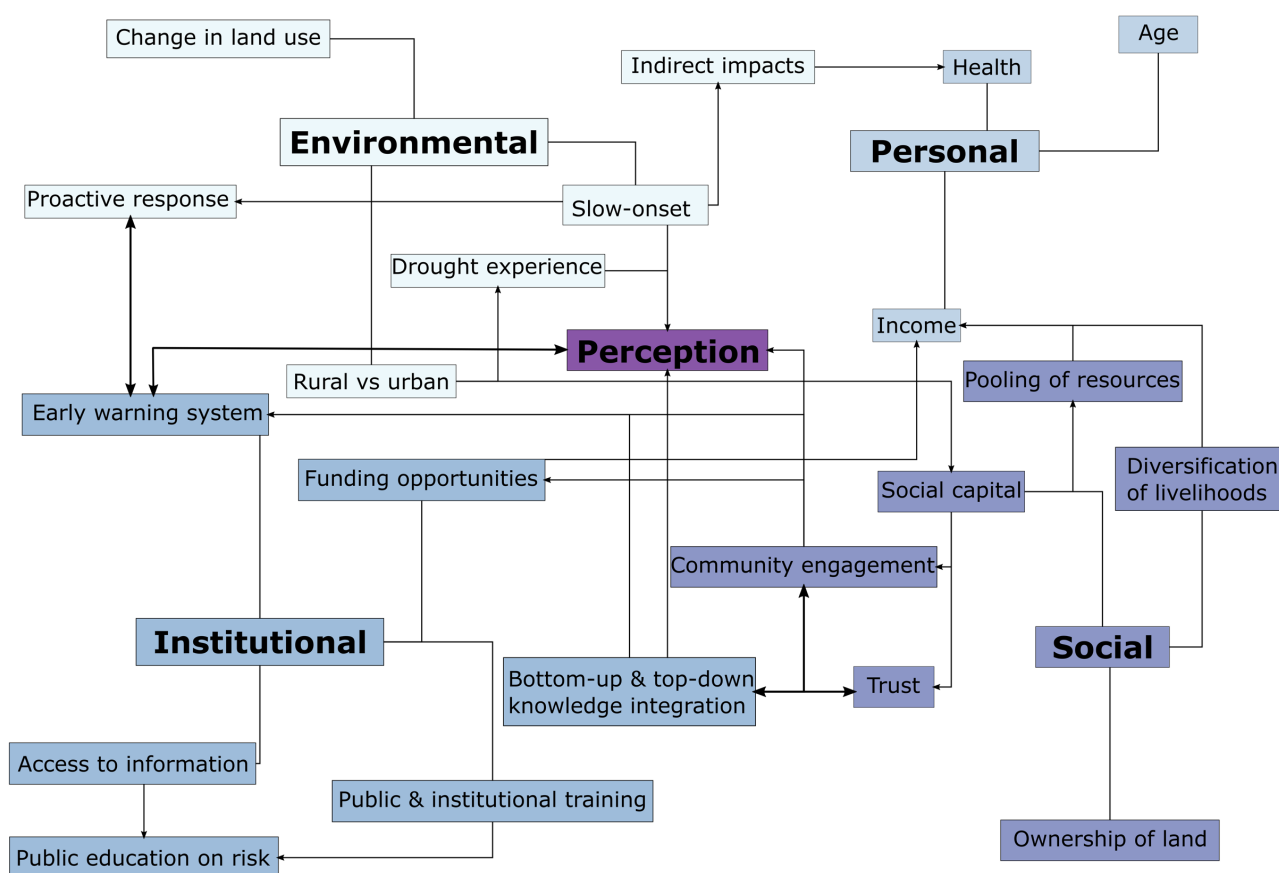


Figure 3 Interactions between and across different personal, social, environmental and institutional conversion factors, and how these influence public perception. Note that connectors with arrows indicate feedbacks, either unidirectional or bidirectional.

4.0 Objective 2:

Drought communication in Scotland to improve resilience

The international literature review provides a broad overview of the personal, social, environmental, and institutional factors that make people vulnerable to drought. Improving communication around drought risk can help mitigate the impact these factors have on vulnerability. To identify key policy implications for Scotland, relevant conversion factors were selected around communication, focusing on drought forecasting, drought preparedness and drought response. Whilst the policy recommendations do not target the social factors themselves to reduce vulnerability, they target conversion factors that can help improve communication to help people on PWS to be more resilient to drought. Future research is required to change the underlying social factors which make people more vulnerable to droughts in Scotland.

4.1 Drought forecasting

The review identified that early warning systems are important for drought resilience as they enable communities to be more prepared. However, the different interactions of conversion factors highlight that not everyone makes the same use of early warning systems to convert them into actions for resilience. The conversion factors that can be targeted by communication policy to allow people to turn the information into practical improvements for resilience include:

- Ability to understand weather and/or drought forecasts⁶⁴
- Access to information⁴⁹
- The timing of the forecast⁶⁴
- The perceived accuracy of information⁶⁴
- Translation of information into adaptation strategies⁶⁴

These conversion factors are relevant in a Scottish context. SEPA translates the weather forecast and monitoring data into a [weekly water scarcity report](#) for the water environment to provide information to operators as well as the public. The forecast is simplified into plain language to ensure it can be understood and a drought indicator is given (Normal conditions, Early warning, Alert, Moderate Scarcity, Significant Scarcity). Through the National Water Scarcity Plan, SEPA provide advice to abstractors when water levels are getting low. Further information on how to look after PWS is provided through a [Scottish Government website link](#). However, there needs to be a more spatially detailed drought early warning system, monitoring more surface and groundwater locations than at present, integrated with input from local authorities and their 'on the ground' experience of water scarcity. It is also important for policy to acknowledge inequality in access to drought forecasting

information. Some people on PWS might not have internet access or be part of a community group that receives water scarcity information. In Scotland, 93% of households have access to the internet. However, this is varied by deprivation: only 87% of households in the 20% most deprived areas had access to the internet whereas almost all households (99%) in the 20% least deprived areas had access to the internet in 2020³⁸. Therefore, communities preferred source of information should be taken into consideration in drought forecasting communication.

Droughts are a slow onset hazard which provide a longer lead time for early warnings to increase public awareness⁴¹. However, Scotland is perceived as a wet country. This creates complications around the timing of the drought forecast warnings if it coincides with several flood or storm warnings. This can feed into the perceived accuracy of the drought forecasting report. Policy needs to recognise the challenges around public perception to drought as a hazard in Scotland. This requires further research to understand people's current perception and how communication can subsequently be improved.

A recent CREW report on communicating flood risk in Scotland highlights that communication is only useful if people know what to do with that information (See Section 4.2)⁶⁶. This applies across many contexts and is equally relevant in a drought context. Policy changes can improve communication around drought preparedness to translate the early warning information into adaptation strategies.

4.2 Drought preparedness

Drought forecasting can help people only if they know how to prepare for droughts. Social capital and dissemination of information were identified as important conversion factors for drought vulnerability in the literature review. These informed conversion factors around drought preparedness that can be targeted by communication policy to provide practical improvements for resilience are:

- Reducing uncertainty around what to prepare for^{17, 64}
- Education on risk¹
- Integrating bottom-up and top-down knowledge¹⁷
- Access to funding opportunities for water supply maintenance or adaptation strategies¹⁷

A key challenge for Scotland is the national messaging around how climate change is likely to increase drought exposure and water scarcity in the future. People's actions

to prepare for drought will differ between those on PWS and those on a public supply. Even within PWS groups there are a lot of different variables – both socially and geographically – which can make the communication on preparedness more complex. National messaging needs tailored for different local authorities, then tailored for different communities. More research is required on the personal and social conversion factors that are relevant in Scotland for those on PWS.

There is a need to communicate increasing drought exposure in Scotland but also action communities can take to be better prepared for droughts and water scarcity. An example of integrating top-down and bottom-up knowledge on drought preparedness is the [Local Authority Waters Programme](#) in Ireland. It is a national shared service working on behalf of 31 local authorities in Ireland to collaborate with local authorities, state agencies, public bodies, private sector stakeholders and local communities. It emphasises the importance of community engagement to combine local and expert knowledge for a better understanding of what is happening in a local catchment and waterbody. Their use of community water officers offer support with for PWS, flooding, drought, and resilience, and can direct communities on where to find funding for resilience support. Whilst local authorities already provide advice and support in Scotland, the role of a dedicated community water officer could help to improve drought preparedness.

4.3 Drought response

The literature highlighted that urban and rural perspectives and experiences have an influence on drought perception and subsequently on drought response⁴⁵. The conversion factors that communication policy can target around drought response to improve resilience include:

- Experience with drought or water scarcity⁴⁷
- Public perception to drought^{28, 52, 53, 55, 59, 61, 65}
- Policy response to drought^{52, 55, 61}
- Stakeholder engagement with communities⁵²

Drought response policies supported by urban and rural communities are likely to be different because of different experiences of water scarcity and connections to the land⁴⁷. A key finding in the literature was on supply vs demand policy responses and the feedback this has on public perceptions. The review found that policies which focus on managing drought supply may reduce public perceptions that water scarcity may be a concern in the future and encourage lifestyle changes that are more water intensive⁴⁷. Those which focused on demand reduction policies had perceptions around equity and efficiency concerns⁵⁵.

In Scotland, people on PWS do not necessarily require information on when to start reducing their water use as they are aware of their source of water and when it is becoming low. As Ash (2021)⁷ states, “[Citizen Advice Scotland’s] body of evidence shows that the extent to which private water communities and users have the capacity to anticipate, cope with, resist and recover from natural hazards, such as drought, is limited within the current regulatory, support and funding structure” (pg. 8). They need support, training, and advice on what action to take, as well as funding, to increase their resilience to varying supply⁷. People on public water supply are ensured supply of water and are less likely to be aware of increasing water scarcity issues for those on PWS. This requires different communication around water efficiency. Therefore, greater responsiveness to water availability should be encouraged in urban areas⁴⁷.

Action plans can help people know what to do in response to a drought warning. Both formal and informal volunteer groups can improve drought response. In Scotland, people in accessible and remote rural areas are more likely to have stronger social participation, community cohesion as well as stronger social networks than the Scottish average⁹. This indicates that there are already potential routes in which community groups can be established. Community resilience groups could be supported with action plans, similar to those constructed in response to increasing flood risk with the support of the Scottish Flood Forum.

In the literature, higher community engagement was associated with stronger support for drought response policy⁴⁷. In Scotland, the role of a community water officer (See Section 4.2) could act as a point of contact between communities and organisations to report information on drought response. This can provide an iterative process to inform future top-down and bottom-up information on drought forecasting, preparedness and response.

5.0 Objective 3: Policy implications for Scotland

5.1 Policy recommendations

In response to the conversion factors that can help improve communication around drought forecasting, drought preparedness, and drought response, the policy recommendations for PWS are:

- An integrated database of PWS that can be accessed by all stakeholders to allow a more targeted approach to drought preparedness and response.
- There is a need to understand the linkages between land-use planning and drought planning policy, and where these policies can ensure longer-term resilience to drought. The integrated database could help inform this.
- An improved early drought warning system which is informed by the integrated database as well as bottom-up knowledge.
- Tailored support about adaptation and resilience beyond what is currently offered by local authorities for those on PWS. There is a need to better understand the nature of households that are served by PWS to target support. A potential avenue could be a dedicated community water officer to liaise with communities and stakeholders to advise them on how to make their supplies more resilient.
- Support for both formal and informal resilience groups to create local action plans for those on PWS, including where to get information on how to be more resilient.

Policy recommendations for public water supply include:

- Those on public supplies need more awareness on drought and water scarcity as an issue in Scotland in the context of climate change.
- A potential avenue for raising awareness of water efficiency could be through tourism campaigns that raise awareness of water scarcity and asks visitors to use water wisely.

5.2 Future research

This systematic review of international literature has highlighted the conversion factors in communication policy which can be targeted to improve drought resilience in Scotland. Future research areas include combined mapping of PWS, areas of social disadvantage, and climate change projections for drought hazards to understand their interactions. Qualitative research is also required to understand baseline perceptions around drought and water scarcity in Scotland. Future research could explore water consumption and water efficiency behaviour in the context of climate change for Scotland. This will help inform communication strategies and resilience support as policy moves towards a more proactive response to water scarcity and drought. Research is also required on multi-hazards in Scotland and their implications for resilience policy and drought communication. The future research suggested would support the potential options being explored by SEPA for a drought warning system the public can sign up to.

6.0 References

1. Zaidi Z, Pelling M. Chapter 6 - Vulnerability to Drought and Heatwave in London: Revealing Institutionally Configured Risk. Elsevier Inc; 2014. p. 125-48. in Birkmann, J., Kienberger, S. and Alexander, D. E. (eds.) *Assessment of Vulnerability to Natural Hazards*.
2. Lindley S, O'Neill J, Kandeh J, Lawson N, Christian R, O'Neill M. Climate change, justice and vulnerability. Joseph Rowntree Foundation; 2011.
3. Kamara JK, Akombi BJ, Agho K, Renzaho AMN. Resilience to Climate-Induced Disasters and Its Overall Relationship to Well-Being in Southern Africa: A Mixed-Methods Systematic Review. *International journal of environmental research and public health*. 2018;15(11):2375.
4. SEPA. Water resources management plan consultation. 2020.
5. Cardona OD, M.K. van Aalst, J. Birkmann, M. Fordham, G. McGregor, R. Perez, et al. Determinants of risk: exposure and vulnerability. In: Field CB, V. Barros, T.F. Stocker, D. Qin, D.J. Dokken, K.L. Ebi, et al., editors. *Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation. A Special Report of Working Groups I and II of the Intergovernmental Panel on Climate Change (IPCC)*. Cambridge, UK, and New York, NY, USA: Cambridge University Press; 2012. p. 65-108.
6. Visser-Quinn A, Beevers L, Lau T, Gosling R. Mapping future water scarcity in a water abundant nation: Near-term projections for Scotland. *Climate Risk Management*, 32. 2021. <https://doi.org/10.1016/j.crm.2021.100302>
7. Ash E. Private Water Supplies: A framework to deliver universal access to safe and affordable drinking water for all. Citizens Advice Scotland; 2021.
8. Rivington M, Akoumianaki I, Coull M. Private Water Supplies and Climate Change The likely impacts of climate change (amount, frequency and distribution of precipitation), and the resilience of private water supplies.: Scotland's Centre of Expertise for Waters (CREW). 2020.
9. McClymont K, Jacobs P, Cavanagh B. Social Capital in Scotland: Measuring and understanding Scotland's social connections. In: The Scottish Government - Office of the Chief Social Policy Adviser. 2020.
10. Aldrich DP, Meyer MA. Social Capital and Community Resilience. *American Behavioral Scientist*. 2014;59(2):254-69.
11. Sen A. *Development as Freedom*. Oxford: Oxford University Press; 1999.
12. Ton KT, Gaillard JC, Adamson CE, Akgungor C, Ho HT. Expanding the capabilities of people with disabilities in disaster risk reduction. *International journal of disaster risk reduction*. 2019;34:11-7.
13. Manyena SB. Disaster resilience: A question of 'multiple faces' and 'multiple spaces'? *International journal of disaster risk reduction*. 2014;8:1-9.
14. Becerra S, Saqalli M, Gangneron F, Dia AH. Everyday vulnerabilities and "social dispositions" in the Malian Sahel, an indication for evaluating future adaptability to water crises? *Regional Environmental Change*. 2016;16(5):1253-65.
15. Grigorescu I, Mocanu I, Mitrica B, Dumitrascu M, Dumitrica C, Dragota C-S. Socio-economic and environmental vulnerability to heat-related phenomena in Bucharest metropolitan area. *Environmental research*. 2021;192:110268.
16. Tora TT, Degaga DT, Utallo AU. Schematizing vulnerability perceptions and understanding of drought-prone Gamo lowland communities: an evidence from Southwest Ethiopia. *International journal of climate change strategies and management*. 2021;13(4/5):580-600.
17. Wittrock V, Kulshreshtha SN, Wheaton E. Canadian prairie rural communities: their vulnerabilities and adaptive capacities to drought. *Mitigation and Adaptation Strategies for Global Change*. 2011;16(3):267-90.
18. Menezes JA, Madureira AP, Santos RBd, Duval IdB, Regoto P, Margonari C, et al. Analyzing Spatial Patterns of Health Vulnerability to Drought in the Brazilian Semiarid Region. *International journal of environmental research and public health*. 2021;18(12):6262.
19. Sam AS, Abbas A, Arshad M, Kächele H. Analysing Vulnerability to Climate Change in India with Special Reference to Drought Risk: Results from a Field Survey. Cham: Cham: Springer International Publishing; 2016. p. 409-27. in Nautiyal, S., Schaldach, R., Raju, K. V., Kaechele, H., Pritchard, B. and Rao, K. S. (eds.) *Climate Change Challenge (3C) and Social-Economic-Ecological Interface-Building: Exploring Potential Adaptation Strategies for Bio-resource Conservation and Livelihood Development*.
20. Ng FY, Wilson LA, Veitch C. Climate adversity and resilience: the voice of rural Australia. *Rural and remote health*. 2015;15(4):3071-.

21. Inkani AI, Saleh H, Rumah MM. Toward tackling urban water scarcity: linking risk, vulnerability adaptive capacity and adaptation at household level. *Journal of environmental planning and management*. 2021;64(3):536-58.
22. Wang P, Qiao W, Wang Y, Cao S, Zhang Y. Urban drought vulnerability assessment – A framework to integrate socio-economic, physical, and policy index in a vulnerability contribution analysis. *Sustainable cities and society*. 2020;54:102004.
23. Murtinho F. What facilitates adaptation? An analysis of community-based adaptation to environmental change in the Andes. *International journal of the commons*. 2016;10(1):119-41.
24. Lwanga-Ntale C, Owino BO. Understanding vulnerability and resilience in Somalia. *Jamba*. 2020;12(1):1-9.
25. Oriangi G, Albrecht F, Di Baldassarre G, Bamutaze Y, Mukwaya PI, Ardö J, et al. Household resilience to climate change hazards in Uganda. *International journal of climate change strategies and management*. 2020;12(1):59-73.
26. Petkova EP, Celovsky AS, Tsai W-Y, Eisenman DP, Leal Filho W, Keenan JM. Mental Health Impacts of Droughts: Lessons for the U.S. from Australia. 2017:289-304. In Leal Filho, W. and Keenan, J. M. (eds.) *Climate Change Adaptation in North America: Fostering Resilience and the Regional Capacity to Adapt*.
27. Kabir ME, Davey P, Serrao-Neumann S, Hossain M. Seasonal Drought Thresholds and Internal Migration for Adaptation: Lessons from Northern Bangladesh. Cham: Cham: Springer International Publishing; 2017. p. 167-89. in Hossain, M., Hales, R. and Sarker, T. (eds.) *Pathways to a Sustainable Economy : Bridging the Gap between Paris Climate Change Commitments and Net Zero Emissions*.
28. Milhorance C, Le Coq J-F, Sabourin E, Andrieu N, Mesquita P, Cavalcante L, et al. A policy mix approach for assessing rural household resilience to climate shocks: Insights from Northeast Brazil. *International Journal of Agricultural Sustainability*. 2021:1-17.
29. Pavageau C, Locatelli B, Sonwa D, Tiani A-M. What drives the vulnerability of rural communities to climate variability? Consensus and diverging views in the Congo Basin. *Climate and Development*. 2018;10(1):49-60.
30. Hart CR, Berry HL, Tonna AM. Improving the mental health of rural New South Wales communities facing drought and other adversities. *The Australian journal of rural health*. 2011;19(5):231-8.
31. Ahmed MT, Nagi I, Farag M, Loutfi N, Osman MA, Mandour NS, et al. Vulnerability of Ras Sudr, Egypt to climate change, livelihood index, an approach to assess risks and develop future adaptation strategy. *Journal of water and climate change*. 2014;5(3):287-98.
32. Dean J, Stain HJ. The Impact of Drought on the Emotional Well-Being of Children and Adolescents in Rural and Remote New South Wales. *The Journal of rural health*. 2007;23(4):356-64.
33. Friel S, Berry H, Dinh H, O'Brien L, Walls HL. The impact of drought on the association between food security and mental health in a nationally representative Australian sample. *BMC public health*. 2014;14(1):1102-.
34. Luong TT, Handley T, Austin EK, Kiem AS, Rich JL, Kelly B. New Insights Into the Relationship Between Drought and Mental Health Emerging From the Australian Rural Mental Health Study. *Frontiers in psychiatry*. 2021;12:719786-.
35. Rogers S, Xue T. Resettlement and climate change vulnerability: Evidence from rural China. *Global environmental change*. 2015;35:62-9.
36. Austin EK, Handley T, Kiem AS, Rich JL, Perkins D, Kelly B. Drought, Wellbeing and Adaptive Capacity: Why Do Some People Stay Well? *International journal of environmental research and public health*. 2020;17(19):1.
37. Teedon P, Hakeem N, Helwig K, Henderson F, Martina M. Private water supplies and the local economic impacts in Scotland. Scotland's Centre of Expertise for Waters (CREW); 2020.
38. Government S. Scottish Household Survey: 2020 Telephone Survey | Key findings. Scottish Government; 2020.
39. Teedon P, Currie M, Helwig K, Creaney R. Engaging communities around private water supplies. CREW; 2017.
40. Behlendorf B, Jadoon A, Penta S. Rivalry and recovery: The social consequences of climatic hazards in rural India. *International journal of disaster risk reduction*. 2020;46:101488.
41. Amirzadeh M, Barakpour N. Strategies for building community resilience against slow-onset hazards. *International journal of disaster risk reduction*. 2021;66:102599.
42. Zheng Y, Byg A. Coping with climate change: households' response strategies to drought and hailstorm in Lijiang, China. *Environmental Hazards*. 2014;13(3):211-28.
43. Boyd E. Exploring Adaptive Governance for Managing Tipping Points. In: O'Riordan T, Lenton T, editors. *Addressing Tipping Points for a Precarious Future*. Oxford :2014. p. 258-76.

44. O'Brien LV, Berry HL, Coleman C, Hanigan IC. Drought as a mental health exposure. *Environmental research*. 2014;131:181-7.
45. Parry L, Davies G, Almeida O, Frausin G, de Moraes A, Rivero S, et al. Social Vulnerability to Climatic Shocks Is Shaped by Urban Accessibility. *Annals of the American Association of Geographers*. 2018;108(1):125-43.
46. Bjornlund H, Zuo A, Wheeler S, Xu W, Edwards J. Policy preferences for water sharing in Alberta, Canada. *Water resources and economics*. 2013;1:93-110.
47. Lindsay J, Dean AJ, Supski S. Responding to the Millennium drought: comparing domestic water cultures in three Australian cities. *Regional Environmental Change*. 2017;17(2):565-77.
48. Scott CA, Zilio MI, Harmon T, Zuniga-Teran A, Díaz-Caravantes R, Hoyos N, et al. Do ecosystem insecurity and social vulnerability lead to failure of water security? *Environmental development*. 2021;38:100606.
49. Jedd T, Bathke D, Gill D, Paul B, Wall N, Bernadt T, et al. Tracking Drought Perspectives: A Rural Case Study of Transformations Following an Invisible Hazard. *Weather, climate, and society*. 2018;10(4):653-72.
50. Waterwise. Save Water 2022. Available at: <https://www.waterwise.org.uk/save-water/> Accessed 09/05/2022
51. Segnestam L. Gendered Experiences of Adaptation to Drought: Patterns of Change in El Sauce, Nicaragua. *Latin American research review*. 2017;52(5):807-23.
52. Bettini Y, Brown R, De Haan FJ. Water scarcity and institutional change: lessons in adaptive governance from the drought experience of Perth, Western Australia. *Water science and technology*. 2013;67(10):2160-8.
53. Haeffner M, Baggio JA, Galvin K. Investigating environmental migration and other rural drought adaptation strategies in Baja California Sur, Mexico. *Regional Environmental Change*. 2018;18(5):1495-507.
54. Noemdoe S, Jonker L, Swatuk LA. Perceptions of water scarcity: The case of Genadendal and outstations. *Physics and chemistry of the earth Parts A/B/C*. 2006;31(15):771-8.
55. Dilling L, Daly ME, Kenney DA, Klein R, Miller K, Ray AJ, et al. Drought in urban water systems: Learning lessons for climate adaptive capacity. *Climate risk management*. 2019;23:32-42.
56. Stebbing MS, Carey M, Sinclair M, Sim M. Understanding the vulnerability, resilience and adaptive capacity of households in rural Victorian towns in the context of long-term water insecurity. *Australasian Journal of Water Resources*. 2013;17(2):193-201.
57. Sam AS, Kumar R, Kächele H, Müller K. Quantifying household vulnerability triggered by drought: evidence from rural India. *Climate and Development*. 2017;9(7):618-33.
58. Patrick HO. Climate change and water insecurity in rural uMkhanyakude District Municipality: an assessment of coping strategies for rural South Africa. *H2Open Journal*. 2021;4(1):29-46.
59. Gilbert G, McLeman R. Household access to capital and its effects on drought adaptation and migration: a case study of rural Alberta in the 1930s. *Population and environment*. 2010;32(1):3-26.
60. Ahmed B, Kelman I, Kamruzzaman M, Mohiuddin H, Rahman MM, Das A, et al. Indigenous people's responses to drought in northwest Bangladesh. *Environmental development*. 2019;29:55-66.
61. Leong C. Resilience to climate change events: The paradox of water (In)-security. *Sustainable cities and society*. 2016;27:439-47.
62. Fatehpanah A, Jahangiri K, Seyedin SH, Kavousi A, Malekinezhad H. Water safety in drought: an indigenous knowledge-based qualitative study. *Journal of water and health*. 2020;18(5):692.
63. Aldunce P, Bórquez R, Adler C, Blanco G, Garreaud R. Unpacking Resilience for Adaptation: Incorporating Practitioners' Experiences through a Transdisciplinary Approach to the Case of Drought in Chile. *Sustainability (Basel, Switzerland)*. 2016;8(9):905.
64. Grey MS. Accessing seasonal weather forecasts and drought prediction information for rural households in Chirumhanzu district, Zimbabwe. *Jamba*. 2019;11(1):1-9.
65. Ivey JL, Smithers J, de Loë RC, Kreutzwiser RD. Community Capacity for Adaptation to Climate-Induced Water Shortages: Linking Institutional Complexity and Local Actors. *Environmental management (New York)*. 2004;33(1):36-47.
66. Henderson F, Helwig K, Teedon P. Effective future communication of flood risk in Scotland. *CREW*; 2022.

CREW CENTRE OF EXPERTISE FOR WATERS

CREW Facilitation Team

Hydro Nation International Centre

James Hutton Institute

Craigiebuckler

Aberdeen AB15 8QH

Scotland UK

Tel: +44 (0)344 928 5428

Email: enquiries@crew.ac.uk

www.crew.ac.uk



CREW is a partnership between the James Hutton Institute and all Scottish Higher Education Institutes and Research Institutes.
The Centre is funded by the Scottish Government.

