DEPARTAMENTO DE INGENIERÍA Y GESTIÓN FORESTAL Y AMBIENTAL

ESCUELA TÉCNICA SUPERIOR DE INGENIEROS DE MONTES

LA GESTIÓN DE LA SEQUÍA: CONTRIBUCIONES PARA SU EVALUACIÓN

Julia Urquijo Reguera Ingeniera Agrónoma

DIRECTORES

David Pereira Jerez
Dr. Ingeniero Agrónomo

Lucia De Stefano
Dra. en Ciencias Geológicas

Madrid, 2015

Tribunal nombrado por el Mgfco. y Excmo. Sr. Rector de la Universidad Politécnica de Madrid, el día .... de .... de 2015.

Presidente D. ....

Vocal D. ....

Vocal D. ....

Vocal D. ....

Secretario D. ....

Realizado del acto de defensa y lectura de la Tesis

el día .... de .... de 2015 en Madrid.

Calificación ……………………………………………………

EL PRESIDENTE LOS VOCALES

EL SECRETARIO

A la memoria de mi abuelo Arturo

A mis padres Ana y Horacio

A mis hermanas y hermanos, Agustina, Mariana, Enrique y Manuel

A mi querida abuela Ana y mi familia de Argentina

A mi compañero Javier

AGRADECIMIENTOS

Mi más sincero agradecimiento a mi familia, amigos y amigas y compañeros de trabajo y profesión por haberme ayudado a desarrollar y escribir esta tesis.

A mis dos directores de tesis. A la Dr. Lucia De Stefano por haberme brindado la oportunidad de realizar esta tesis y por su apoyo incondicional a nivel profesional y personal a lo largo de cuatro años que han sido muy enriquecedores.

Al Dr. David Pereira por su apoyo a lo largo de muchos años, por sus buenos consejos y capacidad para hacerme reflexionar y actuar con toda su generosidad.

A todos los compañeros y compañeras del proyecto DROUGHT R&SPI sin excepción, porque ha sido una gran experiencia de trabajo profesional y personal.

A todas las personas con quienes he tenido la oportunidad de compartir el despacho en la Facultad de Ciencias Geológicas desde 2011, especialmente a Laurent Hardy e Itziar González Tánago.

A mis amigos y amigas distribuidos por el mundo por sus vidas y trabajos: Jairo Paizano, Ana P. Camporeale, Agueda Sainz, Abigaid Fernández, Maria Rey, Cecilia Spottorno, Marta Uriarte, Beltrán Uriarte, Irene Solana, Erika Ramirez y muchos más.

RESUMEN

La sequía afecta a todos los sectores de la sociedad y se espera que su frecuencia e intensidad aumente debido al cambio climático. Su gestión plantea importantes retos en el futuro. El enfoque de riesgo, que promueve una respuesta proactiva, se identifica como un marco de gestión apropiado que se está empezando a consolidar a nivel internacional. Sin embargo, es necesario contar con estudios sobre las características de la gestión de la sequía bajo este enfoque y sus implicaciones en la práctica.

En esta tesis se evalúan diversos elementos que son relevantes para la gestión de la sequía, desde diferentes perspectivas, con especial énfasis en el componente social de la sequía.

Para esta investigación se han desarrollado cinco estudios: (1) un análisis de las leyes de emergencia aprobadas durante la sequía 2005-2008 en España; (2) un estudio sobre la percepción de la sequía de los agricultores a nivel local; (3) una evaluación de las características y enfoque de gestión en seis casos de estudio a nivel europeo; (4) un análisis sistemático de los estudios de cuantificación de la vulnerabilidad a la sequía a nivel global; y (5) un análisis de los impactos de la sequía a partir en una base de datos europea.

Los estudios muestran la importancia de la capacidad institucional como un factor que promueve y facilita la adopción del enfoque de riesgo. Al mismo tiempo, la falta de estudios de vulnerabilidad, el escaso conocimiento de los impactos y una escasa cultura de la evaluación post-sequía destacan como importantes limitantes para aprovechar el conocimiento que se genera en la gestión de un evento.

A través del estudio de las leyes de sequía se evidencia la existencia de incoherencias entre cómo se define el problema de la sequía y las soluciones que se plantean, así como el uso de un discurso de securitización para perseguir objetivos más allá de la gestión de la sequía.

El estudio de percepción permite identificar la existencia de diferentes problemas y percepciones de la sequía y muestra cómo los regantes utilizan principalmente los impactos para identificar y caracterizar la severidad de un evento, lo cual difiere de las definiciones predominantes a otros niveles de gestión. Esto evidencia la importancia de considerar la diversidad de definiciones y percepciones en la gestión, para realizar una gestión más ajustada a las necesidades de los diferentes sectores y colectivos.

El análisis de la gestión de la sequía en seis casos de estudio a nivel europeo ha permitido identificar diferentes niveles de adopción del enfoque de riesgo en la práctica. El marco de análisis establecido, que se basa en seis dimensiones de análisis y 21 criterios, ha resultado ser una herramienta útil para diagnosticar los elementos que funcionan y los que es necesario mejorar en relación a la gestión del riesgo a la sequía.

El análisis sistemático de los estudios de vulnerabilidad ha evidenciado la heterogeneidad en los marcos conceptuales utilizados así como debilidades en los factores de vulnerabilidad que se suelen incluir, en muchos casos derivada de la falta de datos.

El trabajo sistemático de recolección de información sobre impactos de la sequía ha evidenciado la escasez de información sobre el tema a nivel europeo y la importancia de la gestión de la información. La base de datos de impactos desarrollada tiene un gran potencial como herramienta exploratoria y orientativa del tipo de impactos que produce la sequía en cada región, pero todavía presenta algunos retos respecto a su contenido, proceso de gestión y utilidad práctica.

Existen importantes limitaciones vinculadas con el acceso y la disponibilidad de información y datos relevantes vinculados con la gestión de la sequía y todos sus componentes. La participación, los niveles de gestión, la perspectiva sectorial y las relaciones entre los componentes de gestión del riesgo considerados constituyen aspectos críticos que es necesario mejorar en el futuro.

Así, los cinco artículos en su conjunto presentan ejemplos concretos que ayudan a conocer mejor la gestión de la sequía y que pueden resultar de utilidad para políticos, gestores y usuarios.

SUMMARY

Drought affects all sectors and their frequency and intensity is expected to increase due to climate change. Drought management poses significant challenges in the future. Undertaking a drought risk management approach promotes a proactive response, and it is starting to consolidate internationally. However, it is still necessary to conduct studies on the characteristics of drought risk management and its practical implications.

This thesis provides an evaluation of various relevant aspects of drought management from different perspectives and with special emphasis on the social component of droughts. For the purpose of this research a number of five studies have been carried out: (1) analysis of the emergency laws adopted during the 2005-2008 drought in Spain; (2) study of farmers perception of drought at a local level; (3) assessment of the characteristics and drought management issues in six case studies across Europe; (4) systematic analysis of drought vulnerability assessments; and (5) analysis of drought impacts from an European impacts text-based database.

The results show the importance of institutional capacity as a factor that promotes and facilitates the adoption of a risk approach. In contrast, the following issues are identified as the main obstacles to take advantage of the lessons learnt: (1) lack of vulnerability studies, (2) limited knowledge about the impact and (3) limited availability of post-drought assessments

Drought emergency laws evidence the existence of inconsistencies between drought problem definition and the measures proposed as solutions. Moreover, the securitization of the discourse pursue goals beyond management drought.

The perception of drought by farmers helps to identify the existence of several definitions of drought. It also highlights the importance of impacts in defining and characterizing the severity of an event. However, this definition differs from the one used at other institutional and management level. As a conclusion, this remarks the importance of considering the diversity of definitions and perceptions to better tailor drought management to the needs of different sectors and stakeholders.

The analysis of drought management in six case studies across Europe show different levels of risk adoption approach in practice. The analytical framework proposed is based on six dimensions and 21 criteria. This method has proven to be a useful tool in diagnosing the elements that work and those that need to be improved in relation to drought risk management.

The systematic analysis of vulnerability assessment studies demonstrates the heterogeneity of the conceptual frameworks used. Driven by the lack of relevant data, the studies point out significant weaknesses of the vulnerabilities factors that are typically included

The heterogeneity of the impact data collected at European level to build the European Drought Impact Reports Database (EDII) highlights the importance of information management. The database has great potential as exploratory tool and provides indicative useful information of the type of impacts that occurred in a

particular region. However, it still presents some challenges regarding their content, the process of data collection and management and its usefulness.

There are significant limitations associated with the access and availability of relevant information and data related to drought management and its components. The following improvement areas on critical aspects have been identified for the near future: participation, levels of drought management, sectorial perspective and in-depth assessment of the relationships between the components of drought risk management

The five articles presented in this dissertation provides concrete examples of drought management evaluation that help to better understand drought management from a risk-based perspective which can be useful for policy makers, managers and users.

LISTA DE ABREVIACIONES

AEVAL	Agencia Estatal de Evaluación de las Políticas Públicas y la Calidad de los Servicios
CHJ	Confederación Hidrográfica del Júcar
DMA	Directiva Marco de Agua
DMCSEE	Drought Management Centre for Southeastern Europe
DMP	Drought Management Plans
EDII	European Drought Impact Inventory
EDO	European Drought Obserbatory
EDR	European Drought Reference
EEA	European Environmental Agency
EWSDEN	European Water Scarcity and Drought Expert Network / Red Europea de Expertos sobre Sequía y Escasez
FAO	Food and Agricultural Organization / Organización de las Naciones Unidas para la Agricultura y la Alimentación.
GWP	Global Water Partnership / Partenariado Mundial para el Agua
M&EWS	Monitoring and Early Warning System / Sistema de Monitoreo y Alerta Temprana
Med EUWI	Mediterranean Water Scarcity and Drought Working Group
MMA	Ministerio de Medio Ambiente
NDMC	National Drought Mitigation Centre / Centro Nacional de Mitigación de la Sequía
NNUU	Naciones Unidas
OCHA	Oficina de Coordinación de la Ayuda Humanitaria de la Unión Europea
RAE	Real Academia Española
UNCCD	United Nation Convention to Combact Desertification
UNDP	United Nations Development Programme / Programa Mundial de Desarrollo (PNUD)
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNISDR	United Nations International Strategy for Disaster Reduction / Estrategia Internacional para la Reducción de Desastres
WMO	World Meteorological Organization /Organización Meteorológica Mundial (OMM)
WS&D Com	Water Scarcity & Drought Communication / Comunicación sobre Escasez y Sequía de la Unión Europea.

ÍNDICE

ÍNDICE DE TABLAS

ÍNDICE DE FIGURAS

CAPÍTULO 1. INTRODUCCIÓN Y OBJETIVOS

1.1. Introducción

La sequía es un fenómeno natural que afecta a todas las regiones y climas del planeta. Se considera uno de los riesgos climáticos más importantes por los daños que produce, causando impactos socioeconómicos y ambientales que afectan a todos los sectores de la sociedad. Por tanto, es especialmente importante gestionar las sequías de manera adecuada y eficiente, de lo contrario, pueden convertirse en un desastre natural. Además, se prevee que la frecuencia, magnitud y duración de las sequías podría agravarse en Europa debido al cambio climático (IPCC, 2007; Bates et al., 2008; Seneviratne et al., 2012).

La gestión de las sequía es compleja debido a las características propias del fenómeno y a que es uno de los riesgos climáticos que peor se conocen (Wilhite, 2002; Wilhelmi & Wilhite, 2002; Bonaccorso et al., 2003; Mishra & Singh, 2010; Pulwarty & Sivakumar, 2014). Su desarrollo progresivo, su duración prolongada y la dificultad para determinar su inicio y final, hacen que sea difícil implementar medidas de gestión que sean adecuadas.

Para hacer frente a esta complejidad, actualmente se promueve una gestión basada en la reducción del riesgo, con la planificación de acciones preventivas y de respuesta para reducir y mitigar los impactos. Esto implica la necesidad de abordar la problemática de la sequía de una forma más integral, incorporando los principios de gestión del riesgo a través de medidas que no sean solo de emergencia sino que también incluyan acciones encaminadas a disminuir la vulnerabilidad a la sequía.

Diversas instituciones y organismos a nivel internacional promueven la adopción de dicho enfoque y han realizado importantes esfuerzos para entenderlo y promover su desarrollo. Sin embargo, todavía no se cuenta con suficiente información y metodologías concretas para evaluar el grado de adopción de este enfoque en los diferentes países. Esto se suma a que tampoco existen muchas experiencias concretas sobre cómo evaluar una política de sequía y su gestión.

Surge por tanto la necesidad de conocer las características de la gestión de la sequía en cada contexto y de desarrollar metodologías específicas para su evaluación. Esto ayudaría a comprender mejor cómo estamos abordando el problema de la sequía. La determinación del grado de adopción del enfoque de riesgo y de los factores que facilitan u obstaculizan su puesta en marcha resultaría muy útil para mejorar la gestión de la sequía y realizar recomendaciones concretas sobre el diseño de políticas públicas relacionadas.

Según Knutson et al. (1998), el análisis del riesgo a la sequía implica considerar tres componentes principales: (i) el fenómeno de la sequía, (ii) los impactos y la vulnerabilidad, y (iii) la gestión y medidas de mitigación y respuesta. Estas grandes categorías son propuestas por otros autores (e.g. Wilhite, 1999, 2001, 2002; Hayes et al., 2004; UNISDR, 2009a) y comunes en la literatura del riesgo, aunque con matices y variaciones en la terminología y conceptos utilizados. Este marco de análisis sienta las bases para identificar los elementos clave que puede ser interesante considerar en los diferentes niveles de gestión y escalas afectadas por la sequía. Pero primero, dada la diversidad y heterogeneidad de términos y conceptos relacionados con la sequía (Yevjevich, 1967; Wilhite & Glantz, 1985; Wilhite, 2002) y su gestión, se hace necesario aclarar qué entendemos por cada uno de ellos.

Tradicionalmente el estudio de la sequía se ha abordado con análisis climatológicos e hidrológicos que tratan de caracterizar o predecir un evento de sequía, y esto a veces ha estado desligado de su componente social (Kallis, 2008; Lackstrom et al., 2013; Van Loon 2015). Por otro lado, existe un grupo extenso de literatura que evalua las medidas y sus impactos desde una perspectiva principalmente económica (Iglesias et al., 2007; Martín-Ortega & Markandya, 2009; Gil et al., 2011). Sin embargo, pocos estudios profundizan en el análisis de la sequía desde una perspectiva social o que tengan en cuenta los factores de vulnerabilidad. Además, apenas se han podido encontrar metodologías específicas que se dirijan a abordar el análisis de la política de la sequía en su conjunto (Garrido & Rey, 2014).

La evaluación de la gestión de la sequía requiere buscar enfoques metodológicos y perspectivas de evaluación nuevas que permitan superar las tradicionales limitaciones de datos, a la par que generen información y conocimientos que sean relevantes para diferentes actores, sectores, gestores y políticos. Estos enfoques deben hacer frente inequívocamente a la complejidad asociada a la sequía y su gestión, ya que ésta influye sobre el planteamiento metodológico y conceptual de la evaluación. La complejidad es una característica inherente de la sequía y su gestión, que se manifiesta desde la propia definición y caracterización del episodio en cuestión, pasando a sus efectos e impactos, que derivan en distintos niveles de vulnerabilidad y sistemas de gestión que engloban diferentes ámbitos y tipos de medidas. La evaluación de la gestión de la sequía, por tanto, debe incluir diferentes niveles de análisis y debe captar las especificidades del contexto afectado por la sequía.

El objetivo principal de este trabajo es contribuir a entender mejor la gestión de la sequía y proporcionar algunos marcos de análisis que puedan servir para evaluar aspectos relevantes de la misma.

1.2. Objetivos

El **objetivo general** de esta tesis doctoral es contribuir a aumentar el conocimiento sobre la gestión de las sequías y su evaluación desde diferentes perspectivas y contextos.

Se han desarrollado una serie de herramientas de evaluación y de análisis de la gestión de la sequía para aportar ejemplos concretos y prácticos que aumenten las referencias de evaluación de temas ambientales utilizando como caso de estudio la problemática de la sequía.

En el marco del trabajo de esta tesis se ha identificado la necesidad de profundizar en el conocimiento de ciertos aspectos de la sequía y su gestión, lo cual ha guiado la formulación de los **objetivos específicos:**

- *Evaluar la gestión a través de las leyes de emergencia en España*. La evaluación de las leyes de emergencia aprobadas como respuesta a la sequía persigue profundizar en las implicaciones del uso de estas herramientas en la política de sequía y de agua.
- *Analizar la percepción de la sequía y respuesta de los agricultores en la Demarcación del Júcar*. Este análisis se centra en el estudio de la sequía desde una perspectiva local y sectorial. Se pretende profundizar en cómo se percibe el fenómeno de la sequía, los factores de vulnerabilidad y las estrategias de respuesta implementadas en el pasado por los agricultores de regadío.
- *Evaluar la gestión de la sequía en varios casos de estudio a nivel europeo*. La evaluación se centra en analizar el enfoque y características de la gestión de la sequía desde una perspectiva política y teniendo como marco de referencia la gestión del riesgo. Su aplicación a varios casos de estudio a nivel europeo permite entender la influencia de las características del contexto, niveles de gestión y escala espacial en la gestión de las sequías.
- *Analizar las evaluaciones de vunerabilidad a la sequía*. El análisis sistemático de los estudios de vulnerabilidad a la sequía se dirige a entender mejor cómo se mide la vulnerabilidad en la práctica y las tendencias actuales sobre este tipo de estudios. Pretende servir como punto de partida para mejorar el diseño de las metodologías concretas de evaluación de la vulnerabilidad a la sequía al identificar sus principales elementos y retos.
- *Analizar los impactos de la sequía en Europa.* La creación de un inventario de los impactos de las sequías se ha realizado en base a datos textuales recogidos en diversas fuentes documentales. A partir de este tipo de información se realiza un análisis sistemático de cúales han sido los principales impactos en el pasado, sus categorías y características.

Asimismo se han planteado una serie de **objetivos transversales**:

- *Revisar las bases teóricas de los principales temas relacionados con la sequía y su gestión*. Esto incluye la definición de sequía, los impactos, la vulnerabilidad, las medidas y la gestión, dada la necesidad de orientarse en la heterogeneidad de marcos conceptuales y metodológicos presentes en la literatura. Entender las causas de esta heterogeneidad ayuda a establecer un marco común y mejorar así la comunicación sobre los diferentes temas.

- *Revisar los enfoques de evaluaciones de la gestión de la sequía*. Se trata de realizar una revisión de los principales enfoques utilizados para analizar las políticas de sequía y su gestión.

El trabajo de investigación ha llevado al desarrollo de cinco herramientas de análisis, cuyo diseño e implementación ha dado lugar a los siguientes artículos científicos:

1. Urquijo, J., De Stefano, L., La Calle, A. (2015). Drought and exceptional laws in Spain: The official water discourse. *International Environmental Agreements: Politics, Law and Economics15 (3), 273-292. (*DOI: 10.1007/s10784-015-9275-8).
2. Urquijo, J., & De Stefano, L. Perception of drought and local responses by farmers: a perspective from the Jucar River Basin, Spain. *Water Resources Management*. (DOI: 10.1007/s11269- 015-1178-5)
3. Urquijo, J., Pereira Jerez, D., Dias, S., & De Stefano, L. A Methodology to Assess Drought Management as Applied to Six European Case Studies. *Journal of Water Resources Development* (Aceptado con revisión)
4. González Tánago, I., Urquijo, J., Blauhut, V., Villarroya, F., & De Stefano, L. (2015). Learning from Experience: A Systematic Review of Assessments of Vulnerability to Drought. *Natural Hazards* (DOI:10.1007/s11069-015-2006-1)
5. Stahl, K., Kohn, I., Blauhut, V., Urquijo, J., De Stefano, L., Acacio, V., Dias, S., Stagge, J.H., Tallaksen, L.M., Kampragou, E., Van Loon, A.F., Baker, L.J., Melsen, L.S., Bifulco, C., Musolino, D., de Carli, A., Massarutto, A., Assimacopoulos, D., & Van Lanen, H.A.J. (2015) Impacts of European drought events: insights from an international database of text-based reports. *Natural Hazards Earth System Science (NHESS)* (Aceptado, en revisión) (DOI:10.5194/nhessd-3-5453-2015)

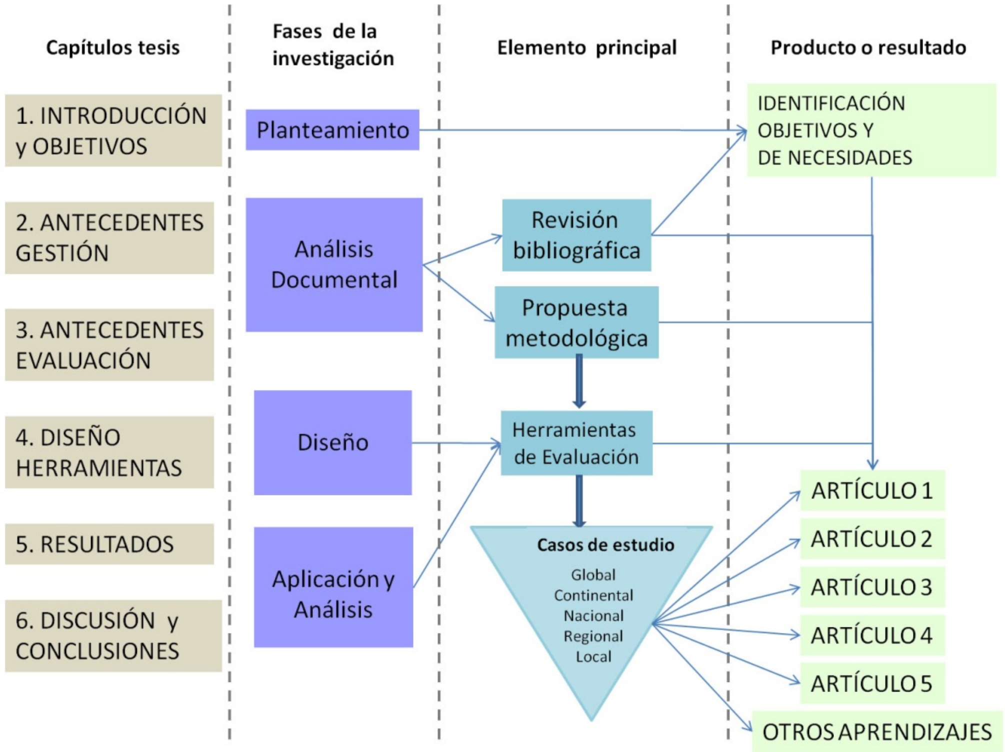
Esta tesis es el resultado de cuatro años de trabajo desarrollados en el marco del proyecto de investigación europeo "*DROUGHT R&SPI: Fostering European Drought Research and Science-Policy Interfacing*", 2011 - 2015 (http://www.eu-drought.org/). Esta circunstancia ha influido en la definición de las metodologías y también ha posibilitado el alcance europeo de este trabajo, al establecer el marco de colaboración de las diferentes universidades involucradas en el proyecto y proveer la financiación necesaria para el desarrollo de esta tesis.

1.3. Estructura de la tesis

El documento se estructura en seis capítulos (Figura 1):

- Capítulo 1. Introducción y Objetivos. Este primer capítulo plantea la justificación de la investigación y presenta los objetivos de la tesis.
- Capítulo 2. La gestión de las sequías y su evaluación. Este capítulo comprende los antecedentes y revisión de la literatura de esta tesis. Se presenta una revisión del marco conceptual de la gestión de las sequías donde se trata de identificar y caracterizar el marco de la gestión del riesgo para mejorar su comprensión y poder abordar su análisis. También se realiza una revisión desde la perspectiva de la evaluación, que servirá para sentar las bases tanto metodológicas como conceptuales sobre las que se sustenta el trabajo de esta tesis.
- Capitulo 3. Materiales y métodos. En este capítulo se resume el diseño de las herramientas de evaluación y análisis utilizadas en esta tesis. Se presenta el planteamiento metodológico y se justifica la selección de la metodología utilizada en cada uno de los estudios.
- Capítulo 4. Artículos. Se presentan los cinco artículos elaborados en el marco de este trabajo de tesis.
- Capítulo 5. Conclusiones. Este capítulo recoge las principales conclusiones y flexiones teóricas y metodológicas que surgen del conjunto del trabajo realizado y las líneas de investigación futuras identificadas.

Figura 1. Esquema general de la estructura de la tesis



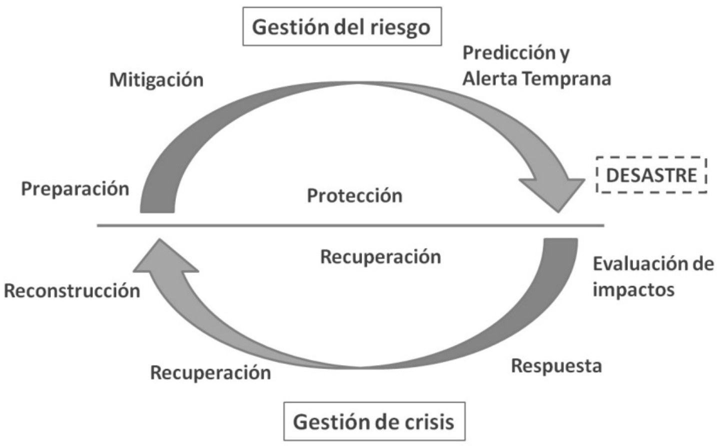
CAPÍTULO 2. LA GESTIÓN DE LAS SEQUÍAS Y SU EVALUACIÓN

2.1. Enfoque de gestión de la sequía

En esta tesis la **gestión de la sequía** se refiere al conjunto de "*Acciones y respuestas técnicas (ingenieriles) e institucionales (sociales, económicas, legales y políticas) ante situaciones de sequía*" (WMO/UNESCO, 2012, p. 98). Esto incluye actuaciones muy variadas que operan a diferentes niveles administrativos y de gestión, con distintos marcos temporales y espaciales, que afectan a diferentes sectores o colectivos y que puede adoptar diferentes formas, como una política, plan o medidas concretas individuales.

Tanto a nivel teórico como práctico se distinguen dos enfoques de gestión claramente diferenciados: (i) Gestión de crisis y (ii) Gestión de riesgo (Wilhite, 1999, 2001, 2002; Wilhite et al., 2000; 2005; 2007, 2014; MEDROPLAN, 2007; Kampragou et al., 2011) (Figura 2).

Figura 2. Ciclo de gestión de riesgo a desastres



Fuente: Traducido de Wilhite (1999), 'Risk and crisis management cycle'.

La **gestión de crisis** ha sido la forma tradicional de abordar la sequía en el pasado (Wilhite, 2001; UNISDR, 2005), que ha demostrado ser ineficaz para reducir los impactos de la sequía (Kossida et al., 2012). Esta forma de gestión se caracteriza por su carácter reactivo, centrado en la puesta en marcha de acciones durante la fase de emergencia para hacer frente a los impactos detectados, es decir, actuar principalmente sobre los efectos una vez que estos ya han aparecido. La sequía se considera como una situación excepcional y los principales instrumentos políticos utilizados son medidas de emergencia excepcionales y temporales, obras o infraestructuras para aumentar la oferta de recursos y compensaciones económicas por los daños y pérdidas. Esto refleja un énfasis en la respuesta de emergencia, a menudo asociada a una escasa planificación previa de las acciones de reducción y mitigación de los impactos. Esta falta de anticipación o prevención sustenta una de las principales críticas a este enfoque, y, además, aumenta la vulnerabilidad a largo plazo (Wilhite, 2001) e implica soluciones más costosas (FAO & NDMC, 2008; UNISDR, 2009a; Logar & van den Bergh, 2013; Rossi & Cancellieri, 2013). Además, en ocasiones la urgencia no permite un buen análisis de posibles medidas alternativas y limita la participación de las partes interesadas.

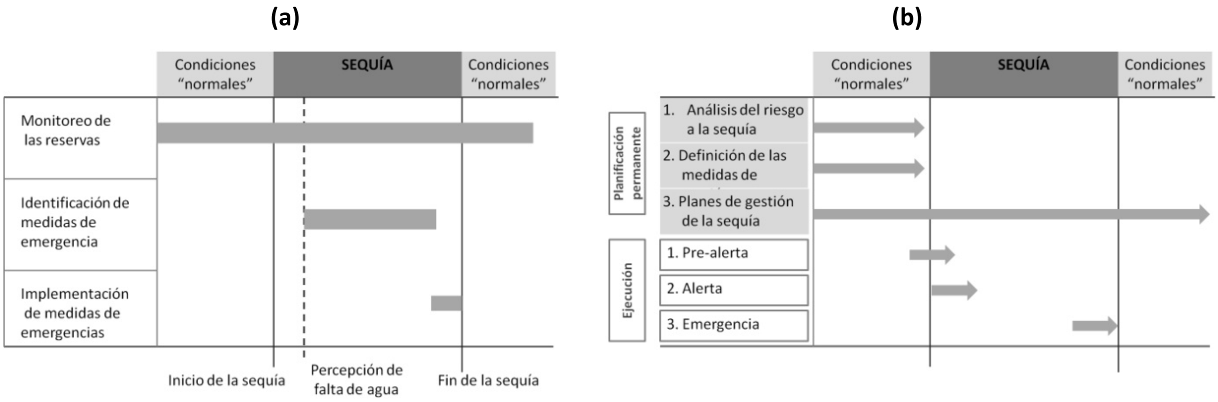
El enfoque de **gestión del riesgo a la sequía** es proactivo y está orientado a la prevención y mitigación de los impactos a través de la planificación y con una visión de largo plazo (Wilhite et al., 2000; UNISDR, 2007, 2009a, 2012; FAO & NDMC, 2008; Kampragou et al., 2011; UNDP, 2011), que permite identificar a los sectores vulnerables y analizar opciones de respuesta antes de que ocurra el evento (FAO & NDMC, 2008). Tal y como se refleja en la Figura 2, el énfasis se pone, por tanto, en la adaptación a la sequía y no tanto en la respuesta de emergencia (Knutson et al., 1998). Incluye medidas a corto, medio y largo plazo e implica actuar antes, durante y después del episodio de sequía. Cabe señalar que, aunque se adopte un enfoque de gestión del riesgo, siempre habrá una parte de gestión de crisis relacionada con la incertidumbre y características únicas de cada evento de sequía que requieren una cierta actuación de emergencia y por tanto, ponen límites a la planificación.

Algunas de las medidas más representativas de este enfoque son los planes de gestión de sequía (DMP) y los sistemas de monitoreo y alerta temprana (M&EWS). La planificación de la respuesta a la sequía se considera una forma más eficaz de reducir los impactos (FAO & NDMC, 2008; UNISDR, 2009a) respecto al enfoque de crisis, aunque Logar & van den Bergh (2013) reconocen que existen pocos estudios sobre los costes y beneficios de las medidas de prevención, mitigación o adaptación a la sequía y alertan sobre que los gobiernos son en general reacios a invertir en medidas de mitigación por la escasa información sobre estas (Ding et al., 2011).

Este enfoque también resalta la necesidad de fijarse en las cadenas causales entre la sequía (causas) y las medidas (solución), lo cual implica una mayor coordinación institucional y la participación de los stakeholders (Kallis, 2008; Supramaniam et al., 2011). Esto fomenta la colaboración y la sostenibilidad (FAO & NDMC, 2008), y ayuda a reducir la vulnerabilidad y a aumentar la resiliencia de una sociedad a la sequía (Kampragou et al., 2011).

En la Figura 3 se presentan las diferencias entre el enfoque reactivo y proactivo. Si bien no se pueden utilizar como sinónimos, el enfoque reactivo se asocia a la gestión de crisis y el enfoque proactivo a la gestión de riesgo.

Figura 3. Esquema de gestión de la sequía bajo un enfoque reactivo (a) y proactivo (b)



Fuente: Rossi et al. (2005), MEDROPLAN (2007)

2.1.1. Experiencias sobre la gestión del riesgo

Existen numerosas iniciativas y experiencias a nivel internacional y nacional sobre la gestión del riesgo a desastres en general, y de la sequía en particular, entre las que destacan: (i) las iniciativas a nivel internacional, lideradas por varias agencias de las Naciones Unidas; (ii) Las iniciativas a nivel Europeo, a través de diversas iniciativas comunitarias específicas enmarcadas fundamentalmente dentro de la política de agua, y (iii) otras referencias de carácter nacional, como por ejemplo el caso de EEUU.

(i) Nivel internacional

Desde Naciones Unidas (NNUU) se han desarrollado varias líneas de trabajo relacionadas con la gestión y reducción de desastres naturales. Destaca la *Estrategia Internacional para la Reducción de Desastres*[1] (UNISDR, 2001). Se trata del marco estratégico adoptado por los Estados miembro de NNUU en 2001 para guiar y coordinar los esfuerzos dirigidos a la reducción de los impactos de los desastres desde la gestión del riesgo. Su objetivo es crear comunidades resilientes como condición esencial para un desarrollo sostenible y supone una apuesta por la reducción de los desastres a través de la cultura de la prevención.

La *Estrategia y Plan de Acción de Yokohama* adoptada en 1994, supone el primer esfuerzo concreto que enfatiza el papel de la acción humana en la reducción de la vulnerabilidad ante desastres naturales. En el año 2005, para continuar con dichos esfuerzos, se puso en marcha a nivel internacional el *"Marco de Acción de Hyogo para el 2005-2015: Aumento de la Estrategia Internacional para la Resiliencia de las Naciones y las Comunidades ante los Desastres,* conocida como el Marco de Acción de Hyogo[2] (UNISDR, 2007). Su objetivo es "*reducir considerablemente las pérdidas que ocasionan los desastres, tanto de vidas como de bienes sociales, económicos y ambientales de las comunidades y los países*" (p.3). Pretende contribuir a la generación de capacidades y resiliencia ante desastres de los países y comunidades para reducir su vulnerabilidad ante estos eventos, entre los que se incluye la sequía. También promueve que la reducción de desastres sea una prioridad nacional y se considera un

[1] United Nations International Strategy for Disaster Reduction (UNISDR), www.unisdr.org
[2] Hyogo Framework for Action (HFA) 2005-2015

instrumento clave para implementar la reducción del riesgo a desastres a nivel nacional. El Marco de Hyogo establece cinco áreas prioritarias de acción, y establece los principios y una guía práctica para su implementación en el contexto del desarrollo sostenible (UNISDR, 2009a).

Recientemente, el 18 de marzo del 2015, los Estados Miembro de NNUU han adoptado el "*Marco de Sendai para la Reducción del Riesgo de Desastres 2015-2030"*, en Sendai (Japón). Este plantea la necesidad de *"fortalecer las competencias y capacidad de gestión y ejecución de los distintos niveles de gobierno como condición necesaria para avanzar en la reducción del riesgo a desastres y las pérdidas asociadas a estos eventos a todos los niveles, global, regional y local"*[3]. Se trata del nuevo marco de referencia para los próximos 15 años que da continuidad al Marco de Hyogo.

En 2013 tuvo lugar la *Conferencia de Alto Nivel sobre Política Nacional de Sequía*[4] que reunió a las agencias más importantes que trabajan sobre el tema, (e.g. WMO, FAO, UNCCD, UNESCO, UNISDR; UN-Water), marcando un hito a nivel internacional (Sivakumar et al., 2014). En el marco de esta conferencia, la Organización Meteorológica Mundial (WMO) y el Partenariado Mundial para el Agua (GWP) lanzaron un "*Programa Conjunto de Gestión Integral de la Sequía"*[5] (Bokal et al., 2014). Su objetivo central es apoyar a las partes interesadas a todos los niveles, proporcionando orientación normativa y de gestión, y mediante el intercambio de información científica, el conocimiento y las mejores prácticas para la gestión integrada de la sequía. Pretende apoyar así la coherencia de los esfuerzos realizados por diferentes agencias y organismos que luchan contra la sequía.

El *Programa de Desarrollo de Capacidades de NNUU para el Agua* (UNW – CPD) ha lanzado también una "*Iniciativa de desarrollo de capacidades para el desarrollo de políticas nacionales para la gestión de la sequía"'*[6], en la que colaboran conjuntamente WMO, UNCCD, FAO y UNW-DPC.

En el seno de otras agencias de NNUU, se han desarrollado guías y manuales de apoyo para su adopción, planificación e implementación de la gestión del riesgo a la sequía. La Organización de las Naciones Unidas para la Agricultura y la Alimentación (FAO), en colaboración con el Centro Nacional de Gestión de la Sequía de Nebraska (NDMC), EEUU, desarrollaron en 2008 un *Manual para la planificación de la Sequía en Oriente Medio* (FAO & NDMC, 2008). El Programa de Desarrollo de las Naciones Unidas (UNDP), ha desarrollado una *Guía para la Incorporación de la Perspectiva de la Gestión del Riesgo a la Sequía* ('Mainstreaming Drought Risk Management') (UNDP, 2011) que pretende dar soporte a los proyectos de sequía y cambio climático.

La Organización para la Cooperación y el Desarrollo Económico (OECD) ha preparado un documento donde analiza las políticas de sequía e inundaciones en cinco países a nivel mundial (España, Francia, Inglaterra, Canadá y Australia), ilustrando no solo el conjunto de medidas disponibles en cada caso de estudo, si no las características de cada modelo de gestión y cómo están avanzando hacia la adopción de un enfoque de

---

[3] www.eird.org

[4] High-Level Meeting on National Drought Policy (HMNDP), 11-15 Marzo 2013, Ginebra, Suiza

[5] Integrated Drought Management Programme; ww.droughtmanagement.info; www.gwp.org

[6] Capacity Development initiative on National Drought Management Policies (NDMP), www.ais.unwater.org

riesgo, proactivo y basado en la prevención, preparación y mitigación (Garrido & Rey, 2014).

Por tanto, se aprecia una creciente preocupación por mejorar la gestión de las sequías a nivel internacional a través de la promoción del enfoque de riesgo como marco de referencia y el desarrollo de sus bases conceptuales, lo cual se refleja en el creciente número de iniciativas lanzadas a nivel internacional a lo largo de la última década.

(ii) Nivel europeo

En el contexto europeo, la gestión de la sequía se aborda principalmente a través de las políticas de agua, pero también desde las políticas agrícolas y otras políticas sectoriales (ej. energía, industria).

Las iniciativas europeas para la gestión de la sequía de referencia son la *Comunicación sobre Sequía y Escasez* (WS&D Com) (EC, 2007a), y la *Directiva Marco de Agua* (DMA) (CEC, 2000) y su trasposición a la legislación de cada Estado Miembro.

La WS&D Com establece como prioridad el desarrollo de planes de gestión de la sequía bajo un enfoque de riesgo y de sistemas de monitoreo y alerta temprana. Establece siete opciones políticas[7] ('policy options') y directrices específicas para su implementación que se dirigen a minimizar los impactos socioeconómicos y sobre el medioambiente en el marco de la DMA (EC, 2007a). Sus ideas clave son: (i) Avanzar hacia la adopción de enfoques de gestión del riesgo para construir sociedades resilientes a la sequía y escasez; (ii) Aprovechar el amplio potencial de ahorro de agua que existe a nivel europeo, y (iii) Adoptar el principio de "jerarquía", que establece que las medidas de demanda deben tener prioridad mientras que las medidas de oferta solo se deben considerar cuando se hayan agotados otras opciones (EC, 2007a).

La DMA establece el marco legislativo de la política de agua introduciendo una nueva perspectiva al establecer objetivos ambientales para todas las masas de agua. La DMA se refiere a la sequía de dos maneras: (1) como excepción al cumplimiento de los objetivos ambientales en el caso de tener lugar una sequía prolongada, y (2) a través de su consideración en diferentes instrumentos, medidas o indicadores. Entre estos destacan el Artículo 13, que menciona la elaboración voluntaria de Planes de Gestión de Sequía, y el Artículo 11, que considera la inclusión de medidas de sequía en el Plan de Gestión de la Demarcación (Kampragou et al., 2011)

Existen otras iniciativas a nivel europeo sobre sequía más centradas en predecir, monitorear y analizar los episodios de sequía. Algunas de estas son:

- *Observatorio Europeo de la Sequía*[8] del 'Joint Research Centre' de la Comisión Europea. Se trata de un portal específico sobre la sequía que contiene información sobre las características físicas de las sequías en formato de mapas o índices.

[7] (1) Putting the right price tag on water; (2) Allocating water and water-related funding more efficiently; (3) Improving drought risk management; (4) Considering additional water supply infrastructures; (5) Fostering water efficient technologies and practices; (6) Fostering the emergence of a water-saving culture in Europe; (7) Improve knowledge and data collection

[8] EDO - European Drought Observatory'; http://edo.jrc.ec.europa.eu

- *Centro para la Gestión de la Sequía en el Sudeste Europeo*[9]. Su misión es coordinar y facilitar el desarrollo, evaluación y aplicación de instrumentos y políticas de gestión del riesgo de sequía en el sudeste de Europa, con el objetivo de mejorar la preparación para la sequía y la reducción de los impactos de la sequía. Su trabajo se centra en el monitoreo y determinación de la sequía así como en el análisis de riesgo y vulnerabilidad.

Destaca también el trabajo realizado por la Agencia Europea del Medioambiente (EEA), que desarrolla numerosos estudios e investigaciones sobre diversos aspectos de la sequía, como la evaluación de los recursos hídricos para hacer frente a la escasez y la sequía (EEA, 2009) y el estudio de vulnerabilidad a la sequía y la escasez en Europa (Kossida et al., 2012).

Por último cabe destacar algunos proyectos de investigación europeos sobre diferentes aspectos de la sequía y su gestión entre los que destacan XEROCHORE, CLICO, CLIMWATADAP, DEWFORA, DMCSEE, ESPON CLIMATE, MOVE, RESPONSES, DROUGHT R&SPI, entre otros.

Sin embargo, a pesar de todos estos esfuerzos, según la Red Europea de Expertos sobre Sequía y Escasez ('European Water Scarcity and Drought Expert Network'), los episodios de sequía se abordan principalmente a través de un enfoque de gestión de crisis mediante la implementación de programas nacionales o regionales de emergencia para paliar los impactos de la sequía (EC, 2007c). Existe una creciente preocupación por la falta de efectividad asociada a este tipo de gestión de crisis (Wilhite et al., 2000; Wilhite et al., 2014; Bokal et al., 2014), que ha resultado en fallos importantes en la mitigación de los impactos de la sequía, fomentando también la continuidad de prácticas no sostenibles que aumentan la vulnerabilidad de los sistemas de recursos hídricos (Kampragou et al., 2011).

A la luz de un incremento de los impactos de la sequía (Stahl et al., 2012) y de las previsiones de aumento de frecuencia y severidad de los episodios de sequía debido al cambio climático (EEA, 2009; IPCC 2007, 2012), se hace todavía más necesario adoptar este enfoque de gestión del riesgo a la sequía. Por ello se trata de una prioridad identificada a nivel europeo (EC, 2007c; EEA, 2009; Kampragou et al., 2011; EC, 2012) y se está comenzando a producir un cambio en el enfoque de gestión del problema. En España, un claro ejemplo de las mejoras en la planificación y prevención de las sequías, es la ley 10/2001 del Plan Hidrológico Nacional[10] que plantea la obligatoriedad de elaborar Planes Especiales de Sequía (PES) en todas las demarcaciones hidrográficas.

Esto supone un cambio de paradigma en la gestión de la sequía. Sin embargo, a pesar de la existencia de cierta tendencia a adoptar este enfoque de gestión, que también se ha identificado en otros países (Garrido & Rey, 2014), todavía falta mucho por hacer.

(iii) Otras iniciativas: Centro Nacional de Mitigación de la Sequía

El *Centro Nacional de Mitigación de la Sequía* (NDMC)[11], localizado en la Universidad de Lincoln, Nebraska, EEUU, es una de las principales referencias que existen a nivel

[9] DMCSEE - Drought Management Centre for Southeastern Europe; www.dmcsee.org
[10] La Ley 10/2001, de 5 de julio, del Plan Hidrológico Nacional (Artículo 27)
[11] National Drought Mitigation Centre (NDMC), (http://drought.unl.edu/)

internacional por su trabajo e investigación sobre todos los aspectos y facetas de la sequía y su gestión.

Entre sus actividades destaca el *Monitor de Sequía (*'U.S Drought Monitor')[12] (Svoboda et al., 2002; Wilhite et al., 2007), la base de datos de impactos de la sequía ('Drought Impact Reporter')[13], en funcionamiento desde 1995, y una base de datos sobre medidas de gestión y respuesta ('Drought Management Database')[14]. Además disponen de numerosos materiales divulgativos e información técnica así como publicaciones científicas.

Sus investigaciones sobre la gestión de la sequía se consideran pioneras y de referencia a nivel mundial, aportando las principales bases conceptuales y metodológicas que se están utilizando actualmente. Sus últimos trabajos se centran en cómo desarrollar las políticas de sequía a nivel nacional, como se explica más adelante en este documento.

2.1.2. Características de la gestión del riesgo a la sequía

Implicaciones de la consideración de la sequía como un riesgo

La sequía es un riesgo climático y su consideración como tal tiene ciertas implicaciones para su análisis. Partimos de la definición del **riesgo** como "*la combinación de la probabilidad de que se produzca un evento y sus consecuencias negativas*" (UNISDR, 2009a, p. 12). Esto significa entender la sequía como la amenaza de sufrir un evento y la vulnerabilidad como las características, condiciones y factores sociales, económicos, políticos y ambientales que hacen que el sistema sea susceptible a sufrir determinados impactos.

La consideración de la sequía como un riesgo implica reconocer que existe incertidumbre, es decir, que se va a dar inevitablemente en algún momento, pero sin conocer el momento preciso y su duración, intensidad y extensión (Knutson et al., 1998). También implica que un cierto nivel de impactos debe ser aceptado por la sociedad, ya que no es posible evitarlos completamente. Sin embargo, el nivel "aceptable" de impactos, puede variar de una sociedad a otra y debe tenerse en cuenta en los procesos de gestión y planificación de la sequía.

Existen diferentes formas de entender el riesgo de acuerdo con Wisner et al., (2003).

Desde una perspectiva "realista", el riesgo es un evento objetivo que puede ser medido independientemente de los procesos sociales y culturales. Esta forma de entender el riesgo se asocia con enfoques científico-técnicos que se apoyan principalmente en métodos estadísticos.

Desde una perspectiva constructivista siempre median procesos sociales y culturales en la forma de entender el riesgo a un evento (Oliver-Smith & Hoffman, 1999). Esto implica que el riesgo es una concepción social, es decir, surge como resultado de determinados procesos sociales que van cambiando a lo largo del tiempo y en el espacio, y que en general responden a un determinado modelo de desarrollo resultado de procesos de transformación social y económica. Esto es importante porque implica

[12] http://droughtmonitor.unl.edu/
[13] http://droughtreporter.unl.edu/
[14] http://drought.unl.edu/droughtmanagement/Home.aspx

el reconocimiento de las acciones del hombre como parte del origen del problema y como factores que afectan a la percepción de riesgo, en contraste con la visión realista. En esta tesis se entiende el riesgo a la sequía desde la perspectiva constructivista. De esta manera, el riesgo a la sequía estará compuesto por una dimensión socioeconómica y su fundamento no es exclusivamente natural.

En el extremo de esta postura, que Wisner et al. (2003) denominan 'hard – constructivists', se encuentran aquellos que defienden que "*nada es un riesgo en sí mismo, pero es un producto contingente creado histórica, social y políticamente de diversas 'formas de ver'*" (Lupton, 1999, p.35). Por tanto, según esta aproximación epistemológica, el riesgo está sujeto a valoraciones objetivas, pero también subjetivas. Esto significa que la gestión del riesgo no puede prescindir de la participación de los sujetos del riesgo en su caracterización y en las decisiones sobre su gestión.

El riesgo se expresa en los niveles microsociales y territoriales; sin embargo, sus causas no pueden reducirse exclusivamente a estos niveles porque éste puede ser también el resultado de procesos y actores sociales extralocales, regionales, nacionales y hasta internacionales. Esto presenta retos metodológicos respecto a la selección de la escala de análisis y niveles de gestión que es necesario tener en cuenta.

Principales componentes y elementos de la gestión del riesgo

Existen diversas propuestas sobre las dimensiones o componentes que debe incluir la gestión del riesgo a la sequía. Aunque cada autor propone su propio marco y utiliza su propia terminología, existen dos partes bien diferenciadas pero comunes a todos (Hayes et al., 2004) ya que están presentes, de alguna manera, en todas las propuestas analizadas (Tabla 1):

(i) Identificación y caracterización del riesgo
(ii) Gestión del riesgo

Tabla 1. Comparación de marcos de análisis de la gestión del riesgo a la sequía

	Knutson et al., 1998	Wilhite, 1999, 2001, 2002	Cardona, 2003*	Hayes et al., 2004	WMO, 2005*	UNISDR, 2009a*
(i) Identificación y caracterización del riesgo	• Episodio de sequía • Impactos • Vulnerabilidad	• Preparación • Seguimiento y alerta temprana • Evaluación de Impactos	• Identificación del riesgo (percepción)	• Análisis del episodio de sequía • Análisis de vulnerabilidad (incluye impactos)	• Identificación y análisis del riesgo	• Identificación del riesgo y alerta temprana
(ii) Gestión del riesgo	• Medidas	• Mitigación • Respuesta • Recuperación y reconstrucción	• Reducción del riesgo (prevención-mitigación) • Gestión de desastres (respuesta y recuperación)	• Acciones de mitigación • Responsabilidades • Plan de acción	• Reducción del Riesgo (Preparación y Mitigación) • Transferencia del riesgo	• Política y gobernanza • Mitigación y preparación • Sensibilización y educación

Fuente: Elaboración propia; (*) No exclusivo de la sequía.

La **identificación y caracterización del riesgo**, a su vez, comprende siempre una parte de análisis del fenómeno de sequía y otra vinculada con la vulnerabilidad y los impactos, donde algunos autores ponen el énfasis en el análisis de la vulnerabilidad (Hayes et al., 2004), otros en los impactos (Wilhite, 1999) y otros en ambos, reconociendo su estrecha relación (Knutson et al., 1998).

La **gestión del riesgo** recoge principalmente las medidas y actuaciones. Las propuestas de los diferentes autores también varían bastante pero, en general, siempre diferencian una parte de *prevención o preparación*, otra de *actuación durante el evento*, ya sea de mitigación o respuesta de emergencia, y otra de acciones de *recuperación* post-evento. Entre ellas se considera clave disponer de sistemas de monitoreo y alerta temprana, el desarrollo de planes de sequía y de contingencia, la promoción de la participación y coordinación entre agentes, el desarrollo de campañas de sensibilización y educación y la mejora de los aspectos institucionales y capacidades (Wilhite et al., 2005; Kossida et al., 2012; Wilhite et al., 2014).

Los esfuerzos dirigidos a mejorar la incorporación del enfoque de riesgo a la gestión de la sequía han estado centrados en los procesos de planificación, a través de la elaboración de planes de sequía. Diversas guías y recomendaciones que ayudan a la elaboración de dichos planes (e.g. EC, 2007c; FAO & NDMC, 2008; UNDP, 2013) se encuentran disponibles, pero todavía hay pocas referencias sobre si funcionan adecuadamente (Benítez Sanz & Schmidt, 2012; Gómez Gómez & Pérez Blanco, 2012; Fu et al., 2013a; Fontaine et al., 2014). Como se observa, todas estas referencias son muy recientes y se espera que aumenten en los próximos años con el fin de ampliar la información disponible y poder evaluar el funcionamiento de los planes de sequía como instrumentos de reducción del riesgo.

En los últimos años están aumentando las referencias sobre la necesidad de ir un paso más hacia adelante y desarrollar políticas nacionales de sequía. Kampragou et al. (2011) presentan una hoja de ruta para el desarrollo y la implementación de una política de sequía para los países europeos, indicando los principales componentes de cada fase de desarrollo de la política:

(1) Definición de los objetivos,

(2) Formulación y planificación de dicha política y de los posibles instrumentos,

(3) Consulta a los stakeholders, adopción e implementación de las acciones,

(4) Evaluación y revisión de la política

Más recientemente, Wilhite et al. (2014) han presentado una serie de principios y objetivos sobre los que se debe apoyar la planificación de una Política Nacional de Sequía con enfoque de riesgo y que cuenta con 10 pasos[15] (Tabla 2).

Tabla 2. Proceso de planificación de la política de sequía

PASOS	DESCRIPCIÓN*
PASO 1	Designar una comisión para la política nacional de gestión de la sequía
PASO 2	Exponer o definir las metas y los objetivos de la política nacional de gestión de la sequía basada en los riesgos
PASO 3	Fomentar la participación de los interesados; definir y solucionar conflictos entre los principales sectores de usuarios de recursos hídricos, teniendo en cuenta las consecuencias transfronterizas
PASO 4	Hacer un inventario de los datos y los recursos financieros disponibles y determinar los grupos de riesgo
PASO 5	Identificar los postulados clave de una política nacional para la gestión de la sequía y los planes de prevención conexos, que incluyan los siguientes elementos: la

[15] Estos pasos fueron presentados inicialmente en la década de los 90 y han sido revisados ligeramente posteriormente en varias ocasiones (Wilhite 1999; Wilhite et al. 2000; Wilhite et al. 2005)

PASOS	DESCRIPCIÓN*
	vigilancia; la alerta temprana y la predicción; la evaluación de riesgos y repercusiones; y la mitigación y respuesta
PASO 6	Determinar las necesidades de investigación y subsanar las deficiencias institucionales
PASO 7	Integrar la ciencia con los aspectos normativos de la gestión de la sequía
PASO 8	Difundir la política nacional para la gestión de la sequía y los planes de prevención conexos y fomentar la sensibilización y el consenso de la población
PASO 9	Desarrollar programas de educación para todas las edades y todos los grupos de interesados
PASO 10	Evaluar y revisar la política nacional de gestión de la sequía y los planes de prevención conexos

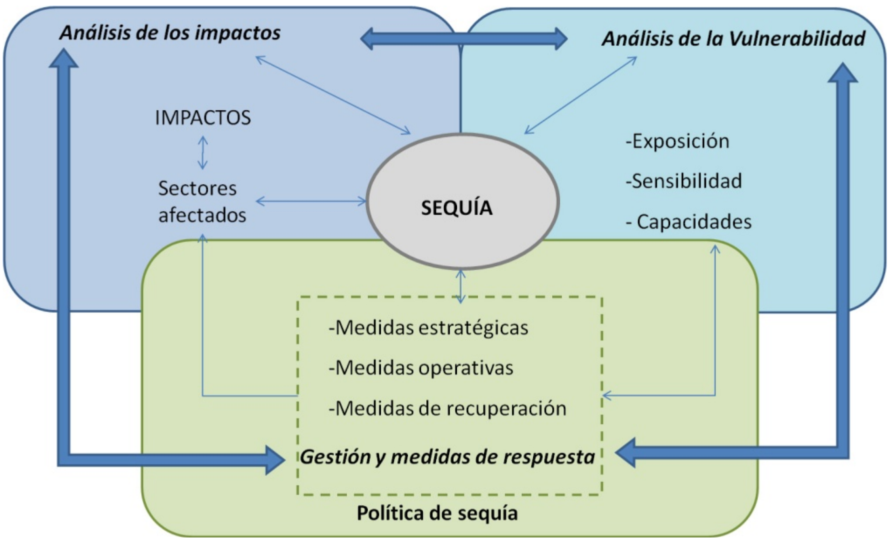
Fuente: Adaptado de Wilhite et al. (2014). *Traducción basada en WMO & GWP (2014)

Retomando todos estos aspectos, se considera que **la gestión del riesgo a la sequía debe incluir no solo el análisis (biofísico o climatológico) de la sequía si no también de los impactos y aspectos de vulnerabilidad así como de las medidas de gestión en su conjunto**.

Con el fin de profundizar en cada uno de estos elementos clave, se ha tomado como referencia el planteamiento de Knutson et al. (1998) por su carácter práctico y se han establecido **cuatro componentes o dimensiones principales de análisis** (Figura 4), que guían la estructura de esta tesis y que se presentan a continuación.

1. Sequía
2. Impactos
3. Vulnerabilidad
4. Medidas de sequía

Figura 4. Planteamiento del análisis de la gestión de riesgo a la sequía



Elaboración propia.

2.2. La sequía

La sequía es un fenómeno natural cíclico, de carácter hidro-climatológico, que se origina por una reducción de las precipitaciones. En términos generales, la sequía se refiere a una disminución de las precipitaciones suficientemente intensa y prolongada como para causar impactos (Pita López, 2007).

Se trata de una característica normal de nuestro clima (UNCDD, 1994; Wilhite et al., 2000; Wilhite, 2001; Wilhite, 2002; FAO & NDMC, 2008; UNDP, 2011) que afecta a todas las regiones y climas del planeta de forma recurrente, aunque sus efectos se manifiestan de forma diferente de una región a otra, y es difícil de predecir. Se caracteriza por su aparición progresiva (‘*creeping phenomenon*’, Wilhite & Glantz 1985, p.111), por su duración prolongada y por la dificultad para determinar su inicio y final (Wilhite & Glantz, 1985; Med EUWI, 2008; Mishra & Singh, 2010). Esto constituye una de sus características diferenciadoras respecto a otros fenómenos naturales adversos, como las inundaciones y terremotos, que suelen presentarse de forma rápida y repentina.

La sequía puede producir un desastre natural si no es gestionada adecuadamente (Wilhite, 2001; Wilhite et al., 2007; MMA/CHJ, 2007). De hecho, se considera uno de los riesgos climáticos más importantes por los daños que produce, provocando importantes impactos socioeconómicos y ambientales que afectan a diversos sectores. Se calcula que en los últimos 30 años las sequías han producido daños por valor de 100 billiones de euros a nivel europeo (EC, 2007a; EC, 2007c).

Las proyecciones de cambio climático para Europa indican que es probable que este fenómeno sea cada vez más frecuente y severo debido a una mayor probabilidad de inviernos más cálidos en el norte y veranos más calurosos en el Mediterráneo, junto con una disminución de la precipitación y un aumento de la evapotranspiración potencial (IPCC, 2007; Bates et al., 2008; Seneviratne et al., 2012).

2.2.1. Definiciones de sequía

Tal como apuntan diversos autores, no existe una definición universal de sequía (Wilhite & Glantz, 1985; Wilhite, 2001; Wilhite et al., 2007; Lloyd-Hughes, 2014). Se han identificado hasta 150 definiciones distintas (Wilhite & Glantz, 1985), reflejando una gran diversidad y su tratamiento desde diferentes disciplinas y enfoques así como respecto a diferentes estados o sistemas afectados.

Sin embargo, existe cierto acuerdo sobre que la sequía se refiere a una disminución de las precipitaciones respecto a una cantidad y a un periodo que se considera ‘normal’. Por ejemplo, en esta línea, la RAE[16] (1984) define la sequía como “*un tiempo seco de larga duración*”; la WMO también se refiere a la “*ausencia prolongada o deficiencia marcada de la precipitación*” o a un “*período anormal de tiempo seco, suficientemente prolongado, en el que la falta de precipitación causa un grave desequilibrio hidrológico*” (WMO/UNESCO, 2012, p.98). Otras definiciones se refieren a la sequía como un fenómeno de carácter temporal (UNDP, 2011) que produce importantes desequilibrios hidrológicos (UNCDD, 1994) produciendo importantes daños y pérdidas

[16] Real Academia Española, www.rae.es.

de rendimiento en los cultivos (FAO, 1983) o que afecta a la actividad de diferentes grupos, sectores y el medio ambiente (Wilhite, 2002).

La sequía se puede definir en términos **conceptuales u operativos** (Wilhite & Glantz, 1985; AMS, 2004; Med EUWI, 2008; Mishra & Singh, 2010; UNDP, 2011; WMO/UNESCO, 2012). Mientras que una definición conceptual trata de definir los límites generales del concepto de sequía y se centra en apuntar a la reducción de las precipitaciones como el origen del problema, las definiciones operativas tratan de identificar el inicio, terminación, la frecuencia y la magnitud de dichos episodios y de ser más concretas y prácticas. A este nivel, existe cierto consenso en clasificar la sequía en cuatro tipos[17]: meteorológica, agrícola, hidrológica y socioeconómica:

- **Sequía meteorológica**. Se refiere a la disminución de la precipitación respecto al valor medio para una región en un plazo de tiempo determinado (MMA/CHJ, 2007; Mishra & Singh, 2010). Según el Ministerios de Medioa Ambiente (MMA) "*Se da cuando se produce una escasez continuada de las precipitaciones* y *es la sequía que da origen a los restantes tipos de sequía y normalmente suele afectar a zonas de gran extensión*", que además apunta que "*El origen de la escasez de precipitaciones está relacionado con el comportamiento global del sistema océano-atmósfera*". Puesto que depende de la precipitación, es específica de cada contexto local y los umbrales para diferenciar periodos secos de húmedos deben fijarse en función de estas características locales (Wilhite & Glantz, 1985).
- **Sequía agrícola**. Se refiere al "*Déficit de humedad en el suelo para satisfacer las necesidades de crecimiento de un cultivo determinado en cualquiera de sus fases de crecimiento*" (MMA/CHJ, 2007, p. 8). Hay que tener en cuenta que la demanda de agua de una planta varía para los diferentes tipos y especies pero también en relación a las condiciones meteorológicas precedentes, el estado de crecimiento de la propia planta o las características y condiciones del suelo (Wilhite & Glantz, 1985). También se denomina hidroedáfica o déficit de la humedad del suelo ('Soil Moisture drought').
- **Sequía hidrológica:** Se refiere a la "*Disminución en las disponibilidades de aguas superficiales y subterráneas en un sistema de gestión durante un plazo temporal dado respecto a los valores medios, que puede impedir cubrir las demandas de agua al cien por cien*" (MMA/CHJ, 2007, p. 8). "*La capacidad de gestionar los recursos hídricos hace que la sequía hidrológica no dependa exclusivamente de los caudales fluyentes en ríos y manantiales, sino también del volumen de agua almacenado en los embalses y acuíferos, es decir, de la manera en que se gestionen estas reservas. De ahí su definición vinculada al sistema de gestión*" (MMA/CHJ, 2007, p 8).
- **Sequía socioeconómica**. Se define como la "*afección de la escasez de agua a las personas y a la actividad económica como consecuencia de la sequía"* (MMA/CHJ, 2007, p. 9) y se asocia con la existencia de impactos, generalmente relacionados con la insuficiencia del sistema para atender todas las demandas.

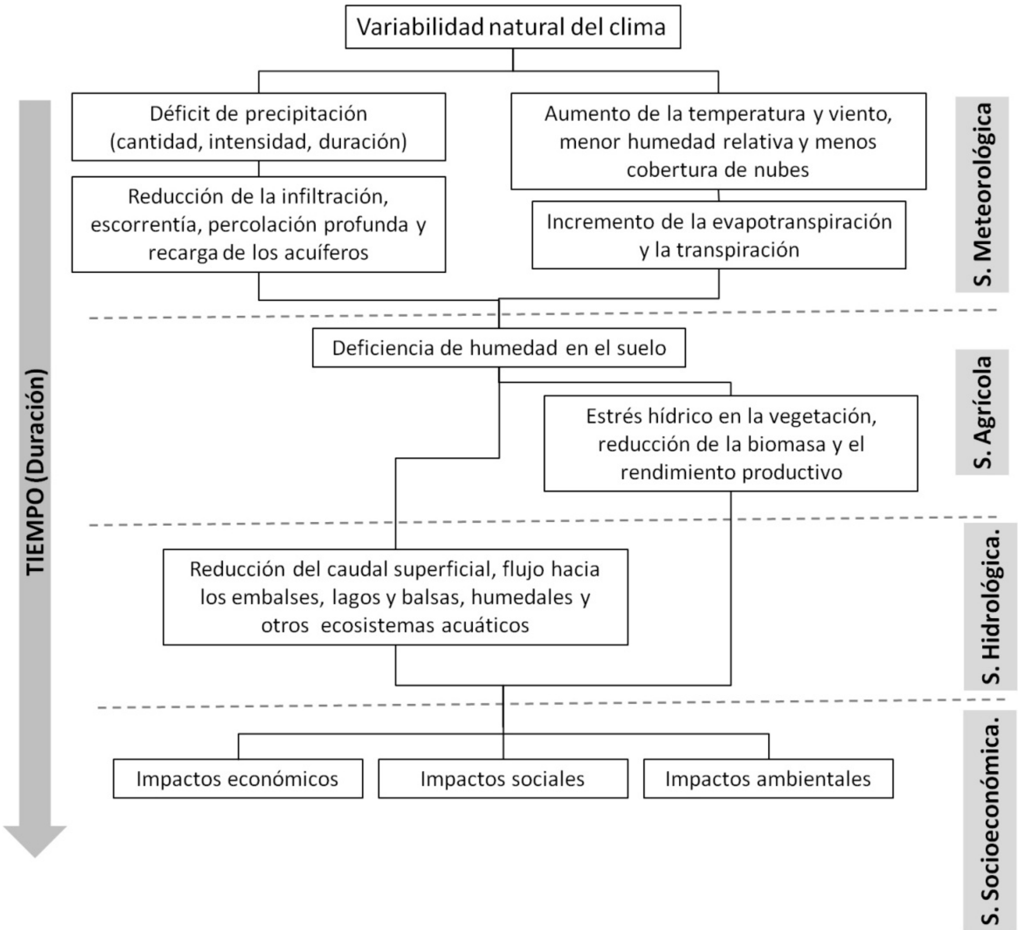
[17] Revisiones más detalladas sobre las definiciones de sequía se pueden encontrar en Wilhite & Glantz 1985; American Meteorological Society 2004; Med EUWI 2008; Mishra & Singh 2010; Sheffield & Wood 2011; Van Loon 2015.

Recientemente algunos autores proponen otras categorías adicionales como **Sequía Subterránea** ('Groundwater Drought') (Van Lanen & Peters, 2000; Peters et al., 2005; Peters et al., 2006; Mishra & Singh, 2010), pero todavía su uso es limitado y existen ciertas dudas sobre si realmente se pueden considerar como un nuevo tipo de sequía.

Cada tipo de sequía tiene efectos a diferentes niveles y sobre distintos sectores, y por tanto la claridad sobre qué tipo de sequía se está considerando es necesaria para poder planificar y estructurar una respuesta adecuada y eficiente.

En términos generales se puede considerar que existe una secuencia temporal en el desarrollo de los diferentes tipos de sequía (Figura 5), aunque esto puede variar y va a depender de las características del contexto y la vulnerabilidad de los diferentes sectores afectados. Asimismo, la sequía socioeconómica, puesto que está vinculada con la aparición de impactos, puede tener lugar en cualquier momento y estar vinculada a cualquiera de las tipologías anteriores (Van Loon, 2015).

Figura 5. Secuencia y progreso de los tipos de sequía



Fuente: NDMC, traducción propia

Si bien los tres primeros tipos de sequía (meteorológica, agrícola e hidrológica) se definen en relación con los aspectos físicos de los efectos de la propagación de la sequía en el medio, la sequía socioeconómica se refiere a los impactos económicos, sociales y ambientales (Wilhite & Glantz, 1985). En este sentido, es necesario reconocer que la sequía es el resultado de la combinación de factores naturales y la influencia de factores antrópicos (Wilhite et al., 2007), si bien el desencadenante es siempre una reducción de las precipitaciones. La sequía meteorológica es por tanto la única que tiene exclusivamente causas atmosféricas mientras que en el resto también influyen factores ambientales y socioeconómicos.

La reducción de los recursos disponibles y sus potenciales impactos sociales y ambientales dependen de la intensidad de la reducción de la oferta, los niveles de demanda y uso, y se suelen manifestar de manera diferente a lo largo del tiempo, según va evolucionando el evento y afectando a los diferentes sectores (Tabla 3).

Por ejemplo, los cultivos de secano, puesto que dependen de la humedad natural del suelo, se ven afectados por la sequía meteorológica y agrícola, y sufren impactos con un pequeño desfase temporal desde que se detecta la reducción de las precipitaciones. La agricultura de regadío está más relacionada con la sequía hidrológica, ya que depende de la capacidad del sistema de proveer el agua de riego que necesita. Sus efectos suelen tardar más en aparecer ya que el regadío proporciona cierta capacidad de adaptación a la variabilidad climática. El sector de la energía hidroeléctrica también se ve afectado una vez alcanzada la sequía hidrológica, cuando los ríos presentan niveles bajos de caudales y su capacidad de producción hidroeléctrica se ve disminuida.

Tabla 3. Relación entre sectores y tipos de sequía

Sectores	Sequía Meteorológica	Sequía Agronómica	Sequía Hidrológica	Sequía Socioeconómica
Abastecimiento población			X	X
Agricultura secano	X	X	X	X
Agricultura regadío			X	X
Ganadería	X	X	X	X
Industria			X	X
Energía hidroeléctrica			X	X
Turismo y ocio	X	X	X	X
Navegación			X	X
Medio Ambiente/ Ecosistemas	X	X	X	X

Fuente: Elaboración propia.

Todas estas formas de definir la sequía reflejan la existencia de diferentes percepciones de la sequía que, en última instancia, determinan la forma en que cada sector de la sociedad y los gobiernos responden a este tipo de eventos (Wilhite & Glantz, 1985; Supramaniam et al., 2011).

Diferencias entre sequía, aridez y escasez

Es necesario distinguir la sequía de otros conceptos similares y relacionados sobre los que existe cierta confusión (Schmidt et al., 2012). Esto ocurre fundamentalmente con los términos de Escasez, Áridez, Desertificación y Olas de calor.

Una manera de diferenciarlos es atendiendo a su escala temporal y origen, destacando el origen natural y carácter temporal y extremo de la sequía, pero también atendiendo a otros criterios como se muestra en la Tabla 4.

Tabla 4. Comparación términos relacionados con la sequía

	SEQUÍA	ESCASEZ	ARIDEZ
Carácter temporal	Temporal Disminución temporal de precipitación o caudal natural	Permanente Situación permanente de déficit en relación con la demandas	Permanente Característica permanente de zonas con precipitaciones bajas
Duración	Meses / años	Continuo / Permanente	Continuo/ Permanente
Origen	Natural	Antrópico	Natural
Característica del clima	Normal	-	Normal
Causa	Disminución temporal de la precipitación	Desequilibrio entre la demanda y la oferta	Bajo nivel de precipitaciones característico de esa zona climática
Interdependencia	Incrementa los efectos negativos de la escasez y de la aridez	Incrementa los efectos negativos de la sequía y las condiciones de aridez	Factor que facilita el desarrollo de situaciones de escasez
Medidas	Medidas preventivas, de emergencia y de recuperación	Medidas estructurales, cambio de modelo de uso y consumo de los recursos hídricos	Estrategias a medio y largo plazo que promuevan un uso sostenible de los limitados recursos y para combatir la desertificación

Fuente: Elaboración propia, basado en Med EUWI (2008), Mishra & Singh (2010), Schmidt et al. (2012).

La **aridez** comparte su origen natural con la sequía, y se considera una situación estructural natural de una región, que normalmente se refiere a bajos niveles de disponibilidad de agua debidos a una baja precipitación o altas tasas de evapotranspiración, siendo un rasgo que caracteriza ciertos climas.

La **desertificación** se refiere principalmente a fenómenos de degradación de la tierra y el suelo que tienen lugar en regiones áridas, semi-áridas o sub-húmedas y que son provocados por varios factores entre los que se incluyen variaciones climáticas y la actividad humana (UNCDD, 1994; Kassas, 1995). Periodos de sequía pueden agravar problemas de desertificación (Van Loon, 2015).

La **escasez** es el término más problemático ya que opera en la misma escala temporal que la sequía y es el más similar a ella. De hecho, los términos sequía y escasez en ocasiones son utilizados indistintamente como si fueran sinónimos (Schmidt et al., 2012). La escasez de agua se refiere básicamente a situaciones de déficit permanentes donde existe un desequilibrio entre la oferta y la demanda es decir, los aportes no son suficientes para hacer frente a las demandas de la sociedad. Esta situación se agrava en gran medida durante los periodos de sequía y, por tanto, sequía y escasez se manifiestan de manera parecida en la práctica (Van Loon, 2015). Es especialmente importante distinguir entre estos dos conceptos ya que al ser sus causas diferentes, requieren de medidas distintas.

Las **olas de calor** se refieren a un periodo de tiempo prolongado con temperaturas superiores a la media en una determinada región. Sin embargo, tampoco existe consenso sobre su definición (Meehl & Tebaldi, 2004). Su principal diferencia con la sequía es que estas tienen una menor duración. Mientras que la sequía puede durar meses o años, la duración de las olas de calor es del orden de semanas (Mishra & Singh, 2010).

2.2.2. Medición de la sequía

Dada la diversidad de definiciones sobre la sequía, tal y como argumenta Lloyd-Hughes (2014), resulta impracticable definir la sequía con un único indicador o fórmula matemática. Sin embargo, muchos autores subrayan la necesidad de cuantificar la sequía para poder gestionarla (Van Loon, 2015) o de contar con ciertos estándares numéricos para poder comparar entre regiones o con episodios del pasado (Heim, 2002).

A lo largo de las últimas décadas se han ido desarrollado una serie de indicadores e índices para intentar medir diferentes características o tipos de sequía. En general los esfuerzos se han dirigido a determinar su duración, incluyendo la determinación de su inicio y final, frecuencia, magnitud o severidad, intensidad y extensión espacial:

- *Magnitud o severidad*: se refiere al nivel de déficit acumulado por debajo del nivel crítico.
- *Intensidad*: es la media del valor del parámetro de sequía por debajo del nivel crítico.
- *Duración*: se define mediante la determinación del principio y fin del evento, esta puede ser corta, media o prolongada.
- *Extensión espacial*: se refiere a la amplitud de la zona afectada por la sequía. Esta varía desde lo local a regional y nacional.

Sin pretender que sea un listado exahustivo, en la Tabla 5 se presentan los principales índices existentes, con sus características y principales aplicaciones. Este resumen pretende dar una visión general de los índices más importantes pero para mayor detalle sobre su construcción, funcionamiento, fortalezas y debilidades, se pueden consultar otros estudios específicos sobre índices y cuantificación de la sequía (Wilhite & Glantz, 1985; Heim, 2002; Keyantash & Dracup, 2002; MEDROPLAN, 2007; Kallis, 2008; Niemeyer, 2008; FAO & NDMC, 2008; Mishra & Singh, 2010; Hayes et al., 2011).

El Índice de Precipitación Estandarizado[18] (SPI) es el índice más comúnmente utilizado para definir la sequía meteorológica (Heim, 2002; Hayes et al., 2011) y ha sido el adoptado por la WMO para su medición (WMO, 2009). Sin embargo, para el resto de sequías todavía no existe consenso sobre cuál es el índice más apropiado. La utilidad de cada uno de estos índices debe ser analizada en cada caso particular y para cada contexto de aplicación. Seneviratne et al. (2012), recomiendan una cuidadosa selección de los indicadores teniendo en cuenta las características de la sequía que se quieren considerar. La disponibilidad de datos es una de las principales limitaciones para el uso de la mayoría de los índices presentados. El cálculo de los umbrales de sequía y la necesidad de largas series de datos son otros limitantes y retos que todavía hay que superar (Mishra & Singh, 2010).

Los indicadores que tratan de medir el componente socioeconómico se refieren más bien a la vulnerabilidad a la sequía (Iglesias et al., 2009) o a la medición o estimación de los impactos per se, pero no en relación a tratar de medir este cuarto tipo de sequía. De hecho, ninguno de los índices de la Tabla 5 incluye la dimensión

[18] Standard Precipitation Index (SPI)

socioeconómica de la sequía, lo que muestra la falta de índices de sequía que incluyan los impactos en su medición (Mishra & Singh, 2010; Todisco et al., 2013).

La tendencia actual se centra en el uso de un grupo de índices que intentan, en su conjunto, reflejar la realidad de la sequía en todas sus dimensiones (Lloyd-Hughes, 2014). Un ejemplo de esto es el Monitor de la Sequía de EEUU (Svoboda et al.; 2002).

El análisis de la percepción de los desastres es otra forma de acercarse a cómo se entienden los diferentes individuos o colectivos este fenómeno. En el caso de la sequía, existen varios estudios que tratan de indagar en la forma en la que la sequía es percibida por distintos stakeholders, aunque generalmente se centran en los usuarios y agricultores (e.g. Taylor et al., 1988; Dagel, 1997; Noemdoe et al., 2006; Giordano & Vurro, 2010; Habiba et al., 2012). Este tipo de estudios permiten contrastar las definiciones realizadas a nivel científico y su utilidad en un contexto específico y a nivel local, presentando un interesante potencial para hacer la definición de los umbrales de severidad de la sequía más socialmente transparentes (Smakhtin & Shipper, 2008).

Tabla 5. Principales índices de sequía, características y aplicaciones

Indicador	Descripción	Usos	Datos que necesita	Sequía Meteorológica	Sequía agrónómica	Sequía Hidrológica	Sequía socioeconómica	Referencia
Indicador de la Intensidad de la Sequía de Palmer (PDSI)	Mide el estado de humedad del suelo de una región; Se encuentra calibrado para regiones relativamente homogéneas, Hace un seguimiento meteorológico de los períodos húmedos y secos a largo plazo; + Información regional y perspectiva histórica + Representación espacio-temporal - Retraso en pronosticar la sequía - No adecuado para zonas montañosas o con cambios de clima extremos - Algunas reglas para su cálculo son arbitrarias	Ampliamente utilizado para el seguimiento de la sequía en grandes regiones; Boletín Semanal del Clima y los Cultivos en EEUU.	• Variables meteorológicas (temperatura, precipitación, contenido de agua del suelo) • Rango de valores: -6/+6* • Mensual (También semanalmente)	X	X			Palmer, 1965
Deciles	La distribución de la ocurrencia de las largas series temporales de precipitacionesse divide en deciles para determinar la existencia y severidad de una sequía según unos umbrales establecidos. + Es una manera sencilla y uniforme de determinar periodos secos de acuerdo a datos históricos de referencia + Calculo estadístico preciso + Permite compración entre regiones - Necesita registros climátológicos históricos para que la determinación de los deciles sea precisa. - Necesita calcular PET	Utilizado por el Australian Drought Watch System (NDMC)	• Variables meteorológicas (precipitación) • Rango de valores: Deciles de 1-10	X				Gibbs & Maher, 1967
Indicador de la Humedad del Cultivo (CMI)	Enfocado al seguimiento de las condiciones de humedad que afectan a un cultivo en desarrollo a corto plazo. + Responde con rapidez a los cambios de condiciones - No bueno para hacer seguimiento a largo plazo - Asociados a ciclos vegetativos anualmente, por lo que no es útil para periodos fuera de esta época o sequías prolongadas	Seguimiento condiciones de cultivos en EEUU	• Variables meteorológicas (temperatura, precipitación) • Semanal (durante periodo crecimiento vegetativo)		X			Palmer, 1968
Indicador del Suministro de Aguas Superficiales (SWSI)	Indicador de las condiciones del agua superficial, observa las anomalías, complementario al PDSI y específico para cada cuenca o región; Se calcula específicamente para cada cuenca o región; + Sencillo de calcular + Medida representativa de los recursos de aguas superficiales - Si hay cambios en la característica de la cuenca (ej. Nuevo embalse) o si fenómeno extremo fuera de la serie de datos histórica, hay que recalcularlo. - No representa bien los eventos extremos	Puesta en marcha la activación y desactivación del Plan de Sequías en Colorado	• Variables meteorológicas (precipitación) • Variables hidrológicas (volumen de nieve, caudal de los ríos, agua almacenada en los embalses) • Rango de valores: -4,2/+4,2 • Mensuales (diferencias entre periodo invernal y estival)			X		Shafer & Dezman, 1982
Índice de Condiciones de la Vegetación (VCI)	Indicador para medir el inicio, la intensidad, duración e impacto sobre la vegetación de la sequía basado en información satelital. + Información continua en el tiempo y en el espacio que permite monitorea áreas extensas a tiempo real + Útil durante la época de cultivo y para areas donde la cobertura de estaciones meteorológicas e hidrológicas es escasa + Buen indicador de alerta temprana - Limitada utilidad en la estación fría cuando la vegetación está en estado latente	Usado para determinar el inicio y monitorear la evolución de la sequía. Ej. Junta de Andalucía, España	• Variables: % de cobertura, el índice de área foliar y el vigor clorofílico. • Rango de valores: 0 – 100 (Sequia < 50)	X				Kogan & Sullivan, 1993

Indicador	Descripción	Usos	Datos que necesita	Sequia Meteorológica	Sequía agrónómica	Sequía Hidrológica	Sequía socioeconómica	Referencia
Indicador Normalizado de Precipitaciones (SPI)	Cuantificación de los déficits de precipitaciones durante diferentes periodos de tiempo. Basado en registros de precipitación para largos periodos de tiempo, se ajusta la distribución de probabilidad para su normalización. Determinación de periodos húmedos y secos. + Tiene en cuenta la escala temporal a la que se manifiestan los efectos del déficit de precipitación desde el corto plazo al largo plazo. + Determina inicio, final e intensidad para cada mes y magnitud en base a datos acumulados para el periodo dado. + Sirve como alerta temprana porque monitorea la disponibilidad de agua a corto plazo. - La longitud de la serie temporal influye en la distribución de probabilidad y esta da problemas en climas donde las precipitaciones tienen un marcado carácter estacional	Ampliamente extendido su uso para caracterizar la sequía y determinar su inicio y final (e.j. US Monitor; WMO) y también en sistemas de monitoreo y alerta temprana.	• Variables meteorológicas (Precipitation) • Rango de valores: -2/+2** • Mensual (para de 3, 6, 12, 24 y 48 meses)	**X**	**X**	**X**		McKee et al.,1993
Reconnaissance Drought Index (RDI)	Mide el déficit acumulado entre la precipitación y la demanda evapotranspirativa de la atmósfera. Indice estandarizado cuyo funcionamiento e interpretación es similar al SPI, basado en probabilidades pero utilizando una distribución lognormal. + Se puede calcular para diferentes periodos de tiempo. + Permite comparaciones en areas geográficas extensas e.j. Mediterráneo. - Uso limitado en monitoreo y alerta temprana	En estudios aplicados	• Variables meteorológicas (precipitación;evapotranspira ción potencial) • Rango valores: -4/+4***	**X**	**X**			Tsakiris et al., 2006
Índice de Precipitación Evapotranspira ción Estandarizada (SPEI)	Este índice considera la anomalías acumuladas en el balance hídrico climático; Es similar al SPI en tanto utiliza la distribución de probabilidad y la ajusta a una función normal. + Relativo al contexto ya que utiliza el balance hídrico y tiene en cuenta la variabilidad de la temperatura. + Se puede calcular para diferentes periodos y regiones + Considera el efecto de PET sobre la severidad - Calculo de PET complejo	Monitor global de la sequía a tiempo real del CSIC, España	• Variables meteorológicas (temperatura, precipitación, evapotranspiración potencial)	**X**	**X**	**X**		Vicente-Serrano et al., 2009

Fuente: Elaboración propia, basado en Wilhite & Glantz, 1985; Keyantash & Dracup, 2002; Tsakiris et al., 2006; MMA web; FAO & NDMC, 2008; Kallis, 2008; Niemeyer, 2008; Mishra & Singh, 2010; Van Loon, 2015.

(*) **PDSI**	**(**) SPI**	**(3) RDI**
4,00 ó más: humedad extrema	2,0 o superior: humedad extrema	De 0 a -1,5 normal a suave 0 a 1,5
3 a 3,99: muy húmedo	1,5 a 1,99: muy húmedo	-1,5 a - 4,0 moderada de 1,5 a 4,0
2 a 2,99: humedad moderada	1,0 a 1,49: humedad moderada	< – 4 extrema > 4,0
1 a 1,99: ligeramente húmedo	-0,99 a 0,99: casi normal	
0,5 a 0,99: humedad incipiente	-1,0 a –1,49: moderadamente seco	
0,49 a – 0,49: casi normal	-1,5 a –1,99: muy seco	
-0,50 a – 0,99: sequía incipiente	-2,0 o por debajo: sequedad extrema	
-1 a –1,99: sequía ligera		
-2 a –2,99: sequía moderada		
-3 a –3,99: sequía intensa		
-4 ó menos: sequía extrema		

2.2.3. Consideraciones para su análisis

- Es un fenómeno de duración extensa y de comienzo y final difusos, que se implanta de manera lenta y paulatina, siendo difícil determinar su inicio y final.
- Las sequías son recurrentes pero altamente impredecibles y se pueden dar en todos los climas y áreas geográficas, pudiendo afectar a un ámbito geográfico relativamente extenso.
- Cada sequía es única en cuanto a sus características físicas y a su extensión geográfica y localización. Por tanto, se trata de un fenómeno específico de un cada contexto.
- Produce una gran diversidad de impactos, tanto en términos socioeconómicos como ambientales, que trascienden a todos los sectores de la sociedad.
- Es importante distinguir la sequía de otros fenómenos similares, especialmente de la escasez, para poder abordar mejor el problema.
- Se deben adoptar definiciones operativas para mejorar su comprensión y medición.
- Es necesario contar con índices de sequía socioeconómica o incluir datos de impactos en los ya existentes.
- Es preciso elegir varios índices para intentar reflejar todas las facetas de la sequía y matizar en cada caso qué tipo de sequía estamos intentando medir y se deben adaptar a su contexto de utilización.
- El cálculo de los umbrales y la disponibilidad de datos suelen ser el principal limitante y reto para la utilización de un índice determinado.
- El análisis de percepción puede ayudar a contrastar las definiciones científicas con la realidad del contexto local.

2.3. Los impactos de la sequía

Las sequías se encuentran entre los desastres naturales de mayor alcance e impacto. Se estima que, sobre la base de las sequías reportadas internacionalmente desde 1900, más de 11 millones de personas han muerto y más de 2.000 millones se han visto afectadas, más que por cualquier otra amenaza física (Guha-Sapir, Below, Hoyois - EM-DAT, 2010; UNISDR, 2011). Esta situación se ve agravada en los países en desarrollo donde la sequía se asocia comúnmente a situaciones extremas de escasez de alimentos y al 60% de las emergencias alimentarias (FAO, 2003).

Kossida et al. (2012) apuntan que Europa ha experimentado varios episodios de sequía de diversas intensidades, duración y extensión, que han tenido diversos impactos ambientales y socioeconómicos. En los últimos 30 años los impactos de la sequía se estiman en 100 billones de euros (EC, 2007a; EC, 2007c; EEA, 2009) y que su coste anual se ha cuadriplicado durante este mismo periodo (EC, 2007a). A pesar de la importancia que señalan estas cifras, existen pocos estudios que aborden la complejidad de los impactos desde el nivel local al global y el desarrollo de bases de datos que documenten los impactos a nivel regional y sectorial es casi inexistente (Wilhite et al., 2007).

Conocer y poder anticipar los impactos es clave para poder responder y planificar las acciones de mitigación de una forma adecuada (Wilhite et al., 2007; Hayes et al., 2011; Karavitis et al., 2014). Estos constituyen el punto de partida para profundizar en los factores de vulnerabilidad (Knutson et al., 1998, Wilhite et al., 2007; Hayes et al., 2011; UNDP, 2013). Asimismo, se considera información clave para incorporar en los sistemas de monitoreo, aunque las experiencias al respecto son todavía muy limitadas e incipientes (Hayes et al., 2011; Lackstrom et al., 2013). Según Hayes et al., (2011) existe falta de comprensión sobre la importancia de monitorear los impactos, la utilidad de esta información y el tipo de datos que hace falta recolectar. También son ampliamente reconocidas las dificultades para la recolección sistemática de este tipo de datos, especialmente a nivel global (Wilhite et al., 2007; UNISDR, 2011).

2.3.1. Definición y características de los impactos

No existe una definición estandarizada sobre los impactos de un desastre natural (Okuyama & Sahin, 2009) y los términos 'daños, 'pérdidas' o 'impactos' se utilizan como sinónimos e intercambiables, lo cual añade confusión a su análisis. En el caso concreto de los impactos de la sequía, se encuentra una situación similar.

Se entiende por **impacto** de la sequía aquellos efectos (principalmente) negativos, tanto esperados como no esperados, que tienen lugar como consecuencia de un evento de sequía. Su origen depende tanto de factores climatológicos e hidrológicos como sociales y del contexto (Wilhite et al., 2007). Knutson et al., (1998) entiende que estos efectos son síntomas de vulnerabilidad y explica que existen impactos directos e indirectos y de diversa naturaleza, que clasifica en sociales, económicos, ambientales de una manera práctica.

Los impactos de la sequía son múltiples: pérdidas de vida, reducción del bienestar, aumento de la pobreza y la inseguridad alimentaria por la pérdida de cosechas, problemas en el abstecimiento de agua potable y reducción de la producción energética, entre otros. Además la sequía puede causar migraciones forzosas y generar conflictos sociales, así como deteriorar el medioambiente y los ecosistemas acuáticos y terrestres (UNISDR, 2011).

Los impactos afectan a todos los sectores de una sociedad (Wilhite & Glantz 1985; Knutson et al., 1998; Wilhite, 2002; Wilhite et al., 2007; FAO & NDMC, 2008; Med EUWI, 2008; UNISDR, 2009a; Ding et al., 2011). Su manifestación temporal puede no coincidir plenamente con el periodo de sequía que lo produce, y durar incluso varios años más (Wilhite & Glantz, 1985; Kallis, 2008).

Los impactos son dinámicos (Wilhite & Glantz, 1985) por su evolución en el tiempo y en el espacio, y las relaciones de causalidad no son siempre bien conocidas (Kallis, 2008; Logar and van den Bergh, 2013; Lackstrom et al., 2013) o fáciles de medir. Existen efectos indirectos (secundarios, terciarios) que son difíciles de definir y que en ocasiones exceden el ámbito territorial del propio evento de sequía.

Los impactos dependen de una combinación de factores socioeconómicos, culturales, políticos o ambientales, dado que están influídos por la vulnerabilidad local en cada momento (Wilhite & Glantz, 1985; Wilhite et al., 2007). La severidad de la sequía a veces se expresa en función del nivel de impactos (Wilhite & Glantz, 1985), pero un elevado nivel de impactos detectado no tiene por qué corresponder con un episodio más intenso o severo de sequía (Kundzewicz et al., 2007) ya que también hay que tener en cuenta la capacidad de adaptación (FAO & NDMC, 2008).

La escala de análisis de los impactos adoptada es importante ya que en función de esta, los impactos pueden variar. A una escala mayor de análisis, a nivel regional o continental, la sequía puede tener impactos positivos en una zona mientras que en otra se detectan consecuencias negativas. Es decir, puede enmascarar diferencias regionales (Kallis, 2008). Por ejemplo, la pérdida de cereales en Rusia en el año 2011 provocó cuantiosas pérdidas a los agricultores rusos mientras que los del centro y sur de Europa se vieron beneficiados porque acapararon mayor cuota de mercado. Esto es un ejemplo de la importancia de delimitar de manera apropiada y clara el ámbito espacial de análisis de los impactos de la sequía (Ding et al., 2011) y la identificación de posibles "ganadores" fuera de los límites geográficos afectados por la sequía considerados (Wilhite et al., 2007; Ding et al., 2011) o en otros grupos de la cadena de producción y comercialización agraria (Musolino et al., 2015). De la misma manera, un análisis a nivel nacional puede esconder diferencias regionales y locales (Ding et al., 2011). Por tanto, conjugar las especifidades del contexto local que caracterizan a los impactos con la necesidad de contar con una imagen más global a nivel nacional dirigido a la toma de decisiones (Lackstrom et al., 2013) es un importante reto que todavía es necesario superar.

Otro aspecto importante es la dificultad que existe para atribuir un determinado episodio de sequía como causa de un impacto particular (Lackstrom et al., 2013) o para asociarlo a los diferentes tipos de sequía definidos, ya que en general los impactos son consecuencia de múltiples factores de estrés (Laskstrom et al., 2013). Según Van Loon (2015) "*las investigaciones sobre los aspectos físicos de la sequía hidrológica y sus impactos se encuentran en sus inicios*" (p. 378). Esto se puede hacer extensivo al resto de los tipos de sequía.

Distinguir entre los impactos de la sequía y de las medidas de gestión es importante pero difícil de realizar. El análisis de los impactos globales de una sequía, lleva implícito el resultado de las medidas ejecutadas, mientras que el análisis del funcionamiento y los resultados alcanzados (o efectos) de una determinada medida no nos dice nada sobre el nivel general de impactos de una sequía. Conocer los resultados de las medidas ejecutadas es importante para analizar su relación con los impactos, pero estas relaciones son poco conocidas ya que casi no existen estudios al respecto (Logar & van den Bergh, 2013).

Ding et al. (2011) resaltan el interés de calcular el coste de los desastres porque el beneficio de los programas de mitigación puede ser cuantificado usando el coste estimado del desastre que se hubiera evitado con dichos programas de mitigación.

2.3.2. Clasificación y medición de los impactos

Existen varias formas de clasificar los impactos de la sequía. En primer lugar, los impactos se pueden clasificar en función de su naturaleza siendo **económicos, ambientales y sociales** (Wilhite & Glantz, 1985; Knutson et al., 1998; Wilhite et al., 2007; Med EUWI, 2008; UNISDR, 2009a). En segundo lugar se pueden diferenciar en función de su relación con el evento, pudiendo ser **directos, indirectos e intangibles** (Martin-Ortega & Markandya, 2009; Ding et al., 2011; Logar & van den Bergh, 2013; Jenkins, 2013). Por último, se pueden catalogar en función de los **sectores** afectados (Stahl et al., 2012).

Según el NDMC, los *impactos económicos* son aquellos que producen algún coste a las personas afectadas o que afectan al desarrollo de su actividad económica. Los *impactos ambientales* son aquellos que afectan al medioambiente, ya sean los animales, plantas o ecosistemas en general. Los *impactos sociales* son los que afectan de alguna manera la salud, el bienestar y la seguridad de las personas, incluyendo los conflictos por los recursos hídricos. En la Tabla 6 se presentan algunos ejemplos de impactos para cada una de estas categorías.

Tabla 6. Principales impactos de la sequía

Tipo de impactos	Ejemplos
Impactos económicos	Pérdidas de producción en agricultura y ganadería; Aumento de costes de producción ej. compra de alimento adicional para el ganado; Aumento del coste del agua para los usuarios o de suministro para las empresas abastecedoras; Coste de interrupción de proceso de producción ej. en industrias o hidroeléctricas; Pérdidas económicas relacionadas con la interrupción de la navegación y transporte de mercancías.
Impactos ambientales	Aumento de la erosión del suelo; Degradación de hábitats naturales; Insuficiente agua y alimentos para la fauna salvaje; Aumento de la mortalidad de peces en los ríos; Empeoramiento de la calidad de las aguas; Migración de la fauna salvaje; Aumento de incendios forestales; Pérdida de humedales.
Impactos sociales	Problemas de salud relacionados con la contaminación de las fuentes de agua o ecosistemas; Problemas de salud relacionados con las altas temperaturas y sequedad del ambiente; Pérdidas de empleo en la agricultura; Disminución de actividades de ocio al aire libre.

Fuente: Elaboración propia adaptado de NDMC.

Es importante conocer en qué orden o secuencia se producen los impactos para poder identificarlos mejor y entender por qué se producen. Por ejemplo, la reducción de la producción de un determinado cultivo causa una disminución de los ingresos del agricultor y eso puede llevar a un aumento de los precios de dicho producto y del desempleo. Así, el primero se puede considerar como *impacto directo* y los dos siguientes como *indirectos*. En general también se puede estimar que los impactos directos tienen lugar a corto y medio plazo mientras que los indirectos se manifiestan en el largo plazo (Jenkins, 2013), aunque tampoco existe consenso en la literatura sobre este asunto. Karavatis et al. (2014) se refiere al "orden de interacciones" para identificar esta secuencia de impactos y alude a tres niveles de interacciones, que van desde las más directas (de primer orden), a las más indirectas (de tercer orden). Los impactos de primer orden son aquellos relacionados con cambios en el sistema hidrológico, los de segundo orden con las actividades humanas tales como la agricultura o la industria, entre otras, y los de tercer orden corresponden a adaptaciones a los impactos anteriores.

Sectores afectados por la sequía son: abastecimiento, agricultura y ganadería, industria, energía, turismo, transporte y navegación, medioambiente y salud pública. Los impactos de la sequía son mejor conocidos y estudiados en relación al abastecimiento y la agricultura (Kallis, 2008; Logar & van den Bergh, 2013; Lackstrom et al., 2013). Los daños sociales y ambientales se han estudiado con menos profundidad que los impactos económicos (Shahbazbegian & Bagheri, 2010), en parte por la dificultad para ser identificados y medidos.

A pesar de todos los esfuerzos realizados por analizar de manera sistemática los impactos de la sequía, todavía faltan estudios de carácter global que aborden el análisis de los impactos a la sequía de manera completa y por evento (Wilhite et al., 2007; UNISDR, 2011; Ding et al., 2011; Lackstrom et al., 2013; Logar & van den Bergh, 2013; Karavatis et al., 2014) y apenas existen estudios de los impactos de la sequía a nivel nacional (Ding et al., 2011).

Los estudios de los impactos de la sequía se pueden agrupar en tres tipos:

A. Bases de datos globales sobre desastres naturales

B. Estimaciones y cálculos económicos de los impactos de la sequía

C. Bases de datos específicas con registros de impactos de la sequía

A. Bases de datos e iniciativas sobre desastres a nivel global

La información disponible a nivel mundial sobre los impactos se enmarca dentro de los estudios sobre Reducción de Desastres Naturales y Gestión del Riesgo (UNISDR, 2009a, 2011, 2013). Dichos estudios recogen los impactos de diversos desastres naturales en términos de (i) número de personas muertas, (ii) número de personas heridas y/o afectadas, (iii) pérdidas materiales o costes económicos.

La EM-DAT – '*Emergency Events Database*'[19] desarrollada por el Centro de Investigación sobre la Epidemiología de los Desastres desde 1988 en Louvain, Bélgica, es la más utilizada y una referencia a nivel mundial. En esta base de datos, un evento

[19] www.emdat.be/

se considera un "desastre" si cumple uno de los siguientes criterios: (a) 10 o más personas muertas; (b) 100 personas reportadas como afectadas; (c) declaración de estado de emergencia; (d) llamamiento de ayuda internacional (Ferris & Petz, 2012).

La compañía aseguradora MunichRe[20] brinda datos en sus informes anuales, y posee la mayor base de datos sobre catástrofes naturales del mundo desde 1980 con más de 28.000 entradas (Ferris & Petz 2012). Presenta los datos agrupados por (i) daños asegurados, (ii) pérdidas totales, (iii) lesiones corporales y (iv) infraestructuras e industrias afectadas. La información se encuentra disponible de manera gráfica pero no desglosada por evento. Según Ferris & Petz (2012), la base de datos de MunichRe presenta un mayor número que EM-DAT porque incluye impactos de desastres menos importantes. Existen otras diferencias significativas como que EM-DAT utiliza el término "impacto estimado" mientras que MunichRe se refiere a "pérdidas totales", lo cuál tiene implicaciones en cómo se mide cada una de ellas.

Otra fuente de información interesante es la del Servicio de Seguimiento Financiero ('Financial Tracking Service') de la Oficina de Coordinación de la Ayuda Humanitaria de la Unión Europea[21], que aporta datos sobre la financiación de la respuesta humanitaria ante desastres en el mundo.

La Estrategia Internacional para la Reducción de los Desastres (UNISDR) apoya a los países en el desarrollo de bases de datos que recojan información sobre las pérdidas debidas a los desastres. Además, publica bianualmente el "Informe de evaluación global sobre la Reducción del Riesgo de Desastres"[22] donde sistematiza y presenta una gran cantidad de información.

Existen otras iniciativas de referencia más específicas, algunas de carácter nacional o regional, entre las que destaca**:**

- 'Global Risk Data Platform: The PREVIEW Global Risk Data Platform'[23]. Se trata de un esfuerzo de múltiples agencias para compartir información de datos espaciales de riesgo global de los principales riesgos naturales.
- Preventionweb[24]. Es una plataforma web participativa de referencia para la comunidad de reducción de riesgo a desastres.
- DESINVENTAR[25]: Es un sistema de manejo de información sobre desastres. Enfocada a desarrollar inventarios nacionales sobre desastres y construcción de bases de datos sobre daños e impactos. Se encuentra información en español y para America Latina.
- 'Global Facility for Disaster Reduction and Recovery'[26]. Es una asociación global formada por más de cinco donantes y gestionada por el Banco Mundial que ayuda a reducir el riesgo e implementar el Plan de Acción de Hyogo en los países que lo necesitan.

[20] www.munichre.com
[21] http://fts.unocha.org/pageloader.aspx?page=home
[22] Global Assessment Report on Disaster Risk Reduction; www.unisdr.org/we/inform/gar
[23] http://preview.grid.unep.ch/index.php?preview=home&lang=eng
[24] www.preventionweb.net/english/hazards/drought/
[25] www.desinventar.org/es/
[26] www.gfdrr.org/

- ‘DaLA’s – Damage and Loss Assessment’[27]. Es una metodología de evaluación inicialmente desarrollada por la Comisión Económica para América Latina y el Caribe de las Naciones Unidas en 1972. Desde entonces ha sido mejorada poco a poco y actualmente se enfoca en calcular el impacto global de un desastre sobre la economía global de un país y es utilizada por el Banco Mundial.
- UN-SPIDER[28]: Iniciativa para compartir información espacial generada por satélite y poderla utilizar para la gestión de riesgos naturales.

B. La evaluación económica de los impactos

La evaluación económica de los impactos es una forma bastante extendida en la literatura de analizar los impactos de la sequía. La cuantificación económica de los impactos produce información que es necesario conocer para el desarrollo y la planificación de políticas dirigidas a reducir los impactos de los desastres naturales en general y de la sequía en particular (Logar & van den Bergh, 2013).

En términos generales, Perris & Petz (2012) mencionan tres grandes problemas relacionados con la cuantificación económica de los impactos de desastres naturales: primero, la falta de consistencia y transparencia en la medición y cálculo de los mismos; en segundo lugar, puesto que en muchos casos se basan en reportes e información gubernamental, estos utilizan diferentes enfoques e instrumentos y presentan diferentes métodos, por lo que las comparaciones son complicadas y deben realizarse con suma cautela; y por último, porque el cálculo de algunos impactos, por ejemplo, los daños en las infraestructuras, son claros y directos mientras que la cadena causal de otros impactos son complejos de identificar y calcular.

No existe consenso en la literatura sobre la categorización o terminología sobre costes de la sequía (Logar & van den Bergh, 2013) pero sí es común distinguir entre costes directos, indirectos e intangibles (Martin-Ortega & Markandya, 2009; Ding et al., 2011; Logar & van den Bergh, 2013). Además existen varios modelos y métodos que se pueden utilizar para estimar los costes de la sequía (ver Kallis, 2008 y Logar & van den Bergh, 2013).

Logar & van den Bergh (2013) argumentan que es necesario diferenciar entre los costes de los impactos de la sequía y los costes de las medidas de gestión. Según esto autores, en general hay estudios que se basan en el análisis de los costes de la sequía para un determinado sector o tipo de coste – e.g. económico, social o ambiental, pero apenas nos encontramos con estudios que midan los daños de una determinada sequía (ver por ejemplo Martín-Orgeta & Markandya, 2009; Hernández-Mora et al., 2013) o a nivel nacional (Shahbazbegian & Bagheri, 2010).

C. Registros sobre impactos de sequía

Aunque a nivel global no existe ninguna base de datos específica para los impactos de la sequía, existen algunas experiencias interesantes a nivel continental o nacional que han surgido para rellenar este vacío de información.

[27] World Bank post-disaster damage and loss assessments; https://www.gfdrr.org/Track-III-TA-Tools
[28] http://www.un-spider.org/

En primer lugar cabe señalar el *Monitor de Sequía*. Se trata de una base de datos de impactos para EEUU que se encuentra principalmente enfocado al sector agrario y que distingue 10 categorías de impactos: (i) Agricultura (ii) Industria y negocios, (iii) Energía, (iv) Incendios, (v) Concienciación general, (vi) Vegetación y vida salvaje, (vii) Ayudas, respuesta y restricciones, (viii) Sociedad y salud pública, (ix) Turismo y recreación, (x) Abastecimiento de agua y calidad. Se trata de una iniciativa única a nivel mundial lanzada en 1999 (Svoboda et al., 2002; Wilhite et al., 2007). Se nutre de información aportada por los propios afectados y se encuentra en constante evolución y actualización.

A nivel europeo destaca el lanzamiento de dos iniciativas recientemente: la *Base de datos de Referencias de la Sequía en Europa*[29], y el *Inventario Europeo de Impactos Reportados*[30] (Stahl et al., 2012). Ambas iniciativas han sido desarrolladas en el marco del proyecto DROUGHT R&SPI. La EDII comenzó a funcionar en 2012 y cuenta ya con más de 6.000 impactos individuales, de más de 4.700 entradas de registro para Europa (Stahl et al., 2015), que clasifica en función de 15 categorías de impactos subdivididas a su vez en numerosos sub-tipos de impactos. A partir de esta información, se han desarrollado varios estudios que exploran su utilidad para predecir impactos o su relación con algunos índices de sequía (Bachmair et al., 2014; Stagge et al., 2015; Blauhut et al., 2015).

2.3.3. Consideraciones para su análisis

De la revisión de la literatura presentada, se puede concluir que es importante:

- Profundizar en las características de los impactos teniendo en cuenta su naturaleza (económica, social y ambiental) pero también si son directos, indirectos o intangibles. También es esencial conocer cómo afectan a cada sector.
- Mejorar el conocimiento sobre la cadena causal de impactos para todos los sectores, especialmente para aquellos a los que tradicionalmente se les ha prestado menos atención.
- Identificar su escala temporal y geográfica de la manera más precisa que sea posible.
- Distinguir entre impactos de las medidas de gestión e impactos de la sequía.
- Mejorar la transparencia y comparabilidad de las metodologías de evaluación de los impactos de la sequía.
- Mejorar y aumentar el registro sistemático de los impactos de la sequía para promover el uso de este tipo de información y permitir comparaciones más rigurosas entre casos de estudio o regiones.

En esta tesis se aborda el análisis de los impactos de la sequía profundizando en el proceso de registro de los impactos de la sequía para alimentar la EDII existente a nivel europeo.

[29] EDR - European Drought Reference, www.geo.uio.no/edc/droughtdb/
[30] EDII - European Drought Impact Report Inventory

2.4. La vulnerabilidad

La vulnerabilidad ha sido una cuestión de interés y estudio de diferentes disciplinas o campos de investigación (Janssen & Ostrom, 2006; Füssel, 2007), por ejemplo, el cambio climático, el riesgo a desastres, la ecología, la sostenibilidad o las ciencias sociales, por lo que cada una de ellas ha descrito y adaptado su significado de diferentes maneras, y esto ha hecho que se haya desarrollado, a veces en paralelo (Füssel, 2007).

De acuerdo con Birkmann (2006), se pueden encontrar más de 25 definiciones diferentes en la literatura. Esta diversidad da cuenta de su complejidad y es una fuente de confusión para su estudio (Ionescu et al., 2009; Wolf, 2012, Costa & Kropp, 2013). Algunos autores (Füssel, 2007; Wolf, 2012) incluso lo consideran un término casi inútil si no viene acompañado de especificaciones adicionales que traten de delimitar el concepto de vulnerabilidad: de qué (sistema), a qué estimulo (evento), y cuál es la relación entre ambos (Ionescu et al., 2009). Recientemente han aparecido varios estudios que tratan de entender las diferentes perspectivas planteadas desde el cambio climático y la reducción de riesgo a desastres y converger hacia una conceptualización común para ambas disciplinas (Wolf, 2012; IPCC, 2012; Costa & Kropp, 2013; Birkmann et al., 2013).

En términos generales, existe cierto consenso en que la **vulnerabilidad** muestra el grado de susceptibilidad de una sociedad a un peligro determinado y su capacidad para afrontar el impacto que produce (Janssen & Ostrom, 2006), es decir, que puede variar tanto como resultado de la exposición al evento como por las capacidades para afrontarlo (Wilhelmi & Wilhite, 2002; Kundzewicz et al., 2007)

2.4.1. Características y componentes de la vulnerabilidad

La vulnerabilidad es un concepto de construcción social (Birkmann et al., 2013), es decir, es una idea o artefacto que se crea para ayudar a darle significado a la realidad para entenderla, pero que no se relaciona con algo tangible o material. Según Cardona (2003), se trata de la manifestación más palpable de la construcción social del riesgo.

Se caracteriza por su naturaleza transversal y multidimensional – social, natural, económica, física, institucional, etc, ya que afecta a diferentes sectores de la sociedad, de diferente manera y en diferentes momentos. Algunos autores incluyen además una dimensión psicológica (Alcamo et al., 2008; Zarafshani et al., 2012).

Es una condición específica de un determinado contexto (Cutter, 1996; Brooks et al., 2005) más que una condición genérica, ya que viene determinada por la combinación de factores subyacentes que se manifiestan a nivel local y varían dependiendo de los grupos sociales a los que afecta (IPCC, 2001, 2007; Birkmann, 2006; Soares et al., 2012).

Es multi-escalar y dependiente de la escala (Turner et al., 2003; Adger, 2006; Birkmann, 2006; Fekete et al., 2010). Las conexiones entre las diferentes dimensiones y elementos operan a diferentes escalas espacio-temporales y generalmente incluyen relaciones y procesos aleatorios o no lineares (Turner et al., 2003).

Es un concepto de naturaleza dinámica, tanto temporal como espacialmente (Cutter, 1996; Downing & Bakker, 2000; Wilhelmi & Wilhite, 2002; Birkmann, 2006; Wilhite et al., 2007; Cutter et al., 2008; Birkmann et al., 2013), marcada por la ocurrencia y evolución de los eventos de sequía, y por las características del contexto socio cultural, económico, institucional y ambiental, que también se van modificando a lo largo del tiempo.

La vulnerabilidad siempre va unida a un evento, estímulo, perturbación o factor de estrés (Füssel, 2007; Wolf, 2012) y tiene cierto carácter predictivo al referirse a los impactos potenciales o futuros de dicho evento, independientemente de que estos vayan a ocurrir o no después (Adger, 2006; Hinkel, 2011; Wolf, 2012).

Para profundizar en la comprensión y conocimiento de la vulnerabilidad es necesario indagar en cuáles son sus causas y las relaciones causa-efectos que aparecen con los impactos. Knutson et al., (1998) plantean partir de los impactos registrados para analizar sus causas, entendidas como factores de vulnerabilidad.

Para facilitar su análisis, en general la vulnerabilidad se estudia en base a los componentes que la conforman. Algunos autores distinguen entre vulnerabilidad **biofísica o natural** y vulnerabilidad **social o socioeconómica** (Birkmann, 2006; Füssel, 2007; Cutter et al., 2008; Kuhlicke et al., 2011).

Birkman (2007) apunta a dos formas dominantes de describir la vulnerabilidad. La primera y más intuitiva se basa en identificar sus elementos principales y clasificarlos en función de su naturaleza, refiriéndose a factores **naturales o ambientales, sociales, económicos, político-institucionales o técnicos**. Una segunda opción es describir la vulnerabilidad en relación a tres componentes principales: **Exposición, Sensibilidad y Capacidad de Adaptación** (IPCC, 2001, 2007, 2012; Adger, 2006; Cutter et al., 2008; Ionescu et al., 2009; Fontaine & Steinemann, 2009; Costa & Kropp, 2013). Esta es una forma bastante extendida en la literatura. Al igual que para la definición y concepto de vulnerabilidad, también existen diferentes formas para definir estos conceptos, y cierta dificultad para delimitar las fronteras de cada concepto. Por tanto, es necesario entenderlas desde las dos perspectivas dominantes para evitar incosistencias conceptuales y un uso inapropiado (Tabla 7).

Tabla 7. Diferencias desde la perspectiva del riesgo y del cambio climático

Concepto	Perspectiva de Reducción del Riesgo a Desastres	Perspectiva de Cambio Climático
Vulnerabilidad	Las características y circunstancias de una comunidad, sistema o bien que lo hacen susceptibles a los efectos dañinos de una amenaza.	Cuando un sistema susceptible es incapaz de hacer frente a los efectos adversos del cambio climático, incluyendo la variabilidad y los extremos climáticos. Es una función del carácter, magnitud y tasa de variación climática a la que está expuesto un sistema, su sensibilidad y su capacidad de adaptación
Amenaza (‘Hazard’)	Principalmente percibido como un factor externo a la vulnerabilidad y por tanto no incluído en su medición	Incluído dentro de la vulnerabilidad, normalmente dentro de Exposición
Exposición	Activos expuestos; elementos en riesgo (personas, infraestructura, bienes, actividades económicas, etc.) presentes en la zona de riesgo, que por tanto están sujetos a pérdidas potenciales. Se podría considerar como la vulnerabilidad externa	La presencia de la gente, medios de vida, servicios y recursos ambientales, infraestructura, o activos económicos, sociales o culturales en lugares que podrían ser afectados adversamente. También relacionada con la magnitud y la frecuencia de riesgo potencial.

Concepto	Perspectiva de Reducción del Riesgo a Desastres	Perspectiva de Cambio Climático
Sensibilidad	Condiciones o estado del sistema que condiciona el grado y tipo de impactos del evento. Algunos modelos la entienden como la propia vulnerabilidad. Se utilizan otros términos como sinónimos: fragilidad o susceptibilidad	Grado de modificación o perturbación del sistema causado por el evento debido a la falta de la resistencia y la predisposición de la sociedad y los ecosistemas sufran daños.
Capacidad de Adaptación	Se refiere al aumento de capacidades, entendidas como la combinación de todas las fortalezas, los atributos y los recursos disponibles dentro de una comunidad, sociedad u organización que pueden ser utilizados para lograr los objetivos acordados. Utiliza el concpeto de 'coping capacity' para referirse a la capacidad de afontar, gestionar condiciones adversas, emergencias o desastres naturales.	Se refiere a la capacidad de un sistema o individuo a adaptarse al cambio climático. Es la habilidad del sistema para evolucionar y ajustarse al cambio producido por un evento natural o cambios políticos, moderar sus efectos y hacer frente a esa perturbación

Fuente: Elaboración propia basada en IPCC (2001, 2007, 2012) y UNISDR (2007, 2009b)

2.4.2. Marcos de análisis de la vulnerabilidad

El estudio de la vulnerabilidad ha dado lugar al desarrollo de diversos modelos conceptuales para identificar y analizar sus componentes o elementos principales y describir cómo y se relacionan entre ellos. Estos se han desarrollado desde diferentes enfoques epistemológicos tanto de las ciencias naturales como de las ciencias sociales.

Existen algunos trabajos enfocados a realizar una revisión sistemática de las conceptualizaciones y modelos de vulnerabilidad, entre las que cabe destacar Birkmann (2006), Adger (2006), Eakin & Leurs (2006), Gallopín (2006); Füssel (2007), Hufschmidt (2011), Soares et al. (2012); Costa & Kropp (2013). Estos esfuerzos de síntesis ponen de manifiesto las dificultades encontradas para su clasificación (Tabla 8).

Tabla 8. Enfoques y modelos conceptuales para el análisis de la vulnerabilidad

PERSPECTIVA	PARADIGMA	ENFOQUE	EJEMPLO MODELOS
Biofísica	**Comunidad de gestión del riesgo**	*Puramente deterministas; Perspectiva tecnocrática*	(1) 'Vulnerability within the context of hazard and risk' (Davidson, 1997) (2) 'UNISDR framework for disaster risk reduction' (UNISDR, 2004)
Social	**Paradigma estructuralista**	*Política económica*	(3) 'PAR Model' (Blaikie et al., 1994; Wisner et al., 2003;)
		Desarrollo y sostenibidad	(4) 'The Sustainable Livelihood Framework' (DFID, 1999) (5) 'Double structure of vulnerability' (Bohle, 2001)
	Escuela de Ecología Humana	*Ecología humana o enfoque socioecológico*	(6) 'Vulnerability in the context of global environmental change community' (Turner et al., 2003) (7) 'The DROP Model /'Hazard of place' Model' (Cutter, 2003)
Integral	**Enfoque integral**	*Vulnerabilidad y riesgo a desastres desde un enfoque holítico*	(8) 'The 'onion framework' (Bogardi & Birkmann, 2004) (9) 'The 'BBC conceptual' framework' (Birkmannn, 2006) (10) 'MOVE Framework' (Brikman et al., 2013)

Fuente: Elaboración propia, basada en Birkmann (2006), Hufschmidt (2011), Soares et al. (2012); Costa & Kropp (2013).

Los modelos conceptuales suelen ofrecer pocas indicaciones sobre los métodos a emplear para su aplicación y qué modelo es mejor utilizar en cada situación (Hinkel, 2011), ya que en ocasiones resultan vagos y poco intuitivos.

Birkmann (2006) encuentra paradójicos los intentos de medir la vulnerabilidad desde una perspectiva científica, si apenas somos capaces de definirla y conceptualizarla. Esto en parte es porque se trata de un concepto teórico y no un fenómeno observable (Hinkel, 2011). Luers et al. (2005) afirman que la definición de criterios para la cuantificación de la vulnerabilidad es difícil, ya que la vulnerabilidad no es un fenómeno directamente observable.

Según Kossida et al. (2012), existen principalmente tres enfoques metodológicos para desarrollar un análisis de vulnerabilidad:

(a) Perfiles de vulnerabilidad

(b) Índice de vulnerabilidad

(c) Modelos de simulación multi-criterio

El desarrollo de **Perfiles de vulnerabilidad** es una herramienta muy útil para entender el riesgo y guiar la planificación de la prevención y planificación de la sequía (UNISDR, 2005). Consiste en desarrollar un marco formal que asegure la representación de la vulnerabilidad de manera sistemática considerando de manera concreta (a) la entidad o sistema vulnerable, (b) el estímulo al que se es vulnerable y (c) las relaciones entre la entidad y estímulo (Kossida et al., 2012). Este ha sido el enfoque utilizado en el proyecto europeo NeWater para el desarrollo de un Protocolo Rápido de Evaluación de la Vulnerabilidad[31] (Downing & Bharwani, 2006). También se relaciona con diagnósticos más participativas que utilizan métodos principalmente cualitativos y que se dirigen a describir la vulnerabilidad más que cuantificarla (e.g. Fontaine & Steinemann, 2009).

Los **Índices de vulnerabilidad** se construyen a partir de un conjunto de indicadores de vulnerabilidad. Según Hinkel (2011) estos puede ser de tres tipos principalmente: *deductivos* (basados en la teoría), *inductivos* (basados en datos disponibles u observaciones) y *normativos* (basados en juicios de valor). Los indicadores de vulnerabilidad utilizados son variados y se suelen basar en los datos cuantitativos disponibles de fuentes secundarias (estadísticas oficiales gubernamentales o de instituciones), sobre todo en estudios a escala global o regional (Naumann et al., 2013; De Stefano et al., 2015). Este enfoque, si bien es común en la literatura, es criticado por las limitaciones de datos que encuentra y la simplificación excesiva, en algunos casos, de la realidad que pretende medir.

Los **Modelos de simulación multicriterio** consideran un conjunto de variables entre las que de incluyen variables tanto biofísicas como socioeconómicas, para las que aplican diferentes ponderaciones. Este enfoque ha sido utilizado por el DMCSEE, dirigido a calcular la vulnerabilidad a la sequía a nivel nacional en varios países del sureste de Europa, por ejemplo Hungría (Popova et al., 2012).

En la práctica, la explicación de la metodología utilizada para evaluar la vulnerabilidad

[31] BRAVA - Baseline Rapid Vulnerability Assessment, www.newater.uni-osnabrueck.de

a menudo es escasa o poco transparente. Para aumentar el potencial de comparación entre casos sería necesario que se especifiquen las decisiones tomadas acerca de la metodología y del proceso de investigación (Hinkel, 2011).

La mayoría de los estudios de vulnerabilidad son de carácter local (e.g. Wilhelmi & Wilhite, 2002; Fontaine & Steinemann, 2009; Gbetibouo & Ringler, 2009), ya sea a nivel de comunidad o escala regional. A nivel nacional también existen algunos estudios importantes (e.g. Erian et al., 2011; UNEP, 2013) mientras que a nivel continental o global hay pocas experiencias (e.g. Eriyagama et al., 2009; Iglesias & Garrote, 2012; Naumann et al., 2013).

2.4.3. Consideraciones para su análisis

Hay algunos aspectos sobre los que es necesario reflexionar a la hora de plantear el análisis de la vulnerabilidad:

- Al igual que para la sequía, la vulnerabilidad no es un concepto universal ni estático y su definición es compleja.
- Existe un mayor desarrollo y consenso a nivel conceptual que a nivel operativo o metodológico sobre cómo medirla.
- Es preciso definir de forma clara el sistema que estamos considerando como vulnerable y las características del evento al que somos vulnerables.
- Es necesario tener en cuenta cierto nivel de incertidumbre sobre la vulnerabilidad, ya que la vulnerabilidad siempre indica una potencialidad a futuro que está sujeta a las características concretas de cada evento de sequía.
- Los factores de vulnerabilidad o componentes en los que se descomponga la misma deben ser concretos y especificar la manera en la que contribuyen a aumentar o disminuir la vulnerabilidad. Esto es porque el efecto que tienen sobre la vulnerabilidad no es siempre claro y unívoco, ya que un mismo factor tiene un efecto distinto sobre la vulnerabilidad dependiendo de las circunstancias y los sectores considerados.
- Se necesitan datos de numerosas variables y a diferentes escalas espacio-temporales que no siempre se encuentran disponibles o accesibles.

A partir de esta revisión bibliográfica sobre vulnerabilidad a la sequía se plantea la necesidad de indagar sobre las características y tendencias de las evaluaciones dirigidas a medir de forma cuantitativa la vulnerabilidad a la sequía, cuyos resultados forman parte de uno de los cinco artículos que componen esta tesis.

2.5. La implementación y gestión de la sequía: instrumentos y medidas

Las políticas de gestión de la sequía se implementan a través de un conjunto muy amplio de medidas. Esto es común a la formulación de cualquier política, pero es especialmente evidente en el caso de las políticas ambientales y, en concreto, en la gestión de la sequía. Así muchas de las formas de intervención pueden pertenecer a una política determinada o provenir de políticas afines, relacionadas o complementarias. Esto conlleva la ausencia de una delimitación precisa de los límites de la propia política de sequía.

Esta característica, muy frecuente en el campo ambiental, incrementa sustancialmente las posibilidades de actuación, al tiempo que dificulta las posibilidades de una clasificación concreta y operativa de las medidas de gestión. Al mismo tiempo y dado que una medida determinada puede no haberse diseñado específicamente para la gestión de la sequía, el abanico de potenciales medidas se incrementa también de forma relevante.

2.5.1. Tipos de medidas de gestión de la sequía

El análisis de la gestión de las sequías, especialmente si se desea evaluar el enfoque adoptado, requiere una clasificación de las medidas de acuerdo a sus características fundamentales. En este sentido, procede dividir las clasificaciones propuestas por la literatura en dos grandes grupos: (a) Genéricas y (b) Específicas. En el presente trabajo nos centraremos en este segundo grupo, pero a continuación se describen, de forma breve y sin ánimo de ser exhaustivos, algunas de las principales medidas de cada grupo.

A. Genéricas

Este primer conjunto procede de los campos de la planificación y la teoría política, que establecen categorías genéricas, y por lo tanto aplicables a cualquier política.

Una de las formas más extendida de clasificación genérica procede del campo de la planificación y formulación de políticas. Sigue un *ciclo de formulación teórico* (‘policy cycle framework’, Jann & Wegrich, 2006), a lo largo del cual, los objetivos de la política se van volviendo explícitos y las intervenciones se van concretando presupuestaria, espacial y temporalmente. Los instrumentos que desarrollan las políticas siguen una secuencia jerárquica que los clasifica en normas, estrategias, planes, programas y medidas concretas.

Otras clasificaciones se basan en el *mecanismo de intervención*. Un ejemplo es la clasificación propuesta por Vedung (1997), que clasifica las medidas de gestión como *regulatorias* (normas, prohibiciones, permisos, etc.), *económicas* (inversión directa, ayudas y subvenciones, impuestos, tasas, mecanismos financieros, etc), *informativas* (campañas de sensibilización, educación) y *organizacionales* (creación de instituciones, grupos de trabajo, instituciones).

B. Específicas

Este segundo grupo es específico del contexto de la sequía, por lo que es más relevante en el presente trabajo.

Este tipo de clasificaciones son muy variadas porque en la mayoría de los casos se realizan *ad hoc* para ajustarse al contexto de desarrollo de la política.

En base a la revisión de la literatura específica de la gestión de las sequías y su planificación, se han identificado **ocho formas principales de clasificar las medidas** en función del uso de diferentes criterios.

(i) Según las fases de actuación y enfoque (e.g. FAO & NDMC, 2008; UNISDR, 2009b)

- *Preparación*: Se trata de medidas adoptadas antes de la sequía para mejorar las capacidades institucionales, y establecer herramientas para predecir y monitorear el evento y sus impactos, y garantizar una respuesta coordinada y efectiva.
- *Mitigación*. Incluye las medidas orientadas a evitar o limitar los efectos adversos de la sequía, incluyendo medidas estructurales y no estructurales.
- *Respuesta*. Se trata de los esfuerzos de gestión que tienen lugar durante o inmediatamente después de una sequía para paliar sus consecuencias.
- *Recuperación*. Son las decisiones y acciones tomadas después de una sequía, con miras a restablecer o mejorar las condiciones de vida de la comunidad afectada anteriores a la sequía.

(ii) Según el nivel de formulación (e.g. Dziegielewski et al., 1997; MMA/CHJ, 2007; Ferrer Polo & Mondéjar, 2015)

- Las medidas *estratégicas* son actuaciones a largo plazo que forman parte de la planificación hidrológica (e.g. estructuras de almacenamiento y regulación, normativa y ordenación de usos). A menudo tienen plazos de implementación largos y altos presupuestos. Además, suelen necesitar negociación política, aceptación social y modificaciones legislativas.
- Las medidas *tácticas* son actuaciones a corto plazo planificadas y validadas con anticipación, normalmente en el marco de un plan de gestión de la sequía. Este tipo de medidas han sido estudiadas sobre situaciones históricas y se adoptan una vez constatada la situación de sequía mediante el sistema de indicadores.
- Las medidas de *emergencia* se adoptan bien avanzada la sequía y varían en función de la gravedad de la misma y su extensión o grado de afección a la cuenca. Se caracterizan por su inmediatez y urgencia.

(iii) Según los objetivos o estrategia en relación con la planificación y gestión del agua (e.g. MEDROPLAN, 2007; Rossi & Cancilliere, 2013; Karavatis et al., 2014).

- *Reducción de la demanda*. Aquellas medidas dirigidas a reducir el uso de los recursos, ya sea fomentando el ahorro, evitando pérdidas o promoviendo un uso más eficiente (e.g. incentivos económicos para el ahorro, técnicas de riego más eficientes).
- *Aumento de la oferta*. Aquellas acciones encaminadas a aumentar los recursos hídricos disponibles a través de la construcción de infraestructuras de almacenamiento o incorporación de nuevos recursos (e.g. aumento de la reutilización, desalación, trasvases).

- *Reducción de los impactos*. Acciones dirigidas a minimizar los impactos, por ejemplo a través de actividades educativas y de sensibilización, programas de seguros y ayudas públicas. Se refiere tanto a las medidas que van dirigidas a prevenir los efectos negativos de la sequía como las que se destinan a reducirlos una vez ya han ocurrido.

(iv) Según la naturaleza de las medidas (e.g. Rossi et al., 2007; UNISDR, 2009b)

- *Estructurales*. La construcción de infraestructuras para reducir o evitar los posibles impactos de las amenazas, o la aplicación de técnicas de ingeniería para lograr incrementar la resiliencia de las estructuras o de los sistemas frente a las amenazas.
- *No estructurales*. Cualquier medida que no suponga la construcción de infraestructuras y que utiliza el conocimiento, las prácticas o los acuerdos existentes para reducir el riesgo y sus impactos, especialmente a través de políticas y leyes, una mayor concientización pública, la capacitación y la educación.

(v) Según su temporalidad o duración (e.g. MEDROPLAN, 2007; Rossi & Cancilliere, 2013)

- Las medidas a *largo plazo* son aquellas que se implementan antes del evento y que se dirigen a prevenir sus impactos. Generalmente se orientan a mejorar los sistemas de abastecimiento de agua para satisfacer las demandas futuras en condiciones de sequía.
- Las medidas a *corto plazo* se dirigen a mitigar los impactos de una sequía en particular con el marco de gestión e infraestructuras existente en ese momento y en base a una planificación previa.

(vi) Según el sistema o sector al que van dirigidas (e.g. MEDROPLAN, 2007, Strosser et al., 2012)

Estos sistemas incluyen, por ejemplo: *abastecimiento, agricultura, energía, industria, medioambiente, navegación y turismo*.

(vii) Según el tipo de organismo gestor (e.g. MEDROPLAN, 2007)

- Las medidas se consideran *públicas* cuando son iniciadas e implementadas por el gobierno o la administración a cualquier nivel. Estas son el resultado de una decisión política dirigida a atender las necesidades de la población.
- Las medidas son *privadas* cuando son iniciadas e implementadas por individuos, organizaciones o empresas.
- Las medidas *mixtas* son aquellas en las que participan tanto las administraciones públicas como los agentes privados, por ejemplo, a través de la implementación de programas educativos financiados con fundos públicos pero ejecutados por entidades privadas.

(viii) Según su nivel de importancia (Benítez Sanz & Schmidt, 2012; CLIMAWATADAPT; EC, 2012)

- *Medidas* ('measures'). Se refieren a las medidas técnicas, de infraestructuras verdes y de manejo del uso del suelo que se dirigen al ahorro de agua y de los impactos de las sequías.
- *Medidas complementarias o de apoyo* ('support actions'). Se refieren a las medidas de control administrativo, instrumentos financieros, regulaciones, planes de manejo, iniciativas voluntarias y actividades educativas como la investigación y la sensibilización, que apoyan la implementación de las 'medidas'.

En esta tesis se ha definido una clasificación que combina las clasificaciones (i), (ii) y (iii), ya que ninguna de las opciones individuales satisfacía del todo las necesidades de una definición amplia pero operativa. Las clases de esta nueva clasificación quedan definidas de la siguiente forma:

- Preventivas/Estratégicas
- Operativas/Respuesta/Tácticas
- De recuperación
- Organizativas o de gestión

En cada categoría se ha tratado de agrupar bajo un mismo epígrafe aquellos términos que se consideran conceptos muy similares. Es común relacionar las actuaciones estratégicas con medidas de tipo preventivo, y las tácticas u operativas con mediadas de respuesta. Las medidas de respuesta se separan de las tácticas u operativas e, igualmente, las medidas organizativas de las de carácter estratégico para convertirse en una categoría diferente porque se pretende resaltar su importancia y su propósito específico, dado que se considera que las medidas organizativas se dirigen a apoyar la implementación del resto de medidas más que a reducir los impactos de la sequía.

Es importante señalar que, el sistema combinado planteado coincide en gran medida y es compatible con el análisis de los planes de sequía españoles, que utilizan el sistema de clasificación (ii).

Algunos autores también utilizan combinaciones es estas clasificaciones puesto que esto permite obtener mayor información sobre las características de las propias medidas y del enfoque de gestión implementado. Por ejemplo, MEDROPLAN (2007), primero divide las medidas según su temporalidad/duración (v) y luego según su objetivo (iii), dentro del cual distingue entre los sistemas afectados (vi).

Además de la revisión de la literatura mencionada, se han identificado y clasificado, las medidas contenidas en todos lo estudios de caso considerados en esta tesis, dando lugar al listado de medidas de la Tabla 9. Este listado no pretende ser exhaustivo pero si reflejar el conjunto de potenciales medidas de sequía.

Tabla 9. Tipología de medidas de sequía

MEDIDAS ESTRATÉGICAS (o de planificación o preventivas)
Desarrollo de PES/PE/PC y otros planes Elaboración de estudios, investigaciones y proyectos piloto (inventario y seguimiento de estado de los recursos y ecosistemas) Desarrollo de sistemas de información sobre la sequía (SAT(EWS&M, observatorios, etc) Definición de prioridades de uso del agua Seguimiento y monitoreo de las medidas/resultados/planes…
MEDIDAS TÁCTICAS (u operativas)
Gestión de la demanda
Mejorar la eficiencia del uso del agua Gestión de derechos, bancos y mercados de agua Reducir las pérdidas de distribución y fugas Promover el ahorro en diferentes sectores Regulaciones de uso (prioridades, limitaciones, restricciones)
Gestión de la oferta
Conservación de los recursos Mejora de la recarga y almacenamiento natural Mejora de la eficiencia de las instraestructuras Manejo de las extracciones de los acuíferos Promoción de la recolección de agua de lluvia Aumento de la reutilización de aguas recicladas Establecimiento de plantas desalinizadoras Recarga artificial de acuíferos Transvases de recursos (internos, externos)
Educación y Sensibilización
Campañas de concienciación Educación, sensibilización y capacitación para el ahorro
Ambientales
Protección y restauración de ecosistemas
MEDIDAS DE RECUPERACIÓN
Esquemas de compensación (seguros, subsidios, credits) Restauración de ecosistemas
MEDIDAS ORGANIZATIVAS (o de gestión)
Medidas Económicas
Desarrollo de incentivos económicos y fiscales Precio del agua
Medidas Administrativas
Medidas de gestión administrativa Medidas legales Control y penalización
Promoción de la participación
Promover la participación pública en los procesos de planificación Resolución de conflictos de uso del agua
Medidas complementarias
Promover medidas agro-ambientales Promover la planificación territorial y uso sostenible del suelo Limites al desarrollo urbano Investigación y transferencia tecnológica, Distribuir información meteorologica a tiempo real Mejorar la protección ambiental Promover y asegurar la seguridad de determinados usos (navegación, transporte) Prevenir efectos sobre la salud

Fuente: Elaboración propia.

La adecuación de cada medida para reducir los impactos de la sequía depende de las condiciones del contexto local y de los objetivos perseguidos en cada caso. Sin embargo, es necesario tener en cuenta que las medidas de mitigación y adaptación se consideran complementarias y que por tanto, lo importante es contar con un conjunto de medidas que aseguren una efectiva distribución del riesgo y sinergias entre ellas (Logar & van den Bergh, 2013).

La información sobre las medidas individuales puestas en marcha para la gestión de una sequía suele estar dispersa, ser incompleta y no estar disponible, lo cual plantea importantes limitaciones para su estudio. En general no se conocen bien ni sus características, ni su grado de contribución a la reducción de los impactos de la sequía. Strosser et al. (2012) identifican esta situación como una "laguna de información y evaluación" (p. 50), con repercusiones para la gestión de la sequía en Europa. Estos mismos autores, además, apuntan a que esto se debe a que se necesita para su análisis una importante cantidad de información, no solo sobre las medidas, si no también sobre las características de la sequía y sus causas.

Los estudios que analizan algunas de las medidas contempladas en la Tabla 9 no suelen abordar de manera específica cómo éstas contribuyen a reducir los impactos de la sequía, como ocurre en diversos casos como en los estudios de modernización de regadíos (e.g. Soto-García et al., 2013; Gómez Gómez & Pérez Blanco, 2014), reutilización (e.g. Lazarova et al., 2001; Bixio et al., 2006), trasvases (e.g. López Ortiz & Melgarejo Moreno, 2010; Hernández-Mora et al., 2013), y mercados de agua (e.g. Hernández-Mora & Del Moral, 2015).

Sin embargo se han realizado esfuerzos para entender el papel de una determinada medida respecto a la gestión de la sequía, como por ejemplo el estudio sobre el uso conjunto de los recursos hídricos desarrollado por Daneshmand et al. (2014) y el análisis crítico sobre el uso de la desalación en España publicado recientemente por March et al. (2014).

Los planes de sequía han sido promovidos como un instrumento estratégico para adoptar el enfoque de riesgo en la gestión de la sequía. Estos pueden tener diferentes características y ser globales o sectoriales (Fu et al., 2013b). En España, los planes de sequía relacionan los niveles de sequía con acciones concretas, en base al monitoreo de la situación y al establecimiento de umbrales para identificar estados de normalidad, pre alerta, alerta, emergencia (EC, 2007c; Estrela & Vargas, 2012). Normalmente se circunscriben a una cuenca o demarcación hidrográfica (e.g. los Planes Especiales de Sequía en España), pero también se pueden encontrar a nivel municipal o de ciudad (e.g. Planes de Emergencia para el abastecimiento en España).

Las primeras experiencias de evaluación de los planes de sequía se han desarrollado en EEUU recientemente (Fu et al., 2013a; Fu et al., 2013b; Fontaine et al., 2014), por lo que todavía es necesario contar con más evidencias sobre su funcionamiento y potencial para evitar y reducir los impactos de la sequía de una manera eficiente y sostenible.

A través de estos ejemplos se pone en evidencia que falta mucho por hacer para avanzar en el análisis y evaluación de las medidas de sequía. Es necesario contar con metodologías claras y transparentes que permitan analizar el impacto de dichas medidas para entender mejor su funcionamiento y eficacia real (Hernández-Mora et al., 2013; Garrido & Rey, 2014).

2.5.2. Implicaciones para su análisis

Las medidas de sequía presentan una serie de particularidades que es importante tener en cuenta y destacar a la hora de analizarlas:

- Se trata de acciones que son relativas a un contexto de aplicación determinado. Esto significa que de por sí no son medidas de sequía, si no que se convierten en tales dependiendo de cuándo y cómo se ejecuten. Otras son medidas de sequía en sí mismas (como por ejemplo los planes de sequía). Por tanto, es esencial identificarlas y analizar su rol durante una sequía.
- Las medidas afectan de manera distinta a los diferentes sectores y, por tanto, se deben analizar desde una perspectiva sectorial.
- Es importante describir las medidas en función de su enfoque, objetivos, tipología, naturaleza, alcance temporal y geográfico, duración, momento de ejecución, público u objetivo al que van destinadas y resultados que esperan alcanzar.
- El alcance temporal y geográfico de las medidas no siempre coincide con el alcance espacio-temporal de la sequía.
- Las medidas de gestión de la sequía operan a diferentes niveles administrativos y operativos, tanto en la toma de decisiones como en la ejecución y en la manifestación de sus efectos. Por tanto, es importante prestar atención a los diferentes niveles de gestión, desde lo local a lo nacional.

Todas estas consideraciones realzan la importancia de identificar de forma clara y concisa cuáles son las medidas de sequía disponibles, cómo funcionan y cómo contribuyen a la mitigación y reducción de los impactos de la sequía.

Se han planteado tres estudios concretos que contribuyen a avanzar en el estudio de las medidas de gestión de la sequía desde diferentes perspectivas. Primero, se analizan las leyes de emergencia a la sequía en España. En segundo lugar, se analiza la respuesta a la sequía desde la perspectiva de los agricultores de regadío de la Demarcación del Júcar. Por último, se estudia la gestión de la sequía en distintos casos de estudio a nivel europeo.

2.6. La evaluacion de la gestión de la sequía

Es importante reflexionar sobre la práctica de la evaluación aplicada a las políticas ambientales antes de revisar las experiencias existentes de evaluación de la gestión de la sequía. Esta revisión de la literatura responde a la necesidad de entender los enfoques, metodologías y técnicas propias de la evaluación de políticas y programas y su relación con la gestión de sequía en cualquiera de sus formas y etapas.

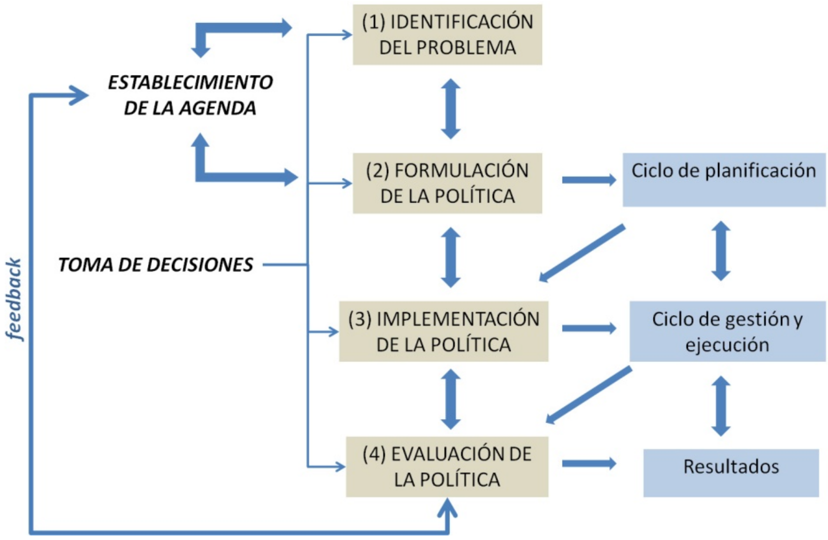
Primero se presentan algunos aspectos conceptuales de la evaluación de las políticas públicas y se describen brevemente y las principales experiencias de evaluación de la gestión de la sequía encontradas. En segundo lugar se presenta un resumen de las principales opciones metodológicas - en cuanto al enfoque, diseño y elementos clave - para la evaluación de la gestión de la sequía.

2.6.1. Aspectos conceptuales de la evaluación de políticas

La **evaluación**, en general, se refiere al proceso de *determinar el mérito o valor de algo*, según Scriven (1991). Se trata de un proceso analítico clave en todas las disciplinas intelectuales y prácticas (Vedung, 1997) y, por tanto, trasciende a cualquier dominio o campo de conocimiento.

Desde la perspectiva del ciclo de la política (‘*policy cycle framework*’), la evaluación se concibe como una etapa del diseño e implementación. De acuerdo Jann & Wegrich (2006) el proceso de evaluación es una de las cuatro fases constitutivas de una política: (i) Establecimiento de la agenda: reconocimiento del problema y selección de temas importantes; (ii) Formulación de la política y toma de decisiones; (iii) Implementación; (iv) Evaluación y terminación (Figura 6).

Figura 6. La evaluación y el ciclo de la política



Fuente: Elaboración propia, adaptado de Vedung (1997) y Jann & Wegrich (2006).

En este contexto y, como sucede en otros campos, el término evaluación es utilizado con distintos significados y matices, reflejando diferentes enfoques y concepciones que afectan desde el plano más conceptual, a aspectos prácticos o tácticos de cómo aborar el proceso. Sin embargo, existe cierto consenso acerca de que el proceso de evaluación implica determinar el valor, en este caso de la política o de cualquiera de sus componentes (proyectos, planes, programas…), de acuerdo a unos criterios explícitos o implícitos.

Los objetivos de la evaluación de una política van desde el interés por la mejora de los resultados concretos de la política o proceso político hasta la rendición de cuentas ante la sociedad o los órganos de supervisión. También puede ser un fin el querer establecer la evaluación como una parte central de la política, a través de decisiones basadas en la evidencia racional (Jann & Wegrich, 2006). La evaluación está relacionada con procesos de aprendizaje que pretende tener implicaciones para los siguientes pasos del proceso político en cuestión. También se puede utilizar para reforzar o dar por terminada la política aunque, en este último caso, pueden mediar otros factores externos que van más allá de los propios resultados de la evaluación (Jann & Wegrich, 2006).

Los diseños y enfoques de evaluación varían de forma notable, dependiendo de la aproximación conceptual y metodológica, las características del proceso y el tipo de política objeto de estudio. Sin embargo, y tal y como reconocen varios autores, *"a pesar de la inclinación hacia el uso de herramientas cuantitativas y diseños experimentales o quasi-experimentales, el problema general de aislar la influencia y los impactos de una determinada medida implementada como resultado de una determinada política, todavía no ha sido resuelto, dadas las numerosas variables que afectan a los resultados de dicha política"* (Jann & Wegrich 2006, p. 54).

Vedung (1997) presenta algunas características del proceso de evaluación de una política que deben ser tenidas en cuenta desde un punto de vista metodológico:

- Perspectiva sistémica: la política, la administración pública y el resto de agentes relacionados conforman un sistema cuyos componentes están interrelacionados y dependen unos de otros. Así, la lógica general de su funcionamiento (en su formato más simplificado) se concibe como la utilización de unos recursos que la administración convierte o transforma en unos productos (outputs) y resultados (outcomes) inmediatos, intermedios o últimos (también llamados impactos).
- Sistema dinámico: el alcance, objetivos, medidas y recursos de la política cambian a lo largo del tiempo (Hanberger, 2001). En un momento dado, las acciones objeto de evaluación pueden encontrarse en proceso de diseño, de ejecución o terminadas (Vedung, 1997).
- El análisis del problema es un elemento central que proporciona la estructura y dirección de la evaluación de la política (Hanberger, 2001).
- La evaluación de políticas va más allá de la evaluación del impacto, ya que en ocasiones no es posible su medición, dado el carácter complejo y sistémico de la sociedad. Otros aspectos como el análisis de la eficacia de las intervenciones, el nivel de consecución de los objetivos o el nivel de eficiencia en el uso de los recursos movilizados son igualmente relevantes.
- Los objetivos de la intervención no son los únicos criterios de valor adecuados y el análisis de dichos criterios requiere de unos niveles mínimos de calidad que vienen determinados por la recolección sistemática de la información y su análisis.

- Tiene que ser útil, ya que la evaluación se presupone una actividad con implicaciones prácticas (Patton, 1986). Sin embargo, Huitema et al. (2011) alertan que demostrar que una evaluación dada tiene (o no tiene) un impacto directo sobre la política es una tarea muy difícil.
- Tiene carácter retrospectivo cuando se centra en el análisis de cómo se ha actuado y cómo se han implementado las acciones o medidas. Esto afecta tanto a las actuaciones planificadas inicialmente, sus modificaciones y a aquellas no previstas que han aparecido con posterioridad. En definitiva es necesario tener en cuenta el carácter dinámico de las políticas así como ser consciente de que el proceso de decisión – implementación – evaluación no es secuencial ni continuo, si no que tiene lugar simultáneamente y a diferentes niveles de gobierno y administración.

La evaluación de políticas difiere de la evaluación de programas. La evaluación de políticas se puede caracterizar por ser más compleja y tener un alcance más amplio, ya que puede abarcar la evaluación de varios programas a la vez. Los programas suelen ser más fáciles de abordar ya que se trata de objetos de evaluación cuyos límites suelen ser mejor conocidos. También suelen estar más estructurados o ser más explícitos si los comparamos con una política. Sin embargo, en la literatura se utilizan frecuentemente como sinónimos ya que a veces la evaluación de una política puede reducirse a la suma de la evaluación independiente de varios programas o simplemente se simplifica su complejidad y se aborda como si fuera un programa. La evaluación de políticas tiene una importancia considerable a pesar de la menor atención que recibe este tema en la literatura sobre evaluación (Mark et al., 2009). Esta situación contrasta con la amplia atención que recibe la evaluación de programas, no solo a nivel teórico sino también en la práctica profesional.

2.6.2. Experiencias de evaluación de la gestión de las sequías

La evaluación de las políticas ambientales se mueve en un ámbito de elevada incertidumbre y de limitaciones en el conocimiento de los problemas (Huitema et al., 2011). Las políticas de gestión de las sequías no son una excepción al respecto.

Para hacer frente a esta realidad cada vez más compleja se necesitan políticas ambientales con dos características importantes: en primer lugar con carácter adaptativo, de tal forma que sean flexibles como para revisarse y recoger la información y conocimiento que se va generando; y en segundo lugar, con carácter prospectivo, de tal forma que sean capaces de preveer y mitigar los impactos en diferentes escenarios futuros.

La evaluación adquiere un papel aún más importante, puesto que es responsable de retroalimentar la implementación de dichas políticas, mejorar el conocimiento acerca de su funcionamiento y evaluar sus resultados en términos de eficacia, eficiencia y reducción de impactos. Bellamy et al. (2001) consideran *la "evaluación como fundamental para identificar cambios y apoyar enfoques adaptativos que sean suficientemente flexibles y que contribuyan al aprendizaje a nivel individual, comunitario, institucional y político"* (p. 408).

A pesar de su creciente importancia y necesidad, la evaluación de políticas y programas ambientales continúa teniendo un desarrollo lento (Mickwitz, 2003) y la literatura al respecto sigue siendo escasa si se compara con la desarrollada para otros campos como puede ser el educativo o el de las intervenciones sociales (Huitema et al., 2011; Knaap & Kim, 1998; Mickwitz & Birnbaum, 2009; Mark et al., 2009).

Así, aunque este tipo de evaluaciones presentan actualmente una creciente atención (Mickwitz, 2003; Gysen et al., 2006; Huitema et al., 2011), todavía existen limitadas experiencias de su aplicación concreta (Mickwitz, 2003).

El creciente interés por el desarrollo de la evaluación en este contexto se refleja en el desarrollo de algunas guías y manuales de evaluación[32] o en la obligatoriedad de realizar evaluaciones en determinadas políticas o programas, como por ejemplo, los Fondos Estructurales y Política de Cohesión de la Unión Europea. En Europa destacan las experiencias sobre evaluación de carácter ex post sobre fondos estructurales (e.g. Ekins & Medhurst, 2006), medidas agroambientales (e.g. Zalidis et al., 2004) o la reciente experiencia de evaluación de la política de aguas conocida como “*Blueprint to Safeguard Europe's Water*” (EC, 2012).

En el marco de estudio del ‘Blueprint’ se ha analizado cómo se incluye la sequía en la DMA. Se ha realizado un análisis de las deficiencias (‘gap analysis’) de la política de sequía y escasez (Strosser et al., 2012) que se centra en el análisis de las medidas y su relación con los siete opciones políticas contempladas en la Comunicación sobre Sequía y Escasez de la EU (EC, 2007a), y además de los informes de seguimiento de la WS&D Com (EC, 2007b), también se han analizado de forma general los planes de sequía (Benítez Sanz & Schmidt, 2012) y las medidas de sequía contempladas dentro de los planes de demarcación (Schmidt & Benítez Sanz, 2012). Se trata de la primera evaluación de la política de sequía a este nivel y refleja un gran esfuerzo de recopilación de información que sirve de punto de partida para futuros análisis.

En España, las principales referencias encontradas están relacionadas con el trabajo de la Agencia Estatal de Evaluación de las Políticas Públicas y la Calidad de los Servicios – AEVAL[33]. La AEVAL es un organismo público que tiene como misión la promoción y realización de evaluaciones y análisis de impacto de las políticas y programas públicos, así como el impulso de la gestión de la calidad de los servicios, favoreciendo el uso racional de los recursos y la rendición de cuentas a la ciudadanía. Desde su constitución en 2007, AEVAL ha desarrollado alrededor de 37 evaluaciones de programas y políticas públicas, previa aprobación por el Consejo de Ministros con base anual. Entre ellas, destacan cinco que abordan diferentes aspectos relacionados con el medio ambiente. Estas constituyen los principales ejemplos de evaluación de políticas públicas medioambientales en España y son:

- Evaluación de la Gestión y Funcionamiento de las Confederaciones Hidrográficas (2009)
- Evaluación de la Gestión y Funcionamiento de las Demarcaciones de Costas para la Protección del Dominio Público Marítimo-Terrestre (2010)
- Evaluación del Plan Español de Energías Renovables 2005-2010 (2010)

[32] Evalsed. Evaluation of socioeconomic development. The Sourcebook. Comisión Europea (2009). el Manual de evaluación de Europaid, entre otras.
[33] www.aeval.es

- Evaluación de las acciones financiadas con cargo a los presupuestos generales del Estado en las áreas de influencia socioeconómica de la Red de Parques Nacionales (2008)
- Evaluación del Programa Nacional de Reformas de España (2007)

De estos trabajos, la "*Evaluación de la Gestión y Funcionamiento de las Confederaciones Hidrográficas*" se centra en las Demarcaciones del Segura y del Guadiana. Si bien arroja interesantes conclusiones sobre el funcionamiento y la eficacia en el cumplimiento e implementación de la DMA, no aborda los aspectos relativos a la sequía, ya que estos no se consideran prioritarios a la hora de diseñar la evaluación. A pesar de esto, la recolección de datos realizada para la evaluación y sus resultados han inspirado algunos aspectos metodológicos de esta tesis.

Para el caso concreto de las políticas de gestión de las sequías, apenas se han encontrado referencias de evaluación desde una perspectiva de análisis político. La mayoría de los estudios encontrados se centran en evaluar o analizar aspectos biofísicos o climatológicos relacionados con el fenómeno de la sequía, mientras que los estudios del componente socioeconómico y cultural de la sequía son muy escasos. Aunque existen pocos marcos de evaluación de la política de sequía, sí existen experiencias de evaluación relacionadas.

El análisis económico del riesgo a la sequía en España (Gil et al., 2011) aplicado a zonas de regadío ha resultado ser útil como herramienta de análisis ex ante de los impactos enfocado a la toma de decisiones. El desarrollo de un "Índice Económico de Gestión de la Sequía" ('Economic Drought Management Index') (Iglesias et al., 2007), permite analizar el desempeño de las instituciones del agua en situación de incertidumbre. Otros estudios encontrados se centran en el análisis de los costes económicos de los impactos en un región concreta (Pérez & Hurlé, 2009; Hernández-Mora et al., 2013) o en medidas concretas como las campañas de sensibilización en el área metropolitana de Barcelona (March et al., 2013). Recientemente han surgido una serie de estudios en EEUU que tratan de evaluar la calidad de los planes de sequía a través de análisis del contenido y basadas en criterios pre-establecidos (Fu et al., 2013a; Fu et al., 2013b; Fu & Tang, 2013; Fontaine et al., 2014).

En resumen, hay cierta falta de referencias metodológicas para la evaluación de la gestión de la sequía. Asimismo, también faltan análisis concretos de la gestión de la sequía desde diferentes niveles administrativos o de gestión (nacional, regional, local) y que incluyan la visión de los diferentes stakeholders involucrados (perspectiva oficial, sectorial, usuarios).

En el siguiente apartado se presenta una revisión de los principales enfoques de evaluación de políticas. El objetivo de esta revisión es identificar las decisiones metodológicas que es necesario tomar para diseñar una evaluación de la gestión de la sequía.

2.6.3. Elementos clave para la evaluación de la gestión de la sequía

Perspectiva de la evaluación

A la hora de evaluar, es indispensable situarnos bajo el paraguas de un determinado **paradigma** de evaluación. Por paradigma se entiende el conjunto de creencias, supuestos y principios sobre cómo entendemos la realidad. Es decir, nos posiciona ideológicamente y esto nos marca metodológicamente. Esto se aplica al diseño, desarrollo y e interpretación de los resultados de la evaluación.

Los dos paradigmas principales que han guiado el desarrollo y evolución de la evaluación desde sus comienzos son el Positivista y el Constructivista.

El *paradigma positivista* fue predominante en el estudio de las ciencias sociales durante los años 50 y 60. Se basa en un modelo científico-técnico basado en la racionalidad de la consecución de objetivos de los programas y políticas. Utiliza fundamentalmente métodos estadísticos y, a través de estrategias deductivas, trata de formular leyes causa-efecto que sean generalizables (Vélez Méndez, 2007). Los diseños experimentales, la medición objetiva y el uso de métodos cuantitativos son la única forma de obtener evidencias sobre los logros del programa para muchos de sus defensores, entre los que cabe mencionar a Schuman o Campbell.

El *paradigma constructivista* surge en respuesta a las limitaciones y desconfianzas que fueron suscitando los enfoques positivistas, tratando de incorporar la participación de los stakeholders y de considerar los procesos y el contexto. Unos de los autores de referencia son Guba & Lincoln (1989), quienes acuñan el término de evaluación de cuarta generación, también conocida como evaluación sensible o constructivista. Se toman como punto de partida para la evaluación las percepciones, opiniones o saberes de los diferentes actores afectados o relacionados con el programa, reconociendo la pluralidad de valores e intereses y su importancia para sustentar los juicios de valor de la evaluación. Esto supone reconocer la *"existencia de múltiples realidades no gobernadas por leyes causales predeterminadas, con lo que para aprehenderla es necesario conocer las diferentes visiones que de ella se tiene"* (Vélez Méndez, 2007, p.155).

Varios autores han reflexionado sobre las características e implicaciones de ambas perspectivas (Tabla 10).

Tabla 10. Características de las perspectivas positivista y constructivista

	Visión positivista	**Visión constructivista**
Característica de la política	La política es un medio para alcanzar ciertos objetivos preestablecidos	Carácter autónomo de la política y tendencia a seguir su propio desarrollo
Responsable, ejecutor	El Estado como principal responsable de la implementación de las políticas	Análisis de los discursos y marcos de los diferentes actores, incluyendo la naturaleza del problema
Uso, propósito	Uso instrumental de la evaluación, para determinar si se han alcanzado las metas o no	La evaluación debe ir mas allá de la medición y debe considerar las demandas, preocupaciones y problemas de los actores y no centrarse solo en los objetivos de la política; asociada con el aprendizaje
Principales elementos o acciones	Necesidad de recoger hechos objetivos y describir el funcionamiento del programa	Implica un proceso iterativo de descripción y enjuiciamiento que culmine en proceso de negociación
Principales Criticas	Uso limitado en situaciones complejas; poco crítico con los objetivos pre-establecidos; escasa consideración de efectos secundarios y negativos; limitada participación de los stakeholders	Los procesos deliberativos pueden llegar a ser un bloqueo y prolongarse excesivamente en el tiempo; alcanzar una participación efectiva exige mucho tiempo y recursos; conocimiento subjetivo, no científico

Fuente. Elaboración propia basado en Ballart (1992), Vélez Méndez (2007), Huitema et al. (2011).

Los **propósitos** de la evaluación suelen responder a multitud de intereses pero, en general, se puede distinguir entre el aprendizaje y la rendición de cuentas, aunque en muchos casos ambos propósitos están presentes simultáneamente.

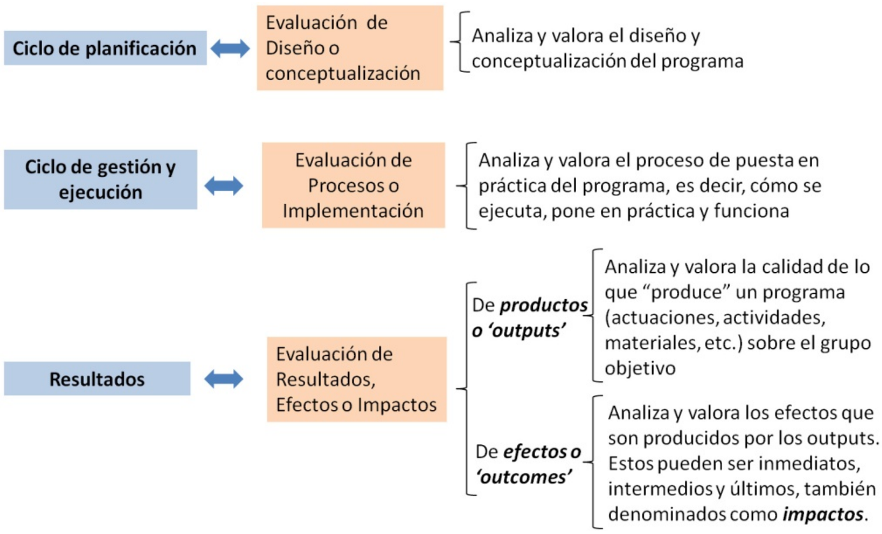
La *mejora del conocimiento y aprendizaje* persigue aumentar el conocimiento que se tiene sobre el funcionamiento del programa y sus resultados. Puede estar centrado en los resultados e impactos del programa, pero también en los procesos de implementación. En muchos casos va orientado a la toma de decisiones sobre cómo mejorar el siguiente ciclo de planificación.

La *rendición de cuentas* está muchas veces vinculada con la implementación de inversiones públicas y la necesidad de determinar su coste y beneficio para la sociedad. Además es clave para aumentar la transparencia y también está ligada al proceso de decisión sobre la continuidad (o no) de un programa.

En el caso de la sequía, parece que el paradigma constructivista facilita la inclusión de las visiones de todos los actores afectados por la sequía. Respecto a su propósito, la necesidad de aprendizaje y mejora prima sobre la rendición de cuentas.

Según el *contenido o fase del programa*, la evaluación se puede clasificar según diversos tipos atendiendo a donde se pone el énfasis (Figura 7).

Figura 7. Esquema tipos de evaluación según la fase del programa



Fuente. Elaboración propia

Las *evaluaciones de diseño* suelen estar destinadas a analizar las características del programa o política en relación al problema que pretenden abordar y se suele realizar en base a criterios de adecuación, coherencia y relevancia. Se trata de analizar si lo que se propone se ajusta a las necesidades derivadas del problema al que se pretende dar solución. Este tipo de evaluaciones presenta un interesante potencial en el marco de la gestión de la sequía, porque, como la definición de la sequía no es única, es necesario tener claro cómo se percibe y define el problema.

La *evaluación de procesos o implementación* se centra en analizar los procesos y mecanismos que se ponen en marcha para la consecución de los resultados. Esto implica analizar cómo se gestiona o administra el programa en el tiempo y en el espacio. Este tipo de evaluaciones ayuda a entender el porqué de una baja consecución de los resultados o impacto cuando los objetivos son adecuados y se encuentran bien formulados en base al problema a tratar porque indica que las limitaciones se encuentran en la ejecución. Para el caso de la sequía, este tipo de análisis presenta limitaciones sobre todo si se realiza de manera expost por la falta de información sobre algunos aspectos.

La *evaluación de resultados o de impacto* es la que se centra en analizar el grado de consecución de los resultados respecto a los objetivos planteados y en determinar en qué medida los cambios en los '*outcomes*' pueden ser atribuidos a la intervención (y no a otros factores externos). Aislar los efectos de una política en relación a las medidas implementadas es una tarea difícil, especialmente para las políticas medioambientales (Mickwitz, 2003). Para el caso de la sequía, se reconoce que este tipo de análisis es casi imposible de realizar en la práctica, dada la escasa información que existe sobre los impactos y el funcionamiento de las propias medidas.

Enfoques y modelos

El *modelo o enfoque de evaluación* viene determinado en gran medida por las características del programa a evaluar y las posibilidades de aplicar un determinado diseño metodológico. Si bien en algunas disciplinas concretas se encuentran ciertos modelos más extendidos que otros, en el caso de las políticas ambientales en general y de sequía en particular, no existe una clara apuesta por un modelo de evaluación determinado.

En términos generales, los diseños de evaluación se pueden agrupar en Experimentales, Cuasi-experimentales, No-experimentales y Cualitativos.

Los *diseños experimentales* nos permiten efectuar una comparación entre la situación antes y después de la intervención que estamos evaluando. En ocasiones se puede utilizar un grupo de control, que es un grupo equivalente o similar al grupo objetivo de la intervención. Esto nos permite analizar si los efectos medidos se deben al proyecto o intervención o a otros factores del contexto.

Los *diseños cuasi-experimentales* son similares a los diseños experimentales pero en vez de utilizar un grupo de control, plantean grupos de comparación, asumiento que estos no son equivalentes y por tanto, pierden cierto poder explicativo en relación a los diseños experimentales. En este caso también se utilizan comparaciones del propio grupo de tratamiento consigo mismo a lo largo del tiempo.

Los *diseños no-experimentales* son aquellos donde solo es posible medir los efectos una vez finalizada la intervención o proyecto, pudiéndose utilizar un grupo de comparación sólo en algunos casos.

La selección de los grupos de control y comparación se puede realizar respectivamente al azar o atendiendo a características específicas previamente identificadas como posibles intervinientes. Estas técnicas suelen ser costosas y difíciles de implementar en contextos complejos.

Por último, los *diseños cualitativos* se caracterizan por ser más deliberativos y se suelen basar en la selección de pequeñas muestras de individuos, expresamente seleccionados, o individuos clave. Es muy raro que incluyan grupos de control en sus diseños. Estos diseños son muy utilizados para analizar determinados aspectos con un mayor nivel de detalle y se apoyan en muchos casos en la formulación o selección de casos de estudio. Generalmente se centran en el análisis de los conocimientos, percepciones, actitudes y comportamientos en relación a la intervención (Margoluis et al., 2009).

Bellamy et al. (2001) identifican una brecha entre la teórica y la práctica de la evaluación en torno a las políticas de gestión de los recursos naturales que se puede hacer extensible al caso de la sequía. Estos autores también apuntan que los modelos de evaluación se encuentran dispersos y fragmentados, y raramente son sensibles al contexto socioeconómico y ambiental en el que se desarrollan (Bellamy et al., 2001).

Huitema et al. (2011) además alertan sobre que las decisiones que originalmente informan la práctica de este tipo de evaluaciones, todavía no son bien explicadas. En este sentido, Preskill (2009) "*encuentra curiosa e incluso sorprendente la escasa discusión sobre el rol de cómo centrar la evaluación*" (p. 98), dada la influencia que ésta tiene en la definición del diseño y métodos.

Mickwitz & Birnbaum (2009) identifican algunos aspectos clave que afectan el diseño de la evaluación en el campo del medioambiente, que se hace extensible al caso de la sequía:

(i) El desfase de los marcos temporales

La sequía ocurre a diferentes niveles y escalas y afecta a diferentes grupos o sectores de la población de diferentes maneras. Esto requiere políticas que abarquen diferentes niveles de gestión y actuación ('multi-level governance'), así como la participación de todos los actores afectados o interesados (Newing & Fritsch, 2009; Moss & Newing, 2010; Preskill, 2009). Además, las escalas temporales y espaciales a las que se manifiestan los problemas ambientales y las medidas, no suelen coincidir ni en el tiempo ni en el espacio. Es decir, que los marcos temporales del fenómeno de la sequía puede exceder los ciclos de programación y de gestión de la política. Suele ser difícil determinar el inicio y el fin de la sequía, ya que ésta evoluciona de forma lenta y progresiva afectando a amplias aéreas y diversos sectores económicos de manera diferente. Esto complica la elección del alcance temporal de la propia evaluación.

En general no existe coincidencia entre (i) *los tiempos de los procesos naturales* – suelen ser extensos, evolucionar lentamente y presentar una perspectiva de largo plazo, (ii) *la duración de los programas o políticas ambientales* – suelen ir con un cierto retraso respecto a la aparición del problema ambiental y tener una duración más corta comparativamente y una visión 'cortoplacista' (Hildén, 2009), (iii) *la manifestación de los resultados, efectos, impactos del programa o política,* en muchos casos aparecen a medio o largo plazo (Mickwitz, 2003) por lo que son difícilmente observables durante el periodo de desarrollo de la política, y (iv) *la duración, alcance, momento de la evaluación* – en el caso de ser una evaluación ex post algunos efectos pueden haber desaparecido o terminado, mientras que otras manifestaciones puede que todavía no hayan tenido lugar.

En resumen, es importante conocer todas estas consideraciones acerca de los marcos temporales de la política y de la evaluación a la hora de definir el momento de su realización, de seleccionar el periodo de análisis que abarca y el rango temporal de los datos a utilizar, ya que todo esto va a influir de manera significativa en los resultados de la evaluación.

(ii) Multiples escalas

Para el caso de la sequía y su gestión, la escala ambiental y la escala social no suelen coincidir. La sequía, como fenómeno climático extremo se manifiesta en un amplio territorio abarcando diferentes ecosistemas y territorios administrativos.

La terminología utilizada para referirse a la escala es confusa (Fekete et al., 2010) y en ocasiones se refiere a diferentes ideas. En términos generales se entiende por escala *el sistema de medida de algo*. Se entiende por escala ambiental aquella a la que tienen lugar los fenómenos naturales (e.g. ecosistema, comunidades, especies, individuos), mientras que la escala social responde a una construcción social sobre los límites y fronteras de las actividades humanas (e.g. global, continental, regional, subnacional, local, unidad familiar, individual).

Además es importante distinguir entre (i) *la escala del problema ambiental*, (ii) *la escala de la política o programa*, (iii) *la escala de las medidas, (iv) la escala de la evaluación y (v) la escala de la unidad de análisis*. Todas ellas pueden coincidir o no pero es importante tenerlo claro para no incurrir en errores durante la recolección de los datos e interpretación de los resultados.

Como punto de partida para poder definir el ámbito espacial que abarca una evaluación hay que identificar qué procesos ambientales tienen lugar, a qué escala y dónde está el problema. Además es necesario conocer cuáles son las soluciones o medidas propuestas, cuáles son los diferentes niveles de gobernanza y a qué escala operan. Todo esto tiene implicaciones significativas en todas las fases y elementos de la evaluación, afectando desde el establecimiento de los objetivos, el diseño de las herramientas y recursos destinados a la recolección de información, la interpretación de los datos y formulación de conclusiones.

Por último es importante justificar bien la escala de trabajo y análisis de la evaluación. Pullin & Knight (2009) plantean que la escala temporal y espacial a la que se deben medir los resultados de una intervención puede afectar directamente a la credibilidad de los datos y por tanto a la interpretación de los resultados de la evaluación.

(iii) Los problemas de atribución

A veces somos capaces de atribuir determinados resultados o impactos a nuestra intervención pero aún así no somos capaces de explicar porqué, es decir, las causas. Esto es lo que se denomina el problema de la "*caja negra*" ('*black box'*) (Astbury & Leeuw, 2010). A esto no ayuda el hecho de que múltiples intervenciones tengan lugar simultáneamente (Mickwitz & Birnbaum, 2009). Resulta difícil aislar los resultados de su contexto de ocurrencia y de los efectos e influencia de otras políticas (Rauschmayer et al., 2009), como ocurre en relación a las políticas ambientales, y en particular con la sequía. En el caso de la evaluación de la gestión de la sequía, parece muy difícil establecer relaciones de atribución por estas razones. Sin embargo, es posible estimar cómo las diferentes medidas implementadas contribuyen a reducir los impactos de la sequía.

La gestión de la sequía bajo un enfoque proactivo y de gestión del riego comparte los mismos retos metodológicos de la evaluación de las políticas de adaptación al cambio climático que plantean Bours et al. (2014). Estos autores identifican varias razones por las que su monitoreo y evaluación supone un reto actual, que, adaptadas a la sequía, se entiende de la siguiente forma y se presentan a modo se resumen de esta sección:

- La gestión de la sequía no es un objetivo o un punto final en sí mismo
- La gestión de la sequía abarca diversas escalas y sectores
- Los marcos temporales de planificación de la sequía son de largo plazo y se extienden más allá de los ciclos de gestión o programación
- La incertidumbre es un rasgo inherente en la implementación de intervenciones de gestión del riesgo a la sequía
- Respuestas de sequía inadecuadas pueden dar lugar a mayores impactos, a la maladaptación
- La medición de los impactos evitados es un concepto clave
- Plantea el seguimiento de objetivos móviles y de situaciones dinámicas
- No hay un único conjunto de indicadores o enfoques para su monitoreo y evaluación
- Evaluación de la contribución frente a la atribución

CAPÍTULO 3. MATERIALES Y MÉTODOS

3.1. Planteamiento general y diseño de las herramientas

Este capítulo resume el planteamiento metodológico de los cinco estudios que constituyen esta tesis. Su diseño se apoya en la revisión de la bibliografía presentada en el Capítulo 2 de esta memoria y se describe con más detalle en cada uno de los artículos elaborados (Capítulo 4).

El enfoque de evaluación viene determinado en gran medida por las características de la política a evaluar y por el propósito de esta. En esta tesis se ha buscado un enfoque que resalte el componente social y enfatice la recolección de datos más descriptivos o inductivos, como una forma de superar el uso predominante de análisis basados en datos cuantitativos disponibles. Así, se ha adoptado un enfoque constructivista, que toma como punto de partida de la evaluación las percepciones, opiniones o saberes de los diferentes actores afectados por la sequía, reconociendo la pluralidad de valores e intereses y su importancia para sustentar los juicios de valor de la evaluación. Esto supone una alternativa metodológica a los diseños experimentales o quasi-experimentales típicos de la evaluación de impacto ya que en el caso de la evaluación de la gestión de la sequía son imposibles de realizar.

Para la evaluación de la gestión de la sequía se ha explorado el uso de cinco técnicas de análisis: (i) análisis de marcos políticos; (ii) análisis de discurso y contenido, (iii) análisis de la percepción, y (iv) evaluación orientada por la teoría; (v) análisis sistemático.

Por último cabe recordar que algunas de las decisiones metodológicas han estado condicionadas o dirigidas por los requerimientos relacionados con la implementación del proyecto de investigación en el marco del cual se ha desarrollado esta tesis doctoral. Esto ha afectado principalmente a la selección de los casos de estudio a nivel europeo.

A continuación se presenta un resumen del planteamiento de cada una de las herramientas y de las características de su contexto de aplicación.

3.1.1. Evaluación de leyes de emergencia a la sequía en España

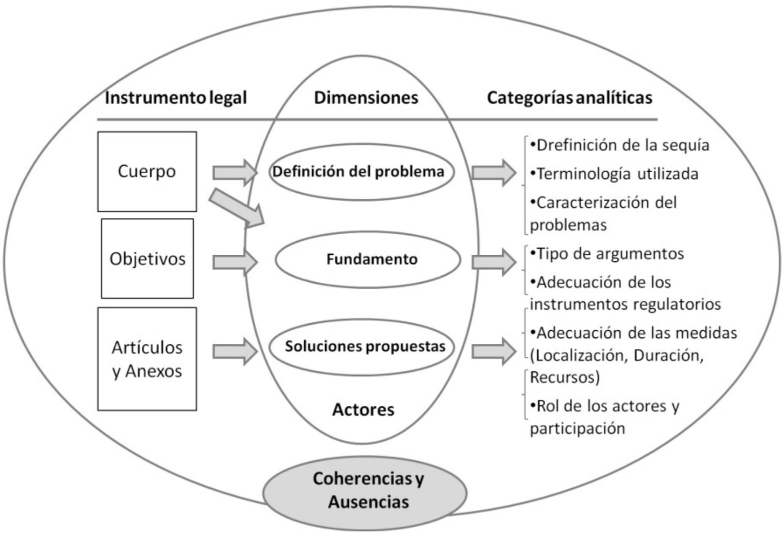
Artículo 1. Urquijo, J., De Stefano, L., & La Calle, A. (2015). Drought and exceptional laws in Spain: The official water discourse. *International Environmental Agreements: Politics, Law and Economics, 15 (3), 273-292*. (DOI 10.1007/s10784-015-9275-8)

Este estudio se centra en el análisis de la sequía a nivel nacional a través del análisis del discurso de las leyes de emergencia de sequía aprobadas por el Gobierno español durante la sequía 2005-2008 y profundiza en el uso de las leyes de emergencia como herramienta de gestión.

El artículo se apoya en el análisis de marcos políticos, para desarrollar el análisis de discurso oficial que se desprende de nueve textos normativos (reales decretos y reales decreto-ley).

Puesto que un marco es el esquema de interpretación que estructura el sentido que le damos a la realidad (Goffman, 1974), el análisis de marcos ayuda a estructurar el discurso en torno al problema y solución (Verloo, 2005). Por tanto, la estructura del análisis de marcos es fácilmente ajustable a la estructura y contenido de las leyes (Figura 8). Asimismo, este esquema permite analizar, también, los medios y mecanismos de securitización utilizados y la coherencia entre problema y solución las implicaciones para la respuesta.

Figura 8. Marco analítico para el estudio de las leyes de emergencia



El análisis del discurso considera el lenguaje como el medio de comunicación e interacción inmerso en su contexto cognitivo, cultural, social e histótico. Las características de la sequía hacen que la sequía sea un tema particularmente abierto a definiciones competentes sobre cuál es el problema y la solución (Sonnet et al., 2006), de ahí la importancia de profundizar en qué se dice y cómo se dice a través de las leyes.

El principal aspecto innovador de este artículo es la aplicación del análisis de discurso a la sequía bajo una perspectiva de securitización y el análisis de las leyes de emergencia en España.

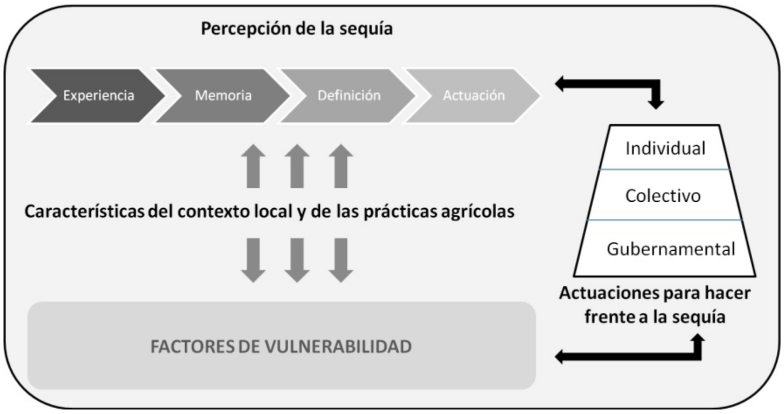
3.1.2. Análisis de la percepción de los regantes en la Demarcación del Júcar

Artículo 2. Urquijo, J., & De Stefano, L. Perception of drought and local responses by farmers: a perspective from the Júcar river basin, Spain. *Water Resources Management.* (DOI: 10.1007/s11269- 015-1178-5).

Este estudio se centra en el análisis de la sequía y las medidas de respuesta desde una perspectiva local y sectorial. Estudia la percepción de la sequía, niveles de vulnerabilidad y estrategias locales de respuesta por parte de los regantes en siete comunidades de regantes de la Demarcación del Júcar.

Basado en un enfoque constructivista, el uso de entrevistas en profundidad semi-estructuradas permite capturar la diversidad de percepciones e interpretaciones sobre la realidad y, en concreto, sobre el fenómeno de la sequía y sus implicaciones para la gestión de los recursos a nivel local. Esto permite analizar no solo la percepción si no también los factores subyacentes vinculados con la vulnerabilidad percibida y resaltar las principales preocupaciones y conflictos relacionados con la gestión de los recursos hídricos en la cuenca (Figura 9).

Figura 9. Marco analítico de la percepción a la sequía



Las entrevistas en profundidad son una técnica de investigación cualitativa que permite recolectar información detallada acerca de la opinión de una persona y la experiencia en relación con un tema específico. Se considera una herramienta flexible, interactiva y generativa (Legard et al., 2003) que promueve la aparición de temas de una manera informal y flexible que puede contribuir a una mejor comprensión e ilustrar un nuevo tema, en este caso particular, la diferentes percepciones acerca de la sequía, la vulnerabilidad y las respuestas a la sequía. El tamaño de la muestra vino definido por la saturación del discurso, es decir, cuando la recopilación de nuevos datos no arrojaban más luz sobre el tema objeto de la investigación (Mason, 2010).

El trabajo de campo se llevó a cabo en el verano de 2013, y en la selección de los entrevistados se seleccionaron agricultores que utilizaban distintas fuentes de agua (superficial, subterránea y reciclada), realizándose un total de 24 entrevistas.

El análisis de la percepción a la sequía es escaso en la literatura sobre sequía y novedoso en España. Además, el análisis de la influencia del origen del recurso como factor determinante para la percepción y respuesta no se encuentra casi presente en la literatura sobre percepción a la sequía.

3.1.3. Evaluación de la gestión de la sequía en seis casos de estudio europeos

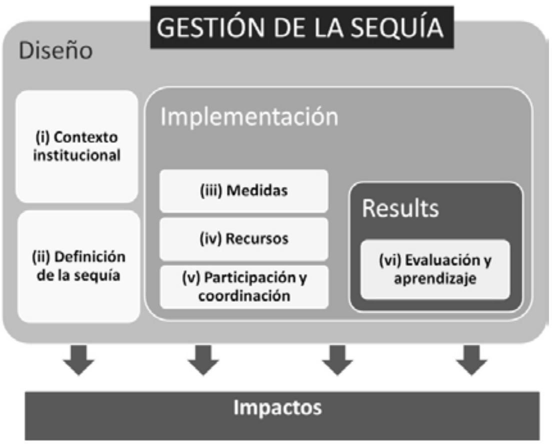
Artículo 3. Urquijo, J., Pereira, D., Dias, S., & De Stefano, L. A methodology to assess drought management as applied to six case Europen case studies. *Journal of Water Resources Development* (Aceptado con revisión)

Este estudio se centra en el análisis de la gestión de la sequía en seis casos de estudio europeos que representan diversas escalas: Nacional (Holanda, Portugal y Suiza), Demarcación Hidrográfica (Júcar en España y Po en Italia); y local (Isla de Syros, Grecia). Su desarrollo se basa principalmente en las actividades realizadas en el marco del proyecto DROUGHT R&SPI durante el periodo 2011 -2012 (De Stefano et al., 2012).

En este estudio se ha utilizado el enfoque de evaluación orientado por la teoría[34], que bajo un enfoque constructivista, se basa en el desarrollo de un modelo conceptual que guía el diseño, proceso y la interpretación de los resultados de una evaluación (Rogers, 2000). Este enfoque contribuye a entender los factores y mecanismos que posibilitan la implementación de la respuesta y las características de la gestión de la sequía en este caso particular. Se presenta como una alternativa a la falta de información sobre los impactos y de las relaciones causales entre la intervención y sus efectos, como ocurre claramente con las medidas de sequía. A pesar de que se trata de un enfoque de creciente uso en diferentes disciplinas (Coryn et al., 2011), apenas ha sido utilizado en el campo de las políticas ambientales (Mickwitz, 2003), y de aquí su surge el interés de probar su utilidad para el caso de la sequía.

En este análisis se han identificado seis dimensiones que son relevantes desde una perspectiva política (Figura 10). Se realizó un extenso trabajo de campo de revisión documental, entrevistas (40), cuestionarios (65) y grupos de discusión (5) para la recogida de datos durante el periodo marzo – octubre 2012. Se buscó la participación de los stakeholders más representativos en cada caso de estudio y de aquellos que estuvieron vinculados con la gestión de la sequía.

Figura 10. Marco analítico de la gestión de la sequía aplicado a los casos de estudio



Como aspecto innovador, destacan el uso de un marco de evaluación que incluye el análisis no solo de las medidas si no también de factores contextuales e institucionales bajo el enfoque de la gestión del riesgo, pero también el uso del enfoque de evaluación basada en la teoría aplicado al análisis de la sequía.

[34] También denomidana teoría del programo o teoría del cambio

3.1.4. Análisis sistemático de las evaluaciones de vulnerabilidad a la sequía

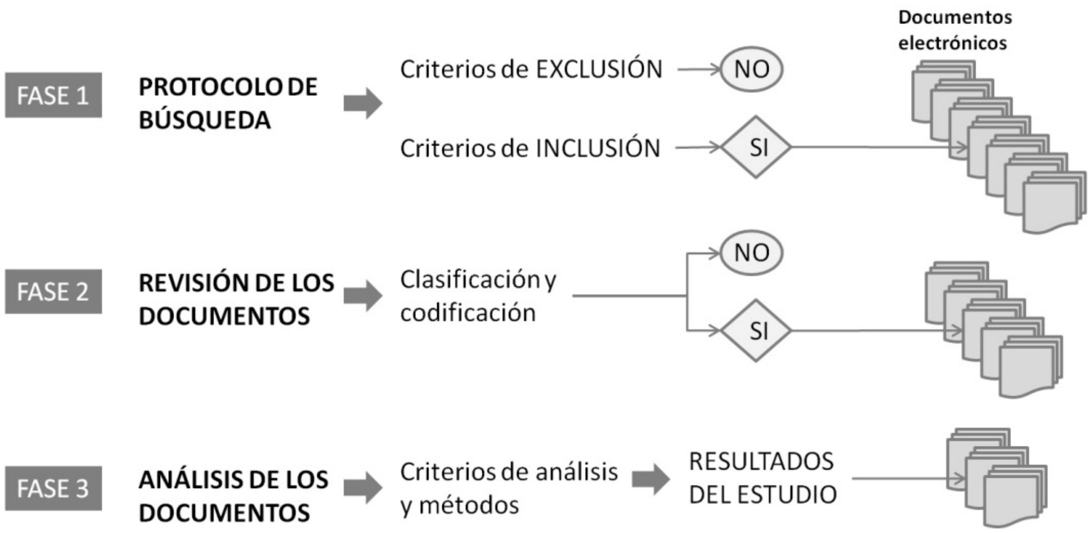
Artículo 4. Gonzalez Tánago, I., Urquijo, J., Blauhut, V., Villaroya, F., & De Stefano, L. (2015). Learning from experience: A systematic review of assessments of vulnerability to drought. *Natural Hazards* (DOI 10.1007/s11069-015-2006-1).

Este trabajo realiza una revisión sistemática de los estudios que miden de forma cuantitativa la vulnerabilidad a la sequía. El análisis sistemático permite resumir y evaluar el estado del conocimiento sobre un tema en particular (Ford & Pearce, 2010), lo cual permite reducir potenciales sesgos del autor o inconsistencias, manejar grandes cantidades de información, y detectar lagunas de información (Peticrew & Roberts, 2006).

El análisis sistemático se inicia con una búsqueda sistemática en internet, a través de diferentes buscadores y usando palabras clave, tanto en la literatura científica como en documentos generales. Posteriormente se aplicaron una serie de criterios de inclusión (ej. estudios cuantitativos, centrados en el sistema socio-ambiental) y de exclusión (ej. estudios descriptivos o centrados en la vulnerabilidad de un tema específico), seleccionando finalmente 46 estudios publicados a partir del año 2000 y con diferente cobertura espacial y geográfica (Figura 11).

El análisis del contenido de los estudio se realizó teniendo en cuenta las siguientes variables: (1) ámbito territorial y escala del análisis, (2) localización geográfica, (3) año de publicación, (4) modelo teórico de vulnerabilidad adoptado, (5) principales componentes y factores utilizados, (6) transparencia del diseño y proceso de validación, y (7) usuarios y usos de los estudios.

Figura 11. Marco de análisis de los estudios de vulnerabilidad a la sequía



El principal aspecto innovador de este estudio es que analiza de manera sistemática los trabajos aplicados que tratan de cuantificar la vulnerabilidad a la sequía presentando una imagen completa de las características y tendencias de la práctica de este tipo de análisis a nivel global.

3.1.5. Estudio de los impactos de la sequía a nivel europeo

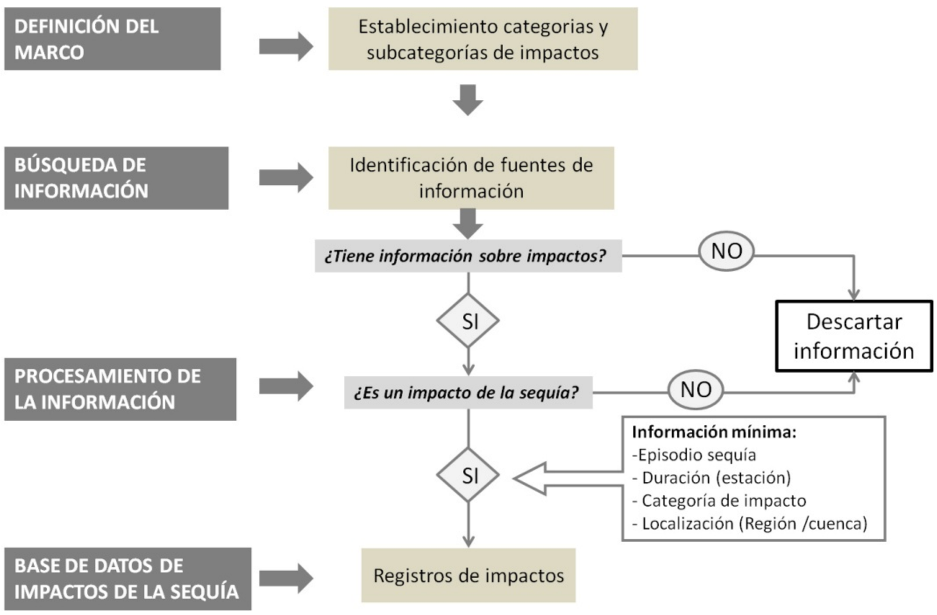
Artículo .5 Stahl, K., Kohn, I., Blauhut, V., Urquijo, J., De Stefano, L., Acacio, V., Dias, S., Stagge, J.H., Tallaksen, L.M., Kampragou, E., Van Loon, A.F., Baker, L.J., Melsen, L.S., Bifulco, C., Musolino, D., de Carli, A., Massarutto, A., Assimacopoulos, D., & Van Lanen, H.A.J. Impacts of European drought events: insights from an international database of text-based reports. *Natural Hazards Earth System Science* (DOI:10.5194/nhessd-3-5453-2015) (Aceptado, en discusión)

Este estudio esta relacionado con la construcción de la base de datos internacional de impactos reportados de la sequía y que son recogidos en el denominado 'Inventario de Impactos Reportados de la Sequía en Europa' (EDII – European Drought Impacts Inventory) (Stahl et al. 2012). En concreto se presentan las principales características y resultados preliminares alcanzados hasta este momento (Figura 12).

La EDII permite recolectar información sobre variables importantes para analizar diferentes aspectos de los impactos de la sequía: (i) Categorías de impactos (15); (ii) Subcategorías de impactos (106); (iii) Episodios de sequía; (iv) Localización geográfica (Nacional, regional o local); (v) Tipo de fuente de información (16); (vi) Otros datos secundarios asociados (Impactos indirectos, medidas).

Actualmente, la EDII cuenta con más de 5.000 reportes de impactos de 33 países europeos diferentes. El trabajo de recolección de datos para España ha tenido lugar en 4 momentos: (i) agosto-septiembre 2012; (ii) marzo - abril 2013; (iii) diciembre 2013 y (iv) septiembre – octubre 2014. Acualmente se cuenta con 177 registros de impactos, más de 370 registros de subtipos de impactos provenientes de más de 73 referencias bibliográficas y 10 tipos de fuentes de información.

Figura 12. Esquema de recolección y análisis de los impactos de la sequía



Se trata de un estudio innovador puesto que refleja un esfuerzo colectivo de consensuar los tipos de impactos según una clasificación común para todos los sectores, episodios y ámbito europeo, y además realiza un importante trabajo de recolección de información documental.

3.2. Resumen del planteamiento de los estudios

En la Tabla 11 se presentan las principales características del planteamiento de cada de los artículos desarrollados a partir de ellas.

Tabla 11. Resumen del diseño metodológico de cada herramienta de evaluación

	ESTUDIO 1	ESTUDIO 2	ESTUDIO 3	ESTUDIO 4	ESTUDIO 5
Tema central	Evaluación de la respuesta a través de las leyes de emergencia en España	Análisis la percepción de la sequía y respuesta de los agricultores en el Júcar	Evaluación de la gestión de la sequía en varios casos de estudio a nivel europeo	Análisis de las evaluaciones de vunerabilidad a la sequía	Análisis de los impactos de la sequía en Europa
Objetivos	Analizar la respuesta a la sequía a nivel nacional/regulatorio; Analizar las características de la respuesta de crisis; Analizar el papel de las leyes en la gestión de la sequía	Analizar la respuesta a la sequía a nivel sectorial y de usuario final; Analizar la percepción a la sequía y como influye en las estrategias de respuesta a nivel local; Analizar la influencia del origen de los recursos	Analizar la respuesta a la sequía a nivel de gestión; Analizar el grado de adopción de la perspectiva de riesgo en la respuesta a la sequía; Analizar los elementos clave y su interrelación	Analizar las principales tendencias y aspectos a mejorar de los estudios de evaluación de la vulnerabilidad que presentan una cuantificación de la misma.	Analizar los impactos de la sequía desde el punto de vista de los impactos observados a nivel europeo.
Gap al que pretende responder	Falta de análisis sobre las leyes de emergencia como instrumento de gestión de la sequía. Necesidad de conocer el uso de procesos de securitización en contextos de sequía y sus implicaciones en el tipo de respuesta.	Falta de conocimiento sobre la percepción de los agricultores a la sequía, sus respuestas locales y su vulnerabilidad. Necesidad de conocer si el tipo de recurso utilizado es un factor determinante	Falta de conocimiento sobre cómo se gestionan las sequías y sobre su grado de adopción de un enfoque de riesgo	Necesidad de evidencias sobre las características de los análisis de vulnerabilidad a la sequía y su aplicación en la práctica.	Falta de conocimiento y registro sistemático de los impactos de la sequía sobre los diferentes sectores afectados y sobre la cultura de evaluación asociada.
Pregunta de investigación	¿En que medidas son adecuadas las leyes de emergencia?; ¿En qué medida se encuentra securitizado el discurso de la sequía?; ¿Qué medios, cómo y cuáles son las implicaciones para la respuesta?	¿Cómo perciben los agricultores la sequía?; ¿Cuáles son los factores del contexto que influyen en la vulnerabilidad?; ¿Cuáles son las estrategias implementadas para hacer frente a la sequía?	¿Cómo se gestionan las sequías en cada caso de estudio?; ¿En qué medida las políticas de sequía siguen un enfoque de gestión del riesgo en cada caso de estudio?; ¿Qué hemos aprendido del pasado?	¿Cuáles son las principales tendencias en el análisis aplicado de la vulnerabilidad a la sequía?; ¿Cuáles son las principales limitaciones?	¿Cuáles son los principales impactos de la sequía en Europa?; ¿Cuáles han sido los episodios más dañinos?; ¿Quién reporta los impactos?; ¿Cuáles son los principales limitaciones de información?

	ESTUDIO 1	ESTUDIO 2	ESTUDIO 3	ESTUDIO 4	ESTUDIO 5
Componente del riesgo	Gestión/medidas	Gestión/medidas	Gestión/medidas	Vulnerabilidad	Impactos
Centrado en	Diseño	Procesos y resultados	Diseño y procesos	-	Resultados
Nivel de gestión	Nacional	Local	Gestión	Múltiple	Múltiple
Contexto aplicación	España	Demarcación Hidrográfica del Júcar	6 Casos de Estudio en Europa	Global	Europa
Marco temporal	Sequía 2005-2008	Episodios de sequía 80s, 90s, 2000s	Principales episodios de sequía desde el año 2000	Estudios de vulnerabilidad aplicada desde el año 2000	Episodios de sequía desde los años 70s
Materiales	9 RD y RD-Ley sobre sequía	24 entrevistas en profundidad y observación directa	40 entrevistas, 65 cuestionarios y 5 grupos de discusión con stakeholders; Informes oficiales sobre sequía o la gestión del agua.	46 Estudios de evaluación de la vulnerabilidad a la sequía	Más de 5.000 reportes de 33 países europeos.
Metodología, diseño	Análisis de marcos basado en el análisis de discurso y contenido de las leyes	Análisis de la percepción de los agricultores basado en el análisis cualitativo de su discurso	Evaluación orientada por la teoría; Análisis ex post	Análisis sistemáticos de estudios de evaluación.	Revisión y análisis sistemáticos de fuentes documentales
Método/ Herramientas	Análisis documental, A. crítico del discurso, A. contenido	Entrevistas semi-estructuradas en profundidad y análisis documental.	Multi-método (análisis documental, cuestionarios, entrevistas semi- estructuras)	Búsqueda sistemática de estudios; Análisis documental y análisis estadístico básico	Análisis documental para la identificación de los registros y análisis estadístico básico

Fuente: Elaboración propia

CAPÍTULO 4. ARTÍCULOS

4.1. Las leyes de emergencia a la sequía en España

Urquijo J, De Stefano L., La Calle A (2015). Drought and exceptional laws in Spain: The official water discourse. *International Environmental Agreements: Politics, Law and Economics 15(3),* 273-292. (DOI: 10.1007/s10784-015-9275-8)

Int Environ Agreements
DOI 10.1007/s10784-015-9275-8

ORIGINAL PAPER

Drought and exceptional laws in Spain: the official water discourse

Julia Urquijo[1] · Lucia De Stefano[1,2] · Abel La Calle[3]

Accepted: 2 April 2014

Abstract Only recently securitization research is exploring which mechanisms are used to securitize the water discourse and how securitization affects decision-making processes. In this context, legal texts convey messages and shape public actions, but have been rarely considered in the analysis of water securitization. Moreover, security is usually meant as the absence of violent conflict, while discourse securitization can exist also where there are only vaguely defined threats to the society. This may be the case of water scarcity asso- ciated with drought. This paper undertakes a policy frame analysis of nine exceptional laws passed in Spain during the 2005–2008 drought, to address the following questions: To what extent and how can the water discourse in legal texts be securitized? and What are the consequences of that securitization? The analysis shows that securitization is achieved using both linguistic and institutional mechanisms. Dry spells are presented as exceptional situations and using alarmist terms, even if drought is inherent to Spain's Mediterranean climate. The sense of urgency is used to fast-track the approval of measures that could be part of ordinary water planning. The securitization of the water discourse contributes to consolidate an existing water paradigm, which, in the case of Spain, is based on State-subsidized, technical and legal measures addressing water scarcity (real or exaggerated). It is an example of a "creeping" securitization of the water discourse, meant as the dramatization of otherwise natural circumstances to spur projects and investments con- ceived for other purposes.

& Lucia De Stefano lstefano@ucm.es

Julia Urquijo juliaurquijo@gmail.com

Abel La Calle abel.lacalle@gmail.com

[1] Departamento de Geodinámica - Facultad de Ciencias Geológicas, Universidad Complutense de Madrid, c/ José Antonio Nováis 12, 28040 Madrid, Spain
[2] Observatorio del Agua, Fundación Botín, Madrid, Spain
[3] Fundación Nueva Cultura del Agua, Almería, Spain

Keywords Drought · Discourse analysis · Exceptional law · Securitization · Water paradigm · Frame analysis

Abbreviations

DEP Drought Emergency Plan for cities of over 20,000 inhabitants DMP
Drought Management Plan
EU European Union
WFD Water Framework Directive NIP
National Irrigation Plan
NGO Non-governmental Organization NHP
National Hydrological Plan NWC New
Water Culture
RBD River Basin District
RBMP River Basin Management Plan RBOs River
Basin Organizations
RD Royal Decree
RD-Law Royal Decree-Law
UGSP Upper Guadiana Special Plan

1. Introduction

Environmental security is a subject of current debate. It is framed around the idea of environmental threats that need to be urgently addressed and that pose a risk to human safety and human well-being (Graeger 1996; Fischhendler and Katz 2012). Securitization approaches were originally developed by the 'Copenhagen School' (Buzan et al. 1998), which emphasizes the importance of the processes and the reasons why a certain issue is treated as a matter of security (Stetter et al. 2011). According to Buzan et al. (1998), securitization is about breaking the rules of the normal political decision making, placing issues beyond normal politics or beyond public debate (Schmitt 1985; Williams 2003). From a legal perspective, this can imply a misuse of powers, as the Authority can use its powers for purposes that go beyond its legal mandate.

Water securitization processes have received particular attention from different research fields such as climate change (e.g. Ludwig et al. 2011; Feitelson et al. 2012), water conflicts (e.g. Stetter et al. 2011; Katz 2011; Fischhendler et al. 2011), and hydro-politics (e.g. Warner and Zeitoun 2008). Water securitization research normally links water with national security or the occurrence of violent conflicts (Fischhendler, this volume), while it rarely considers situations where there are only vaguely-defined threats to the society. This paper aims at filling this gap by exploring an additional spatial and mental context of securitization, *creeping securitization*, which consists in showing water management issues through the lens of emergency, often to serve specific economic and political interests. Thus, here we define water securitization as a situation *when the scarcity or lack of access or availability of water (real or exaggerated) is used to justify a specific intervention so as to avoid potential negative consequences on the society*.

Few scholarly studies explore the mechanisms operating to achieve securitization and the short- and long-term implications of discourse securitization on the decision-making process (Fishhendler, this volume). Since drought can create situations of water scarcity, it provides a suitable context for the analysis of both the securitization of water discourse and its practical consequences (Fischhendler in this volume). This paper analyses exceptional laws passed in Spain during the 2005-2008 drought to explore the following questions: *To what extent and* *how can the water discourse in legal texts be securitized?* and *What are the consequences of that securitization?*

These questions are addressed through a policy frame analysis, which “is an organizing principle that transforms fragmentary information into a structured and meaningful problem, in which a solution is implicitly or explicitly included” (Verloo 2005, p. 20). This is achieved using analytical categories that assess the coherence between the problem and the proposed solutions and indicate possible securitization elements in the policy discourse.

A frame analysis of Spanish drought-related exceptional laws yields a description of how securitization is achieved through different mechanisms and, most importantly, shows that the securitization of the discourse can play a role in either weakening or reinforcing a particular water paradigm. At an international level, discourse analyses attempt to compare different elements of the discourse on globally relevant issues like biodiversity, deforestation (e.g. Adger et al. 2001) or climate change (e.g. Risbey 2008; Sonnet 2010). Most of that literature, however, focuses on the analysis of the discourse in the mass media, while little work has been done so far on regulatory texts or policy documents. The policy frame analysis presented here could be applied to international policy or regulatory documents where specific actions are prescribed based on the exposition of a specific problem. That analysis would contribute to identify possible securitization processes in the international policy agenda and understand their implications in shaping the international or supranational response to a given water challenge.

Two issues should be stressed here. First, this paper focuses on the official discourse adopted by the Spanish State in exceptional drought laws. The analysis of the discourses of other actors (e.g. regional governments, agricultural or environmental lobbying groups) or even of the State’s unofficial discourse (emerging e.g. from the analysis of media) is beyond the scope of this study. Second, we focus on nine exceptional laws that deal mainly - but not exclusively - with drought in river basin districts managed by the Spanish central government. Thus, our analysis does not necessarily reflect the discourse of drought in basins managed by regional agencies.

Section 2 presents Spain’s water and drought policy, Section 3 outlines the methodological framework, Section 4 presents an overview of the content of the exceptional laws, and Section 5 describes the main mechanisms used to securitize the drought discourse and the implications of that securitization. Before the concluding remarks (Sect. 7), Section 6 explores how the securitization of drought discourse fits into the current water policy context and its contribution to the existing water paradigms.

2. Drought in the Spanish water context

Drought is a characteristic feature of the Mediterranean region and can be defined as a slow-onset natural hazard that results from a deviation from expected or normal rainfall levels during a given time period (Wilhite and Glantz 1985). This deviation can translate into amounts of water insufficient to meet the demands of both human activities and the environment (Estrela and Vargas 2012). In Spain, dry spells can last several years, having impact on socioeconomic and environmental systems. With a population of 46.7 million inhabitants (INE 2013), Spain covers 500,000 km^2 and experiences a variety of rainfall regimes. With an average annual rainfall of 665 mm, large differences are found between the wet north (average annual rainfall 2,200 mm) and the dry southeast (<300 mm). This is also reflected in how dry spells hit the country, as droughts present significant spatial differences in terms of severity, duration, and time of occurrence (Vicente-Serrano and Cuadrat 2007).

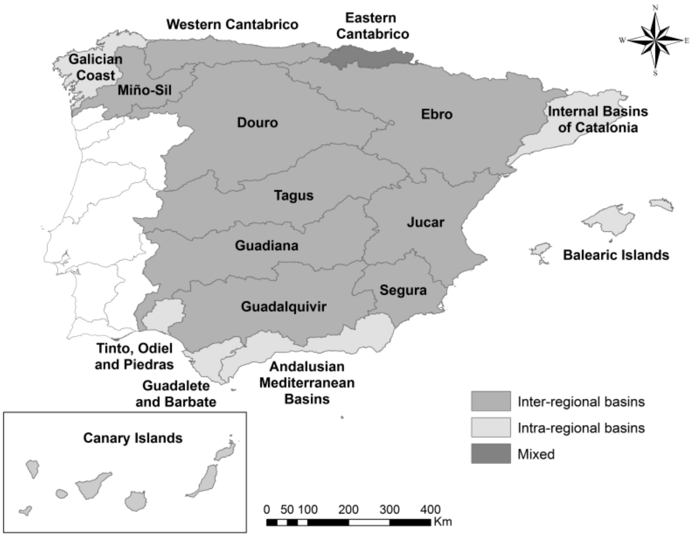
Since the beginning of systematic rainfall monitoring in 1941, four main drought episodes have occurred: 1941-1945; 1979-1983; 1990-1995; and 2005-2008 (MMA 2008). The 1990s drought impacted the domestic supply to over 8 million people in different parts of Spain (Llamas 1997) and economic losses were reported due to water supply restrictions or shortages. During the 2005-2008 drought domestic water supply was guaranteed, while water rates for irrigation had to be reduced in several areas (MMA 2008). This study focuses on the 2005-2008 drought, which was the last prolonged drought affecting most of the Spanish territory.

2.1. Water policy context

The exceptional laws analysed here must be framed in the landscape of Spain's water policy, which, in the last two decades, has been very dynamic, and characterized by the interaction (and clash) of different, coexisting water paradigms.

Spain is a quasi-federal country, where autonomous regions with their own governments have broad competence on many policy areas. The 1978 Constitution requires that water is managed at central level for inter-regional basins (those shared by two or more regions), whereas for intra-regional basins (i.e. those located within a single region) water is managed through the creation of regional water agencies (Figure 1). As a result, currently there are nine River Basin Organizations (RBOs) that depend on the central government, covering 85% of Spain's territory, and 12 regional water agencies. Since 1978, however, the Spanish political landscape has significantly changed, and regions are now pressing to increase their control also over inter-regional water resources flowing within their boundaries (see López-Gunn and De Stefano 2014).

Fig. 1 Inter- and intra-regional basins

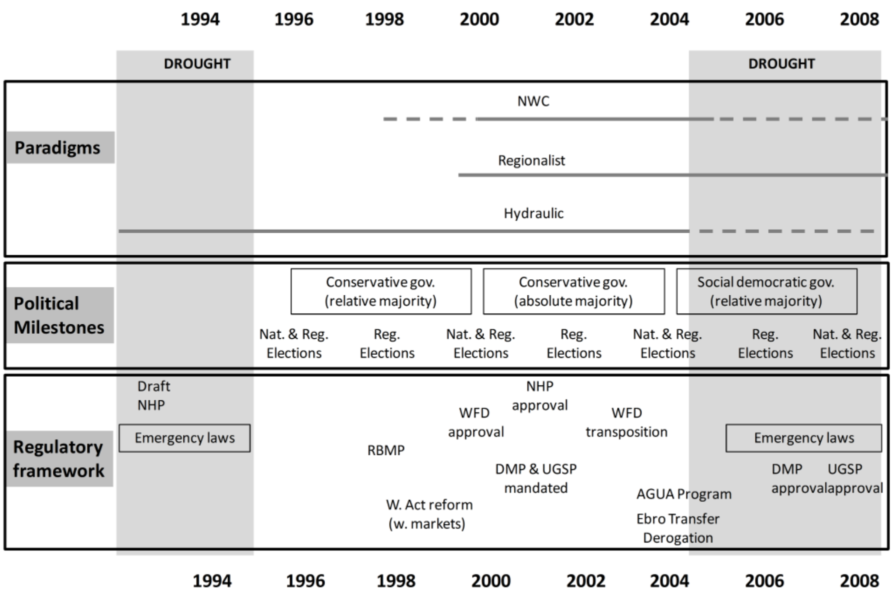


During the past 15 years, legal activity around water has been intense (Figure 2). In 1998, River Basin Management Plans (RBMPs) were approved in all the basins, while the National Hydrological Plan (NHP) (addressing issues affecting several river basins) was passed in 2001. The NHP included a long list of water works and its cornerstone was a 914 km-long transfer of 1,050 hm^3/year from the lower Ebro river in the northeast of Spain to several provinces along the Mediterranean coast. This was a highly disputed project which polarized the water debate (see e.g. Albiac et al. 2006; Garrido and Llamas 2009). In 1999 and 2003, the 1985 Water Act was amended. The 1999 reform introduced the option of trading water (Garrido et al. 2012), while in 2003 legislators transposed the requirements of the 2000 European Union Water Framework Directive (EU WFD) into the Water Act, which set new, environment-oriented objectives for water policy in all the EU countries (De Stefano and Hernández-Mora 2012). In 2004 a newly elected central government abrogated the Ebro transfer project, marking a milestone in Spanish water policy for several reasons. First, it meant a rupture with the long-standing discourse of *hydrosolidarity* among water-abundant and water-scarce regions.

Second it showed that water issues could be used as a political weapon to gain or lose votes[35]. Third, it confirmed the strength of regionalist claims over water. And fourth, it implied a shift of emphasis from reservoirs and transfer schemes to desalination plants as a means of augmenting water supply[36] (Downward and Taylor 2007).

Despite the focus on water infrastructure, the 2001 NHP also paved the way for 'softer', non-engineering solutions. For instance, it required the elaboration of normative Drought Management Plans (DMPs) at the river basin level and Drought Emergency Plans for cities of over 20,000 inhabitants (DEPs). The NHP also mandated the development of a special management plan for the Upper Guadiana basin, a region where a 40-year-long intensive (and often uncontrolled) groundwater development has contributed to the degradation of protected groundwater-dependent wetland ecosystems. The Upper Guadiana Special Plan (UGSP) was approved in 2008, representing a first attempt to tackle the problem of uncontrolled groundwater use not only through water infrastructure but also through a battery of administrative, legal and economic tools (Martínez-Santos et al. 2008).

Fig. 2 Main milestones in Spanish water policy between 1990 and 2008.



These developments set the scene for three main water paradigms coexisting in the Spanish context (López-Gunn 2009; López-Gunn and De Stefano 2014). The '(*old) hydraulic paradigm*' (Saurí and Moral 2001), has dominated Spain's water landscape for decades (Swyngedouw 1999; 2007) and focuses on water supply enhancement through water infrastructures promoted by the central State. Since the end of the 1990s, however, the water scene has seen the rise of two other paradigms. First, the '*regionalist hydraulic paradigm*' reflects the utilization of water by the regional governments as a means for achieving political gains. And second, the '*new water culture paradigm'* (NWC), which advocates a demand management approach and the inclusion of social and environmental concerns, and is embraced by

[35] The donor and recipient areas of the transfer were of opposite political colour and the abrogation or continuation of the transfer was a political flag during the 2004 national elections campaign. The abrogation of the project was the second major act by the newly elected Government, after the withdrawal of Spanish troops from Iraq.

[36] The AGUA Program, approved in 2005, emphasized the construction of desalination plants along the Mediterranean coast to substitute the water that the Ebro transfer would have contributed. The planned desalination capacity amounted to over 700 hm^3/year. Today many of the planned plants are operational, and desalinated water is heavily subsidized to make it affordable to farmers. However, plants are dramatically underused (only operational at 20% capacity for the most part), and farmers still rely on groundwater resources, aggravating the situation of many intensively used aquifers along the coast.

environmental NGOs, local grassroots movements and several water-related EU guidelines (López-Gunn 2009). The heated debate around the NHP reflects the rise of these two 'new' paradigms, and the derogation of the Ebro transfer in 2004 sanctions the recognition of their strength (for more on the rise of the NWC see Tàbara and Ilhan 2008).

From a political standpoint, the 2005-2008 drought overlaps in time with a national election (2008) and two rounds of regional elections (2006 and 2008), where water-related decisions were means to gain or lose votes. This is the realm of water policy where the 2005-2008 drought occurred and where the exceptional laws were conceived.

2.2. Drought management tools

In 2005-2008 the 1985 Water Act (and subsequent amendments), the 2001 NHP and the 1998 RBMPs constituted the main legal sources for water and drought management. The Water Act allows these legal instruments to be complemented by exceptional laws to face drought situations.

Spain has different national legal instruments that are passed by the central government or the parliament: Laws, Royal Decree-Laws, and Regulations. Two of them were used to regulate drought responses during 2005-2008:

a) The Royal Decree-Law (RD-Law) is a decree with a rank of law, which is used for promulgating exceptional and urgent measures 'in the case of extraordinary and urgent necessity'. It is approved by the executive power and has to be validated or repealed by the Parliament within 30 days. RD-Laws need to meet two requirements: they have to justify with facts the exceptionality and urgency of the situation that they address; and they have to show that the measures they approve are aimed at dealing with that situation (Brufao 2012).
b) The Royal Decree (RD) has a lower legal rank and is used by the Government to rule specific, often technical, issues that do not need to be regulated by a law.

Among the nine exceptional laws approved for the management of the 2005-2008 drought, six were RD-Laws and three RDs. While three of them have a country-wide scale (RD-Law 10/2005, RD-Law 15/2005 and RD 287/2006), the rest refer to a particular group of inter-regional river basins.

Since this paper focuses on the official discourse of the central government, regional and local regulations dealing with drought have not been included. The 2007 DMPs were approved at the end of the 2005-2008 drought and therefore had a limited application to that episode. They currently constitute the primary drought tools together with the Spanish System of Drought Indicators and the Drought Emergency Plans for cities of over 20,000 inhabitants.

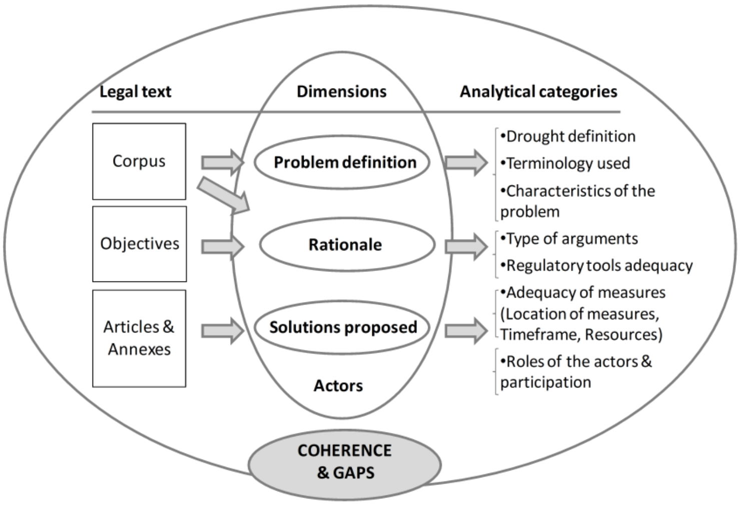
3. Methodological approach

Discourses constitute systems of knowledge and belief shared by a group of actors and "shaped by political, economic, infrastructural, cultural, and physical factors" (Sonnet et al. 2006; p. 95). Under a constructivist research approach (e.g. Guba and Lincoln 1994), *discourse analysis* focuses on the systematic analysis of a written or oral discourse, considering the use of language as a means of communication and interaction embedded in its cognitive, social, historic and cultural contexts. According to Sonnet et al. (2006, p. 95), "understanding discursive context is especially important for 'slow-onset hazards' such as drought […] because such hazards are diffuse in time and space, and are therefore particularly open to competing definitions of problems and solutions".

According to discourse theory, reality is shaped by *language* (Fischhendler and Kratz 2012), thus the analysis of the texts produced by a specific actor allows understanding how that actor perceives the reality and will intervene on it. We use *policy frame analysis* to guide and structure the discourse analysis process. According to Goffman (1974), a frame is generally described as an interpretation scheme that structures the meaning of reality. Policy frames organize scattered information into a "structured and meaningful problem" that includes also a solution, in an implicit or explicit way (Verloo 2005). The main advantage of a policy frame approach is that it helps to analyse a policy act in terms of *Diagnosis* (problem definition), *Rationale* (justification of the need to act), *Prognosis* (solutions proposed), and *Voices* (roles and actors involved). These four dimensions of analysis, adapted from Verloo (2005), enable the assessment of the internal *Coherence* and *Gaps* of a given text, and to explore the reasons behind them. Those reasons can be seen through securitization lenses and will point to what instruments are used to securitize the discourse and the consequences of securitization.

The content of each legal text can be divided into: (i) the *corpus*, where the problem is presented, including its background and justification of the need for action, (ii) the *objectives*, as the formal aim of the norm, and (iii) the *solution*, which includes all the actions established to address the problem (Figure 3). The characterization of the discourse was undertaken using the software Atlas-ti version 6.2 for the systematic analysis of textual data.

Fig. 3 Theoretical Framework of the analysis



4. Overview of the content of the drought laws

In the legal texts, two main problems are attributed to drought. The first one relates to the difficulty to meet the existing water demands, particularly from the irrigation and domestic water supply sectors, while other sectors (e.g. rain-fed agriculture, livestock farming, ecosystems) are barely mentioned. The second most frequently mentioned problem is related to the economic impact of drought, which stresses the consequences of drought on the agricultural sector, particularly irrigated agriculture. The legal texts always refer to potential economic impacts and not to reported ones.

The solutions provided in the laws can be classified into five categories: (i) Water management measures (e.g. granting special powers to the River Basin Authorities), (ii) Measures to increase water supply (e.g. emergency wells or works to increase irrigation efficiency), (iii) Financial-economic measures (special conditions for public loans to farmers or exemptions from water tariffs for irrigation), (iv) Administrative and control measures (e.g. declaration of expropriation and urgent land occupation to undertake the approved works), and (v) Environmental measures.

Additionally, each legal text includes an annex listing specific water infrastructure, a total of 441. These represent a very large share of the budget for the execution of the norms. They are mainly focused on increasing water supply to agriculture through the modernization of irrigation systems (64%) and the improvement of domestic water supply (16%), followed by the construction or upgrade of reservoirs and irrigation ponds (5%), treated-water reuse (4%), desalination (4%), wastewater treatment (3%), environmental protection (1%), groundwater wells (1%) and other works (2%).

5. How is securitization achieved?

The application of the theoretical framework allows identifying the mechanisms employed to securitize the discourse on drought in Spain. Fischhendler (this volume) identifies structural, institutional, and linguistic mechanisms for securitizing water issues. This section shows that in the case of exceptional laws, institutional and linguistic tools were used to securitize the discourse. Table 1 shows the relationship among the analytical categories, the securitization mechanisms, and the reasons for securitization, as well as the sub-sections of the paper where those results are presented.

Table 1 Overview of water securitization means by analytical category

	Analytical categories	Securitization means	Reasons behind securitization	Section of this paper
Linguistic Mechanisms	*Drought definition*	Although their causes and intensity are different, meteorological drought and social drought are presented without clear boundaries between them	Stressing the natural origin of the event, to justify the contention that the cause of the threat is out of human control and therefore requires the approval of exceptional measures	Section 5.2
Linguistic Mechanisms	*Terminology used*	Alarmist terms, exceptionality of the drought, contrast between 'normality' (average rainfall) and 'anomaly' (drought)	Creating sense of danger and exceptionality	Section 5.2
Linguistic Mechanisms	*Type of arguments*	Threats to domestic water supply; water use restrictions; damage to economic activities	Justifying the need to act immediately, in order to avoid damages to the society	Section 5.2
Institutional Mechanisms	*Regulatory tools adequacy*	Use of RD-Laws; Attribution of exceptional powers to the competent Authorities; declaration of general interest and urgency	Skipping regular procedures in the approval of legal changes and water works	Section 5.1 Section 6.3
Institutional Mechanisms	*Adequacy of measures*	Legal texts present measures that are not designed for giving relief from the on-going drought as emergency actions: e.g. water works that will be completed within several years; located in areas not affected by drought; or unrelated to drought.	Meeting goals not related to drought management	Section 6.1 Section 6.2 Section 6.4
Institutional Mechanisms	*Role of actors*	Nature as the main responsible for low water reserves. The State government is the main actor in decision making, budget allocation and execution of the measures. It shares some power with regional governments and agricultural users	Drought is a problem of the society as a whole and therefore the State has to mitigate its impact	Not presented in this paper

5.1. Using institutional mechanisms to securitize

Fischhendler (this volume) states that the exclusion of civil society and NGOs from governance using arguments of urgency and security is an 'institutional mechanism' of securitization. The use of exceptional legal instruments to deal with drought represents an example of this mechanism, even if a mild one (relative to other cases presented in this volume). Indeed, exceptional laws take drought management out of the track of regular policy making, in practice bypassing parliamentary debate and reducing the input from third parties having a stake in the decisions made.

RD and RD-Law have different purposes and different approval procedures. RDs normally deal with technical matters and regulate issues that can be addressed directly by the government; while RD-Laws are approved using exceptional procedures and have the ability to change other laws. The use of RD-Laws implies 'breaking the rules of normal politics' (Buzan et al. 1998) because they enable legal changes beyond the regular approval procedures. Here parliamentary debate is limited to acknowledging or rejecting the exceptional nature of the situation justifying the use of such a legal instrument, while no real debate is about the RD-Law measures is possible. RDs follow the normal path to regulate a specific issue, but the RDs analysed repeatedly use the 'urgent need to act' to justify the 'public interest declaration' of a large number of water infrastructures, thus decreasing accountability in public spending and leaving the people affected defenceless before the actions of the Authorities.

The government needs to prove that the situation addressed by the RD-Laws and RDs is 'extraordinary' and requires 'urgent measures' to face it. This characterization is at odds with the fact that prolonged droughts are a normal feature of Spain's climate. Indeed, deviations from that average are to be expected, even if it is not possible to predict when exactly they will occur. Brufao (2012) explains that, since 1947, dry spells of over two consecutive years have occurred every decade in most of Spain's large basins. Thus, drought seems to be the rule more than the exception that requires acting urgently and using extraordinary mechanisms. Moreover, the justification of urgency and exceptionality both for RD and RD-Law is based on the idea that low reserves and inability to meet water demands are exceptional situations. This seems to ignore that regions such as the Guadalquivir and Segura – two important targets of the exceptional laws – have more water demand than available resources even during times of average precipitation.

Thus, the use of exceptional laws for regulating a non-emergency situation can be seen as a securitization mechanism itself within the broad category of institutional tools. Additionally, the need to justify the use of exceptional laws has implications on the language and the arguments used in the characterization of drought and of the problems that the legal texts address.

5.2. Using linguistic mechanisms to securitize

Wilhite and Glantz (1985) recommend a distinction between conceptual and operational definitions of drought. Droughts are generally classified into meteorological, agricultural, hydrological and social droughts[37] (Mishra and Singh 2010). While meteorological drought is a natural phenomenon, social droughts are the result of the interaction between nature and water-related management decisions.

In the texts analysed, the description of drought moves back and forth between meteorological drought and the level of reserves (social drought) as if both had the same

[37] Meteorological drought is defined as lack of precipitation for a period of time; hydrological drought is a period with inadequate water resources for established uses; agricultural drought refers to a period with declining soil moisture and consequent crop failure; socio-economic drought is associated with failure of water systems to meet water demands (Mishra and Singh, 2010).

origin and intensity. In the texts, low reserves are always attributed to insufficient rainfall ('as it is logical', 'as a logical consequence', RD-Law 14/2009) and never to the high levels of demands or to management rules that are not able to increase or maintain the water reserve levels.[38] Most legal texts refer to the very low rainfall in 2004-05, when precipitation was the lowest registered since 1947, and indirectly attribute low reserves in the following four years to the impossibility to fully recover from that event, even if at the beginning of 2004-05 the reserves were 31% higher than average (RD-Law 8/2008).

The analysis of the discourse around drought helps to identify also a "*psychological drought*" (Brufao 2012), i.e. a feeling of public danger due to the fact that messages about droughts are often imprecise and alarmist,[39] The legal texts in all but two cases refer only to the level of reserves of surface water, ignoring that groundwater plays a key role in many regions of Spain both during wet and dry spells, due to its intrinsic resilience to drought (Brufao 2012). The legal texts use alarmist terms to stress the existence of an exceptional situation that justifies an urgent intervention by the State. Interestingly, RDs use less alarmist terms than the RD-Laws even if they are referring to the same situation (Table 2). A possible reason for this difference is that RDs do not need to pass any parliamentary validation as the RD-Laws.

Table 2 Terms describing the drought situation in the corpus of the laws.

	I	II	III	IV	V	VI	VII	VIII	IX
"Important climatic adversity"	✓					✓	✓	✓	✓
"Extreme climatic conditions"	✓					✓	✓	✓	✓
"Markedly atypical and deficient evolution"								✓	✓
"Extraordinary drought"		✓		✓					✓
"Persistence of the drought"						✓			
"Pluriannual drought"						✓			
"Intense drought"	✓		✓					✓	
"Extraordinary effect of this drought"	✓								
"Unusual impact"	✓								
"Seriousness/worsening of the situation"	✓	✓	✓	✓	✓	✓	✓	✓	
"Dramatic situation"					✓				
"Natural disaster"								✓	

Note: Column numbering corresponds to the laws numeration in the References. Note: Shaded columns indicate RD. Translated from Spanish by the authors.

6. Evidence and consequences of securitization

The main consequences of the securitization of drought are the approval of permanent changes in a contingent situation; approval of water-related works not linked to drought; abuse of the declaration of general interest; creation of economic advantages for some sectors; and lack of accountability of the Authorities for poor management of public funds.

[38] In Spain surface water reserves are used as the main indicator for social drought. However, reservoir reserves are largely a result of the Water Authorities' management decisions. For instance, if they (imprudently) decide to release a large volume of water for a given use despite the fact that the dry spell is forecast to continue, their decision could provoke a worsening of the drought.

[39] Referring to the idea of "psychological drought", Castro and Guijarro (2004) argue that most of the news about water in Spain are negative and alarming, for instance when media report that surface water reserves decrease during summer time. As the authors remark, "this is no news in itself, as in summer, with no rain and a sustained demand, the stored water volume has necessarily to decrease. The contrary would be a miracle and that would be a real news" (Castro and Guijarro 2004, translation from Spanish by the authors).

6.1. Approval of permanent changes in a contingent situation

The implementation time frame (short, medium or long period) and the permanence in time (temporary or permanent) of the approved measures were analysed. For most of the measures the time of validity is explicitly defined, which is in agreement with the transient nature of drought. This is the case for all the financial exemptions, granting special powers to River Basins Authorities, the establishment of special loans or allowing inter-basin water trade. Other measures, however, (a) will persist over time; and/or (b) will have an impact on water use only after the end of the emergency situation. These two characteristics raise questions about whether they should be approved under the umbrella of an emergency and reveal the use of a declared emergency to bypass regular approval procedures. We cite here three cases of permanent and long-term initiatives approved in exceptional laws.

Only one year after the start of the drought, RD-Law 9/2006 used the 'pluriannual drought' to justify a set of permanent legal changes in the Upper Guadiana aquifer in central Spain. In this aquifer, since the 1970s, intensive (and often uncontrolled) groundwater development for irrigation has contributed to the degradation of groundwater-dependent wetland ecosystems. Since the 1980s, Water Authorities have attempted to address overexploitation and its negative consequences using a wide array of measures (Martínez-Santos et al. 2008). The RD-Law states that the legal changes will 'reduce socio-economic tensions', 'ensure short term supply to towns and villages', and represent 'agile reply to the current problematic imposed by the drought'. These arguments are problematic as first, 'socio-economic tensions' have existed for decades before the 2005-2008 drought; second, aquifers are intrinsically resilient to drought and therefore the 'current problems' addressed by the RD-Law are not 'imposed by the drought'; third, RD-Law 9/2006 approves a socially sensitive transformation of private groundwater rights into public ones and the regulation of a much disputed public water bank. These measures do not suppose an immediate relief to the stress on the aquifer nor contribute to ensuring domestic supply, which are the stated objectives of the RD-Law.

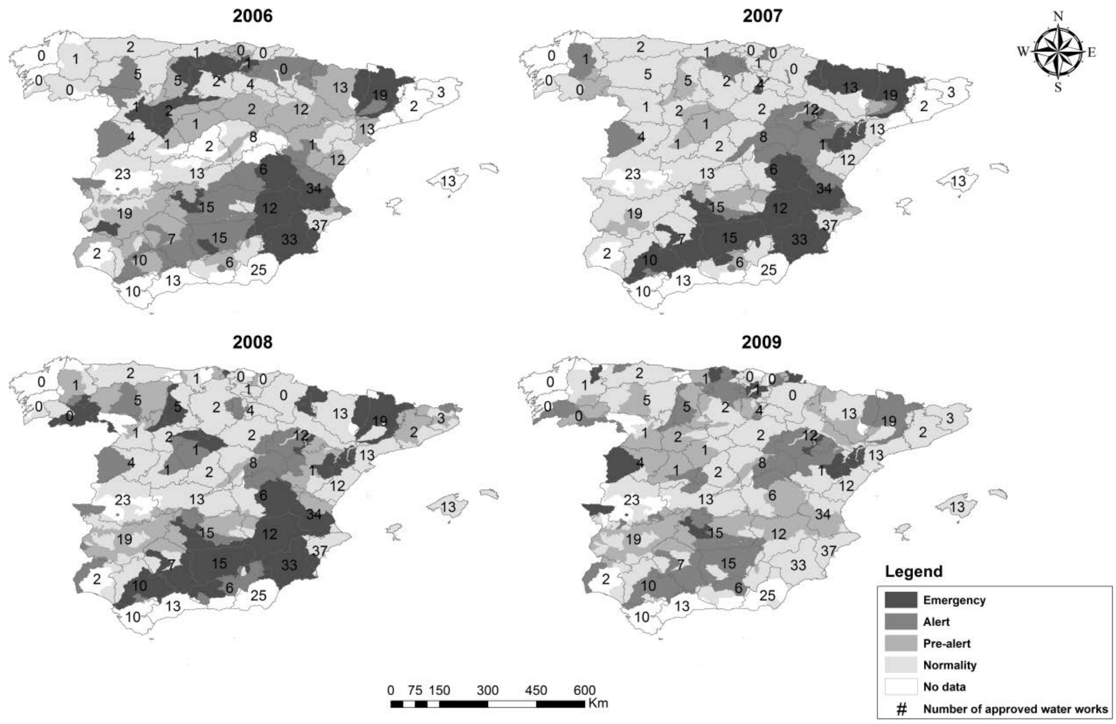
A second example of permanent changes is in RD-Law 15/2005, which authorizes the registration of water rights of large irrigation districts promoted by the State in the 1960s and which never received the corresponding administrative concession for water use. A reason behind this authorization is that the legislator wanted those irrigation districts to be able to participate in exceptional inter-basin water trade from the upper Tagus to the Mediterranean coast. These irrigated areas use almost 80% of Spain's total regulated surface waters and therefore their registration, even if desirable, has a lasting effect and should not have been done through hasty approval procedures but rather should be addressed in regular water management processes.

Finally, the execution of most of the water works included in the annexes of the analysed legal texts cannot be completed within a short time frame and is likely to span several dry-wet cycles. Thus, they should be approved within the normal planning process and not using a fast-track approval procedure or the declaration of urgency and the subsequent expropriation of private land. These works include the modernization of irrigation systems and the construction of desalination plants or new dams. This practice is not new. During Spain's 1991-1995 drought, the government approved by RD-Law some very controversial water works, including the construction of three disputed dams of Itoiz, Biscarrués (both in the Pyrenees) and Melonares (Andalusia), the regulation of the Sorbes river near Madrid, and the improvement of the water supply system to the city of Santander on the Atlantic coast (Brufao 2012). The execution of some of those works has been plagued by technical, social and economic problems and is not fully completed as of 2014, almost 20 years after their approval under exceptional and urgent procedures.

6.2. Approval of water-related works not linked to drought

Some water works are unrelated to drought either for their location or for their scope or both. The analysis of the geographical location of the approved measures shows evidence of the use of drought as a means to approve water infrastructures and implement them using urgency procedures. Approximately 46% (204 out of 441) of the infrastructures are located in Andalusia, Murcia and Valencia, where a situation of emergency due to drought was declared at least once during the period 2005-2008. Nonetheless, others are located in areas barely hit by drought according to the official drought indicators system (Figure 4), which foresees three possible levels of alert: 'Prealert', when there is no water shortage, but monitoring measures are increased; 'Alert', when limitations in water uses could be established; and 'Emergency', when the deterioration of water bodies should be minimized and water consumption restrictions are applied (Brufao 2012).

Fig. 4 Levels of drought severity by exploitation system and location of the approved water works



Note: The level of alert in a given polygon is the mode of the series of monthly alert levels. When the series had more than two modes, the most negative one was selected; based on the data of the official drought monitoring system; no data were available for 2005.

RD-Law 9/2007 declares the urgent occupation of land to allow the cleaning up of toxic sediments in the Flix reservoir (Ebro basin, North East of Spain). This reservoir contains high levels of trace metals and organochlorine pollutants due to the accumulation through decades of wastes from a chlor-alkali plant (Soto et al. 2011). Thus, it is difficult to justify its inclusion in a drought exceptional law and its approval using fast-track procedures instead of addressing it within regular water planning processes.[40] Some water works are for flood management (RD-Law 15/2005 and RD-Law 9/2007) and therefore are unrelated to the explicit objective of the legal texts where they are included (to regulate water trade transactions and to mitigate the effects of drought, respectively). Other water works include the expansion of irrigated land in already highly water-stressed areas. This is the case of new lands irrigated with recycled water

[40] Works for the cleaning up of the sediments started in 2013, six years after the approval of RD-Law 9/2007.

from the urban wastewater treatment plant in the town of Palma, in the Balearic islands (RD-Law 10/2005), or the increase of irrigated land in Murcia, on the Mediterranean coast (RD-Law 10/2005). In other cases (e.g. RD-Law 9/2007; RD-Law 10/2005), the annexes include a very generic description of the water works – 'modernization of irrigation system' or 'upgrade and modernization of irrigation system', 'desalination in Costa del Sol' (Mediterranean coast) - which makes it impossible to evaluate the consistency of the measure with the objectives of the Law.

6.3. Abuse of the declaration of general interest

The declaration of general interest of a large number of water works has consequences on the contracting procedures (urgency), on the administrative competences for their execution, and on the funding (Brufao 2012), as well as on the expropriation process associated to some water works. In such cases, the public Administration is entitled to expropriate a private property before defining the compensation value and reaching an agreement with the affected owner. RD 1265/2005 and RD 1419/2005 attribute temporary special powers to the presidents of River Basin Districts (RBDs) hit by drought allowing them to 'impose' the execution of emergency water works, and establish shorter than usual deadlines for public consultation and hearing of third parties affected by the works. These special powers and the above-mentioned declaration of general interest contribute to shortcutting the debate about adequacy of the measures, and the budget executed is subject to little, if any, public scrutiny.

Even if it is not accompanied by a declaration of general interest, it is worth mentioning that RD-Law 15/2005 and its subsequent extensions (RD-Law 9/2006, RD-Law 9/2007, RD-Law 8/2008 and RD-Law 14/2009) use drought as an argument to allow water export from two basins – Tagus and Guadalquivir – to other regions, thus overriding the water exploitation rules established by Law in the water management plans of both basins. Interestingly, since inter-basin water trade started, there have been intense negotiations between users and the State to make that exception a rule.

6.4. Creation of economic advantages for some sectors and unaccountability for management shortcomings

RD-Laws create economic advantages for users affected by water restrictions, who are exempt from payments for water use even if water rights do not create an obligation for the Water Authority to ensure the availability of water. Especially striking is the case of the exemption from payment of water-transfer fees applied to the users of the Tagus-Segura transfer (Hernández-Mora et al. 2014). RD-Law 15/2005 authorizes the exceptional use of the Tagus-Segura aqueduct for water trade between users of both basins and establishes that the applicable economic conditions are those defined by law. Nonetheless, since 2006, the extensions of RD-Law 15/2005 state that those conditions have provoked 'unexpected and important imbalance' in the 'commercial operations' of the recipients of the traded water and that the State has to compensate for those impacts. Two aspects should be stressed here. On one hand, the RD-Law extensions in 2007, 2008 and 2009 state that 'important imbalance' are 'unexpected': but how can the imbalance be unexpected if it has occurred every year since the trade approval? On the other hand, each law extension, after acknowledging the 'imbalance', extends the authorization for inter-basin water trade for one more year, thus maintaining the economic burden of the trading transactions on the tax-payer.

RD-Law 10/2005 and RD-Law 9/2007 establish the exemption from paying water transfer fees for an emergency water transfer from Tagus to the Daimiel wetlands (Upper Guadiana) arguing that the effectiveness of the transfer had been poor.[41] The RD-Laws do not explain the reasons for this poor effectiveness but establish that the State should pay for it. Possible causes could be that water infiltrated into the aquifer before reaching the wetland (the transfer was made through a river) or was captured by water users on its way to the wetland, suggesting inadequate management decisions or their poor implementation.

7. Securitization and Spain's water paradigms

Section 2 described three main water paradigms present in Spain's water policy context. *How do the exceptional laws fit into that context? What paradigm do they reflect and how do they reinforce it?*

From the analysis of the exceptional laws a water paradigm emerges that considers water as a scarce and cheap resource, key to ensuring Spain's economic development. Economic development is jeopardized by water scarcity and therefore increasing water availability (or at least ensuring no shortage of it) becomes an issue of public interest. The securitization of the discourse – i.e. creating a sense of urgency and using fast-track approval procedures to approve water-related measures – contributes to strengthening that paradigm, as most of the approved interventions focus on ensuring sufficient and cheap (for the users) water resources for economic uses. The measures benefit the agricultural and domestic supply sectors, especially on the Mediterranean coast. This is an area that historically has claimed (and often obtained) that its natural water resources should be increased in order to fully exploit the advantages of its mild climate. The 2005-2008 drought comes at a time when the Ebro transfer has been ruled out and water actors are debating about the future of water management in Spain.

From this perspective, drought becomes an opportunity, rather than a trigger, to spur the implementation of solutions already present in Spain's water debate before the drought. This is evident in the case of water markets. These were introduced in the 1999 reform of the Water Act but had been barely implemented. Something similar happens with the modernization of irrigation systems, which was on the policy agenda since 1993 draft NHP and the 2002 National Irrigation Plan (NIP), and whose implementation is jumpstarted using drought as a justification.

The paradigm spurred by exceptional drought laws borrows water management objectives from the traditional and regionalist paradigms, as they both present water as a limiting factor for socioeconomic development and advocate making cheap water available for water users. The measures to achieve this objective are carefully selected, so that they do not clash with regional interests: they do not take water from one region to another and, when they do (Tagus-Segura transfer), the users directly affected are largely compensated for their water. At the same time, they include solutions supported by the NWC movement when arguing against the Ebro transfer (Arrojo 2003), thus making it somehow more difficult for environmentalists to oppose them. The NWC paradigm, however, supports cost-effective analysis of management measures, full recovery of the cost of water services provided to water users, and considers transparency and accountability as key elements of good water governance. This is barely present in the water paradigm emerging after the derogation of the Ebro transfer. The securitization of drought helps eluding cost recovery and accountability, as it allows for the approval of new large public spending and legal changes, with little debate and no public scrutiny of their outcome. The resulting paradigm promotes new, State-subsidized technological and market solutions to old water claims, thus leaving the substance of water policy unchanged. This is in line with the considerations by Tábra and Ilhan (2008, p. 70), who

[41] The transfer of surface water was used to bring temporary relief to those wetlands suffering from intense groundwater exploitation in their recharge area.

observe that the NWC was “able to readdress some of the worst outcomes of the business-as-usual water policies” but was “not able to develop the necessary encompassing changes in the power structures”.

8. Conclusions

The analysis of the discourse in the exceptional laws approved during the 2005-2008 drought in Spain shows a securitization of the water discourse through linguistic and institutional mechanisms. This is an example of *creeping securitization* - rarely considered in the literature. Creeping securitization is distinctive as a) it frames water issues in a context of overstated urgency to act, in order to achieve a preset policy agenda; and b) it is not associated with a threat of violence or war, but rather with gloomy forecasts of unquantified consequences in case of inaction.

The characterization of drought as an extraordinary event with exceptional impacts, despite being an inherent feature of Spain’s climate, and without providing data about the magnitude of those impacts, is evidence of the use of language for securitization purposes. Moreover, the characterization of drought emphasizes the climatic component of drought, minimizing the importance of water management decisions in creating or exacerbating scarcity problems.

Institutional mechanisms are related to the use of RD-Laws. The use of exceptional instruments is not justified, because drought is not an extraordinary event and because many of the water works included in the approved laws (e.g. upgrade of irrigation systems, desalination plants) cannot give immediate relief nor address the urgency situation described, as their implementation timeframe exceeds the duration of the drought episode. These measures should be included in regular water resources planning. Thus, the exceptional laws are used to bypass the normal procedures in decision-making process,

The discourse in these exceptional laws is anchored in the hydraulic and regionalist water paradigms, which aim at maintaining economic development at the lowest cost for the user pursued through technological measures and water trade. The policy frame analysis also shows that securitizing drought enables the approval of legal changes and additional public spending and eludes accountability and cost recovery by the users. When the securitization mechanisms are framed in the context of the existing water paradigms, the analysis contributes to identify the implications of securitization and the vested interests supported by such securitization.

ACKNOWLEDGMENTS

The authors are thankful to Maria Bustelo, Ana M. Pérez Camporeale and Carolina Garcés for their methodological advice; to Mario Ballesteros and Mario Valle for their help with the graphic material; Jill Simon for her linguistic edits and Itziar González Tánago for her useful comments. The manuscript benefited from valuable comments of two anonymous reviewers and the journal editor. The study was undertaken in the framework of the EU-funded project “Fostering European Drought Research and Science-Policy Interfacing” (DROUGHT R&SPI).

REFERENCES

Albiac, J., Hanemann, M., Calatrava, J., & Uche, J. (2006). The Rise and Fall of the Ebro Water Transfer. Natural Resources Journal, 46 (3), 727-757.

Arrojo, P. (2003). Spanish National Hydrological Plan: Reasons for its Failure and Arguments for the Future. Water International, 28(3), 295-302.

Brufao Curiel, P. (2012). El régimen jurídico de las sequías: crítica a la regulación extraordinaria y urgente de un fenómeno natural y cíclico propio del clima. Revista de Administración Pública, 187(1), 199–239.

Buzan, B., Waever, O., & de Wilde, J. (1998). Security: A new framework for analysis. Boulder, CO: Lynne Rienner Pub.

Castro A., & Guijarro, L. (2004). La sequía en los medios de comunicación. La sequía en España. Directrices para minimizar su impacto. In Comité de Expertos en Sequías; Ministerio de Medio Ambiente (pp. 235-293) Madrid: MMA.

De Stefano, L., & Hernández-Mora, N. (2012). Water Planning and Management after the EU Water Framework Directive. In: L. De Stefano & M.R. Llamas (Eds.). Water, Agriculture and the Environment in Spain: can we square the circle? (pp. 35-44). RCR Press – Taylor and Francis.

Directive 2000/60/EC of the European Parliament and of the Council establishing a framework for the Community action in the field of water policy (EU Water Framework Directive), 2000 Official Journal (L 327) (EC).

Downward, S. R., & Taylor, R. (2007). An assessment of Spain's Programa AGUA and its implications for sustainable water management in the province of Almería, Southeast Spain. Journal of Environmental Management, 82(2), 277-289.

Drought Emergency Plans for cities of over 20,000 inhabitants (Article 27, section 3, Law 10/2001, of July 5th, of National Hydrological Plan).

Estrela, T., & Vargas, E. (2012). Drought Management Plans in the European Union. The Case of Spain. Water Resources Management, 26(6), 1537–1553.

Feitelson, E., Tamimi, A., & Rosenthal, G. (2012). Climate change and security in the Israeli–Palestinian context. Journal of Peace Research, 49(1), 241-257.

Fischhendler, I. (2015). The securitization of water discourse: theoretical foundations and research gaps. (in this volume)

Fischhendler, I., & Katz, D. (2012). The use of «security» jargon in sustainable development discourse: evidence from UN Commission on Sustainable Development. International Environmental Agreements: Politics, Law and Economics, 13(3), 321-342.

Fischhendler, I., Dinar, S., & Katz, D. (2011). The Politics of Unilateral Environmentalism: Cooperation and Conflict over Water Management along the Israeli-Palestinian Border. Global Environmental Politics, 11(1), 36-61.

Garrido, A., & Llamas, M.R (2009). Water Management in Spain: an example of changing paradigms. In Dinar & Albiac (Eds.). Policy and Strategic Behaviour in Water Resource Management (pp. 125–144). London: Earthscan.

Garrido, A.; Rey, D.; & Calatrava, J. (2012). Water trading in Spain. In De Stefano, L & Llamas, M.R (Eds.). Water, Agriculture and the Environment in Spain: can we square the circle? (pp. 205-216) CRC Press– Taylor and Francis.

Goffmann, E. (1974). Frame Analysis. An essay on the organization of experience. Cambridge, MA, US: Harvard University Press

Graeger, N. (1996). Environmental security?. Journal of Peace Research, 33(1), 109–116.

Guba, E., & Lincoln, Y. (1989). Fourth generation evaluation. London, UK: Sage.

Hernández-Mora, N., del Moral, L., La Roca, F., La Calle, A., & Schmidt, G. (2014). Interbasin Water Transfers in Spain: Inter-regional Conflicts and Governance Responses. In G. Schneier-Madanes (Ed.), Globalized water. A Question of Governance (pp. 175-196). Dordrecht: Springer

Instituto Nacional de Estadística -INE (2013). Cifras de Población y Censos Demográficos. http://www.ine.es/jaxi/menu.do?type=pcaxis&path=%2Ft20%2Fp321&file=inebase&L=0. Accessed 15 September 2013.

Katz, D. (2011). Hydro-Political Hyperbole: Examining Incentives for Overemphasizing the Risks of Water Wars. Global Environmental Politics, 11(1), 12-35.

Law 10/2001, of July 5th, of National Hydrological Plan.

Law 11/2005, of June 22nd, for the modification of the Law 10/2001 of July 5th, of National Hydrological Plan.

Law 29/1985, of August 2nd, of Water (Water Act) (In force till July 25th 2001).

Llamas, R. (1997). Consideraciones sobre la sequía de 1991 a 1995 en España. Ingeniería del Agua. Vol.4 Num.1 pp. 39-50.

Lopez-Gunn, E. (2009). Agua para todos: A new regionalist hydraulic paradigm in Spain. Water Alternatives 2 (3), 370-394.

López-Gunn, E., & De Stefano, L. (2014). Between a Rock and a Hard Place: Re-defining Water Security, Decentralisation and the Elusive 'Water Pact' in Spain. In D. E. Garrick, G.R.M. Anderson, D.Connell, J. Pittock (Eds.). Federal Rivers. Managing Water in Multi-Layered Political Systems. (pp. 158-176). Northampton: Eduard Elgar.

Ludwig, R., Roson, R., Zografos, C., & Kallis, G. (2011). Towards an inter-disciplinary research agenda on climate change, water and security in Southern Europe and neighbouring countries. Environmental Science and Policy, 14(7), 794–803.

Martínez-Santos, P., De Stefano, L., Llamas, M. R., & Martínez-Alfaro, P. E. (2008). Wetland Restoration in the Mancha Occidental Aquifer, Spain: A Critical Perspective on Water, Agricultural, and Environmental Policies. Restoration Ecology, 16(3), 511–521.

Ministerio de Medio Ambiente, Medio Rural y Marino-MMA (2008). Gestión de la sequía de los años 2004 a 2007. Estrela, T y Rodriguez Fontal, A (coord.). Madrid.

Mishra, A. K., & Singh, V. P. (2010). A review of drought concepts. Journal of Hydrology, 391(1–2), 202-216.

Order MAM/698/2007, of March 21st, for the approval of Special Drought Management Plans for the territory of the inter-regional river basins.

Royal Decree - Law 10/2005, of June 20th, through which urgent measures are adopted to palliate damages produced in the agricultural sector by drought and other climatic adversities (Law I).

Royal Decree - Law 14/2009, of December 4th, through which urgent measures are adopted to palliate the effects produced by drought in specific river basins (Law IX).

Royal Decree - Law 15/2005, of December 16th, urgent measures for the regulation of transactions of water use rights (Law III).

Royal Decree - Law 8/2008, of October 24th, through which urgent measures are adopted to palliate the effects produced by drought in specific river basins (Law VIII).

Royal Decree - Law 9/2006, of September 15th, through which urgent measures are adopted to palliate the effects produced by drought in urban settlements and in irrigated farms in specific river basins (Law VI).

Royal Decree - Law 9/2007, of October 5th, through which urgent measures are adopted to palliate the effects produced by drought in specific river basins (Law VII).

Royal Decree 1265/2005, of October 21st, through which exceptional administrative measures are adopted for the management of hydraulic resources and to correct the effect of drought in the Jucar, Segura and Tagus river basins (Law II).

Royal Decree 13/2008, of January 11th, for the approval of the Upper Guadiana Special Plan.

Royal Decree 1419/2005, of December17th, through which exceptional administrative measures are adopted for the management of hydraulic resources management and for correcting the effects of drought in the Guadiana, Guadalquivir and Ebro river basins (Law IV).

Royal Decree 287/2006, of March 10th, through which urgent works of improvement and consolidation of irrigation are regulated, in order to obtain an adequate water saving that palliates the damages provoked by drought (Law V).

Royal Decree 329/2002, of April 5th, for the approval of the National Irrigation Plan.

Saurí, D. & Moral del, L. (2001). Recent developments in Spanish water policy. Alternatives and conflicts at the end of the hydraulic age. Geoforum 32(3), 351–62.

Schmitt, C. (1985). Political theology: Four chapters on the concept of sovereignty. Cambridge, MA: MIT Press.

Sonnett, J., Morehouse, B. J., Finger, T. D., Garfin, G., & Rattray, N. (2006). Drought and declining reservoirs: Comparing media discourse in Arizona and New Mexico, 2002–2004. Global Environmental Change, 16(1), 95-113.

Soto, D. X., Roig, R., Gacia, E., & Catalan, J. (2011). Differential accumulation of mercury and other trace metals in the food web components of a reservoir impacted by a chlor-alkali plant (Flix, Ebro River, Spain): Implications for biomonitoring. Environmental Pollution, 159(6), 1481-1489.

Stetter, S., Herschinger, E., Teichler, T., & Albert, M. (2011). Conflicts about water: Securitizations in a global context. Cooperation and Conflict, 46(4), 441-459.

Swyngedouw, E. (1999). Modernity and hybridity: Nature, regeneracionismo, and the production of the Spanish waterscape. Annals of the Association of American Geographers, 89(3), 443-465.

Swyngedouw, E. (2007). Technonatural Revolutions: The Scalar Politics of Franco's Hydro-Social Dream for Spain, 1939-1975. Transactions of the Institute of British Geographers, 32(1), 9-28.

Tàbara, J. D., & Ilhan, A. (2008). Culture as trigger for sustainability transition in the water domain: the case of the Spanish water policy and the Ebro river basin. Regional Environmental Change, 8(2), 59-71.

Verloo, M. (2005). Mainstreaming gender equality in Europe. A critical frame analysis. The Greek Review of Social Research, 117(B), 11-34.

Vicente-Serrano, S. M., & Cuadrat, J. M. (2007). North Atlantic oscillation control of droughts in north-east Spain: evaluation since 1600 a.d. Climatic Change, 85 (3-4), 357–379.

Warner, J. F., & Zeitoun, M. (2008). International relations theory and water do mix: A response to Furlong's troubled waters, hydro-hegemony and international water relations. Political Geography, 27(7), 802-810.

Wilhite, D. A., & Glantz, M. H. (1985). Understanding: the Drought Phenomenon: The Role of Definitions. Water International, 10(3), 111-120.

Williams, M. C. (2003). Words, images, enemies: Securitization and international politics. International Studies Quarterly, 47(4), 511–531.

4.2. La percepción de la sequía y respuesta de los agricultores de regadío

Urquijo, J., & De Stefano, L. Perception of drought and local responses by farmers: a perspective from the Jucar River Basin, Spain. *Water Resources Management*. (DOI: 10.1007/s11269- 015-1178-5)

Estado: Aceptado en octubre 2015

Perception of drought and local responses by farmers: a perspective from the Jucar River Basin, Spain

Julia Urquijo* & Lucia De Stefano

Departamento de Geodinámica,

Facultad de Ciencias Geológicas,

Universidad Complutense de Madrid

C/ José Antonio Novais, 12, 28040, Madrid, Spain

(*) Corresponding author

Abstract

Farmers play a key role in water management at all levels and their role becomes even more relevant during droughts, when water systems are under increased pressure. This paper presents a study based on interviews to farmers in eastern Spain using different types of water sources, to explore how that factor determines perceptions and actions during droughts. Results show that farmers often perceive droughts through non-climatic factors, e.g. the volume of water stored in the reservoirs or water restrictions, rather than through meteorological parameters. The type of water source highly influences farmers' perception of drought and the type of strategies implemented to face it, confirming the key role of groundwater in buffering drought. In areas using surface water, practices to mitigate impacts include temporary changes in cropping practices, temporary modification of water distribution shifts or the use of emergency wells. In areas irrigated with different water sources – groundwater, reclaimed water – farmers' actions address mainly permanent water scarcity problems and their concerns are focused on the long term viability of their activity – in terms of cost of water or water quality – rather than on variability of rainfall. Both in surface and groundwater-based irrigation areas, local responses often require close cooperation among users, as they may involve redistributing the available resources, sharing extra costs, or combining water from different sources to achieve the desired water quality.

Key words: drought, perception, farmers, responses, irrigation community, vulnerability

Introduction

"Perception refers to a range of judgments, beliefs and attitudes" (Taylor et al 1988, p. 152) and, in the case of drought, it is influenced by the characteristics of the dry spell as well as by the context of whom experiences it (Patt and Schröter 2008; Dessai and Sims 2010; Higginbotham et al. 2014). Thus "drought means different things to different people, and there are probably as many definitions as there are users for water" (Heathcote 1969, p. 176).

The diversity of drought definitions makes it important to understand stakeholders' perception of it, as that will influence their actions and their acceptance of mitigation actions (Giordano and Vurro 2010; Stoutenborough and Vedlitz 2014). Moreover, understanding people's perception can help identifying barriers to behavioural changes that are needed to achieve sustainable water management (Dessai and Sims 2010) and it is a necessary condition for the effective formulation and implementation of policies (Patt and Schröter 2008; Sherval and Askew 2012).

The first studies of drought perception were developed by Saarinen (1966) in Australia, and by Heathcote (1969) and Taylor et al (1988) in the USA. Since then, a number of studies have been undertaken in those two countries (Raphael et al. 2009; Sherval and Askew 2012; Higginbotham et al. 2014; Diggs 1991; Dagel 1997; Keenan and Krannich 1997; Woudenberg et al. 2008; Knutson et al. 2011), in Africa (e.g. Slegers 2008; Patt and Schröter 2008; Noemdoe et al. 2006), Asia (e.g. Habiba et al. 2012; Mehta 2001), and Europe (e.g. Dessai and Sims 2010; Giordano and Vurro 2010). In Spain, Morales Gil et al. (2000) analysed the perception of drought by the Spanish society, while Ortega-Reig et al. (2014) studied farmers' perception of drought as part of a research on conjunctive water use and drought management. March et al (2013) focussed on the perception of drought in the city Barcelona, while other Spanish authors (e.g. Ruiz Sinoga and León Gross 2013) study drought perception through the analysis of mass media.

Most of these studies focus on the analysis of differences in drought perception within a given group of water users, mainly among different types of farmers (e.g. rangers, Dagel 1997; irrigated vs non-irrigated farmers, Habiba et al. 2012), different geographic locations (rural – coastal areas, Higginbotham et al. 2014) or different farming methods (Knutson et al. 2011). However, few previous works have been found that explore how the type of water source influences drought perception and response practices and even less have used in-depth interviews as a means to let water users guide the researcher to those themes and concerns that are relevant to them.

This paper aims at filling this gap by using in-depth interviews to explore drought perception among farmers that use different water sources in the Jucar River Basin District (JBRD, eastern Spain). The study also provides insights into individual and collective response to drought, thus complementing existing studies that focus mainly on governmental response to drought. Moreover, it also offers empirical evidence about what factors influence farmers' vulnerability to drought, which is critical information when designing vulnerability assessments (González Tánago et al. 2015).

The Study Area

The JRBD (42,989 km^2) has a permanent population of 5.1 million people and stretches over four regions (Valencia, Castilla-La Mancha, Aragón and Catalonia). The Jucar River Basin Organization (JRBO) is the main governmental agency responsible for water management and is in charge of developing and implementing the River Basin Management Plan and the associated Drought Management Plan (DMP).

According to the JRBO (CHJ 2014), the average annual precipitation is 485 mm and the total renewable water resources are 3,842 Mm^3/yr. Reused water amounts to approximately 146 Mm^3/yr, while desalinated water is about 3.5 Mm^3/yr. The JRBD also receives 50 Mm^3/yr from other basins, to supply several urban areas on the Mediterranean coast.

The main economic activities in the area are related to tourism and agriculture, with over 380,000 hectares under irrigation dedicated mainly to citrus (42% of the total irrigated area), vegetables (11%), grain cereals (10%) and vineyard (9%). Agriculture employs 81,000 people and generates approximately 3% of the total Gross Value Added of the JRBD.

Total gross demand for agriculture is 2,512 Mm^3/yr (or 79% of the total demand). Over 53% of water resources for agriculture are surface water, while 43% is withdrawn from aquifers and only 2.6% are treated wastewater. About 36% of the irrigated area uses flood irrigation, while drip irrigation accounts for 38% and sprinkle irrigation accounts for near 25% of the total irrigated area (CHJ 2014).

This study focuses on two main irrigation areas: (i) an area of surface water irrigation that receives water from the Júcar and Turia rivers; (ii) an area of groundwater irrigation in the watershed of the Vinalopó river (Figure 1). Within these two areas, we studied seven Irrigation Communities (ICs), whose main characteristics are summarised in Table 1.

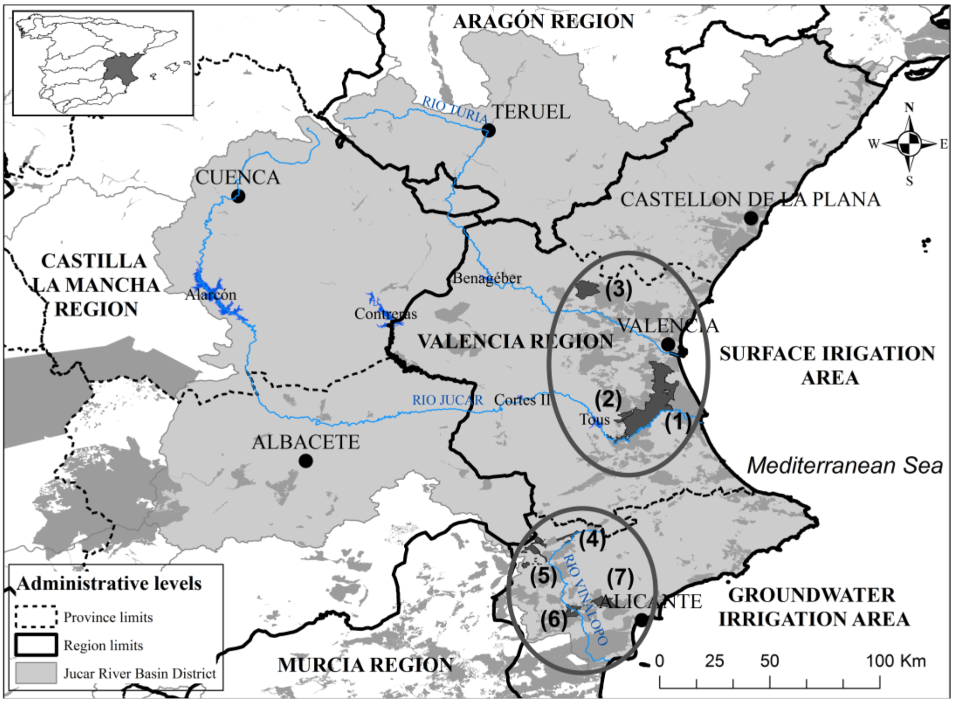


Figure 1. Location of the Irrigation Communities: (1) Acequía Real del Júcar, (2) Canal Júcar – Turia , (3) Casinos, (4) Benejama, (5) Villena, (6) Novelda, (7) Agost.

Table 1. Main characteristics of the Unit of Agricultural Demand (UAD) where the ICs are located (CHJ 2014).

Irrigation Community	Unit of Agricultural Demand	Irrigated area (ha)	Main water use	Allocation (Mm^3/yr)	Water sources in 2009 (Mm^3/yr)	Irrigation methods in 2009 (%)	Average net demand ($m^3\ ha^{-1}\ yr^{-1}$)	Main crop types (%, average net demand in $m^3\ ha^{-1}\ yr^{-1}$)
Acequía Real del Júcar (ARJ)	Regadíos Tradicionales del Júcar - Acequía Real del Júcar y AC particular de Antella	20,329	Agriculture	224.3	SW= 223.95 GW = 0.05 Other = 0.3	Flood: 94 Drip: 6	5,282	Citrus (67%- 4.050), rice (22% - 9.400), vegetables (11%- 4.600)
Canal Júcar Turia M.D (CJT)	Regadíos del Canal Júcar Turia M.D.	10,888	Agriculture and Urban Supply	94.29	SW= 80.15 GW= 14.14	Flood: 46,35 Drip: 53.65	3,972	Citrus (55%- 4.050), Fruit trees (39% - 4.050), vegetables (6%- 2.744)
Casinos	Regadíos del Canal del Campo del Turia	18,470	Agriculture	89.50	SW= 40 GW= 49.5	Flood: 29 Sprinkle: 1 Drip:70	3,324	Citrus (70,3% - 3.568); Fruit trees (11,7% -2.016); Other crops (18%-3.219)

Irrigation Community	Unit of Agricultural Demand	Irrigated area (ha)	Main water use	Allocation (Mm^3/yr)	Water sources in 2009 (Mm^3/yr)	Irrigation methods in 2009 (%)	Average net demand (m^3 ha^{-1} yr^{-1})	Main crop types (%, average net demand in m^3 ha^{-1} yr^{-1})
Benejama	Riegos Mixtos del Alto Vinalopó	917	Agriculture	3.32	SW= 1.96 GW= 0.73 Reused= 0.63	Flood: 4 Drip: 96	1,963	Olive trees (35,7%- 686), Vineyard (wine) (20,1%- 1.650), cereals (12,4% - 2.650), vegetables (11,5%- 5.450); Fruit trees (11,1% - 1.350); Other crops (9,3% - 3.030);
Villena (VIL)	Riegos Subterráneos del Alto Vinalopó	13,198	Agriculture	27.67	SW= 0,3 GW= 27.08 Reused= 0.29	Flood: 23.7 Sprinkle: 25.6 Drip: 50.7	2,328	Olive trees (33,1 %- 686 , Vineyard (wine) (27,7%- 1.650), vegetables (16,3%- 6.812); Other crops (22,9% - 2.331);
Novelda	Riegos del Vinalopó Medio	10,890	Agriculture	29.63	SW= 0,5 GW= 26,31 Reused= 2.82	Sprinkle: 10 Drip: 90	2,658	Table grape (49,8 %- 3.100), Vineyard (wine) (21,3%- 1.650), Fruit trees (11,9%- 1,715); Other crops(17% - 3.292);
Agost	Riegos del Alicantí	2,963	Agriculture	13,12	SW= 0.07 GW= 6.03 Reused= 7.03	Flood: 55 Drip: 45	3,093	Table grape (25,4 %- 3.098), Fruit trees (21,9%- 2.162); Olive trees (13,4 - 1.410), Citrus (10,9%-4.186), Other crops (28,4% - 4.176);

Surface water irrigation farmers (SW) grow mainly fruit trees. The JRBO supplies surface water to the different irrigation areas by operating several reservoirs and distribution channels. During drought, the JRBO can apply water restrictions if needed to better meet water needs of all the users in the river basin. In these areas, farmland abandonment is a reason for concern and is attributed to the progressive decrease in plot size (due to the traditional land-heritage scheme) and the reduced benefits of traditional crops (García-Molla et al. 2013).

In the Vinalopó basin, farmers using mostly groundwater (GW) cultivate mainly vegetables, vineyard and olive trees and rely on a complex network of groundwater pumping stations and irrigation ponds to drip-irrigate their crops. Within the basin there is also a system of pipelines that transfer groundwater abstracted from wells in Upper Vinalopó to the middle Vinalopó. Intensive aquifer exploitation has caused the progressive decrease of water table levels and degradation of water quality, and is a major reason for concern among users and water managers (Rico Amorós 2002; López Ortiz and Melgarejo Moreno 2010).

Methodological approach

The analytical framework of this study is based on the elements that shape perception according to Taylor et al. (1988): Experience, Memory, Definition, and Expectation (Figure 2). We aim to understand not only farmers' *perception* of drought, but also their *behaviour* during drought as reflected in the measures they implemented. Due to space constraints and while acknowledging the important role of governmental actions in managing drought, this paper focusses only on farmers' individual and collective actions during dry spells.

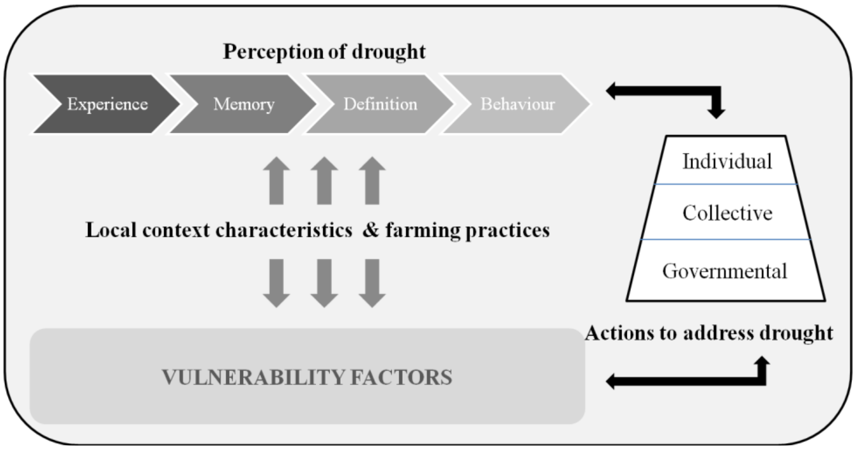


Figure 2. Conceptual framework (adapted from Taylor et al 1988)

Experience refers to the episodes of drought that have hit a given region. *Memory* refers to "those drought events that were part of the farmers direct experiences and could be recalled" (Taylor el at. 1988; p.154). As Heathcore (1969) explains, "not all water shortages are droughts, and, unless some economic setback results from the shortage, drought may not be recognized" (p. 176). This implies that farmers may not recall a drought episode, simply because it did not affect them. *Definition* refers to the way a drought episode is characterized by farmers using "a set of criteria (…) for classifying a time period as a drought" (Taylor el at. 1988; p.155). The analysis of drought definition contributes to understand why some events are remembered and others are not. *Behaviour* is captured through the type of measures implemented to address water shortages. Additionally we explore the *vulnerability* factors that influence such perception and farmers' concerns about the future. These elements were studied in both SW and GW ICs to detect whether and how the type of water source influences perception and behaviour during droughts.

The conceptual framework was applied through semi-structured in-depth interviews. This is a qualitative research technique considered to be a flexible, interactive and generative tool (Legard et al. 2003) that promotes the emergence of relevant themes during the fieldwork and allows researchers to explore a given issue through the personal experiences and opinions of the interviewees. The sample of interviewees was not chosen to seek a statistically representative sample of the studied population. As remarked by Mason (2010), the "sample size in the majority of qualitative studies should generally follow the concept of saturation (…), when the collection of new data does not shed any further light on the issue under investigation" (p.10). We met saturation after 24 in-depth interviews, which is also in line with the indicative number of interviews suggested by different authors for qualitative studies (Creswell 1998; Guest et al. 2006; Charmaz 2006). Generating quantitative data for statistical analysis – e.g. through a survey – and to complement the information obtained in the interviews proved to be unfeasible since no list of the irrigation communities was available for a random sampling of the participants.

Interviewees were selected in consultation with key informants in the study area, and included farmers (n=20) and irrigation technicians (n=4). Seventy-five percent of the interviewees worked in SW irrigation areas and 25% in areas where groundwater was the main water source. All the interviewees but two were male and their age ranged between less than 45 and over 75 years (<45, 21% of the interviewees; 46-55, 37.5%; 56-65, 16.5%; 66-75, 21%; >75, 4%). The interviews were carried out between June and July 2013 in the premises of the farmer associations or on the farmer's plot. They lasted between 1 and 2 hours and included ten open-ended questions (see Supplementary Material) to capture information on the analytical categories defined in Figure 2. Interviews ended when speech saturation was reached (Glaser & Strauss, 1967).

Interviews were tape-recorded, transcribed and coded for analysis and interpretation. Following Dagel (1997), we analysed the discourse of the interviewees using content and cluster analysis. Content analysis permits replicative extraction of perception data from qualitative communication, while cluster analysis allows the formulation of conclusions from those data.

Results and Discussion

Experience and Memory of Droughts

According to the DMP in the past thirty years the JRBD experienced four drought episodes: 1983/84 - 1985/86 (extreme), 1992/93 -1995/96 (extreme), 1997/98-2000/01 (mild) and 2004/05-2007/08 (extreme)[42] (CHJ 2007). This can be understood as the *experience* of drought in the area and can be compared with farmers' memory of drought events.

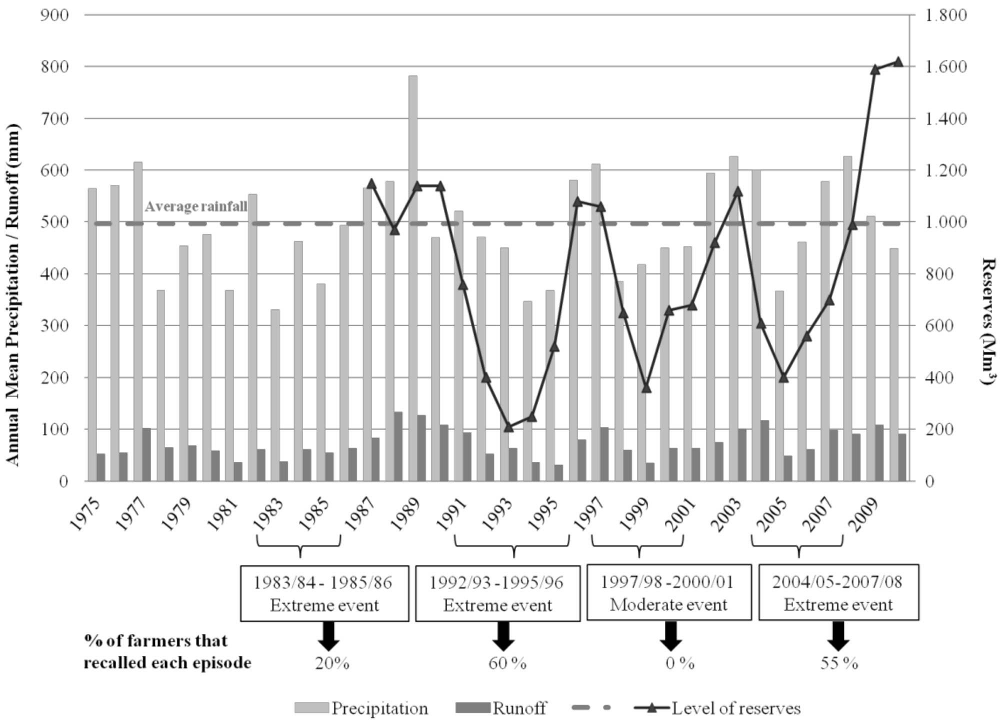


Figure 3. Precipitation, runoff and surface water reserves in the JRBD.

The memory of drought differs among farmers depending on their main water source . Only one of the interviewed GW farmers recalled suffering a drought. All the SW farmers stated having experienced at least one drought, 66% two, and only 20% of them recalled three episodes. Sixty percent of the interviewed farmers mentioned the 1992/96 drought, 55% the 2005-2008 drought and 20% the one in the 1980s. Thus, the most frequently-mentioned drought was the 1992-96 event and not the most recent one. This could be due to the fact that, according to several farmers, drought impacts were more severe in the 90s than in 2005-2008. This is in line with the fact that water reserves decreased more in the 90s than during the 2005-2008 drought, even if rainfall levels were similar in both events (Figure 3). The 1997/98-2000/2001 drought, classified by the JRBO as "mild", was not recalled by any of the interviewees, corroborating the idea that "intermediate years and droughts are lost from memory" (Saarinen 1966). The low number of farmers that recall

[42] The Júcar DMP defines drought as an "unpredictable extreme hydrological phenomenon that: entails a significant decrease in water resources during a sufficiently prolonged time period; affects a large area; and can impede fully meeting water demands and has adverse economic consequences". Drought severity is: Extreme (SPI< -1.65), Severe (SPI<-1.28), Moderate (SPI<-1.84).

the drought in the 1980s confirms that ”the farther the year in the past, the fewer identified it as a drought year” (Taylor et al. 1988; p. 160). Most of the interviewees had difficulties in determining the exact onset and end, or the duration of the drought episodes, which is consistent with the fact that drought is a creeping phenomenon (Wilhite and Glantz 1985).

Farmers' definition of drought

Farmers defined drought mainly as a time when they suffer negative impacts, meant as losses in agricultural production (55% of the interviewed farmers) or changes in their cropping practices due to water restrictions (65%). Among traditional SW farmers, changes in irrigation shifts are seen as a clear symptom of drought: they usually irrigate their plot every 20 or 25 days, while, during drought, irrigation shifts take place every 32 or even 40 days. Cropland fallowing and the risk of tree death were the most frequently mentioned impacts, followed by the reduction in quality and volume of agricultural production.

Dagel (1997) found that rangers often described drought as "when ranch operation is affected" (p.197), while other studies mention crop rotation or selection of crops, changes in crop and land management practices, diversification of farming activities and income sources (Slegers 2008; Habiba et al. 2012; Knutson et al. 2011). In our study, the role of impacts in the perception of drought is particularly evident in the case of GW farmers, who stated that they did not experience any drought as they never suffered temporary water shortage or impacts for lack of water: *"So far we have watered our fields every year"* (GW2)*; "So far we have had any problems related to whether it rains more or less because we pump groundwater"* (GW1).

The second most common way of referring to drought (50% interviewed farmers) is as a time when the level of water reserves in the reservoirs or the flow in the river (or in the irrigation channel) are low. Thus, these farmers perceived a hydrological drought, meant as "the effects of dry spells on surface or subsurface hydrology*" (*Wilhite and Glantz 1985, p. 115). This definition suggests that the visibility of the resource is a factor that influences drought perception and the attitude of farmers. On one hand, if the irrigation channels or reservoirs have low water levels, farmers will be aware of the problem and act accordingly. On the other hand, high water levels in the distribution channels or the riverbed due to releases from reservoirs may induce the wrong perception that reserves are abundant.

The third way of defining drought is as a time of low precipitation (25% of the interviewed farmers). Several farmers mentioned that the real problem is when there is a lack of rain during a couple of years, either locally or in the headwaters of the river. Some farmers seemed to confuse drought with intra-annual variability: "*Here we have drought every year from March to October because it never rains*" (SW5 and SW6). Other perception studies found that drought definition is more closely related to rainfall than to impacts. For example, Slegers (2008) found that 65% of the descriptions of drought referred to precipitation reduction.

These different ways of describing the same dry period confirm that drought is a relative concept, influenced by context and values at stake, and that drought perception has an impact on farmers' behaviour. The definitions used by farmers roughly correspond to socioeconomic drought, hydrological drought and meteorological drought (Wilhite and Glantz 1985), respectively. In particular, this study shows that impacts play a prominent role in shaping drought perception, and thus confirms the relevance of initiatives that record impact data (e.g. Drought Impact Reporter, Wilhite et al. 2007) and of studies looking for correlations between hydro-meteorological indicators and impact records (e.g. Bachmair et al. 2014; Blauhut et al. 2015). Indeed, linking drought severity thresholds and drought perceptions "could lead to more socially transparent definitions of drought severity thresholds and have a direct impact on drought-related policies and programs" (Smakhtin and Schipper 2008, p. 141).

Contextual factors influencing vulnerability

During the interviews, farmers mentioned several issues that determine or at least influence the vulnerability level that they experience during drought (Table 2).

Table 2. Factors influencing farmers' vulnerability to drought. % indicates the proportion of farmers that mentioned that topic during the interviews.

Vulnerability Factors	Description	% SW farmers	% GW farmers
Water quantity	Major reductions in water supply increase vulnerability to drought	93%	80%
Water quality	Higher water quality reduces vulnerability	40%	80%
Diversification of water source	When alternative water sources exist vulnerability to drought decreases	33%	80
Cost of water abstraction	High price of energy for groundwater abstraction increases vulnerability to economic losses	40%	60%
Type of irrigation system	Drip irrigation permits a more efficient use of water resources (relative to flood irrigation) and avoids spaced irrigation shifts	53%	80%
Type of crops	Vegetables are more vulnerable than fruit trees during short droughts; Fruit trees risk to dry during prolonged droughts, this may cause an irreversible damage; Rice is less vulnerable than other crops as in the area it is culturally and environmentally important	40%	--
Plots management	A correct maintenance and cleaning of plots and distribution network increase water use efficiency Soil types (e.g. clay and sandy) have different water infiltration and retention characteristics	53%	--
Plots location	Proximity to the main distribution channel and to protected wetlands increases water guarantee	20%	--

The amount of water available for irrigation is at the heart of the concerns of SW farmers. During dry spells, the RBO can impose restrictions on surface water use that are determined taking into account the existing water rights and the water availability in each exploitation system. As in the study area SW rights are often higher than the actual water needs, these restrictions does not always cause important impacts on SW farmers. GW farmers do not face water restrictions during droughts because aquifers buffer rainfall variability and because groundwater pumping is difficult to control. Their major concern, though, is water availability on the long term, due to the high level of aquifer overexploitation in the area.

Water quality is a major concern for GW farmers, as stated by one farmer of the Middle Vinalopó: "*Here we have water, if you dig a well you find water, but its quality is poor*", GW2). This induces some ICs to build their own treatment plant to enhance groundwater quality. Moreover, some GW farmers use treated wastewater, which has a rather poor quality. In contrast, in the study area SW farmers are reluctant to use other water sources because of their lower quality relative to surface water.

As remarked also by Wilhelmi and Wilhite (2002) and Knutson et al. (2011), the diversification of water sources is a key aspect in managing vulnerability to drought, as different sources are affected differently by rainfall variability. In the study area, SW farmers have little diversification of their water sources during average or wet periods. During drought, however, some of them get access to groundwater through common wells or get extra treated wastewater to complement the available surface water. On the contrary, GW farmers have developed a stable portfolio of water sources, including transferred groundwater and treated wastewater. For instance, the Agost IC, in the Middle Vinalopó, holds a water right to use 1.75 Mm^3 of treated wastewater from the coastal area, even if water has to be pumped 400 metres up to reach the plots of the IC. This entails an additional cost for farmers that increases the final price of water to about 0.5 €/m^3.

The use of each type of water has a different cost. For farmers using groundwater (GW farmers but also SW farmers during drought), the high cost of energy for operating the wells constantly acts as an incentive to optimize water use, as the energy bill can jeopardize the economic profitability of their crops: ”*Here, since water is expensive, we do not start the pumps if it is not necessary…If others paid the electricity bill, maybe we would pump more but, since that is not the case, we do not*” (GW1)˙ SW farmers, and especially those still using flood irrigation, are reluctant to use any alternative water source as “*Every alternative to the traditional channel system is more costly, thus we ask for treated water only when there is a drought*” (SW2).

Another recurring theme in the interviews is the type of irrigation system and, in particular, how the shift from flood to drip irrigation influences the level of vulnerability to drought. SW farmers that have already moved to drip irrigation assert that they need much less water than before and, most importantly, that they do not have to follow strict irrigation shifts, as their rate of water is available on demand.

The type of crop is another element that influences vulnerability to drought since different crops have different water needs (Knutson et al. 2011; Slegers 2008). In SW districts, vegetables are very vulnerable to drought, and they are not planted when there is no guarantee that water be available during the whole irrigation campaign. Several interviewees stated that they had decided to shift from vegetables to fruit trees after the 1995 drought because they had lost their entire vegetable harvest. The loss of trees, however, is seen as the major risk during prolonged droughts. Reduced fruit production due to water stress is another major reason for concern. Among fruit trees present in the area, kaki and citrus are more resilient to drought than peach trees, which are extremely sensitive to water shortage during the flowering and fruit setting seasons. Interestingly, rice was not seen as a very vulnerable crop despite its high water requirements. Indeed, supplying water for rice farming is always guaranteed because of the environmental role of rice ponds close to the Albufera wetland[43] and because rice is a traditional crop associated with high cultural values in the area.

Plots management practices (e.g. weeding) and the maintenance of the irrigation channels are two recurrent issues mentioned by SW farmers. Several authors remark that the characteristics of the soil has direct impact on its water holding capacity (Wilhelmi and Wilhite 2002; Slegers 2008; Knutson et al. 2011), and therefore influences the adaptation capacity of farmers. However, in our study only three farmers mentioned soil characteristics as a factor of vulnerability.

[43] The Albufera wetland is a freshwater lagoon with high biodiversity value, declared Natural Reserve and Ramsar site.

A recent systematic review of 46 drought vulnerability assessments (González Tánago et al. 2015) showed that most of the DVAs do not include the characteristics of water resources and of water uses among their vulnerability factors. This is in contrast with the picture resulting from our interviews to water users on the ground, which revealed that these are key determinants of vulnerability.

Local responses and adaptation to drought

The interviews led to the identification of 21 different types of practices implemented by farmers to mitigate or pre-empt problems associated with drought (Table 3). Measures can be grouped into three broad categories (demand management, supply management, user self-organization) and can be individual or collective. In the case of GW farmers, practices mentioned by the interviewees were presented as actions to face water scarcity rather than temporary water shortages.

Table 3. List of local strategies identified in the case study area

Measures: Category		Measures: Sub-category	Type of farmers (#)	Focus	Type of action	Timeframe
Reduction of demand	Changes in water and land use practices	Postponement of the start of the irrigation season	SW (3)	D	C	T
Reduction of demand	Changes in water and land use practices	Establishment of strict irrigation shifts and decrease of their frequency	SW(10)	D	C	T
Reduction of demand	Changes in water and land use practices	Cleaning of plots from weeds and irrigation of alternated furrows	SW(7)	D	I	T
Reduction of demand	Changes in water and land use practices	Emergency irrigation to ensure the survival of trees and field fallowing	SW(9)	D	I	T
Reduction of demand	Changes in water and land use practices	Connection of springs to the irrigation channel	SW(2)	D	I/C	T
Increase supply	Increase groundwater abstraction & use of non-conventional resources	Activation of existing drought wells and drilling of new ones	SW(13)	D	I/C	T
Increase supply	Increase groundwater abstraction & use of non-conventional resources	Maintenance of drought wells	SW(6) /GW(1)	D	I/C	P
Increase supply	Increase groundwater abstraction & use of non-conventional resources	Re-deepening of existing wells	GW(3)	D / WS	I	P
Increase supply	Increase groundwater abstraction & use of non-conventional resources	Increase in the use of recycled water	SW(2) /GW(2)	D/WS	C	T/P
Increase supply	Water transfers	Purchase of water from other irrigation communities	GW(2)	D / WS	C	P
Increase supply	Water transfers	Internal and external water transfers	GW(3)	WS	C	P
Increase supply	Improve efficiency	Improvements of distribution networks	SW(4) /GW(1)	D / WS	C	P
Increase supply	Improve efficiency	Shift to drip irrigation system	SW(4) / GW(2)	D / WS	I/C	P
Increase supply	Improve efficiency	Development of irrigation ponds system for water regulation	GW(3)	D / WS	C	P
Increase supply	Enhance quality	Improvement of wastewater treatment to increase reuse	GW(1)	D / WS	I/C	P
Increase supply	Enhance quality	Combination of different water qualities from different sources to improve water quality standards	GW(2)	D / WS	I/C	T
mic and organizational	Cost-sharing	Distribution of electricity costs among farmers	SW(1) / GW(2)	D	C	T/P
mic and organizational	Cost-sharing	Joint purchases of electricity to obtain lower prices	SW(1) /GW(1)	D / WS	C	P

	Self-organization	Strict enforcement of internal rules	**SW(4) /GW(1)**	**D**	**C**	**T/P**
		Strategic planning of the use of wells and irrigation ponds	**GW(2)**	**D / WS**	**C**	**P**
		Interfacing with the River Basin Authority to negotiate water restrictions (through the Permanent Drought Commission)	**SW(2) / GW(1)**	**D**	**C**	**P**

A first group of measures consist in actions to reduce water demand. The most common practice is the temporary decrease of the frequency of irrigation shifts. This strategy is implemented by SW irrigators based on collective decisions on how to manage water restrictions imposed by the JRBO. Other measures include postponing the start of the irrigation season, ridge maintenance and irrigation of alternated furrows (see also Ortega-Reig et al. 2014).

In the SW ICs, the progressive shifting from flood to drip irrigation systems has been promoted through the National Irrigation Program[44] issued in 2002 and the subsequent Plan for Irrigation Modernization[45], passed in 2006 to increase resilience to drought (among other stated objectives). The progress of modernization is slow and its outcomes have not yet been assessed. However, some studies evaluating the effects of modernization projects in other areas (e.g.; Gómez and Perez Blanco 2014; Soto- García et al. 2013; WWF/ADENA 2015) have found evidences of a rebound effect in water consumption.

A second group of actions is oriented to increasing water supply. During drought, SW farmers seek augment water availability by drilling and pumping drought wells with the support of the regional Government or the JRBO, or, to less extent, by using treated wastewater. Water supply measures are at the core of the strategies of groundwater users to face permanent water scarcity. They consist in optimizing the use of available resources through networks of water ponds, using highly efficient irrigation systems, re-deepening existing wells. When the IC's capacity to increase groundwater resources reaches the boundaries of economic viability, farmers seek other water sources, such as treated wastewater and surface water transfers. Combining different sources helps also addressing water quality problems. Thus, these measures represent a local adaptation strategy to allow cultivating vegetables and grapes every year, rather than only during dry spells.

A third group of measures implemented by both types of farmers is related to sharing electricity costs of groundwater abstraction. In the CJT IC (SW), when farmers pump groundwater into the distribution network during droughts they equally split the associated costs. In the Vinalopó area (GW) farmers also make a careful planning of their wells operations to optimize energy costs.

Most of the measures listed above require cooperation among farmers, both in GW and SW irrigation areas. This confirms that it is crucial for farmers to work jointly to effectively manage limited water resources. Cooperation, however, is not exempt from tensions and problems, especially in relation to surface water restrictions, when farmers, worried of losing their harvest or even their trees, vigorously complain to the watermaster about irrigation shifts and even withdraw water without authorization.

According to the interviews, connections between the measures implemented by the farmers and other actions promoted at RBD or national level are limited. Farmers barely mentioned the JRBD

[44] Royal Decree 329/2002, of 5th April, for the approval of the National Irrigation Plan

[45] Royal Decree 287/2006, Royal Decree 287/2006, of March 10th, through which urgent works of improvement and consolidation of irrigation are regulated, in order to obtain an adequate water saving that palliates the damages provoked by drought.

Drought Management Plan or the exceptional laws approved at national level to address drought (Urquijo et al. 2015). Their main concern regarding other management levels was their representation in the Drought Permanent Commission of the RBO. SW farmers were especially concerned about negotiations on water releases from the reservoir and how they would affect their production. GW farmers were concerned by the negotiation of measures to solve their problem of overexploitation. Interestingly, none of the interviewees mentioned the agricultural policy of the Valencian regional government, which has full competences on agriculture, as a factor influencing their farming activity.

Conclusion

Traditionally, drought research has focused mainly on physical aspects of the phenomenon and has rarely considered how it is actually perceived by water users on the ground. Our analysis showed that drought is far from being perceived in a homogeneous way among water users, even within the same river basin. Moreover, it revealed that, in parallel to the development of a response to drought by the water authorities, there are a number of local behaviours and decisions that influence the actual management of drought on the ground. It also confirmed that cooperation among users is key to mitigate and adapt to water variability.

This study has shown that vulnerability to drought is dynamic, and that technological and institutional solutions to increase flexibility in water availability are the main drivers of the evolution of vulnerability over time. Moreover, it has confirmed that the type of water source used for irrigation clearly affects vulnerability to drought and the response that farmers implement to face water shortages.

In-depth semi-structured interviews have allowed the study of drought starting from farmers' personal experience, since relevant topics were brought up by farmers during the interviews rather than being predefined by the researcher. This has produced a qualitative dataset that, where a random sampling of farmers is possible, could be complemented by a survey to combine qualitative and statistical analyses.

This paper aimed at shedding light onto the granularity of drought and drought response in a specific context, as an example of the value of undertaking also local studies in order to grasp the full picture of response to drought. We believe that showing these aspects can be useful for water management in at least four ways: a) it points to the value for water managers to combine the traditional hydro-climatological perspective of drought with the analysis of its social aspects, as a way of better understanding what happens on the ground and which intangible factors can influence the behaviour of water users; b) it leads to the identification of vulnerability factors that are relevant to water users but that often are not considered in drought vulnerability assessment (e.g. type of water source, sources diversification, water quality). This information can help better tailor strategies and policy options to the actual needs of water users on the ground; c) it highlights which impacts play a significant role in defining drought, thus underscoring the value of current incipient efforts in creating inventories of drought impacts; and d) it strengthens the idea that governmental actors need to reach out to users and effectively communicate with them in order to enhance coordination and coherence of drought response.

Acknowledgements

The authors are grateful to all the farmers that shared their knowledge on drought and farming. Special thanks are due to Acequía Real del Júcar and Junta Central de Usuarios del Vinalopó; to María del Carmen Morales; and to José Vicente Richart Diaz. Prof. Joaquín Andreu and Dr. David Haro Monteagudo contributed to the initial design of this work and Mario Ballesteros helped with the graphic material. Thanks also to Itziar González Tánago and Mario Valle for their helpful comments. The study was undertaken in the framework of the EU-funded project ‘‘Fostering European Drought Research and Science-Policy Interfacing’’ (DROUGHT R&SPI, contract no. 282769).

References

Bachmair S, Kohn I, & Stahl K (2014) Exploring the link between drought indicators and impacts. Nat Hazards Earth Syst Sci Discuss 2(12), 7583-7620.

Blauhut V, Gudmundsson L, Stahl K (2015) Towards pan-European drought risk maps: quantifying the link between drought indices and reported drought impacts. Environ Res Lett 10(1), p.014008

Charmaz K (2006) Constructing grounded theory: A practical guide through qualitative analysis. Thousand Oaks, CA: Sage.

CHJ Confederación Hidrográfica del Júcar- CHJ (2014). Plan Hidrológico de cuenca de la Demarcación del Júcar 2009 – 2015. Confederación Hidrográfica del Júcar (Available at http://www.chj.es/es-es/medioambiente/planificacionhidrologica/Paginas/PHC-2009-2015-Plan-Hidrologico-cuenca.aspx)

Creswell J (1998) Qualitative inquiry and research design: Choosing among five traditions. Thousand Oaks, CA: Sage.

Dagel KC (1997) Defining drought in marginal areas: The role of perception. Prof Geogr 49(2): 192-202.

Dessai S, Sims C (2010) Public perception of drought and climate change in southeast England. Environmental Hazards 9(4): 340-357.

Diggs DM (1991) Drought Experience and Perception of Climatic Change Among Great Plains Farmers. Great Plains Research 1(1): 114-132.

Drought Impact Reporter - DIR. National Drought Mitigation Centre (Available at http://droughtreporter.unl.edu/)

García-Mollá M, Sanchis-Ibor C, Ortega-Reig MV, Avellá-Reus L (2013) Irrigation Associations Coping with Drought: The Case of Four Irrigation Districts in Eastern Spain. In K. Schwabe, J. Albiac, J. D. Connor, R. M. Hassan, & L. M. González (Eds.), Drought in Arid and Semi-Arid Regions (pp. 101-122). Springer Netherlands.

Giordano R, Vurro M (2010) Fuzzy Cognitive Map to Support Conflict Analysis in Drought Management. En M. Glykas (Ed.), Fuzzy Cognitive Maps (pp. 403-425). Springer Berlin Heidelberg.

Glaser B & Strauss A (1967) The discovery of grounded theory: Strategies forqualitative research. New York: Aldine Publishing Company

Gómez CM, Pérez-Blanco CD (2014) Simple Myths and Basic Maths About Greening Irrigation. Water Resour Manag 28(12): 4035-4044.

González Tánago I, Urquijo J, Blauhut V, Villarroya F, De Stefano L (2015) Learning from Experience: A Systematic Review of Assessments of Vulnerability to Drought. Nat Hazards (J. No. 11069; Article No. 2006)

Guest G, Bunce A, Johnson L (2006) How many interviews are enough? An experiment with data saturation and variability. Field Methods 18(1): 59-82.

Habiba U, Shaw R, Takeuchi Y (2012) Farmer’s perception and adaptation practices to cope with drought: Perspectives from Northwestern Bangladesh. International Journal of Disaster Risk Reduction 1: 72-84.

Heathcote R L (1969) Drought in Australia: A Problem of Perception. Geogr Rev 59(2): 175-194.

Higginbotham N, Connor L H, Baker F (2014) Subregional differences in Australian climate risk perceptions: coastal versus agricultural areas of the Hunter Valley, NSW. Reg Environ Change 14(2): 699-712.

Keenan SP, Krannich RS (1997) The social context of perceived drought vulnerability. Rural sociol 62(1): 69-88.

Knutson CL, Haigh T, Hayes MJ, Widhalm M, Nothwehr J, Kleinschmidt M, Graf L (2011) Farmer perceptions of sustainable agriculture practices and drought risk reduction in Nebraska, USA. Renew Agr Food Syst 26(3): 255-266.

Legard R, Keegan J, Ward K (2003) In-depth interviews. In Ritchie J and Lewis J (eds).Qualitative research practice: a guide for social science students and researchers, pp. 138-169. London: Stage

López Ortiz MI, Melgarejo Moreno J (2010) El trasvase Júcar-Vinalopó. Una respuesta a la sobreexplotación de acuíferos. Investigaciones geográficas 51: 203-233.

March H, Domènech L, Saurí D (2013) Water conservation campaigns and citizen perceptions: the drought of 2007–2008 in the Metropolitan Area of Barcelona. Nat Hazards 65(3): 1951-1966.

Mason M (2010) Sample Size and Saturation in PhD Studies Using Qualitative Interviews. Forum Qualitative Sozialforschung / Forum: Qualitative Social Research, 11(3). (Available from: http://www.qualitative-research.net/index.php/fqs/article/view/1428)

Mehta L (2001) The Manufacture of Popular Perceptions of Scarcity: Dams and Water-Related Narratives in Gujarat, India. World Dev 29(12): 2025-2041.

Mishra AK, Singh VP (2010) A review of drought concepts. J Hydrol 391: 202-216.

Morales Gil A, Olcina Cantos J, Rico Amorós AM (2000) Diferentes percepciones de la sequía en España : adaptación, catastrofismo e intentos de corrección. Investigaciones geográficas 22: 1-46

Noemdoe S, Jonker L, Swatuk LA (2006) Perceptions of water scarcity: The case of Genadendal and outstations. Phys Chem Earth, Parts A/B/C, 31(15–16): 771-778.

Ortega-Reig M, Palau-Salvador G, Cascant i Sempere MJ, Benitez-Buelga J, Badiella D, Trawick P (2014) The integrated use of surface, ground and recycled waste water in adapting to drought in the traditional irrigation system of Valencia. Agr Water Manage 133: 55-64.

Patt AG, Schröter D (2008) Perceptions of climate risk in Mozambique: Implications for the success of adaptation strategies. Global Environ Chang 18(3): 458-467.

Raphael B, Taylor M, Stevens G, Barr M, Gorringe M, Agho K (2009) Factors associated with population risk perceptions of continuing drought in Australia. Aust J Rural Health 17(6): 330-337.

Rico Amorós AM (2002) Insuficiencia de recursos hídricos y competencias de usos en la Comunidad Valenciana. Boletín de la A.G. E. 33: 23-50

Ruiz Sinoga JD, León Gross T (2013) Droughts and their social perception in the mass media (southern Spain). Int J Climatol 33(3): 709–724.

Saarinen TF (1966) Perception of the drought hazard on the Great Plains. University of Chicago Department of Geography, Research Paper.

Sherval M, Askew LE (2012) Experiencing 'drought and more': local responses from rural Victoria, Australia. Popul Environ 33(4): 347-364.

Slegers MFW (2008) «If only it would rain»: Farmers' perceptions of rainfall and drought in semi-arid central Tanzania. J Arid Environ 72(11): 2106-2123.

Smakhtin VU, Schipper ELF (2008) Droughts: The impact of semantics and perceptions. Water Policy 10(2): 131-143.

Soto-García M, Martínez-Alvarez V, García-Bastida PA, Alcon F, Martin-Gorriz B (2013) Effect of water scarcity and modernisation on the performance of irrigation districts in south-eastern Spain. Agr Water Manage 124: 11-19.

Stoutenborough JW, Vedlitz A (2014) Public Attitudes Toward Water Management and Drought in the United States. Water Resour Manag 28(3), 697-714.

Taylor JG, Stewart TR, Downton M (1988) Perceptions of Drought in the Ogallala Aquifer Region. Environ Behav 20(2): 150-175.

Urquijo J, De Stefano L, La Calle A (2015) Drought and exceptional laws in Spain: the official water discourse. Int Environ Agreem - P 15(3): 273-292.

Wilhelmi OV, Wilhite DA (2002) Assessing Vulnerability to Agricultural Drought: A Nebraska Case Study. Nat Hazards 25(1): 37-58.

Wilhite DA, Glantz MH (1985) Understanding: the drought phenomenon: the role of definitions. Water Int 10 (3): 111-120.

Wilhite DA, Svoboda MD, Hayes MJ (2007) Understanding the complex impacts of drought: A key to enhancing drought mitigation and preparedness. Water Resour Manag 21(5): 763-774.

Woudenberg DL, Wilhite DA, Hayes MJ (2008) Perception of Drought Hazard and Its Sociological Impacts in South-Central Nebraska. Great Plains Research 18(1): 93-102.

WWF/Adena (2015) Modernización de Regadíos. Un mal negocio para la naturaleza y para la sociedad. Madrid, Spain. (Available at: www.wwf.es/informe_modernizaciones/)

4.3. La gestión de la sequía en seis casos de estudio a nivel europeo

Urquijo, J., Pereira Jeréz, D., Dias, S., & De Stefano, L. A Methodology to Assess Drought Management as Applied to Six European Case Studies. *Journal of Water Resources Development* .

Estado: Aceptado con revision

A Methodology to Assess Drought Management as Applied to Six European Case Studies

Julia Urquijo[a, b], David Pereira[b] Susana Dias[c] & Lucia De Stefano[a]

[a] *Departamento de Geodinámica, Facultad de Ciencias Geológicas, Universidad Complutense de Madrid. J.A. Nováis 12, 28040 Madrid, Spain.*

[b] *Departamento de Proyectos y Planificación Rural, E.T.S. Ingenieros Agrónomos. Universidad Politécnica de Madrid, Ciudad Universitaria s/n, 28040 Madrid, Spain*

[c] *Centro Ecologia Aplicada Baeta Neves; Instituto Superior de Agronomia. University of Lisbon, Tapada da Ajuda 1349 - 017 Lisboa, Portugal*

E-mail: jurquijo@ucm.es; lstefano@ucm.es; d.pereira@upm.es; susanadias@isa.ulisboa.pt

Abstract:

The enhancement of future responses to drought requires evaluating past management practices. This paper presents a methodology to assess drought management through the analysis of six key policy dimensions. It uses a qualitative approach that combines different sources of information to include both factual data and stakeholders' perception. The assessment is undertaken in six case studies in Europe having different spatial scales and characteristics, to capture the context-specific nature of response to drought. The results of the assessment contribute to analyze drought management from a risk-management perspective and help to identify key policy gaps and recommendations.

Key words: Drought management, risk management, stakeholder's perception, theory-based evaluation, qualitative analysis, Europe.

Introduction

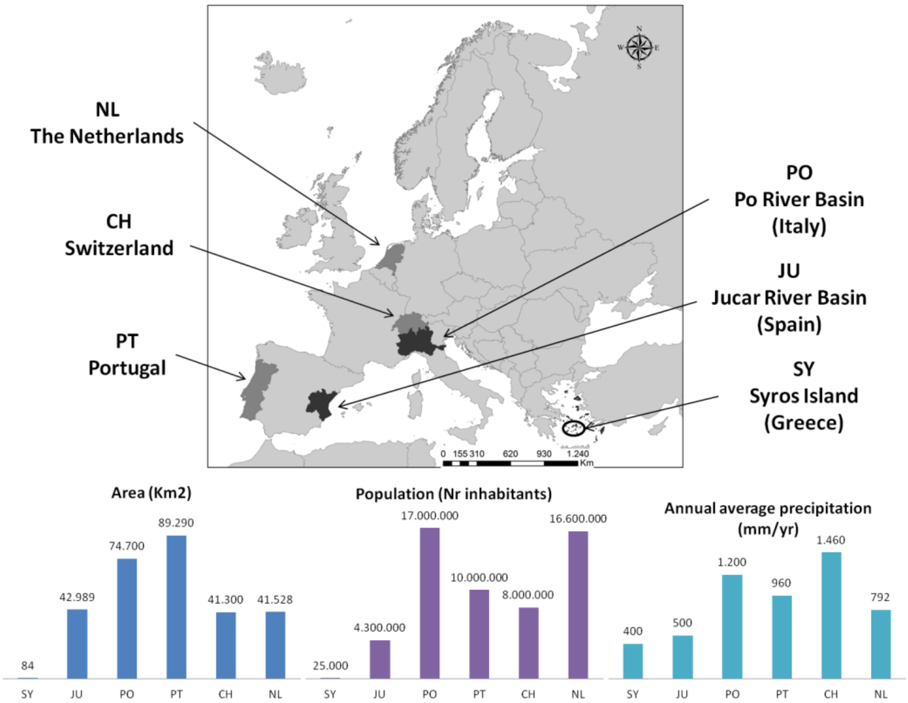
Droughts are recurrent natural phenomena whose socioeconomic costs, only in Europe, have been estimated in 100 billion € over the last 30 years (EC, 2007a; EC, 2011). Droughts affect "virtually all climate regions" (Kossida, Kakava, Tekidou, Iglesias & Mimikou, 2012) and their frequency, duration and intensity is expected to increase in the future as a consequence of climate change (Kallis, 2008; IPCC, 2012). Thus, it is not surprising that drought management has become a policy priority of the European Union (EU), as reflected by the publication of several European Commission (EC) Communications and Follow-up Reports on Water Scarcity and Drought in Europe and the Blueprint to Safeguard Europe's water resources (e.g. EC2007a, 2007b, 2009; EEA 2009; Strosser et al., 2012). Moreover, the importance of minimizing the socio-economic and environmental impact of drought is emphasized in the EU Water Framework Directive (WFD), which represents the legal umbrella for water management in the EU (Estrela & Vargas, 2012).

At the same time, growing international efforts have been made to move from crisis management to a risk-based management approach in the field of Disaster Risk Reduction and other related disciplines. For example, the 'Hyogo Framework for Action – HFA 2005-2015: Building the Resilience of Nations and Communities to Disaster' is a key instrument developed to promote the adoption of a risk-management approach to natural disasters (UNISDR, 2007). In spite of these initiatives, drought episodes in Europe are still faced mainly through a crisis-management approach, e.g. by issuing national or regional emergency programs when droughts set in (EC, 2007c). This has resulted in significant failures in the mitigation of drought impact (Wilhite, 2001) and has fostered the perpetuation of unsustainable practices that increase the vulnerability of water resource systems (Kampragou, Apostolakis, Manoli, Froebrich & Assimacopoulos, 2011). On the contrary, the adoption of a risk-management approach to drought is considered to improve the society's resilience to water scarcity and drought (Wilhite, 2001; EC, 2007a; Kampragou et al., 2011; Kossida et al., 2012; Rossi & Cancelliere, 2013). This approach requires proactive management, based on drought preparedness and long-term risk reduction (Kampragou et al., 2011).

Major improvements in drought management have focused on monitoring and forecasting climatic conditions (Dryden-Cripton, Smithers, Loë & Kreutzwiser, 2007), analysis of drought risk (e.g. Wilhite, Hayes, Knutson & Smith, 2000; Hayes, Wilhelmi & Knutson, 2004), drought impacts (e.g. Wilhite, Svoboda & Hayes, 2007) and drought policy development, especially in the USA (Wilhite, Sivakumar, & Pulwarty, 2014) and Australia (e.g. Botterill, 2003), but also in the EU (e.g. Rossi, 2009; Iglesias, Garrote, Diz, Schlickenrieder & Martin-Carrasco, 2011; Quevauviller, 2011). A well-designed and well-implemented response to drought is likely to reduce the negative impact on environmental and socio-economic systems and should be constantly adapted to new circumstances through systematic analysis of performance of practices implemented during past droughts. Despite this need, there are limited examples of comprehensive frameworks for the evaluation of responses to drought (e.g. Rossi, 2000; Rossi, Cancelliere & Giuliano, 2005; MEDROPLAN, 2007; Rossi & Cancelliere, 2013), even when ex-post assessment of drought measures is recommended in drought management plans or national drought policies (e.g. EC, 2007c; Strosser et al., 2012; Wilhite et al., 2014). This may be linked to the quite young tradition - relative to other fields such as e.g. education (Knaap & Kim, 1998; Mickwitz, 2003; Mickwitz & Birnbaum, 2009) - of the evaluation of environmental policies.

This paper presents a methodology to assess key aspects of drought management during past drought events, in order to identify strengths and weaknesses of response, and formulate recommendations for actions that can contribute to move toward a risk-management approach. The methodology was applied to six case studies (CSs) across Europe (Figure 1): the Netherlands (NL), Switzerland (CH), Portugal (PT), Jucar River Basin in Spain (JU), Po River Basin in Italy (PO) and Syros Island in Greece (SY).

Figure1. Localization of the six case studies



When working with case studies two main approaches can be followed: selecting similar case studies, to draw conclusions about one specific type of contexts; or observing the same phenomenon in cases that are diverse, to explore how diversity reflects on the results of the analysis. In this paper we followed the latter approach, considering drought management in six case studies across a range of climates, scales, socio-economic environments and types of drought impacts. Six research teams participating in a EU-funded research project provided the local support for undertaking this study.

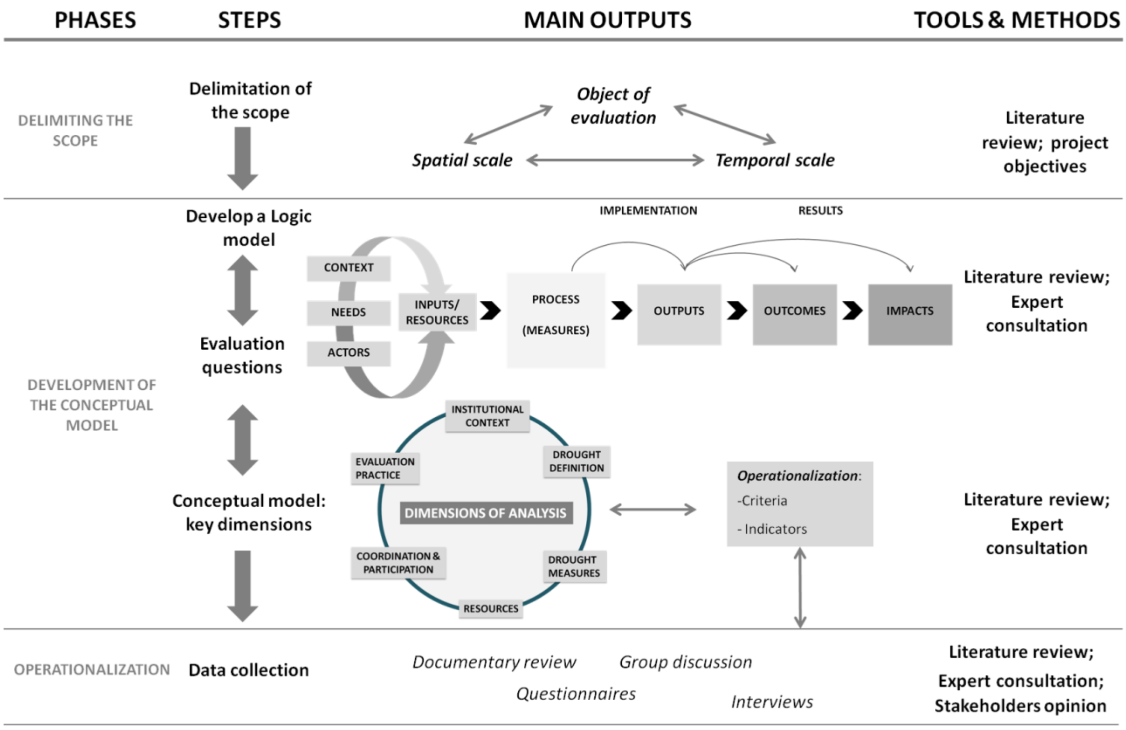
The next section describes the framework used for the assessment and its operationalization. Then, the paper presents and discusses the results of the application of our methodology to the selected CSs, and summarizes the main conclusions of the study.

Methodological Framework

The methodological framework follows a Theory-based Evaluation approach (TBE; Chen, 1990; Weiss, 1997, 2000; Rogers, 2000; 2008), which establishes that the design of any evaluation should be preceded and guided by the development of a conceptual model (Rogers, 2000). TBE approach is particularly suitable when few data are available to establish causal conditions between intervention and its effects, as it is the case for drought, a natural phenomenon that requires complex and context-specific solutions. Moreover, TBE has the advantage of overcoming what evaluators call ‘the black box problem’, meant as “the practice of viewing social programs primarily in terms of effects, with little attention paid to how those effects are produced” (Astbury & Leeuw, 2010; p. 364). TBE attempts to unpack that black box, in order to understand the mechanisms enabling the implementation of a given policy and the delivery of results. The TBE approach has been adopted in different settings and disciplines, like public health (Donaldson & Gooler, 2003; Conner, Mishra & Lewis, 2004; Cho & Witte, 2005), education (Cook et al., 1999; Crew & Anderson, 2003, Nesman, Batsche, & Hernandez, 2007; Hense, Kriz, & Wolfe, 2009), community change initiatives (Stame, 2004; Carvalho & White, 2004; Mulroy & Lauber, 2004), or child nutrition programs (White & Masset, 2007) but it was been rarely applied to the assessment of environmental policies (e.g. Finnish Wastewater Permits in Mickwitz, 2003).

The process followed to design the assessment process included three phases (Figure 2): defining the scope and scale of the assessment; developing the conceptual model of the analysis; and defining the data collection process. Each phase will be described in the next subsections.

Figure 2. Schematic view of the evaluation process: phases, steps, main outputs of each phase, and main tools and methods used.



Delimiting the scope of the assessment

In this study, the object of the evaluation is the management and response to drought, understood as the set of management practices, risk-reduction options and drought-relief actions implemented before, during and after drought. Thus, this evaluation considers not only actions taken as a reaction for emergency relief under a crisis-management approach (Wilhite et al., 2000; Wilhite, 2001), but also instruments such as legal regulations, strategies and plans that configure the overall drought policy at different levels and for different policy domains (e.g. water, agriculture, public health), as well as political, social and economic factors that influence the implementation of drought measures and illustrate the context of intervention. In the rest of the paper we will refer to the object of the evaluation as “management”, “response” or “management and response”.

Approaching the assessment of drought management entails several methodological challenges. As acknowledged in the literature of policy evaluation (Vedung, 1999), and in particular in the field of environmental policies (Mickwitz, 2003), direct causal links between a given policy response to drought and the level of mitigation of drought impact are extremely difficult to establish and measure. Moreover, droughts act at different spatial and temporal scales (Kossida et al., 2012), their delimitation being not always univocal. Regarding the spatial scale, mismatch usually occurs between social and natural boundaries (Fekete, Damm & Birkmann, 2010; Bruyninckx, 2009), which means that responses can stem from a territorial level that does not fit the natural one and that drought impacts could be felt outside the drought-stricken area. As for time scales, onset and end of the drought event are difficult to determine with precision (Wilhite & Glantz, 1985), drought effects can last longer than the drought itself, and delays in actions to face drought problems are common (Wilhite, 2001). Moreover, measures addressing drought can be implemented before, during and after the drought episode itself and it is necessary to draw boundaries to define whether they are all part of the drought response. For this paper we used the physical boundaries of each case study (country, river basin, island) to delimit the spatial scale of the analysis, and considered actions and policy originating at other levels only when they had a clear relevance for the case study. As for the time scale, for each case study we selected a specific past drought event as the focus of the evaluation (Table 1), but considered also measures linked to that event.

Table 1. Case studies and of past drought event under study

Case Study	Scale	Area (Km^2)	Annual average precipitation (mm)	Assessed Drought	Characteristics of the assessed drought	Main sectors affected
SY	Local	84	400	2007	Nation-wide drought event of moderate severity in SY. Accompanied by a heat wave.	Agriculture
JU	River Basin	42,989	500	2005-2008	Severe drought episode according to the River Basin Authority. With strong decrease in available water resources in streams, aquifers and reservoirs.	Agriculture, environment, energy production
PO	River Basin	74,700	1,200	2006-2007	Drought was a combination of low rain and snow precipitations and delayed snow melting in the mountains, which led to low levels of in-stream flows, sea water intrusion in the Po Delta, and problems for some domestic water supply systems.	Energy production, agriculture, urban supply
PT	National	89,290	960	2004-2006	Severe drought that affected most of the Portuguese mainland. The high decrease in water reserves derived in restrictions for domestic supply and other uses	Agriculture, urban supply, energy production, industry, environment
CH	National	41,300	1,460	2003	The driest summer in the past 500 years. Drought was accompanied by a heat wave and lack of in-stream flow in some rivers.	Health, hydropower, water domestic supply, agriculture, forestry, tourism
NL	National	41,528	792	2003	The driest and hottest summer in the decade. It led to a long period of low river flow (Rhine) and high water temperature.	Agriculture, navigation, energy production; environment, tourism/recreation

Source: own elaboration based on EU project CS description

The conceptual model

According to the TBE approach, the elaboration of a *conceptual model* of the object to be evaluated sets the basis for the entire evaluation process and subsequent analysis (Rogers, 2000). The aim of this step is to make the conceptual background explicit and therefore support the design of the assessment, as it facilitates understanding complex intervention schemes through the construction of a simplified model of the reality. The resulting model allows the identification of key factors and conditions that facilitate or hamper its implementation in a given context.

In this study, we used a logic model (W.K. Kellogg Foundation, 2004) to organize the elements of drought response and management into Resource/inputs, Process (measures), Outputs, Outcomes, and Impacts (Figure 2 and Supplementary material, Sect. A). The development of this model led to the formulation of the evaluation questions that identify the most relevant aspects of drought management to be taken into account. These, in turn, led to the definition of a conceptual model including policy-relevant dimensions of analysis.

The formulation of evaluation questions and the resulting conceptual model was based on consultations with water experts and stakeholders in the case studies and the analysis of the extant literature on policy analysis, and water and drought management. Our conceptual model includes six dimensions of analysis, which largely correspond to policy cycle dimensions (Jann & Wegrich, 2006): (i) institutional context, (ii) drought definition, (iii) drought measures, (iv) resources, (v) coordination and participation, and (vi) evaluation and learning (Table 2). The design of the conceptual model was highly influenced by the characteristics of each case study. Since CSs were diverse, the model had to include dimensions and categories broad enough to fit the peculiarities of each case study. For instance, in order to study the "Drought Measures" dimension, instead of selecting specific measures and check whether they were present in each case study, it was chosen to identify measures categories and then ask the CS teams to identify the specific measures that could fit in those categories.

Table 2. Description of the six dimensions of analysis

Dimension	Description
1. Institutional Context	The institutional framework sets the context for policy implementation. Policy is understood as "a purposive course of action followed by government in dealing with some problem or matter of concern" (Anderson, 1997). Drought policies are defined in several types of documents: strategic plans, programmes, projects, regular or exceptional laws, and regional or local regulations as well as unofficial or unwritten norms. Drought Management Plans are seen as the main representative tool to deal with drought management under a proactive, risk-based approach (Wilhite et al., 2000). In this context, the analysis of vulnerability to drought guides the establishment of measures in an effective and proactive way (Knutson et al., 1998).
2. Drought definition	The analysis of the problem is the first step of the policy cycle (Jann & Wegrich, 2006). How drought is defined in official documents influences the response. It is key that definitions be made explicit and that they allow a phased implementation of planned measures. Thus, it is important to acknowledge and address the diversity of definitions (Mishra & Singh, 2010), the confusion with other related concepts (e.g., water scarcity) and the different perceptions of the phenomenon (Heathcote, 1969).
3. Drought measures	Drought measures should be planned in advanced in order to be able to anticipate drought impacts. They are concrete actions implemented to address drought issues; a proactive approach includes strategic, operative and recovery measures (EC, 2007c; FAO & NDMC, 2008; UNDP, 2011). Drought measures are context specific and should be implemented before, during and after the drought episode to address the different needs of the sectors and the stakeholders affected.
4. Resources	The availability of adequate human and financial resources influences the ability to undertake adaptation at the local level (Smit & Wandel, 2006) and the effectiveness of institutions (Gupta et al., 2010). Insufficient or inadequate human capacities and financial resources are recognized to cause failure in the implementation and enforcement of interventions (EC, 2012).
5. Coordination & Participation	Supramaiam, Masso & García-Sastres (2011) remark that "alternative risk management should set the emphasis on the initial steps of the causality chain, which entails better institutional coordination and the involvement of stakeholders" (p.74). Participation entails the commitment of the authorities to create venues for involving stakeholders and civil society in decision-making processes as well as their willingness to take into account the results of that involvement (De Stefano, Hérnandez-Mora, López-Gunn, Willarts & Zorrilla-Miras, 2013).
6. Evaluation & Learning	Evaluation is an important phase of policy cycle implementation (Vedung, 1999; Jann & Wegrich, 2006) as it supports learning capacity. Monitoring and evaluation practices allow the identification of gaps and pitfalls that need to be addressed in order to improve drought management (Kampragou et al., 2011). Post–drought evaluations give insights into how much drought policy and planning contributed to impact mitigation (Wilhite et al., 2005; 2014), thus informing initiatives to enhance institutional capacity.

Operationalization of the Assessment

The six dimensions were further characterized through twenty-one criteria, to be measured through relevant indicators (Table 3). While the literature does not provide a detailed description of what a risk-management approach means in the case of drought, there are some key elements that are commonly associated with such an approach that were taken into account when defining criteria and indicators: monitoring systems for early warning (Wilhite et al., 2014); existence of vulnerability assessment (Knutson, Hayes & Phillips, 1998; Hayes et al., 2004); elaboration of drought management plans (Wilhite et al., 2000; Fu, Svoboda, Tang, Dai & Wu, 2013; Wilhite et al., 2014), use of detailed drought definitions (Wilhite & Glantz, 1985; Mishra & Singh, 2010); existence of a wide array of measures covering all aspects and phases of drought (EC, 2007c; FAO & NDMC, 2008). Other criteria and indicators were supported by broadly accepted recommendations for effective drought and water management: clear distinction between drought and water scarcity (EC; 2007a; Schmidt, Benítez & Benítez, 2012), public participation (Roger & Hall 2003; Perry 2013); importance of ex-post evaluations of drought management (Kampragou et al., 2011; Wilhite et al., 2014).

Data to populate indicators were collected using four types of tools: (i) data collection form, designed to systematically analyze official drought-relevant documents in each case study; (ii) semi-structured interviews, designed to capture the opinion of key stakeholders directly involved in drought response management; (iii) a questionnaire, to gather the perception of a wider set of stakeholders involved in drought management; and (iv) a SWOT matrix (Strengths, Weaknesses, Opportunities and Threats) to analyze drought management in focus groups with stakeholders.

The set of tools included the collection of both quantitative and qualitative data, and was designed to be flexible enough to adapt to the specific features and the data availability in the different case studies. Each variable was assessed through two tools, so data could be collected using different sources, which is particularly useful when dealing with complex evaluation objects (Hockings, Stolton, Dudley & James, 2009). Moreover, this approach also reduces reliance on only one data source and the risk of data gaps due to possible underperformance – for diverse and sometime unpredictable reasons – of a specific tool.

Local teams of researchers collected the data needed for the evaluation of each case study. The dataset was assembled with involvement of 81 stakeholders across the CSs, and includes: a) one data collection form for each CS, prepared with information obtained from academic publications, regulatory documents, technical reports, management plans or sectorial strategies; b) the transcriptions of 40 interviews (Policy makers , 18% of the interviewees; Water users, 20%; Decision-makers/Managers e.g. River Basin Organizations, Regional Authorities, 45%; and others e.g. research institutions and environmental NGOs, 18%); c) 65 questionnaire replies from stakeholders (replies were anonymous); and d) the results of 5 SWOT analyses carried out with stakeholders (Policy makers, 25%; Decision-makers/Managers, 35%; Water users, 15%; and others, 26%). For resources constraints, no SWOT analysis could be carried out in NL.

The local teams selected the experts to be involved in the study based on a stakeholder analysis, ensuring representativeness from the different sectors affected by drought. Each CS team carried out data collection (literature review, interviews, questionnaires, SWOT analysis) in their native language.

The analysis of the entire datasets led to the definition of a three-value qualitative scale (Low = 1; Medium = 2; High = 3; see Table 3) to score each indicator. To determine the fuzzy-set values, we followed the main steps defined by Basurto & Speer (2012). During the scoring process, two researchers were responsible for scoring each indicator independently, and then reaching consensus on the scores if there were differing interpretations.

Table 3. Description of the fuzzy-set values and main (column 1) and complementary (column 2) sources of information used in the coding process. Data collection form (D); Semi-structured interviews (I) and Questionnaires (Q).

Dim	Criteria	Indicator description	Fuzzy-set values	Source of information 1	Source of information 2
1. Institutional context	C1. Drought policy development	Level of drought policy development	Existence of a drought-management plan = High, Drought issues are included in River Basin Management Plan and/or other type of water-management tool or a drought monitoring systems exist = Medium; Drought issues are included in other general management tools or only emergency plans exist= Low	D	I
	C2. Legal and regulatory instruments	Adequacy of the regulatory framework to deal with drought	Stakeholders mainly perceive the regulatory framework to be sufficient and adequate = High; Stakeholders point out to some deficiencies in the regulatory framework (in its design or in its implementation) = Medium; The regulatory framework is considered to be insufficient or inadequate = Low	I	D
	C3. Vulnerability assessment	Existence of an assessment of vulnerability to drought	There is an official and comprehensive assessment of vulnerability to drought = High; The assessment is official but incomplete or comprehensive, but not official = Medium; There is no assessment of vulnerability for the case study = Low	D	I
2. Drought definition	C4. Drought definition	Presence of an official definition of drought	A formal definition of drought exists in official documents on drought or water-management issues = High; Drought definition is confused with other concepts (e.g. scarcity) = Medium; No official definition of drought exists = Low	D	I
	C5. Operative definitions	Presence of operative definition of droughts	Operative definitions are well defined in official documents related to drought and water management = High; Operative definitions are superficially mentioned = Medium; Not mentioned = Low	D	I
	C 6. Practical implications of drought definition	Degree of practical implications of drought definitions in management practices	Stakeholders perceive that the existing definitions had practical implications in management practices = High; Stakeholders perceive partial or indirect implications = Medium; No practical implications are perceived = Low	I	D
	C 7. Clear understanding of drought concept by stakeholders	Degree of stakeholders understanding of the concept of drought	Stakeholders clearly distinguish between drought and other related terms = High; Stakeholders have some confusion about drought and other related terms = Medium; Stakeholders do not distinguish between drought and other related terms = Low	I	D
3. Drought measures	C8. Completeness of the design	Presence of different types of measures established	The CS had measures in all the measure categories (strategic, operative and recovery) = High; No measures for one type of category = Medium; No measures for two or three types of category = Low	D	I
	C9. Quality of measures' implementation	Perception of the implementation of measures	Stakeholders value the implementation of drought measures positively overall = High; Implementation is valued positively but with issues to be improved; Implementation is valued negatively = Low	Q	D
	C10. Effectiveness in mitigating impacts	Degree of contribution of the measures to impact mitigation	Stakeholders perceive that the measures implemented during the last drought did contribute to impact reduction = High; Measures contributed to impact reduction only partially = Medium; Did not contribute to impact reduction = Low	Q	D
4. Resources	C11. Availability of financial resources	Availability of financial resources for drought management	Resources from ordinary and extra-budget lines for drought were made available= High; Only ordinary <u>or</u> extra-budget lines = Medium; No resources were allocated = Low	D	Q
	C12. Sufficiency of financial resources	Level of financial resources assigned	Stakeholders perceive that the financial resources during the last drought were overall sufficient = High; Financial resources were somehow insufficient = Medium; They were insufficient overall = Low	I	Q

Dim	Criteria	Indicator description	Fuzzy-set values	Source of information 1	Source of information 2
	C13. Distribution among sectors/needs	Degree of balanced distribution among sectors and/or needs	Stakeholders perceive that the distribution of financial resources during the last drought was overall balanced across sectors = High; Imbalance for specific sectors/needs = Medium; Imbalanced = Low	I	Q
	C14. Adequacy of human resources	Degree of adequacy of human resources in charge of drought management	Stakeholders perceive the human resources in charge of drought management to be insufficient (in terms of number, skills, clear responsibilities and continuity) = High; Resources were sufficient but improvable = Medium; Resources were insufficient = Low	I	D
5. Coordination & Participation	C15. Drought management responsibilities	Existence of an institution or entity responsible for drought management	Responsibilities for drought management have been clearly assigned to specific entities = High; Responsibilities have not been clearly assigned = Medium; No responsibilities were assigned = Low	D	I; Q
	C16. Coordination	Adequacy of the coordination of drought management	Stakeholders perceive the coordination of drought management to have been good = High; Coordination is perceived to have some weaknesses = Medium; Coordination is perceived to have been poor = Low	Q	I
	C17. Participation	Adequacy of stakeholders' participation	Stakeholders perceive the level of participation during the last drought to have been adequate = High; The level of participation had some deficiencies = Medium; The level of participation was poor = Low	Q	I
	C18. Mechanisms of participation	Degree of formalization of the mechanisms and process to allow participation	Formal mechanisms of participation in drought management exist = High; Deficiencies or weakness in mechanisms are detected = Medium; Only informal procedures exist = Low	I	D
	C19. Stakeholders' inclusiveness	Degree of inclusiveness and balanced representation	All relevant stakeholders were included and their representation was balanced = High; At least one relevant stakeholder was missing or representation was unbalanced = Medium; At least one relevant stakeholder was missing and representation was unbalanced = Low	Q	D
6. Evaluation & Learning	C20. Learning capacity	Degree of improvement of drought management relative to previous drought episodes	Stakeholders perceive the most recent drought to have been better managed relative to the previous one= High, Managed in a similar way = Medium; Managed worse than the previous episode = Low	Q	I
	C21. Evaluation practice	Scope of the evaluation practices	A comprehensive evaluation of drought response was implemented = High; The evaluation was focused only on specific aspects = Medium; No ex-post evaluation was carried out = Low	D	Q

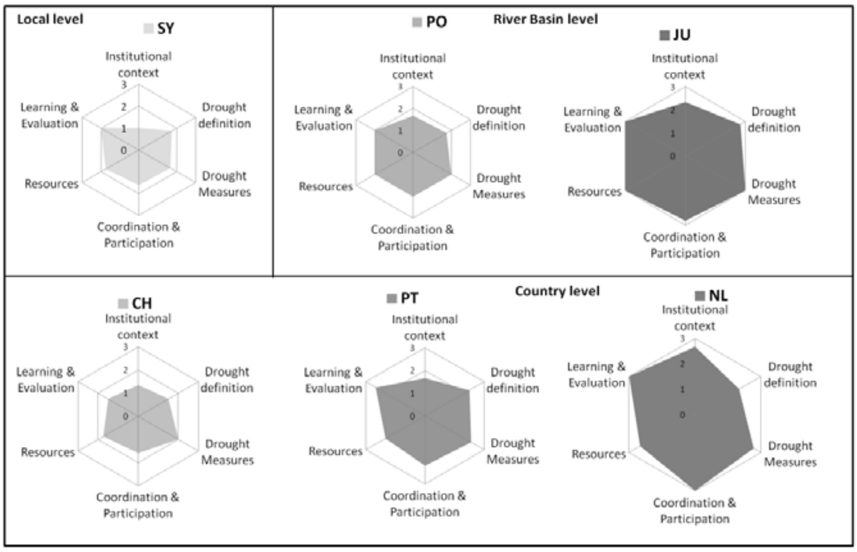
Results and Discussion

The results of the assessment will be presented as case-study profiles and by dimension. Final scores by criterion can be found in the Supplementary Material (Section B).

Drought management profiles

The assessment led to the development of a drought management profile for each CS (Figure 3), which offers an overview of the main strengths and weaknesses, according to the dimensions analyzed, based on the assumption that high scores for each dimension mean a higher degree of adoption of a risk-management approach.

Figure 3. Case Studies profiles



The shape and size of the CS profiles suggest that during the assessed drought event Portugal (PT), Syros Island (SY), Switzerland (CH) and the Po river basin (PO) followed a crisis-management path, while the Jucar river basin (JU) and the Netherlands (NL) proved to have a more proactive approach. The profiles of PT and PO indicate an intermediate stage of drought management development across all the dimensions, while in SY and CH response to drought appears to be fragmented and reactive. Some key features of each Case Study help interpreting their profiles.

The Júcar river basin has a well-developed DMP as well as a battery of tools for drought management (monitoring systems, tools for decision support, Emergency plans for urban water supply). Its institutional framework evolved significantly after a severe drought episode in the 1990s, which led to establishment of the DMP and strengthened the overall response to drought in the river basin. Drought levels are clearly defined and are associated with the activation of specific measures. During the 2005-2008 drought sufficient financial resources were distributed across the affected sectors, and impacts were greatly mitigated. Stakeholders participated in decision-making through a Drought Commission, whose functioning is regulated by law and whose meetings served as an effective platform for consensus building. A post-drought assessment was carried out by the Júcar River Basin Authority but so far has not been made publicly available.

The Netherlands has a flexible drought management system that monitors drought-relevant parameters and, when needed, brings together water managers at different levels and stakeholders to agree on actions to manage drought. For instance, there is continuous monitoring of temperature and discharge of the main transboundary rivers and there is a priority ranking to allocate water in case of scarcity. Drought response is planned in advance and is supported with sufficient human and financial resources. A severe drought in 1976 laid the foundation for current drought management, suggesting also in this case the importance of capitalizing past experiences to enhance institutional capacity. NL has formal mechanisms and a long tradition in participatory processes, and during the assessed drought, effective participation of stakeholders contributed to preempt possible conflicts. The 2003 drought demonstrated that the current water management system, its operation and policy are nearing their limits. While the short-term focus is on flexibility of the water system, for the long term the strategy is aimed at protecting the country against flooding (from the sea and rivers) and securing freshwater supplies.

Despite the current high pressure on the whole river system, the Po CS lacks drought management plans at basin or local level, except for Emilia-Romagna region. During the assessed drought, management efforts mainly involved voluntary water allocation agreements and exceptional measures associated with declaration of emergency by the central government. In 2003, a drought commission was created to manage response to drought. In 2005, the committee was made permanent, with the objective of building a coordinated procedure for monitoring and forecasting water deficiencies in the basin. In spite of this effort, institutional capacity presents weaknesses related to the absence of vulnerability studies, insufficient emphasis on planning of drought measures and definition of clear levels of alert. Regarding drought measures, pitfalls were related to lack of recovery measures, poor control of water withdrawals and water release, or insufficient management of salinity problems in the river delta. The Po River Basin Authority made a significant effort of coordination and inclusiveness. However, the decision-making process was still largely centralized, and not all the stakeholders felt adequately involved or represented. Even if there are some economic analyses of drought impacts, comprehensive and systematic assessment of drought management is still lacking.

In Portugal drought management is undertaken through a set of instruments at different scales and in different sectors. Thus, tools to manage drought exist but they are quite scattered and uncoordinated. The development of systems for drought monitoring and early warning is still ongoing and there is no well-planned response to drought. The regulatory framework is considered to be sufficiently developed, but its effectiveness is sometimes hampered by lack of a clear operational framework and poor implementation on the ground. During the assessed drought, the main venue for participation and coordination was a Drought Commission. Its work was positively valued by the consulted stakeholders, who, however, criticized the limited role of local governmental and non-governmental stakeholders. Moreover, responses were sometimes slow and not fully effective in coping with technical and financial needs at regional and local scales. Conflicts existed in the operation of multiple-purpose reservoirs, the conciliation of different water needs in some rivers and aquifers, and budget allocation according to technical and financial needs.

Even if the local scale allows for a more adapted strategy to address drought problems, Syros Island lacks a drought management plan and has a reactive approach to drought. Main weaknesses identified are lack of operative definitions of drought and poor implementation of groundwater use control. So far, efforts have been mainly focused on reducing the dependency of the domestic and tourism sectors from freshwater resources through sea-water desalination. Agriculture is highly dependent on intensively exploited and degraded aquifers and drought measures focus on compensation to farmers rather on impact prevention. Overall, local capacity needs to be improved, to reduce the fragmentation of responsibilities, to maintain the know-how of local agencies and to ensure a more even distribution of financial resources across sectors. Participation of stakeholders in decision making is limited and often informal, which can create imbalance among stakeholders having different access to the authorities.

During the 2003 drought Switzerland did not have specific policy instruments for drought management and, except for few drought-prone cantons, response was reactive. Even if basic drought-relevant data are collected, there is no integrated drought information system. Drought management regulation is considered to be in its infancy. Cantons hold most of the responsibilities over water, and incentive in inter-canton cooperation lays in the potential benefits of joint response rather than on legal obligations. Most Swiss regions have enough personnel and effective cooperation to face sporadic drought but lack long-term strategies. After the 2003 drought and the associated heatwave, awareness about the importance of managing drought increased, and recently the Swiss government has been revising its water policy strategy to include also drought issues.

While direct comparison of the performance of CSs can be misleading, it is worth noting some common trends across the CS profiles. First, each CS got quite homogenous scores in all the dimensions of evaluation, which seems to confirm that the performance of specific management measures depends on the full context where intervention takes place (Wilhite and Glantz, 1985; Knutson et al., 1998; Wilhite et al., 2000). Second, in the two CSs that obtained the lowest scores (SY and CH), the most developed dimension is related to drought measures. However, when looking at the type of measures, both CSs lack preventive measures and monitoring and early-warning systems, which is consistent with their crisis-management approach. Third, the performance in drought management seems not to be linked to the characteristics of drought, as the two CSs that fared the best were the JU - located on the Mediterranean coast, which suffered from a three-year drought affecting mainly the water supply system and agriculture - and NL- located in Central Europe which had to manage a one-year drought that affected mainly river levels for navigation and agriculture. On the other side of the spectrum, the two CSs that obtained the lowest scores (SY and CH) also have little in common in terms of size, climatic conditions and socioeconomic context. This seems to suggest that a key factor in the adoption of a drought risk management approach is having a strong tradition in water management, as is the case for the Júcar basin and the Netherlands.

Recommendations by Dimension

The assessment led to the identification of gaps in drought management and response, and the subsequent formulation of recommendations for improvement across the CSs (Table 4).

In all the CSs the policy and regulatory instruments dealing with drought are mainly framed within water-related initiatives and instruments (laws, plans) addressing different facets of drought. These instruments are developed with different levels of detail, depending on the CS, and have been established mostly during the past decade. In general the consulted stakeholders valued positively the recent development of drought management in their CS but they still perceived gaps in the establishment of preventive measures and proactive planning drought response and management. This is coherent with the majority of the CSs following a crisis approach as shown in the profiles. In particular, most CSs lack a DMP that defines the different actions to be taken at each stage of drought, despite the fact that this type of plan provides a framework that helps reducing improvisation when droughts occur (Hayes et al., 2004; Kampragou et al., 2011; Wilhite et al., 2014).

All the CSs have a set of legal norms dealing with drought but there are still normative gaps. For example, in PT better regulation of the operation of large reservoirs is needed, while in JU the consulted stakeholders remarked that it would be advisable to improve the regulatory framework of water trade. Moreover, in most CSs (PT, SY, PO, JU) the enforcement of regulation needs to be strengthened, especially in relation to environmental protection and to restrictions on water use during drought.

It should be noted that in none of the CSs there is a comprehensive assessment of vulnerability to drought. This confirms the existence of a gap between the increasing attention to vulnerability in general (Janssen, Schoon, Ke, & Börner, 2006), and of drought vulnerability in particular (González Tánago, Urquijo, Blauhut, Villarroya, & De Stefano, 2015), and their limited integration into management, and reveals the need for more socio-economic and environment-oriented studies to complement the traditional biophysical approach in drought analysis (Wilhite & Glantz, 1985; Lackstrom et al., 2013).

Our assumption, based on Hanberger (2001), is that a clear definition of the problem provides a sound basis for action. In the case of drought, this is particularly important, as its definition is not unique or univocal (e.g. Wilhite & Glantz, 1985; Lloyd- Hughes, 2014). From a practical point of view, it is advisable to have a detailed definition of drought associated with a drought monitoring system that takes into account the impact of drought on the different sectors. This allows the establishment of clear thresholds to activate or deactivate specific drought measures and to support communication between water managers and water users and the general public. All the CSs have at least one drought definition in their official drought-related documents but, except for JU, there is no further detail on the different levels of alert or different levels of drought that can be used to guide management actions.

Interviews with stakeholders confirmed that that at local level individuals perceive and define drought differently (Heathcote, 1969), depending on personal, cultural, historical and contextual factors (Slegers, 2008; Patt & Schroter, 2008; Dessai & Sims, 2010; Higginbotham, Connor & Bakker, 2014). In our study, stakeholders often used water scarcity as a synonymous for drought, primarily in a water stressed context like the Mediterranean area (SY, JU, PT), where drought is often perceived as an intensification of a water scarcity situation. In contrast, in contexts where water is more abundant (NL, CH, PO), they perceived drought mainly as an unusual phenomenon where abnormal high temperatures are also a matter of concern. Since perception will influence stakeholders' behavior (Giordano & Vurro, 2010), it is important for water managers to work with operational definitions but also taking into account the perception of water users on the ground, to make sure that there is a shared vision of the problem and that solutions are accepted also at the local level (Urquijo & De Stefano, in press).

As mentioned earlier, the Drought Measures dimension was built combining the inventory of measures implemented in each CS. This provides flexibility to the assessment, to adapt to the specificities of each case, but also entails high heterogeneity of the mapped measures. Thus, conclusions about this dimension are meaningful only when considering our broad measures categories: a) strategic measures, including measures to prepare for drought and monitor its occurrence; b) management measures, meant as actions to address different aspects of drought and mitigate its impacts; and c) recovery measures, including actions undertaken during or after drought to ensure swift damage recovery. Moreover, this study aimed at providing an overview of the whole process of response to drought rather than the evaluation specific measures, which is also scarce in the literature (Hernandez-Mora, Gil, Garrido & Rodriguez-Casado, 2013; Lackstrom et al., 2013). Thus, our analysis focused on the balance of measures categories in each particular CS, as the presence or absence of a given type of measures gives insights into the strategy followed to address drought. For instance, the existence of preventive and monitoring measures can be interpreted as a sign of a risk-management approach.

When considering the overall picture, it can be observed that, in all the CSs during the assessed drought, recovery measures were the least developed ones. Similarly, the development of environmental measures was also very limited.

Participation of stakeholders in drought management was found to be uneven across the assessed CSs. In most of the cases, decisions were made by the responsible organization(s) after involving governmental stakeholders. In general, at least some non-governmental stakeholders were involved in the decision-making process, but their involvement was not always judged to be sufficient (SY) or well-balanced (JU), as not all the affected sectors were involved (SY, PO, PT) or had a similar chance to influence decisions. In general, the coordination of drought response by the responsible authorities during the past drought events was valued in a positive way by stakeholders. This is an encouraging finding, as good coordination and communication is crucial to avoid work fragmentation (Bokal, Grobicki, Kindler, & Thalmeinerova, 2014) and to reduce institutional barriers towards adaptive drought management (Rossi & Cancelliere, 2013). In all the CSs, however, there is room for improvement, especially to find mechanisms that solve possible disputes among the involved authorities and speed up decision-making processes during the drought emergency.

In some CSs (PT and SY), human and financial resources to face drought were perceived as insufficient, leading to an uneven (and unfair) distribution of the resources. In other cases (JU, CH, NL, PO) the availability of staff and funds was considered adequate, for the presence of sufficient permanent staff or resources in the responsible management agencies or because extraordinary financial resources were approved during the drought. In the future, it would be advisable to ensure a more even distribution of funds among the affected sectors and also to foster staff continuity in the agencies responsible for drought management, so that the human capital created during a given drought can be available also in those that follow. Moreover, data about the economic impacts of drought and the cost-benefit ratio of measures should be systematically generated (Gopalakrishnan, 2013; Hernández Mora et al., 2013; Garrido & Rey, 2014).

In all the CSs an increase in the level and quality of stakeholders' participation between the assessed drought and the previous one was reported, which suggests that the responsible authorities are making efforts to open up their decision-making processes by including the actors affected by drought. The existence of formal mechanisms of participation in drought meetings with the authorities was positively valued by stakeholders. Indeed, formal arrangements create a structured venue of communication, beyond discretionary initiatives from the authorities, and an opportunity for stakeholders to influence decisions. In particular, the establishment of well-regulated mechanisms for consultation and active involvement, with frequent and regular meetings during the emergency phase, was remarked as positive (JU, NL). Nevertheless, it is important to continuously monitor the actual functioning and effectiveness of those formal mechanisms, as sometimes participation is regulated and compulsory, but decisions are taken beyond closed doors (Hernández- Mora, Cabello, De Stefano & Del Moral, 2015). This can discourage participation and hamper the implementation of measures to mitigate drought impacts.

The assessment revealed that in the CSs there is a poor tradition of ex-post evaluation of drought management and responses (Hernandez-Mora et al., 2013; Garrido & Rey 2014), despite the fact that post-drought evaluation are the last and crucial step toward full development of a drought national policy (Wilhite et al., 2014). The most advanced CSs in this field are the JU and NL, where an official evaluation was undertaken after the last drought.

Table 4. Main recommendations by dimension. Based on surveys, interviews, SWOT analyses and documentary analysis in the six CSs.

Dim	Recommendations
1. Institutional context	• Promote a risk-management approach (SY, PO, PT, CH). • Enhance drought planning and develop preventive measures or develop DMP (SY, PO, PT, CH) • Improve law enforcement mechanisms (PT), especially by controlling abstractions or dry wells (SY, PO) • Improve specific legal issues: e.g. clear rules for the operation of large reservoirs, update of current public water supply legislation, revision of transboundary treaties to better define actions during drought (PT); revision of water trade regulation (JU) • Establish clear rules on water uses, especially where resources are scarce (PT) • Include drought issues in RBMP under development (PO) • Develop drought vulnerability assessment (SY, CH); In-depth studies about real economic, social and environmental effects of drought (JU, CH); Development of studies on vulnerability to drought and management under different drought Scenarios (PT); To discuss the drivers behind the impact of drought on the different sectors (PT)
2. Drought definition	• Establish a clear definition of drought that can be tied to different alert levels to triggered interventions (PO, PT, CH) • Tailor the drought definition to the local context (SY, CH) and clearly distinguish between water scarcity and drought (SY)
3. Drought measures	*Strategic or planning measures* • Develop drought planning based on a reliable monitoring network (e.g. climate data, water use data, status of groundwater bodies) (SY, PT, PO) • Improve research and studies to increase knowledge on storage capacity, overall demands and water availability (PT, PO) • Promote monitoring and early warning system (SY, PO, PT); • Undertake research on specific measures such as multi-functional use of pumping systems (flood and drought prevention), and on water storage for high-value agriculture (e.g. horticulture) (NL) • Improve the mechanisms of drought phases activations based on drought monitoring systems (JU) • Improve the adequacy of the time of activation of specific measures to avoid delays (JU) • Revise the "emergency state declaration" criteria and homogenize the procedures of drought funding request among municipalities (SY)

Dim	Recommendations
3. Drought measures	*Demand management* • Prioritize demand management over supply management (JU) • Revise pricing policy to avoid overexploitation of groundwater due to higher prices of desalinated water (relative to groundwater) (SY); Improve the current water pricing policy and provide incentives for efficient use and water savings, particularly in the agricultural sector (PT) • Establish a clear prioritization of uses according to drought scenarios provision to reduce water allocation conflicts during drought (PO); Prioritize water uses and adjust of the uses within the basin and subsystems in the basin and better adjustment of demand to the real needs, especially in the agricultural sector (JU), or to reduce high pressures on water resources (PO) • Include nature conservation needs in the ranking of priority for water allocation, especially for highly valuable natural areas (NL) • Implement a multi-annual resources management for ensuring strategic reserves available during drought episodes (JU) • Develop a well register (SY); upgrade the existing groundwater and surface water rights registers (PT) • Enhance control of extractions and existing drills (SY) or improve water withdrawals control systems and its implementation (PO); To curb illegal extraction (PT) • Modernize the existing irrigation systems and create a National Irrigation Plan (PT) • Develop awareness-raising campaigns about drought issues and include drought issues in professional education (e.g. of farmers) (CH) *Supply management* • Promote waste water reuse (PT) • Undertake an inventory of water infrastructure for emergency water supply (e.g. wells) and ensure their maintenance during wet and average rainfall periods (JU) • Develop clear procedures for the use and control of desalination plants to ensure the long-term financial support for the their maintenance (SY) *Environmental measures* • Enhance environmental measures to address ecosystems protection, fish mortality, groundwater depletion and salt-intrusion (JU, PT, SY, PO, NL) • Evaluate possible alternative measures like barriers against salty water in the Po delta and barriers or dams at different points along the river (PO) • Improve management of ecological flows and fish protection during droughts (PT) *Recovery measures* • Improve recovery measures, particularly agricultural compensation schemes (SY, JU, PO, PT)
4. Resources	• Ensure availability of resources for the implementation of drought measures (e.g. increased aids for farmers to compensate production losses (PO, PT) • Develop a clear procedure for the allocation of financial resources among water uses and sectors (SY, PT) and among different types of measures (JU) • Define clear responsibilities and personnel assignment for drought management at a municipal level (SY) • To enhance transparency and information mechanism of economic resources utilization (SY)
5. Coordination & Participation	• Improve coordination among municipalities to improve drought management (SY) and among public administration authorities (JU); To improve communication between the technical committee (Cabina di Regìa) and external actors/stakeholders, including public opinion (PO); To improve drought management coordination between the national and cantonal levels and between neighbouring cantons (CH) • Improve communication among all stakeholders at all levels (PO, PT, JU, CH, SY) • Enhance active involvement of the agricultural sector (SY, PT), civil protection (PO) and environmental NGOs (SY, PT, PO, JU) in decision-making processes • Create mechanisms that reduce delayed response during drought events (SY) or improve efficiency of participatory process to reduce time consuming in meetings and decision making due to consensus reach requirements (JU); • Establish formal participation mechanisms. (SY) e.g. creation of drought commission (PO) or maintain a permanent drought commission (JU); • To integrate groundwater and surface water in water planning (PT) • Enhance conjunctive management on transboundary water with Spanish authorities (PT) • Improve integration of DMP into RBMP and Municipal Contingency Plans (JU)

Dim	Recommendations
6. Evaluation & learning	• Promote a comprehensive evaluation of drought, including social, environmental and economic impacts (PT, SY, PO, CH) • Develop a monitoring systems of the implementation of drought measures (JU, PO) • Carry out an ex-post evaluation of the adopted individual measures after each drought episode (PT, SY, PO) • Promote 'institutional memory' in the organizations involved in drought management, by ensuring the stability of staff or creating action protocols including past experiences (PT)

Some methodological considerations

The application of our methodology to several case studies helped to identify some issues worth to be considered when undertaking an assessment of drought management.

In terms of scale, the local level represented by the SY proved to be particularly suitable for analyzing specific drought measures and linkages with context and other factors. Policies, however, are usually defined at a higher level and the influence of other administrative spheres on local problems and solutions can be crucial but difficult to capture when working at a strictly local level. A similar problem can occur also at a river-basin level, although many drought responses can be effectively defined and implemented at such scale. Finally, the national scale can be too broad for a comprehensive assessment of drought response, as a country-wide study can hide important regional differences and needs. Additionally, as national policies are generally defined in generic terms (Jann & Wegrich, 2006), locally their implementation can be hindered by conflicts, as it may affect stakeholders' interests in a particular context or sector. Thus, it is important to combine the establishment of a country-wide policy frame for drought management with adaptation of national guidelines to the local context.

The study is mainly based on qualitative sources of information, due to the value of considering also the perception of actors involved in drought management and because quantitative data on several relevant issues (e.g., executed budget by implemented measure, economic impacts) were heterogeneous and incomplete. This reveals a significant data gap hampering a comprehensive assessment of drought management, based on both qualitative and quantitative data.

Conclusions

The paper presents a methodology for ex-post evaluation of response to drought in a European context. The evaluation aims at offering a snapshot of drought management from a risk-management perspective in a given location rather than an in-depth assessment of the performance of selected individual measures.

The implementation of the methodology in six case studies has demonstrated the capability of a theory-based evaluation (TBE) approach to organize and structure the analysis of key aspects of drought management in very different contexts, at different scales and with different degrees of drought policy development. Indeed, it allows the formulation of evaluation questions with the input of stakeholders, the identification of evaluation dimensions broad enough to include the specificity of each case study, and the design of tools that can be adjusted to the actual data availability.

The information resulting from the assessment is useful in at least four ways. Firstly, it offers an overall picture of drought management in a given case study. This serves as starting point for more in-depth studies when information and knowledge about drought management is dispersed and fragmented, and to frame those detailed analyses into a specific context. Secondly, it can be used to reveal whether the current drought-management strategy follows a crisis- or a risk-management approach. In particular, the use of visual CS profiles can be an effective instrument to signal to policy-makers pitfalls in the shift toward a risk-management approach. Thirdly, the evaluation contributes to identify good practices and management pitfalls, and therefore can inform actions for improvement of drought management in the future. This can also contribute to identify a pool of good practices that can be considered for possible use in other areas once they have been adapted to their specific context (Biswas & Tortajada, 2010). And fourth, the evaluation serves for documenting past practices and their performance, in order to create a body of knowledge that could otherwise get lost due to lack of institutional continuity.

Results suggest that the existence of a drought management plan or a similar integrated system substantially contributes to a coordinated and structured response to drought. Moreover, the involvement of all management levels and of stakeholders in decision-making processes has proven to be a crucial ingredient in seeking and implementing effective response to drought. For this reason, comprehensive participation of all stakeholders at different territorial levels through clearly regulated participatory mechanisms has to be ensured. Areas for improvement that have emerged in the case studies are presented in the paper. Some outstanding issues that need to be addressed are: environmental protection to avoid irreversible damage to ecosystems; systematic assessment of vulnerability to drought and of drought impacts; balanced and transparent distribution of economic resources across sectors affected by drought; and, last but not least, systematic and comprehensive ex-post evaluation of drought management and responses. Indeed, the assessment of past responses paves the way to an enhanced management of drought, by strengthening positive practices and addressing challenges that were not managed in a satisfactory way in the past.

References

Anderson, J. (1997). Public Policy Making, 3rd ed. Boston. Houghton Mifflin Co.

Astbury, B., & Leeuw, F. L. (2010). Unpacking Black Boxes: Mechanisms and Theory Building in Evaluation. *American Journal of Evaluation*, *31*(3), 363 -381.

Basurto, X., & Speer, J. (2012). Structuring the Calibration of Qualitative Data as Sets for Qualitative Comparative Analysis (QCA). *Field Methods* 24(2), 155-174.

Biswas, A. K., & Tortajada, C. (2010). Future Water Governance: Problems and Perspectives. *International Journal of Water Resources Development*, 26(2), 129-139.

Bokal, S., Grobicki, A., Kindler, J., & Thalmeinerova, D. (2014). From national to regional plans – the Integrated Drought Management Programme of the Global Water Partnership for Central and Eastern Europe. *Weather and Climate Extremes*, 3, 37-46.

Botterill, L.C. (2003). Uncertain Climate: The Recent History of Drought Policy in Australia. *Australian Journal of Politics & History, 49(1)*, 61-74.

Bruyninckx, H. (2009). Environmental evaluation practices and the issue of scale. *New Directions for Evaluation, 122,* 31–39.

Carvalho, S., & White, H. (2004). Theory-Based Evaluation: The Case of Social Funds. *American Journal of Evaluation*, 25(2), 141-160.

Chen, H.-T. (1990). Theory-driven evaluations. Newbury Park, CA: Sage Publications Inc

Cho, H., & Witte, K. (2005). Managing fear in public health campaigns: A theory-based formative evaluation process. *Health Promotion Practice*, 6, 482-490.

Conner, R. F., Mishra, S. I., & Lewis, M. A. (2004). Theory-based evaluation of AIDS-related knowledge, attitudes, and behavior changes. New Directions for Program Evaluation, 46, 75-85.

Crew, R. E. Jr., & Anderson, M. R. (2003). Accountability and performance in charter schools in Florida: A theory-based evaluation. *American Journal of Evaluation*, 24, 189-212.

De Stefano, L., Hernández-Mora, N., López-Gunn, E., Willaarts, B., Zorrilla-Miras, P. (2013). Public Participation and transparency in water management, in: De Stefano, L. & Llamas, R. (Eds.), Water, agriculture and the environment in Spain: Can we square the circle?. Fundación Botín & CRC Press, Madrid, pp. 217-225.

Dessai, S., & Sims, C. (2010). Public perception of drought and climate change in southeast England. *Environmental Hazards, 9(4)*, 340-357.

Donaldson, S. I., & Gooler, L. (2003). Theory-driven evaluation in action: Lessons from a $20 million statewide work and health initiative. *Evaluation and Program Planning*, 26, 355-366.

Dryden-Cripton, S., Smithers, J.A., de Loë, R.C., Kreutzwiser, R. D. (2007). An Evaluation of Options for Responding to Agricultural Droughts and Water Shortages in Canada. Final Report. Prepared for Natural Resources Canada, Climate Change Impacts and Adaptation Program. Guelph, ON: Guelph Water Management Group.

Estrela, T., & Vargas, E. (2012). Drought Management Plans in the European Union. The Case of Spain. *Water Resources Management, 26 (6),* 1537–1553.

European Commission (2007a). Communication `from the Commission to the European Parliament and the Council. Addressing the challenge of water scarcity and droughts in the European Union. COM (2007) 414 final. European Commission, Brussels.

European Commission (2007b). Water Scarcity and Droughts. In-Depth-Assessment. Second Interim Report. DG Environment. European Commission, Brussels.

European Commission (2007c). Drought Management Plan Report: Including Agricultural. Drought Indicators and Climate Change Aspects. Technical Report – 208 – 023. Water Scarcity and Drought Expert Network. DG Environment.

European Commission (2009). White Paper. Adapting to Climate Change: Towards a European framework for action. European Commission. Brussels.

European Commission (2011). Third Follow-up Report to the Communication on water scarcity and droughts in the European Union. COM (2010) 228 final. European Commission. Brussels.

European Environmental Agency, (2009). Water resources across Europe— confronting water scarcity and drought. EEA Report No 2/2009. European Environment Agency.

FAO & NDMC (2008). The Near East Drought Planning Manual: Guidelines for Drought Mitigation and Preparedness Planning. Food and Agriculture Organization of the United Nations Regional Office for the Near East, Cairo, Egypt and National Drought Mitigation Center University of Nebraska-Lincoln, Nebraska, USA59pp.

Fekete, A., Damm, M., Birkmann, J. (2010). Scales as a challenge for vulnerability assessment. *Natural Hazards, 55(3),* 729-747.

Fu, X., Svoboda, M., Tang, Z., Dai, Z., & Wu, J. (2013). An overview of US state drought plans: crisis or risk management? *Natural Hazards*, *69*(3), 1607-1627.

Garrido, A., & Rey, D. (2014). Description and analysis of policy approaches to drought and floods in agriculture in five OECD countries. Joint Working Party on Agriculture and the Environment. Trade and Agricultural Directorate & Environmental Directorate. Report COM/TAD/CA/ENV/EPOC(2014)2015. OECD. (Disponible en www.oecd.org)

Giordano, R., & Vurro, M. (2010). Fuzzy Cognitive Map to Support Conflict Analysis in Drought Management. En M. Glykas (Ed.), *Fuzzy Cognitive Maps* (pp. 403-425). Springer Berlin Heidelberg.

González Tánago, I., Urquijo, J., Blauhut, V., Villarroya, F., & De Stefano, L. (2015). Learning from Experience: A Systematic Review of Assessments of Vulnerability to Drought. *Natural Hazards* (DOI:10.1007/s11069-015-2006-1)

Gopalakrishnan, C. (2013). Water and disasters: a review and analysis of policy aspects. International Journal of Water Resources Development, 29(2), 250-271.

Gupta, J., Termeer, C., Klostermann, J., Meijermink, S., Brink, M. van den, Jong, P., Bergsma, E. (2010). The Adaptive Capacity Wheel: A method to assess the inherent characteristics of institutions to enable the adaptive capacity of society. *Environmental Science & Policy, 13(6)*, 459-471.

Hanberger, A. (2001). What is the Policy Problem? Methodological Challenges in Policy Evaluation. *Evaluation, 7(1),* 45-62.

Hayes, M., Wilhelmi, O., Knutson, C. (2004). Reducing Drought Risk: Bridging Theory and Practice. *Natural Hazards Review, 5(2),* 106-113.

Heathcote, R. L. (1969). Drought in Australia: A Problem of Perception. *Geographical Review, 59(2),* 175-194.

Hense, J., Kriz, W. C., & Wolfe, J. (2009). Putting theory-oriented evaluation into practice: A logic model approach for evaluating SIMGAME. Simulation & Gaming, 40, 110-133.

Hernández-Mora, N., Cabello, V., De Stefano, L., and Del Moral, L. (2015). Networked water citizen organizations in Spain: Potential for transformation of existing power structures in water management. *Water Alternatives 8(2),* 99-124.

Hernández-Mora, N., Gil, M., Garrido, A., & Rodriguez-Casado, R. (2013). La sequía 2005-2008 en la cuenca del Ebro: Vulnerabilidad, impactos y medidas de gestión. Universidad Politécnica de Madrid - Centro de Estudios e Investigación para la Gestión de Riesgos Agrarios y Medioambientales – CEIGRAM

Higginbotham, N., Connor, L. H., & Baker, F. (2014). Subregional differences in Australian climate risk perceptions: coastal versus agricultural areas of the Hunter Valley, NSW. *Regional Environmental Change*, 14(2), 699-712.

Hockings, M., Stolton, S., Dudley, N., & James, R. (2009). Data credibility: What are the «right» data for evaluating management effectiveness of protected areas? *New Directions for Evaluatio*n, 2009(122), 53–63.

Iglesias, A., Garrote, L., Diz, A., Schlickenrieder, J., Martin-Carrasco, F. (2011). Re-thinking water policy priorities in the Mediterranean region in view of climate change. *Environmental Science & Policy, 14 (7),* 744-757.

International Panel on Climate Change (2012). Field, C.B., V. Barros, T.F. Stocker, D. Qin, D.J. Dokken, K.L. Ebi, M.D. Mastrandrea, K.J. Mach, G.-K. Plattner, S.K. Allen, M. Tignor, P.M. Midgley (Eds.). Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation, Cambridge University Press. England (582 pp).

Jann, W., & Wegrich, K. (2006). Theories of the policy cycle. In Handbook of Public Policy Analysis. Theory, Politics, and Methods. Fisher F., Miller, G.J. & Sidney, M.S (Eds), CRC Press (pp. 43-62).

Janssen, M. A., Schoon, M. L., Ke, W., & Börner, K. (2006). Scholarly networks on resilience, vulnerability and adaptation within the human dimensions of global environmental change. *Global Environmental Chang*e, 16(3), 240-252.

Kallis, G. (2008). Droughts. *Annual Review of Environment and Resources, 33 (1),* 85-118.

Kampragou, E., Apostolaki, S., Manoli, E., Froebrich, J., Assimacopoulos D. (2011). Towards the harmonization of water-related policies for managing drought risks across the EU. *Environmental Science & Policy, 14 (7),* 815–824.

Knaap, G. J., & Kim, T. J. (1998). Environmental Program Evaluation: A Primer. University of Illinois Press.

Knutson, C., Hayes, M., & Phillips, T. (1998). How to Reduce Drought Risk. Western Drought. Coordination Council Preparedness and Mitigation Group.

Kossida, M., Kakava, A., Tekidou, A., Iglesias, A., Mimikou, M. (2012). Vulnerability to Water Scarcity and Drought in Europe. ETC/ICM Technical Report 3/2012.

Lackstrom, K., Brennan, A., Ferguson, D., Crimmins, M., Darby, L., Dow, K., Ingram, K., 5 Meadow, A., Reges, H., Shafer, M., and Smith, K. (2013). The missing piece: drought impacts monitoring, in: Workshop Report Produced by the Carolinas Integrated Sciences &Assessments Program and the Climate Assessment for the Southwest, 5–6 March 2013, Tucson, AZ, 1–23, 22 pp., 2013.

Lloyd-Hughes, B. (2014). The impracticality of a universal drought definition. Theoretical and Applied Climatology, 117(3-4), 607-611.

MEDROPLAN (2007). Drought Management Guidelines and Examples of Application. Iglesias. A., Cancelliere, S., Gabiña, D., López-Francos, A., Moneo, A. and Rossi, G. (eds). European Commission. MEDA-Water programme. Zaragoza. Retrieved from www.iamz.ciheam.org/medroplan]

Mickwitz, P. & Birnbaum, M. (2009). Key insights for the design of environmental evaluations. *New Directions for Evaluation, 122,* 105–112.

Mickwitz, P. (2003). A Framework for Evaluating Environmental Policy Instruments. *Evaluation, 9 (4)*, 415 –436.

Mishra A.K. & Singh V.P (2010). A review of drought concepts. *Journal of Hydrology, 391 (1–2)*, 202–216.

Nesman, T. M., Batsche, C., & Hernandez, M. (2007). Theory-based evaluation of a comprehensive Latino education initiative: An interactive evaluation approach. Evaluation and Program Planning, 30, 267-281.

Patt, A. G. & Schröter, D. (2008). Perceptions of climate risk in Mozambique: Implications for the success of adaptation strategies. *Global Environmental Change*, 18(3), 458-467.

Perry, C. (2013). ABCDE+F: a framework for thinking about water resources management. *Water International, 38 (1),* 95-107.

Quevauviller, P. (2011). Adapting to climate change: reducing water-related risks in Europe – EU policy and research considerations. *Environmental Science & Policy, 14 (7)*, 722-729.

Rogers, P. & Hall, A. (2003). Effective Water Governance. TEC Background Paper 7.: Global Water Partnership Technical Committee, Stockholm, Sweden.

Rogers, P. J. (2000). Causal models in program theory evaluation. New Directions for *Evaluation¸ 87,* 47-55.

Rogers, P. J. (2008). Using Programme Theory to Evaluate Complicated and Complex Aspects of Interventions. *Evaluation, 14 (1),* 29-48.

Rossi, G. (2000). Drought Mitigation Measures: A Comprehensive Framework. En J. V. Vogt & F. Somma (Eds.), Drought and Drought Mitigation in Europe (pp. 233-246). Springer Netherlands.

Rossi, G., & Cancelliere, A. (2013). Managing drought risk in water supply systems in Europe: a review. International Journal of Water Resources Development, 29(2), 272-289.

Rossi, G., Cancelliere, A., Giuliano, G. (2005). Case Study: Multicriteria Assessment of Drought Mitigation Measures. *Journal of Water Resources Planning & Management, 131(6),* 449-457.

Rossi. G. (2009). European Union policy for improving drought preparedness and mitigation. *Water International, 34 (4),* 441-450.

Schmidt, G., Benítez, J. J., & Benítez, C. (2012). Document: Working definitions of Water scarcity and Drought. Version 4.0. Inecsa-Inarsa (based on a previous draft by TYPSA

Slegers, M. F. W. (2008). «If only it would rain»: Farmers' perceptions of rainfall and drought in semi-arid central Tanzania. *Journal of Arid Environments, 72(11),* 2106-2123.

Smit, B., & Wandel, J. (2006). Adaptation, adaptive capacity and vulnerability. *Global Environmental Change, 16(3),* 282-292.

Stame, N. (2004). Theory-Based Evaluation and Types of Complexity. Evaluation, 10(1), 58-76.

Strosser, P., Dworak, T., Garzon Delvaux, P.A., Berglund, M., Schmidt, G., Mysiak, J., Kossida, M., Iacovides, I., Ashton, V. (2012). Gap analysis of the Water Scarcity and Droughts Policy in the EU. Final report. European Commission Tender ENV.D.1/SER/2010/0049 / Acteon 2012. Inception Report of Water Scarcity & Droughts Policy in the EU - Gap Analysis. Tender ENV.D.1/SER/2010/0049

Supramaniam, M., Di Masso, M. & García Sastre, A. (2011). Lessons learnt and challenges with regard to social capacity building: Heat-related hazards – droughts, forest fires and heat waves in Southern Europe. CapHaz-Net WP7 Report, Institute for Environmental Sciences and Technology (ICTA), Autonomous University of Barcelona, Spain.

UNDP (2011). Mainstreaming drought risk management - a primer. 73pp

UNISDR (2005). Drought. Living With Risk: An Integrated Approach to Reducing Societal Vulnerability to Drought ISDR Ad Hoc Discussion Group on Drought.

UNISDR (2007). Hyogo Framework for Action 2005-2015: Building the Resilience of Nations and Communities to Disasters. Extract from the final report of the World Conference on Disaster Reduction (A/CONF.206/6). International Strategy for Disaster Reduction (UNISDR). Geneva. Switzerland. 25pp.

Urquijo, J., & De Stefano, L. (in press). Perception of drought and local responses by farmers: a perspective from the Jucar River Basin, Spain. Water Resources Management. (DOI: 10.1007/s11269- 015-1178-5)

Vedung, E. (1999). Public Policy and Program Evaluation. New Brunswick. NJ. and London: Transaction

W. K. Kellogg Foundation (2004). Logic Model Development Guide.

Weiss, C.H. (1997). Evaluation (2.a ed.). Prentice Hall.

White, H., & Masset, E. (2007). Assessing interventions to improve child nutrition: A theory-based impact evaluation of the Bangladesh Integrated Nutrition Project. Journal of International Development, 19, 627-652.

Wilhite, D. A., Hayes, M. J., Knutson, C. L. (2005). Drought preparedness planning: building institutional capacity. In: Wilhite DA. (ed.) Drought and Water Crisis: Science, Technology and Management Issues. CRC Press, Boca Raton, Florida, pp. 93-136 (chapter 5)

Wilhite, D. A., Hayes, M. J., Knutson, C., Smith, M. H. (2000). Planning for drought: moving from crisis to risk management. *Journal of the American Water Resources Association, 36 (4),* 697-710.

Wilhite, D. A., Sivakumar, M. V. K., & Pulwarty, R. (2014). Managing drought risk in a changing climate: The role of national drought policy. *Weather and Climate Extremes, 3,* 4-13.

Wilhite, D. A., Svoboda, M., Hayes, M. (2007). Understanding the complex impacts of drought: A key to enhancing drought mitigation and preparedness. *Water Resources Management, 21 (5),* 763-774.

Wilhite, D.A. (2001). Moving Beyond Crisis Management. After nearly a century of ad hoc drought management, the United States needs a new paradigm centered on risk management. FORUM for Applied Research and Public Policy

Wilhite, D.A., & Glantz, M.H. (1985). Understanding: the drought phenomenon: the role of definitions. *Water International, 10 (3),* 111-120.

4.4. Las evaluaciones de vulnerabilidad a la sequía

González Tánago, I., Urquijo, J., Blauhut, V., Villarroya, F., & De Stefano, L. (2015). Learning from Experience: A Systematic Review of Assessments of Vulnerability to Drought. *Natural Hazards* (DOI:10.1007/s11069-015-2006-1)

Nat Hazards
DOI 10.1007/s11069-015-2006-1
ORIGINAL PAPER

Learning from experience: a systematic review of assessments of vulnerability to drought

Itziar González Tánago[1] · Julia Urquijo[1] · Veit Blauhut[2] · Fermín Villarroya[1] · Lucia De Stefano[1]

Received: 10 July 2015 / Accepted: 30 September 2015

Abstract In the last decades, there have been an increasing number of vulnerability studies undertaken in the frameworks of several schools of thought and disciplines. This spur of activity is linked to the growing awareness about the importance of shifting from a crisis-reactive approach to a proactive and preventive risk management approach to deal with natural disasters. The severity of the impacts that drought provokes worldwide has also contributed to raise awareness about the need to improve its management. In this context, drought vulnerability assessments are the first step in the identification of underlying causes that generate drought impacts. This paper presents a systematic review of past assessments of vulnerability to drought, to enhance the understanding of vulnerability and help orientating future research in this field. Results suggest that there are important geographical and thematic gaps to be filled in the assessment of drought vulnerability. Transparency in the design and validation of results should be improved, while the availability of relevant, reliable, and updated data is still a major constraint at all levels.

Keywords Drought o Vulnerability o Assessment o Systematic o Review

Electronic supplementary material The online version of this article (doi:10.1007/s11069-015-2006-1) contains supplementary material, which is available to authorized users.

& Itziar González Tánago itanago@gmail.com

1 Universidad Complutense de Madrid, Madrid, Spain

2 University of Freiburg, Freiburg, Germany

1. Introduction

Drought is a complex phenomenon and one of the least understood natural hazards (Swain and Swain 2011). Estimates of global economic losses caused by drought are higher than any other meteorological disaster (Wilhite 2000) and drought impacts affect directly or indirectly several sectors (social, economic, environmental) and large geographical areas.

In 2013, several UN agencies[46] organized a high-level meeting on National Drought Policy (HMNDP) to provide decision makers with relevant recommendations and science- based actions to address key drought issues. The meeting conclusions expressed concern for the absence of drought preparedness and drought management policies in the majority of the countries, as the lack of national drought policy makes that ''responses are generally reactive in terms of crisis management, and often untimely and poorly coordinated'' (Si- vakumar et al. 2014). Strategies for drought mitigation and preparedness are thus needed in order to reduce societal vulnerability, and drought vulnerability assessments are the first step in this direction (Knutson et al. 1998; Wilhelmi and Wilhite 2002; Zarafshani et al. 2012; Zhang et al. 2014). Drought vulnerability assessment can support decision-making processes (So¨nmez et al. 2005; Pereira et al. 2014) through the identification of adequate mitigation actions (Wilhelmi and Wilhite 2002), the design of contingency plans (So¨nmez et al. 2005), and the setup of early warning systems (Villholth et al. 2013; Naumann et al. 2013). In this context, several authors warn that more efforts are spent on studying and quantifying drought as a natural hazard than in exploring societal vulnerability to drought, despite the fact that the latter is the underlying cause of most of drought impacts (Downing and Bakker 2000 in Wilhelmi and Wilhite 2002; Shiau and Hsiao 2012; Kim et al. 2013).

According to Knutson et al. (1998) a vulnerability assessment provides a framework for identifying the root causes of drought impacts at social, economic, and environmental levels, linking drought mitigation with ''true causes'' of vulnerability that generate impacts. In other words, vulnerability assessments attempt to understand who is vulnerable to what, when, and why, and what can be done to reduce vulnerability (Gbetibouo and Ringler 2009). Since vulnerability is very context specific and location specific, its assessment should be multidimensional and should take into account socioeconomic and cultural aspects as well as physical ones (Sivakumar et al. 2014).

In the literature, there is a broad diversity of drought vulnerability assessments (DVAs) depending on the purposes, the scope, the conceptual framework, or the methodology used. For instance, there are descriptive studies that explore drought vulnerability and coping strategies (Abraham 2006; Derbile 2013); assessments focused on a specific socioeco- nomic sector (e.g., Thomas et al. 2013), or several ones (Karavitis et al. 2012; Assima- copoulos et al. 2014; De Stefano et al. 2015); studies that use ethnographic techniques (Adepetu and Berthe 2007; Keshavarz et al. 2013), modelling (Fraser et al. 2013; Flo¨rke et al. 2011), fuzzy systems (Bhattacharya and Das 2007; Cheng and Tao 2010), or vul- nerability curves (Lei and Luo 2011). There are also DVAs that study natural systems, human systems, or coupled human-environmental systems; that stress biophysical aspects or socioeconomic aspects or both; and that focus exclusively on responses or exclusively on drought hazard. Besides, DVAs are undertaken at different geographical (subnational to global) and temporal scales (past, current and future vulnerability). The diversity within drought vulnerability studies is extremely high, and there is a lack of common conceptual understanding of vulnerability, standardized

[46] World Meteorological Organization (WMO), the Secretariat of the United Nations Convention to Combat Desertification (UNCCD) and the Food and Agriculture Organization of the United Nations(FAO), in collaboration with a number of partners.

methodology, and common vulnerability metrics. All this hampers comparisons of results obtained by different DVAs. Compara- bility of vulnerability levels, however, is frequently demanded by decision makers (Hinkel and Klein 2006; Wolf 2012), in order to identify hotspots of vulnerability where they should focus efforts to strengthen adaptive capacity (Cutter et al. 2003; Hinkel and Klein 2006; Eriksen and Kelly 2007; Sivakumar et al. 2014). DVAs also contribute to identify the sources of risk inherent in the assessed system, and, for this reason, they are important elements for the development of drought risk management plans. Moreover, they can be used as a diagnostic tool to understand why some areas have suffered impacts in past events (Knutson et al. 1998), thus informing ex post evaluation of response to drought.

This paper presents a systematic literature review of existing applied assessments of vulnerability to drought, with the objective of identifying gaps and trends in this field. Thus, this work has the potential to support future research and practice related to the assessment of vulnerability to drought.

2. Methods

"A systematic literature review is a summary and assessment of the state of knowledge on a given topic area" (Ford and Pearce 2010). It systematizes the state of the art and is necessary to support practice and policy, as well as to identify gaps and new directions for further research efforts, policy, and methods (Petticrew and Roberts 2006; Ford and Pearce 2010; Johnson et al. 2011; Plummer et al. 2012). Systematic reviews allow overcoming potential author's bias and inconsistencies, manage and handle information overload, shed light into gaps, and inform policy makers by providing robust and reliable summaries of evidence (Petticrew and Roberts 2006).

In recent years, there have been several efforts to synthesize investigations and assessments in different domains, such as global environmental and climate change (e.g., Rudel 2008; Ford and Pearce 2010; Thompson et al. 2010; Hofmann et al. 2011) or vulnerability and risk assessments (e.g., Plummer et al. 2012; or Sohrabizadeh et al. 2014), but none of these addresses specifically vulnerability to drought.

A systematic literature review usually follows three steps (Hofmann et al. 2011). Firstly, a search protocol must be designed through the establishment of inclusion and exclusion criteria for the selection of the studies to be reviewed (Rudel 2008; Hofmann et al. 2011; Plummer et al. 2012); then the information from the selected studies is classified or coded (Rudel 2008; Hofmann et al. 2011); and finally, the information is analyzed following specific criteria and using statistical, descriptive, or qualitative methods.

These steps were followed to study the existing applied assessments of vulnerability to drought that have been documented in the scientific literature until April 2015.

2.1. Search protocol

Table 1 summarizes the criteria used for the selection of items to be analyzed. We focused specifically on DVAs that quantify vulnerability and present vulnerability values in a graphic or numerical way. Furthermore, we prioritised studies focused on human systems, excluding those exploring only natural systems (e.g., vulnerability to drought of flora and fauna).

Table 2 presents the outcomes of the application of the search protocol to diverse databases of scientific literature (ProQuest, Springer Link, Science Direct, Willey Online and Google Scholar). To undertake the search, we worked under the assumption that relevant items should include in the abstract the words "DROUGHT VULNERABILITY ASSESSMENT". To complement the search, and not limit it to peer review journals, we also followed the CEE protocol[47] for internet searches, fully reviewing the first

Table 1. Criteria for items selection

Inclusion criteria	Exclusion criteria
English literature	All non-English literature
Drought vulnerability assessment	Assessment of the vulnerability of water resources, climate variability or climate change (broadly) vulnerability assessment
	Drought hazard assessment or drought risk assessment not measuring vulnerability
Human systems and/ or Coupled Human-Environmental Systems	DVAs focused exclusively on natural system (forest, fishes, aquatic ecosystem, etc.)
	DVAs focused exclusively on functioning of water supply systems
	DVAs focused only on agriculture productivity
Applied assessment with a quantification of vulnerability	Theoretical framework, ethnographic or qualitative studies that do not include vulnerability quantification.

Table 2. Search outcomes

DATASET	SEARCH PARAMETERS	OUTCOME
ProQuest	1st search: Drought AND vulnerability AND assessment - ALL (Except full text) 2nd search: + drought (title)	1st search 334 items found 21 included 2nd search: 71 items found - 16 duplicated - 3 included - 52 excluded
Springer link	1st search: Drought AND vulnerability AND assessment 2nd search: + drought (title)	6431 items found 2nd search: 298 items found - 36 included - 262 excluded
Science Direct	1st search: Drought AND vulnerability AND assessment + ABSTRACT TITLE KEYWORDS	50 items found - 8 duplicated - 2 included - 40 excluded
Willey online	1st search: Drought AND vulnerability AND assessment + - ABSTRACT	27 items found: - 1 Included - 26 excluded
Google Scholar	1st search "Drought vulnerability assessment"	121 items found: - 35 duplicated - 88 excluded

50 items presented in Google, and exploring the following 50 for relevance. We explored also the references of selected studies to identify further relevant investigations. To narrow the search and identify relevant studies, in those search motors that allowed it, the search was restricted using specific words as search parameters (see Table 2). We conducted the searches along a 4-month period (April–July, 2014) and repeated the exploration in October 2014 and April 2015.

[47] Collaboration for Environmental Evidence (CEE) is a specialized library of systematic reviews.

During the search, we found some DVAs that were presented in more than one pub- lication. Thus, we decided that our unit of analysis (item) should be each DVA and not the single papers. Following the document screening, approximately 190 items were selected for systematic review (see Supplementary Material). After a full-text exploration of those items and the application of the inclusion criteria described above, 46 DVAs were retained for the systematic review.

After the identification of the items to be analyzed, we proceeded to code them to explore methodological and conceptual aspects of the DVAs, and also for basic inferential statistics. The analysis was focused on the following aspects: location and scale of DVAs, to identify possible gaps and scale implications; conceptual frameworks most frequently used within DVAs; dimensions and subdimensions of vulnerability factors included in DVA's, to explore comprehensiveness and identify possible patterns. On the method- ological side, we explored three steps in the assessment process: identification and selection of factors, weighing of factors and components, and validation of results. And finally, we examined the intended uses and users stated in the DVAs.

3. Results and discussion

3.1. Geographical distribution and spatial scope

Trends in the number of vulnerability studies published during the last decade (Fig. 1) mirror the growing interest for vulnerability assessments in the international community, especially within the disaster risk reduction (DRR) and climate change adaptation (CCA) schools.

Diversity in terms of scale, as well as geographical location, is high (Table 3). The majority of the assessments identified focus on Asia, mostly at subnational level in China, India, and Iran, while South and Central America and Northern Africa are the regions where fewer assessments have been found (Table 3 and Table 1 in Supplementary mate- rial). Initially, this gap was attributed to the linguistic criterion applied in the search, since these are mostly Spanish- and French-speaking regions, respectively. However, a test search applying the protocol with Spanish terms ("evaluación or análisis ? vulnerabili- dad ? sequía") returned a very low number of items, thus suggesting that, at least for Latin America, the scarcity of DVAs found cannot be attributed to our search protocol. Also the absence of DVAs in Australia is somehow surprising and requires further research, in order to understand the reasons behind this gap.

It is interesting to compare the spatial distribution of DVAs (Fig. 2) with the magnitude of the impacts of drought registered in EM-DAT[48]. Table 4 shows the 15 countries most affected by droughts in terms of people affected, total economic damage, and number of drought events since 1990. Countries with high drought impacts such as China, USA, or Brazil present at least one DVA, while in others such as Mozambique, Ethiopia, Thailand, or Honduras, no DVAs were found.

3.2. Types of conceptual frameworks

The review has shown that there is a significant diversity in the understanding and defi- nition of vulnerability (see Table 4 Supplementary Material), confirming that the lack of

48 http://www.emdat.be/database

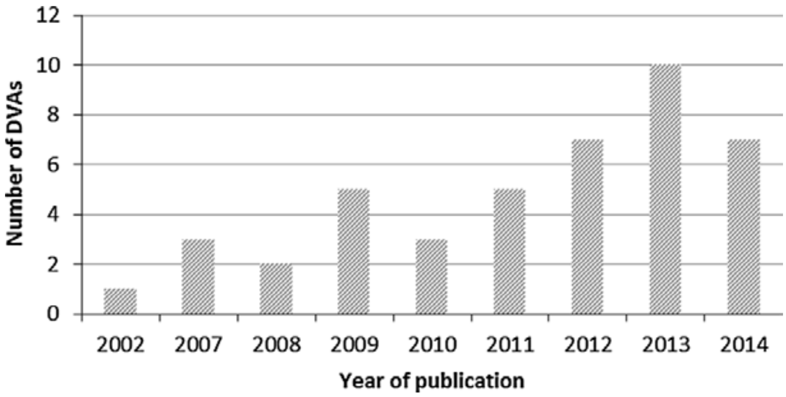


Figure 1. Evolution over time of DVA publications (source: own elaboration).

Table 3 Location and scale of the reviewed DVAs.

Location	Subnational	National	Regional	Continental	Global	Total
Africa	3	1	1	1		6
Asia	21	3				24
Europe	2	4	1	2		9
Mediterranean			1			1
North America	3					3
South America	1					1
World					2	2
Total	**30**	**8**	**3**	**3**	**2**	**46**

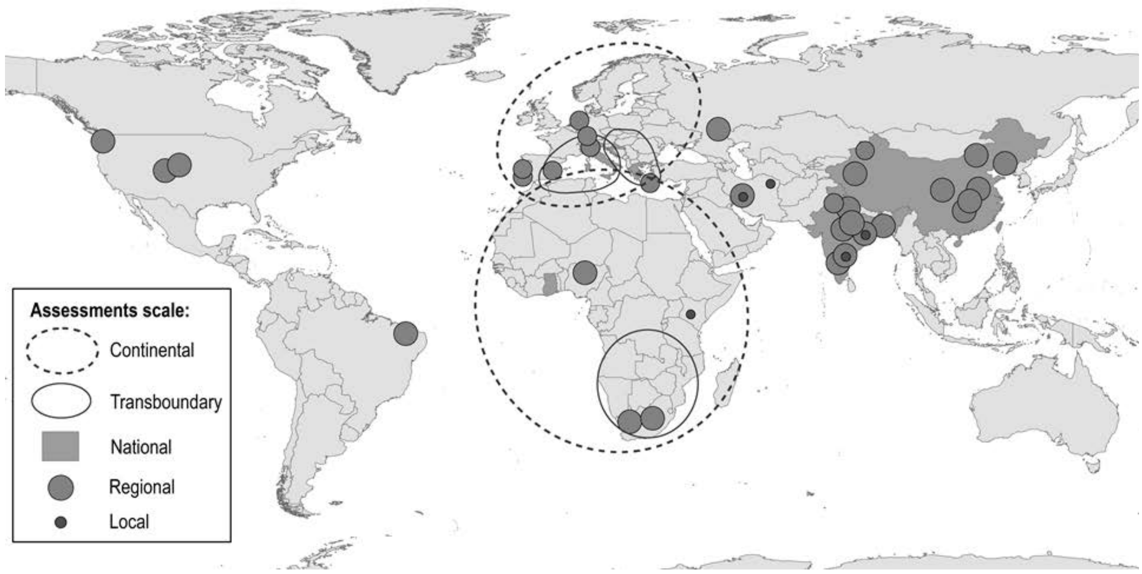


Figure 2 Location of the reviewed DVAs

consensus among scholars regarding the definition, frames, and methods for measuring vulnerability continues to be an unresolved issue (Preston et al. 2011; Costa and Kropp 2013)

Table 4 Drought impacts and losses around the world (1990-2014)

Country	Total people affected (millions)	Country	Total damage ('000$)	Country	Drought events
China P Rep	415.27	**United States**	39,135,000	**China P Rep**	26
India	351.18	**China P Rep**	25,110,415	**United States**	11
Kenya	46.15	**Spain**	7,700,000	**Brazil**	10
Ethiopia	39.49	**Brazil**	7,532,000	Mozambique	9
Iran Islam Rep	37.00	Australia	3,973,000	Ethiopia	9
Thailand	29.98	**Iran Islam Rep**	3,300,000	**Kenya**	9
Malawi	20.15	Russia	2,540,000	Thailand	8
Niger	19.12	**India**	2,041,122	Honduras	8
Sudan	18.86	**Italy**	1,990,000	Bolivia	7
Zimbabwe	17.02	Ukraine	1,690,000	Namibia	6
South Africa	15.30	Mexico	1,610,000	Zimbabwe	6
Brazil	12.06	**Portugal**	1,348,136	Uganda	6
Somalia	11.70	**South Africa**	1,000,000	Malawi	6
Tanzania Uni Rep	10.65	**Greece**	1,000,000	**Niger**	6
Australia	7.00	Yugoslavia	1,000,000	Sudan	6

EM-DATA (2014) (Drought events 1990-2014. In bold locations with DVAs)

Most of the definitions of vulnerability used in the reviewed DVAs originate from the following definitions by the climate change adaptation (CCA) and the disaster reduction risk (DRR) schools:

- CCA school: The degree to which a system is susceptible to, or unable to cope with, adverse effects of drought. Vulnerability is a function of the character, magnitude, and rate of climate variation to which a system is exposed, its sensitivity, and its adaptive capacity (IPCC 2001, 2007), used by, e.g., Chandrasekar et al. (2009), Antwi-Agyei et al. (2012), Deems (2010), and Flörke et al. (2011), De Stefano et al. (2015).
- DDR school: The characteristics of a person or group in terms of their capacity to anticipate, resist, cope with, and recover from the impact of natural or man-made hazards (UN/ISDR 2009) used by, e.g., Iglesias et al. (2007), Adepetu and Berthe (2007), Cheng and Tao (2010), Zarafshani et al. (2012), Safavi et al. (2014), and Naumann et al. (2013).

According to Romieu et al. (2010), both schools have different goals, as DRR aims at highlighting means for risk reduction in shocks, while CCA looks for the most efficient way to adapt to shocks derived from climate change. Hence, DDR considers vulnerability as one step within the process of a risk assessment, whereas CCA considers vulnerability assessment as the expected outcome of the analysis[49]. These differences are reflected in their patterns of conceptualization and operationalization of vulnerability.

Within the reviewed DVAs, 16 assessments adopted the IPCC (2001) definition of vulnerability. Table 5 presents a selection of these DVAs to show that each DVA has a

[49] Some risk assessment studies (e.g., Blauhut et al. 2015) combine data about past drought impacts with hazard measurement in order to assess drought risk. This is a quite new approach that, contrary to traditional risk assessments, does not include a vulnerability assessment sensu stricto

Table 5. Selection of DVAs following the IPCC (2001) model

Study	equation	Exposure	Sensitivity	Adaptive capacity
Antwi-Agyei et al. 2012 (national)	$V = (E + S - AC)$	Long Term growing season rainfall/ yearly growing season rainfall	Crop yield sensitivity index = expected yield/actual yield	Human capital (literacy rate (%), financial capital (poverty rates (%).
Assimacopoulos et al. 2014 (subnational)	$V = (E + S - AC)$	Number of drought events, drought duration, drought intensity, Water Exploitation Index	Ground Water level, Water quality, Population density, (Demand coverage urban and agriculture), % irrigated land, Share of agricultural GDP, Crop pattern/ diversity, Tourism intensity	Access to information, Willingness to change, Conflicts, Existence of drought management policies, Actors & institutions (jurisdictions, availability to resources), Access to (water saving) technology, Access to alternative water sources, Infrastructure
Bhattacharya and Das 2007 (subnational)	$V = f(E, S, AC)$	Probability of drought, labour in agriculture, rural population, share of irrigated/unirrigated land?	Socio economic factors (income per capita, gini coeff); Technology (fertilizer per Ha, tractor per Ha); Activity (share of fruit/vegetable, share of oilseed)	Human capacity (literacy and education expenditure), Governance (Share of tax revenue) Coping options (labour in households (HHs) industries)
Deems 2010 (national)	$V = \frac{(E + S + AC)}{3}$	Precipitation (Average annual precipitation) Drought (SPI)	Water resources (GW, government irrigation scheme, irrigated area) Land resources (slope, soil)	Human Capital (population); Social Capital (services, institution, social participation); Financial capital (farm holders, workforce, unemployed, € / agricultural holdings); Physical capital (agricultural area, livestock, crop and livestock diversity)
De Stefano et al. 2015 (regional)	$V = (E + S - AC)$	Drought characteristics	Water use, Water stress, Water body status, Population, Socioeconomic relevance (by sector)	Law enforcement, drought management tools, public participation, drought awareness , education, innovation capacity, water resources development, availability and distribution of economic resources, financial capacity for drought recovery
Fontaine and Steinemann 2009 (subnational)	$V = (I - AC)$ $I = (E + S)$	Drought frequency, severity, magnitude, duration, spatial extent.	Susceptibility of a water user	Ability of a water user to manage or reduce adverse effects of a drought, through actions taken before, during, or after the drought
Liu et al. 2013 (subnational)	$V = \frac{(E + S)}{AC}$	Temporal and spatial changes of annual precipitation	Precipitation variances; Temperature variances; Vegetation coverage deviation; Average elevation	Population- economic production factor (cultivated land area, ratio of agriculture and industry output, population density), Income-information access factor (savings deposit and access to information), skills and total productivity factor (Technologists and income)
Pereira et al. 2011, 2014 (subnational)	$V = \frac{EI + SI + (1 - ACI)}{3}$	Aridity index	Agricultural employment (%), smallholder farm's production system (%); level of smallholder farming's income dependence on vegetal and livestock production (%), % of rainfed	HHs legally owned by farmer (%), HHs receiving technical assistance (%) HHs whose heads can read and write (%) HHs whose heads are engaged in associations or unions (%) HHs with access to electric energy supply (%)

Study	equation	Exposure	Sensitivity	Adaptive capacity
			smallholder farms; HHs with access to water supply (%)	
Wu et al. 2013 (subnational)	$VI = SI + ACI$	Not included	Amount of water resources per unit, Irrigation water use rate, Sown area rate of farm crops, Population density	GDP, Net income of residents in rural area, Rate of irrigation area to cultivation area, Rate of GW resources, Effective utilization coefficient of irrigated water use, Land reclamation rate, Rate of regular secondary schools
Yuan et al. 2013 (subnational)	$V = f(E, S, AC)$	Share of cultivated fields, share of paddy fields and population density	Share of rural population, water consumption per agriculture Value Added and water consumption per industry VA	Per capita GDP, fixed assets for drought mitigation, emergency irrigation, water supply and rate of effective irrigation area

specific context and scope, but they all conceptualize their assessment components (exposure, sensitivity and adaptive capacity) in a similar manner, e.g., most of them include drought characteristics in exposure, and diverse capitals (social, economic, institutional, etc.) in adaptive capacity. At the same time, it can be noticed that the combination of components to produce a measure of vulnerability varies and that the boundaries between the components are not clearly defined, as variations of the same factor are used to characterize different components (e.g., rural population or the percentage of arable land under irrigation).

Among the reviewed DVAs, 11 assess vulnerability as part of a risk assessment study. These studies apply the formula proposed by the Pressure and Release Model (Blaikie et al. 1994):

$$\mathbf{R = H \times V}$$

where risk (R) is considered to be a function of hazard (H) and vulnerability (V).

Most of these studies build a composite index to measure drought vulnerability but use different conceptualizations. Some of them group factors in renewable natural capital, economic capacity, human and civic resources, institutional capacity and infrastructure and technology (Naumann et al. (2013) or in socioeconomic and physical factors (Shahid and Behrawan, 2008); Jordaan (2012) assesses social, economic, and environmental vulnerabilities separately, whereas Kim et al. (2013) or Kipterer and Mundia (2014) combine diverse individual factors, without grouping them. The dimensions and subdimensions used in these DVAs to assess vulnerability can be found in Table 7.

3.3. Scope of the vulnerability factors

Several vulnerability scholars argue that vulnerability has a multifaceted and multidimensional nature (Turner et al. 2003; Vogel and O'Brien 2004; Birkmann 2006; Birkmann and Wisner 2006; Hufschmidt 2011), and that no single measure can fully capture its complexity (Luers et al. 2003; Gbetiobouo and Ringler 2009). Therefore, vulnerability assessments should be integrative and comprehensive and incorporate different dimensions (social, economic, physical, environmental, and institutional).

To analyze the comprehensiveness of the approaches, we have grouped vulnerability factors in two main dimensions—biophysical and socioeconomic (Preston et al. 2011)— and eleven subdimensions (Table 6). Six DVAs that did not describe vulnerability factors explicitly were not considered in this part of the analysis.

Table 6 shows the number of reviewed DVAs that include each type of subdimension, and the most frequently used vulnerability factor within each subdimension. The most commonly used subdimension (70 % of the DVAs) describes sociocultural characteristics of the assessed system, while the least common one is the one characterizing water uses (27 %).

The number of DVAs that include water resources or water uses within vulnerability factors is quite low (19 and 11, respectively). This is in contrast to reality, where avail- ability of water resources and how it is employed are key elements within drought miti- gation and prevention policies. Even though several scholars consider water scarcity to be a key driver of drought impacts (Wilhite et al. 2007; Ganapuram et al. 2013), only few assessments (Flörke et al. 2011; Shiau and Hsiao 2012; Assimacopoulos et al. 2014; De Stefano et al. 2015) include water stress among their vulnerability factors. Some studies (Deems 2010; Sreedhar et al. 2012; Fraser et al. 2013) acknowledge the relevance of including information about the available water resources (e.g., availability of ground- water, water balance, and water quality) but eventually cannot take them into account in the assessment due to lack of data.

Table 6 Sub-dimensions and most frequent factors.

	Sub-dimension	DVAs		Most frequently included factors (# of DVAs)
		#	%	
Biophysical dimension	Drought characteristics (‘*Drought*’)	**17**	**41%**	SPI (3), NDVI (4)
	Climatic components: rainfall, evapotranspiration, temperature (‘*Climate*’)	**20**	**49%**	Average annual precipitation (9)
	Soil characteristics and topographic factors (*‘Soil*’)	**20**	**49%**	Soil water-holding capacity (10)
	Water resources (SW and GW, storage, runoff, etc.) (‘*Water resource’*)	**19**	**46%**	Status groundwater (12) and surface water (10)
	Water uses (DWS, Industrial, Agricultural, etc.) (‘*Water uses’*)	**11**	**27%**	Agricultural water use (9)
Socioeconomic dimension	Land use (‘*Land use’*)	**17**	**41%**	Agricultural land uses (9)
	Socio-cultural (demography, education, health, gender, drought awareness, etc.) (‘*Socio-cultural*’)	**29**	**71%**	Population (24) and education (16)
	Economic and financial resources (labour, income, consumption, equity, productivity, investments, savings, assets, insurance, etc.) (*‘Econ financ’*)	**28**	**68%**	Economic resources (20), agricultural income (17), employment (9)
	Institutional, Policy and Governance (social networks, taxes, governmental programs, participation, etc.) (*‘Instit’*)	**14**	**34%**	Government presence or programs (9)
	Technical, technological and infrastructural (irrigation, tillage, improved seeds, fertilizers, access to services (electricity, safe water, communications, etc.) (*‘Techn infrastr*)	**28**	**68%**	Irrigation (23)
	Others (*‘Others’*)	**4**	**10%**	Impacts (2)

In cursive and between parentheses are the abbreviated names used in Table 7

Very few DVAs (Villholth et al. 2011, 2013; De Stefano et al. 2015; Murthy et al. 2015) include environmental aspects, such as water body status and water quality. This is sur- prising for two reasons. First, because, in a context of high anthropogenic pressure, the environment is highly vulnerable to drought. And second, because a low quantitative or qualitative status of water bodies decreases the capacity of response of water supply systems and thus exacerbates the vulnerability to drought of the whole socioeconomic system (WWAP 2014; Kossida et al. 2012; Van Vliet and Zwolsman 2008; Strosser et al. 2012). Interestingly, only four studies include gender as a factor (Adepetu and Berthe 2007; Shahid and Behrawan 2008; Cheng and Tao 2010; Zhang et al. 2014).

The majority of the studies reviewed include biophysical as well as socioeconomic factors (Table 7). The number of factors used in each DVA ranges from 3 to 33. Only very few cases [Cheng and Tao (2010), Zarafshani et al. (2012), Khoshnodifar et al. (2012)] explore drought vulnerability from a merely socioeconomic perspective, excluding factors of the biophysical dimensions. On the contrary, Moring et al. (2012), Perčec Tadić et al. (2014) and Safavi et al. (2014) include factors belonging mostly to the biophysical dimensions.

Table 7 Drought vulnerability assessments: dimensions, sub-dimensions and factors

	Biophysical dimensions					Socio economic dimensions						
	Drought	Climate	Soil	Water Resource	Water uses	Land use	Socio cultural	Econ financ	Instit	Techn infrastr	Others	**Total**
Adepetu and Berthe 2007						1	3	9	1			**14**
Antwi-Agyei et al. 2012		1					1	2				**4**
Assimacopoulos et al. 2014	4			2	2		2	2	4	6		**22**
Bhattacharya and Das 2007	1						3	7	1	3		**15**
Chandrasekar et al. 2009	4	2	4	1			2	1		2		**16**
Cheng and Tao 2010							7	7	2	1		**17**
De Stefano et al. 2015	1			2	1		4	3	2	2		**15**
Deems 2010	1	1	2	1			4	8	1	1		**19**
Fraser et al. 2013		2					1	4		2		**9**
Ganapuram et al. 2013		2			3							**5**
Huang et al. 2014		1	2	1		2	1	3		5		**15**
Iglesias et al. 2007		1			2		3	6		4	1	**17**
Jain et al. 2015	2		5			1	1				1	**10**
Jiang et al. 2012		2	1				1	3		2		**9**
Jordaan 2012			2	3		1	1	8	2			**17**
Karavitis et al. 2011	2			1	1					1	1	**6**
Kim et al. 2013					3		1	2		1		**7**
Kipterer and Mundia 2014							1	2				**3**
Kumar 2013		2	2	4		1	1	2		1		**13**

	Biophysical dimensions						Socio economic dimensions					
	Drought	Climate	Soil	Water Resource	Water uses	Land use	Sociocultural	Econ financ	Instit	Techn infrastr	Others	**Total**
Liu et al. 2013	1	3	1				2	4		2		**13**
Long et al. 2011	1		2							1		**4**
Móring et al. 2012		2	2	1		1				1		**7**
Murthy et al. 2015	1	2	1	1								**5**
Naumann et al. 2013		1			2	1	6	4	2	5		**21**
Pandey et al. 2010		1	1	2	1	2						**7**
Perčec Tadić et al. 2014		2	2			1						**5**
Pereira et al. 2011, 2014	1						1	5	1	3		**11**
Safavi et al. 2014		3	2	3		1						**9**
Salvati et al. 2009	1	4	5			2	2					**14**
Shahid and Behrawan 2008			1				2	3		1		**7**
Shiau and Hsiao 2012				3	3							**6**
Simelton et al. 2009	1					4	3	8		3		**19**
Sookhtanlo et al. 2013							7	9	2	9		**27**
Sreedhar et al. 2013		1	3			1						**5**
Swain and Swain 2011	2	1	2	1		2	3	5	1	2		**19**
Villholth et al. 2011, 2013	1	3	1	1			2	2	1	2		**13**
Wilhelmi and Wilhite 2002	1		1			1				1		**4**
Wu et al. 2013				2	1	1	2	3		2		**11**
Yuan et al. 2013				1	2	2	2	2		2		**11**
Zarafshani et al. 2012				1			5	11	3	7	6	**33**
Zhang et al. 2014	1							5	2		1	**9**

Forty-two percent of the reviewed DVAs include less than five subdimensions. The subdimensions and factors most frequently used within DVAs are sociocultural factors and economic and financial resources (both used in 69 % of the reviewed studies); followed by technical, technological, and infrastructural resources (67 %); and climatic components (49 %). Among vulnerability factors, the most used ones are population and irrigation (both 58 %), and economic resources (50 %).

The inclusion of a high number of subdimensions can be interpreted as an attempt to have a comprehensive approach, as they consider different perspectives. None of the selected DVAs includes factors of all subdimensions, although DVAs by Swain and Swain (2011), Deems (2010) and Villholth et al. (2013) include most of them. In this context, a high number of factors can help to improve the understanding of a specific subdimension, but it does not necessarily reflect a comprehensive approach. For instance, Sookhtanlo et al. (2013) use 27 factors but only consider five subdimensions.

3.4. Geographical and temporal scales

The majority of the studies reviewed (65 %) were carried out at subnational level, mainly in a particular region, state, or river basin. According to several authors (Cutter et al. 2009; Fekete et al. 2010; Preston et al. 2011), the subnational scale favors the inclusion of more detailed information and the use of participatory approaches and qualitative techniques, which allows a contextualization of drought vulnerability and could lead to a better identification of intervention tools for reducing vulnerability locally (Cutter et al. 2009). At the same time, very context-specific assessments are not suitable for comparison across regions to identify hotspots and, e.g., guide the allocation of funds, which is often demanded by policy and decision makers at national, regional, or international level. The trade-off between scope and depth of analysis, however, seems inevitable, as spatially broader assessments are usually compelled to simplify their methodological approach due to constraints in data availability, and to consider only issues that are relevant across the whole region assessed.

Interestingly, these differences in depth and scope do not reflect on the number of subdimensions and factors included in the assessment at different geographical scales, as the average mean of factors among subnational assessments is 13 factors against 11 in assessments of national, regional, or global scales. Some of the reviewed DVAs at larger scales (Villholth et al. 2011, 2013; Naumann et al. 2013 and De Stefano et al. 2015) attempt to apprehend multidimensionality of drought vulnerability by including an even higher number of factors (13, 21, and 15, respectively) from different subdimensions (8, 9,and 7, respectively).

Several studies (e.g., Wilhelmi and Wilhite 2002; Naumann et al. 2013; De Stefano et al. 2015) acknowledge that the reliability and accuracy of data represent a significant challenge for the elaboration of policy-relevant DVAs and stress the need to invest in systematic data collection at different scales. This underscores the importance for DVAs to discuss data constraints, as they should be taken into account the interpretation of the DVA results.

In terms of data used, Adger (2006) and Cardona et al. (2012) highlight the importance of complementing quantitative measures with narratives of stakeholders in order to better capture the complexity of vulnerability, and thus enhance the assessment. According to Cardona et al. (2012), the diversity of tangible and intangible features of vulnerability in complex systems, cannot be grasped and assessed using the same methodology. Besides, Adepetu and Berthe (2007) argue that ethnographic methods can provide valuable information that might improve further capacity-building measures to reduce vulnerability, especially in contexts where “long-standing cultural and economic differences among multiple ethnic groups produce different adaptation strategies to natural disasters” (p. xi).

Table 8. Scale and type of data

	Type of data				Scale
Scale	Mixed	Qualitative	Quantitative	Total	%
Subnational	5	5	20	30	65%
National	1		7	8	17%
Regional			3	3	7%
Continental	1		2	3	7%
Global			2	2	4%
Total	7	5	34	46	100%

As it can be observed in Table 8, qualitative data are used only in 11 DVAs (24 %), mostly corresponding to subnational scales, with the exception of Deems (2010), who assessed vulnerability to drought in Cyprus at national level. The majority of DVAs use data compiled from secondary sources such as official census and governmental or international statistics datasets. There are very few studies that collect or produce their own data ad hoc for the assessment, such as Fontaine and Steinemann (2009).

Within the studies that use qualitative or mixed methods, data are gathered mostly through surveys (Jordaan 2012; Zarafshani et al. 2012; Khoshnodifar et al. 2012; Sookh-tanlo et al. 2013), interviews (Alcamo et al. 2008; Fontaine and Steinemann; 2009; Khoshnodifar et al. 2012; Sookhtanlo et al. 2013; Jordaan 2012; Assimacopoulos et al. 2014), stakeholder meetings (Jordaan 2012; Assimacopoulos et al. 2014), and visits in loco (Adepetu and Berthe 2007; Jordaan 2012). The use of qualitative methods is not limited to data gathering, as it occurs also in other steps of the vulnerability assessment processes, such as the identification and weighting of vulnerability factors (Adepetu and Berthe 2007; Khoshnodifar et al. 2012; Sookhtanlo et al. 2013); the design of the assessment process (CWCB 2010); or the validation of results (Deems 2010).

3.5. Transparency of design and validation of results

Vulnerability assessments necessarily involve a certain level of subjectivity. Several authors (Luers et al. 2003; Vincent 2004; Eriksen and Kelly 2007) highlight the need for improving transparency along the process, by making the assumptions as well as the decisions adopted for the assessment explicit. Wiréhn et al. (2015) also prove how methodological choices influence the final results of the DVA and stress that "methods and underlying factors must be visible." Transparency increases the robustness of the assess- ments (Eriksen and Kelly 2007) and contributes to comparability across studies. To examine transparency, we have focused on two key methodological aspects of the design and operationalization of the DVAs: the selection of vulnerability factors and, where several factors are aggregated, the process used to weight their relative importance.

The review of DVAs shows that only 57 % of the studies actually describe their process of selection of vulnerability factors. Usually, it is based on previous studies and specialized literature, and adjusted on data availability. Some studies limit it to data availability (Liu et al. 2013; Antwi-Agyei et al. 2012; Kim et al. 2013; Naumann et al. 2013), while others specifically refer to expert knowledge (Wilhelmi and Wilhite 2002; Shahid and Behrawan 2008; Cheng and Tao 2010; Khoshnodifar et al. 2012; Sookhtanlo et al. 2013; Yuan et al. 2013; Assimacopoulos et al. 2014). Others involve stakeholders in the selection process

(Adepetu and Berthe 2007). Moreover, 56 % of the studies describe the hypothesized relationship between factors and vulnerability; 13 % provide brief explanations; while the remaining 31 % do not explicitly describe the logic underlying the factors' selection.

Applied weighing schemes can be categorized into three groups: (a) arbitrary choice of equal weights; (b) statistical methods; and (c) expert judgment (Gbetibouo and Ringler 2009; Deems 2010). In the review, we found that only 28 DVAs (61 % of the total) mention and describe the weighing scheme applied. Almost half of these (12) use statistical methods such as principal component analysis, while eight consult experts and/or stakeholders for weighing the indicators. Iglesias et al. (2007) present two scenarios, one with equal weights, and another with weights based on expert opinion, so as to support an explicit theoretical assumption.

Finally, an important step within the research process is the validation of results. As Eriksen and Kelly (2007) explain, this process increases the credibility of the set of measures and contributes to improve the understanding of vulnerability. Also Fekete et al. (2010) stress the importance of the validation process using an independent dataset. Nonetheless, only a third of the reviewed studies attempt to validate their results, or explicitly mention that they attempted to do so. The most common method employed (Table 9) is to correlate vulnera-bility results to past disasters data (Vincent 2004; Brooks et al. 2005).

Seven studies validate the assessment by comparing their results with previous impacts of past drought events using data from media (Alcamo et al. 2008), from international data bases such EM-DAT (Naumann et al. 2013), or their own register, such as the impact archive developed by the DMCSEE project (Karavitis et al. 2012). Villholth et al. (2011, 2013) explain that, due to lack of data, they could undertake only a partial validation of results. Other studies (Deems 2010; Pandey et al. 2010; Jordaan 2012; Safavi et al. 2014) validate their findings with field surveys, through community meetings, interviews, or visit in loco. This method is more feasible in assessments with a narrow geographical scope, where proximity makes data gathering easier. And finally, some of the studies consult experts or specialist literature to validate their results with expert opinion (Fontaine and Steinemann 2009; Chandrasekar et al. 2009; Flörke et al. 2011; Zarafshani et al. 2012).

The validation of DVA results is hampered by several factors. First, vulnerability is frequently conceptualized and measured as a potential state, and thus no dataset of observed variables can fully reflect and measure it. Despite this important difference, however, past impact data are often used as a proxy for vulnerability. This leads to a second important constraint, linked to the fact that drought impacts are difficult to quantify (Mishra and Singh 2010) and that the vast majority of countries and regions lack com- prehensive and systematic drought impact databases. Although there are recent regional and global initiatives to create impacts inventories (e.g., EM-DAT, North America Impact

Table 9. Validation process

Validation Process	DVA	%
Experts and/ or specialist literature	6	13%
Field surveys	5	11%
Partial validation due to lack of past event data	1	2%
Impacts recorded during past drought events	7	15%
Not mentioned validation process	27	59%
	46	100%

Reporter, European Drought Impact Inventory), these are still far from complete, especially in terms of evaluation of economic losses and indirect impacts. And finally, even when impact data are available, the reporting methods heavily influence issues such as the count or the magnitude of the reported impacts, thus making those parameters highly imperfect indicators to validate vulnerability assessments.

3.6. Users and uses of the results of vulnerability assessments

The majority of the reviewed studies state that policy makers or decision makers, disaster reduction or water managers, other stakeholders (e.g., farmers) or the scientific community are the intended users of their results. Nevertheless, only one-third of the DVAs involve prospective final users in some of the steps of the assessment process, even though that inclusion could enhance relevance and adequacy of assessments, relating them to the "real world" (Tscherning et al. 2012). Tscherning et al. (2012) observed similar trends in their systematic review of DPSIR framework studies. This suggests the difficulties that still exist in creating a good communication between science and policy, and points to the need to further invest in bridging that gap.

The majority of the reviewed assessments present final results through maps of vulnerability (72 %), while 18 % present scores and 10 % spider diagrams. This is in line with the fact that mapping undoubtedly is an appropriate method to communicate complex spatial and temporal information (WHO 2014). Vulnerability mapping can help decision makers to visualize the hazard and communicate it to potentially affected stakeholders such as agricultural producers (Wilhelmi and Wilhite 2002). Ganapuram et al. (2013), for example, expressly chose an intuitive range of color for mapping, to reach illiterate farmers. Nevertheless, practitioners and stakeholders should be cautious with the use of maps since mapping can also be a misleading instrument, as they can lead to premature decisions, under the assumption that "once a map is available, sufficient information is at hand for effective decision making" (Preston et al. 2011).

Only a third of the assessments reviewed expressly link their results with recommen- dations for drought mitigation, prevention or adaptation strategies. According to Costa and Kropp (2013), scientists frequently use DVAs to understand general principles of a system and what can be learned from observed situations, while stakeholders expect concrete solutions regarding what to do to cope with specific threats. Considerations such as Per- eira's et al. (2014) of building a vulnerability assessment tool that is "simple, easy to use for decision makers while at the same time being sufficiently representative of reality" are not frequent within DVAs. This could due to the fact that DVAs are a way of combining and presenting data to systematically characterize vulnerability, pointing to areas where there is a concomitance of factors that can exacerbate vulnerability. However, the for- mulation of specific recommendations and solutions requires an in-depth understanding of a range of dynamics that influence decision-making processes and that are too complex and diverse to be taken into account in a DVA.

4. Conclusions

The assessment of vulnerability to drought is a very complex task. The diversity of scope, approach, focus, methodology, and measurement criteria used within assessments hampers a common understanding of vulnerability to drought. In this paper, we have undertaken a systematic literature review of existing applied assessments of vulnerability to drought, with the objective of identifying gaps and trends in this field, and contributing to future research and practice related to the assessment of vulnerability to drought. The review has identified and analysed 46 drought vulnerability assessments from different perspectives: location and scale of DVAs; type and characteristics of the most commonly used conceptual frameworks; processes used in the identification and selection of assessment factors; weighting and validation methods; and intended uses and users of the DVAs.

The review has shown that the assessment of vulnerability to drought is not a widespread practice. The spatial distribution of existing DVAs suggests the need to increase assessment efforts in general, but especially in Central and South America and in North African countries. This has been remarked also by Belal et al. (2014), who recommend the development of national drought policies and preparedness plans based on drought risk assessments in drought-prone countries, in order to effectively shift from a reactive approach to a proactive and preventive risk management approach. In this context, drought vulnerability at different scales (subnational to global) are both necessary and complementary, since local studies might help to design more adequate mitigation tools, whereas larger-scale DVAs offer an overview of broader trends of vulnerability as required by policy makers.

The DVA's design and implementation are strongly influenced by the context, the focus, and objective of the study and data availability. Thus, while it is possible to for- mulate some recommendations about the design and implementation of DVAs, the specific content of the assessment will have to reflect the specific needs of each DVA.

Vulnerability is multidimensional and multifaceted, so assessments should attempt to increase comprehensiveness and use different types of data to get new and more integrated insights into drought vulnerability. The review found that 42% of the reviewed DVAs include less than five subdimensions and only one-fifth use qualitative or mixed data. The subdimensions and factors most frequently used within DVAs are sociocultural factors and economic and financial resources, followed by technical, technological, and infrastructural resources, and climatic components. This diversity of approaches shows that there is no consensus on the number and type of factors and dimensions to be considered in a DVA. However, the intrinsically multidimensional nature of any DVA makes it advisable to include at least the analysis of the needs (of the assessed system) that could be threatened by drought and the physical and institutional capacity to address them.

Knowing the most commonly used vulnerability factors is a starting point in the construction of common drought vulnerability datasets. This is particularly relevant in view of the fact that that several DVAs acknowledge the difficulties faced in the inclusion of several relevant factors due to constraints in data availability. Thus, the improvement in DVAs clearly requires the improvement in data gathering, mostly by national and local authorities. In particular, the improvement in data on drought impacts, as well as on water uses, water balance, and water status, is an urgent task in order that these aspects be more accurately appraised within DVAs.

At methodological level, several authors recommend the explicit inclusion of the underlying assumptions used during the whole process, especially those employed in the construction of the conceptual model used to assess drought vulnerability, as well as those employed in the selection and weighing of indicators. This is crucial in order to ensure transparency and increase comparability. Regrettably, there is still a significant number of DVAs that do not make the selection of factors or the hypothesized relation of factors with vulnerability explicit. Moreover, the final step of validation that can make results more robust and sound and enhance their durability, is undertaken only by a third of the studies reviewed, mainly due to lack of data and methodological constraints. Steps toward data gathering of past drought impact data such as the European Drought Impact Inventory (Stahl et al., under review) could contribute to overcome this handicap and ease validation process.

Drought as a natural hazard can be very destructive, but its slow onset and development provides a major opportunity to prevent and mitigate its impacts. The understanding and appraise of drought vulnerability is key to develop adequate drought management strategies, and thus its practice should be promoted and enhanced.

Acknowledgments The authors thank Mario Ballesteros for his help with the graphic material for this paper. This study was undertaken in the framework of the EU-funded project ‘‘Fostering European Drought Research and Science-Policy Interfacing’’ (DROUGHT R&SPI, contract no. 282769).

References

Abraham J (2006) Assessing drought vulnerability. Ph.D. Dissertation, University of Arizona

Adepetu AA, Berthe A (2007) Vulnerability of rural Sahelian Households to Drought: options for adaptation a final report. Submitted to Assessments of Impacts and Adaptations to Climate Change (AIACC), Project No. AF 9, The International START Secretariat Washington, USA

Adger WN (2006) Vulnerability. Glob Environ Change 16(3):268–281

Alcamo J, Acosta-Michlik L, Carius A, Eierdanz F, Klein R et al (2008) A new approach to quantifying and comparing vulnerability to drought. Reg Environ Change 8(4):137–149

Antwi-Agyei P, Fraser ED, Dougill AJ, Stringer LC, Simelton E (2012) Mapping the vulnerability of crop production to drought in Ghana using rainfall, yield and socioeconomic data. Appl Geogr 32(2):324–334

Assimacopoulos D, Kampragkou E, Andreu J, Bifulco C, De Carli A, De Stefano L et al (2014) Future drought impact and vulnerability—case study scale. DROUGHT-R&SPI Technical Report No. 20

Belal AA, El-Ramady HR, Mohamed ES, Saleh AM (2014) Drought risk assessment using remote sensing and GIS techniques. Arabian J Geosci 7(1):35–53

Bhattacharya S, Das A (2007) Vulnerability to drought, cyclones and floods in India. European Commission BASIC project, BASIC project paper, 9

Birkmann J (2006) Measuring vulnerability to promote disaster-resilient societies: conceptual frameworks and definitions. In: Birkmann J (ed) Measuring vulnerability to natural hazards: towards disaster resilient societies. UNU Press, Hong Kong, pp 9–54

Birkmann J, Wisner B (2006) Measuring the un-measurable. The challenge of vulnerability. UNU-EHS, Bonn

Blaikie P, Cannon T, Wisner B (1994) At risk: natural hazards, people’s vulnerability and disasters. Routledge, London

Blauhut V, Gudmundsson L, Stahl K (2015) Towards pan-European drought risk maps: quantifying the link between drought indices and reported drought impacts. Environ Res Lett 10(1):14008

Brooks N, Adger N, Kelly MP (2005) The determinants of vulnerability and adaptive capacity at the national level and the implications for adaptation. Global Environ Change 15(2):151–163

Chandrasekar K, Sai MS, Roy P, Jayaraman V, Krishnamoorthy R (2009) Identification of agricultural drought vulnerable areas of Tamil Nadu, India using gis-based multi criteria analysis. Asian J Environ Disaster Manage 1(1):40–61

Cheng J, Tao JP (2010) Fuzzy comprehensive evaluation of drought vulnerability based on the analytic hierarchy process—an empirical study from Xiaogan City in Hubei Province. Agric Agric Sci Procedia 1:126–135

Colorado Water Conservation Board CWCB (2010) Drought vulnerability assessment technical information. Annex B to the Colorado Drought Mitigation and Response Plan. Department of Natural Resources, Colorado

Costa L, Kropp JP (2013) Linking components of vulnerability in theoretic frameworks and case studies. Sustain Sci 8(1):1–9

Cutter SL, Boruff BJ, Shirley WL (2003) Social vulnerability to environmental hazards. Soc Science Q 84(2):242–261

Cutter SL, Emrich CT, Webb JJ, Morath D (2009) Social vulnerability to climate variability hazards: a review of the literature. University of South Carolina, Hazards and Vulnerability Research Institute, Department of Geography, Columbia

De Stefano L, González Tánago I, Ballesteros M, Urquijo J et al (2015) Methodological approach con- sidering different factors influencing vulnerability—pan-European scale. DROUGHT-R&SPI Tech-nical Report No. 26

Deems HJ (2010) Vulnerability of rural communities in the Mediterranean region to climate change and water scarcity: the case of Cyprus. Master thesis, University of Barcelona

Derbile EK (2013) Reducing vulnerability of rain-fed agriculture to drought through indigenous knowledge systems in north-eastern Ghana. Int J Clim Change Strateg Manag 5(1):71–94

Downing TE, Bakker K (2000) Drought discourse and vulnerability. In: Wilhite DA (ed) Drought: a global

assessment, natural hazards and disasters series, chap 45. Routledge Publishers, London

Eriksen SH, Kelly PM (2007) Developing credible vulnerability indicators for climate adaptation policy assessment. Mitig Adapt Strateg Global Change 12(4):495–524

Fekete A, Damm M, Birkmann J (2010) Scales as a challenge for vulnerability assessment. Nat Hazards 55(3):729–747

Flörke M, Wimmer F, Laaser C, Rodrigo R, Tröltzsch J, Dworak T et al (2011) Final report for the project climate adaptation-modelling water scenarios and sectoral impacts. Contract No. DG ENV.D.2/SER/ 2009/0034

Fontaine MM, Steinemann AC (2009) Assessing vulnerability to natural hazards: impact-based method and application to drought in Washington state. Nat Hazards Rev 10(1):11–18

Ford JD, Pearce T (2010) What we know, do not know, and need to know about climate change vulnerability in the western Canadian arctic: a systematic literature review. Environ Res Lett 5(1):014008

Fraser ED, Simelton E, Termansen M, Gosling SN, South A (2013) Vulnerability hotspots: integrating socio-economic and hydrological models to identify where cereal production may decline in the future due to climate change induced drought. Agric For Meteorol 170:195–205

Ganapuram S, Nagarajan N, Balaji V (2013) Village-level drought vulnerability assessment using geo- graphic information system (GIS). Int J Adv Res Comput Sci Softw Eng 3(3):1–10

Gbetibouo GA, Ringler C (2009) Mapping South African farming sector vulnerability to climate change and

variability: a subnational assessment. International Food Policy Research Institute Discussion paper 00885

Hinkel J, Klein RJ (2006) Integrating knowledge for assessing coastal vulnerability to climate change. In: McFadden L, Nicholls RJ, Penning-Rowsell EC (eds) Managing coastal vulnerability: an integrated

approach. Elsevier Science, Amsterdam

Hofmann ME, Hinkel J, Wrobel M (2011) Classifying knowledge on climate change impacts, adaptation, and vulnerability in Europe for informing adaptation research and decision-making: a conceptual meta-

analysis. Glob Environ Change 21(3):1106–1116

Huang L, Yang P, Ren S (2014) The vulnerability assessment method for beijing agricultural drought. Computer and computing technologies in agriculture VII, pp 269–280

Hufschmidt G (2011) A comparative analysis of several vulnerability concepts. Nat Hazards 58(2):621–643

IPCC (Intergovernmental Panel on Climate change) (2001) Climate change 2001: impacts, adaptation, and vulnerability. In: McCarthy JJ et al (eds) Contribution of working group II to the third assessment report of the intergovernmental panel on climate change, Cambridge University Press, Cambridge IPCC (Intergovernmental Panel on Climate change) (2007) Climate change 2007: impacts, adaptation and vulnerability. In: Parry ML, Canziani OF, Palutikof JP, van der Linden PJ, Hanson CE (eds) Con- tribution of working group II to the fourth assessment report of the intergovernmental panel on climate change, Cambridge University Press, Cambridge

Iglesias A, Moneo M, Quiroga S (2007) Methods for evaluating social vulnerability to drought. OPTIONS Méditerranéennes. Série B: Etudes et Recherches (CIHEAM)

Jain VK, Pandey RP, Jain MK (2015) Spatio-temporal assessment of vulnerability to drought. Nat Hazards 76(1):443–469

Jiang G, Yu F, Zhao Y (2012) An analysis of vulnerability to agricultural drought in China using the expand grey relation analysis method. Proced Eng 28:670–676

Johnson V, Fitzpatrick I, Floyd R, Simms A (2011) What is the evidence that scarcity and shocks in freshwater resources cause conflict instead of promoting collaboration. CEE review, 10-010

Jordaan AJ (2012) Drought risk reduction in the Northern Cape, South Africa. Ph.D., University of the Free State Bloemfontein

Karavitis C et al (2012) Drought impacts archive and drought vulnerability index, in DMCSEE Summary of project results

Keshavarz M, Karami E, Vanclay F (2013) The social experience of drought in rural Iran. Land Use Policy 30(1):120–129

Khoshnodifar Z, Sookhtanlo M, Gholami H (2012) Identification and measurement of indicators of drought vulnerability among wheat farmers in Mashhad Country, Iran. J Ann Biol Res 3(2012):4593–4600

Kim H, Park J, Yoo J, Kim TW (2013) Assessment of drought hazard, vulnerability, and risk: a case study for administrative districts in South Korea. J Hydro-environment Res 9(2015):28–35

Kipterer J, Mundia C (2014) Drought risk and vulnerability assessment; a case study of Baringo County, Kenya. In: Scientific conference proceedings

Knutson C, Hayes M, Phillips T (1998) How to reduce drought risk, preparedness and mitigation working group of the western drought coordination council, Lincoln, pp 1–43

Kumar R (2008) Studies on assessment of vulnerability to drought. National Institute of Hydrology, India Lei Y, Luo L (2011) Drought risk assessment of China's mid-season paddy. Int J Disaster Risk Sci 2(2):32–40

Liu X, Wang Y, Peng J, Braimoh AK, Yin H (2013) Assessing vulnerability to drought based on exposure, sensitivity and adaptive capacity: a case study in middle Inner Mongolia of China. Chin Geogr Sci 23(1):13–25

Luers AL, Lobell DB, Sklar LS, Addams CL, Matson PA (2003) A method for quantifying vulnerability, applied to the agricultural system of the Yaqui Valley, Mexico. Glob Environ Change 13(4):255–267

Mishra A, Singh VP (2010) A review of drought concepts. J Hydrol 391(1):202–216

Moring A, Németh, A. Bihari Z (2012) Estimation and mapping of drought vulnerability on the basis of climate, land use and soil parameters using GIS technique. Final conference of DMCSEE project. Ljubljana

Murthy CS, Yadav M, Ahamed JM, Laxman B, Prawasi R, Sai MS, Hooda RS (2015) A study on agri- cultural drought vulnerability at disaggregated level in a highly irrigated and intensely cropped state of India. Environ Monit Assess 187(3):1–14

Naumann G, Barbosa P et al (2013) Exploring drought vulnerability in Africa: an indicator based analysis to inform early warning systems. Hydrol Earth Syst Sci Discuss 10(10):12217–12254

Pandey RP, Pandey A, Galkate RV, Byun HR, Mal BC (2010) Integrating hydro-meteorological and physiographic factors for assessment of vulnerability to drought. Water Resour Manage 24(15):4199–4217

Perčec Tadić M, Gajić-Čapka M, Zaninović K, Cindrić K (2014) Drought vulnerability in Croatia. Agricu Conspec Sci ACS 79(1):31–38

Pereira FN (2011) Climate change and vulnerability to drought in the semiarid: the case of smallholder farmers in the Brazilian Northeast. In: da Motta RS et al (eds) Climate change in Brazil: economic, social and regulatory aspects. IPEA, Brasilia

Pereira D, Rocha JD, Debortoli N, Parente II, Eiró F, Bursztyn M, Rodrigues-Filho S (2014) Integrated assessment of smallholder farming's vulnerability to drought in the Brazilian Semi-arid: a case study in Ceará. Clim Change 127:1–13

Petticrew M, Roberts H (2006) Systematic reviews in the social sciences: a practical guide. Blackwell Publishers, Malden

Plummer R, de Loë R, Armitage D (2012) A systematic review of water vulnerability assessment tools. Water Resour Manage 26(15):4327–4346

Preston BL, Yuen EJ, Westaway RM (2011) Putting vulnerability to climate change on the map: a review of approaches, benefits, and risks. Sustain Sci 6(2):177–202

Romieu E, Welle T, Schneiderbauer S, Pelling M, Vinchon C (2010) Vulnerability assessment within climate change and natural hazard contexts: revealing gaps and synergies through coastal applications. Sustain Sci 5(2):159–170

Rudel TK (2008) Meta-analyses of case studies: a method for studying regional and global environmental change. Glob Environ Change 18:18–25

Safavi HR, Esfahani MK, Zamani AR (2014) Integrated index for assessment of vulnerability to drought, case study: zayandehrood River Basin, Iran. Water Resou Manage 28(6):1671–1688

Salvati L, Zitti M, Ceccarelli T, Perini L (2009) Developing a synthetic index of land vulnerability to drought and desertification. Geogr Res 47(3):280–291

Shahid S, Behrawan H (2008) Drought risk assessment in the western part of Bangladesh. Nat Hazards 46(3):391–413

Shiau J, Hsiao Y (2012) Water-deficit-based drought risk assessments in Taiwan. Nat Hazards 64(1):237–257

Simelton E, Fraser ED, Termansen M, Forster PM, Dougill AJ (2009) Typologies of crop-drought vul- nerability: an empirical analysis of the socio-economic factors that influence the sensitivity and resilience to drought of three major food crops in China (1961–2001). Environ Sci Policy 12(4):438–452

Sivakumar MV, Stefanski R, Bazza M, Zelaya S, Wilhite D, Magalhaes AR (2014) High level meeting on national drought policy: summary and major outcomes. Weather Clim Extrem 3:126–132

Sohrabizadeh S, Tourani S, Khankeh HR (2014) The gender analysis tools applied in natural disasters management: a systematic literature review. PLoS Curr. http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3958564/

Sönmez FK, Koemuescue AU, Erkan A, Turgu E (2005) An analysis of spatial and temporal dimension of drought vulnerability in Turkey using the standardized precipitation index. Nat Hazards 35(2):243–264

Sookhtanlo M, Gholami H, Es'haghi SR (2013) Drought risk vulnerability parameters among wheat farmers in Mashhad County Iran. Int J Agric Manage Dev 3(4):227–236

Sreedhar G, Mishra SS, Nagarjan R, Balaji V (2012) Micro-level drought vulnerability assessment in Peddavagu basin, a Tributary of Krishna River, Andhra Pradesh. Earthzine, India

Stahl K, Kohn I, Blauhut V, Urquijo J, De Stefano L, Acacio V, Dias S, Stagge JH, Tallaksen LM, Kampragou E, Van Loon AF, Barker LJ, Melsen LA, Bifulco C, Musolino D, de Carli A, Massarutto A, Assimacopoulos D, and Van Lanen H A J (under review) Impacts of European drought events: insights from an international database of text-based reports. Nat Hazards Earth Syst Sci Discuss 3:5453–5492. doi:10.5194/nhessd-3-5453-2015

Strosser P, Dworak, T, Garzon PA Berglund M, Schmidt G et al (2012) Gap analysis of the Water Scarcity and Droughts Policy in the EU. Final report. European Commission Tender ENV.D.1/SER/2010/0049/ Acteon 2012. Inception report of water scarcity & droughts policy in the EU—gap analysis. Tender ENV.D.1/SER/2010/0049

Swain M, Swain M (2011) Vulnerability to agricultural drought in Western Orissa: a case study of repre- sentative blocks. Agric Econ Res Rev 24:1

Thomas DS, Wilhelmi OV, Finnessey TN, Deheza V (2013) A comprehensive framework for tourism and recreation drought vulnerability reduction. Environ Res Lett 8(4):044004

Thompson HE, Berrang-Ford L, Ford JD (2010) Climate change and food security in sub-Saharan Africa: a systematic literature review. Sustainability 2(8):2719–2733

Tscherning K, Helming K, Krippner B, Sieber S, Paloma SG (2012) Does research applying the DPSIR framework support decision making? Land Use Policy 29(1):102–110

Turner BL, Kasperson RE, Matson PA, McCarthy JJ et al (2003) A framework for vulnerability analysis in sustainability science. Proc Natl Acad Sci 100(14):8074–8079

Van Vliet MTH, Zwolsman JJG (2008) Impact of summer droughts on the water quality of the Meuse river. J Hydrol 353(1):1–17

Villholth KG, Tøttrup C, Stendel M, Maherry A et al (2011) Groundwater drought vulnerability mapping in the SADC region. Researcher's day, climate change impact, Adaptation and Mitigation, University of Copenhagen, (ppt)

Villholth KG, Tøttrup C, Stendel M, Maherry A (2013) Integrated mapping of groundwater drought risk in the Southern African Development Community (SADC) region. Hydrogeol J 21(4):863–885

Vincent K (2004) Creating an index of social vulnerability to climate change for Africa. Working Paper 65, Tyndall Centre for Climate Change Research, University of East Anglia, Norwich

Vogel C, O'Brien K (2004) Vulnerability and global environmental change: rhetoric and reality. Aviso 13:1–8

WHO (2014) Maps and spatial information technologies (Geographical Information Systems) in health and environment decision-making. (www.who.int/heli/tools/maps/en/)

Wilhite DA (2000) Drought: a global assessment, vols 1 and 2, Routledge, New York, pp 89–104, vols 1 and 2, Routledge, New York, pp 129–448

Wilhelmi OV, Wilhite DA (2002) Assessing vulnerability to agricultural drought: a nebraska case study. Nat Hazards 25(1):37–58

Wilhite DA, Svoboda MD, Hayes MJ (2007) Understanding the complex impacts of drought: a key to enhancing drought mitigation and preparedness. Water Resour Manage 21(5):763–774

Wiréhn L, Danielsson Å, Neset TSS (2015) Assessment of composite index methods for agricultural vulnerability to climate change. J Environ Manage 156:70–80

Wolf S (2012) Vulnerability and risk: comparing assessment approaches. Nat Hazards 61(3):1099–1113 Wu D, Yan DH, Yang GY, Wang XG, Xiao WH, Zhang HT (2013) Assessment on agricultural drought vulnerability in the Yellow River basin based on a fuzzy clustering iterative model. Nat Hazards 67(2):919–936

WWAP (United Nations World Water Assessment Programme) (2014) The United Nations world water development report 2014: water and energy. UNESCO, Paris

Xin L, Lin Z, Shengkui C, Suchuang D (2011) Quantitative assessment and spatial characteristics of agricultural drought risk in the Jinghe Watershed, Northwestern China. J Resour Ecol 2(4):338–344

Yuan XC, Wang Q, Wang K, Wang B, Jin JL, Wei YM (2013b) China's regional vulnerability to drought and its mitigation strategies under climate change: data envelopment analysis and analytic hierarchy process integrated approach. Mitig Adapt Strateg Glob Change 20(3):341–359

Zarafshani K, Sharafi L, Azadi H, Hosseininia G, De Maeyer P, Witlox F (2012) Drought vulnerability assessment: the case of wheat farmers in western Iran. Glob Planet Change 98:122–130

Zhang Q, Sun P, Li J, Xiao M, Singh VP (2014) Assessment of drought vulnerability of the Tarim River basin, Xinjiang, China. Theor Appl Climatol 121(1):337–347

4.5. Los impactos de la sequía en Europa

Stahl, K., Kohn, I., Blauhut, V., Urquijo, J., De Stefano, L., Acacio, V., Dias, S., Stagge, J.H., Tallaksen, L.M., Kampragou, E., Van Loon, A.F., Baker, L.J., Melsen, L.S., Bifulco, C., Musolino, D., de Carli, A., Massarutto, A., Assimacopoulos, D., & Van Lanen, H.A.J. (2015) Impacts of European drought events: insights from an international database of text-based reports. *Natural Hazards Earth System Science* (DOI: 10.5194/nhessd-3-5453-2015)

Estado: Aceptado, en discusión.

Nat. Hazards Earth Syst. Sci. Discuss., 3, 5453–5492, 2015 www.nat-hazards-earth-syst-sci-discuss.net/3/5453/2015/ doi:10.5194/nhessd-3-5453-2015

Natural Hazards and Earth System Sciences Discussions

This discussion paper is/has been under review for the journal Natural Hazards and Earth System Sciences (NHESS). Please refer to the corresponding final paper in NHESS if available.

Impacts of European drought events: insights from an international database of text-based reports

K. Stahl[1], I. Kohn[1], V. Blauhut[1], J. Urquijo[2], L. De Stefano[2], V. Acacio[3], S. Dias[3], J. H. Stagge[4], L. M. Tallaksen[4], E. Kampragou[5], A. F. Van Loon[6,a], L. J. Barker[7], L. A. Melsen[6], C. Bifulco[3], D. Musolino[8], A. de Carli[8], A. Massarutto[9], D. Assimacopoulos[5], and H. A. J. Van Lanen[6]

[1]University of Freiburg, Freiburg, Germany

[2]Universidad Complutense de Madrid, Madrid, Spain

[3]Centre for Applied Ecology Baeta Neves (CEABN/INBIO), Institute of Agronomy, University of Lisbon, Lisbon, Portugal

[4]Dept. of Geosciences, University of Oslo, Oslo, Norway

[5]Hydrology and Quantitative Water Management Group, Wageningen University, Wageningen, the Netherlands

[6]National Technical University of Athens, Athens, Greece

[7]Centre for Ecology and Hydrology, Wallingford, UK

[8]CERTeT – Bocconi University, Milan, Italy

[9]CERTeT – Bocconi University & DISES – University of Udine, Udine, Italy

[a]now at: School of Geography, Earth & Environmental Sciences, University of Birmingham, Birmingham, UK

Received: 14 August 2015 – Accepted: 22 August 2015 – Published: 8 September 2015 Correspondence to: K. Stahl (kerstin.stahl@hydrology.uni-freiburg.de)

Published by Copernicus Publications on behalf of the European Geosciences Union.

Keywords: drought, impacts, Europe, textual reports, database, agriculture, water supply

Abstract

Drought is a natural hazard that can cause a wide range of impacts affecting the environment, society, and the economy. Assessing and reducing vulnerability to these impacts for regions beyond the local scale, spanning political and sectoral boundaries, requires systematic and detailed data regarding impacts. This study presents an assessment of the diversity of drought impacts across Europe based on the European Drought Impact report Inventory (EDII), a unique research database that has collected close to 5000 impact reports from 33 European countries. The reported drought impacts were classified into major impact categories, each of which had a number of subtypes. The distribution of these categories and types was then analyzed over time, by country, across Europe and for particular drought events. The results show that impacts on agriculture and public water supply dominate the collection of drought impact reports for most countries and for all major drought events since the 1970s, while the number and relative fractions of reported impacts in other sectors can vary regionally and from event to event. The data also shows that reported impacts have increased over time as more media and website information has become available and environmental awareness has increased. Even though the distribution of impact categories is relatively consistent across Europe, the details of the reports show some differences. They confirm severe impacts in southern regions (particularly on agriculture and public water supply) and sector-specific impacts in central and northern regions (e.g. on forestry or energy production). As a text-based database, the EDII presents a new challenge for quantitative analysis; however, the EDII provides a new and more comprehensive view on drought impacts. Related studies have already developed statistical techniques to evaluate the link between drought indices and impacts using the EDII. The EDII is a living database and is a promising source for further research on drought impacts, vulnerabilities, and risks across Europe. A key result is the extensive variety of impacts found across Europe and its documentation. This data coverage may help drought policy planning at national to international levels.

Introduction

Much progress has been made since Wilhite and Glantz (1985) criticized the drought research community for a disproportionate research focus on climate and hydrology, while not sufficiently incorporating the economic, political, and other human aspects that affect this hazard. It is now accepted that a purely natural sciences perspective is not capable of capturing the multi-faceted impacts of drought (Kallis, 2008; Lackstrom et al., 2013). An assessment of past drought impacts is a crucial step in developing measures to reduce vulnerability against drought hazard (Knutson et al., 1998; Wilhite et al., 2000; Wilhite et al., 2007; UN/ISDR, 2009). Systematic quantitative knowledge on the environmental and socio-economic impacts of drought, however, is often the missing piece in drought planning and management. According to Hayes et al. (2011), there "appears to be a fundamental lack of knowledge or understanding about the importance of monitoring impacts, the usefulness of impact information, and the type of information that is worthwhile to collect". As a result, large-scale studies related to drought monitoring, early-warning, drought planning, and policy development often do not incorporate information on societal drought impacts; the drought indicators typically are chosen arbitrarily and not linked to specific impacts (Wilhite, 2000; Kallis, 2008; Lackstrom et al., 2013; Steinemann, 2014).

The monitoring and assessment of drought impacts is complex because different types of impacts vary in their intensity, often in different phases of the given drought event. Most empirical studies of drought impacts have focused on agricultural crop production, which is direct, immediately observable, well understood, and easy to quantify (Wilhite, 2000; Ding et al., 2011). Lackstrom et al. (2013) concluded that there was a lack of data and understanding of impacts on sectors other than agriculture and water resources. Studies of cross-sectoral drought impacts are generally limited by data availability, as impact data is often maintained by different organizations, e.g. agriculture, fisheries, and hydropower statistics are rarely housed by the same department. Moreover, in-depth case studies may be very useful in the context of the specific sector and region they are focused on, yet they are methodologically heterogeneous and rarely cross-comparable (Kallis, 2008). In the USA, the National Drought Mitigation Center (NMDC, drought.unl.edu) has considerable interest and experience in the collection and use of trans-regional and trans-sectoral drought impact reports. Their Drought Impact Reporter (DIR) tool is used in near-real time as part of the monitoring and early-warning system (droughtreporter.unl.edu; Wilhite et al., 2007; Dieker et al., 2010; Lackstrom et al., 2013). For example, the collected impact information supports expert judgement that contributes to the drought severity classification for the weekly release of the US Drought Monitor map (www.droughtmonitor.unl.edu).

In an international setting such as in the European Union, which also spans different geoclimatic regions, a trans-boundary and trans-sectoral assessment of drought impacts is particularly important. A number of databases exist that collect statistics on elements affected by drought: crop yield, hydropower production, wildfires, or various aspects of water resources (e.g. Eurostat: epp.eurostat.ec.europa.eu/; European Forest Fire Information System (EFFIS), http://forest.jrc.ec.europa.eu/effis/; Water Information System for Europe (WISE): water.europa.eu/). However, these statistics do not make an assignment of cause (drought) and effect (the statistics). The unambiguous attribution of a reported loss in a particular season, year, or multi-year period to a particular causing drought event requires additional information to isolate the drought cause from complex and sometimes competing extraneous factors. Information on impacts that are directly linked to drought is often available in regional or national reports of environment agencies, in newsletters from stakeholders such as agricultural associations, in the media, or even from personal observation in the field. In Europe, however, such textual evidence has found limited application in drought impact analysis on a larger scale (beyond national boundaries).

The European Union and the European Environment Agency have identified the need to assemble information on a number of natural hazards, including drought (European Commission, 2012; European Environment Agency, 2011, 2012; Kossida et al., 2012). Because of the trans-boundary impacts of large-scale drought in Europe and the trans-national data sharing challenges inherent in the European Union, the development of a comprehensive drought impact database is particularly important for Europe. In support of this request, this study demonstrates the potential of a novel database of categorized drought impact reports for Europe that was developed within the EU FP-7 project DROUGHT-R&SPI (www.eu-drought.org). Specifically, it aims to:

- evaluate the availability of drought impact information and the challenges in categorizing drought impact reports across sectors,
- analyze emerging patterns of reported drought impacts in time, space and categories across Europe's geoclimatic regions, and
- assess pathways to capitalize on this information, considering the limitations discovered by the analyses.

The European Drought Impact report Inventory (EDII): database structure, status and assessment

As commonly encountered with drought research (Smakthin and Schipper, 2008), there is no consistently used standard terminology and classification for drought impacts and related economic losses (Kallis, 2008; Logar and van den Berg, 2013). The impacts of drought are often classified either into the categories "economic", "environmental" and "social", or into "direct", "indirect", and "intangible", which refers to non-market losses (e.g. Wilhite and Vanyarkho, 2000; Ding et al., 2011; Logar and van den Berg, 2013; Gil et al., 2013). Knutson et al. (1998) defined drought impacts as specific effects of drought, which are symptoms of vulnerability. Using this definition of drought impact, the EDII database aims to compile reports on negative environmental, economic or social effects experienced as a consequence of drought. Its impact categorization scheme is tailored to capture the most directly observable impacts across a wide range of sectors.

The EDII is structured into five primary sections that include the following information on the reported impact: (1) reference, (2) location, (3) timing, (4) description, and (5) secondary impacts/response measures (Stahl et al., 2012). Each drought impact report entered into the database must provide information on items 1-4, with item 5 being optional:

1. Impact reference, including the type of source (Table A1.1), author, year, title, and weblink (where applicable). Information on the reported impact entered into the database should closely reflect the reference and thus be traceable and reproducible.
2. Location of reported impact, with at least the country level and options to refer either to different levels of geographical regions using the European Union NUTS (Nomenclature of Territorial Units for Statistics) regions standard or to specific rivers and lakes.
3. Timing of reported impact, with at least the year, but preferably a specification of the season or month of occurrence, and, if possible, a link to a major regional drought event listed in the database.
4. Impact category and sub-type(s) according to the classification in Table A1.2 and a short (free) text description. This text description should be translated to English and reflect the text of the original information source as closely as possible.

5. Associated secondary impacts, response and mitigation measures, and other relevant information that may be available. This information is optional.

Unlike efforts that rely mostly on popular press and news coverage to target real-time occurrence of drought impacts (e.g. the European Media Monitor used by the European Drought Observatory of the Joint Research Centre of the European Commission http://edo.jrc.ec.europa.eu), the EDII database was established for historical drought analysis within a multi-national research project. It incorporates these sources as well, but in order to collect data from past decades, it relies more heavily on scientific and governmental sources, including published regular or special reports in European native languages, theses, scientific articles, and other such sources.

A website interface (http://www.geo.uio.no/edc/droughtdb/) has been developed with pull-down menus to facilitate the submission and categorization of impact reports. This interface allows the submission of impact data into a SQL database, after screening by the database team. The database can be queried through the same web interface. At present it includes over 1200 unique references (original sources), which have resulted in over 4700 drought impact reports, i.e. database entries. We refer to these as "impact report" entries. A given impact report entry made for one of the 15 "impact categories" can then contain reference to several impacts that can further be assigned to different "impact type" subcategories (Table A1.2). The approximately 4700 impact report entries thus resulted in over 6900 individual impacts that are now classified by both their impact category and their impact type subcategory. We refer to these as "reported impacts".

The resulting categorical data can then be analysed and summarized in a number of ways. The overview presented herein is based on an analysis of reported drought impacts as classified and categorized in the EDII. First, we analysed the overall content of the database in terms of the:

- spatial and temporal distribution of the number of impact report entries and their sources, and the
- distribution of reported impact categories and impact types for particular geographical regions and over time.

Second, we investigated selected historical (reference) drought events in Europe with respect to the distribution of reported impact categories and the impacts' text descriptions.

EDII database content

Impact data from 1900 to 2013 at a glance

The EDII contains report entries since 1900 and Figure 1 shows the annual timeseries of the content of the database (as of March 2015). Impact reports prior to 1970 correspond to well-known European drought years, such as the early 1920s, the second half of the 1940s, and 1959 (Figure 1a). However, this earlier time period prior to 1970 is only sparsely covered by report entries in contrast with more recent times (Figure 1b). Consequently, we focused our closer inspection of report sources and impact distributions on the period from 1970 to 2013, and specifically on years with at least 20 drought impact reports (Figure 1b-e).

Within this 43-year study period, the largest numbers of reports refer to impacts reported in the year 2003, followed by 1975-76, 2011-12, and 2005-06 (Figure 1b). Besides those events, the number of annual reports generally appears to have increased since the 1990s. The bulk of drought impact reports from the last 15 years (2000-2015) are reports published by governmental authorities or other institutions, whereas a considerable fraction of the earlier drought impact reports are based also on academic work (Figure 1c). The fraction of media and

internet sources becomes larger in more recent years, with the most current entries almost entirely based on these sources.
The collected impact reports cover many European countries and regions (Figure 1d). Impacts in specific geographical regions, which we grouped based on simplified agro-climatic zones proposed by Bouma (2005), reflect the occurrence of regional drought events: for instance, reports in 2001 are mostly from Southeastern European countries, in 2005 mostly from Spain and Portugal, and in 1976 mostly from Maritime/Western European countries (Figure 1d). By contrast, the period from 1989 to 1995 is characterized by impact reports across several regions in Europe with reports in Maritime/Western Europe dominating the early years of this period and a high number of drought impact reports from Portugal and Spain as well as from Southeastern European countries in the early 1990s (Figure 1d). The fraction of impact reports from Northeastern European countries is relatively small.

The yearly distributions of reported impact categories (Figure 1e) illustrate the characteristic diversity of drought impacts. Throughout, a substantial fraction of the reported drought impacts were assigned to the category 'Agriculture and livestock farming', 'Public water supply', and other impact categories directly linked to water resources. Impacts on 'Energy and industry' appear prominently during the early 2000s and reports on 'Freshwater ecosystems' comprise a large fraction since 2003. Reports in the category 'Terrestrial ecosystems' or those addressing social consequences, i.e. the categories 'Conflicts' and 'Human health', were only found for few years and are limited in number. Overall, recent years show a slightly more diverse and balanced distribution of the reported categories.

The annual distribution of impact categories and regions (Figure 1d and e) reveals some agreement between a large proportion of reports from Southeastern Europe, i.e. drought centered on this region, and increases in reports on 'Agriculture and livestock farming' (i.e. 1983, 1994, 2000-01). By contrast, large proportions of reports from Western European countries generally coincide with a lower fraction of agricultural impacts (i.e. 1975, 1984, 1995, 2010) and more varied impact categories. In years with few impact reports, particular sources, regions, and impact categories often dominated the reported impacts in contrast to the wide range of reported impacts in other years.

Geographical distribution of report sources and impact categories

To date, drought impact reports in the EDII cover 33 countries, but there is a strong imbalance in the distribution of entered reports per country (Figure 2). This geographical imbalance is explained by a number of restrictions and biases regarding the availability of information to populate this database and Section 5 provides a more detailed discussion of the resulting limitations. The map in Figure 2 illustrates some important differences regarding the composition of information sources within the current EDII. The UK, Germany, France, Portugal, the Netherlands, Spain, Bulgaria, Switzerland, Italy, and Norway are the ten countries with the largest numbers of impact report entries (in order of decreasing numbers). Most of these countries are located in Western Europe. Bulgaria is the only country located in Eastern Europe. For Bulgaria, a particular academic information source (Knight et al., 2004), which had previously compiled Bulgarian drought impact information over a long historical period was available. In countries with many reported drought impacts, often governmental reports comprise a high fraction of the EDII entries. Such reports are mostly systematic reviews of a past drought situation and thus provide all necessary information for the EDII (time, location, etc.). In countries with generally fewer impact reports, reports by non-governmental sources as well as internet and (international) media sources comprise a higher fraction of the information sources of drought impact reports (Figure 2).

Figure 3 shows the relative ranking of the three most frequently reported impact categories for each country across Europe. The relative frequency within each country is independent of the absolute number of reports and hence less affected by quantitative report bias. The category 'Agriculture and livestock farming' ranks highest most often and ranks among the top three most frequently reported impact categories for all countries except Finland (Figure 3). Only eight out of the 15 available EDII impact categories are represented in these top three impact categories. Besides agriculture, these are most often the impact categories 'Public water supply', 'Energy and industry' and 'Wildfires', followed by the categories 'Water quality', 'Freshwater ecosystems' and 'Human health and public safety". Categories that are nowhere represented among the three most frequent categories are 'Freshwater aquaculture and fisheries', Waterborne transportation', 'Tourism and recreation', 'Terrestrial ecosystems', 'Soil systems', 'Air quality' and 'Conflicts'.

The high fraction of impacts on 'Public water supply' in southern (Mediterranean) countries is in agreement with the common perception of susceptibility to quantitative water supply problems due to water scarcity in the region. The fraction of reports in the 'Forestry' category is greater in forest-rich countries in Northern and Eastern Europe. Impacts on 'Wildfires' also rank highly in these countries, although in absolute numbers, available EDII data are scarce. Impacts on Energy and Industry rank highly in Norway, Belgium, and several countries in Southeastern Europe. Impacts on 'Water quality' rank highly, in terms of relative frequency, for the UK, the Netherlands, and Germany. 'Human health and public safety' impacts were identified in five countries. Nevertheless, the latter category includes a wide range of impact type subcategories. An analysis of the impacts' text descriptions in the EDII revealed that, in the case of France, the high fraction of reported impacts results mainly from a multitude of reports of increased human mortality rates during the associated heat wave in 2003. However, for Moldova, the 'Human health and public safety' category ranks second with two out of a total number of only 14 drought impact reports. Here, the reports deal with food security issues in response to the droughts in 1946 and 2007. These examples demonstrate the diverse nature of reported impacts within one broad category.

Reported impact type subcategories

The EDII's two-level categorization scheme of assigning main impact categories and more detailed impact types within each category (see Table A1.2) facilitates a further differentiation of the differences of reported impacts across Europe. The category 'Agriculture and livestock farming' is separated into nine impact types. Their relative fractions were assessed for 21 countries with high data availability (Figure 4, upper panels). The proportion of impact types were similarly assessed for the two impact categories 'Public water supply' and 'Water quality' across a selection of seven countries with high data availability in the EDII (Figure 4, lower panels).

For 'Agriculture and livestock farming', reported impacts that relate to a reduced agricultural production and to crop yield losses comprise the largest fraction of the overall agricultural reported impacts. A considerable fraction of reported impacts also relates to livestock farming, particularly in France, Hungary and Moldova. The reported impact types also demonstrate the importance of irrigation in some regions through a high fraction of impact types related to irrigation (e.g. 'Reduced availability of irrigation water') in the Mediterranean countries (Spain, Greece, Italy and Portugal). Compared to other impact categories, the impact type describing economic losses was more often reported in the 'Agriculture and livestock farming' category, even though losses were rarely quantified.

For the category 'Public water supply', the distribution of impact types shows some differences among countries. Within this category, the different impact types categorize increasing impact severity ranging from a mere reporting of shortages to imposed restrictions (e.g. for outdoor water use such as gardening or pools) to actual limitations in the public water supply (e.g. water supply could no longer be provided). In general, the majority of reports describe local or regional water shortages and thus primarily aim to raise awareness. France and the UK have a high total number of reported water supply impacts, with a relatively high fraction of use bans aiming to reduce demand and conserve water. Bulgaria, Spain and Italy have the largest fractions of reports on actual supply limitations during droughts. Reports on increased costs for the public water supply sector were available for Portugal, Spain and the UK only.

Within the category 'Water quality', impact types are classified by their relevance to particular water quality aspects such as temperature, the impaired water service (ecological status, drinking water, irrigation water, etc.), and general consequences. The type 'water quality deterioration in surface waters' typically constitutes a substantial fraction of impact types in all countries, whereas other impact types appear to be more specific to certain countries. In Germany and France, a significant fraction of the reports relates to increased surface water temperature, as the majority of reported water quality impacts refer to the severe summer droughts of 1975-76 and 2003 that were associated with very hot weather conditions. High surface water temperatures during these droughts heavily impacted the energy sector due to an impaired water use for cooling of thermal power plants (fossil and nuclear). In Germany, bathing water quality impairments affected recreational activities during the summer holiday time, but drinking water was rarely impaired. In the Netherlands, a comparatively large fraction of reported impacts in the 'Water quality' category deal with increased salinity of surface waters as a result of direct saltwater intrusion in the river mouths and a higher proportion of brackish groundwater infiltration into the rivers. Increased salinity (of surface water or groundwater) also appears to be a threat for Portugal, Spain and the UK. Water quality problems with drinking water comprise considerable fractions of reports in Portugal, Spain, and particularly in Bulgaria.

Impacts of selected large-scale European drought events

We extracted subsets of the current EDII contents for particular historical drought events and specifically assessed them on an event basis. We analysed seven historical drought events between 1970 and 2013, which included both large-scale and regional droughts. Information about additional events can be found in the detailed event-based summaries in the European Drought Reference Database (EDR, see Stagge et al., 2013; http://www.geo.uio.no/edc/droughtdb/edr/DroughtEvents/). The selected large-scale events include the droughts of 1975-76, 2003, and 2011-12 (Figure 5, upper row). The regional events include multi-year drought events occurring during 1989-90 in France and the Mediterranean, 1992-94 in northern, central and eastern Europe, 2004-08 on the Iberian Peninsula, and 2006-07 in Southeastern Europe (Figure 5, lower row). This selection was made with the objective to cover different regions and impact distributions at the expense of some more well-known regional droughts, such as the 1991-95 on the Iberian Peninsula. Besides looking at the reported impact data frequencies in time and space as in the previous sections, we also analysed the impacts' text descriptions. As a summary, the occurrence of certain words in these text descriptions is presented in the form of word clouds with the words scaled to the frequency of their use in the text descriptions (Figure 5).

Overall, Figure 5 shows that drought impacts have been reported in all seasons, especially for the multi-year events, e.g. 1992-94 and 2004-08. However, as impacts tend to be more frequent during the summer seasons, 'summer' was found to be a frequently used word in the text descriptions. The impact descriptions of the events of 1975-76 and 2003 also contain numerous references to "temperature" as they were accompanied by heat waves in western and central Europe. In contrast, the word 'winter' appears only in the word cloud for the event of 2011-12. Impacts on agriculture, water supply, and water quality dominate for most drought events, and the respective words, such as 'agricultural', 'area', 'crops', 'supply' are therefore used frequently in the text descriptions. During three large-scale events, 1975-76, 2003, and 2011-12, more impacts were generally reported than in regional events; impact reports also tended to cover impact categories that were less commonly reported in smaller events. Whereas impacts on agriculture and water supply also dominate the regional events, they showed specific differences in the impact category distribution that possibly relate to the typical regional water use, economic sectors and relevance in the region. For instance, the reports for events that specifically affected the Mediterranean (e.g. 1990, 2004-08, 2006-07) often mention the words ‘irrigation’, ‘restriction’, ‘shortage’, ‘cost’, ‘request’ and ‘urban’, which suggest a high degree of societal impact. Following the same pattern, reports for the event of 1992-1994, which was characterized by a high number of impacts on northern forests, frequently use the words ‘forest’ and ‘spruce’.

For the drought of 1975-76, the majority of impacts were reported in 1976 in central Europe, although impacts were already reported in the UK, Denmark, and Northern Germany throughout the year 1975. Agriculture and livestock farming suffered over the entire affected region (Figure 5), particularly during the summer of 1976. Besides agricultural losses, impacts were also noticeable for households through increased prices for vegetables and dairy products as well as through losses in kitchen gardens. Water supply shortages were mainly reported in the UK and France, and were largely limited to rural areas. Rivers across Europe recorded low flows and deteriorated water quality, affecting navigation, energy and industrial production and aquatic and terrestrial ecosystems.

The drought of 2003 was a shorter, but more widespread and intense event with impacts in southern, eastern, and central Europe (Figure 5). At the peak of the event, impact reports reflect effects of water shortages combined with high temperatures. The fraction of impacts on public health, on recreation and tourism, as well as the temperature-related energy sector, was higher than during the event of 1975-76, possibly a consequence of the water shortages and higher temperatures. Agricultural losses were again widespread. Water supply problems were reported mostly from small local water suppliers in the Alps and other mountain areas. However, compared to 1975-76, 2003 reports show a smaller fraction of water supply impacts and a larger fraction of water quality impacts, which were often related to the high stream water temperatures. As a result, impacts on freshwater ecosystems were frequently reported in 2003, as were impacts on energy and industry. These categories are reflected in the frequently used words ‘fish’, ‘power production’, and others. As well as the record number of forest fires, the 2003 drought appears to have caused large damage to forests, which showed lagged impacts in subsequent years (e.g. through dieback and pest infestations).

The drought of 2011-12 differs from the other two large-scale events. It had a wider spread of impacts in space and time and a slightly different impact distribution with a lower fraction of impacts related to public health, terrestrial ecosystems, and forests. In contrast to 2003, impacts were not constrained to the summer season but occurred over a long time period and a large fraction of the reported impacts were reported in the UK. The word “England” is one of the frequently used words in the text descriptions, as are words that relate to water use restrictions. The number of reported impacts on waterborne transportation, however, is as high as in 2003, as major European navigation routes such as the rivers Rhine and Danube, were affected by extreme low flows. Similar to the 1976 drought, a high number of impacts on water supply and freshwater ecosystems was reported. The dominance of these impact categories is reflected in ‘levels’ and ‘river’ being the most frequently used words in the text descriptions.

During the late 1980s and early 1990s a number of drought events occurred in Europe that are difficult to separate temporally and regionally. Based on the impact reports in the EDII, we distinguished events with different impact distributions. An event of 1989-91 (or even longer) in the Eastern Mediterranean (Figure 5) was dominated by impacts on water supply, e.g. in

Greece, Sicily/Southern Italy. However, impacts were also reported in France and Spain. The event of 1992-95 in Northern and Eastern Europe (Figure 5) is unique with an unusually high fraction of reported impacts on forestry (in the Northeast) and water supply (in the Southeast). The event of 2004-08 on the Iberian Peninsula is characterized by many reported impacts on agriculture, water supply, water quality and freshwater ecosystems. During this long-term drought the number of reported impacts in the category "Conflicts" was higher than for any other event (Figure 5). The event of 2006-07 in Southeastern Europe peaked with the emergence of an unprecedented heat wave in June 2007 and many forest fires. During this event in Moldova, food security was threatened due to severe impacts on agriculture.

Discussion

Challenges in collecting and organizing drought impacts

The EDII database was developed and populated as part of a three-year research project (Stahl et al., 2012; Van Lanen et al., 2015). The EDII's classification scheme of impact categories and subordinate impact types (Table A1.2) was modeled after the US Drought Impact Reporter (DIR), but was adapted to the project's needs and thus has a more detailed classification scheme. The process of describing, assigning an impact to a category and associated subtype, and entering time and space information may present some challenges if it was to be part of a real time monitoring tool such as the DIR, but for a research database, it has the advantage of allowing an unprecedented detailed stratification and assessment of the gathered data. So far, the scheme has proven to be suitable for capturing impact details and all impacts found in the collected reports could be categorized. It should be kept in mind that the EDII is limited to only considering and categorizing negative impacts of drought. Drought can also have positive impacts. For instance, in the agricultural sector, there may be winners and losers during the same drought (e.g. Ding et al., 2011, Musolino et al., 2015). Furthermore, text descriptions in the EDII were not standardized; the only requirement is that the text descriptions are in English and reflect the text of the original information source as closely as possible. Although the text descriptions often contain common terminology, differences in translation or synonyms may have introduced uncertainty. We identified the correct categorization of reported impacts as the critical step to enable an objective comparative assessment and concluded that a moderator who performs a screening and quality assessment of the data is crucial before impact reports are accepted into the database.

Governmental reports and documents make up a high fraction of referenced sources in the EDII (Figure 2). Governmental reports by national or regional authorities involved in the monitoring and management of droughts were found to provide rather detailed information on the occurrence of past drought impacts and related response measures, and thus proved to be particularly useful for the historical reconstruction of drought impact distributions. It was crucial that a clear association between drought impact and event was given in the referenced source. Lackstrom et al. (2013) named this clear association as one of the major difficulties in drought impact reporting owing to the complexity of drought impacts, especially the complexity of multiple stressors and temporal indefinability of drought. Governmental reports are usually edited in the respective national language. In addition, governmental reporting culture varies across Europe and hence the availability of such reports also differs. By contrast, academic output and reports by multinational organisations are available in English, but are often less detailed on the nature of the impacts. These academic articles and reports represent the major information sources of reported drought impacts in the EDII for countries in Eastern Europe to date (Figure 2).

During the limited time available within the three-year project, the search for drought impact reports revealed a wealth of information on a variety of drought impacts across most of

Europe, even though it was carried out by a group of people limited to searching in only a few European languages, particularly lacking Slavic languages. Generally, the requirement for and availability of data has increased with the emerging prevalence of digital documents and online dissemination techniques during the 20th century. This is reflected in the contents of the database (Figure 1). There are more reports and categorized impacts for more recent droughts. In our assessment, this limits a quantitative comparison of the larger samples of impacts for the more recent drought events e.g. 2003 and 2011-12 to those of earlier events (Figure 5). That the number of drought impacts may be more strongly related to the availability of reports than to the severity of drought impacts confirms the relative approaches taken in this study.

Similarly, the identification of the time and location of reported drought impacts challenges the resolution and accuracy of the dataset. The specific month in which an impact started and ended was often not detailed in the original information source and as a consequence, many database entries only state a season or even only the year of occurrence. For instance, for the selected drought events assessed in Section 4, between 15% and 41% of the reported impacts did not specify the month or season of impact start (Figure 5, top graphs). However, during a severe drought, similar impacts tend to be reported by many sources and we assume that seasonal information still provides a valuable estimate of the onset of major impacts. The same issue applies to the end of an impact. Similar to difficulties to define the termination of drought as a natural phenomenon (Parry et al., 2015), the termination or recovery of drought impacts remains largely unknown, as recovery is rarely reported, which is an issue not yet widely addressed (Lackstrom et al., 2013). Introducing links between entries would allow the identification and tracking of multiple reports of the same impact – this would enable an accurate timeline of impact onset and end to be created. Currently, this information must be distilled manually from the database.

The spatial reference (and so the reported NUTS levels) also show high variability in the level of information details provided. Often, the original source provides only vague location information; then, a larger spatial unit within which the reported impact occurred had to be selected for the categorization. Consequently, for some regions and events, especially those with sparser data coverage, reported impacts rarely referred to subnational scales (e.g. drought events in 1990 and 2007 in Figure 5), whereas for other regions, more detailed spatial information was available (e.g. drought events 2004-08 in the Iberian Peninsula and generally in Germany). Occasionally, however, reports were very specific. For instance, in some cases energy production impacts were provided for specific hydropower sites or fish kills for particular sections of rivers. The flexibility to aggregate from lower (local) to higher (regional/national) levels is desirable but known to be challenging (Lackstrom et al., 2013).

The information gathered provides a number of opportunities for assessment despite the limitation and biases inherited in the collection of impact reports, i.e. provided these are kept in mind. Given the current status of the EDII, the most reliable report samples for pan-European assessments are aggregated information on an annual scale and at the country scale or larger European regions. This is the resolution used by Blauhut et al. (2015a) to model annual likelihood of impact occurrence by the standardized precipitation and evapotranspiration index; and by Van Loon et al. (2015) to study the impacts of temperature-related drought types. However, the more detailed the spatial and temporal reference, the more details can be gained in the identification of similarities and differences across Europe. Bachmair et al. (2015) compared the statistical link between drought impacts and a number of different hydrometeorological drought indicators across Germany based on a higher spatial resolution (NUTS-1 regions); Stagge et al. (2015) used the available monthly impact occurrence for selected countries to identify the best hydrometeorological drought predictors of the likelihood of impact occurrence and addressed the database's biases by building trends into the model. All studies conclude that in order to derive a useful sector-specific operational drought index, future efforts to compile drought impact data should aim at using available higher resolution in time and space that is closer to the resolution of hydrometeorological drought indices.

Emerging patterns in reported drought impacts

Impact reports show a wide range of impacts locally and across Europe. Additionally, impact categories and types appear to have increased in diversity over time (e.g. Figure 1). Whereas such patterns may be related to the overall increase of information availability over time, it may also reflect an increased public awareness (e.g. Wilhite, 2007; Dessai and Sims, 2010), or specific changes in the importance of the impact-related economic sector, both in governance or policies (De Stefano et al., 2012; Tanago et al., 2015; Blauhut et al., 2015b). The spatial distribution of the sheer number of reported impacts in the EDII differs to those recorded in other databases. For example the Emergency Events Database (EM-DAT, www.emdat.be) from the Université Catholique de Louvain in Brussels in Belgium generally returns few entries for Europe compared to other continents, but these are mainly from Mediterranean and (South)eastern European countries. However, with a focus on disasters, EM-DAT and other databases use other definitions for drought impacts.

Availability and accessibility of impact information from reports appears to vary across Europe and thus introduces bias in the volume of information on impacts. In some countries, regular reports detailing the status of a water-dependent sector or special reports detailing a particular drought event were rich sources that provided many database entries. Examples of the former type of regular reports that were used include the Drought Monitoring Briefs for England and Wales produced by the Environment Agency for the 2004-6 and 2010-12 droughts in the UK. Such reports also highlight a sectoral relevance that differs regionally. Comprehensive reports or books on specific drought events for example covered the drought of 2003 in Germany and Switzerland, the event of 1992-94 in Bulgaria, and the event of 1975-76 in the UK. In other regions, such previously assembled information sources were not available and assembling impact information was more tedious and resulted in fewer database entries. In addition, the EDII still lacks targeted searches for information in several countries and languages. For example, data entries for many Eastern European countries rely mostly on international report sources and media coverage available online. As a result of these regional differences, the volume of EDII contents is biased, and therefore our analyses focused instead on the relative fractions and composition of impact reports within each region.

Agricultural drought impacts represent the largest fraction of impacts in most regions across Europe (Figure 3) and for most large-scale or regional drought events (Figure 5). This explains why research on drought impacts across Europe has often used crop failures, losses or yields and other types of drought impacts have been considered less often. Consistent with the conceptual view of drought propagation from its origin as a precipitation deficit to a deficit in soil moisture and finally to hydrological deficits (in groundwater and streamflow, and related water resources), the dominance of agricultural reports may also reflect the typical association the public has with drought. In addition, where agriculture is irrigated, agriculture is often the major water user. This reliance on water for agriculture may explain the high visibility and awareness (Ding et al., 2011) and thus the increased report availability of agricultural impacts. The impact category 'Agriculture and livestock farming' also records the most entries for cost and losses, suggesting a high economic visibility in Europe (Figure 4). The relevance is also reflected in the efforts of drought monitoring systems targeting agricultural drought, e.g. the European Drought Observatory (Sepulcre-Canto et al., 2012) or the Drought Managment Centre for South Eastern Europe (e.g. Ceglar et al., 2012).

Public water supply impacts have also been reported frequently. If considered together with impacts on water quality and freshwater ecosystems, they comprise an even larger fraction of impacts that relate to direct impacts on water resources than impacts on agriculture. In the Mediterranean countries, the fraction of reported impacts on public water supplies is particularly large. These numbers confirm general public perception of drought importance on public water supply impacts in the South. This was illustrated, for example, by stakeholders mapping drought impacts during the 2nd DROUGHT-R&SPI pan-European Dialogue Forum, where water supply was consistently labeled as a concern by Mediterranean stakeholders (Stahl et al., 2014 and Stahl et al., 2015). In addition, the details of reported impact types in this category revealed that water supply impacts in southern regions were more severe. They have been affected by actual limitations to households and drinking water supply, whereas other regions in Europe only reported preventive water use bans to decrease demand (Figure 4). Future work could investigate the feasibility of assigning a relative severity to impact details to improve the ranking and analysis of such differences.

Our analyses show that that physical drought characteristics may be linked to the impact characteristics (Figure 5). Summer droughts combined with heat waves, for example, have invoked unusual impacts on public health and on energy and industry by restricting river water use for cooling. Multi-year events in southern Europe (e.g. Estrela et al., 2000) and in the UK (e.g. Folland et al., 2015) have specifically reduced storage levels (surface reservoirs and groundwater), provoking conflicts among users. The factors controlling meteorological, hydrological, and soil moisture drought in Europe have been previously analyzed (Hannaford et al., 2011; Lloyd Hughes, 2012; Van Loon and Van Lanen, 2012; Tallaksen and Stahl, 2014). The EDII provides a potential data source to investigate the importance of drought severity, surface characteristics, and water management in producing drought impacts. This dataset, or similar products, may provide the necessary link to evaluate whether drought metrics can predict impacts, a research goal consistently stated (e.g. Kallis, 2008).

Conclusions

The EDII, a novel European database of reported drought impacts, was established to facilitate the use of textual evidence and categorized information on drought impacts at the pan-European scale for a variety of analyses. It provides a new view of drought across Europe's different geoclimatic regions and a unique basis for studies relating physical characteristics of the natural hazard of drought events to their various impacts. This contributes to fill an information gap on drought impacts and provides a useful data source for studies linking the hydrological characteristics of droughts with their effects on society at large. Already in its present state, the EDII database confirms the large variety of impacts associated with drought hazards and suggests differences and commonalities among regions and events.

As some examples illustrate, the insights from the impacts' text descriptions will be critical for drought management and policy development and call for more in-depth studies. An important finding was that impacts are diverse in Europe, suggesting that drought management and policy cannot only target one specific sector. The findings further call for a monitoring of variables besides precipitation, e.g. soil moisture, groundwater, water temperature for improved impact-specific drought indicators. Over time, the diversity of impacts appears to have increased and impact details may have changed in response to a more complex society and infrastructure, as has the awareness of the drought hazard, emphasizing the need to increase adaptive capacity. Although impact distributions appear somewhat similar across Europe, the implications and severity of a given event may vary. These details need to be further elucidated, which requires accurate and comparable, more quantitative reporting. Apart from the agricultural sector, little information is available on the economic cost of drought impacts is available. Access to such information likely requires accessing other information sources.

An assessment of the representativeness of the database with respect to European drought impacts and their severity will be a key to any future, more detailed, study. Along with updating and populating the database, continuous efforts are needed to improve the quality of its content and to develop novel approaches to account for the aforementioned uncertainties in categorizing the impact reports, as well as limitations in the data samples at specific spatial and temporal scales. Any specific analysis will need to select, complement, and process the impact data to create suitable samples. It is recommended that further work evaluate the use of more advanced methods to incorporate the textual information than the word frequency ranking presented here. It is anticipated that the combination of different datasets and the use of inter- and trans-disciplinary approaches in drought impact assessments is a promising way forward that will increase the confidence and usefulness of the EDII database.

Despite some biases in its current content, the EDII database constitutes a valuable resource that provides insights into the characteristics and regional patterns of drought impacts. There are still limitations and challenges ahead, but the presented material demonstrates the benefit and potential of such a database of drought impact information at the pan-European scale. European researchers have significant information and expertise regarding droughts; however, this expertise is distributed across many countries and often is not compiled. The EDII is designed to consolidate this drought knowledge. Access to this online database hopefully will inspire public participation. It is our hope that this website will become a standard reference tool and grow with time as more users participate in data collection, sharing, and analysis.

Author contributions

KS, IK and VB designed the research. KS, IK, VB, VA, SD, JU, LDS, LMT developed the database structure and impact categorization scheme. All co-authors provided data. IK or VB moderated all EDII entries, VB designed the data entry interface, JS implemented the online version, IK and VB carried out the analyses and created the graphs, maps and tables in the manuscript, KS, IK, VB prepared the manuscript with contributions and review from all co-authors.

Acknowledgements

The work was funded by the EU FP7 project DROUGHT-R&SPI (contract no. 282769). The following staff and students searched and provided impact reports and/or entered these into the database through the categorization interface: Daniel Eilertz, Barbara Frielingsdorf, Anne Kristina Tvedalen, Trine Jahr Hegdahl, Vassilis Kourentzis, Luigi de Paoli, Lanfranco Senn, Jill Simon and the students of the ‘Projektstudie Trockenheit’ at the University of Freiburg.

Appendix A: EDII database categories

Table A1.1 Overview of information sources for drought impacts entered into the EDII (Stahl et al., 2012)

Type of source (selection)	Explanation/Examples
Journal Article	Article in scientific or professional journals
Book	Book, edited volume or book chapter/section
Newspaper Article	Article in any newspaper or magazine in the popular press
Government Report	Reports by national and regional water/environment agencies etc.
(Other) Government Document	Other government issued sources
River Basin Organisation Report	Reports by river basin organisations
Report by NGO	Reports by environmental, social justice, and other organisations
Report by private sector	Report e.g. by insurance company, water/energy industry
Press Release	Press releases by stakeholders or agencies
Thesis	Academic work
Pamphlet	e.g. information note by water supply company, city, etc
Personal Observation	Personal observation by contributor or contact (e.g. from interview/stakeholder workshops)
URL (WWWeb Page)	Internet resources not published in official reports
Map	Maps
Other	Any other information source

Table A1.2 EDII Impact categories and type subcategories (modified from Stahl et al., 2012)

Impact category	Impact Type	
Agriculture and livestockfarming	1.1	Reduced productivity of annual crop cultivation: crop losses, damage to crop quality or crop failure due to dieback, premature ripening, drought-induced pest infestations or diseases etc.
	1.2	Reduced productivity of permanent crop cultivation
	1.3	Agricultural yield losses >= 30% of normal production (EU compensation threshold)
	1.4	Reduced availability of irrigation water
	1.5	Reduced productivity of livestock farming (e.g. reduced yields or quality of milk, reduced stock weights)
	1.6	Forced reduction of stock(early selling/slaughtering)
	1.7	Regional shortage of feed/water for livestock
	1.8	other
	1.9	Increased costs/economic losses
Forestry	2.1	Reduced tree growth and vitality
	2.2	Decrease in annual non-timber products from forest trees (e.g. cork, pine nuts, etc) (please specify which kind of product)
	2.3	Increased occurrence of water stress indicators and damage symptoms (e.g. premature ripening, seasoning checks, defoliation, worsened crown conditions etc.) (please specify forest type/tree species in the description field!)
	2.4	Increase of pest/disease attacks on trees (please specify species in the description field!)
	2.5	Increased dieback of trees (please specify tree species in the description field!)
	2.6	Increased dieback of planted tree seedlings (in nurseries or afforested area)
	2.7	Damage to short rotation forestry plantations (energy forestry)
	2.8	other
	2.9	Increased costs/economic losses
Freshwater aquaculture and fisheries	3.1	Reduced (freshwater) fishery production (please specify fish species in the description field)
	3.2	Reduced aquaculture production (please specify fish species in the description field)
	3.3	other
	3.4	Increased costs/economic losses
Energy and Industry	4.1	Reduced hydropower production
	4.2	Impaired production/shut down of thermal/nuclear powerplants (due to a lack of cooling water and/or environmental legislation for discharges into streams)
	4.3	Restriction/disruption of industrial production process (due to a lack of process water and/or environmental legislation/restrictions for discharges into streams)
	4.4	other
	4.5	Increased costs/economic losses
Waterborne transportation	5.1	Impaired navigability of streams (reduction of load, increased need of interim storage of goods at ports)
	5.2	Stream closed for navigation
	5.3	other

	5.4	Increased costs/economic losses
Tourism and Recreation	6.1	Reduced number of short-stay-tourists
	6.2	Reduced number of long-stay-tourists
	6.3	Sport/recreation facilities affected by a lack of water
	6.4	Impaired use/navigability of surface waters for water sport activities (including bans)
	6.5	other
	6.6	Increased costs/economic losses
Public water supply	7.1	Local water supply shortage / problems (drying up of springs/wells, reservoirs, streams)
	7.2	Regional/region-wide water supply shortage/problems (drying up of springs/wells, reservoirs, streams)
	7.3	Bans on domestic and public water use (e.g. car washing, watering the lawn/garden, irrigation of sport fields, filling of swimming pools)
	7.4	Limitations in water supply to households in rural areas (supply cuts, need to ensure water supply by emergency actions)
	7.5	Limitations in water supply to households in urban areas (supply cuts, need to ensure water supply by emergency actions)
	7.6	other
	7.7	Increased costs/economic losses
Water quality	8.1	Increased temperature in surface waters (close to or exceeding critical values)
	8.2	(Temporary) water quality deterioration/problems of surface waters(natural & manmade); e.g. significant change of physio-chemical indicators, increased concentrations of pollutants, decreased oxygen saturation levels, eutrophication, algal bloom)
	8.3	(Temporary) impairment of ecological status of surface waters (according to EU Water Framework Directive)
	8.4	(Temporary) impairment of chemical status of surface waters (according to EU Water Framework Directive)
	8.5	Increased salinity of surface waters (saltwater intrusion and estuarine effects)
	8.6	Problems with groundwater quality
	8.7	Increased salinity of groundwater
	8.8	Problems with drinking water quality (e.g., increased treatment, violation of standards)
	8.9	Problems with bathing water quality
	8.10	Problems with irrigation water quality
	8.11	Problems with water quality for use in industrial production processes
	8.12	other
	8.13	Increased costs/economic losses
Freshwater ecosystems	9.1	Increased mortality of aquatic species (specify species (latin term) and state whether a rare/endangered/protected species is concerned in the description field)
	9.2	Increased species concentration near water
	9.3	Migration and concentration (loss of wildlife in some areas and too many in others)
	9.4	Increased populations of invasive (exotic) aquatic species
	9.5	Observation of adverse impacts on populations of rare/endangered (protected) riparian species
	9.6	Observation of adverse impacts on populations of rare/endangered

		(protected) species of wetlands
	9.7	Loss of biodiversity (decrease in species diversity)
	9.8	Danger for or actual violation of minimum flow or environmental flow requirements
	9.9	Drying up of shallow water areas, weed growth or algae bloom
	9.10	Drying up of perennial stream sections
	9.11	Drying up of lakes and reservoirs (which have a habitat function)
	9.12	(Mid-/Long-term) deterioration of wetlands
	9.13	Irreversible deterioration/loss of wetlands
	9.14	other
	9.15	Increased costs/economic losses
Terrestrial ecosystems	10.1	Increased species mortality (specify species (latin term) and state whether a rare/endangered/protected species is concerned)
	10.2	Changes in species biology/ecology
	10.3	Loss of biodiversity (decrease in species diversity)
	10.4	Shift in species composition
	10.5	Reduced plant growth
	10.6	(Mid-/Long-term) deterioration of habitats
	10.7	Irreversible deterioration/loss of habitats
	10.8	Lack of feed/water for terrestrial wildlife
	10.9	Increased attacks of pests and diseases
	10.10	Increased contact of wild animals under stress (shortage/lack of feed and water) with humans/human settlements
	10.11	other
	10.12	Increased costs/economic losses
Soil system	11.1	Drought-related erosion processes (loss of soil fertility)
	11.2	Structural damage to private property due to soil subsidence/shrinkage
	11.3	Structural damages on infrastructures due to soil subsidence/shrinkage
	11.4	other
	11.5	Increased costs/economic losses
Wildfires	12.1	Increased burned area
	12.2	Increased number of wildfires
	12.3	Increased severity of wildfires
	12.5	Increased costs/economic losses
Air quality	13.1	Air quality pollution effects/problems (dust bowl effect, wildfires, substitution of hydropower production by fossil energy)
	13.2	other
	13.3	Increased costs/economic losses
Human health and public safety	14.1	Heat stress problems (if drought is associated with a heatwave)
	14.2	Increased respiratory ailments (heat wave and air quality)
	14.3	Excess mortality during heat waves
	14.4	Drought induced public-safety issues (e.g. increased risk of structural damages)
	14.5	other
	14.6	Increased costs/economic losses
Conflicts	15.1	Water allocation conflicts - international
	15.2	Regional/local user conflicts
	15.3	other
	15.4	Increased costs/economic losses

References

Bachmair, S., Kohn, I. and Stahl, K.: Exploring the link between drought indicators and impacts, Nat. Hazards Earth Syst. Sci., 15, 1381–1397, 2015, doi:10.5194/nhess-15-1381-2015.

Blauhut V., Gudmundsson, L. and Stahl, K.: Towards pan-European drought risk maps: quantifying the link between drought indices and reported drought impacts, Environ. Res. Lett. 10, 014008, doi:10.1088/1748-9326/10/1/014008, 2015a.

Blauhut, V., Stahl, K. and Kohn, I.: The dynamics of vulnerability to drought from an impact perspective, in: Drought: Research and Science-Policy Interfacing, edited by: Andreu, J., Solera, A., Paredes-Arquiola, J., Haro-Monteagudo, D. and van Lanen, H. A. J., CRC Press, London, 349–354, doi:10.1201/b18077-56, 2015b.

Bouma, E.: Development of comparable agro-climatic zones for the international exchange of data on the efficacy and crop safety of plant protection products, Bulletin OEPP/EPPO, 35, 233–238, 2005.

Ceglar, A., Medved-Cvikl, B., Morán-Tejeda, E., Vicente Serrano, S. M. and Kajfež-Bogataj, L.: Assessment of multi-scale drought datasets to quantify drought severity and impacts in agriculture: a case study for Slovenia, Int. J. Spat. Data Infrastruct. Res., 7, 464–487, doi: 10.2902/1725-0463.2012.07.art21, 2012.

De Stefano L., Urquijo, J., Acácio V., Andreu J., Assimacopoulos D., Bifulco C. and Wolters W. : Policy and drought responses – Case Study scale, DROUGHT-R&SPI Technical Report No. 4, 115 pp., available at: http://www.eu-drought.org/technicalreports/10821986/DROUGHT-R-SPI-Technical-Report-No-4-Policy-and-Drought-Responses-Case-Study-scale (last access: 12 August 2015), 2012.

Dessai, S., and Sims, C.: Public perception of drought and climate change in southeast England, Environ. hazards, 9, 340–357, doi: 10.3763/ehaz.2010.0037, 2010.

Dieker, E. van Lanen, H. A. J. and Svoboda, M.: Comparison of Three Drought Monitoring Tools in the USA, WATCH Technical Report No. 25, 86 pp., available at: http://www.eu-watch.org/media/default.aspx/emma/org/10653999/WATCH+Technical+Report+Number+25+Comparison+of+three+drought+monitoring+tools+in+the+USA.pdf (last access: 12 August 2015, 2010.

Ding, Y., Hayes, M. J. and Wildham, M.: Measuring economic impacts of drought: a review and discussion, Disaster Prev. Manage., 20, 434–446, doi: 10.1108/09653561111161752, 2011.

Estrela, M.J., Peñarrocha, D. and Millán, M.: Multi-annual drought episodes in the Mediterranean (Valencia region) from 1950–1996. A spatio-temporal analysis. Int. J. Climatol., 20: 1599–1618. doi: 10.1002/1097-0088, 2000

European Commission: Communication from the Commission to the European Parliament and the Council, the European Economic and Social Committee and the Committee of the Regions: A Blueprint to Safeguard Europe's Water Resources (COM (2012) 0673 Final), available at: http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52012DC0673 (last access: 12 August 2015), 2012.

European Environment Agency: Safe water and healthy water services in a changing environment, EEA Technical Report 7/2011, 33 pp., Publications Office of the European Union, Luxembourg, doi:10.2800/78043, 2011.

European Environment Agency: Water resources in Europe in the context of vulnerability, EEA 2012 state of water assessment, EEA Report No 11/20122, Publications Office of the European Union, Luxembourg, 92 pp., doi:10.2800/65298, 2012.

Gil, M., Garrido, A., and Hernández-Mora, N.: Direct and indirect economic impacts of drought in the agri-food sector in the Ebro River basin (Spain), Nat. Hazards Earth Syst. Sci., 13, 2679–2694, doi:10.5194/nhess-13-2679-2013, 2013.

Hannaford, J., Lloyd-Hughes, B., Keef, C., Parry, S., and Prudhomme, C.: Examining the large-scale spatial coherence of European drought using regional indicators of precipitation and streamflow deficit, Hydrol. Process., 25, 1146–1162, doi:10.1002/hyp.7725, 2011.

Hayes, M., Svoboda, M., Wall, N. and Widhalm, M.: The Lincoln declaration on drought indices: universal meteorological drought index recommended, B. Am. Meteorol. Soc., 92, 485–488, doi: 10.1175/2010BAMS3103.1, 2011.

Kallis, G.: Droughts, Ann. Rev. Env. Resour., 33, 85–118, doi: 10.1146/annurev.environ.33.081307.123117, 2008.

Knight, C.G., Reav, I., Staneva, M.P. (Eds.): Drought in Bulgaria: A Contemporary Analog for Climate Change, Ashgate Publishing, Aldershot, 336 pp., 2004.

Knutson, C. L., Hayes, M. J. and Philipps, T.: How to Reduce Drought Risk, Western Drought Coordination Council, Preparedness and Mitigation Working Group, Lincoln, 10 pp., available at: http://drought.unl.edu/portals/0/docs/risk.pdf (last access: 12 August 2015), 1998.

Kossida, M., Kakava, A., Tekidou, A. and Mimikou, M.: Vulnerability to Water Scarcity and Drought in Europe, ETC/ICM Technical Report 3/2012, European Topic Centre on Inland, Coastal and Marine Waters (ETC/ICM), Prague, 102 pp., available at: http://icm.eionet.europa.eu/ETC_Reports/VulnerabilityToWaterScarcityAndDroughtInEurop (last access: 12 August 2015), 2012.

Lackstrom, K., Brennan, A., Ferguson, D., Crimmins, M., Darby, L., Dow, K., Ingram, K., Meadow, A., Reges, H., Shafer, M., and Smith, K.: The Missing Piece: Drought Impacts Monitoring. Workshop report produced by the Carolinas Integrated Sciences & Assessments program and the Climate Assessment for the Southwest, 5–6 March 2013, Tucson, AZ, 1–23, 22 pp., 2013.

Lloyd-Hughes, B.: A spatio-temporal structure-based approach to drought characterisation. Int. J. Climatol., 32, 406–418, doi: 10.1002/joc.2280, 2012.

Logar, I. and van den Bergh, J. C.: Methods to assess costs of drought damages and policies for drought mitigation and adaptation: review and recommendations, Water Resour. Manage., 27, 1707–1720, doi: 10.1007/s11269-012-0119-9, 2013.

Musolino, D., Massarutto, A. and De Carli, A.: Ex-post evaluation of the socio-economic impacts of drought in some areas in Europe, in: Drought: Research and Science-Policy Interfacing, edited by: Andreu, J., Solera, A., Paredes-Arquiola, J., Haro-Monteagudo, D. and van Lanen, H. A. J., CRC Press, London, 71–77, doi:10.1201/b18077-56, 2015.

Parry, S., Prudhomme, C., Wilby, R. and Wood, P.: Chronology of drought termination for long records in the Thames catchment, in: Drought: Research and Science-Policy Interfacing, edited by: Andreu, J., Solera, A., Paredes-Arquiola, J., Haro-Monteagudo, D. and van Lanen, H. A. J., CRC Press, London, 165–170, doi:10.1201/b18077-56, 2015.

Tánago, I. G., Ballesteros, M., Urquijo, J. and De Stefano, L.: Exploring situations of vulnerability to drought from a sectorial perspective: A starting point for regional assessments, in: Drought: Research and Science-Policy Interfacing, edited by: Andreu, J., Solera, A., Paredes-Arquiola, J., Haro-Monteagudo, D. and van Lanen, H. A. J., CRC Press, London, 341–348, doi:10.1201/b18077-56, 2015.

Smakhtin, V. U. and Schipper, E. L.: Droughts: The impact of semantics and perceptions, Water Policy, 10, 131–143, doi: 10.2166/wp.2008.036 , 2008.

Stagge, J. H., Tallaksen, L. M., Kohn, I., Stahl, K. and van Loon, A. F.: A European Drought Reference (EDR) Database: design and Online Implementation, DROUGHT-R&SPI Technical Report No. 12, 42 pp., available at: http://www.eu-drought.org/technicalreports/10832306/DROUGHT-R-SPI-Technical-Report-No-12-A-European-Drought-Reference-Database-Design-and-Online-Implementation (last access: 12 August 2015), 2013.

Stagge, J. H., Kohn, I., Tallaksen, L. M. and Stahl, K.: Modeling drought impact occurrence based on climatological drought indices for Europe. J. Hydrol., in review, 2015.

Stahl, K., Blauhut, V., Kohn, I., Acácio, V., Assimacopoulos, D., Bifulco, C., De Stefano, L., Dias, S., Eilertz, D., Frielingsdorf, B., Hegdahl, T. J., Kampragou, E., Kourentzis, V., Melsen, L., van Lanen, H. A. J., Van Loon, A. F., Massarutto, A., Musolino, D., de Paoli, L., Senn, L., Stagge, J. H., Tallaksen, L. M. and Urquijo, J.: A European Drought Impact Report Inventory (EDII): Design and Test for Selected Recent Droughts in Europe, DROUGHT-R&SPI Technical Report No. 3, 23 pp., available at : http://www.eu-drought.org/technicalreports/10814306/DROUGHT-R-SPI-Technical-Report-No-3-A-European-Drought-Impact-Report-Inventory-EDII-Design-and-Test-for-Selected-Recent-Droughts-in-Europe (last access: 12 August 2015), 2012.

Stahl K., Blauhut V., Kohn I., De Stefano L., Dias S., Urquijo J., Tallaksen L. M., Van Lanen H. A. J. and Wolters W. (2014) Stakeholder views on drought impacts and Drought Risk Maps at the Pan-European scale: results from the 2nd Pan-European Drought Dialogue Forum, DROUGHT-R&SPI Technical Report No. 17, available at: http://www.eu-drought.org/technicalreports/10850944/DROUGHT-R-SPI-Technical-Report-No-17-Stakeholder-views-on-drought-impacts-and-drought-risk-maps-at-the-pan-European-scale-results-from-the-2nd-pan-European-Drought-Dialogue-Forum (last access: 12 August 2015), 2014.

Stahl, K., Kohn, I., De Stefano, L., Tallaksen, L. M., Rego, F.C., Seneviratne, S. I., Andreu, J. and van Lanen, H. A. J.: An impact perspective on pan-European drought sensitivity, in: Drought: Research and Science-Policy Interfacing, edited by: Andreu, J., Solera, A., Paredes-Arquiola, J., Haro-Monteagudo, D. and van Lanen, H. A. J., CRC Press, London, 329–334, doi:10.1201/b18077-56, 2015.

Steinemann, A.: Drought Information for Improving Preparedness in the Western States, B. Am. Meteorol. Soc., 95, 843–847, 2014 doi: 10.1175/BAMS-D-13-00067.1, 2014.

Tallaksen, L. M. and Stahl, K.: Spatial and temporal patterns of large-scale droughts in Europe: model dispersion and performance, Geophys. Res. Letters, 41, 429–434, doi: 10.1002/2013GL058573, 2014.

UN/ISDR: Drought Risk Reduction, Framework and Practices, Contributing to the Implementation of the Hyogo Framework for Action, United Nations secretariat of the International Strategy for Disaster Reduction (UNISDR), Geneva, 213 pp., 2009.

Van Lanen, H. A. J., Tallaksen, L. M., Stahl, K., Assimacopoulos, D., Wolters, W., Andreu, J., Rego, F., Seneviratne, S. I., De Stefano, L., Massarutto, A., Garnier, E. and Seidl, I.: Fostering Drought Research and Science-Policy Interfacing: Achievements of the DROUGHT-R&SPI project. in: Drought: Research and Science-Policy Interfacing, edited by: Andreu, J., Solera, A., Paredes-Arquiola, J., Haro-Monteagudo, D. and van Lanen, H. A. J., CRC Press, London, 3–12, doi:10.1201/b18077-56, 2015.

Van Loon, A. F. and Van Lanen, H. A. J.: A process-based typology of hydrological drought, Hydrol. Earth Syst. Sci., 16, 1915-1946, doi:10.5194/hess-16-1915-2012, 2012.

Van Loon, A. F., Ploum, S. W., Parajka, J., Fleig, A. K., Garnier, E., Laaha, G. and Van Lanen, H. A. J.: Hydrological drought types in cold climates: quantitative analysis of causing factors and qualitative survey of impacts, Hydrol. Earth Syst. Sci., 19, 1993–2016, doi:10.5194/hess-19-1993-2015, 2015.

Wilhite, D. A.: Reducing societal vulnerability to drought, in: Drought: A Global Assessment II, edited by Wilhite, D. A., Routledge, New York/London, 295–298, 2000.

Wilhite, D. A. and Glantz, M. H.: Understanding the drought phenomenon: the role of definitions, Water Int., 10, 111–120, doi: 10.1080/02508068508686328 , 1985.

Wilhite, D. A. and Vanyarkho, O.: Pervasive impacts of a creeping phenomenon, in: Drought: A Global Assessment I, edited by Wilhite, D. A., Routledge, New York/London, 245–255, 2000.

Wilhite, D. A., Svoboda, M. D. and Hayes, M. J.: Understanding the complex impacts of drought: A key to enhancing drought mitigation and preparedness, Water Resour. Manage., 21, 763–774, doi: 10.1007/s11269-006-9076-5, 2007.

Figure Captions:

Figure 1. EDII contents over time: with a) number of entries per year (according to the recorded impact start year) in the period 1900-70 and b) from 1970 onwards. For years with ≥ 20 reported impacts: yearly distribution of c) report sources, d) countries/geographical region, e) impact categories.

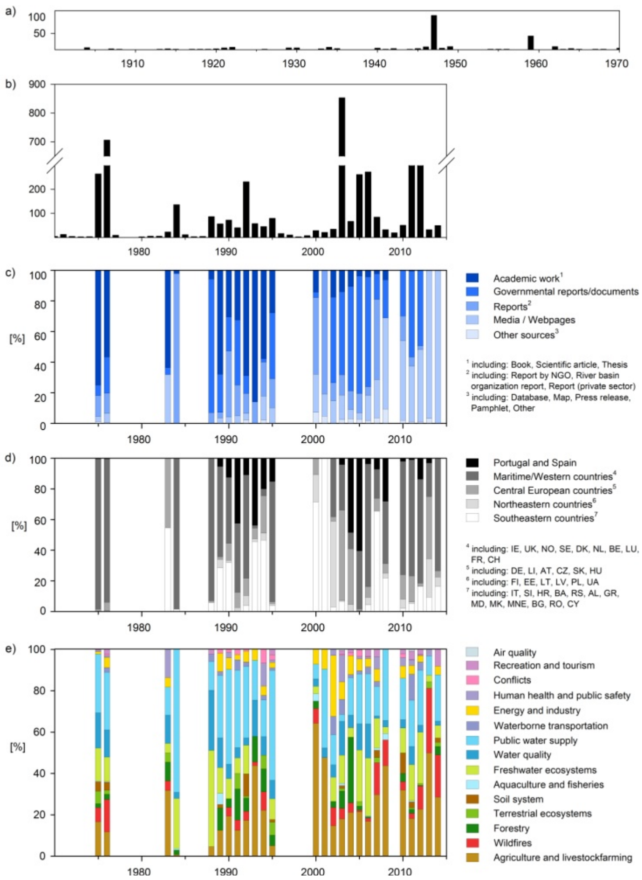


Figure 2. EDII contents by country, with the number of drought impact reports (pie size) and the distribution of underlying information sources (legend details as Figure 1c).

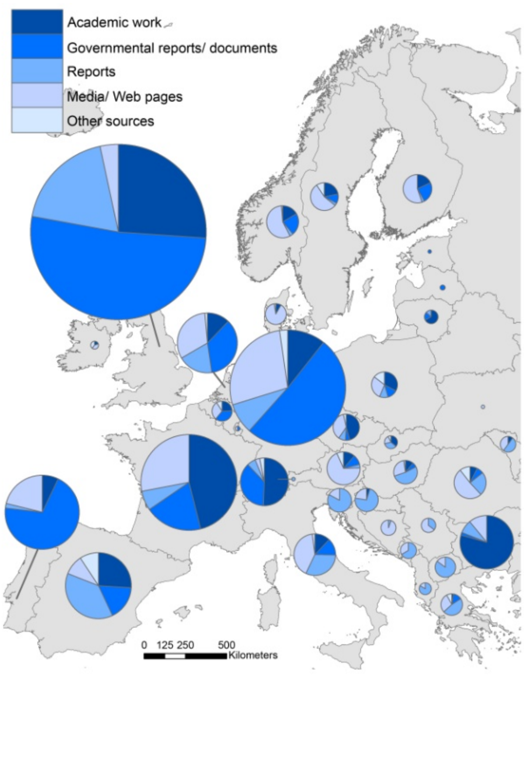


Figure 3. EDII contents by country, with the top three (most frequently reported) impact categories (colors from left to right show ranks 1-3) and the total number of drought impact reports.

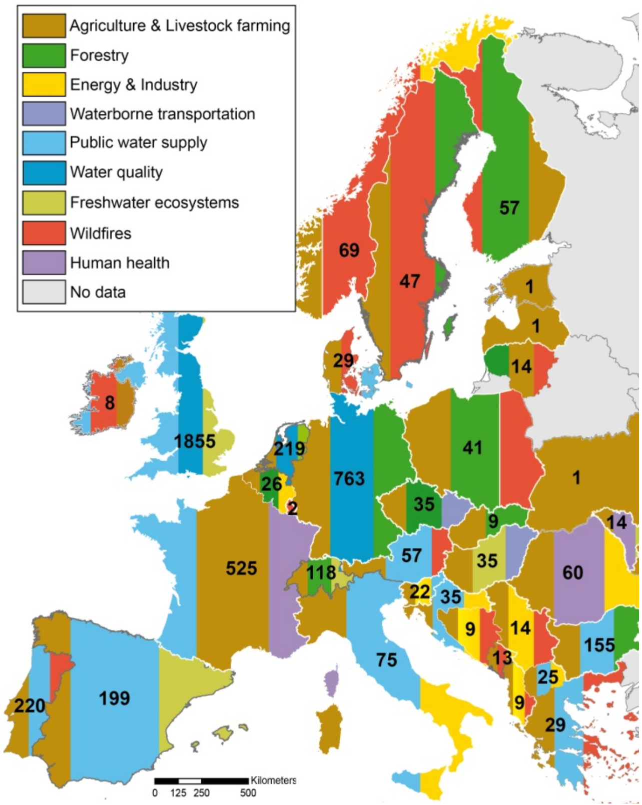


Figure 4. Reported impact types in three selected impact categories for countries with availability of > 15 reported drought impacts in the specific category. Impact type descriptions in the legend are shortened from Table A1.2.

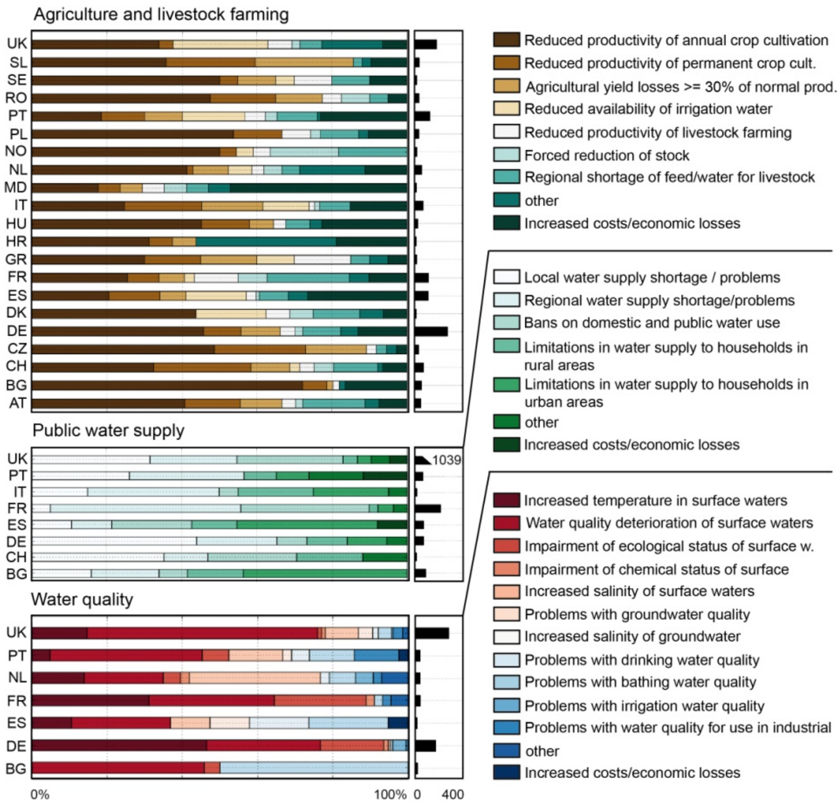
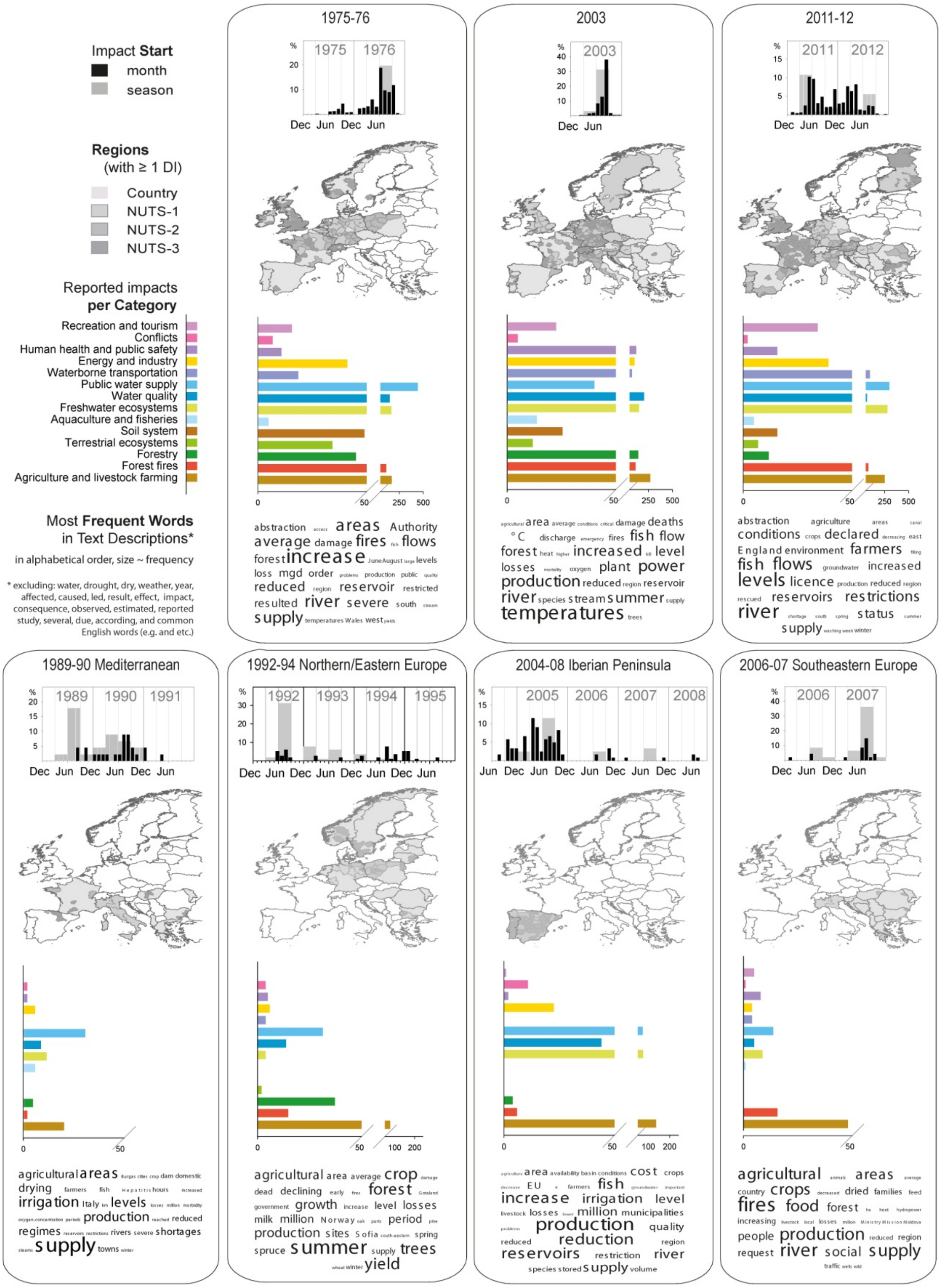


Figure 5. Reported drought impacts for selected European drought events during the period 1970-2013. For each event the following characteristics are shown (up to down): temporal distribution of reported impact starts, geographical location of reported impacts, number of impacts per category, and most frequent words in text descriptions (word clouds generated with TagCrowd.com).



CAPÍTULO 5. CONCLUSIONES

Este capítulo recoge las principales conclusiones derivadas del trabajo realizado en la presente tesis, centrándose en los temas transversales a más de un artículo, ya que las conclusiones específicas de cada artículo se pueden encontrar en el capítulo 4. Además, se presentan algunas líneas de investigación futura.

5.1. Conclusiones generales

Las **sequías juegan un papel importante en la gestión del agua** ya que impulsan procesos o aceleran cambios que de otra manera se darían de manera más lenta. Por ejemplo, el estudio de las leyes de emergencia muestra que la sequía de 2005-2008 en España aceleró la de modernización de regadíos, la aprobación de varias infraestructuras hidráulicas e incluso reformas legales de carácter permanente. De manera similar, el estudio de la sequía en varios contextos europeos ha mostrado que eventos de sequía especialmente severos pueden impulsar cambios importantes en el modelos de gestión de la sequía de un país. Esto se ha visto en relación con la sequía de la sequía de 1976 en Holanda y con la de 1991-1995 en España, mostrando el papel catalizador de la sequía y cómo ésta abre una ventana de oportunidad para actuar. Además, el análisis de la sequía revela información relevante sobre la política de agua de un país, y por tanto, es importante profundizar en su análisis a nivel conceptual y metodológico.

A nivel práctico, la **adopción del enfoque de gestión de riesgo** marca la tendencia actual de gestión de la sequía aunque su implantación en la práctica **es incipiente**. El nivel de implementación de este enfoque varía considerablemente entre los seis casos de estudio europeos analizados. Solo dos casos de estudio, Holanda y la Demarcación Hidrográfica del Júcar, presentan este enfoque de una manera clara. Ambos casos cuentan con una larga tradición de la gestión del agua y, como se ha mencionado arriba, se vieron afectados por eventos de sequía muy severos que actuaron como catalizador de reformas institucionales e inversiones en infraestructruras.

Existe **poca claridad sobre cuál es el significado práctico de la adopción del enfoque de riesgo y sobre cómo medirlo** en un caso concreto. Esto refleja un menor avance práctico que conceptual, como ha evidenciado la revisión de la literatura. En esta tesis se entiende que la adopción de la gestión del riesgo a la sequía debe incluir elementos como (i) Definición, delimitación y estudio del problema, es decir de los diferentes tipos de sequía y sus percepciones; (ii) El conocimiento de los impactos y de los factores de vulnerabilidad para cada contexto y sector afectado; (iii) Un conjunto de medidas que abarque diferentes problemas y que opere a diferente nivel de gestión, donde los sistemas de monitoreo y los planes de sequía son medidas especialmente relevantes; (iv) Procesos de participación eficientes y mecanismos de asignación de recursos transparentes; (v) Capacidad institucional para actuar, implementar las medidas y aprender de la experiencia mediante la evaluación.

El análisis de los tipos de medidas en los diferentes casos de estudio ha ayudado a **entender las características de la estrategia de gestión en cada contexto**. Por ejemplo, la ausencia de medidas preventivas y de monitoreo en el caso de estudio de la isla Syros indica una clara gestión de crisis. La existencia de un plan especial de sequía y de un sistema muy avanzado de monitoreo de la situación hidrológica en la Demarcación del Júcar, refleja cierto nivel de adopción del enfoque de riesgo. Otro indicio de un enfoque de crisis se ha encontrado en las leyes de emrgencia. Ahí, la securitización del discurso tiene implicaciones sobre el tipo de respuesta, ya que permite alterar los procesos de toma de decisiones y la aprobación por vía de urgencia de reformas e inversiones que deberían contemplarse en la planificación hidrológica ordinaria. Esto muestra que el análisis de las medidas propuestas en las leyes de emergencia ayuda a identificar elementos característicos de una respuesta de crisis.

Existen diferentes definiciones y percepciones de la sequía y esto repercute en la manera de responder a ella. En las leyes de emergencia la definición de la sequía utilizada contribuye a crear **incoherencias entre el problema identificado y la solución planteada**. Además, es interesante observar que los agricultores de regadío del Júcar definen la sequía de manera diferente a cómo lo hacen las leyes. Por tanto, a la hora de **gestionar la sequía es importante reconocer que se trata también de un constructo social, que existen diferentes percepciones y que esto tiene implicaciones relevantes en su gestión**.

El análisis de la percepción ha evidenciado la **importancia de los impactos a la hora de identificar los episodios de sequía y de evaluar su severidad**, ya que la presencia de impactos se utiliza para identificar situaciones de sequía por encima de otras definiciones utilizadas en las leyes de emergencia y en documentos oficiales y que se centran en la disminución de las precipitaciones o de las reservas hídricas. Además, los **impactos están relacionados fundamentalmente con la sequía socioeconómica** y juegan un papel esencial en ayudar a definir los umbrales para este tipo de sequía, al menos a nivel local. Por tanto, sería útil prestarle mayor atención a este tipo de sequía y desarrollar indicadores para su medición y su incorporación en los sistemas de monitoreo y alerta temprana existentes. Asimismo, el análisis de las percepciones y medidas de respuesta de los regantes en el Júcar, ha evidenciado un grave problema de escasez en la zona del Vinalopó que transciende al problema de las sequías.

Referirse a la sequía en términos generales puede llegar a carecer de sentido, dada la diversidad de definiciones y características. Para poder analizar y gestionar de manera más coherente y eficaz cada tipo y evento de sequía **es necesario especificar** claramente: (a) el **tipo de sequía** al que nos estamos refiriendo, (b) **los actores o niveles de gestión** que sustentan cada una de las definiciones presentes en un contexto determinado, (c) el **ámbito espacial y temporal** de referencia del evento de sequía.

Mediante los trabajos desarrollados en esta tesis se han podido identificar algunos elementos de la gestión del riesgo que se encuentran menos desarrollados o incompletos, dentro de los cuales es importante centrarse en (i) el análisis de vulnerabilidad, (ii) la evaluación post-sequía y, (iii) los procesos de participación en la gestión de la sequía.

(i) *la vulnerabilidad*

La **ausencia de estudios de vulnerabilidad en los seis casos de estudio europeos** demuestra el escaso desarrollo que tiene este tipo de análisis a nivel práctico. Esto contrasta con el extenso desarrollo conceptual que existe sobre la vulnerabilidad.

El análisis sistemático de los estudios de vulnerabilidad a la sequía (DVA, en su sigla en inglés) muestra que hay cierta **heterogeneidad en los marcos de evaluación de la vulnerabilidad aplicados**. Sin embargo empieza a notarse cierta convergencia hacia el marco del IPCC (2001) basado en la Exposición, Sensibilidad y Capacidad de Adaptación.

Ese mismo estudio muestra como los estudios de vulnerabilidad suelen **fijar a priori los criterios y factores de análisis, condicionados por los datos disponibles y no tanto por su importancia y relevancia.** Por ejemplo, la diversificación, el origen del agua y su calidad fueron considerados por los agricultores de regadío del Júcar como importantes factores de vulnerabilidad. Sin embargo, las características o usos del recurso apenas son incluidos en los estudios de vulnerabilidad a la sequía analizados en la revisión sistématica. Asimismo, destaca el limitado uso de factores institucionales o de gobernanza a pesar de la importancia que estos juegan en la adopción del enfoque de riesgo. El análisis de percepción también ha permitido constatar que el tipo de recurso influye en cómo se percibe la sequía y en cómo se va a gestionar. Esto confirma el papel de las aguas subterráneas como amortiguador de las sequías y surge como un factor relevante de sensibilidad a tener en cuenta en los estudios de vulnerabilidad.

Tener en cuenta factores de vulnerabilidad adicionales a los recogidos en las fuentes o estadísticas oficiales o disponibles permite ahondar en aspectos relevantes de la vulnerabilidad a la sequía y dar cuenta de su naturaleza multifacética, multiescalar y sectorial. También permite orientar mejor la respuesta, puesto que facilita una visión más amplia y ajustada a las necesidades locales y sectoriales del problema. Además ayuda a superar la falta de información, identificada como una de las principales **limitaciones de los estudios de vulnerabilidad y plantea la importancia de aumentar la recolección de datos en un formato y a un nivel que sean relevantes para el análisis de la vulnerabilidad**.

(ii) *el análisis post sequía*

La **escasez de evaluaciones o análisis globales post sequía**, encontrada en los casos de estudio a nivel europeo, se identifica como un **factor limitante** para la adopción del enfoque de gestión del riesgo, ya que refleja la **falta de análisis críticos** sobre la gestión de un determinado evento de sequía. Esto es clave para entender cómo funcionan las medidas y cómo contribuyen a reducir los impactos, promoviendo el aprendizaje para el futuro.

En esta tesis se han desarrollado dos **metodologías de evaluación ex post** que se aplican a niveles de gestión diferentes. La evaluación de las leyes de emergencia ha permitido identificar incoherencias entre las medidas planteadas respecto al problema identificado. Asimismo, el análisis diagnóstico de la gestión de la sequía en los seis casos de estudio ha permitido identificar cuáles elementos funcionan y cuáles no con respecto a las seis dimensiones analizadas. Ambos estudios muestran cómo las **evaluaciones expost permiten rescatar un conocimiento** que puede ser utilizado como punto de partida para mejorar los procesos de gestión de la sequía en el futuro.

En esta tesis, la falta de evaluación post sequía en parte se relaciona con la falta generalizada de datos sobre diferentes aspectos y componentes de la gestión. Esto sugiere la necesidad de **realizar mejoras en los procesos de recolección y acceso a la información sobre la sequía**, principalmente de los impactos y las medidas concretas implementadas. También indica la necesidad de adaptar los sistemas existentes para ser más sensibles a la vulnerabilidad, tal y como se ha comentado anteriormente.

En esta tesis, los **impactos** han sido abordados desde varias perspectivas, mostrando los **diversos roles que pueden jugar** en el análisis de la gestión de la sequía, destacando su uso:

(i) como **argumento para actuar**, justificando la aprobación de leyes de emergencia. En este caso se utilizan principalmente los impactos económicos y agrícolas. Si bien la agricultura tiene una mayor dependencia de los recursos hídricos que otros sectores, esto también muestra que la agricultura es un agente clave en la gestión del agua, al menos en España, y sugiere que forma un importante lobby. Este tipo de análisis puede ser útil en otros contextos para ayudar a identificar posibles grupos de poder y agentes que puedan estar siendo excluidos o menos atendidos.

(ii) como **base para definir e identificar la ocurrencia de episodios de sequía y su severidad**, en el caso de los regantes del Júcar.

(iii) como **indicador de la eficiencia de las medidas en la mitigación de los impactos**, como se desprende de los seis casos de estudio europeo. Los impactos han sido utilizados por los stakeholders para identificar mejoras en la gestión de las sequías ya que en la mayoría de los casos, una disminución de estos ha ido asociada por los stakeholders consultados a una mejora en la gestión de la sequía. Sin embargo, es necesario realizar un análisis más detallado en este tema, porque la relación entre los impactos y la gestión no es siempre unívoca, ya que un menor nivel de impactos también puede ser debido a que la sequía ha sido más moderada y con que los niveles de aceptación de impactos han cambiado y, por tanto, no necesariamente a mejoras en la gestión.

El trabajo realizado para alimentar la 'European Drought Impact Inventory' (EDII), con información sistemática de impactos reportados de la sequía en 33 países europeos, ha evidenciado **importantes limitaciones en el proceso de recolección y difusión de los datos sobre impactos.** En algunos países, como en España, la escasez de información se podría atribuir a una escasa cultura del reporte y a problemas de transparencia en la gestión de información sobre la sequía. Sin embargo, dado el importante rol que juega la información sobre los impactos en la gestión de la sequía, la EDII puede actuar como un buen punto de partida para la institucionalización de la recolección de este tipo de datos, ya que puede promover la creación de mecanismos de reporte e información más homogéneos. En el caso de España, esto podría realizarse en el marco de otros sistemas de monitoreo ambiental existentes.

Es imprescindible **avanzar en el conocimiento de cómo funcionan las medidas de sequía**, principalmente en relación a su coste-eficacia y a su contribución a la reducción y mitigación de los impactos. Las limitaciones para realizar este tipo de análisis se reflejan en la dificultad para dar seguimiento a los presupuestos y plazos de ejecución, como se ha observado al intentar averiguar el estado de ejecución de los proyectos aprobados por las leyes de emergencia. La relación entre las medidas y los factores de vulnerabilidad también ha surgido como un tema relevante en el estudio de percepción, ya que es importante entender qué medidas de gestión de la sequía se dirigen a reducir qué factores de vulnerabilidad y cómo. Sin embargo, también existen pocos estudios al respecto y se ha identificado como un tema de creciente interés para avanzar en un análisis más holístico de la gestión de la sequía desde la perspectiva del riesgo.

(iii) *La participación*

El análisis de los casos de estudio europeos ha permitido detectar un **aumento de la participación de los stakeholders en la gestión de la sequía**, aunque todavía hay margen para mejorar y aumentar su involucración en las tomas de decisión. Es importante que las medidas de mitigación de impactos consideren todos los sectores expustos a la sequía para poder hacer frente a sus demandas y necesidades, algo que no occurre en las leyes de emergencia, que se centran sobre todo en algunos sectores económicos. En el análisis de los casos de estudio se han identificado como clave las mejoras en los procesos de toma de decisiones, coordinación y comunicación. Esto adquiere importancia también si tenemos en cuenta que la incorporación de las diferentes percepciones de los stakeholders, por ejemplo de los regantes, en otros niveles de gestión ayuda a tener una perspectiva más amplia en la gestión de la sequía.

5.2. Conclusiones metodológicas

En esta tesis se ha mostrado el potencial que tienen nuevos enfoques de análisis para recabar información de interés para la gestión de la sequía en el futuro. Por tanto, se ha podido contribuir a la literatura sobre la gestión del riesgo desde una perspectiva teórica y metodológica.

El **análisis de marcos** enfatiza la importancia de analizar el binomio problema-solución, ya que esto ayuda a detectar incoherencias entre la formulación del problema y las medidas de sequía propuestas como soluciones. Además, ha resultado especialmente apropiado en su aplicación al análisis de leyes ya que se ajusta a la estructura y contenido de las mismas, facilitando su análisis e interpretación. Así mismo, ha permitido identificar el uso de la sequía como elemento ‘securitizador’ y analizar las implicaciones que esto tiene para la gestión de la sequía y del agua.

El **análisis de discurso** permite profundizar en la perspectiva de los diferentes stakeholders indagando en por qué la sequía es importante para ellos, cuáles son los impactos que sufren, los factores de vulnerabilidad que les afectan, las medidas que implementan y sus propuestas de mejoras. Dadas las diferentes percepciones, este tipo de análisis permite identificar el tipo de sequía al que se refiere cada agente en base a las definiciones que utiliza. Esto pone en evidencia la importancia de los estudios de percepción sobre el tema y la necesidad de distinguir entre definiciones formales e informales, ya que ayuda a orientar la respuesta hacia las propias necesidades de cada grupo de actores o sector.

El **análisis de vulnerabilidad** permite profundizar en las causas de los impactos y orientar la respuesta hacia ellas. Asimismo, el análisis de los factores de vulnerabilidad en el estudio de los regantes del Júcar ha resultado útil para distinguir en la práctica entre problemas de sequía y escasez. Esto es importante porque contribuye con un ejemplo concreto a rellenar una laguna en la literatura, ya que existen pocas referencias al respecto. El análisis sistemático de los DVA ayuda a entender las tendencias actuales y a identificar las principales debilidades y retos a superar en el futuro. Esto puede contribuir de manera importante a la mejora de los DVA, al hacer explícitos estos aspectos clave y retos, y al aportar referencias concretas sobre buenas prácticas.

El uso de un enfoque de **evaluación orientado por la teoría** ha facilitado el análisis de la gestión de la sequía en los seis casos de estudio por varias razones. Por un lado, ha sido esencial para estructurar y abordar de manera lógica todos los conceptos y factores que son relevantes para la gestión de la sequía. Por otro, al permitir construir un marco común de análisis de la gestión a la sequía lo suficientemente flexible, para poder adaptarse a la diversidad de casos contemplados. Este proceso ha ayudado a generar nuevos conocimientos sobre la gestión de las sequías y sus resultados han ayudado a entender el contexto de cada caso de estudio y pueden servir como punto de partidad para análisis más en detalle.

El **análisis de percepción** ha resultado útil para dar cuenta de la diversidad de definiciones y percepciones de la sequía. Esto ha permitido evidenciar diferentes formas de definir la sequía así como identificar la ocurrencia de un evento o su severidad. Además, ha ayudado a determinar aquellos factores del contexto que influyen de manera significativa en la percepción y respuesta a la sequía, como por ejemplo el origen del agua utilizada por los regantes.

La **construcción de la base de datos EDII** se presenta como una herramienta potente para el análisis de los impactos de la sequía a nivel europeo. El uso de datos textuales de impactos representa un enfoque novedoso pero también plantea importantes retos metodologicos y prácticos. Es importante mejorar su contenido en cuanto a la precisión de la duración y ámbito territorial de cada impacto y la evalución de su coste económico. Otro aspecto crítico es que actualmente la EDII apenas incluye datos sobre las medidas de gestión de la sequía, a pesar de que la recolección de esta información se contempla en la EDII.

Se ha constatado que existe una **brecha entre el nivel conceptual y práctico** que afecta a todos los componentes del riesgo analizados: sequía, impactos, vulnerabilidad y medidas, y la **necesidad de integrar la perspectiva biofísica y social** de una manera contundente y coherente en todos estos campos.

Dado el importante papel que juegan las características del **contexto**, es necesario aplicar enfoques metodológicos similares a diferentes contextos para poder analizar la influencia de dichas variables en la construcción e implementación de las políticas de sequía. La **flexibilidad** metodológica es un aspecto clave para asegurarnos de que nuestro estudio se adapta al contexto y para permitir su posterior replicación, creando así un potencial de comparación entre casos de estudio y contextos.

La **triangulación** de datos y métodos puede contribuir a mejorar el análisis y aportar mayor fiabilidad de los resultados, haciendo frente a la falta de datos. El hecho de tener que buscar la información en diferentes fuentes o a través de diferentes técnicas ha ayudado a identificar las fuentes de información más relevantes en cada contexto y a constatar la disponibilidad y acceso a los datos así como las lagunas de información existentes. Esto puede ser muy útil de cara a orientar la mejora de la recolección de información para la gestión en el futuro.

La **participación** de los stakeholders se ha centrado en el diseño de la evaluación en los casos de estudio europeos y en la recolección de datos en esos casos de estudio y la análisis de percepción en el Júcar. En el futuro sería deseable hacerles partícipes de todas las fases de evaluación.

Identificar la **escala territorial** la que operan los diferentes actores y medidas es clave para poder seleccionar de una manera apropiada el nivel de análisis de cada componente o dimensión, ya que ésta condiciona tanto los resultados de la evaluación como la interpretación de los mismos. Por tanto, es importante ser lo más precisos posible a la hora de considerar (a) la escala del fenómeno, (b) la escala de intervención de las medidas y (c) la escala de análisis de la evaluación.

En cuanto a la **escala temporal**, es importante delimitar la duración del episodio de sequía estudiado y también el periodo de análisis de la evaluación. Esto es especialmente relevante para analizar la temporalidad de las actuaciones y medidas, debido a que hay que tener en cuenta (a) el periodo necesario para su puesta en marcha o construcción (ej. embalses), (b) su duración (ej. duración de las restricciones de uso), y (c) el periodo o los plazos en los que se prevee que se van a manifestar los efectos de dichas medidas. Tener en cuenta estos aspectos ayuda a centrar la escala temporal de la evaluación y repercute también en el análisis de los resultados de ésta.

5.3. Futuras líneas de investigación

Como resultado de esta tesis han surgido algunas líneas de trabajo para el futuro:

- Análisis de la situación y desarrollo de los Planes de Sequía en el mundo, Europa y España. Se trata de determinar en qué países existen esfuerzos directos de gestión proactiva de sequía, indagando en aquellos casos donde exista una política de sequía como tal o existan planes específicos de sequía.
- Continuar con la recolección de información sobre impactos para España explorando nuevas fuentes de datos de forma que se alcance un número suficiente como para poder realizar una análisis de impactos más amplio.
- Desarrollar un marco de análisis de la vulnerabilidad a la sequía para el caso de España tomando como punto de partida el marco utilizado a nivel europeo (De Stefano et al., 2015). Se persigue profundizar en la identificación de variables más detalladas, relevantes o precisas que se puedan utilizar en el caso de España para realizar un análisis más detallado de la vulnerabilidad.

BIBLIOGRAFÍA

Adger, W.N. (2006). Vulnerability. *Global Environmental Change*, 16 (3), 268-281.

Agencia de Evaluación y Calidad AEVAL (2009). Evaluación de la Gestión y Funcionamiento de las Confederaciones Hidrográficas. Informe E17/2009. Agencia Estatal de Evaluación de las Políticas Públicas y de la Calidad de los Servicios. Ministerio de la Presidencia. (http://www.aeval.es/es/difusion_y_comunicacion/publicaciones/Informes/Informes_de _Evaluacion/Evaluaciones_2009/E17.html)

Alcamo, J., Acosta-Michlik, L., Carius, A., Eierdanz, F., Klein, R., Krömker, D., & Tänzler, D. (2008). A new approach to quantifying and comparing vulnerability to drought. *Regional Environmental Change*, 8(4), 137-149.

American Meteorological Society (AMS). (2004). Statement on meteorological drought. *Bull. Am. Meteorol. Soc*. 85, 771–773

Astbury, B., & Leeuw, F.L. (2010). Unpacking Black Boxes: Mechanisms and Theory Building in Evaluation. *American Journal of Evaluation*, 31(3), 363 -381.

Bachmair, S., Kohn, I., & Stahl, K. (2014). Exploring the link between drought indicators and impacts. *Nat Hazards Earth Syst Sci Discuss*, 2(12), 7583-7620.

Ballart, X. (1992). ¿Cómo evaluar programas y servicios públicos? Aproximación sistemática y estudios de caso. Madrid. Ministerio Administraciones Públicas (http://www.inap.es/biblioteca-digital)

Bates, B.C., Kundzewicz, Z.W., Wu, S. & Palutikof, J.P. (Eds.) (2008): Climate Change and Water. Technical Paper of the Intergovernmental Panel on Climate Change, IPCC Secretariat, Geneva, (Available at: http://www.ipcc.ch/pdf/technical-papers/climate-change-water-en.pdf)

Bellamy, J. A., Walker, D. H., McDonald, G. T., & Syme, G. J. (2001). A systems approach to the evaluation of natural resource management initiatives. *Journal of Environmental Management*, *63*(4), 407-423.

Benítez Sanz, C., & Schmidt, G. (2012). Analysis of the implementation of Drought Management Plans in the wider context of the River Basin Management Plans. Final deliverable. Version: Draft 1.0. INTECSA-INARSA

Birkmann, J. (2006). Measuring vulnerability to promote disaster-resilient societies: conceptual frameworks and definitions. In Birkmann, J. (Ed.). Measuring Vulnerability to Natural Hazards: Towards Disaster Resilient Societies (pp. 9-54). United Nations University Press, Tokyo, Japan,.

Birkmann, J., Cardona, O. D., Carreño, M. L., Barbat, A. H., Pelling, M., Schneiderbauer, S., … Welle, T. (2013). Framing vulnerability, risk and societal responses: the MOVE framework. *Natural Hazards*, 67(2), 193-211.

Bixio, D., Thoeye, C., De Koning, J., Joksimovic, D., Savic, D., Wintgens, T., & Melin, T. (2006). Wastewater reuse in Europe. *Desalination*, 187(1–3), 89-101.

Blaikie, P., Cannon, Y., Davis, I., & Wisner, B. (1994). A*t Risk: Natural Hazards, People's Vulnerability and Disasters.* Routledge: London, 1994 (1st Edition)

Blauhut, V., Gudmundsson, L., Stahl, K. (2015). Towards pan-European drought risk maps: quantifying the link between drought indices and reported drought impacts. *Environmental Research Letters,* 10(1), p.014008

Bogardi, J., & Birkmann, J. (2004). Vulnerability Assessment: The First Step Towards Sustainable Risk Reduction. In Malzahn, D. and T. Plapp, eds,Disaster and Society – From Hazard Assessment to Risk Reduction, Berlin: Logos Verlag Berlin, pp. 75–82.

Bohle, H. (2001). Vulnerability and criticality: perspectives from social geography. IHDP Update, 2/2001. Newsletter of the International Human Dimensions Programme on Global Environmental Change: 1–7

Bokal, S., Grobicki, A., Kindler, J., & Thalmeinerova, D. (2014). From national to regional plans – the Integrated Drought Management Programme of the Global Water Partnership for Central and Eastern Europe. *Weather and Climate Extremes*, 3, 37-46.

Bonaccorso, B., Bordi, I., Cancelliere, A., Rossi, G., & Sutera, A. (2003). Spatial Variability of Drought: An Analysis of the SPI in Sicily. *Water Resources Management*, 17(4), 273-296.

Bours, D., McGuinn, C., & Pringle, P. (2014). Twelve reasons why climate change adaptation M&E is challenging. Guidance note 1. SEA Change, UKCIP (http://www.managingforimpact.org/resource/guidance-note-1-twelve-reasons-why-climate-change-adaptation-me-challenging)

Brooks, N., Adger, W., & Mick Kelly, P. (2005). The determinants of vulnerability and adaptive capacity at the national level and the implications for adaptation. *Global Environmental Change*, *15*(2), 151-163.

Cardona, O.D. (2003). The need for rethinking the concepts of vulnerability and risk from a holistic perspective: a necessary review and criticism for effective risk management. In: Bankoff G, Frerks G, Hilhorst D (Eds) Mapping vulnerability: disasters, development and people (pp 37–51). Publishers, London.

CEC (2000). Water Framework Directive 2000/60/EC of the European Parliament and of the Council Establishing a Framework for the Community Action in the Field of Water Policy, 23 October 2000.

Coryn, C. L. S., Noakes, L. A., Westine, C. D., & Schröter, D. C. (2011). A Systematic Review of Theory-Driven Evaluation Practice From 1990 to 2009. *American Journal of Evaluation*, 32(2), 199 -226.

Costa, L., & Kropp, J. P. (2013). Linking components of vulnerability in theoretic frameworks and case studies. *Sustainability Science*, 8(1), 1-9.

Cutter, S. L., Barnes, L., Berry, M., Burton, C., Evans, E., Tate, E., & Webb, J. (2008). A place-based model for understanding community resilience to natural disasters. *Global Environmental Change*, *18*(4), 598-606.

Cutter, S. L., Boruff, B. J., & Shirley, W. L. (2003). Social Vulnerability to Environmental Hazards. *Social Science Quarterly*, 84(2), 242–261. REV

Cutter, Susan L. (1996). Vulnerability to environmental hazards. *Progress in Human Geography* 20, 529–539

Dagel, K. C. (1997). Defining drought in marginal areas: The role of perception. *Professional Geographer*, 49(2), 192-202.

Daneshmand, F., Karimi, A., Nikoo, M. R., Bazargan-Lari, M. R., & Adamowski, J. (2014). Mitigating socio-economic-environmental impacts during drought periods by optimizing the conjunctive management of water resources. *Water Resources Management*, 28(6), 1517-1529.

Davidson, R. (1997). An Urban Earthquake Disaster Risk Index, The John A. Blume Earthquake Engineering Center, Department of Civil Engineering, Report No. 121, Stanford: Stanford University

De Stefano, L., González Tánago, I., Ballesteros, M., Urquijo, J., Blauhut, V., & Stahl, K. (2015) Methodological approach considering different factors influencing vulnerability - Pan-European scale. DROUGHT-R&SPI Technical Report No. 26, 121 pp., (http://www.eu-drought.org/technicalreports/2; 2015)

De Stefano, L., Urquijo, J., Acácio V., Andreu, J., Assimacopoulos, D., Bifulco, C., and Wolters, W. (2012). Policy and Drought Responses – Case Study Scale, DROUGHT-R&SPI Technical Report No. 4, 115 pp., (http://www.eu-drought.org/technicalreports/ 10821986/DROUGHT-R-SPI-Technical-Report-No-4-Policy-and-Drought-Responses-Case-Study-scale, 2012)

Department for International Development (DFID) (1999). Sustainable Livelihood Guidance Sheets, London: DFID, (http://www.livelihoods.org/ info/info_guidancesheets.html)

Ding, Y., Hayes, M. J., & Widhalm, M. (2011). Measuring economic impacts of drought: a review and discussion. *Disaster Prevention and Management*, 20(4), 434-446.

Downing, T. E., & Bakker, K. (2000). Drought discourse and vulnerability. Drought: A global assessment, 2, 213-230.

Downing, T.E. & Bharwani, S. (2006). Baseline vulnerability assessment. Newater Report D2.1.1. 39pp. Oxford: Stockholm Environment Institute

Dziegielewski, B., Garbharran, H. P., & Langowsky, J. F. Jr. (1997). Lessons Learned from the California Drought (1987-1992): National Study of Water Management During Drought. DIANE Publishing.

Eakin, H., & Luers, A. L. (2006). Assessing the Vulnerability of Social-Environmental Systems. *Annual Review of Environment and Resources*, *31*(1), 365-394.

EC (2007a). Communication `from the Commission to the European Parliament and the Council. Addressing the challenge of water scarcity and droughts in the European Union. COM (2007) 414 final. European Commission, Brussels. (available at: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2007:0414:FIN:EN:PDF)

EC (2007b). Water Scarcity and Droughts. In-Depth-Assessment. Second Interim Report. DG Environment. European Commission, Brussels.

EC (2007c). Drought Management Plan Report: Including Agricultural. Drought Indicators and Climate Change Aspects. Technical Report – 208 – 023. Water Scarcity and Drought Expert Network. DG Environment (available at: http://ec.europa.eu/environment/water/quantity/pdf/dmp_report.pdf)

EC (2009). EVALSED. The resource for the evaluation of Socio-Economic Development. (ec.europa.eu/.../sources/.../evaluation/.../guide_evals...

EC (2012). A Blueprint to Safeguard Europe's Water Resources (COM(2012) 673 final). Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions. SWD(2012) 381 final, SWD(2012) 382 final. Brussels, 14.11.2012 (http://ec.europa.eu/environment/water/blueprint/index_en.htm)

EEA (2009). Water resources across Europe - confronting water scarcity and drought. EEA Report No 2/2009 European Environment Agency (EEA). (http://www.eea.europa.eu/publications/water-resources-across-europe)

Ekins, P., & Medhurst, J. (2006). The European Structural Funds and Sustainable Development. *Evaluation*, 12(4), 474 -495.

Erian, W., Katlan, B., & Babah, O. (2011). Drought vulnerability in the Arab region: Special case study: Syria. *Background paper prepared for the Global Assessment Report on Disaster Risk Reduction (GAR) 2011*.

Eriyagama, N.; Smakhtin, V.; Gamage, N. 2009. Mapping drought patterns and impacts: a global perspective. Colombo, Sri Lanka: International Water Management Institute. 31p. (IWMI Research Report 133)

Estrela, T., & Vargas, E. (2012). Drought Management Plans in the European Union. The Case of Spain. *Water Resources Management*, *26*(6), 1537-1553.

FAO & NDMC (2008). The Near East Drought Planning Manual: Guidelines for Drought Mitigation and Preparedness Planning. Food and Agriculture Organization of the United Nations Regional Office for the Near East, Cairo, Egypt and National Drought Mitigation Center University of Nebraska-Lincoln, Nebraska, USA59pp.

FAO (1983). Guidelines: Land evaluation for Rainfed Agriculture. FAO Soils Bulletin 52, Rome

FAO (2003). The state of food insecurity in the world: monitoring progress towards the World Food Summit and Millennium Development Goals. Rome (http://www.fao.org/docrep/006/y5096e/y5096e00.htm)

Fekete, A., Damm, M., & Birkmann, J. (2010). Scales as a challenge for vulnerability assessment. *Natural Hazards*, *55*(3), 729-747.

Ferrer Polo, J., & Mondéjar Martín, N. (2015). From Drought planning to Drought management: Administrative and follow up tasks. En Andreu, J., Solera, A., Paredes-Arquiola, J., Haro-Monteagudo, D., & van Lanen, H. (Eds.). Drought: Research and Science-Policy Interfacing. (pp. 385-390). CRC Press, Leiden: The Netherlands

Ferris, E., & Petz, D. (2012). The year that shook the rich: a review of natural disasters in 2011. The Brookings Institution – London School of Economics Project on Internal Displacement. March 2012

Fontaine, M., & Steinemann, A. (2009). Assessing Vulnerability to Natural Hazards: Impact-Based Method and Application to Drought in Washington State. *Natural Hazards Review*, 10(1), 11-18.

Fontaine, M., Steinemann, A., & Hayes, M. (2014). State Drought Programs and Plans: Survey of the Western United States. *Natural Hazards Review*, *15*(1), 95-99.

Ford, J. D., & Pearce, T. (2010). What we know, do not know, and need to know about climate change vulnerability in the western Canadian Arctic: a systematic literature review. *Environmental Research Letters*, 5(1), p. 014008.

Fu, X., & Tang, Z. (2013). Planning for drought-resilient communities: An evaluation of local comprehensive plans in the fastest growing counties in the US. *Cities*, *32*, 60-69.

Fu, X., Svoboda, M., Tang, Z., Dai, Z., & Wu, J. (2013a). An overview of US state drought plans: crisis or risk management? *Natural Hazards*, *69* (3), 1607-1627.

Fu, X., Tang, Z., Wu, J., & McMillan, K. (2013b). Drought planning research in the United States: An overview and outlook. International Journal of Disaster Risk Science, 4(2), 51-58.

Füssel, H.-M. (2007). Vulnerability: A generally applicable conceptual framework for climate change research. *Global Environmental Change*, *17*(2), 155-167.

Gallopín, G. C. (2006). Linkages between vulnerability, resilience, and adaptive capacity. *Global Environmental Change*, 16(3), 293-303.

Garrido, A., & Rey, D. (2014). Description and analysis of policy approaches to drought and floods in agriculture in five OECD countries. Joint Working Party on Agriculture and the Environment. Trade and Agricultural Directorate & Environmental Directorate. Report COM/TAD/CA/ENV/EPOC(2014)2015. OECD. (Disponible en www.oecd.org)

Gbetibouo, G. A, & Ringler, C., (2009). *Mapping South African farming sector vulnerability to climate change and variability: a subnational assessment*. International Food Policy Research Institute Discussion Paper 00885.

Gibbs, W.J., & Maher, J.V. (1967). Rainfall deciles as drought indicators. Bureau of Meteorology Bulletin 48, Commonwealth of Australia, Melbourne.

Gil, M., Garrido, A., & Gómez-Ramos, A. (2011). Economic analysis of drought risk: An application for irrigated agriculture in Spain. *Agricultural Water Management*, *98*(5), 823-833.

Giordano, R., Vurro, M. (2010). Fuzzy Cognitive Map to Support Conflict Analysis in Drought Management. En M. Glykas (Ed.), *Fuzzy Cognitive Maps* (pp. 403-425). Springer Berlin Heidelberg.

Goffmann, E. (1974). Frame Analysis. An essay on the organization of experience. Cambridge, MA, US: Harvard University Press

Gómez Gómez, C. M., & Pérez Blanco, C. D. (2012). Do drought management plans reduce drought risk? A risk assessment model for a Mediterranean river basin. *Ecological Economics*, *76*, 42-48.

Guba, E. G., & Lincoln, Y. S. (1989). *Fourth generation evaluation*. Newbury Park, CA

Guha-Sapir, R. Below, Ph. Hoyois - EM-DAT (2010). The CRED/OFDA International Disaster Database – www.emdat.be – Université Catholique de Louvain – Brussels – Belgium.

Gysen, J., Bruyninckx, H., & Bachus, K. (2006). The Modus Narrandi. *Evaluation*, *12*(1), 95 -118.

Habiba, U., Shaw, R., & Takeuchi, Y. (2012). Farmer's perception and adaptation practices to cope with drought: Perspectives from Northwestern Bangladesh. *International Journal of Disaster Risk Reduction*, 1, 72-84.

Hanberger, A. (2001). What is the Policy Problem? Methodological Challenges in Policy Evaluation. *Evaluation*, 7(1), 45-62.

Hayes, M., Svoboda, M., Wall, N., & Widhalm, M. (2011). The Lincoln Declaration on drought indices: Universal Meteorological Drought Index Recommended. Drought Mitigation Center Faculty Publications.

Hayes, M., Wilhelmi, O., Knutson, C. (2004). Reducing Drought Risk: Bridging Theory and Practice. *Natural Hazards Review*, 5(2), 106-113.

Heim, R. R. (2002). A Review of Twentieth-Century Drought Indices Used in the United States. *Bulletin of the American Meteorological Society*, 83(8), 1149-1165.

Hernández-Mora, N. & L. Del Moral (2015). Developing markets for water reallocation: Revisiting the experience of Spanish water mercantilización. *Geoforum* (2015)

Hernández-Mora, N., Gil, M., Garrido, A., & Rodriguez-Casado, R. (2013). La sequía 2005-2008 en la cuenca del Ebro: Vulnerabilidad, impactos y medidas de gestión. Universidad Politécnica de Madrid - Centro de Estudios e Investigación para la Gestión de Riesgos Agrarios y Medioambientales – CEIGRAM

Hildén, M. (2009). Time horizons in evaluating environmental policies. *New Directions for Evaluation*, 122, 9–18.

Hinkel, J. (2011). Indicators of vulnerability and adaptive capacity: Towards a clarification of the science–policy interface. *Global Environmental Change*, *21*(1), 198-208.

Hufschmidt, G. (2011). A comparative analysis of several vulnerability concepts. *Natural Hazards*, *58*(2), 621-643.

Huitema, D., Jordan, A., Massey, E., Rayner, T., Asselt, H. van, Haug, C., … Stripple, J. (2011). The evaluation of climate policy: theory and emerging practice in Europe. *Policy Sciences, 44* (2), 179-198.

Iglesias, A. & Garrote, L. (2012). *Methods for mapping drought vulnerability at different spatial scales*– WP3-D3.2 DEWFORA Project Report (www.dewfora.net)

Iglesias, A., Moneo, M., & Quiroga, S. (2009). Methods for Evaluating Social Vulnerability to Drought. En A. Iglesias, A. Cancelliere, D. A. Wilhite, L. Garrote, & F. Cubillo (Eds.), *Coping with Drought Risk in Agriculture and Water Supply Systems* (pp. 153-159). Springer Netherlands.

Iglesias, E., Garrido, A., & Gómez-Ramos, A. (2007). Economic Drought Management Index to Evaluate Water Institutions' Performance under Uncertainty. *Australian Journal of Agricultural and Resource Economics*, *51*(1), 17-38.

Ionescu, C, R J. T. Klein, J Hinkel, K. S. K Kumar, and R Klein. (2009). Towards a Formal Framework of Vulnerability to Climate Change. *Environmental Modeling & Assessment* 14 (1), 1–16.

IPCC (2001). Climate Change 2001: Synthesis Report. A Contribution of Working Groups I, II, and III to the Third Assessment Report of the Integovernmental Panel on Climate Change [Watson, R.T. and the Core Writing Team (eds.)]. Cambridge University Press, Cambridge, United Kingdom, and New York, NY, USA, 398 pp. (Completo)

IPCC (2007): Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, M.L. Parry, O.F. Canziani, J.P. Palutikof, P.J. van der Linden and C.E. Hanson, Eds., Cambridge University Press, Cambridge, UK, 976pp

IPCC (2012) 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 [Field, C.B., V. Barros, T.F. Stocker, D. Qin, D.J. Dokken, K.L. Ebi, M.D. Mastrandrea, K.J. Mach, G.-K. Plattner, S.K. Allen, M. Tignor, and P.M. Midgley (eds.)]. Cambridge University Press, Cambridge, UK, and New York, NY, USA, 582 pp.

Jann, W, & Wegrich, K. (2006). Theories of the policy cycle. In Fisher F., Miller, G.J. & Sidney, M.S (Eds), *Handbook of Public Policy Analysis. Theory, Politics, and Methods*. (pp. 43-62) CRC Press

Janssen, M. A., & Ostrom, E. (2006). Resilience, vulnerability, and adaptation: A cross-cutting theme of the International Human Dimensions Programme on Global Environmental

Change. Global *Environmental Change*, 16(3), 237-239.

Jenkins, K. (2013). Indirect economic losses of drought under future projections of climate change: a case study for Spain. *Natural Hazards*, 69(3), 1967-1986.

Kallis, G. (2008). Droughts. *Annual Review of Environment and Resources*, 33(1), 85-118.

Kampragou, E. Apostolaki, S. Manoli, E. Froebrich, J., Assimacopoulos D., (2011). Towards the harmonization of water-related policies for managing drought risks across the EU. *Environmental Science & Policy*, 14 (7), 815–824.

Karavitis, C. A., Tsesmelis, D. E., Skondras, N. A., Stamatakos, D., Alexandris, S., Fassouli, V., … Vlachos, E. C. (2014). Linking drought characteristics to impacts on a spatial and temporal scale. *Water Policy*, 16(6), 1172 - 1197.

Kassas, M. (1995). Desertification: a general review. Journal of Arid Environments, 30(2), 115-128.

Keyantash, J., & Dracup, J. A. (2002). The Quantification of Drought: An Evaluation of Drought Indices. *Bulletin of the American Meteorological Society*, 83(8), 1167-1180.

Knaap, G. J. & Kim, T. J. (1998). Introduction: Environmental Program Evaluation: Framing the Subject, Identifying Issues. In G. J. Knaap and T. J. Kim (eds), *Environmental Program Evaluation: A Primer*, (pp. 1–20). Urbana: University of Illinois Press.

Knutson, C., Hayes, M., Phillips, T. (1998). How to reduce drought risk, preparedness and mitigation working group of the western drought coordination council, Lincoln, NE. (disponible en http://drought.unl.edu/portals/0/docs/risk.pdf)

Kogan, F., & Sullivan, J. (1993). Development of global droughts-watch system using NOAA/AVHRR data. *Advanced Space Research*, 13, 219–222.

Kossida, M.,Kakava, A., Tekidou, A., Iglesias, A., Mimikou, M. (2012). Vulnerability to Water Scarcity and Drought in Europe. ETC/ICM Technical Report 3/2012. (available at: http://icm.eionet.europa.eu/ETC_Reports/VulnerabilityToWaterScarcityAndDroughtInEurope)

Kuhlicke, C., Scolobig, A., Tapsell, S., Steinführer, A., & Marchi, B. D. (2011). Contextualizing social vulnerability: findings from case studies across Europe. *Natural Hazards*, *58*(2), 789-810.

Kundzewicz, Z.W., L.J. Mata, N.W. Arnell, P. Döll, P. Kabat, B. Jiménez, K.A. Miller, T. Oki, Z. Sen & I.A. Shiklomanov, (2007). Freshwater resources and their management. Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, M.L. Parry, O.F. Canziani, J.P. Palutikof, P.J. van der Linden and C.E. Hanson, Eds., Cambridge University Press, Cambridge, UK, 173-210

Lackstrom, K., Brennan, A., Ferguson, D., Crimmins, M., Darby, L., Dow, K., Ingram, K., 5 Meadow, A., Reges, H., Shafer, M., and Smith, K. (2013). The missing piece: drought impacts monitoring, in: Workshop Report Produced by the Carolinas Integrated Sciences &Assessments Program and the Climate Assessment for the Southwest, 5–6 March 2013, Tucson, AZ, 1–23, 22 pp., 2013.

Lazarova, V., Levine, B., Sack, J., Cirelli, G., Jeffrey, P., Muntau, H., Salgot, M., & Brissaud, F. (2001). Role of water reuse for enhancing integrated water management in Europe and Mediterranean countries. *Water Science and Technology*, 43 (10), 25–33.

Legard, R., Keegan, J., Ward, K. (2003). In-depth interviews. In Ritchie J and Lewis J (eds).*Qualitative research practice: a guide for social science students and researchers* (pp. 138-169). London:Stage.

Lloyd-Hughes, B. (2014). The impracticality of a universal drought definition. *Theoretical and Applied Climatology*, 117(3-4), 607-611.

Logar, I., & van den Bergh, J. C. J. M. (2013). Methods to Assess Costs of Drought Damages and Policies for Drought Mitigation and Adaptation: Review and Recommendations. *Water Resources Management*, 27(6), 1707-1720.

López Ortiz, M. I., & Melgarejo Moreno, J. (2010). El trasvase Júcar-Vinalopó. Una respuesta a la sobreexplotación de acuíferos. *Investigaciones geográficas*, 51: 203-233

Luers, A. L. (2005). The surface of vulnerability: An analytical framework for examining environmental change. *Global Environmental Change*, *15*(3), 214-223.

Lupton, D. (1999). Risk and sociocultural theory: new directions and perspectives. (Eds). Cambridge University Press.

March, H., Domènech, L., & Saurí, D. (2013). Water conservation campaigns and citizen perceptions: the drought of 2007–2008 in the Metropolitan Area of Barcelona. *Natural Hazards*, *65*(3), 1951-1966.

March, H., Saurí, D., & Rico-Amorós, A. M. (2014). The end of scarcity? Water desalination as the new cornucopia for Mediterranean Spain. *Journal of Hydrology*, 519, Part C, 2642-2651.

Margoluis, R., Stem, C., Salafsky, N., & Brown, M. (2009). Design alternatives for evaluating the impact of conservation projects. *New Directions for Evaluation*, 122, 85–96.

Mark, M. M., Cooksy, L. J., & Trochim, W.M.K. (2009). Evaluation policy: An introduction and overview. In W.M.K. Trochim, M. M. Mark, & L. J. Cooksy (Eds.), *Evaluation policy and evaluation practice*. *New Directions for Evaluation, 123,* 3–11.

Martin-Ortega, J., & Markandya, A. (2009). The Costs of Drought: the Exceptional 2007-2008 Case of Barcelona. BC3 Working Paper Series 2009-09. Basque Centre for Climate Change (BC3), Bilbao, Spain. (http://www.bc3research.org/working_papers/view.html)

Mason, M. (2010). Sample Size and Saturation in PhD Studies Using Qualitative Interviews. Forum Qualitative Sozialforschung / Forum: Qualitative Social Research, 11(3). (Disponible en http://www.qualitative-research.net/index.php/fqs/article/view/1428)

McKee, T. B., Doesken, N. J. & Kleist, J. (1993): The relationship of drought frequency and duration of time scales. Eighth Conference on Applied Climatology, American Meteorological Society, Jan17-23, 1993, Anaheim CA, pp.179-186.

Med EUWI (2008). Mediterranean Water Scarcity and Drought report. Mediterranean Water Scarcity and Drought Working Group – Med EUWI. Joint Mediterranean EUWI/WFD Process, EU water initiative. (http://www.emwis.net/topics/WaterScarcity)

MEDROPLAN (2007). Drought Management Guidelines and Examples of Application (2 volumes in 6 languages). Iglesias, A., Cancelliere, S., Gabiña, D., López-Francos, A., Moneo, A. and Rossi, G. (eds). European Commission. MEDA-Water programme, Zaragoza. [available at: www.iamz.ciheam.org/medroplan]

Meehl, G. A., & Tebaldi, C. (2004). More Intense, More Frequent, and Longer Lasting Heat Waves in the 21st Century. Science, 305(5686), 994-997.

Mickwitz, P. (2003). A Framework for Evaluating Environmental Policy Instruments. *Evaluation*, *9*(4), 415 -436.

Mickwitz, P., & Birnbaum, M. (2009). Key insights for the design of environmental evaluations. *New Directions for Evaluation*, 122, 105–112.

Mishra, A. K., & Singh, V. P. (2010). A review of drought concepts. *Journal of Hydrology*, 391(1–2), 202-216.

MMA/CHJ (2007). Plan especial de alerta y eventual sequía en la confederación hidrográfica del Júcar. Ministerio de Medio Ambiente y Confederación Hidrográfica del Júcar.

Moss, T., & Newig, J. (2010). Multi-Level Water Governance and Problems of Scale: Setting the Stage for a Broader Debate. *Environmental Management* 46, pp. 1-6

Musolino, D., Massarutto, A., and De Carli, A. (2015). Ex-post evaluation of the socio-economic impacts of drought in some areas in Europe. In Andreu, J., Solera, A., Paredes-Arquiola, J., Haro-Monteagudo, D., and van Lanen, H. A. J. (Eds.). *Drought: Research and Science-Policy Interfacing* (pp. 71–77). CRC Press, London,

Naumann, G., P. Barbosa, Garrote, L., Iglesias, A., & Vogt, J. (2013). Exploring drought vulnerability in Africa: an indicator based analysis to inform early warning systems. *Hydrology and Earth System Sciences Discussions* 10(10): 12217-12254.

NDMC - National Drought Mitigation Centre (http://drought.unl.edu/)

Newig, J., & Fritsch, O. (2009). Environmental Governance: Participatory, Multi-Level – And Effective? *Environmental Policy and Governance,* 19 (3), 197-214

Niemeyer S. (2008). New drought índices. In López-Francos A. (ed.) .Drought management: scientific and technological innovations. Zaragoza : CIHEAM.Options Méditerranéennes : Série A. Séminaires Méditerranéens; n. 80. (pp. 267- 274)

Noemdoe S, Jonker L, Swatuk LA (2006) Perceptions of water scarcity: The case of Genadendal and outstations. Physics and Chemistry of the Earth, Parts A/B/C, 31(15–16): 771-778.

Okuyama, Y., & Sahin, S. (2009). Impact Estimation of Disasters: A Global Aggregate for 1960 to 2007 (SSRN Scholarly Paper No. ID 1421704). Rochester, NY: Social Science Research Network. (http://papers.ssrn.com/abstract=1421704)

Oliver-Smith, A., & Hoffman, S. M. (1999). *The Angry Earth: Disaster in Anthropological Perspective*. Psychology Press.

Palmer, W.C. (1965): Meteorological drought. Documento de Investigación Nº 45, Oficina Meteorológica del Departamento de Comercio, Washington, D.C.

Palmer, W.C. (1968): Keeping track of crop moisture conditions, nationwide: the new Crop Moisture Index – Weatherwise, 21:156-161.

Patton, M. Q. (1986). *Utilization-focused evaluation*. London, Sage Publications. (Comprobar citas)

Pérez, L. P., & Hurlé, J. B. (2009). Assessing the socio-economic impacts of drought in the Ebro river basin. *Spanish journal of agricultural research*, (2), 269-280.

Peters, E., Bier, G., van Lanen, H. A. J., & Torfs, P. J. J. F. (2006). Propagation and spatial distribution of drought in a groundwater catchment. *Journal of Hydrology*, 321(1–4), 257-275.

Peters, E., van Lanen, H. A. J., Torfs, P. J. J. F., & Bier, G. (2005). Drought in groundwater—drought distribution and performance indicators. *Journal of Hydrology*, 306(1–4), 302-317.

Petticrew, M., & Roberts, H. (2006). *Systematic Reviews in the social science. A practical guide*. Blackwell Publishing, UK. 336pp

Pita López, M.F. (2007). Recomendaciones para el establecimiento de un sistema de indicadores para la previsión, el seguimiento y la gestión de la sequía. Artículo publicado en "La sequía en España directrices para minimizar su impacto", elaborado por Comité de Expertos en Sequía, Ministerio de Medio Ambiente. (Pág. 71)

Popova, Z., Ivanova, M., Pereira, L.S., Alexandrov, V., Doneva, K., Alexandrova, P., & Kercheva, M. (2012). Assessing Drought Vulnerability of Bulgarian Agriculture through Model Simulations. *Journal of Environmental Science and Engineering* B 1, 1017-1036.

Preskill, H. (2009). Reflections on the dilemmas of conducting environmental evaluations. *New Directions for Evaluation*, 122, 97–103.

Pullin, A. S., & Knight, T. M. (2009). Data credibility: A perspective from systematic reviews in environmental management. *New Directions for Evaluation*, 122, 65–74.

Pulwarty, R., & Sivakumar, M. V. K. (2014). Information systems in a changing climate: Early warnings and drought risk management. *Weather and Climate Extremes*, 3, 14-21.

RAE – Real Academia Española (http://www.rae.es/)

Rauschmayer, F., Berghöfer, A., Omann, I., & Zikos, D. (2009). Examining processes or/and outcomes? Evaluation concepts in European governance of natural resources. *Environmental Policy & Governance*, *19*(3), 159-173.

Rogers, P. J. (2000). Causal models in program theory evaluation. *New Directions for Evaluation*, 87, 47-55.

Rossi, G., & Cancelliere, A. (2013). Managing drought risk in water supply systems in Europe: a review. *International Journal of Water Resources Development*, 29(2), 272-289.

Rossi, G., Cancelliere, A., Giuliano, G., (2005). Case Study: Multicriteria Assessment of Drought Mitigation Measures. *Journal of Water Resources Planning & Management*, 131(6), 449-457.

Rossi, G., Vega, T., & Bonaccorso, B. (2007). *Methods and Tools for Drought Analysis and Management*. Springer Science & Business Media.

Schmidt, G. & Benítez-Sanz, C. (2012). Topic report on: Assessment of Water Scarcity and Drought aspects in a selection of European Union River Basin Management Plans. Study by Intecsa-Inarsa for the European Commission (under contract "Support to the implementation of the Water Framework Directive (2000/60/EC)" (070307/2011/600310/SER/D.2)). URL: http://ec.europa.eu/environment/water/quantity/pdf/Assessment%20WSD.pdf.

Schmidt, G., Benítez, J.J., & Benítez, C (2012). Working definitions of water scarcity and drought. INTECSA-INARSA. Versión 4.0, 27 abril 2012. (disponible en https://circabc.europa.eu).

Scriven, M. (1991). *Evaluation thesaurus* (4th ed.). Newbury Park, CA: Sage (BUSCAR)

Seneviratne, S.I., Nicholls, N., Easterling, D., Goodess, C.M., Kanae, S., Kossin, J., Luo, Y., Marengo, J., McInnes, K., Rahimi, M., Reichstein, M., Sorteberg, A., Vera, C., and Zhang, X (2012): Changes in climate extremes and their impacts on the natural physical environment. In: Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation, Field, C. B., Barros, V., Stocker, T. F., Qin, D., Dokken, D. J., Ebi, K. L., Mastrandrea, M. D., Mach, K. J., Plattner, G.-K., Allen, S. K., Tignor, M., and Midgley, P. M. (Eds.), A Special Report of Working Groups I and II of the Intergovernmental Panel on

Climate Change (IPCC), Cambridge University Press, Cambridge, UK, and New York, NY, USA, pp. 109- 230. (Seneviratne et al 2012)

Shafer, B.A. – L.E. Dezman (1982): Development of a Surface Water Supply Index (SWSI) to assess the severity of drought conditions in snowpack runoff areas – Actas de la Conferencia sobre la Nieve en el Oes-te, pp. 164-175.

Shahbazbegian, M., & Bagheri, A. (2010). Rethinking assessment of drought impacts: a systemic approach towards sustainability. Sustainability Science, 5(2), 223-236.

Sivakumar, M. V. K., Stefanski, R., Bazza, M., Zelaya, S., Wilhite, D., & Magalhaes, A. R. (2014). High Level Meeting on National Drought Policy: Summary and Major Outcomes. *Weather and Climate Extremes*, 3, 126-132.

Smakhtin, V. U., & Schipper, E. L. F. (2008). Droughts: The impact of semantics and perceptions. *Water Policy*, 10(2), 131-143.

Soares, M. B., Gagnon, A. S., & Doherty, R. M. (2012). Conceptual elements of climate change vulnerability assessments: a review. *International Journal of Climate Change Strategies and Management*, *4*(1), 6-35.

Sonnett, J., Morehouse, B. J., Finger, T. D., Garfin, G., & Rattray, N. (2006). Drought and declining reservoirs: Comparing media discourse in Arizona and New Mexico, 2002–2004. *Global Environmental Change*, 16(1), 95-113.

Soto-García, M., Martínez-Alvarez, V., García-Bastida, P.A., Alcon, F., Martin-Gorriz, B. (2013). Effect of water scarcity and modernisation on the performance of irrigation districts in south-eastern Spain. *Agricultural Water Management*, 124: 11-19.

Stagge, J.H., Kohn, I., Tallaksen, L.M.; Stahl, K. (2015). Modeling drought impact occurrence based on climatological drought indices for Europe. J. Hydrol., (in review)

Strosser, P., Dworak, T., Garzon Delvaux, P.A., Berglund, M., Schmidt, G., Mysiak, J., Kossida, M., Iacovides, I., Ashton, V. (2012). Gap analysis of the Water Scarcity and Droughts Policy in the EU. Final report. European Commission Tender ENV.D.1/SER/2010/0049 / Acteon 2012. Inception Report of Water Scarcity & Droughts Policy in the EU - Gap Analysis. Tender ENV.D.1/SER/2010/0049

Supramaniam M, Di Masso, M. & García Sastre, A (2011): Lessons learnt and challenges with regard to social capacity building: Heat-related hazards – droughts, forest fires and heat waves in Southern Europe. CapHaz-Net WP7 Report, Institute for Environmental Sciences and Technology (ICTA), Autonomous University of Barcelona, Spain (available at: http://caphaznet.org/outcomes-results/CapHaz-Net_WP7_Report.pdf)

Svoboda, M., LeComte, D., Hayes, M., Heim, R., Gleason, K., Angel, J., … Stephens, S. (2002). The Drought Monitor. *Bulletin of the American Meteorological Society*, 83(8), 1181-1190.

Taylor, J. G., Stewart, T. R., & Downton, M. (1988). Perceptions of Drought in the Ogallala Aquifer Region. *Environment and Behavior*, 20(2): 150-175

Todisco, F., Mannocchi, F., & Vergni, L. (2013). Severity–duration–frequency curves in the mitigation of drought impact: an agricultural case study. *Natural Hazards*, 65(3), 1863-1881.

Tsakiris, G., Pangalou, D., & Vangelis, H. (2006). Regional Drought Assessment Based on the Reconnaissance Drought Index (RDI). Water Resources Management, 21(5), 821-833.

Turner, B. L., Kasperson, R. E., Matson, P. A., McCarthy, J. J., Corell, R. W., Christensen, L., ... & Schiller, A. (2003). A framework for vulnerability analysis in sustainability science. *Proceedings of the national academy of sciences*, *100*(14), 8074-8079.

UNCDD (1994). Intergovernmental Negotiating Committee for the elaboration of an International Convention to Combat Desertification in those countries experiencing serious drought and/or desertification, particularly in Africa. Final text of the Convention. A/AC.241/27. 12 September 1994

UNDP (2011). Mainstreaming drought risk management - a primer. United Nations Development Programme, 73pp.

UNDP (2013). Preparation of drought vulnerability assessment study to develop Iraq national framework for integrated drought risk management (DRM). Inception report. Earth Link And Advanced Resources Development (ELARD), draft report, pp. 31. United Nations Development Programme

UNISDR (2001). Estrategia Internacional de Reducción de Desastres (EIRD), Drought Management Plan Report Including Agricultural, Drought Indicators and Climate Change Aspects. Water Scarcity and Droughts Expert Network 2007. EC - WSDEN (2007).

UNISDR (2004). Living with Risk: A global review of disaster reduction initiatives. Version 2004, Volumne 1. United Nations

UNISDR (2005). Drought. Living With Risk: An Integrated Approach to Reducing Societal Vulnerability to Drought ISDR Ad Hoc Discussion Group on Drought UNISDR 2005

UNISDR (2007). Hyogo Framework for Action 2005-2015: Building the Resilience of Nations and Communities to Disasters. Extract from the final report of the World Conference on Disaster Reduction (A/CONF.206/6). International Strategy for Disaster Reduction (UNISDR). Geneva. Switzerland. 25pp (available at: http://www.unisdr.org/we/coordinate/hfa] UN-ISDR 2007 Marco de Hyogo)

UNISDR (2009) Drought Risk Reduction Framework and Practices Contributing to the Implementation of the Hyogo Framework for Action United Nations secretariat of the International Strategy for Disaster Reduction (UNISDR), Geneva, Switzerland, 213 pp

UNISDR (2009b). Glosario de términos de la UNISDR (www.unisdr.org/files/7817_UNISDRTerminologySpanish.pdf)

UNISDR (2011). Revealing Risk, Redefining development. Global Assessment Report on Disaster Risk Reduction. Geneva, Switzerland: United Nations for Disaster Risk Reduction (UNISDR) (http://www.preventionweb.net/english/hyogo/gar/2011/en/home/download.html(UNISDR-GAR 2011, p. 54_SP)

UNISDR (2012). Disaster reduction in Africa. UNISDR Informs. Special Issue on Drought Risk Reduction 2012, 68pp. UNISDR 2012, p. 10)

UNISDR (2013). From Shared Risk to Shared Value –The Business Case for Disaster Risk Reduction. Global Assessment Report on Disaster Risk Reduction. Geneva, Switzerland: United Nations Office for Disaster Risk Reduction (UNISDR). (http://www.preventionweb.net/english/hyogo/gar/2013/en/home/index.html)

Van Lanen, H. A. J. V., & Peters, E. (2000). Definition, Effects and Assessment of Groundwater Droughts. En J. V. Vogt & F. Somma (Eds.), Drought and Drought Mitigation in Europe (pp. 49-61). Springer Netherlands.

Van Loon, A. F. (2015). Hydrological drought explained. *Wiley Interdisciplinary Reviews: Water*, 2(4), 359-392.

Vedung, E. (1997). *Public Policy and Program Evaluation*. New Brunswick. NJ and London: Transaction

Vélez Méndez, C. (2007). El cambio de paradigma en evaluación de políticas públicas: el caso de la cooperación al desarrollo. Nuevas Políticas Públicas: Anuario multidisciplinar para la modernización de las Administraciones Públicas, (3), 145–170

Verloo, M. (2005). Mainstreaming gender equality in Europe. A critical frame analysis. *The Greek Review of Social Research*, 117(B), 11-34.

Vicente-Serrano, S. M., Beguería, S., & López-Moreno, J. I. (2009). A Multiscalar Drought Index Sensitive to Global Warming: The Standardized Precipitation Evapotranspiration Index. Journal of Climate, 23(7), 1696-1718.

Wilhelmi, O. V., & Wilhite, D. A. (2002). Assessing Vulnerability to Agricultural Drought: A Nebraska Case Study. *Natural Hazards*, 25(1), 37-58.

Wilhite, D. A. (2000). *Drought: A Global Assessment*. Routledge.

Wilhite, D.A. (1999). Drought preparedness in Sub-Saharan Africa context. In: Proc. Int. Conf. on Integrated Drought Management – Lessons for Sub Saharan Africa, 20–22 September.

Wilhite, D.A. (2001). Moving Beyond Crisis Management. After nearly a century of ad hoc drought management, the United States needs a new paradigm centered on risk management. FORUM for Applied Research and Public Policy. (forum.ra.utk.edu/Archives/Spring2001/wilhite.pdf)

Wilhite, D.A. (2002). Combating drought through preparedness. *Natural Resources Forum*, 26, 275–285.

Wilhite, D.A., & Glantz, M.H. (1985). Understanding: the drought phenomenon: the role of definitions. *Water International*, 10 (3), 111-120.

Wilhite, D.A., Hayes, M.J., Knutson, C., Smith, M.H. (2000). Planning for drought: moving from crisis to risk management. *Journal of the American Water Resources Association*, 36 (4), 697-710.

Wilhite, D.A., Hayes, M.J., Knutson, C.L. (2005). Drought preparedness planning: building institutional capacity. In: Wilhite DA. (ed.) Drought and Water Crisis: Science, Technology and Management Issues. CRC Press, Boca Raton, Florida, pp. 93-136 (chapter 5)

Wilhite, D.A., Sivakumar, M. V. K., & Pulwarty, R., (2014). Managing drought risk in a changing climate: The role of national drought policy. *Weather and Climate Extremes, 3, 4-13.*

Wilhite, D.A., Svoboda, M., Hayes, M. (2007). Understanding the complex impacts of drought: A key to enhancing drought mitigation and preparedness. *Water Resources Management*, 21 (5), 763-774.

Wisner, B., Blaikie, P., Cannon, T., & Davis, I. (2003). *At Risk: Natural Hazards, People's Vulnerability and Disasters* (2nd edition.). London ; New York: Routledge.

WMO & GWP. (2014). Directrices de política nacional para la gestión de sequías: Modelo para la adopción de medidas (D.A. Wilhite). Serie 1 de herramientas y directrices del Programa de gestión integrada de sequías. OMM, Ginebra (Suiza) y GWP, Estocolmo (Suecia).

WMO (2005). Guidelines on Integrating Severe Weather Warnings into Disaster Risk Management. Report No. WMO/TD No. 1292

WMO (2009): Experts agree on a universal drought index to cope with climate risks. Press release No. 872, December 2009. World Meteorological Organization. https://www.wmo.int/pages/mediacentre/press_releases/pr_872_en.html)

WMO/UNESCO (2012). Glosario Hidrológico Internacional / International Glossary of Hydrology. WMO/UNESCO, 2012 (http://wmo.multicorpora.net/MultiTransWeb/Web.mvc)

Wolf, S. (2012). Vulnerability and risk: comparing assessment approaches. *Natural Hazards*, *61*(3), 1099-1113.

Yevjevich, V. M. (1967). An objective approach to definitions and investigations of continental hydrologic droughts /. (Disponible en: https://dspace.library.colostate.edu:443/handle/10217/61303)

Zalidis, G. C., Tsiafouli, M. A., Takavakoglou, V., Bilas, G., & Misopolinos, N. (2004). Selecting agri-environmental indicators to facilitate monitoring and assessment of EU agri-environmental measures effectiveness. *Journal of Environmental Management*, 70(4), 315-321.

Zarafshani, K., Sharafi, L., Azadi, H., Hosseininia, G., De Maeyer, P., & Witlox, F. (2012). Drought vulnerability assessment: the case of wheat farmers in western Iran. *Global and Planetary Change*, 98, 122-130.