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An Assessment Framework to Analyze Drought Management Plans: The Case of Spain

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Abstract: Droughts affect all socio-economic sectors and have negative impacts on the environment. Droughts are expected to increase in frequency and severity due to climate change, which makes their effective management a high priority for policy makers and water managers. Drought Management Plans (DMPs) are a key instrument to deal with droughts and help to prepare for them in a proactive way as a framework for coordinated action before and during droughts. The development of DMPs is still incipient worldwide and their assessment remains limited. In Spain, DMPs at a river basin level were first approved in 2007. Following the legal obligation set in Spanish law, those plans were revised after ten years and a new version was approved in 2018. A content analysis was developed for assessing the 2018 DMPs of eight river basins managed by their corresponding River Basin Authorities, which depend on the Spanish central government. The evaluation criteria were set using the extant scientific literature and official guidelines on drought preparedness and management. The analysis showed that some aspects of the DMPs are especially well-developed, e.g., the distinction between drought and water scarcity, the definition of thresholds to trigger different levels of drought and water scarcity alerts and actions for drought management and coordination. Other issues still need further improvement, especially those related to the analysis of drought impacts, the assessment of vulnerability and the ex-post evaluation of DPM performance.

Keywords: drought; water scarcity; risk-based approach; drought management plan; assessment protocol; river basin scale

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1. Introduction

Droughts are expected to increase worldwide due to climate change [1,2], and "by the late twenty-first century, the global land area and population in extreme-to-exceptional terrestrial water storage drought could more than double, each increasing from 3% during 1976–2005 to 7% and 8%, respectively" [3]. Drought is a complex natural hazard that affects more people in relation to other disasters at a global level [4,5]. In Europe, the "overall economic impacts of droughts events in the past thirty years are estimated in a total of 100 billion € at EU level" [6] (p. 2) and are estimated at €9 billion per year currently but are projected to increase with climate change [7]. Moreover, FAO [8] estimates that there were USD29 billion in agricultural losses to developing countries between 2005 and 2015 from drought impacts alone. Our knowledge on drought impacts is still limited despite their characterization being essential to plan and manage drought episodes adequately [9–12]. Van Loon et al. [13] argues that feedbacks between drought and people are not fully understood, making drought management inefficient. Recently, Enenkel et al. [9] argued that that granularity of data on climate hazards such drought are increasing but it is not aligned with socio, economic and impact data, which is a priority for planning emergency as well as mitigation strategies.

To effectively mitigate such impacts, drought management should follow a proactive risk-based approach [8–11,14–16]. Moreover, preparedness and risk management reduce the cost of drought actions compared to crisis management or inaction [15]. This implies considering, at least, hazard characterization and drought event monitoring, vulnerability assessment and risk management including actions to address drought effects.

Despite a proactive risk-management approach being considered as the best way to mitigate drought impacts [8,14,17–22], drought management in many countries is still a reactive crisis management, instead of following a risk-management approach [23]. According to Fu et al. [24] (p. 53), "as drought directly and indirectly affects almost all aspects of a community, it appears there is not a holistic planning framework for droughts", which can limit its development. Raikes et al. [23] found that planning and preparedness was less common for drought than for floods, and, for instance, in the USA, progress towards proactive and planned management for drought has been more limited than for other natural hazards [25,26].

Drought Management Plans (DMPs) are a major management tool for proactive risk-based drought management [27–32] and are still rather uncommon, as only 27 countries around the world are listed as having drought policies and plans under the Integrated Drought Management Programme initiative. An overview of the limited development of DMPs in the European Union (EU) was first provided by Benitez and Schmidt [32] and was recently updated by Vogt et al. [33]. Other studies report some relevant experiences, particularly in the USA, Australia, South Africa, Iraq, India, Brazil and Central America, among others [14,15,20,21,34]. Existing DMPs are quite heterogeneous in terms of the problems addressed and the legal and regulatory frameworks and sectors considered.

While numerous scholarly works have analyzed drought as a natural hazard, the literature on DMPs is much more limited [9,35]. There is a need for evidence on their adequacy and usefulness, which can be framed as analysis of DPM content and quality (ex-ante assessment) or as analysis of performance once applied (ex-post assessment). Ex-ante assessment implies obtaining a comprehensive understanding of DMPs characteristics and, more importantly, exploring to what extent they are designed for proactive drought management. This is the focus of this paper. The ex-post assessment analyzes the effectiveness of such plans in reducing drought impacts once the drought ends [35]. This type of assessment, however, is particularly challenging for at least three reasons: first, because it can be difficult to attribute observed impacts to a drought or to other concurrent non climate-driven factors; second, because the definition of a baseline against which to measure impacts and the capacity of measures to mitigate them can be controversial; and third, because it requires the systematic collection of impact data, which is rarely a priority.

From an evaluation perspective, in the last decade, some interesting efforts have emerged in the USA and Europe that can serve as a reference for analyzing the adequacy of the design and content of DMPs. In the USA, several authors [24,26,36,37] have assessed drought management initiatives at different levels. In the EU, two studies on water scarcity and drought set the basis for the analysis of DMPs across countries. The first one [32] provides an overview of the existence of DMPs, while the second one [38] focuses on how water scarcity and drought issues are considered in River Basin Management Plans (RBMP). Both studies were developed in the framework of the 'Blueprint to Safeguard water in Europe' [39], a European Commission initiative to assess the implementation of the EU water policy. Nonetheless, clear guidelines for the systematic assessment of DMPs using a risk-management approach are still lacking.

This study contributes to the field of DMPs evaluation by developing a framework for assessing the adequacy of the design and content of DMPs according to a risk-management approach. The purpose of this framework is to provide an ex-ante assessment tool to analyze the completeness of already existing DMPs in terms of a risk-management approach. The developed framework was applied to Spain to test its adequacy and to help to identify areas where DMPs can be improved and lessons for other countries where the use of this drought management tool is still incipient or absent.

The paper is structured as follows: the following section presents the assessment protocol developed, and Section 3 describes the case study based on drought characteristics and drought management experience in Spain. The results of the analysis and their discussion are presented in Sections 4 and 5, respectively. In Section 6, some research limitations are mentioned and, finally, conclusions are drawn in Section 7.

2. Materials and Methods

A conceptual framework was developed to organize and address relevant aspects for a DMP according to the literature on drought risk management (Figure 1). This includes three main components (drought hazard characterization, drought vulnerability and drought measures and management) originally proposed by Hayes et al. [11] and later adapted by Fu, et al. [24], WMO/GWP [14] and Vogt et al. [16]. In this framework, the first component looks at the hazard itself; the second characterizes the system exposed to the hazard, while the third component analyzes actions taken to minimize the impact of the hazard on the system.

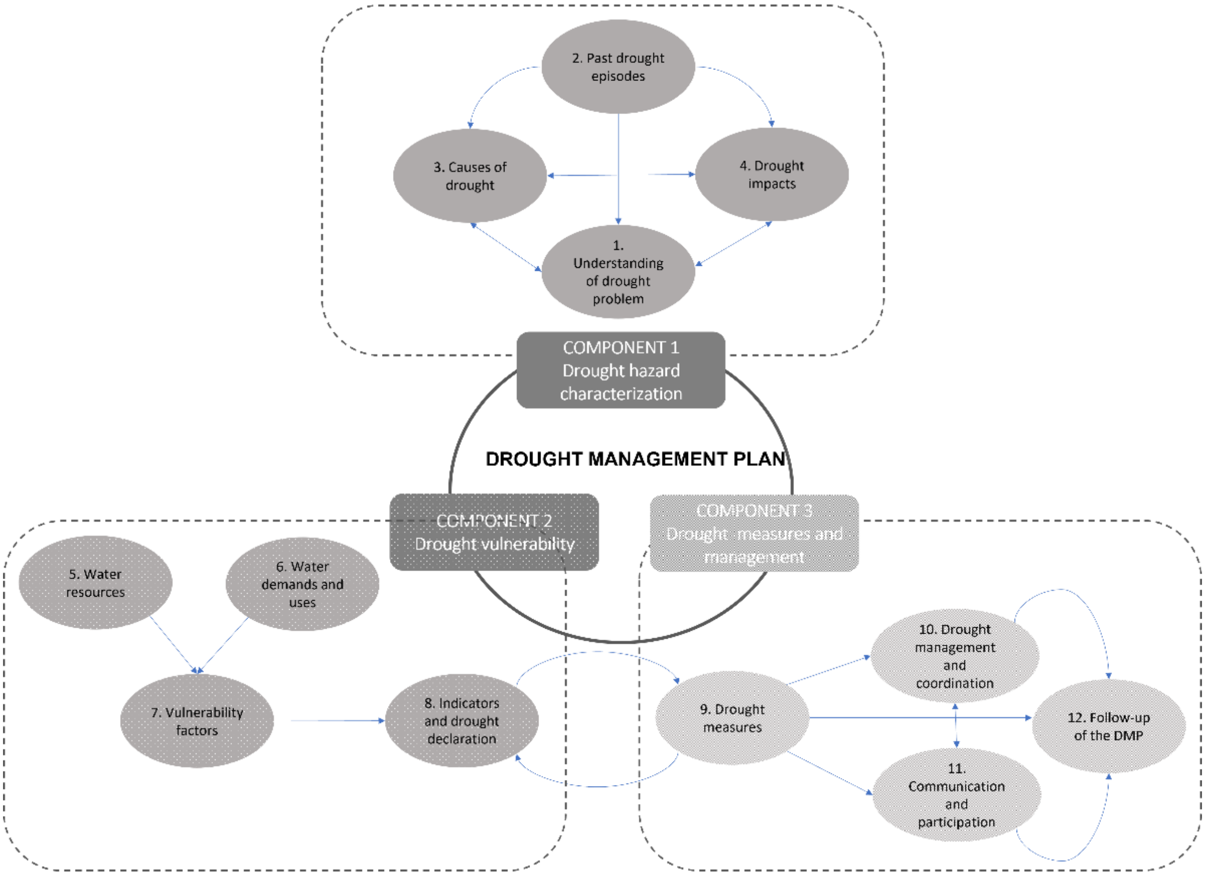

Figure 1. Conceptual framework for the assessment of drought management plans.

Assessment of these three components requires working with a set of criteria (12 in total), that, in turn, are made operative through specific indicators (43) (Table 1). They were selected or defined taking into account several sources: (a) extant literature on drought risk management [5,8,14,17,20,21,25,40–45]; (b) DMP guidelines developed in different geographical contexts [22,46–52]; and (c) applied assessments of DMPs from the literature [24,26,36,53].

Table 1. Assessment Protocol.

Component	Criteria	#	Indicators
1. Drought hazard characterization	1. Understanding of the problem	1	Definition of drought and drought types
		2	Definition of prolonged droughts
		3	Relation with other similar terms (water scarcity, aridity, desertification)
	2. Identification and assessment of past drought episodes	4	Identification of past drought episodes
		5	Number of episodes assessed
		6	Level of detail of the assessment
	3. Analysis of the causes of drought	7	Identification of the causes of drought
		8	Presence of references to climate change
		9	Identification of cause–effect relationship
	4. Analysis of drought impacts	10	Identification of type of impacts (social, economic, environmental)
		11	Identification of impacts by sectors
		12	Quantification of drought impacts
2. Drought Vulnerability	5. Analysis of water resources	13	Assessment of available water resources
		14	Analysis of water quality
		15	Assessment of environmental elements related to water resources
	6. Analysis of water demands and uses	16	Analysis of urban supply
		17	Analysis of agricultural demand
		18	Analysis of industry and/or hydroelectrical demand
		19	Analysis of other water demands
		20	Analysis of environmental water needs
		21	Identification by areas or geographical references or systems
	7. Analysis of vulnerability factors	22	Calculation of water balance
		23	Identification of vulnerable zones, sectors or groups
		24	Identification of vulnerability factors
		25	Identification of measures or actions to reduce vulnerability
	8. Indicators and drought declaration	26	Identification of drought indicators
		27	Establishment and calculation of indicators
		28	Relationship between drought indicators and alert levels
		29	Procedure for drought phase declaration
3. Drought measures and management	9. Analysis of drought measures	30	Definition of drought measures
		31	Analysis of the effectiveness of measures
		32	Estimation of drought measures costs
		33	Relationship between measures and drought phases
		34	Implementation mechanism of the measures
		35	Relation of the DMP with other plans
	10. Drought management and coordination	36	Plan foundation and legal aspects
		37	Allocation of responsibilities
		38	Identification of resources needs (means, staff and budget)
	11. Communication and participation	39	Dissemination and communication of the DMP
		40	Public participation
	12. Follow-up of the DMP	41	Definition of follow-up indicators and tools
		42	Ex-post assessment
		43	Plan revision process

Source: Own elaboration based on [5,8,19–21,24,26,32,34,36,42,48,50–55].

The indicators are scored through a content analysis of the DMPs considered. Following the recommendations of the UN [56], a 1–4 scale was used. This type of scale allows for higher granularity than the absent/present (0–1) scale employed in [24] Fu et al. (2013b) and it is an alternative to the 0–2 scale used by Fu and Tang [26] which is linked to potential personal bias in the scoring process. In this assessment, the scoring values should be understood as follows: very poorly described or absent (=1); insufficiently described and/or not supported by data (=2); well described and supported by some relevant data (=3); and well described and supported by data (=4).

The indicator scores are aggregated by criterion with equal weight and then by component. To reduce subjectivity in the coding process, at least two independent coders should score each DMP. When disagreements arise, the coders should discuss their scores to reach an agreement. This is a crucial step in content analysis, as it may show the clarity and adequacy of the coding protocol where a high level of disagreement between coders may reflect deficiencies in the scoring protocol [57]. Moreover, it helps reduce bias in the interpretation of the data [58]. However, there are limited standards and guidelines on how to report intercoder reliability [59].

3. The Case Study

3.1. Drought Management Context in Spain

Drought is a characteristic feature of Spain's climate. Several droughts have occurred in the Iberian Peninsula since 1941, with significant spatial differences in terms of their severity, duration and time of occurrence [60,61]. The main episodes occurred in 1941–1945, 1979–1983, 1990–1995 and 2005–2008 [55].

Drought management in Spain is part of a broader water management system that is largely determined by the EU Water Framework Directive (WFD 2000/60/EC) [62]. According to this directive, water resources are managed with River Basin Management Plans (RBMPs), which should be drafted and revised by the River Basin Authorities (RBAs) every 6 years. In 2001, article 27 of the Spanish National Hydrological Plan (SNHP, Law 10/2001) [63] established that inter-regional RBAs should develop a DMP for the river district within two years of the approval of the law (i.e., 2003). It also required local governments in towns with populations over 20,000 inhabitants to develop their Drought Emergency Plans for urban water supplies. In 2005, the ministry in charge of water management drafted a guidance document [48] to support RBAs in the elaboration of drought management plans, which in the spirit of the WFD should complement RBMPs. Eventually, the first generation of DMPs was approved in March 2007 (ORDEN MAM/698/2007) [64], at the end of a prolonged drought (2004/05–2007/08) that affected most of Spain. Several authors analyzed the process of development of those DMPs in the context of the WFD implementation [27,28,31].

In 2017, the official DMP guidelines were upgraded [52] and a second generation of DPMs was approved at the end of the year 2018 (Orden TEC/1399/2018) [65]. Figure 2 summarizes the key milestones related to DMPs approval in Spain during recent decades.

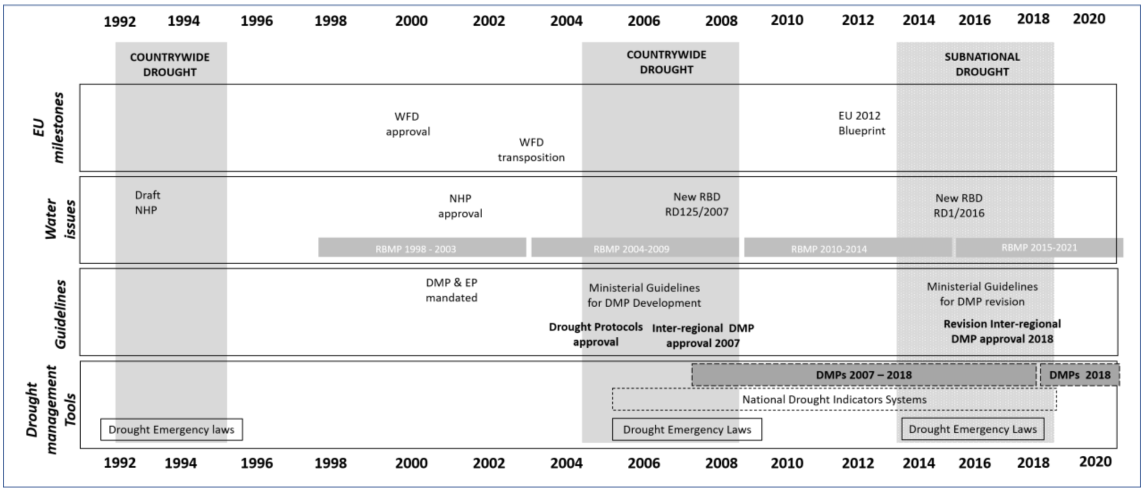

Figure 2. Timeline of the development of a drought management framework in Spain. Source. Adapted from Urquijo et al. [66].

The need for planning for drought has been present in the national legislation for almost two decades now, which puts Spain among the most advanced countries in the EU in the development of DMPs [32]. This and the following reasons make Spain an interesting case study to analyze drought planning practices at a river basin level: (a) It is a drought-prone country representative of drought risks in the Mediterranean region; (b) the approval of DMPs by RBDs has been compulsory since 2001; (c) DMPs were first developed during a prolonged and severe drought nation-wide, but since then, several droughts have occurred in different parts of the country; and (d) the 2018 DMPs are the result of a revision process, which should have led to a refinement and improvement of the original plans based on lessons from experience.

In Spain, the ministry in charge of water management undertook an assessment of drought management during the period of 2004–2008 [55] and, more recently, analyzed the DPMs approved in 2007 [67]. The latter study includes a descriptive review of the DMPs and focuses on monitoring procedures and results of the DMPs. However, no clear criteria of analysis were established to guide the assessment, which limits its ability to deliver a diagnosis and make recommendations for improvement. Additionally, a specific assessment of the 2007 DMP in the Segura River Basin was undertaken by Gómez Gómez and Pérez Blanco [68]. Other studies have explored current challenges in the integration of water resource management and drought risk management in Spain [30].

3.2. Geographical Scope of the Study

The proposed framework was applied to the DMPs developed in eight RBDs managed by River Basin Authorities belonging to the ministry in charge of water management and were approved in December 2018 (Figure 3, Table 2).

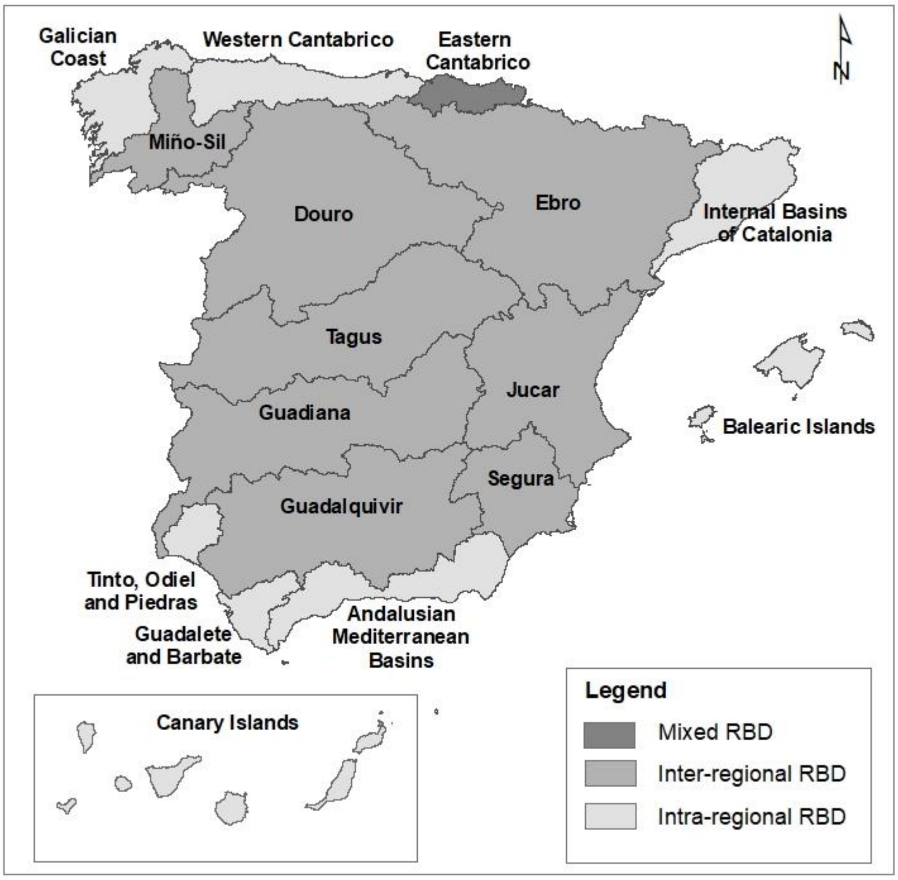

Figure 3. Spanish River Basin Districts.

Table 2. Spanish River Basin Districts: DMPs overview.

River Basin District		Sup. Km^2	Average Precipitation (mm/Year)	Available Resources (hm^3/Year)
Douro	DOU	98,073	612	12,777
Tagus	TAG	55,781	636	7865
Guadiana	GUA	55,527	808	4869
Segura	SEG	20,234	385	1425
Ebro	EBR	85,362	622	14,340
Guadalquivir	GDQ	57,527	582	7071
Jucar	JUC	42,730	475	3194
Miño-Sil	MIN	17,619	1257	11,823

The analysis was applied to the main document of the DMPs (memoria in Spanish) and complementary documentation (Strategic Environmental Assessment report, public consultation process document, post-drought evaluation report) were analyzed only when clarification about specific topics was needed.

4. Results

4.1. Overall Drought Plan Content and Characteristics

The selected DMPs obtained a mean score of 3.04, which represents 76% of the maximum possible score (4), with a 0.16 standard deviation (Table 3).

Table 3. Results for each component and criteria by DMP.

	Min Score of a DMP	Max Score of a DMP	STDesv	Mean Score	% of Possible Max Score
Component 1. Drought hazard characterization	**2.11**	**3.18**	**0.43**	**2.73**	**68%**
1.1 Understanding of the problem	3	3.33	0.15	3.08	77%
1.2 Identification and assessment of past drought episodes	2.33	3.92	0.56	3.48	87%
1.3. Analysis of causes of drought	1.67	3.33	0.67	2.33	58%
1.4 Analysis of drought impacts	1.11	3.22	0.78	2.04	51%
Component 2. Drought vulnerability	**3.44**	**3.65**	**0.10**	**3.53**	**88%**
2.1 Analysis of water resources	3.44	3.65	0.1	3.17	79%
2.2 Analysis of water demands and uses	3	3.33	0.18	4.00	100%
2.3 Analysis of vulnerability factors	4	4	0	2.97	74%
2.4 Indicators and drought declaration	2.5	3.25	0.28	4.00	100%
Component 3. Drought measures and management	**2.86**	**2.86**	**0.00**	**2.86**	**72%**
3.1 Analysis of drought measures	2.86	2.86	0	2.42	60%
3.2 Drought management and coordination	2.42	2.42	0	3.20	80%
3.3 Communication and participation	3.2	3.2	0	3.00	75%
3.4 Follow-up of DMPs	3	3	0	2.83	71%

See Supplementary Materials Table S1.

The drought vulnerability component had the highest mean value (3.5/4 or 88% of the total possible score) followed by the component of drought measurement and management (2.8/4 or 72% of the total possible score) and the drought hazard characterization component (2.7/4 or 68%).

4.2. Results by Component

4.2.1. Drought Hazard Characterization

All the DMPs include a clear definition of drought but do not distinguish among drought typologies (meteorological, agricultural, hydrological and socioeconomic), despite these operational definitions being considered important for drought management [38,50,69,70]. However, all the DMPs include a specific definition for prolonged drought, a key element [31] in the WFD, which states that prolonged droughts can justify the temporary non-compliance of the good status objective of the directive in the specific water body. Moreover, droughts are clearly defined as a natural phenomenon and differentiated from water scarcity caused by human water demands that exceed the availability of resources. Long-term water scarcity problems require different solutions as they have different causes, thus, a clear differentiation through an indicator-based monitoring system can have a positive practical implication for drought management. DMPs only tackle "temporary" water scarcity problems and leave "permanent" water scarcity problems to the ordinary planning in RBMPs. At times this distinction can be challenging, as temporary and permanent water scarcity situations may coexist within a territory or in time.

A detailed *Identification and assessment of past drought episodes* is included in all the plans. The *Analysis of the causes of drought*, water deficits or unsatisfied demands and drought impacts in general results in quite low scores. The plans that fare the lowest on this issue define and describe structural and conjunctural shortages but do not clearly identify their causes. Only two DMPs make a comprehensive analysis of drought causes, water deficits or unsatisfied demands, with the identification of drought causes and cause–effect relationships.

In general, references to climate change are generic, and even when some projections are provided, they are not downscaled to the specific RBD or are included in the DMPs only in terms of a relative reduction of natural runoff in 2027 and 2033 scenarios [30].

Similarly, the *Identification of drought impacts* is generic and qualitative. Only a small number of DMPs identify impacts by sectors and by type (social, economic and environmental). This criterion received the lowest scores in the component, which may be because limited information is available on impacts of past droughts. The literature on drought management widely acknowledges the need for a systematic inventory of environmental, economic and social impacts [10,71,72].

4.2.2. Drought Vulnerability

The DMPs obtained the highest global score in this component. All the DMPs include an extensive analysis of water availability, including surface water, groundwater and non-conventional resources (transfers, reuse, desalination) by territorial subunits within the river basin. This is complemented by the analysis of water quality and the assessment of associated environmental elements, which, in some DMPs, are insufficiently described and documented.

Most DMPs consider environmental flows, whose establishment is mandatory in the elaboration of the RBMP. Nonetheless, there is still a weak link between environmental flows and the operational system for drought management. Moreover, environmental concerns should not be limited to environmental flows if the recovery of the ecological status of water bodies after a drought is pursued [73].

All the DMPs obtain the highest possible score in the *Analysis of water demands* and uses (Table 3). This includes analysis of urban supply, agricultural, industry, hydropower, tourism and environmental needs, each identified by area or hydrological unit. As for the previous criterion, this information is easily available in the corresponding RBMP, which explains the high level of detail in the DMPs on this issue.

The scores received by the criterion of the *Analysis of vulnerability* factors vary widely across the assessed DMPs. The calculation of a water balance and the quantification of water deficits at different scales is present in all the plans and serves as a starting point for the identification of vulnerable zones. However, none of the plans relate those areas to specific factors of vulnerability [74] and concrete measures to reduce them. The analysis of vulnerability is often challenging but it is key in the adoption of a risk-management approach. The IPCC [75] proposed a conceptual framework that lays the foundation to develop a comprehensive analysis of vulnerability to drought within DMPs. The quantification of vulnerability should be context-specific and requires the integration of different types of data that are often not available at an RBD level [76].

All the DMPs received the maximum score in the criterion of the *Establishment and definition of indicators and a drought declaration process*. The system developed by RBAs to analyze and declare drought phases was established in 2007 for the first generation of DMPs, and since then it has been fine-tuned and homogenized across all the RBDs.

4.2.3. Drought Measures and Management

In this component, all the DMPs obtained the same scores (Table 3). This may be surprising at first, but, actually, it reveals an interesting pattern in the elaboration of the plans. As mentioned earlier, the DMPs were developed using an official guidance document [52] as a reference. In the case of three of the four criteria (*Drought management and coordination, Communication and participation*, *Follow-up of DMPs*) all the RBAs followed a similar approach for different reasons. In some cases, the legal framework defines intervention provisions and does not foresee basin-specific adjustments. In other cases, the score uniformity points to gaps shared across river basins, as is the case with the lack of availability of follow-up tools. Finally, the homogeneity reveals that RBAs in some instances have opted to just use standard information to fill in some sections of the DMP, without making an effort to consider the specific features of their basin.

The *Analysis of drought measures* criterion received the lowest score in this component and the second lowest value of all the indicators analyzed. Although all the plans identify drought measures and describe their implementation mechanisms, they do not make the criteria for the selection of measures explicit. In all DMPs, the definition of drought measures is associated with specific drought or water scarcity scenarios and is linked to a specific territorial unit within the RBD. In general, the planned measures are activated incrementally as the level of drought/water scarcity severity increases: (a) strategic planning and monitoring (non-drought/scarcity situation); (b) water saving, monitoring and public awareness (pre-alert); (c) demand and supply-side measures, monitoring and control (alert); and (d) intensification and exceptional actions (emergency). However, the DMPs do not assess the cost-effectiveness of each measure, which would allow for comparison across measures and the selection of the best option at each moment of the drought event.

The criterion *Drought management and coordination* is well rated. The allocation of responsibilities is described in detail in all the DMPs through the establishment of a drought task force and the definition of the role of each of the concerned actors during each stage of the drought event. Additionally, all the DMPs clearly identify the means, staff and budget needed for drought management in each RBD.

All the DMPs emphasize the importance and benefits of *Public participation* and highlight the need for effective communication. The plans present the participation process implemented during their revision, but they do not report results of consultation or how stakeholders' contributions have been taken into account. They state the need to undertake an assessment of the drought management performance after a drought episode (*Follow-up indicators*) but provide little detail on how to perform this in practice.

5. Discussion

The scoring produced by the application of the assessment framework can be useful for comparisons across similar management units (in this case, the river basin districts) to identify best practices and gaps and to detect general patterns that point to common challenges or strengths.

The analysis of some of the issues in DMPs, which are disaggregated at smaller territorial units within the RBD, is supported by extensive data. These are mostly issues related to information already available in the RBMP, such as water resources availability, demand and uses, hydraulic balances or ecological flows.

All the DMPs include an innovative indicator system that distinguishes between prolonged drought as a natural event and water scarcity situations and links them to a set of phases and triggers that activate different sets of measures. This system has been adapted to the specific characteristics of each RBD, as each RBA defines the parameters to be used to calculate the indicators and the thresholds that trigger the activation of the drought management phases. This provides enough flexibility to monitor and manage different situations in a context-specific manner and, at the same time, allows for comparison across sub-units within an RBD or also across RBDs. This flexibility points to the potential of this indicator system in other countries, especially in an EU context, where, to date, "there is not a proposed common agreed indicator system to be used across the EU" [31] p.6. The Spanish drought indicator system could be particularly relevant for countries that have already developed drought policy initiatives and are interested in designing or refining their drought monitoring system. This could be the case of some EU countries such as Italy, Portugal or Greece [32,49], but also can apply for other countries in Asia, e.g., India, Iran and Iraq [20,21,34]; Africa, e.g., South Africa, Kenia, Ethiopia and Namibia [5,20,21]; Australia [77]; the USA, specifically in the Midwestern United States [14,24,36]; or countries of the Mesoamerican Dry Corridor such as Guatemala, Honduras, Nicaragua and El Salvador [78]. Even if, in general, this indicator system is positively valued by scholars and practitioners, it has also been criticized by some because it does not couple streamflow forecasting models and seasonal climate forecasts [31]. Moreover, several other drought and water scarcity indicators [79] could be considered in the existing indicator system to broaden its scope.

Several areas for improvement that should be included in the next generation of Spain's DMPs were identified. DMPs should consider and analyze specific vulnerability factors. A better understanding of those factors is key to mitigate drought and water scarcity impacts at an RBD level and by sectors. Vulnerability is a complex issue and different conceptual frameworks already exist, but none of them has been systematically applied in the development of the DMPs analyzed in this study. This can limit the understanding of the root causes of vulnerability to drought in each territory, which in turn hampers the effective mitigation of impacts [35,41,46,71].

Climate change will aggravate the frequency, duration and intensity of drought episodes in the Mediterranean region [1,75], and this will affect several issues such as the characteristics of drought as well water availability and demands, and, hence, will determine the type of measures to be considered in each DPM. While some climate change considerations are included in the development of RBMPs, a specific analysis of the effect of climate change on drought characteristics would be key to understanding vulnerability to drought in the future.

The lack of a systematic analysis of drought impacts is one of the main weaknesses of the studied DMPs. The plans lack specific guidelines on how to characterize and register drought impacts. This is not an easy task, as the evaluation of drought impacts varies across sectors and territories. However, this type of information is crucial to complement the system of indicators related to the status of the availability of water resources and adequately inform decisions on drought management.

Another element that presents a great potential for improvement is related to the follow-up of the DMPs' measures, as also stated by Hervás-Gómez and Delgado-Ramos [80]. This requires a comprehensive analysis of all the DMP elements that are implemented during a specific drought episode and should be based on a specific effort to monitor the development and the effects of the measures. Currently, DMPs focus on monitoring drought and water scarcity conditions, and the measures to be implemented pivot on this indicator system. However, the systematic monitoring of the effectiveness of drought measures, the evolution of vulnerability factors and the characterization of drought impacts would contribute to more adaptive management. This should be done in coordination with the implementation and follow-up of the Emergency Plans for urban areas over 20,000 inhabitants. However, only a small number of Emergency Plans have been drafted and are operative (8.5% of those that should exist by law, according to Vargas and Paneque [30]), and, where they do exist, they are poorly coordinated with the corresponding DMP.

The analysis of the relation between drought and its impacts on environmental flows is still incipient. Despite the great progress made in the establishment of environmental flows in RBMPs, they are not still sufficiently integrated into DMPs as a variable for water demands analysis as well as a vulnerability factor-related to ecosystem. In future revisions of DMPs, this issue should receive larger attention. Moreover, more information on other relevant environmental issues and water quality parameters should be included in the next generation of DMPs.

In some cases, the RBAs have followed the official guidelines for the elaboration of DMPs with a limited effort to truly analyze and describe the mandated topics in the specific context of their RBD. Thus, some issues are dealt with superficially and their inclusion adds little to the actual management of drought (e.g., impacts analysis, ex post evaluation).

The assessment of DMPs is relevant to all the socioeconomic sectors that heavily depend on blue water, first among which is irrigated agriculture, which is responsible for 65% of water demand in Spain [81] and 70% worldwide [82]. In Spain, in case of prolonged drought, water rights for irrigation can be curtailed, and our study assesses the completeness of the legal and operational framework used to implement such restrictions. The analysis also reveals a bias that is present not only in Spain’s DMPs but in the drought management literature in general. Drought management is mostly seen solely as a (blue) water management issue, whereas drought effects go far beyond a reduction in the amount of water available in reservoirs, streams or aquifers. Moreover, drought evolution over time largely depends on the conditions of land, soil and vegetation when the dry spell sets in and, more broadly, on how land and natural systems are managed. The view of drought management from a blue water perspective has several causes, the main possibly being that the lack of water for domestic water supply and economic uses is the most evident and severe consequence of a poorly-managed drought. While this is understandable, it misses the fact that drought is a complex, multifaceted phenomenon that would require a holistic approach in order to be managed in an effective way.

The analysis reveals that the studied DMPs have been developed using a reasonably complete, proactive risk-management based approach. Thus, the Spanish experience of drought management is worth being closely considered by countries that plan to develop or update their own DMPs. Our work also revealed aspects of drought management planning which are especially challenging in Spain and that will require special attention in future DMPs in Spain and may be bottlenecks in other countries.

The analysis of Spanish drought plans showcases the fact that having well-developed DMPs is no panacea. Those plans are intended to manage temporary situations of water stress in a structured way, with the ultimate goal of minimizing its negative effects. However, their existence or quality says little about the effectiveness of water policy to deliver a truly sustainable use of water resources, as shown by the fact that, currently, in Spain, 42.2% and 40.4% of surface and groundwater water bodies, respectively [83], fail to meet the good status requirements set by the EU Water Framework Directive. Moreover, since the effectiveness of drought management is rooted in water planning and in the daily management of water resources, it is possible to have well-developed DMPs and still suffer severe drought impacts.

6. Caveats and Future Research

This study develops and applies a framework to assess the content of eight DMPs in Spain in relation to a risk-management approach to drought management. The analysis of the actual performance of that approach during a drought event is beyond the scope of this paper and is a necessary next step in this research.

The analysis of public consultation documents may be of great value for further analysis of Spain's DMPs, as it may help identify controversial or critical issues as perceived by the different players who have a stake in how drought and water scarcity are managed.

The DMPs analyzed in this study have been developed by inter-regional RBAs to respond to a legal requirement. In order to comply with this, technical guidelines were provided by the Spanish Ministry in charge of water management. It would be interesting to expand the current analysis to Spain's intra-regional RBDs, where the development of DMPs is the responsibility of the regional water agency and there is no obligation to follow the Ministry's guidelines. The comparison of both types of DMPs could provide new insights into possible alternative approaches to manage drought in a similar geographical, legal and sociocultural context.

More research on specific issues related to drought management may contribute to the enhancement of DMPs. This includes (1) the role of groundwater resources as a buffer of drought impacts within a specific territory, (2) the integration of climatic and inflow forecast models more effectively and (3) the assessment of drought measures through, e.g., cost-benefit analysis that could help inform the selection of mitigation options during the drought event.

In Spain, drought management is mainly framed in terms of water policy and, as a result, DMPs have a strong emphasis on blue water. As highlighted in the previous section, our framework of analysis was developed using such a water-related focus and for this reason it does not assess the inclusion in DMPs of issues that are highly relevant in order to achieve holistic drought management (e.g., soil and land conditions, forest management, biodiversity conservation, public health, energy production). The analysis of how drought is considered in sectorial plans that do not fall under water management would be of great value in order to find synergies and gaps across sectors and therefore improve drought management in a transversal way.

7. Conclusions

During the past two decades, water authorities at different levels in Spain have made important efforts to shift from a reactive to a proactive risk-based management approach to deal with drought. This is reflected in the development of guidelines by the ministry in charge of water management for the elaboration of DMPs by different RBAs. As a result, all the DPMs analyzed in this study include, to some extent, the key elements of this approach according to the academic and specialized literature.

Some elements of the risk-management approach are well developed in the current DMPs. These are: the system of drought indicators and thresholds to trigger phased interventions to deal with drought and water scarcity, the analysis of past drought episodes and the characterization of water availability and demands, among other aspects. There is room for improvement in some other elements, namely: the identification and analysis of vulnerability factors, the inventory of past drought impacts, the relation of drought with climate change and environmental issues, the role of environmental flows and groundwater resources, the analysis of the effectiveness of drought measures options and the post-drought evaluation of management procedures.

The framework applied is a useful tool for the identification of possible gaps in and strengths of drought management plans, where they already exist. The resulting numerical scores help identify thematic and territorial trends and can contribute to the debate about the aspects of drought management that require special attention in the future. Moreover, the Spanish experience in this field can be considered as an interesting starting point for the development of DMPs in other countries where drought management is still incipient or absent.

Supplementary Materials: The following supporting information can be downloaded at: https://www.mdpi.com/article/10.3390/agronomy12040970/s1, Table S1: Indicators scores byDMPs.

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