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in

López-Francos A. (ed.).
Drought management: scientific and technological innovations

Zaragoza : CIHEAM
Options Méditerranéennes : Série A. Séminaires Méditerranéens; n. 80

2008
pages 97-100

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SUMMARY – One of the main specificities of droughts is that their impacts are non-structural, disseminated in time and space over various components of the water cycle, and affecting different human activities. Such features cause significant difficulties in quantifying economic losses and integrating impacts in different sectors, calling for a combined use of both quantitative and qualitative data sources. In this paper, the impacts of the 2004-06 drought event in the Algarve (South Portugal) are assessed, using a combination of statistics, reports, news and other sources, thus providing an integrated framework to drought impact assessment.

Key words: Droughts, impacts, sources, data, integration, Algarve.

RESUME – *"Intégrer les sources d'information quantitatives et qualitatives dans l'évaluation des impacts de la sécheresse". L'une des spécificités principales des sécheresses est que leurs impacts ne sont pas structurels, qu'ils sont disséminés dans le temps et dans l'espace sur plusieurs composants du cycle de l'eau, et affectent des activités humaines diverses. Ces caractéristiques causent des difficultés significatives dans l'évaluation quantitative des pertes économiques et l'intégration des impacts sur différents secteurs, faisant appel à un usage combiné de sources quantitatives et qualitatives d'information. Dans cet article, les impacts de la sécheresse de 2004-06 en Algarve (Sud du Portugal) sont évalués au moyen d'une combinaison de statistiques, de rapports, d'actualités et d'autres sources, ce qui nous fournit un cadre intégré d'évaluation de ces impacts.*

Mots-clés : *Sécheresses, impacts, sources, données, intégration, Algarve.*

Introduction

Drought impacts differ from those caused by other natural hazards, since they disseminate in time and space, usually linger beyond the event duration, are non-structural, cover several components of the water cycle, and affect various sectors of human activity (Wilhite, 2000).

According to their nature, drought impacts can be classified as economic, social, or environmental (Mitchell *et al.*, 1989). Although most economic impacts may be quantified in monetary terms, social and environmental impacts can hardly be fully described quantitatively, despite recent efforts developed to calculate monetary costs of natural resources and goods (Rodrigo and Matos, 2001). Thus, a comprehensive impact assessment must be complemented in qualitative terms, using concepts of social and environmental costs, as proposed, respectively, by Kapp (1976) and Salmona (1988).

The integration of these different types of impacts is only pertinent in a specific territorial context. The corresponding geographic analysis allows integrating impacts spatially, according to water sources (aquifers, reservoirs), second level territories (regions, counties, municipalities), or affected sectors (agriculture, urban supply, energy production), but the different nature of impacts, assessment methods and even unit measures, should always be kept in mind.

The 2004-06 drought event that affected most of south-western Europe, including the southern Portuguese region of the Algarve, was fertile ground for this research to be conducted, providing an appropriate impact analysis case study. Nevertheless, such research is always dependent upon available and usable data sources, using both quantitative and qualitative methods. In this case, after a thorough research of all potential data sources, a set of documents and reports was selected, which can be classified in three major groups, according to the nature of information: (i) quantitative economic information; (ii) qualitative economic, social and environmental information; and (iii) thematic qualitative information from the Media. These are all described and analysed as follows.

Quantifyed economic impacts

Only two sources quantifying the economic impacts of this event were found at the national level: the assessment for the public sector produced by the Drought Commission (formed in 2005 by the Government to tackle drought impacts), and the agricultural sector assessment conducted by the Ministry of Agriculture. The former simply grouped direct data with estimations covering all costs imposed on public administration at national level, in 2005 only. This included: (i) additional fuel imports to compensate the low hydro-electrical production (182 million euros / M €); (ii) contingency cereals storage due to low crop production (74 M €); (iii) additional purchase of CO_2 emissions licenses to compensate increasing thermo-electrical production (38 M €); (iv) losses in the paper industry due to low tree growth (30 M €); and (v) other measures of relief and assistance to farmers and consumers affected by water shortages, reaching a total of 364 M €. The latter, a national assessment conducted by the Ministry of Agriculture by request of the European Commission, in preparation of the Communication on Water Scarcity and Drought (EC, 2007), estimated an overall cost (loss of income and costs increase) in the agricultural sector of 519 M €. Although based on solid field work and thorough estimation procedures, this value refers to 2005 only, not accounting for impacts during previous (2004) and following years (mainly due to damages on permanent crops).

At the regional level, the Algarve Department of Agriculture estimated the overall economic losses at 36 M €, 15 M € of which refer to citrus production, the main agricultural production of the Algarve, which was strongly affected. Once again, this estimation did not include the future costs caused by damages to trees, which are likely to affect their production in the coming years. This could only be found in the estimations provided by a local irrigation farming association (covering almost 1000 ha of citrus groves), which estimated losses in the regional sub-sector at nearly 29 M €, which is the most reliable figure available up to the present.

Economic losses of the agricultural sector can also be found in the official statistics, although indirectly and at national level only. According to the Portuguese Statistics Institute (INE, 2006), the liquid results of agriculture dropped from around 2200 M € in 2004 to 1800 M € in 2005 (the same value as in 1999). The Institute justifies this loss as a consequence of drought, but also as a result of changes in the European Common Agricultural Policy financing rules, thus making it difficult to isolate drought impacts. Nevertheless, the 400 M € difference between these two years is close enough to the Ministry estimation of 519 M € losses to validate the latter explanation.

Non quantifyed impacts

The analysis of available qualitative data sources is equally important, and is likely to be more complete, regionally targeted, but also more complex. Sources used were the official reports, specific legislation, and other documents elaborated by the national public administration, and more specifically by the Drought Commission (www.inag.pt/seca2005), and the information included in news reports by the Media, which will be analysed in the next section.

In the Algarve, the Drought Commission identified several economic impacts of drought, which are not quantified, but allow one to rank the different sectors and economic activities according to the severity of impacts, as well as to identify some of the major social and environmental impacts.

The most significant impacts identified in the agriculture sector were: (i) low production of winter cereals, partially deviated for fodder; (ii) low production of fodder, and consequent reduction of animal food availability; (iii) exhaustion of drinking water supplies for livestock during summer; (iv) low production of ruminants (goats and sheep) derived products; (v) low production and reduced cultivated area of spring/summer cereals; (vi) damage or loss of citrus trees, affecting production in the near future; and (vii) almond production reduced to half.

In the urban supply sector, only a few punctual interruptions occurred in private and local supply systems, mostly relying on groundwater, and located in the upper hills. In the main public supply system, covering over 90% of the regional population, several low-priority uses were restricted, such as car and street washing, garden hosing, swimming pools filling, and others. Simultaneously, public water saving campaigns were launched, both at national and regional levels.

In terms of environmental impacts, the most significant were: (i) increased forest fire risk (and consequent increase of fire ignitions and burnt area); (ii) excessive fish biomass concentration and cyanobacteria proliferation in reservoirs; and (iii) reduced stream water quality, with increasing mortality in several species and exotic species proliferation.

Besides the Drought Commission reports, all other sources analysed had no regional coverage, and references to drought impacts were identified, classified and ranked at the national level. The most referenced sector was agriculture, specifically in terms of low production of cereals, fodder, permanent crops and pastures, and of reduced irrigation water and livestock drinking water availability. Numerous references were found on the impacts to urban water supply system, increased forest fire risk, and reduced hydroelectric production. Additionally, regular references appear on the potential increase of human diseases related to low water storage in urban supply sources (mainly infectious, digestive-related), and on reduced surface water quality and its impacts on habitats, mainly affecting reservoir fish populations, which in several cases had to be withdrawn.

Identification of impacts from the media

Media sources are of particular relevance in drought impact assessment due to its key role in public perception, basis of risk management policy building (Do Ó, 2007). According to Ungar (1999), these sources should only be used when no other sources are available, or as complementary to others. In the present study, this indirect method of impact assessment is used as a validation complement to the main sources, previously analysed.

Two press publications were selected: a national reference diary newspaper, *Público* (www.publico.pt), and a regional weekly one, *Jornal do Algarve* (www.jornaldoalgarve.pt), both chosen because of their recognised professionalism and journalistic objectivity. All news that included the key word "drought" published in 2005 (when drought impacts were more visible and gained more projection) were collected, analysed and classified. In both newspapers, an average of almost one news report was published in each edition – 308 news in 364 editions for *Público* (0.84 average), and 45 news in 52 editions for *Jornal do Algarve* (0.87 average). Of all collected news, only a small part mentioned drought impacts in the Algarve, or in the whole country including this region, and only these were classified, according to the nature and type of reported impacts.

The majority of reported impacts refer to the social and agricultural sectors. In the social group are included both two types of impacts with more numerous references: "Political confrontation, pressure on governments", and "Rupture or restrictions on urban water supply". The former includes mainly news on public lobbying, demonstrations and press releases, both from environmental groups, farmers associations, or the government's opposition, and from the national government towards the European Union institutions. Significantly, all these news were collected from the national newspaper, since they refer mainly to impacts affecting the whole country, and particularly the neighbouring southern region of Alentejo, with little regional expression in the Algarve. The latter type refers mostly, for the whole country, to small scale supply systems unable to cope with such low water inputs, and at the regional level, to reports on falling storage levels in aquifers and reservoirs, and on fears of rupture and successive changes of water origins in the public urban supply system.

In the agricultural sector, a large set of impacts was referenced, and the most common was once again a national issue ("difficulties to feed livestock"), with no references found in the regional newspaper. This is strongly explained by the regional productive structure, with few animals feeding on fodder. In early summer, news reports on low production of pastures and fodder were progressively replaced by news on hay shortage (which is usually the basis of livestock feeding during this dry season). Secondly, "low production of winter cereals" and "damages and losses in permanent crops" were key issues throughout springtime, both at national and regional level, as well as those referring to "restrictions on irrigation" and "difficulties in supplying drinking water to livestock", with rupture situations reported in the Algarve from July on.

In other sectors, a significant number of news reports refer to: (i) the falling level of reservoirs (up to October, when average rainfall returned) and aquifers, most of which on the largest aquifer in the Algarve (Querença-Silves); (ii) increasing forest fire risk in springtime, and the relation of large summer forest fires with drought conditions; and (iii) low hydro-electrical production, compensated

with increased thermo-electrical production using imported fossil fuels – the largest quantified economic impact at national level, as presented in the previous section.

Conclusions

Data sources used in this study present important limitations, as follows: (i) most information was collected and produced for 2005 only; (ii) aggregated information at the national level has no available regional data; and (iii) agriculture and energy statistics do not allow one to separate drought impacts from other factors of production variability. Nevertheless, the combination of multiple sources enables their validation and provides a thorough assessment of impacts, especially at the national level.

The most reliable quantitative estimations of drought impacts in Portugal during 2005, were focused on the agricultural sector and on public administration, and reached a total amount of 883 M €, equivalent to 0.6% of the GNP. No solid estimations were made available at the regional level, but it is acceptable to consider a relatively higher value, based on the estimations for the agricultural sector, and considering the spatial distribution of all impacts reported.

In qualitative terms, which allows one to assess impacts at the regional level, all data sources agree in referring the following as this drought's major impacts: (i) low agricultural production; (ii) damages or losses in permanent crops; and (iii) difficulties in providing drinking water to livestock. Other major impacts cross-referenced include water shortages outside the public supply system, and increasing forest fire risk.

The combined use of different and indirect sources to assess drought impacts in the Algarve is needed only because no regional drought management plan is enforced, which should oblige all stakeholders, users and decision-makers, to report and quantify such impacts in a systematic way.

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