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Does drought always cause economic losses in agriculture? An empirical investigation on the distributive effects of drought events in some areas of Southern Europe

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HIGHLIGHTS

- Drought can create not only "losers", but also "winners".
- In agriculture, the farmers are the winners, while the consumers are the losers.
- However, not all farmers win, and not all consumers lose to the same extent.
- The final total impact in terms of social welfare is usually negative.
- Price effect is the key phenomenon to explain the gains obtained by farmers.

GRAPHICAL ABSTRACT

IMPACTS ON FARMERS, CONSUMERS, AND ON TOTAL SOCIAL WELFARE (Mln euro)

	Quantity effect (Δq*p) (D)	Price effect (Δp*q) (B)	Total (yearly average)	Total	Sign and magnitude of the impacts
PO BASIN (ITALY) 2003					
Cereals	42,4	47,3	-	89,7	+
Fruit trees	-45,8	433,3	-	387,5	+++
Industrial crops	-125	91	-	-34	-
Vegetables	-422,9	685,7	-	262,7	++
PO BASIN (ITALY) 2005-07					
Cereals	47,3	207,7	255	765,1	+++
Fruit trees	-43,4	11,7	-31,7	-95	-
Industrial crops	-127,7	32	-95,6	-286,9	-
Vegetables	-454,8	526,7	71,9	215,6	+
PORTUGAL 2004-06					
Cereals	-38,3	-7,6	-45,9	-137,6	- - -
Fruit trees	-30,9	74,8	43,9	131,7	++
Potatoes	-12,8	12,7	0	-0,1	-
JUCAR BASIN (SPAIN) 1993-96					
Cereals	8,4	0,6	9	36,2	+
Citrics	-5,9	239,2	233,3	933,2	+++
Fruit trees	1,7	-6,5	-4,8	19,4	+
JUCAR BASIN (SPAIN) 2005-08					
Cereals	-2,2	21,9	19,7	78,9	++
Citrics	-3,9	-20	-23,9	-95,5	- -
Fruit trees	-5,5	0,8	-4,8	-19,1	-

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ABSTRACT

Studies on the impacts of drought usually make the implicit assumption that there will always be a negative effect on the environment, the economy and society. However, other approaches, based for example on the framework provided by the consumer surplus theory, try to focus on the distributive effects of drought. In this paper, in the wake of such approaches, we address the question of the distributive effects of drought on agriculture, exploring and studying in depth the characteristics, the signs and the magnitude of the socio-economic impacts of droughts on specific significant agricultural areas in Europe. According to our estimations, essentially based on the analysis of trends and changes in production and prices, we found that drought events can create not only "losers", but also "winners". Some social groups (for example, some categories of farmers) can even "win", while others "lose" (for example, final consumers). These findings apparently introduce questions of social justice in the evaluation of the impacts of climate change.

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1. Introduction

Water resources availability stands out as one of the most dramatic challenges for human being in the perspective of sustainable future (Bakker, 2012). It is not by chance that the World Economic Forum (2014) has placed water supply crises among the global risks of highest concerns.

In the last few decades, the increasing frequency and severity of drought events all over the world has led to in depth investigations into their economic consequences, making use of a wide variety of theoretical approaches and methodologies to identify and estimate the economic effects (Logan and van den Bergh, 2013). Most of these studies have focused in particular on sectors such as urban water supply (Martin-Ortega and Markandya, 2009; Garcia-Valinas, 2006; Grafton and Ward, 2008; Woo, 1994), energy generation (Shadman et al., 2016; Cook et al., 2015) and agriculture (Ferrari et al., 2016; Gunst et al., 2015; FAO, 2015; Howitt et al., 2015; COPA COGECA, 2003), which are claimed to be those hit hardest by these extreme events.

In particular, agriculture is assumed to be one of the most vulnerable sectors to drought, as can affect significantly crops through many direct and indirect mechanisms (Mendelsohn and Dinar, 2009). Moreover, agriculture maintains a fundamental role in the world economy and society: in developed countries, although it accounts for a percentage of GDP lower than 2%,[1] obviously it remains a key sector as food supply depends on it; and in developing countries it is still responsible for a much higher part of the national income.[2]

Notwithstanding their amount and their methodological variety, the studies on the effects of drought (economic, but not only) have always made the implicit assumption that drought has only negative effects, that means they never produce effects of opposite sign (positive effects). In other words, they took for granted that drought always causes environmental, social, economic costs for whomever, but never benefits. We can even point out that this assumption defines the culture and even the language behind these studies. The title of one of the most important and exhaustive work describing all methods and techniques for evaluating the economic impacts of drought (Logan and van den Bergh, 2013), is "Methods for Assessment of the Costs of Droughts". Even from the title, it does take into any consideration the possibility of drought impacts with different sign. And in the introduction of the work by Mendelsohn and Dinar (2009, p. 1), when authors underline the attention paid by the scientific community on drought impacts in agriculture in developed and developing countries, they literally write "*Virtually all developed countries are concerned about whether climate change will damage their agricultural sectors. However, several authors are concerned that agricultural losses will be especially harmful to developing countries* ….". Then, they assume that only damages may occur in agriculture in case of drought. Similarly, Kraemer (2007), in a position paper prepared for the Portuguese Presidency of the EU, focuses on the many dimensions of economic costs (for different social and economic sectors, for society as a whole, on the environment). Although not particularly severe in Europe, due to the relative water abundance, droughts may become a major issue in case magnitude and frequency of drought events would become similar to that of drier areas of the world such as Australia or California.

This way of framing the problem unavoidably calls into action the public sector, either to prompt schemes aimed at compensating damages or to initiate prevention and mitigation actions.

On the contrary, some approaches have questioned this key assumption, trying to explore the distributive effects of droughts to see if alongside the "losers" there may also be some "winners", and to what extent these groups "lose" or "win". Griffin (1998) and Ding et al. (2011), for example, were the first authors, as far as we know, who mentioned and took into consideration at least conceptually the potential gains determined by drought events. Berritella et al. (2007), with the aid of a computable general equilibrium model of the global economy, exploit FAO databases to investigate socioeconomic impacts of droughts; their simulation show that premises that are unaffected by droughts actually may result as net winners.

Applied economic studies, however, have hardly considered this possibility.

Among the few exceptions, some studies pioneered the application of consumer surplus theory to drought impact estimation (Massarutto and de Carli, 2009; Massarutto et al., 2013; Musolino et al., 2015, 2017). In their study on the Po basin, they examined a significant drought event showing that different social groups at the regional and sub-regional have experience different outcomes, and even positive ones.

Applying a different approach to the same case-study area, Mysiak et al. (2013) reach similar conclusion, not only at the sub-regional scale (agrarian district, usually entailing a bunch of municipalities with similar geographical and hydrological features), but considering different crop specializations.

Partial equilibrium studies using the framework provided by the consumer surplus theory in the field of the analysis of the economic impacts of drought actually are not completely new (see, for example, Woo, 1994; Garcia-Valinas, 2006; Grafton and Ward, 2008; Martin-Ortega and Markandya, 2009). But, first they were focused only on one sector (urban water supply), and they did not take agriculture into consideration; and, secondly, again they were devoted to the analysis only of the losses suffered by consumers (for example, estimating welfare losses deriving from the implementation of alternative measures, such as use of volumetric prices versus water rationing). Therefore, they never investigated and verified who loses (which social group) and, eventually, who wins, "thanks to" the drought.

In the wake of the approaches started by Massarutto and de Carli (2009), in this paper we will examine this question - the distributional outcome of drought -further by exploring in depth the effects of droughts on agriculture in terms of social welfare. We will then estimate losses and gains for farmers and consumers, at aggregated level, and by crop category and geographical area, analysing the changes in two key variables (production and price), as suggested by the consumer surplus approach. In particular, in this paper we will refer to some case studies in specific areas of Southern Europe.

In the second section, there will be a short description of the areas under investigation, their "vulnerability" to drought as concerns agriculture, and some of the main drought events that hit these areas in the last decades. The third section illustrates the theoretical and methodological approach that we followed to estimate the distributive effects of drought, focusing in particular on farmers and consumers. The fourth section will be dedicated to the presentation and discussion of the main results. First, it shows the changes in crops production and prices - the variables used in this approach to estimate losses and benefits - in the case study areas in the drought periods; secondly, it presents the main results deriving from the analysis of the distributive effects of drought on farmers and consumers (losses and gains at aggregated level) in the case study areas; thirdly, it focuses on the breakdown by crop category and sub-geographical area. The fifth section will include further discussion on the results, and on some methodological questions related to the costs borne by farms, to the structure of the value chain and the openness of the market. In the last section conclusions are drawn, and some policy implications will be proposed.

[1] 1.6% in European Union in 2016 (data.worldbank.org).

[2] 25% the least developed countries in the world (UN definition) in 2016 (data.worldbank.org).

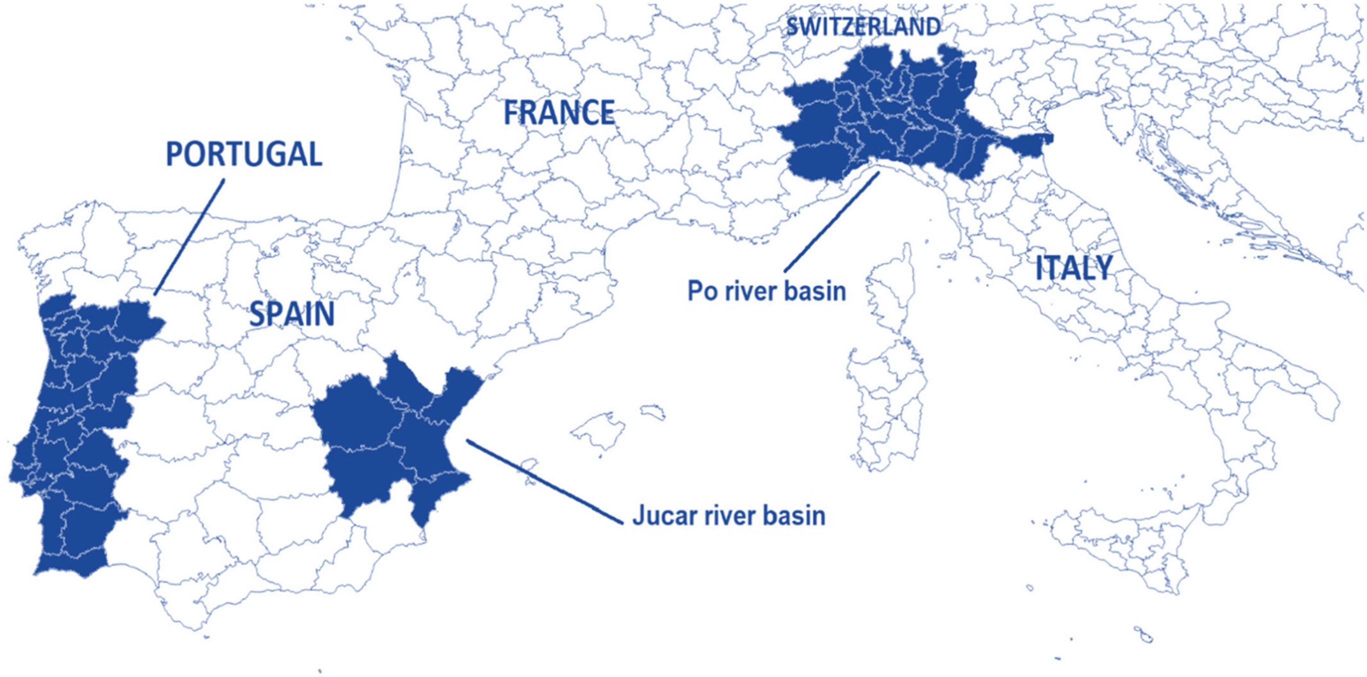


Fig. 1. Case study areas.

2. Case study areas and drought events

The case study areas investigated in this work are the Po river basin in Italy, Portugal, and the Jucar river basin in Spain (Fig. 1).[3] These areas differ in terms of geographical scale, demographic and economic characteristics: they range from the country level (Portugal) to the macro- and micro-basin level (Po basin and Jucar basin). But they have also common geographical characteristics, as not only they are all located in Southern Europe, but they are all coastal areas and all have river basins. Moreover, agriculture plays an important economic role in each of their economy.

The Po river basin covers a very wide area (74,700 km^2) in Northern Italy, approximately corresponding to the Padana region, the vastest flatland area in Italy,[4] inhabited by about 16 millions of people (Massarutto, 2012). Although it is a highly industrialized and developed area, agriculture still remains an important sector, as 2,700,000 ha (about 40% of the total area) are Utilized Agricultural Areas (UUAs), and 35% of national agricultural production comes from this river basin (Massarutto, 2012). Notwithstanding the many Alpine lakes, reservoirs and glaciers, water availability for agriculture is more and more under stress. The causes are climate change (declining rainfalls and increasing temperatures, which have triggered several drought events in the last few decade) and the inefficiency of most of the irrigation network (59% of the UUAs are irrigated areas), which is technologically inadequate, in particular in the upper part of the basin (Autorità di Bacino del fiume Po, 2009).

Portugal is the country located in the Western part of the Iberian Peninsula, with 10.3 million resident people, where agriculture accounts for almost 2.2% of GDP (higher than the EU average).[5] Its water availability is based on the five rivers shared with Spain,[6] and on underground water resources (Castro Rego, 2012). The lack of efficient irrigation techniques (172,000 farms use irrigation water to irrigate a surface area of 464,627 ha),[7] the increasing competition in the demand for water by tourism, and a trend of higher average temperatures and lower mean rainfall over the last few decades, means that the water system is increasingly under stress.[8]

The Jucar river basin, with an area of 42,989 km^{2,} and with a population of 4.3 millions of people, is the smallest of the case study areas taken into consideration. However, agriculture is of considerable importance in the local economy, and requires approximately 1.414 million m^3 of water, which accounts for 88% of the total water demand.[9] Indeed, the total irrigated area is 120,000 ha, of which 33% is served by permanent collective systems, and 67% by pumped groundwater.[10] Although the use of unconventional water sources (recycled wastewater or desalinated seawater) has so far managed to cover the excess demand,[11] increasing urban and industrial requirements, as well as frequently extreme climatic conditions, have placed the system under more and more pressure.

Some dramatic drought events have hit all these areas in the last decades, and they had impacts in any of them, in particular on agriculture (Massarutto et al., 2013). Some of the hardest drought events, taken into consideration in our analysis, are: 2003 and 2005–2007 for the Po

[3] These three case study areas were the object of the analyses conducted within the EU-FP7 project "DROUGHT-R&SPI: Fostering European Drought Research and Science[HYPHEN]Policy Interfacing", whose duration was from October 2011 to October 2014. In the beginning, six case study areas were involved in the project (there were also the Netherlands, Switzerland, and Syros Island, in Greece). But, due to questions of data availability, we had to limit the analyses presented here only to the three case study areas (and five drought events).

[4] It includes three of the biggest Italian administrative NUTS2 regions: Lombardy, Piedmont and Emilia-Romagna.

[5] In 2016 (data.worldbank.org).

[6] 64% of the area of mainland Portugal is located within 5 river basins shared with Spain, corresponding to 67% of the total annual average water resources in Portugal comes from the 5 river basins shared with Spain (20,300 of a total average annual water availability of 30,400 hm^3). (Castro Rego, 2012).

[7] Massarutto et al., 2013.

[8] Massarutto et al. (2013).

[9] Massarutto et al. (2013).

[10] Massarutto et al. (2013).

[11] Andreu (2012).

river basin; 2004–2006 for Portugal; 1993–96 and 2005–08 for the Jucar river basin.[12]

In the Po river basin, in 2003 water streamflow reduced by 50%–75%, as a consequence both of very rare precipitations in spring, and of the increase of the temperatures over the seasonal average (Massarutto and de Carli, 2009). Considerable decrease in the water availability were registered also in the second event (2005–2007), in particular in 2006, which was the worst year during the second drought event (Autorità di Bacino del fiume Po, 2009). The most important impacts caused by both drought events were registered in the energy sector (hydropower and thermopower), in agriculture (reduction in yields and loss of crops, lack of feed and water for livestock), public water supply, plastic industry (lower production), navigation, water-related tourist activities, and regional/local user conflicts (Massarutto et al., 2013).

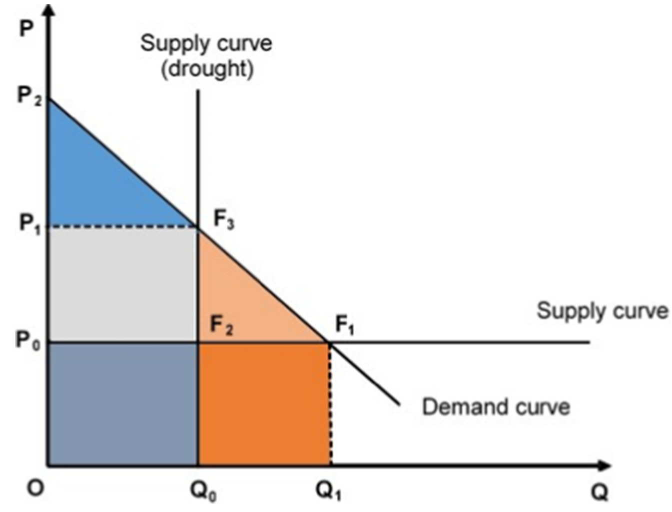
In Portugal, the drought episode of 2004–2006 is supposed to be one of the most severe drought events recorded in Portugal in the last decades in terms of meteorological data and extent of the area affected (Comissão para a Seca, 2005). The level of important aquifers decreased considerably.[13] The severity and extent of this drought episode caused impacts in many different sectors, as reduced yields and loss of crops in rainfed agriculture, reduced hydropower production, and wildfires (increased number, severity and burned area). The long period without soil humidity during 2005 affected the non-irrigated crops, causing a severe shortage in the wheat yield (Gouveia et al., 2009).

In the Jucar river basin, analyses about meteorological data clearly shows the severity of the two selected drought events (Andreu et al., 2013, 2015). The most important impacts in the 1992–95 event were in agriculture (reduced yields, loss of crops and permanent damages), water quality (deterioration, algal bloom and eutrophication), freshwater ecosystems, and regional/local user conflicts. In the second drought event (2005–2008) the magnitude of most of these effects was rather limited, showing that in the meantime drought preparedness and management in the case study area improved.

By the way, this same final reflection can be done for the Po river basin: the experience of the 2003 drought event presumably helped in mitigating the effects of the 2005–2007 event, making the water management system more prepared and flexible enough, e.g. readier to concentrate irrigation on the most valuable crops (De Stefano et al., 2012).

3. Estimating the socio-economic impacts of drought: an approach based on the consumer surplus theory

The distributive effects of drought events on agriculture can be investigated within the theoretical and methodological framework provided by the consumer surplus theory (Massarutto and de Carli, 2009; Massarutto et al., 2013; Musolino et al., 2015, 2017). By means of this approach it is possible to determine and quantify the negative (or positive) effects of drought in terms of social welfare change on two groups: producers (farmers) and consumers.[14]



Source: our own elaboration

Fig. 2. Effects of a drought event on crop production, price, and consumer surplus.

We can represent the distributive effects of drought in terms of welfare basing on the consumer surplus theory in Fig. 2,[15] where the market price (P) of a generic agricultural product is on the vertical axis, while the quantity produced and sold on the market (Q) is on the horizontal axis.

In normal years, when there is normal water availability for crop production, the equilibrium point is at the intersection between the demand curve and the supply curve[16] (F_1), and the area $P_2P_0F_1$ represent the consumer surplus.[17] Instead, in the exceptional situation that occurs in the event of drought, water availability for agriculture decreases, and so it is assumed to do crop production. As a consequence, the supply curve moves on the left, changing its slope and becoming vertical (crop production is now limited by the water shortage caused by drought), and the market demand excess causes a market price increase. Thus, the equilibrium point shifts from F_1 to F_3. Due to these changes in production and price, the consumer surplus also changes and shrinks: it is indeed now represented by the area $P_2P_1F_3$, which is apparently smaller than the area $P_2P_0F_1$.

Therefore, when a drought event occurs apparently consumers suffer a loss in terms of welfare, equal to the area $P_1P_0F_1F_3$, which sums up the deadweight loss ($F_3F_2F_1$) and the loss associated to the (negative) "price effect" ($P_1P_0F_2F_3$) that they bear for consuming Q_0 at an higher price (Fig. 3).

Instead, producers are "victims" of two, opposite, effects. On the one hand, they also suffer a negative effect (i.e. "quantity effect"), which is the income loss ($F_2Q_0Q_1F_1$) due to the partial loss of crop production (Q_1 - Q_0). But, on the other hand, they enjoy a positive effect (i.e. "price effect"), which is the extra-gain ($P_1P_0F_2F_3$) that they realize when they sell the (residual) crop production at an higher price (P_1). The final comprehensive effect on farmers is represented by the

[12] At the beginning the project "DROUGHT-R&SPI: Fostering European Drought Research and Science-Policy Interfacing", for each case study, the consortium partners located in each of them selected no more than two drought events occurred in the previous two decades, among those most severe and with the most dramatic impacts. Consortium partners then identified, classified and ranked the impacts occurred in qualitative terms (high, medium, low) (Massarutto et al., 2013). They based their choice of the drought events, and the identification and evaluation of the impacts, on the relevant literature and on the data and the information available at the case study level. Basically speaking, each of the consortium partners acted as local expert and local data collector.
As concerns the qualitative identification and classification of the drought impacts, they used appropriate methodologies (Knutson et al., 1998, Olsson et al., 2009, 2010; Wilhite and Vanyarkho, 2000). In all three case study areas, and for all selected drought events, they surveyed and highlighted that agriculture suffered relevant impacts (Massarutto et al., 2013).
Once identified the drought events and impacts, the role of our research group was to propose and apply a new methodology for the quantification of those impacts, by the way paying attention in particular to the distributive effects. Of course, we had to limit our analyses to the cases for which we could obtain the required data for applying our approach based on the consumer surplus theory.

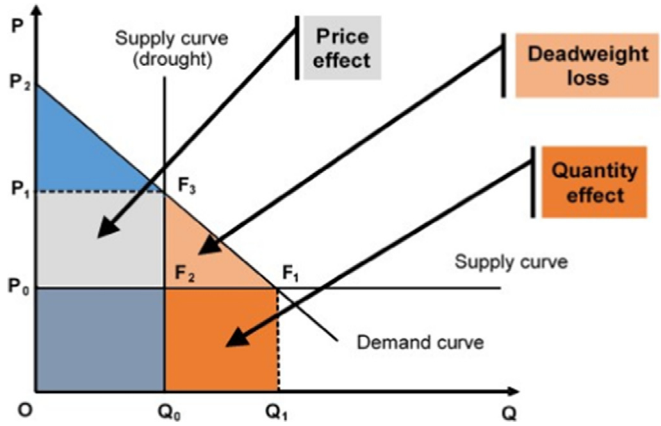
[13] In comparison with average values (1987–2005). In some aquifers (e.g. Querença-Silves, the most important aquifer in Algarve) the water reached the lowest recorded values. Also, in Algarve, two reservoirs were completely depleted of water (Massarutto et al., 2013).

[14] Apparently, we assume that the agri-food value chain has a simplified structure, as it is composed of only two stages: crop production (farming) and consumption.

[15] See, for example, Varian (2010).

[16] For the sake of simplicity, the supply curve is assumed flat.

[17] The difference between the amount of money consumers are willing to pay - the area below the demand curve as far as F_1 ($P_2OQ_1F_1$) - and the price that they actually pay, represented by the area $P_0OQ_1F_1$.



Source: our own elaboration

Fig. 3. Effects of drought event in terms of social welfare: quantity effect, price effect, deadweight loss.

difference between $P_1P_0F_2F_3$ ("price effect") and $F_2Q_0Q_1F_1$[18] ("quantity effect").

Clearly, demand and supply elasticity clearly have a fundamental role in determining the distributional impact: the more inelastic demand is, the higher impact of supply restrictions is shifted onto prices, and therefore away from producers.

The total change in social welfare caused by drought (Table 1) is assumed to be negative, because the community as a whole bears a loss equal to $F_3Q_0Q_1F_1$.

Applying this approach to estimate (positive and negative) effects of drought on agriculture requires a relatively limited number of variables (crop production and price), and it does not need extremely sophisticated calculations and modelling. In fact, by using yearly time series for crop categories and prices in a period long enough to include the year(s) when the drought event occurred, the multiple effects caused by the drought seen above can be estimated.[19]

The methodology, here applied to the three European case study areas under investigation, is comprised of four steps; i.e. the four effects that have to be estimated:

1) "Quantity effect", which merely corresponds to the loss suffered by farmers due to a decrease in production. In order to calculate this effect, you should calculate the difference between crop production in the year(s) of the drought event and average crop production in normal years[20] (Δq), and multiply by the average price in normal years (p).
2) "Price effect", associated to the price change (increase) caused by the reduction of crop production, affects both farmers and consumers. For the former it represents a benefit, and for the latter a loss (opposite, negative sign). The effect is obtained by multiplying the price change (difference between price in the drought year and average price in normal years[21]) (Δp) by crop production in the drought year (q).
3) The third effect to be estimated is the "deadweight loss", which only affected the consumers (negatively), and is equal to the multiplication of price change by production change divided by two ((Δp ∗ Δq) / 2).
4) The fourth and last effect is the total impact on welfare, i.e. the total welfare change experienced by all social groups, which ca be obtained summing up algebrically all the three effect on both groups seen above.

Table 1
Effects of drought in terms of social welfare according to the consumer surplus theory.

	Quantity effect	Price effect	Deadweight loss
Producers (farmers)	$F_2Q_0Q_1F_1$ (−)	$P_1P_0F_2F_3$ (+)	
Consumers		$P_1P_0F_2F_3$ (−)	$F_3F_2F_1$ (−)
Social welfare change	$F_2Q_0Q_1F_1$ (−)		$F_3F_2F_1$ (−)

Table 2
Production changes by crop category in the 2003 and 2005–2007 drought events in the Po river basin, Italy (%).
Source: our elaboration on data by Italian National Institute for Statistics (ISTAT; dati.istat.it).

	2003 (average) vs 2000–2009 (average)	2005–2007 (average) vs 2000–2009 (average)
Cereals	−9,9	2,5
Industrial crops	−29,6	−11,8
Fruit trees	−11,7	−1,9
Vegetables	2,8	−13,5

Table 3
Price changes by crop category in the 2003 and 2005–2007 drought events in the Po river basin, Italy (%).
Source: our elaboration on data by ISMEA (Istituto di Servizi per il Mercato Agricolo Alimentare/Service Institute for the Agricultural and Food Market; www.ismea.it).

	99–02 (average) vs 2003	99–04 (average) vs. 2005–07 (average)
Cereals	+3.1	+13,5
Industrial crops	+13,8	+9.7
Fruit trees	+25,7	+10,3
Vegetables	+27,1	+29,8

4. Results of the analyses

4.1. Trends and changes of production and prices

The following Tables 2–7 give an initial overview of the production and price trends and changes in the case study areas considered.[22] The analysis was conducted with reference to the main crop categories, based on the data availability for each case study.[23]

There is a rather evident decline in almost all crops production in correspondence to drought events, that is to say, in the year(s) when

[18] Needless to say, probably not all farmers will be hit by these effects to the same extent: part of them are likely not to lose any crops, and so they will only win from the combination of these effects, as they will fully exploit the price effect to increase their income and their profits. Another part of farmers probably will lose either a part or even the entire crop production, and so, in the latter case, the quantity effect would exceed the price effect, causing them a net loss.

[19] Clearly, crop production and prices reflect a number of exogenous variables, and their variation cannot be attributed solely to the effect of droughts. However, even though other causes might have impacted, we assume that these other causes are randomly distributed, so as we can interpret the average gap between the average normal year and drought years as the consequence of the drought. As stated in the introduction, rather than providing an interpretation of the causes of price change, in other words in our study we aim to use the price change during drought periods as an indicator of the degree of "burden shifting" between farmers and consumers, crops, agricultural regions.

[20] In order to identify the normal level of crop production, we assumed at least a ten years long period, depending on the data availability for each case study (see legend of Table 8). See also Musolino et al. (2017).

[21] In our calculations, the previous four years, depending on the data availability for each case study (see legenda of Table 8). See also Musolino et al., 2017.

[22] For the trends in crops production, see also Massarutto (2013, ch. 4).

[23] The aggregation in groups, although apparently causes loss of detailed information about the effects on each crop, was necessary in order to provide synthetic outcomes, comprehensive of most the wide variety of crops cultivated. For example, for the Po river basin, in 2011, groups were cereals, industrial crops, fruits and vegetables that account for the 82% of the total crop production, and 40% of the total cultivated area, in the Po river basin (dati.istat.it).

Table 4
Production changes by crop category in the 2004–2006 drought event in Portugal (%).
Source: our elaboration on data by Instituto Nacional de Estatistica (Statistics Portugal; www.ine.pt).

	2004–2006 (average) vs 1999–2011 (average)
Cereals	−17,1
Fruit trees	−6,7
Potatoes	−10,0

Table 5
Price changes by crop category in the 2004–2006 drought event in in Portugal (%).
Source: our elaboration on data by Instituto Nacional de Estatistica (Statistics Portugal; www.ine.pt).

	2004–2006 (average) vs 2000–2003 (average)
Cereals	−3,9
Fruit trees	+21,2
Potatoes	+12,4

Cereals and potatoes.

the drought event occurred. In most of the cases, this effect was followed by a price increase.[24]

The Italian case (Table 2) shows a decline in several types of crop production in the Po river basin in 2003 and 2005–2007. During the 2003 drought event, almost all main categories appear to have been hit by drought, except for vegetables. For example, industrial crop production fell by 29.6% compared to the long-term average, while cereals decreased by 9.9% and fruit by 11.7%. During the 2005–2007 event, a reduction in agricultural production was observed for industrial crops, fruit trees and vegetable production, while for cereals there were a slight increase.

On the contrary, prices increased in all four crop categories compared to the average of the previous years (Table 3), in both drought events, in some cases – fruit trees and vegetables - by more than 25%.

As regards the Portuguese case, there was a considerable decrease in production for all main crop types under investigation - cereals, fruit trees and potatoes - compared to the long-term average (Table 4). On the other hand, the average prices of fruit trees and potatoes rose remarkably, even more than 20% for the former crop category, while the price of cereals diminished (Table 5).

Lastly, in the Spanish case, throughout the long period taken into consideration (long about two decades, considering the periods when the two drought events under investigation happened), trend and changes in crop production were rather similar to that observed in the other case studies,[25] in particular as concerns the 2005–2008 drought event (Table 6). Consequently, all main crop categories experienced a reduction in production during the 2005–2008 drought event, while in the 1993–1996 only production of citrics, the most important crop category in the Jucar basin at that time in terms of quantity, declined. As far as prices are concerned, for most of the crop categories there was a sharp price increase either in 1993–96 or in 2005–08 (only fruit trees had a marked negative price change in 1993–1996) (Table 7).

4.2. The distributive effects on farmers and consumers

Given these trends and changes in the case study areas, the next stage is to understand how the changes in production and prices affected farmers and consumers during the drought events examined. Table 8 shows estimations of the socio-economic effects based on data referring to changes in crop production and prices, as illustrated in Section 3.

The outcomes first show that drought events had significant effects on social welfare in the agricultural sector in all case studies. Indeed, the magnitude of the effects in absolute terms, whether positive or negative, was definitely not negligible, as it ranges from the loss of 1858 mln euro estimated for the 2005–2007 drought event in the Po river basin, to the loss of 245,8 mln euro registered in Portugal, to that of almost 50 mln euro registered in the Jucan basin for the 2005–2008 drought event.

Secondly, not only do the estimations reveal losses, but also gains, as the consumer surplus approach assumes. Consequently, not only are there social groups that lose, as would be usually expected, but also groups that win. It is therefore reasonable to state that drought does not only create losers.

In most of the cases farmers were the winners, while the consumers were always the losers. For example, in 2003 farmers in the Po basin gained more than 700 mln euro because of the drought, while in the Jucar basin benefits for them amounted to 950 mln euro. It can be said that farmers were usually better off after the drought, while consumers were worse off. Only in the case of the three-year drought in Portugal, and of the 2005–2008 drought event in Jucar basin, did the farmers not “win”. However, it is necessary to point out that in both cases their loss was not remarkable (in the Portuguese case, it was almost equal to zero); so one can also say that, overall, in these two cases drought did not substantially modify their welfare.

In order to explain the gains obtained by farmers, price effect is the key phenomenon to look at. In all the case studies in absolute terms this effect was positive; in most of them, again with the exception of Portugal and Jucar basin (2005–2008), in absolute terms this effect largely overcame the quantity effect, which was as expected negative. Therefore in most of the cases farmers, taken in the whole, although lost part of their crops due to the drought (“quantity effect)”, they could benefit from the faming price increase, due to the demand excess that drought presumably created on the agricultural markets, selling their remaining crop production at higher prices. As regards the 2003 drought event that occurred in the Po river basin, the price effect in absolute terms was more than twice as big as the quantity effect.

Table 6
Production changes by crop category in the 1993–1996 and 2005–2008 drought events in the Jucar river basin, Spain (%).
Source: our elaboration on Data about crops production and prices by Ministerio de Agricultura y Pesca, Alimentacion, y Medio Ambiente: MAPAMA (2017) Anuario de estadistica (http://www.mapama.gob.es/es/estadistica/temas/publicaciones/anuario-de-estadistica/).

	1993–1996 (average) vs 1990–1998 (average)	2005–2008 (average) vs 2001–2010 (average)
Cereals	7,4	−2,0
Citrics	−0,8	−0,7
Fruit trees	2,1	−12,5

Table 7
Price changes by crop category in the 1993–1996 and 2005–2008 drought events in the Jucar river basin, Spain (%).
Source: our elaboration on Data about crops production and prices by Ministerio de Agricultura y Pesca, Alimentacion, y Medio Ambiente: MAPAMA (2017) Anuario de estadistica (http://www.mapama.gob.es/es/estadistica/temas/publicaciones/anuario-de-estadistica/).

	1993–1996 (average) vs 1990–1992 (average)	2005–2008 (average) vs 2001–2004 (average)
Cereals	+0,8	+34,4
Citrics	+70,9	−7,8
Fruit trees	−33,2	+11,6

[24] It is important to take also into consideration that in the case study areas the percentage of crops in controlled-environment greenhouse is extremely low. According to Eurostat statistics (http://ec.europa.eu/eurostat/web/agriculture/data/database), in 2013 the percentage of utilized agricultural areas under glass or high accessible cover (fresh vegetables, flowers and ornamental plants, permanent crops), in terms of hectares, in all cases was less than 0.3% (Portugal: 0.1%; Jucar basin - Comunidad valenciana -: 0.2%; Po basin: 0.2%). This is why we can reasonably assume that the effects of drought events in these areas were not affected by the presence of this type of crops.

[25] See Massarutto et al. (2013).

Table 8
Impacts on producers, consumers, and on total social welfare (€m).[a]
Source: own elaboration on data from relevant statistics on a national scale.

	Quantity effect ($\Delta q * p$)	Price effect ($\Delta p * q$)	Deadweight loss ($\Delta p * \Delta q$) / 2	Total (yearly average)	Total	Winners	Losers
PO basin (Italy) 2003							
Producers	−551	1.257	–	–	706	✓	
Consumers	–	−1.257	−41	–	−1.298		✓
Social welfare	−551	–	−41	–	−592		✓
PO basin (Italy) 2005–07							
Producers	−578,6	778,1	–	199,6	598,8	✓	
Consumers	–	−778,1	−40,9	−819,1	−2457,2		✓
Social welfare	−578,6	–	−40,9	−619,5	−1858,5		✓
Portugal 2004–06							
Producers	−82	79,9	–	−2	−6		✓
Consumers	–	−79,9	0	−79,9	−239,8		✓
Social welfare	−82	0	0	−81,9	−245,8		✓
Jucar basin (Spain) 1993–96							
Producers	4,2	233,3	–	237,5	950	✓	
Consumers	–	−233,3	2,4	−226,8	−907,2		✓
Social welfare	4,2	–	2,4	10,7	42,8	✓	
Jucar basin (Spain) 2005–08							
Producers	−11,7	2,7	–	−8.9	−35,7		✓
Consumers	–	−2,7	−0.2	−2.9	−11,8		✓
Social welfare	−11,7	–	−0.2	−11,8	−47,5		✓

Po basin (Italy):

- 2003: Effects calculated from changes in farming prices in 2003 v. average crop prices 1999–2002; and from changes in crops production in 2003 v. average crops production in 2000–2009.
- 2005–2007: Total effects (for the entire three years period) calculated from changes in average farming prices in 2005–2007 v. average farming prices in 2000–2004; and from changes in average crops production in 2005–2007 v. average crops production in 2000–2009.
- Data about crops production by Italian National Institute for Statistics (ISTAT; dati.istat.it); data about prices by ISMEA (Istituto di Servizi per il Mercato Agricolo Alimentare/Service Institute for the Agricultural and Food Market; www.ismea.it).

Portugal:

- 2004–2006: Total effects (for the entire three years period) in 2004–2006 from changes in average national farming prices in 2004–2006 v. average national farming prices in 2000–2003; and from changes in average crops production in 2004–2006 v. average crops production in 1999–2011. Data by Instituto Nacional de Estatistica (Statistics Portugal; www.ine.pt).

Jucar basin (Spain)

- 1993–1996: Total effects (for the entire three years period) calculated from changes in average national farming prices in 1993–1996 v. average national farming prices in 1990–1992; and from changes in average crops production in 1993–1996 v. average crops production in 1990–1998 (data about prices at the basin level not available; they were approximated with data at the national scale).
- 2005–2008: Total effects (for the entire three years period) calculated from changes in average national farming prices in 2005–2008 v. average national farming prices 2001–2004; and from changes in average crops production 2005–2008 v. average crops production in in 01–10 (data about prices at the basin level not available; they were approximated with data at the national scale).
- Data about crops production and prices by Ministerio de Agricultura y Pesca, Alimentacion, y Medio Ambiente: MAPAMA (2017) Anuario de estadistica (http://www.mapama.gob.es/es/estadistica/temas/publicaciones/anuario-de-estadistica/).

[a] Values of the impacts are actualized at 2012 using deflators defined on the basis of the inflation rate time series at the national scale (Consumer Price Index for Italy, Portugal, Spain; www.inflation.eu).

On the contrary, the price effect always results in a loss for the consumers. Only a very small proportion of their loss is associated to the so called “deadweight loss”.

However, notwithstanding the concurrence of negative and positive effects (losses and gains), it has to be again remarked that the total impact of the drought events in terms of social welfare (the total effect on all social groups, on the entire society) is always negative, except the case of the first drought event in Jucar basin, where the total impact was even slightly positive.

4.3. The distributive effects according to crop category and geographical location

If Table 8 clearly shows that there can be positive or negative impacts on social groups (farmers and consumers), and therefore that there are groups who “win” during drought events, the results that follow (Tables 9–10) highlight that even within each of the two social groups the impacts are not the same. In fact, the distributive effects described above are analysed according to crop category and sub-geographical area. The outcome is that: a) again, not all farmers are “winners”; b) not all farmers who win, gain to the same extent; c) not all consumers lose to the same extent.

As far as farmers are concerned (Table 9), it is evident that, when distinguished by crop category, most of them win, but that some of them lose all the same. For example, this is the case of Portugal, where cereals suffered a considerable loss in 2004–06. On the other hand, both in 2003 and 2005–2007, industrial crops was the “main loser” in the Po river basin, together with fruit farming, which suffered a loss in 2005–2007. In all these cases the price effect was not big enough to counterbalance the loss deriving from the (negative) quantity effect.

Moreover, winners differ a lot in terms of the magnitude of the benefit that they are able to obtain from the drought event. For example, vegetable farmers in the Po river basin made considerable gains during both drought events, as the loss of crop production (quantity effect) was offset by a very significant (positive) price effect. Likewise, large benefits were enjoyed by farmers cultivating fruit trees in Portugal, and citrics in the Jucar basin in 1993–1996.

Table 9
Impacts on producers (farmers) by crop category (€m).[a]
Source: own elaboration on data from relevant statistics at national scale (for details see Table 3).

	Quantity effect (Δq ∗ p) (D)	Price effect (Δp ∗ q) (B)	Total (yearly average)	Total	Magnitude of the impacts[b]
Po basin (Italy) 2003					
Cereals	42,4	47,3	–	89,7	+
Fruit trees	−45,8	433,3	–	387,5	+++
Industrial crops	−125	91	–	−34	–
Vegetables	−422,9	685,7	–	262,7	++
PO basin (Italy) 2005–07					
Cereals	47,3	207,7	255	765,1	+++
Fruit trees	−43,4	11,7	−31,7	−95	–
Industrial crops	−127,7	32	−95,6	−286,9	–
Vegetables	−454,8	526,7	71,9	215,6	+
Portugal 2004–06					
Cereals	−38,3	−7,6	−45,9	−137,6	– – –
Fruit trees	−30,9	74,8	43,9	131,7	++
Potatoes	−12,8	12,7	0	−0.1	–
Jucar basin (Spain) 1993–96					
Cereals	8,4	0,6	9	36,2	+
Citrics	−5,9	239,2	233,3	933,2	+++
Fruit trees	1,7	−6,5	−4,8	19,4	+
Jucar basin (Spain) 2005–08					
Cereals	−2,2	21,9	19,7	78,9	++
Citrics	−3,9	−20	−23,9	−95,5	– –
Fruit trees	−5,5	0,8	−4,8	−19,1	–

[a] Values of the impacts are actualized at 2012 using deflators defined on the basis of the inflation rate time series at the national scale (Consumer Price Index for Italy, Portugal, Spain; www.inflation.eu).
[b] Percentage of the sum total of the impact in each crop category in absolute value (more than 50%: +++/– – –; from 25% to 50%: ++/– –; from 0% to 25%: +/–).

Table 10
Impacts on consumers by crop category (€m).[a]
Source: own elaboration on data from relevant statistics on a national scale (for details see Table 3).

	Price effect (Δp ∗ q)	Deadweight loss (Δp ∗ Δq) / 2	Total (yearly average)	Total	Magnitude of the impacts[b]
PO basin (Italy) 2003					
Cereals	−47,3	−2,6	–	−49,9	–
Fruit trees	−433,3	−28,6	–	−461,9	– –
Industrial crops	−91	−19,1	–	−110,1	–
Vegetables	−685,7	9,4	–	−676,3	– – –
PO basin (Italy) 2005–07					
Cereals	−207,7	2,5	−205,2	−615,5	–
Fruit trees	−11,7	−0,1	−11,8	−35,4	–
Industrial crops	−32	−2,1	−34,2	−102,6	–
Vegetables	−526,7	−41,1	−567,8	−1703,5	– – –
Portugal 2004–06					
Cereals	7,6	0	7,6	22,6	+
Fruit trees	−74,8	0	−74,8	−224,3	– – –
Potatoes	−12,7	0	12,7	−38,1	–
Jucar basin (Spain) 1993–96					
Cereals	−0,6	−0,1	7,8	31,4	+
Citrics	−239,2	−2,3	−242,9	−971,5	– – –
Fruit trees	6,5	0	8,2	33	+
Jucar basin (Spain) 2005–08					
Cereals	−21,9	−0,2	−22,2	−88,6	– – –
Citrics	20	0,1	20	80,2	++
Fruit trees	−0,8	−0,1	−0,8	−3,3	–

[a] Values of the impacts are actualized at 2012 using deflators defined on the basis of the inflation rate time series at the national scale (Consumer Price Index for Italy, Portugal, Spain; www.inflation.eu).
[b] Percentage of the sum total of the impact in each crop category in absolute value (more than 50%: +++/– – –; from 25% to 50%: ++/– –; from 0% to 25%: +/–).

Thirdly, as far as consumers are concerned (Table 10), they suffer a loss for almost all kinds of agricultural products, but the size of the reduction in their welfare is not always the same. For example, the greatest losses were observed in the consumption of fruit, vegetables (and citrics, in Jucar basin, in 1993–1996), due to the magnitude of the price effect.

Similar findings regarding differentiation in the impacts within the social groups can be observed in relation to the geographical location of farmers and consumers. Though the impacts could only be calculated for the Po river basin, due to the fact that it can be divided into three geographical sub-areas (Lombardy, Piedmont and Aosta valley, Emilia-Romagna) (Fig. 4), the outcomes are still rather eloquent (Table 11).

During the 2005–07 drought event consumers lost in all sub-areas, while farmers won in all sub-areas, except for Emilia-Romagna. Taking both drought events into consideration, farmers from Lombardy were apparently able to obtain the greatest benefits in absolute terms. The effects for Piedmont farmers were also positive, although their magnitude was not as great as in Lombardy. On the contrary, Emilia-Romagna is the only geographical sub-area where farmers made a significant loss in 2005–07 (Table 11).

It should be noted that Lombardy is the region entirely located in the upper part of the Po river basin, which is assumed to have the biggest water availability, in particular thanks to its Alpine lakes, reservoirs and glaciers. Therefore, Lombardy farmers, thanks to their geographical location within the Po basin, have an advantage, and then they result to be always winners, while farmers located in the downstream region (Emilia-Romagna) are the net loser. At the end, this outcome implicitly suggests that the larger the territorial scale involved, the more likely it is that compensation takes place, following quite predictable patterns.

5. The role of costs, markets and value chain structure: a discussion

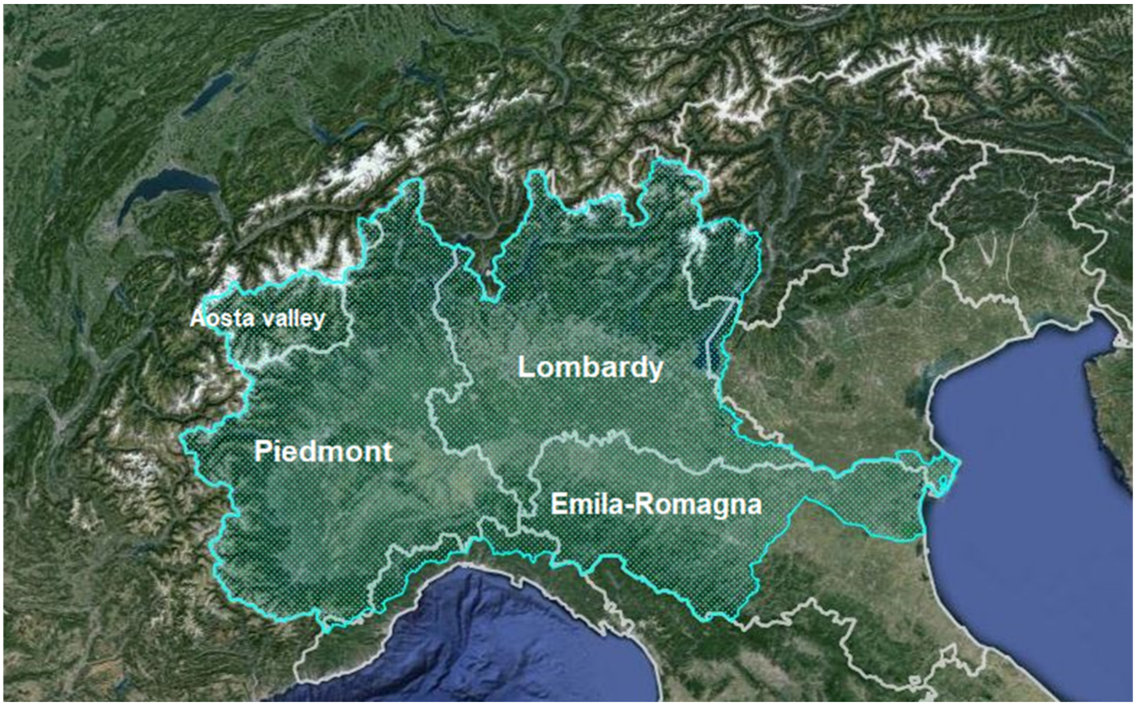
These results raise several questions about the estimation of the actual impacts, either positive or negative, suffered by the social groups taken into consideration.

One of the questions that might be raised is: Can production costs be affected by the drought events as well? And if so, can their potential increase offset the gains made thanks to the price effect? It is a natural question to ask if one considers that farming processes can clearly be affected by drought. For example, farms need additional water, and so they might use private wells, which entails bearing additional energy costs. In addition, farms might need to hire additional workers (or to pay their employees overtime), in order to face up to the exceptional workload, and so on. From other data sources related to the Italian case study, it was possible to observe that in 2003 and 2006 in the Po river basin variable farming costs actually increased considerably (Fig. 5).

However, more interestingly, the following graph clearly shows that it was not only variable costs that changed during the drought events, but there was also an increase in farmers' gross saleable production[26] and profit margins. Therefore, on the one hand, it is undeniable that costs increased as a result of the drought events; but, on the other hand, it is also true that they probably did not erase the net income that some farmers could obtain at that time. Of course, the impact of drought on costs is an issue that requires investigation and more in depth study, but these simple data show that for some farmers increasing costs do not offset possible gains.

A second question concerns the assumption that the regional/national economic system (market area) hypothesized by this approach is closed, which implicitly means that price changes are exclusively caused by internal factors, such as the reduction in supply due to drought, as assumed in our study. Of course, it is easy to underline that the price of several agricultural products is in line with

[26] This result is clearly coherent with the analyses presented in the previous paragraph.



Source: elaboration on cartography by Ministero dell'ambiente e della tutela del territorio e del mare (http://www.va.minambiente.it/it-IT/Oggetti/Info/1432)

Fig. 4. Lombardy, Piedmont and Aosta valley, Emilia-Romagna (administrative NUTS2 borders, within the border of the Po river basin).

international market prices (corn, soy, etc.), and then to claim that such a hypothesis is rather far from being realistic. Though this is correct, it is also true that analysis by crop category allowed us to make distinctions among products and markets, and that it highlighted the modest responsiveness of cereal prices in periods of drought, compared to the large price changes for other products that contributed greatly to the total effects recorded for farmers, consumers, and in terms of social welfare. Moreover, it is also important to reflect on the increasing importance of organic food and quality products, which will reduce the space between farmers and final consumers, and the demand of close substitutable crops on the international market. This long-term trend apparently makes it more and more meaningful to assume that prices in the market area under examination are not considerably influenced by external factors, and then that can be significantly affected by the supply restrictions due to the drought occurred there.

Table 11
Impacts on producers and consumers by geographical area in the Po river basin, Italy (€m).[a]
Source: own elaboration on Istat and Ismea data.

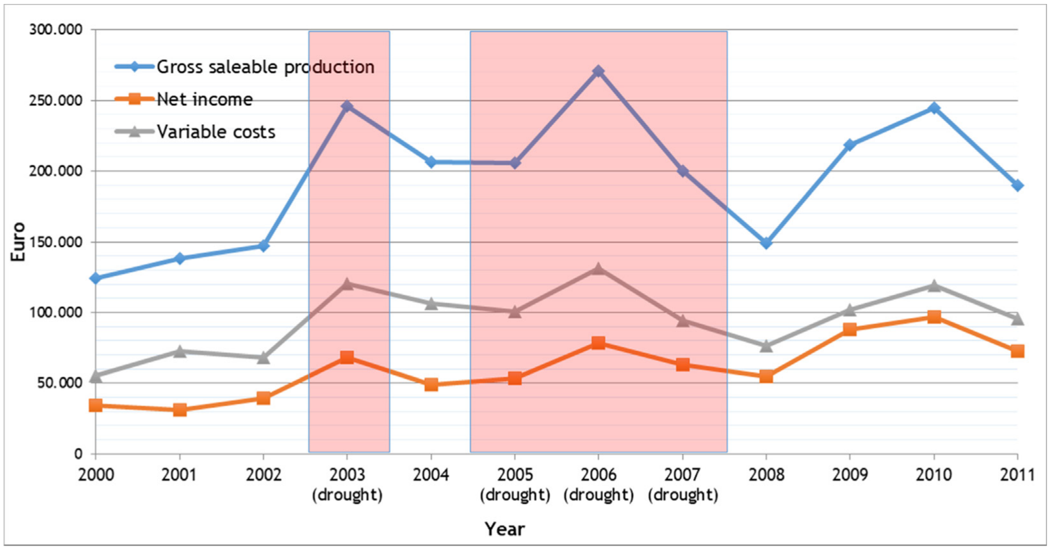
	Lombardy	Piedmont & Aosta valley	Emilia-Romagna
2003			
Producers	279,8	146,8	288,7
Consumers	−425,5	−177,8	−673,5
2005–07			
Producers	806,7	391	−454,5
Consumers	−1.078	−495	−1.025

Po basin (Italy) 2003: Effects calculated from changes in farming prices in 2003 v. average crop prices 1999–2002; and from changes in crops production in 2003 v. average crops production in 2000–2009.
Po basin (Italy) 2005–2007: Total effects (for the entire three years period) calculated from changes in average farming prices in 2005–2007 v. average farming prices in 2000–2004; and from changes in average crops production in 2005–2007 v. average crops production in 2000–2009.
[a] Values of the impacts are actualized at 2012 using deflators defined on the basis of the inflation rate time series at the national scale (Consumer Price Index for Italy; www.inflation.eu).

A third and last question that can be asked concerns the structure of the value chain: Is the extremely simplified structure of the value chain that was considered here, composed only of two stages (producers and consumers), plausible? Actually, the agri-food sector is rather complex, consisting of different kinds of value chains. In some cases, agricultural products are supplied directly to the final market, but there are also several other types of – possibly intertwining - value chains, composed of more than one stage (transformation, distribution, sales, etc.). In our study results for the value chain upstream (farmers) are plausible, as we take price at source into consideration. As far as the value chain downstream is concerned, we can actually assume that consumers hypothetically represent several parts of the value chain, thus including agricultural product processing, distribution, sales, etc. … Consequently, it is not necessarily true that negative effects on social welfare are actually suffered by consumers. However, this does not modify the substantial significance of the analysis when it finally states that a part of society, other than farmers, always loses in a drought. The possibility of assuming different value chain structures potentially opens the door to further analysis about who actually loses along the value chains.

6. Conclusions and policy implications

The analysis conducted in this study seemingly contradicts the popular idea, we can even say the commonplace, according to which drought only causes economic loss or damage is not true. The results of the analyses presented in this paper clearly show, on the one hand, that drought impacts have an overall negative sign, and often also a considerable dimension at the macroeconomic scale. On the other hand, economic effects are socially and regionally differentiated in their sign and in their magnitude; and some farmers (not all), paradoxically, can even obtain considerable gains from such events. It is an observation that may introduce problems of social justice to the issue of the impact of climate change.



Source: our elaboration on data by Farm Accountancy Data Network (FADN; www.rica.inea.it)

Fig. 5. Gross saleable production, variable costs and net income in agriculture in the Po river basin, Italy (Farm average; Euro; 2000–2011).

Whatever is the geographical scale of the case study area, and whatever is the drought event taken into consideration (which of course can differ in terms of length, severity, etc.), the clear social differentiation of the drought impacts, and then existence of "winners" and losers" due to drought is in any case confirmed.

As remarked above, demand and supply elasticity of course have a key role in determining the distributional impact. Our analyses show clearly that a significant part of the cost actually falls on final consumers, while farmers may shift away the most significant part of it (or even more than 100%, i.e. gain from the drought). The decisive aspect is demand elasticity: the more inelastic demand is, the higher negative impact of supply restrictions is shifted onto prices, therefore damaging consumers, and having benefits on farmers. Since elasticity depends on available substitutes, our analysis implicitly predicts that farms producing crops that have closer substitutes will suffer more, while those producing less substitutable crops (as those associated with the production of quality and organic products) will be able to raise prices, and possibly gain from the drought event.

These results of course ask for further investigations, as concerns the number and variety of case study areas and drought events, the level of detail of the breakdown by the type of crop and geographical area (even envisaging analyses for each individual crop), and the balance sheet data of the agricultural firms. But the empirical evidence that they provide can be assumed to be the first important step of this path to the analysis and the knowledge of the distributive effects of natural disasters like droughts.

Policy responses of these results (that, as said in the introduction, usually neglect these effects, and tend to focus on immediate damage, regardless who actually bears the effective cost) are quite straightforward.

As far as droughts generate an overall net economic cost, it is clear that investing in drought preparedness and resilience provides high economic benefits. This suggests to privilege a proactive approach to drought risk mitigation (Kampragou et al., 2015), first, water supply management measures aimed at increasing water availability for irrigation farming remain a key strategy. For example, either increasing water storage of groundwater, or building barriers or dams at different points along the river, as envisaged in the Po river basin, where plans to build barriers against salty water in the delta are also under consideration. Secondly, demand side management measures may reduce vulnerability by internalizing the cost of the risk. This is the case of the improvement of irrigation techniques, investment in water-saving technologies, increase of crops (vegetables and some fruits) growing in controlled-environment greenhouse, more flexible organization of irrigation water delivery, improvements of the controls on water usage, like for illegal withdrawals, etc.

However, considering the distributive effects that our analyses bring to light, it would be necessary to re-think the recovery policy options for farmers (subsidies, insurance schemes, etc.) implemented at the European (for example, Rural Development Programme), national and local scale. If not all farmers are affected negatively by drought, but some may even make a gain, not all farmers should be targeted for these support policies. Rather, policies should be directed towards those who actually suffered losses. Even more, it could make sense to ask winners to contribute: this could be achieved, for example, through the introduction of mutual insurance schemes, possibly funded through basin-scale instruments, such as add-ons on water abstraction charges. A similar idea has been implemented in France in the so called "cat-nat" insurance scheme in the case of flood control (Barraqué, 2014), and could be easily replicated to droughts.

Discriminating either by level of income of farming households, or by turnover and profit margin of the farms, can be one of the ways to follow. However, in order to apply policy measures more efficiently, it is necessary to be able to clearly identify the winners and the losers due to the drought event. That is to say, a key policy recommendation that arises concerns precisely the need to assess more precisely where costs (and possibly benefits) are located. This can be achieved by increasing knowledge regarding the socio-economic effects produced by drought events, enhancing data and improving information concerning all the actors and categories who might potentially be impacted by drought.

It is important to underline that of course all measures aimed at improving resilience and reduce vulnerability to droughts should not be considered as subsidies to agriculture, but rather to the collectivity as a whole, since final consumers are likely to bear the highest share of the total cost of the drought, as out study as showed.

A last remark concerns the accessibility of local markets. It is clear that all measures capable of improving the accessibility of local markets to imported (substitute) products will be able to reduce the magnitude of these effects, in particular the price effect. In this respect, if implemented on various geographical scales (global, international, national, local), all policy strategies aimed at increasing market openness and removing trade barriers, are measures that will be particularly effective.

In conclusion, we want to underline again that obviously more research is needed in order both to improve the quantification technique of these effects, and to suggest appropriate policy measures that fit each context's specific conditions. However, we think that this study can definitely help improving the policy response to droughts by providing a clear and easily replicable framework for assessing drought impacts and their distribution.

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