Deliverable

3.2. Non-monetary impacts of droughts on ecosystem services

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1. Introduction

This WP aimed to value the non-market impacts of droughts. Drought is a natural hazard that is increasing in frequency, duration, and severity throughout the world. Projections of 1.5ºC global warming would mean that more than 75 countries will be completely affected by an increase in drought risk, and an additional 0.5ºC warming would result in another 17 countries suffering from these conditions (Gu et al., 2019). Worryingly, individual prospective evaluations of drought are strongly based on the past, which can create a wrong perception of the future real impacts, possibly greater than expected (Shao & Kam, 2020). Moreover, populations that are frequently exposed to drought can become complacent, which might hinder the progress of adaptive strategies. Drought also makes people that are already vulnerable due to poverty, inequality, and marginalization, more vulnerable. In rural India, (Sam et al., 2020) found that citizens saw drought as a natural cause with humans exerting a limited influence on its occurrence. They considered the government should be responsible for the losses, providing the necessary assistance. People need to understand the human influence on climate change so that they become more conscious about how our actions affect the environment and can act in a way that preserves it.

Droughts are complex natural phenomena that cause a variety of impacts throughout the area in which they occur. They can also induce effects on regions that are not directly affected by drought. The most noticeable way in which drought will reveal itself is in the agricultural sector because of a lack of soil moisture given lower-than-usual precipitations. This, in turn, will affect both crop and pasture production. Meanwhile, the reduction in hydrological resources will affect water supplies such as stream flow, reservoir storage, wetlands, groundwater, snow melt, etc. This lack of provisions will directly affect irrigation, which again will have a direct impact on crop and pasture production, but it will also affect the tourism and recreation sector, public utilities, horticulture and landscaping services, and other water-dependent industries. All of these impacts arising from a direct reduction in rainfall or water provisions are what can be called direct economic impacts (Ding, et al., 2011). These include the business interruptions in these directly affected sectors and consequent unemployment. From these direct impacts will then arise the indirect or induced economic impacts, developing because of the interactions between the different industries and sectors that operate and are linked in a complex developed economy. Drought will even be priced into a firm's cost of raising equity capital because the market immediately introduces the drought conditions into their financing costs. Huynh et al., (2020) found that firms affected by severe drought conditions will have to pay 92 basis points more to raise capital, reflecting that investors require a higher rate of returns on firms affected by droughts.

Many of these impacts (both direct and induced), can be seen as market impacts. Given that there is a market for them, they can be monetized to compare the different affected sectors. This is also why they are the most common impacts studied, with more straightforward approaches for economic valuation. There are numerous studies quantifying drought impacts on agriculture and the indirect impacts on the rest of the economy. For example, in rural Australia, Kelly & Phelps, (2019) found that, in regions highly dependent on agriculture, drought caused reductions in regional expenditure. Farmers were able to spend less at town businesses, which in turn reduced expenditures even more. The unemployment first felt in the agricultural sector was transferred to town businesses, people had to emigrate for work, and the value of assets such as houses decreased due to the fall in demand. Pérez & Barreiro-Hurlé, (2009) studied drought impacts in the Ebro river basin, Spain, in 2005. They found that Gross Value Added fell by €405 million and €77 million for agriculture and the hydroelectric sector, respectively. An input-output model allowed them to determine induced impacts on the rest of the related economy, which were €478 million in lost production value. Of the 11,275 jobs lost, 86% were concentrated in agriculture, forestry, and fishing.

There is another source of impacts that is harder to directly reveal: non-market impacts, also called non-monetary impacts. These can be both social and environmental and might become very large but often go unquantified given their more intangible nature and not having a market to price them. Droughts have been linked to many non-market effects, such as health-related, social, and environmental. From an environmental standpoint, the consequences of drought are many: herbivorous insect and pathogen outbreaks in forests, water quality downstream and increased salinity, hydroelectric production, tree mortality, reductions in pollinators, increased temperatures, and risk of fires, all of them affect the provision of ecosystem services.
As mentioned, the lack of literature quantifying non-market impacts relative to market impacts is probably because of the valuation complexity of the former, which in turn can make the assessment process costlier and time-consuming. Many studies do not quantify these costs; they only make a qualitative assessment of the process that takes place. Surveys can also assess non-market impacts of drought, directly revealing information that would otherwise be hard to access, such as mental health information on a localized area. One common approach for valuating non-market impacts is through State Preferences studies. These methods estimate measures of economic value using responses to survey questions (Johnston et al., 2017). The main SP approaches are contingent valuation (CV) and the discrete choice experiment (CE). This last method is used by (Hensher et al, 2006) to determine the willingness to pay to avoid drought-related water restrictions for households and businesses in Canberra. Andreopoulos et al., (2015) also use choice experiments to determine the value placed by a mountain community on human ecosystem services, Nthambi et al., (2021) apply this method to assess farmers' preferences for different attributes of a sand storage dam project – including the organization governing the dam construction. This method revealed that farmers prefer an NGO as the governing organization and that benefits of $1,779,596 are lost if the government institutions govern the dam construction instead of an NGO. Finally, Revealed Preference (RP) studies can also be used to extract the value someone places on a certain good or service. One example would be the travel cost method: by observing a market related to the non-market good or service under scrutiny, the value placed on such good can be approximated. For example, the travel cost method approaches the recreation value of a day in a National Park by estimating the demand curve of day trips for that specific site and others alike. For this project Choice Experiments and Travel Cost Methods have been applied to estimate a selection of the impacts on the ecosystem services affected by the droughts. In what follows, first we focus on reviewing non-market impacts due to droughts gathered in the literature. Next, the area of study and main assumptions are introduced followed by the methodology and results. Conclusions close this report.

2. Ecosystem services affected by droughts

2.1. Environmental services

There are many ways in which drought causes environmental damage. Reduced stream flow at river deltas can induce increased salinity levels upstream, affecting fish populations (Christian-Smith et al., 2011). Salinity was also found to increase in lake Mead when modeling drought for the Colorado river basin (Harding et al., 1995). The same authors modeled the environmental consequences of water management decisions under drought conditions by using a game theory model, and in all 3 games, there were net losses for wetlands, riparian areas, and national wildlife refuges.

Infestations are a common problem: grasshoppers (Wheaton et al., 2008) and pine caterpillars (Bao et al., 2020) are some of the irruptions seen due to drought. Severe drought has been found to increase bark beetle performance and consequent tree mortality in the western United States. Moreover, drought increases stress on trees severely affected by mistletoe, which predisposes them to be attacked by insects (Kolb et al., 2016). Floral resources are also affected by drought. (Phillips et al., 2018) simulated drought to model effects on calcareous grassland and saw decreased nectar production in some cases and a reduced number of flowers containing nectar in others. Their findings indicate the "*impact on the availability of floral resources in calcareous grassland, and consequently on the pollinator behavior and populations"*.

Increased tree mortality and fire incidence (Wittrock et al., 2011) are also the main problems. The Millennium drought in southeast Australia caused increased tree mortality well away from rivers and an increase in forest fires. More than 57,000 hectares of planted forests were lost between 2003 and 2009, equivalent to 3% of the national plantation estate (Van Dijk et al., 2013). Increased tree mortality has also been observed in US state parks (Jedd et al., 2019).
Moreover, people value the environment and the ecosystem services it provides, and drought threatens certain regions' sustainability. By using choice experiments as their valuation technique, Andreopoulos et al., (2015) compared the costs of adaptation to climate change with the willingness to pay for adaptation measures of a mountain community. The elicited willingness to pay from families led them to believe that they place a strong value on preserving ecological status. Adaptation measures to preserve human ecosystem services outweighed the costs of adaptation, which implied that adaptation would be worthwhile. This shows that people value natural resources stemming from water availability. Nikouei & Brouwer, (2017) measured the welfare values of sustained urban water flows for recreational and cultural amenities and found that more than ¾ of visitors to the study area are willing to pay additional taxes to preserve water flow in the park. Given that the river is drying out, a significant reduction in welfare was expected.

The environment has also got aesthetic beauty and may provide cultural ecosystem services that are important for the sustainability of the area and for the appreciation and satisfaction of the population that lives there and tourists that visit the region. In many studies relating to scenic beauty, conservation of cultural ecosystem services, and people's preferences regarding certain landscapes, there is a tendency towards preferring more natural or, at the most, more traditional farming landscapes over modern intensive farming landscapes. The conservation of not only natural features but simply traditional landscape features is important for visitors to the areas that have them (Van Berkel & Verburg, 2014) and is also important for families in the area (Alfonso et al., 2017), changes towards more homogeneous landscapes are perceived negatively (Schirpke et al., 2013) and in some cases, there is substantial support for cultural landscape conservation (Rewitzer et al., 2017). This has consequences in a drought context, due to the possibility of water becoming scarcer, vegetation drying up and the landscape losing part of its biodiversity and natural landscape features.

Within the context of valuing people's satisfaction derived from natural landscapes, it is important to consider certain demographic characteristics that might influence their preferences. (Howley et al., 2012) observed that the general public understands the importance of traditional farming landscapes and is environmentally concerned, but there is a stronger preference for these landscapes for individuals who are older and/or female, and those living in proximity to these landscapes are more likely to rate traditional farm landscapes highly. (Soy-Massoni et al., 2016) also found that demographics have an impact on people's preferences. Even though in general they found a strong preference for cultural ecosystem services, mainly aesthetic value, tourists were willing to pay more than locals from bigger cities.

2.2. Health

The main categories of drought-related impacts include nutrition-related effects; water-related effects; airborne and dust-related disease; vector-borne disease; mental health effects; and other health effects such as wildfire, effects of migration, and damage to infrastructure. Drought also impacts human health in different ways. One of the observed consequences is on mental health, mainly for farmers and their employees given that drought directly affects them. Mental health impacts due to droughts are mainly on the agricultural sector (Edwards et al., 2019), and are positively correlated with drought intensity. Reduced life satisfaction is also a concern. Carroll et al., (2009) found that very low rainfall during spring in rural Australia affected life satisfaction by US$ 14.500. Based on the projections of increased frequency of spring droughts, they estimated a total loss of over 7$ AUS billion per year. Also, in rural Australia, drought has caused increased mental health problems for children and young people (Carnie et al., 2011).

Physical health may also become affected by drought. Decreased rainfall induces the liberation of dust particles into the air which can, in turn, enter the lungs and cause internal damage. (Machado-Silva et al., 2020) found that drought increased the number of respiratory disease-related hospitalizations, except for asthma. They also found that fires were a secondary influence on respiratory disease hospitalizations.

Another way in which drought can become a problem for health is through food scarcity. Lupu et al., (2018) observed how low rainfall caused some farmers to stop harvesting because the costs were higher than the revenue. Given that the region of the study was economically dependent on agricultural production and drought had already reduced production considerably, the decision of farmers to stop harvesting further increased the food shortage. This is related to how drought affecting less developed regions can have greater impacts on human health. Agricultural-dependent areas with high poverty rates suffer the direct consequences of drought and have problems with food security, which can translate into malnutrition and disease. A study of a rural region with high poverty rates conducted in Odisha, India, found that the number of diseases affecting poor households increases during drought periods (Sam et al., 2017); another study of the same region revealed problems with diseases during drought, to which they added stress and unemployment. Additionally, the main preference to deal with the impacts of the drought was to reduce food consumption (Sam et al., 2020).

For this project, we have selected respiratory-related problems based on the use of the International Classification of Primary Care (ICPC-2, WONCA). The Aragonese Institute of Health Sciences (Instituto Aragonés de Ciencias de la Salud – IACS) supported the selection of pathologies.

Respiratory system Code	Description
R02	Shortness of breath
R03	Wheezing
R04	Other specified breathing problems
R05	Cough
R07	Sneezing or nasal congestion
R08	Nose symptoms or complaints
R09	Sinus symptoms or complaints
R74	Acute upper respiratory infection
R75	Acute or chronic rhinosinusitis

R77	Acute (obstructive) laryngitis or tracheitis or both
R78	Acute bronchitis or bronchiolitis or both
R80	Influenza
R81	Pneumonia
R85	Malignant neoplasm bronchus and lung
R97	Allergic rhinitis
R90	Hypertrophy tonsils or adenoids or both
R95	Chronic obstructive pulmonary disease and emphysema
R96	Asthma

Table 1. Respiratory pathologies codes extracted from ICPC-2.

The sample was composed of all individuals from the area of study (24931 inhabitants) living between 2000 and 2020. Respiratory-related diagnoses count 15545 persons for that period. Figures 1, 2, and 3 show the events by groups of pathologies considering the number of occurrences. *Acute upper respiratory infection* (R74) is shown independently since it contains a large number of cases that, otherwise, would distort the appreciation of the other incidences.

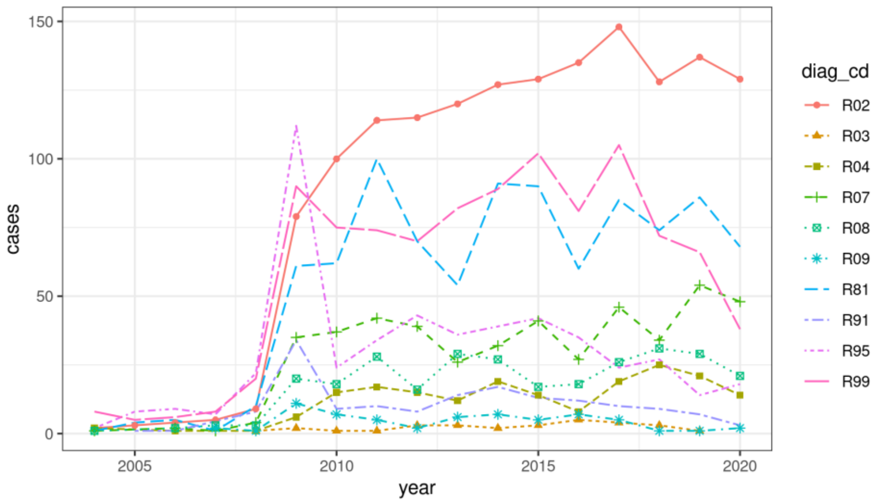

Figure 1. Group of respiratory pathologies with diagnoses under 200 cases

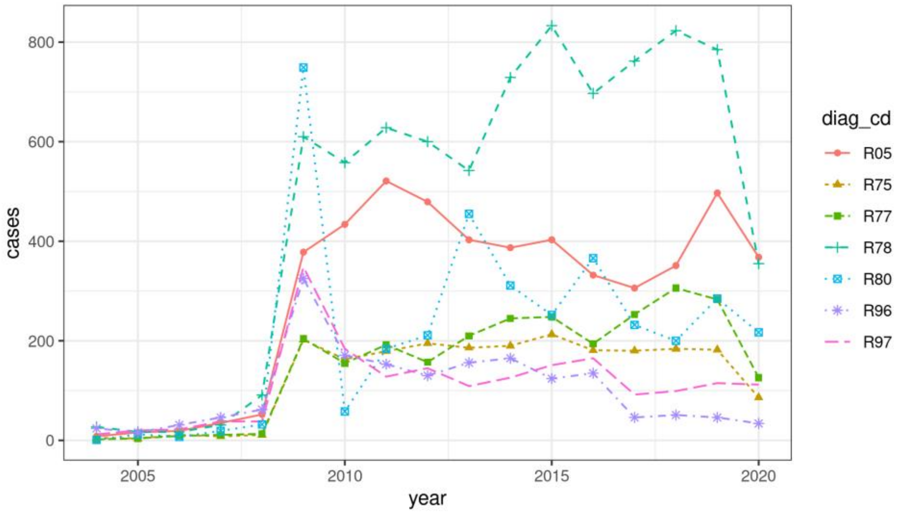

Figure 2. Group of respiratory pathologies with diagnoses above 200 cases

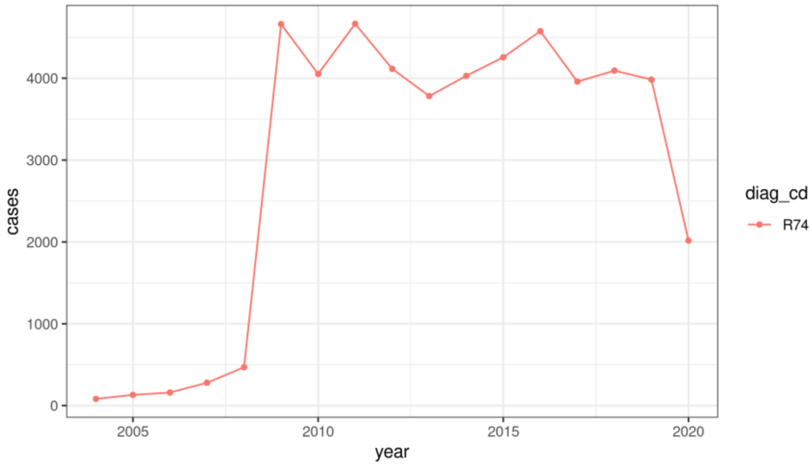

Figure 3. Acute upper respiratory infection

As can be appreciated all respiratory infections distribute accordingly over the years, with signs of a relationship between precipitations and respiratory incidents (Figure 4). With this base, we designed the valuation exercise explained below.

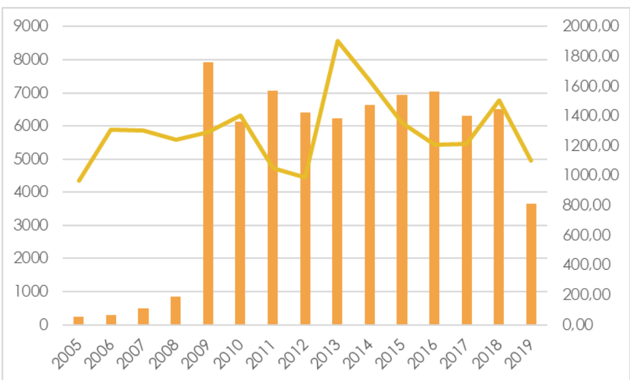

Figure 4. Respiratory incidents and precipitations

2.3. Tourism

One of the sectors that can be directly affected by drought is tourism. Direct impacts on this sector due to reductions in water or snow-dependent activities are boating, rafting, canoeing, fishing, snowmobiling, or skiing. Indirect impacts, harder to quantify because of their intangible nature, may be decreased visitations, cancellations in hotel stays, or a reduction in booked holidays (Thomas et al., 2013).

From a macroeconomic standpoint, (Van Dijk et al., 2013) estimated a 5% reduction in tourism Gross Regional Product in the Murray River region, Australia, in 2008 due to a drought. More specifically, some studies have already found that changes in ecosystem services, like the possibility of Victoria Falls drying up, would lead to sharp decreases in visitations (Dube & Nhamo, 2020). Reductions in the richness of biodiversity might lead to losing attractiveness to tourists, and interviews with tourism stakeholders indicated that due to recent droughts, tourism activities were brought to a near halt (Dube & Nhamo, 2020). Drought can also indirectly increase the chance of wildfires. These were identified by (Wilhelmi et al., 2008) as a major factor in the overall summer tourism decline in Colorado mountain resort communities. Also, the growth of tourism and infrastructure is directly associated with an increase in water use (Baños et al., 2019). This increase in water consumption can lead to questions about the sustainability of the development of a spatial model highly reliant on tourism and real estate development. Hotels spend between 600 and 700 liters of water per day, per person (Everson J., 2015), three times as much as typical domestic consumption. This may cause conflicts of interest between local people and tourist authorities on the use of scarce water (Perry, 2006).
Recreation and tourism may be less frequently identified as a major category of impact because, traditionally, other sectors have been given more attention, such as agriculture or water supplies. However, recreation and tourism may be more sensitive to drought impacts than previously considered. By analyzing the news coverage of 13 newspaper sources spanning the years from 1998 to 2007, (Dow, 2010) found that 13% of drought-related stories mentioned impacts on tourism and recreation. The only activities more frequently observed on the news reports were water supply, agriculture, and other social conflicts outside of the main sectors.
Perceptions also play an important role in tourism trends. (Jedd et al., 2019) found that tourists in the US made decisions based on general perceptions of drought; Perry, (2006) stated that observed changes in the frequency and intensity of events like heatwaves, droughts, and fires may be more important than climate change projections. (Thomas et al., 2013) also point out how perceptions of dryness, wildfires, or any negative impact publicized by the media could be the cause of already-mentioned indirect impacts such as decreased visitations and cancellations. They point out how public perception of drought conditions at popular tourism destinations is as important as the actual conditions themselves. If this is the case, then it could mean that tourist perceptions stemming from media coverage may have a greater influence than actual empirical projections of climate trends or even actual real conditions. In this line, (Wilhelmi et al., 2008) Wilhelmi et al., (2008) pointed out that since public perceptions can be very sensitive to media coverage, there is a need to market the positive aspects of local tourism and recreation that still exist despite a drought.

This high influenceability of tourists through media coverage may now interact with some interesting general facts of the literature. (Hoogendoorn & Fitchett, 2018) Hoogendoorn & Fitchett, (2018) takes notice of the flexibility of the modern tourist, with rapid access to information allowing them to select a destination best suited to their needs. The literature highlights that the primary adaptation response of a tourist to climate change is to alter the destination that they are traveling to in the long term and to cancel or change bookings in the short term. This means that an influenceable tourist through media coverage, who also can rapidly change destination options, could decide not to visit their previously chosen destination. Tourists may also visit certain places if they maintain their ecosystem services unchanged. Changes in the hydrological cycle may induce ecosystem changes that will translate into the area's previous attractiveness for tourists being lost, and therefore it is important to determine how tourists value certain landscapes. It has been found that tourists, value natural landscapes highly, showing a high willingness to pay for increasing and maintaining them (Chen & Chen, 2019). Landscape features like tree lines, lakes and rivers, forests, and wildlife viewing are appreciated by tourists. These services were quantified in the Netherlands and the total monetary value estimate for tourists in the Municipality of Winterswijk was estimated to be somewhere between 850.000€/year and 3.2€ million per year (Van Berkel & Verburg, 2014) (Van Berkel & Verburg, 2014). There is indeed a demand for these services and conservation is important to prevent a loss of satisfaction for tourists and residents or even a loss in revenue if the area in question generates one through tourism.

For this project, we have included a complete block of questions aimed at learning how a drought would change recreational habits, therefore, giving an approximation to the losses in welfare due to outdoor days lost.

2.4. Hydroelectric

Another of the direct impacts of drought is on the hydroelectric sector. The reduction in water resources leads to less hydroelectric production, which in turn translates into higher electricity prices (Harding et al., 1995; James C. Schwab (Ed.), 2013; Van Dijk et al., 2013). The 2005 drought in Spain is estimated to have caused losses worth €77 million for the hydroelectric sector in the Ebro river basin (Pérez & Barreiro-Hurlé, 2009).

Christian-Smith et al., (2011) estimated the increase in electricity costs for the population due to switching from hydroelectric production to other sources, such as natural gas in this case. They estimate that Californians spent an additional 1.7$ billion to produce electricity with gas between 2007 and 2009, apart from a 10% increase in CO2 emissions by California's power plants. Moreover, Wittrock et al., (2011) found that electric producers' cooling costs increased due to water scarcity. This could mean even higher electricity prices on top of the already more expensive energy sources.

Drought and subsequent reduction in hydroelectric production could also pose a threat to the energy supply in some cases. Veijalainen et al., (2019) modeled the effects of drought on modern-day Finland and observed a 42% reduction in hydroelectric production which would increase the average price of electricity. The authors point out that if the drought were large-scale, affecting Norway and Sweden at the same time, there could be problems with electricity security in Finland.

3. Study area

The main objective of this task is to estimate the costs of drought on the welfare of society. To this end, we have surveyed the general Spanish population with an extended sample of the Aragonese population. The effects on the landscape are referred to in the Aragón river basin. This study area is located in the North of Spain in Spanish Pyrenees and covers 28 municipalities. With a total area of, Aragon River (2181 km^2) flows from north to south within a Paleozoic zone, with limestone, shale, and clay formations.

Climatologically, the basin receives an annual rainfall total exceeding 1500 mm in the northernmost sector, declining to 800 mm in the Inner Depression. Apart from summertime, rainfall is distributed all over the year, albeit with higher intensities during spring and autumn. The mean annual air temperature is 10 °C. Snow cover appears in the period from December to April, especially at sites located above 1500 m.a.s.l (López-Moreno and García Ruiz, 2004; López-Moreno et al., 2020). Long-term annual mean runoff is 915 hm3, with a peak occurring mainly during springtime. This corresponds to the annual peak of rainfall and melting of the snowpack.

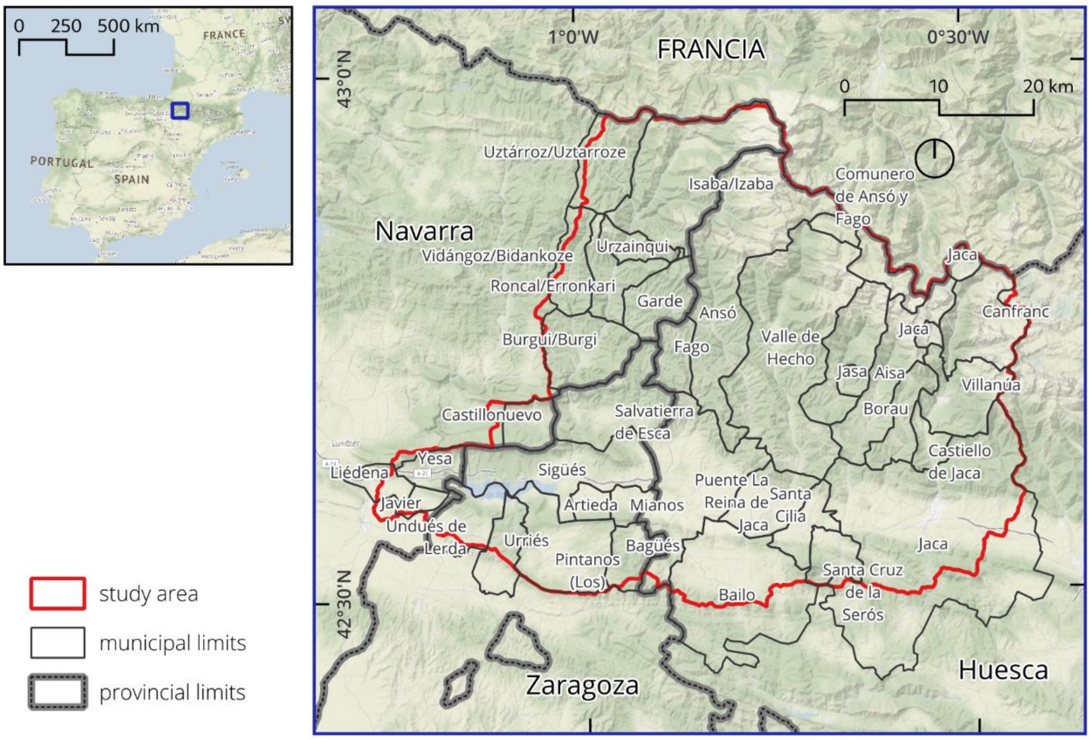

Figure 5. Study area

The area counts 19892 inhabitants of which 9810 are women (INE, 2022). The working population is 53%; 17% have higher education and, around a 5%, have no education at all. Distribution of age groups in figure 6.

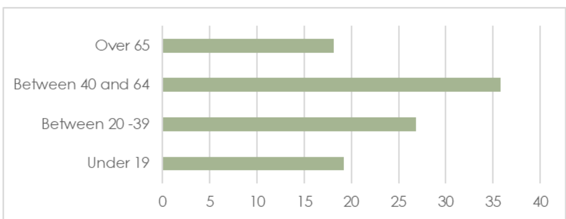

Figure 6. Groups of age in percentage

In this area, changes in the vegetation susceptible to climate change have been simulated, specifically the species *Abies Alba* and *Fagus Sylvatica*.

4. Methodology

The goods and services to be valued in this project are not traded in markets thus they lack a market price. That forces us to make use of other techniques such as those of marketing or mathematical psychology to value the intangible goods and services, like those considered here. These techniques are based on individual preferences, both stated (what people say they would do) and revealed (what they actually do). The first group of techniques will be applied to elicit a valuation on changes in health, vegetation area, biodiversity, and quality of water, while the second group, the revealed preference approach will be used in quantifying the losses in recreational services as a result of a drought. The specific techniques to be applied are *choice experiments* (CE) and *travel cost method* (TCM) respectively.

When Choice Experiments are applied it is necessary to "decompose" the object of the study, (in our case the impacts of droughts on individual welfare) in "attributes" and these attributes should be described in "levels" representing the range of variation. These attributes and levels will be combined in sets and represented in cards. Those cards are the central part of a questionnaire destined for valuation and it will be described in detail in the next section. This will be explained in more detail later on.

All the data necessary for the valuation was collected through a survey conducted in Spain during April and May 2022. Likewise, we have had a group of stakeholders complete some specific information. Details are provided below.

In what follows, first, we introduce the methods to value both *the recreational* and the selected *regulating and support services*. Next, we describe the *study design*, since the key tool for data collection is the questionnaire. This covers i) the choice of impacts as described in attributes and levels; and, ii) the *experimental design* (a field of research itself that conditions the reliability and conclusions of the study).

4.1. Valuation exercise: Recreational services

Travel costs can be a good proxy for the price individuals have to pay to visit a place. It is a measure of the "sacrifice" of some resources (time and money) to access a place and enjoy it. By combining the number of trips taken with the costs of traveling we can estimate a demand curve for recreation to the site or set of sites of our study. This demand curve will allow the estimation of consumer surplus as a measure of the benefits provided by the site/s. Figure 7 succinctly shows this relationship.

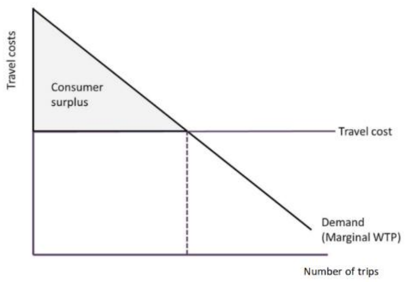

Figure 7. Demand for travel and consumer surplus

The TCM (Hotelling, 1949) main component is a count model of the visits made to a specific site or a set of sites in a given period (Bujosa Bestard & Riera Font, 2010) (Bujosa & Riera 2010). Trip demand to a site is estimated by observing that the quantity of visits to a recreation site is inversely related to travel costs incurred by individuals. That is, those living further will visit less than those living close to the site. The individual TCM takes survey data from visitors to an area such as the number of visits and the travel distances from home as main variables of the model and uses demographic data as well as characteristics and quality of the site, as explanatory variables (Loomis and others 2009). Equation (1) summarize this relationship.

$$\lambda_i = E(x_i) = exp(\beta_{tc}tc_i + \beta_{xp}xp_i + \beta_z z_i) \quad (1)$$

Where $E(x_i)$ is the number of trips each respondent *i* took to the place over the last year, *tc* is the individual travel costs, *xp* are the cross prices of closely related goods and *z* are predictor variables. Travel costs are a compound of out-of-pocket expenses and travel time. Travel costs could include not only transportation costs but those of lodging or souvenirs, etc. Our study adopts a conservative approach, as it includes only the strictly considered costs of transport, leaving aside induced effects on the local economy. On-site surveys exclude people who did not take a trip to the study site which complicates the estimation, truncating the dependent variable. One of the advantages of online surveys is that we have observations with zero trips. We must opt for this type of data collection because of the restrictions during the pandemic.
The number of visits is an integer number therefore the estimation method required is a count regression model such as Poisson or Negative Binomial. The form of the Poisson distribution is in equation 2.

$$P(y_i|x, z_i, e_i) = \frac{1}{y_i!}(\theta_{t,x,z_i}e_{it})^{y_{it}} \quad (2)$$

The use of one or another (Poisson or Negative Binomial) is dependent on the variance of the dependent variable: the number of trips taken, since Poisson regression requires equality of mean and variance. From here we obtain a trip demand curve which can be used to estimate the recreational demand for the site and the corresponding value of the consumer surplus, the shaded área in Fig. 7. Willingness to pay (WTP) is the maximum amount that an individual would be willing to pay to undertake the trip. Consumer surplus is the WTP minus the cost to undertake that trip summed over all participants, which is the additional amount participants would pay for that trip rather than do without. The demand curve slopes downward because of the diminishing marginal value of additional trips taken. From Adamowicz et al. (1989), the consumer surplus per trip is 1/-β_{tc}. (2*bis*)

4.2. Valuation exercise: regulating and supporting services

A valuation exercise aims to obtain a monetary measure of specific changes in the individual's welfare, allowing for comparison among multidimensional changes. Environmental valuation of ecosystem services and impacts departs from the assumption that they can be treated as arguments of the utility function of the individuals affected by those changes (Hanemann, 1984). By aggregating individual responses across groups of interest or the whole society, we can approximate the impact of the change on the services or the asset itself.
Neoclassical economics postulates that individuals derive utility from the consumption of goods and services provided by nature and that maximization of utility is subject to a budget constraint. This optimization produces a set of (Marshallian) demand functions where demand depends on the state of the environment and the prices/income.
Benefit (damage) estimation is obtained by inferring the net change in income that is equivalent to (or compensates for) changes in the quantity or quality of the provision of environmental goods and services (Mariel et al., 2021)(Mariel et al., 2021). In other words, we try to quantify the changes in the welfare that an environmental change (good or bad) provokes. In our study, we measure the willingness to avoid the damages caused by droughts.

Let z be a vector of market commodities and q a vector of environmental services, then u the individual's direct utility function:

$$u(z,q) \qquad (3)$$

The quantity of z is freely chosen given the prices (p) while q is exogenously determined. When individual maximizes utility subject to income (y) this function can be formulated as the indirect utility function v:

$$v(p,q,y) = max¦z\ \{u(z,q) \mid p \cdot z \le y\} \qquad (4)$$

The expenditure function associated with the utility change can be framed as:

$$e(p,q,u) = \min_{z} \{p \cdot z\ |u(z,q) \le u\} \qquad (5)$$

What defines the minimum amount of money an individual has to spend to reach a certain level of utility given the utility function and the prices of market goods.
This indirect utility function together with the expenditure function is the theoretical framework for quantifying welfare effects for non-market goods and services (Mariel et al., 2021), or, in other words, these two make it possible to know how individuals respond to changes in the goods and services in evaluation.
For this purpose, individuals are presented with sets of alternatives from which they have to select their preferred one. These exercises are known as choice experiments/discrete choice models and the purpose is to predict the preferences from the characteristics of alternatives, from choice situations, and from the attributes and considering the varying array of respondents. The basic model is a regression conditional logit model developed by McFadden (1974), an extended multinomial logit model that includes the characteristics of the alternatives offered as explanatory variables. For the data of this project, we have applied an advanced model with a finite mixture structure to capture preference heterogeneity given the purpose of this study. In this case, each latent class matches a segment of the population allocating the same importance to the impacts of droughts of the alternatives offered.
We present in eq. (6) the basic model applied in this study. In table 2 there is the notation.

I, i	Group of cases or individuals i
T, t	Replications
$y_{it,}y_i$	Response variable for case I and replication t. Vector notation
M, m	Alternatives presented to the individual
$z_{itmp}^{att}, z_i, z_{it}^{att}$	Attributes/characteristics of alternatives. Vector notation
$z_{itq}^{att}, z_i, z_{it}^{pre}$	Predictors/characteristics of replications. Vector notation
$z_{ir}^{cov}, z_i^{cov},$	Covariates/characteristics of individuals. Vector notation
p, q, r	Indices to denote a particular attribute, predictor, and covariate
P, Q, R	Total number of attributes, predictors, and covariates
K, x	Total number of latent classes, latent class variable
$\eta_{m\|z_{it}}$ $\eta_{m\|x,z_{it}}$	Systematic component in the utility of alternative *m* for case *i* and replication *t*

Table 2. Notation

$$P\left(y_{it} = m \middle| z_{it}^{att} z_{it}^{pre}\right) = \frac{exp\left(\eta_{m|z_{it}}\right)}{\sum_{m'=1}^{M} exp\left(\eta_{m'|z_{it}}\right)} \qquad (6)$$

Heterogeneity is captured via latent classes. In a latent class conditional model, it is assumed that individuals belong to different latent classes that differ concerning some or all of the β parameters (Kamakura & Russell, 1989). The choice probabilities depend on class membership *x*, the model is now

$$\mathrm{P}\left(\mathrm{y}_{\mathrm{it}} = \mathrm{m} \middle| x, \mathrm{z}_{\mathrm{it}}^{\mathrm{att}} \mathrm{z}_{\mathrm{it}}^{\mathrm{pre}}\right) = \frac{\exp\left(\eta_{\mathrm{m}|x,\mathrm{z}_{\mathrm{it}}}\right)}{\sum_{\mathrm{m'}=1}^{\mathrm{M}} \exp\left(\eta_{\mathrm{m'}|x,\mathrm{z}_{\mathrm{it}}}\right)} \qquad (7)$$

Now, the systematic component in the utility of alternative *m* at replication *t* given that case *i* belongs to latent class *x* is

$$\eta_{\mathrm{m}|x,\mathrm{z}_{\mathrm{it}}} = \beta_{xm}^{con} + \sum_{p=1}^{P} \beta_{xp}^{att} \cdot z_{imp}^{att} + \sum_{q=1}^{Q} \beta_{xmp}^{pre} \cdot z_{itq}^{pre} \qquad (8)$$

Where the logit regression coefficients are allowed to be class-specific (Vermunt & Magidson, 2005).

Once the model is estimated, this allows calculating the welfare measures: the amount of income a person is willing to give up (to receive in compensation) for a certain improvement (damage) of an attribute or for a combination of attributes, that will leave that person at the reference level of utility. These are called *Willingness to Pay* (WTP) and *Willingness to Accept* (WTA), respectively, and are based on microeconomic theory.
WTP is defined as the marginal rate of substitution between the attribute and the price attribute in the utility function, that is,

$$WTP = -V'(att)/V'(c) \qquad (9)$$

Where *V'* is the first partial derivative of the indirect utility function, *att* is the attribute or characteristic of interest, and *c* is the cost attribute. If attributes enter linearly, then this becomes

$$WTP = -\frac{\beta_{att}}{\beta_{cost}} \qquad (10)$$

4.3. Study design

Designing a questionnaire for eliciting non-market values requires a great effort both in design and testing which takes a long iterative period. Our SP questionnaire is the result of a literature review on the effects of droughts, experts' advice (2020) and focus groups held during 2021.
A strong difficulty when collecting primary SP data from surveys is the need to "translate" expert knowledge into understandable information for respondents keeping a proper balance between the length of the survey and the information details. Working with a group of individuals from the lay public may help in the definition of attributes[1] and levels included in the study as well as

[1] Attribute is a term used in the Discrete Choice Analysis regarding the issue to be valued. It can be a characteristic, a good, a service, etc. In this context, "attributes" refers to the effects of droughts considered in this study. Levels refer to the intensity of the effect of a specific attribute.

the description. This kind of group is known as a *focus group*. In this project, we held three focus groups of around 8 individuals where each of the attributes was exhaustively described and all the questions included were discussed. On the other hand, pretesting assures that the scenarios for the valuation of the changes provoked by droughts are well understood and credible. Pretesting is usually done by a series of pilot surveys. In this project, we first ran a short personal series of interviews and, on a second round, we collected 30 complete responses from a selected panel (pilot). Without these two preparation steps is not possible to guarantee a successful valuation exercise. The results from the pilot are the basis for the experimental design.

4.3.1. *Choice of attributes and levels*

The *focus groups* chose the first list of attributes and levels to study how droughts affect an individual's welfare, that is:

- Landscape transformation
- Impacts on health
- Increased risk of fire
- Water restrictions for certain uses
- Changes in the quality and quantity of water
- Invasion of alien species
- Effects on the biodiversity
- Changes in the levels of pollution
- Changes in the tourism patterns
- Infestations
- Decrease in agricultural/livestock production

From here, after pretesting the reduced selection of impacts to value in our study was*:*

Attribute	Name in tables	Range of variation in the study
Changes in natural landscapes	Area	Decrease in the forested area (*Abies Alba* and *Fagus Sylvatica*) in 5, and 10% or, alternatively, no change. Fig. 8
Impacts on health	Health	Number of persons affected in respiratory incidences: 3 in 10, 7 in 10, or no change. Fig. 9
Impacts of biodiversity	Biodiversity	Increase in the number of extinct species in 4 and 12 species or no change. Fig. 10
Restrictions on the use of water	WaterUse	The levels considered were: no water for certain uses (car washing, pools, etc.), water not available for drinking, or water use as usual. Fig. 11
Costs of remediation	Costs	Increase in the price of the shopping basket and the price of supplies (energy, tap water): 0, 5, 10, 15, 20, 25, 30€.
Recreative use	UseR	Changes in the use of recreational natural areas measured via the number of trips to the area

Travel Costs	TC	Cost of traveling in distance (km) and time (minutes) by 0.2€
Forest Importance	ForImp	The importance of the presence of the forest for the choice of the recreational visitation site is measured in three levels: no, medium, and very important.
Alone	Alone	Traveling alone
Education	Educa	Education level achieved: University

Table 3. Selection of impacts and levels for valuation.

These were described to participants in the survey and illustrated with *ad hoc* icons designed for this study. Figures 8, 9, 10, and 11 show each of the attributes and levels as seen in the questionnaire. Each attribute shows three levels of intensity.

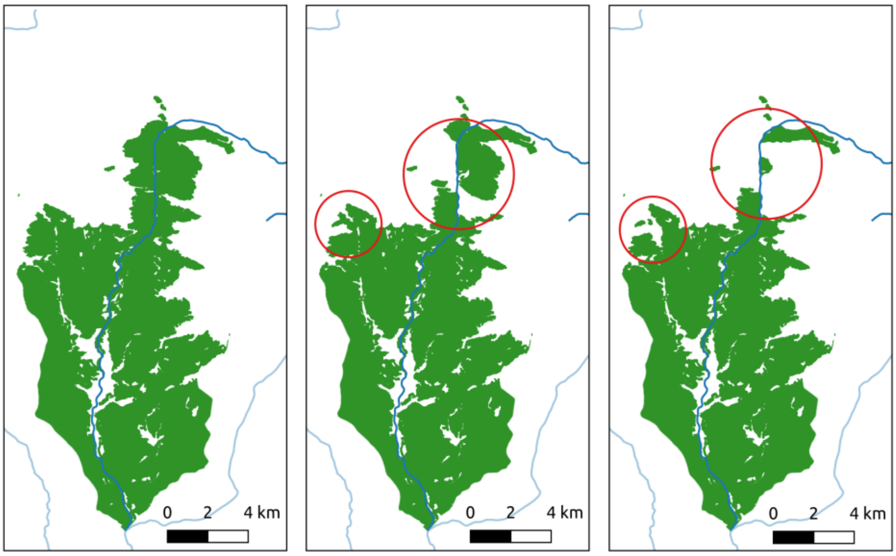

Figure 8. Changes in the forested area: no change, 5%, 10%.

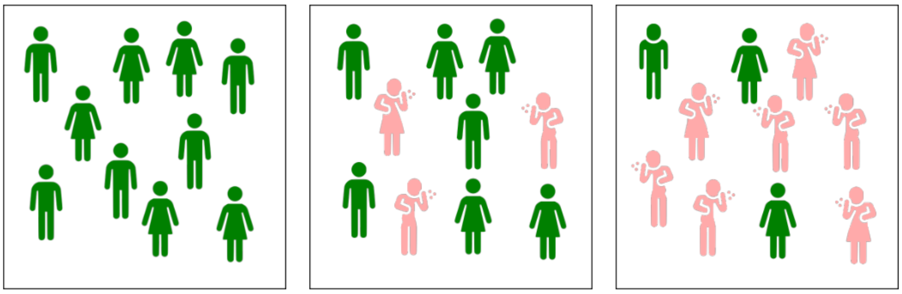

Figure 9. Effects on people's health: none of them/ 3 in 10/ 7 in 10

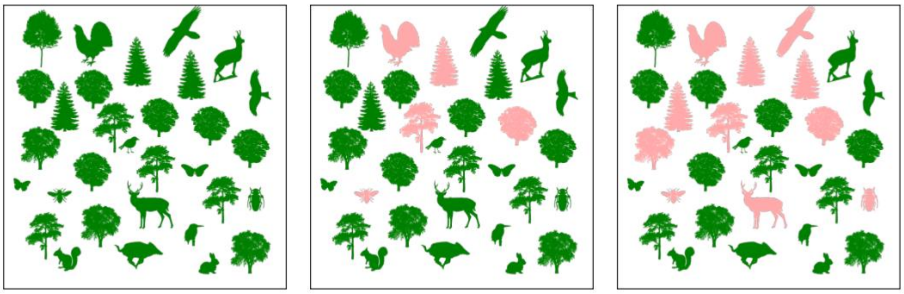

Figure 10. Effects on biodiversity: no loss of species/ 4 species/ 12 species

Figure 11. Effects on water uses: business as usual/ no drinkable water/ restricted uses

4.3.2. *Experimental design*

With a proper design of CE, we should be able to elicit the preferences over drought impacts and their values. This entails that the questionnaire and the information given should be relevant and meaningful and carefully built. The information contained in the exercise has to provide the maximum different possibilities to allow eliciting robust values from the choices made. By choosing among options, individuals reveal what is important for them, making implicit tradeoffs among different attributes and levels. When offering alternatives of action, it is necessary too to include the alternative of not choosing any of the options of change/*opt-out /status quo option*. In market products are clear that the alternative of not choosing is not buying what it is offered, that is, to remain in the initial state (of welfare). In non-market goods, the meaning of choosing the *opt-out* has not such a straightforward reading. In most of the environmental studies where impacts are to be economically quantified, choosing the *opt-out option* does not imply that things remain as they were, or that they remain at the initial state of welfare, but that deterioration will take place unless some course of action is taken. In other words, individuals are presented with options to mitigate the negative effects of droughts but if they reject all the proposals they will have to support the impacts in any case. The other options are presented here as remediation options where the first choice is *to do something* as opposed to *doing nothing*. The *opt-out /status quo option* is usually at zero cost. If a majority of the sample chooses this option, the valuation exercise becomes inviable, therefore, there needs to be a significant number of participants to choose between the available options.

Another essential part of the study design is the experimental design. This is a statistical technique fundamental in discrete choice modeling which focuses on the dimensionality of a choice experiment to allocate the attributes and levels to be evaluated.

The dimensionality of a choice experiment is characterized by the number of attributes to be valued, the number of levels and range of variation of those attributes, the number of alternatives to be presented to each individual, and the number of times they have to choose among alternatives. What is searched here is to increase response efficiency, reducing the measurement error derived from the responses due to lack of attention or other sources (Johnson et al., 2013). In other words, we want to minimize the uncertainty (Mariel et al., 2021) increasing efficiency. The most used efficiency measure is the D-efficiency and the criterion we have pursued here is the lowest D-error. The alternatives are compared to allow minimizing the standard errors and the degree of correlation between parameters (Mariel et al., 2021). We have used Ngene (ChoiceMetrics, 2018) for this design and our D-error was 0,002481.

		Option A					Option B		
Forest	Health	Biodivers	Water	Cost	Forest	Health	Biodivers	Water	Cost
-5	-7	-12	0	5	-5	0	0	-2	30
0	-4	0	-2	25	-10	-4	-12	0	10
-10	-7	0	-2	5	0	0	-12	0	30
-10	-4	0	-2	10	0	-4	-12	0	25
0	-7	-4	-2	10	-10	0	-4	0	25
-5	0	-4	0	30	-5	-7	-4	-2	5
-10	-4	-4	0	15	0	-4	-4	-2	20
-5	-4	0	-1	25	-5	-4	-12	-1	10
-5	0	-12	-1	15	-5	-7	0	-1	20
-5	0	-12	0	25	-5	-7	0	-2	10
-10	-7	0	0	20	0	0	-12	-2	15
-10	0	-12	-2	5	0	-7	0	0	30
0	-7	-4	0	30	-10	0	-4	-2	10
0	0	-12	-2	20	-10	-7	0	0	15
0	-4	-4	-1	20	-10	-4	-4	-1	15
0	-4	-4	0	30	-10	-4	-4	-2	5
-5	0	-12	-2	10	-5	-7	0	0	25
-10	0	-4	0	30	0	-7	-4	-2	5
-5	-4	0	-2	15	-5	-4	-12	0	20
0	-7	-4	-1	15	-10	0	-4	-1	15
-5	-4	0	-1	30	-5	-4	-12	-1	5
0	-7	-4	0	25	-10	0	-4	-2	10
-10	0	0	-2	20	0	-7	-12	0	15
0	-4	-12	-1	15	-10	-4	0	-1	20
-5	-7	-4	-1	5	-5	0	-4	-1	30
-5	-7	-12	-1	5	-5	0	0	-1	30
-10	-7	0	-1	10	0	0	-12	-1	25
-5	-4	-12	0	15	-5	-4	0	-2	20
-10	0	-12	-1	10	0	-7	0	-1	25
0	-4	-4	-1	25	-10	-4	-4	-1	5
-10	-4	-4	-1	10	0	-4	-4	-1	25
-10	-7	0	0	20	0	0	-12	-2	20
-10	0	-12	0	20	0	-7	0	-2	15
0	-7	-12	-2	5	-10	0	0	0	30
-5	0	0	-2	25	-5	-7	-12	0	10
0	0	0	-2	30	-10	-7	-12	0	5
D error		0,002481							
A error		0,011102							

Table 4. Experimental design of attributes and levels for the choice experiment.

Table 4 presents the coding of the two alternatives offered to the individuals. We obtained 6 blocks of 6 different alternatives. We opted for two alternatives plus the status quo. Our decision to include two alternatives is founded on Boyle and Özdemir (2009) and Oehlmann et al. (2017) who found that respondents were more likely to choose the opt-out alternative when they were offered more than two alternatives. The more alternatives the more complex the decisions.
From this design, we built the illustrated cards presented to the individuals for their valuation. Each individual evaluated a choice set of six cards containing every two alternatives plus the opt-out option.

An example of the final cards shown to the participants in the survey is in figure 12. In summary, the first two options offered remediation for the consequences of a drought at different levels of intervention in each attribute. The last option showed the consequences of the drought with no remediation at all.

Figure 12. Example of a choice card

The final questionnaire is presented in Annex I. Data was collected via an online survey on the Tickstat© platform and Netquest© consumer panel ran during March and April 2022. The section of the panel we worked with has been carefully "cleaned" of cheaters after two years of working with the same group. That allowed us to have more information from the individuals beyond this specific questionnaire. In this way, we have information on past choices in environmental concerned issues, a long psychological test (60 items – HEXACO – PI -R), and attitudinal information. Another set of data was collected from a group of stakeholders via personal interviews.

A challenge in questionnaire design is to make the whole exercise credible and that individuals care about the results of the proposal to get honest and valid answers. In this project, we have included a set of questions to test if individuals or their closest family and friends have been ever affected by drought; feelings and ideas about droughts; identification of potential damages; reactions and emotions towards droughts, and changes in recreational behavior as a consequence of drought. These questions, together with others about climate change perceptions, prepare the individuals for the following valuation exercises and complement the information gathered in variables for the analysis. We call these *instrumental questions* and are presented in the next section dedicated to results.

5. Results

Our sample is composed of a slightly higher number of males (55%). 59% of our sample have education beyond high school, nearly 49% were employed, of which 13% were manual or primary sector workers, and 15% non-qualified. We also asked our sample for their place of birth and usual place of residence. 16% were born in cities with more than 100,000 inhabitants while 13.5% were born in towns with less than 5,000 inhabitants. In our sample, the declared place of residence in villages with up to 5,000 inhabitants is almost 26% and above 100,000 it is 39%.

5.1. Instrumental questions: Preparation for the valuation exercise

Previously to the valuation exercise itself, it is necessary to introduce the individual to the object of study and this is especially important in web-based surveys. A good questionnaire has to have a logical order (Dillman et al., 2008) and the first questions must catch the respondent's attention without "guiding" the responses of a posterior question or task such as the valuation exercise itself. However, it is important to describe the hypothetical market and to recreate a simulated situation as accurately as possible to allow individuals to make informed decisions. In this context, we designed an introductory block to make the respondent remind previous experiences with droughts and think about the consequences of a potential new drought in the following years. From their primary answers, we build new variables that allow for a deeper analysis of the values elicited in the second stage[2].

First, we need to know if their answers are affected by their experience or knowledge. 60.4% declared to remember the last drought in their region and 34.2% stated a kind of inconvenience experienced by herself or someone close. Table 5 shows, in percentage, the kind of incidents respondents suffered in the past due to a drought.

	%
Restrictions on the use of water	50.9
Water shutoff	44.2
Closure of natural areas due to fire risk	42.4
Health effects such as respiratory problems, heat stroke, etc.	30.4
Closure of recreational places such as swimming pools.	25.4
Change of plans such as vacation destination	13.1
Loss of income	8.8
On their employment	3.9
Other effects	9.5

Table 5. Incidents experienced by droughts

The perceived recurrence of droughts is in table 6. Half of the respondents stated that the recurrence of droughts in Spain is every two years or less and just 4.7% consider droughts a rare phenomenon. We can assume that a big share of the sample is realistic about the drought's recurrence in Spain but not that sure of its whereabouts.

Drought recurrence	%
Every year	36.5
Every 2 years	14.9
Every 3 or 4 years	24.9
Every 5 or 6 years	11.4
Every 7 years or more	7.6
Rarely	4.7
Total	100

Table 6. Drought's recurrence

They were also asked about the incidence of droughts in their region, and climate change too, the distribution of answers is in figure 13. Only 33.4% think they live in an area with cyclical droughts. There is a significant proportion (54%) of respondents who consider themselves potentially affected by climate change. It is noteworthy the high share of individuals who do not

[2] From these questions we also prepare a set of explanatory variables to help us better understand the models and control the heterogeneity of responses.

know if they live in an area with cyclical droughts (17.5%). On the other hand, drought areas seem to be confused with naturally dry and arid areas. For example, in the north of Spain, they do not believe, in general, affected by droughts or climate change mistaking the humid areas as safe from droughts.

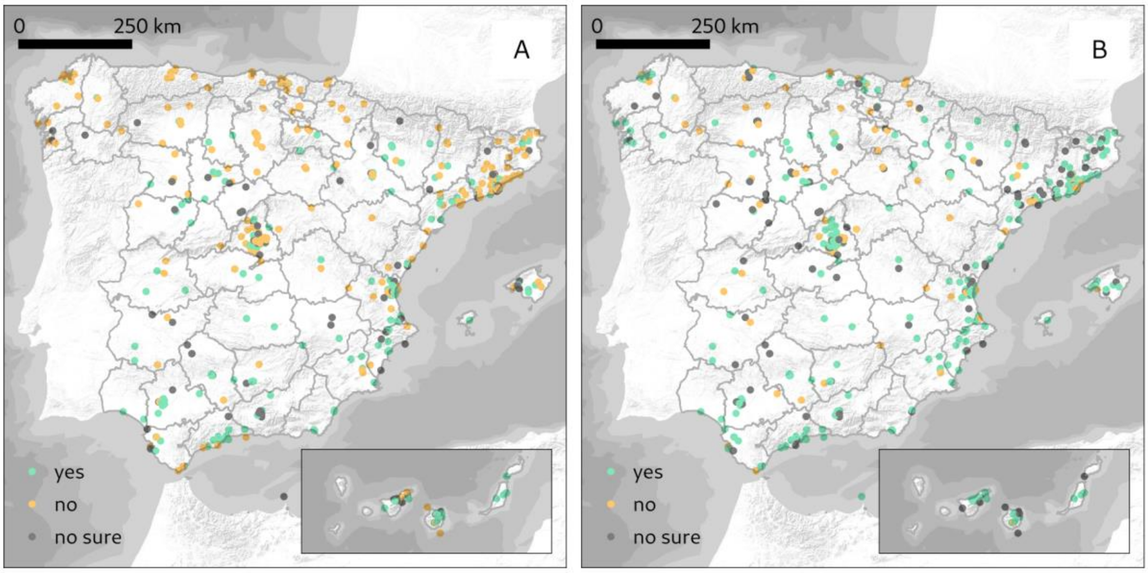

Figure 13. Perception of self-affected by droughts (A) and by climate change (B)

Crossing these answers (Table 7) we see that only 26% of respondents feel being affected by both, droughts and climate change while 18% think they are not affected by any.

Live in an area affected by droughts	*… potentially affected by climate change* Yes	No	Not sure	Total
		%		
Yes	26.0	2.3	5.4	33.30
No	19.6	17.3	12.1	49.40
Not sure	9.0	1.0	7.5	17.30
Total	54.4	20.6	25.0	100

Table 7. Cross responses for drought/climate change

We checked if we could infer this relationship at the population level through Pearson's Chi-Square and found that we can reject independence between answers, that is that both answers are highly related.

When it comes to ideas about droughts, a big share of (first) thoughts is for the lack of water, poverty and hunger, desertification, and agriculture. Figures 14 and 15 show the first and second *words*[3] that come to the mind of interviewees.

[3] We wanted to know which words, more than thoughts, came to mind, to learn about what associations individuals do with droughts.

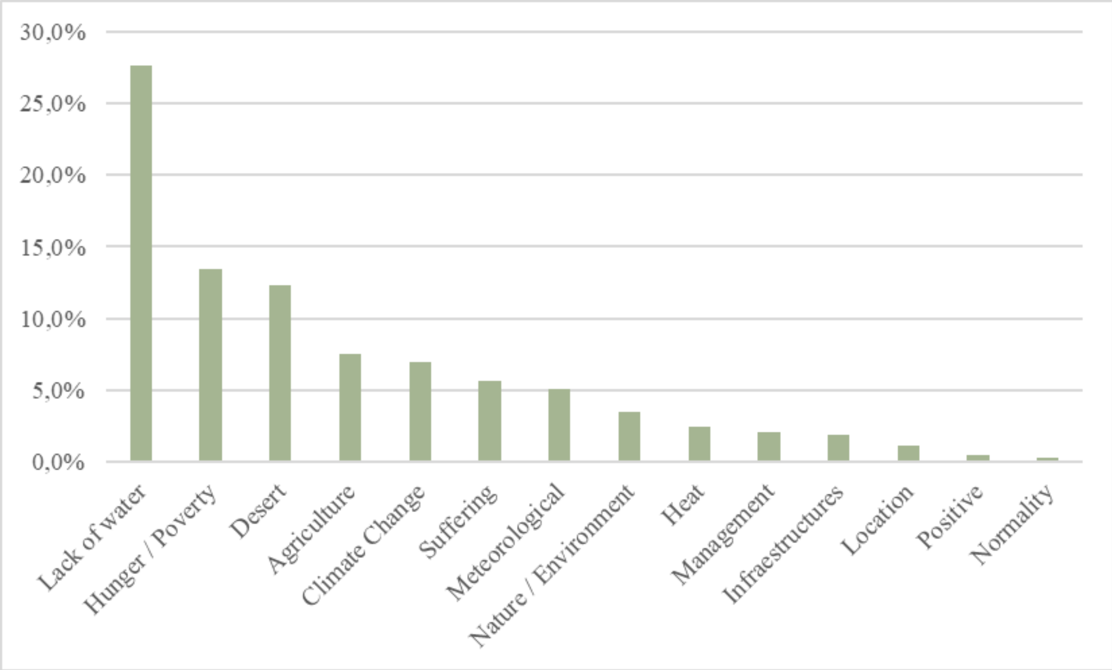

Figure 14. First Ideas about Droughts.

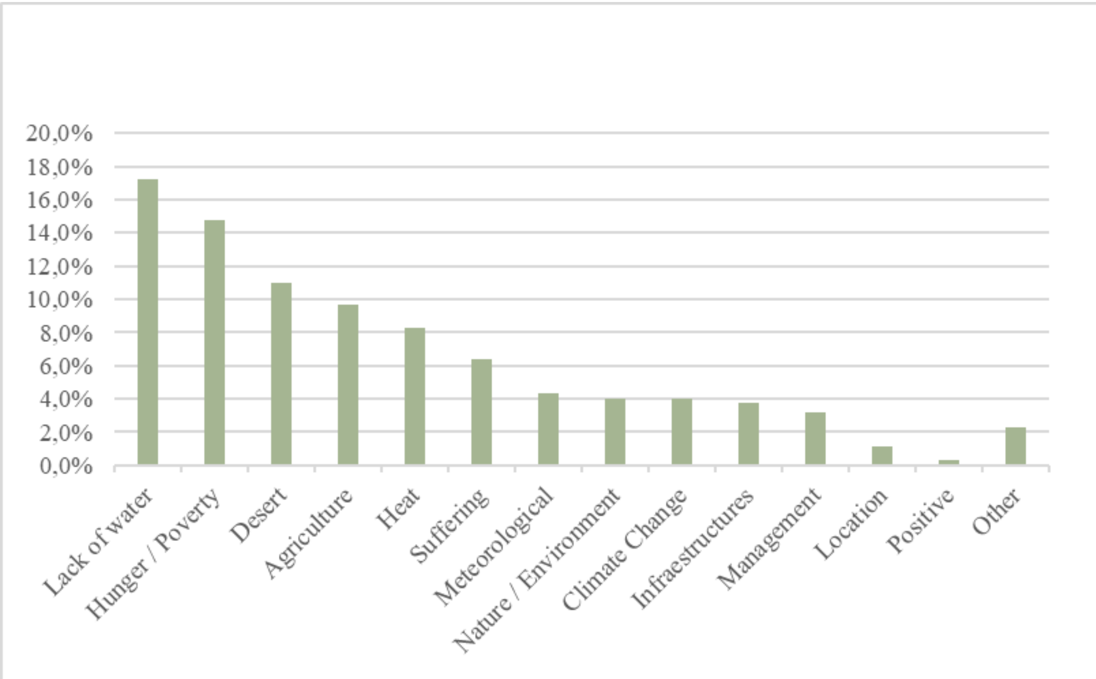

Figure 15. Second Idea about droughts.

They were also asked to associate the ideas they had expressed in the previous step with the emotions or feelings they experienced. As figure 16 shows, most of the feelings are negative, with grief, feelings of loss, worry, and discomfort standing out. Feelings such as fear and guilt are also prominent.

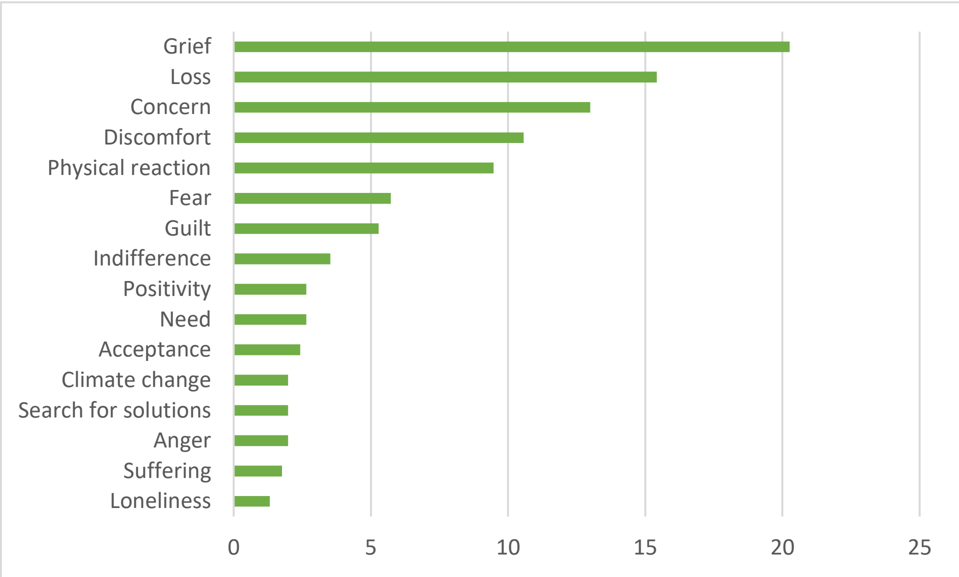

Figure 16. Feelings and emotions

In the survey, they were asked to rank the effects of the drought in Spain according to their severity, from most severe to least severe (recorded in table 8). We will go back to these results when we present the results from the valuation exercise. Biodiversity loss and fire risk are the most serious for respondents.

Gravity of effects
Loss of biodiversity
Increase in the risk of fire
Loss of water quality
Health effects
Changes in landscapes
Water use restrictions
Low agricultural production
Effects on Forest: less plant growth and increased sensitivity to pests
Increased likelihood of invasive species
Decrease tourist demand

Table 8. Gravity of droughts' effects ordered

As far as adaptation to drought is concerned, 85.1% of interviewees answered affirmatively and the main reasons put forward for those who do not believe in adaptation, are that it *is too late*, *lack of conscience,* and *political interest*. Again, the high percentage of pessimistic responses is highlighted. This may be an important indicator to explore inaction on climate change or the choices made in the *choice experiments*.
We had to check if the answers were related to their climate change perception, thus we asked a battery of questions on the subject. Figure 17 shows their responses to climate change effects' timeline. 50% of individuals responded that climate change effects can be appreciated right now and before than 3 years. It is quite surprising that, after the effort spent during the past decade in awareness campaigns, there is still 50% who do not relate the world's environmental present situation with climate change.

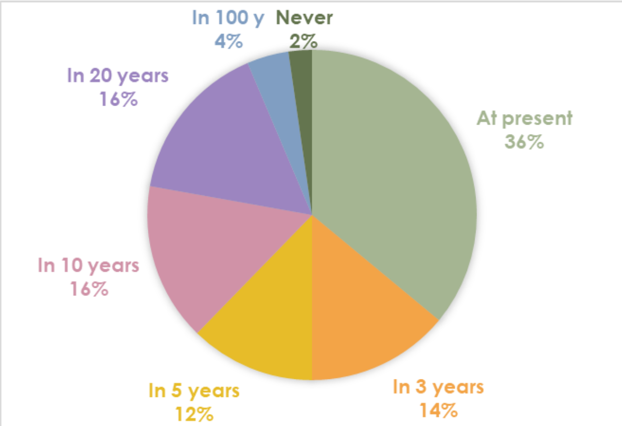

Figure 17. When climate change effects will be felt

About the effects of droughts in the Pyrenees specifically, we divided the sample into two sub-samples, each receiving a set of slightly different questions; the first group answers in table 9 and the second group in table 10. The reasons for this checking were to test if responses change as a result of the wording. Coherently framing a question adds credibility to the interview. However, the main question, in the end, is the same: *how likely do you think the landscape is going to change?* If we add a restrictive condition: *as a result of a severe drought*, the probability should be lower than that provided without that condition but we got the opposite result. Comparing the first two questions of both tables with the U Mann-Whitney (sign. <-0.001) we found that there are significant differences among them. While for the second question *how likely ... a severe drought in the next 10 years / a severe drought in the Pyrenees in the next 10 years due to climate change* is as expected, a more restrictive condition with fewer probabilities of occurrence.

How likely …	Very unlikely	Unlikely	Likely	Very likely
… do you think the landscapes of the Pyrenees changing in the next 10 years as a result of a severe drought?	4.5	19.0	51.1	25.4
… do you think there will be a severe drought in the next 10 years?	1.5	10.4	60.1	28.0
N	267			

Table 9. Probability of Pyrenees landscape change and a severe drought, the first group

How likely …	Very unlikely	Unlikely	Likely	Very likely
… do you see the landscapes of the	6.0	25.4	48.8	19.8

Pyrenees changing in the next 10 years? … do you think there will be a severe drought in the Pyrenees in the next 10 years due to climate change?	7.5	33.7	49.6	9.1
N	254			

Table 10. Probability of Pyrenees landscape change and a severe drought, the second group

5.2. Recreational behavior

Recreational activities require the "use" of the assets. 43% of individuals (table 11) of the sample make regular day trips to natural areas while 22% of the sample never do. Of those who report taking day trips, 54% take 1 or more trips per month. We assume that our sample is representative of the Spanish population, so this implies that the demand for excursions to mountain areas similar to the Hecho Valley is in the order of 17.5 million visits a month in Spain. However, throughout our research, we have adopted a conservative approach by taking the lower values of the estimates and declared values. For example, if the reported number of visits is less than 1 per month, it is assumed to have a value of 0, or if they say several visits greater than 3, no more than 4 trips are attributed. This implies that the values we provide here are conservative as well and that the actual numbers are higher than those estimated and reflected here.

Outdoor recreational habits	%
Day trips	42,9
More than a day	17,5
On holidays	17,9
Never	21,7

Table 11. Outdoor recreational habits

Visits to Hecho Valley or alike	%
All	12,7
More than half	20,4
Half	17,1
Less than half	22,9
None	26,9

Table 12. Visits to Hecho Valley or similar

From this information, we can infer that nearly 33% of the sample makes recreational visits to mountain areas like Hecho Valley (table 12), kinds of sites sensitive to the proposed changes in vegetation.

In our study, individuals were shown the areas where 10% of vegetation could disappear during a severe drought (see figure 18) where the main species are *Abies Alba* and *Fagus Sylvatica*. Around 86% declared that they would stop visiting or decrease the number of visits in this case.

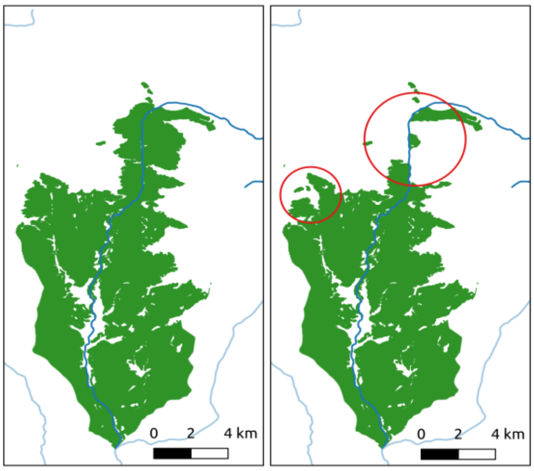

Figure 18. Simulated loss of vegetation 10%

In 2018 we conducted a survey of the Spanish population within the framework of the AGUAMOD Project, where, among others, we wanted to know the recreational uses of Spanish water bodies (https://mycore.core-cloud.net/index.php/s/nllflOREUM5bsij#pdfviewer). From that project, we selected the visits made to the study area (being the 3.6% of the sample) for further analysis we combined this information from that generated in this project. Figure 19 shows the area. Declared visits were 3.12 visits per year. These are very close to the values observed in this survey.

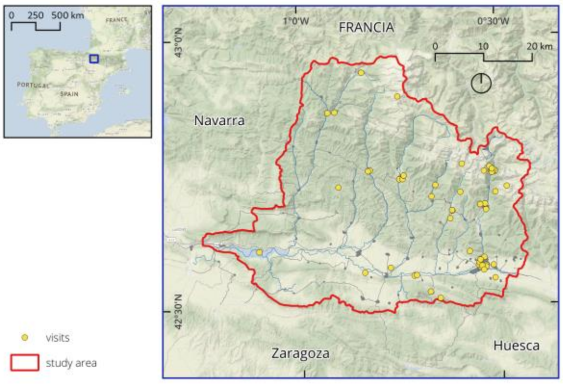

Figure 19. Points of visits selected

As aforementioned above, the most suitable method to learn about and value recreational uses of free access areas is the travel cost method (TCM), an approach based on revealed preferences. It uses the costs incurred by the individuals as a proxy for the costs of access and price of entry. Thus, we have used the travel costs incurred by individuals as a proxy for the "price" of a recreation day out at Hecho Valley.

The best basic model is the one with the travel costs (in time and money), the importance of having a forest to visit, whether traveling alone or with others, and the level of education achieved. The results are in table 13.

	Parameter	p-value
Intercept	1.04	9,8e-8
TC	-0.0026	0.04
ForImp	0,3556	0.0092
Alone	0.1378	0.036
Educa	0.2436	0.015
N	*110*	

Table 13. TCM

From the estimated parameter for the Travel Costs, we derive the valuation per trip per group as in equation (2*bis*), €384.62. The size of the average group is 2,17 people, and the consumer surplus per person per visit is 177.24€. As mentioned, we consider that our samples on the recreational use of natural areas are representative of Spanish recreational behavior in natural areas. In 2018 and 2020 we recorded that the Hecho Valley was visited by 3.6% of the sample, which translated to the general population as 1692000 people. We also know that the average number of visits in 2022 to that area was between 2.1 and 3.16 per year. Taking an intermediate value of the number of visits of 2.7, the recreational use value of the Hecho Valley is estimated at over 788.72 million euros, considering only one-day excursions and leaving aside holidays or long periods and multi-purpose trips in the area. A 10% loss of vegetation in this area would result in a welfare loss valued at over 110.5 million euros.

5.3. Impacts on ecosystem services

Unlike recreational services, the valuation of intangibles is not based on direct use and revealed behavior, so it uses stated preference methods as discussed above. From equation 7, we estimate the model that explains the choices made during the experiments. Table 14 shows the description of other explanatory variables used in the estimation of the model. We found a high correlation between responses on attitudes towards climate change, environmental values, and personality with the choices made in the CE. In the model, we have included a variable (*CCNever*) that identifies those "deniers" of the effects of CC and two variables (*Dependence* and *Liveliness*) that reflect that there are emotional factors and personal characters that affect the valuation of impacts. These variables are measured in relation to the probability of choosing “doing nothing”, that is, the effect of any of these variables on the probability of choosing the *status quo* option. We will come back to explain this later on. In addition, we have included another personality variable (*Sentimentality*) that explains class membership. Other than *Income*, we did not find any significant socio-economic or demographic variables, i.e., age, gender, occupation, etc., explaining the choices or membership in one of the latent classes.

Variables included in the analysis	**Description and Values**
Dum_LastDrought	Dummy for those who remember the last drought
Income	Net monthly household income
CCNever	Dummy for those who believe that the effects of climate change will never be felt
Dependence	Assesses the need for emotional support from others. High scorers want to share their difficulties with those who will provide encouragement and comfort.

Liveliness	Assesses typical enthusiasm and energy. High scorers usually experience a sense of optimism and high spirits.
Sentimentality	Assesses a tendency to feel strong emotional bonds with others. High scorers feel strong emotional attachments and an empathic sensitivity to the feelings of others.

Table 14. Explanatory variables' description

Table 15 shows the parameters of the estimation. The best model (lowest *BIC* and/or *AIC*) is a model with 4 classes. According to economic theory, individuals are expected to want more of those attributes considered "good", which would be indicated by a positive relationship, while those attributes that reflect cost or *sacrifice* or are considered detrimental would show an inverse relationship.

Attributes/*β*	**Class 1**	**Class 2**	**Class 3**	**Class 4**	**Mean/S.D.**
Class size in %	55	26	11	7	
Area	0,064***	0,064***	0,064***	0,064***	0,064/0.0
Health	0,336***	0,185***	0,130***	0,256***	0,268/0.08
Biodiversity	0,150***	0,061***	0,099***	0,051	0,114/0.042
Water restrictions	-0,807	-0,986***	-0,170	-0,745*	-0,782/0.228
Not suitable for drinking	1,154**	-1,031***	-1,126***	0,354	0,270/1.046
Good quality	-0,347	2,017***	1,295***	0,391	0,512/1.040
Cost	0,038***	0,000	-0,148***	-0,127***	-0,004/0.065
Dum_LastDrought	0,000	0,000	-1,373***	1,679***	
Dependence	-0,134	0,308*	-0,663***	-0,614**	
Liveliness	-0,155	0,334**	0,544***	0,883**	
CC Never	0,666***	0,666***	0,666***	0,666***	
Intercept	0,375	0,282	0,257	-0,914	
Income	0,150***	0,040	-0,160***	-0,030	
Sentimentality	0,439***	0,157	-0,124	-0,472***	
R^2	0.58	0.54	0.44	0.44	0.58

*Table 15. LC discrete choice model results. ***, **, *, Significance at 1, 5, and 10% respectively*

To help understand choices and comparison both among attributes and through classes figure 20 provides the relative re-scaled (adds up to one) maximum effects for each of the attributes within latent classes. This is obtained as:

$$relative\ effects_{xp} = \frac{maxeff_{xp}}{\sum_p maxeff_{xp}}$$

It seems an inconsistency that, when respondents were asked to order the effects of droughts according to their severity (table 8), *Biodiversity* or *Loss of Biodiversity* was chosen first but, in the choice experiments, was not that important compared with the rest of the impacts; Class 1 values it the most. For all classes, the effect of *Area* is the same since we fixed this parameter on the estimation for a better model. Health is the most valued attribute for Class 1 and with similar importance for classes 2 and 4. The attribute with the greatest variability in its valuation is *Wateruse*, so we present a separate figure with more detail.

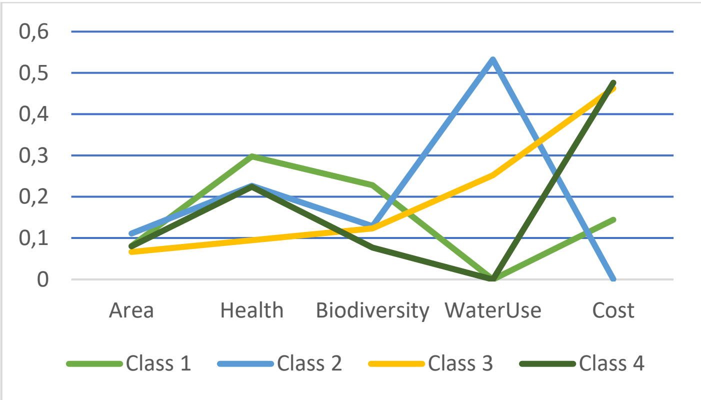

Figure 20. The relative importance of attributes by class

The attribute *Wateruse* is not important at all for class 1, (only *Not suitable for drinking* was significant); to know whether it is not an important attribute or whether it is a case of *attribute non-attendance*, a specific analysis is needed. For Class 2 all levels of *Wateruse* were important. For class 3, although all levels have the expected sign (negative for detrimental and positive for good water quality), restrictions on water use have not affected the choices made by individuals in this segment. And lastly, for class 4, also with the expected sign, restrictions on water use did matter for choices in CEs, but not for good water quality or water supply cuts. As can be seen in Figure 21, maintaining good water quality, except for class 1, is the most chosen level of the *Wateruse* attribute across classes.

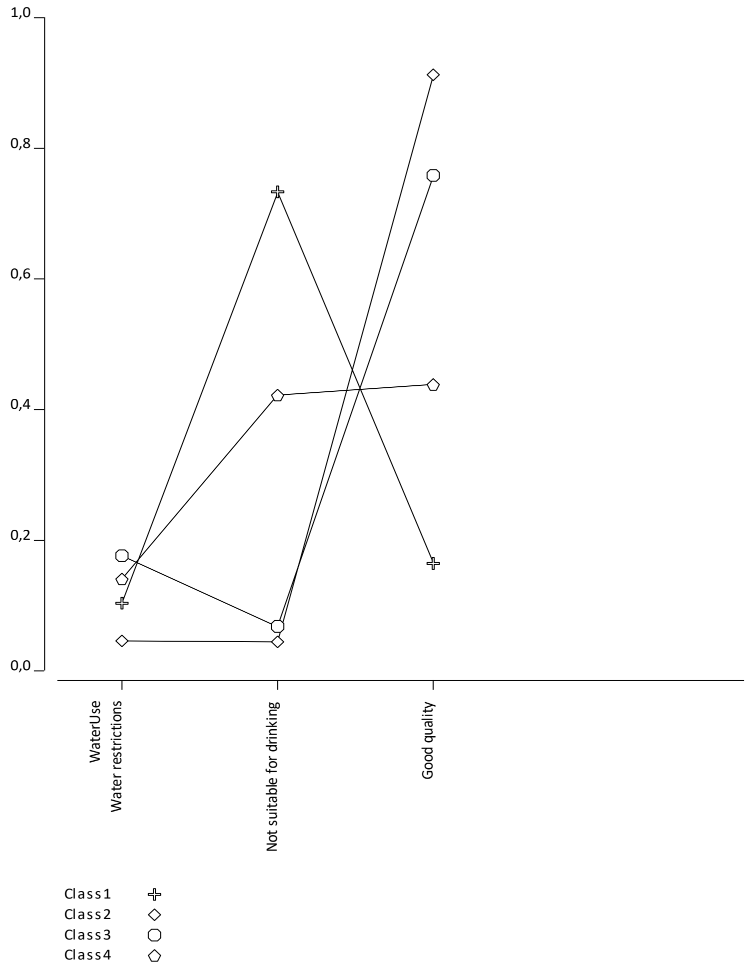

Figure 21. Wateruse conditional probabilities

Figure 22 shows the class-specific attributes' effects (β parameters) that are transformed by an inverse logit transformation and thus sum to 1 across attribute levels within classes. This figure describes the relationship between the latent variable and the explanatory variables by class, here, the comparison between classes is not appropriate.

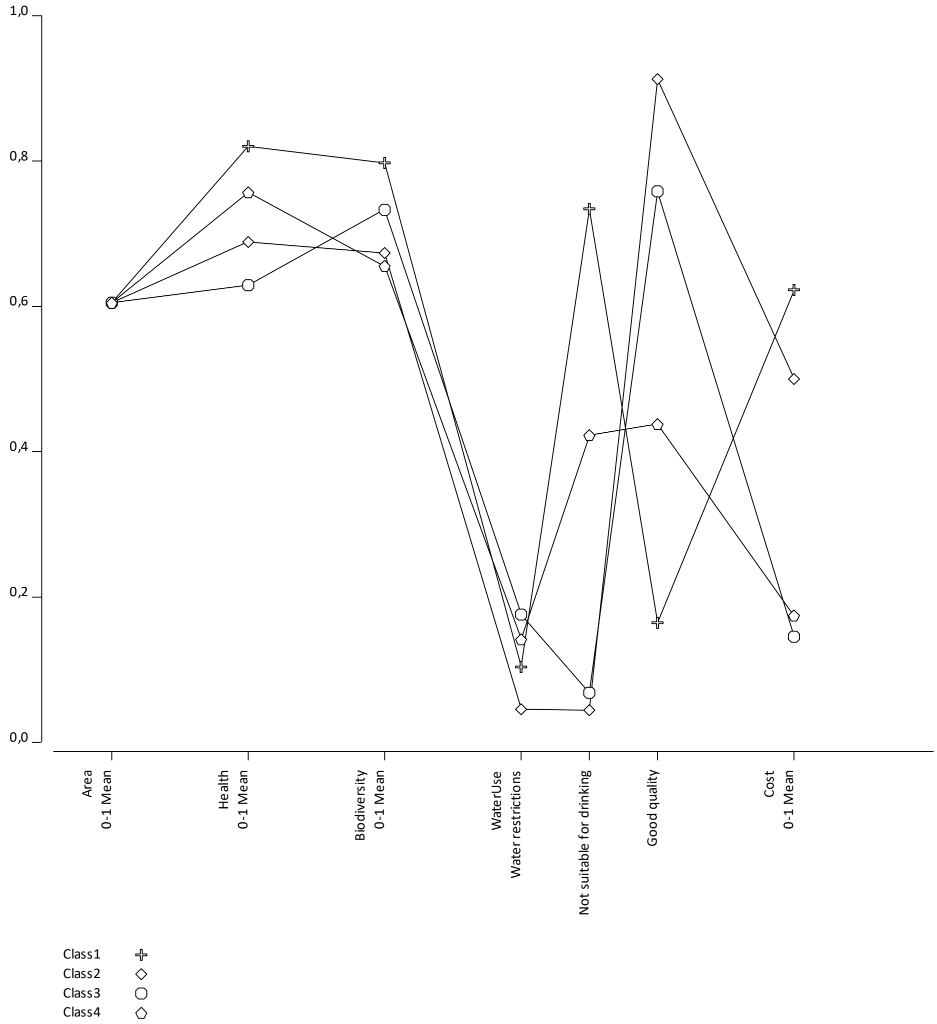

Figure 22. Latent classes' Profile

In this way, it can be appreciated that the most appreciated attribute for *Class 1* is *Health* followed by *Biodiversity* and the least is the *Wateruse* since it was not significant at all in the choices. As mentioned above, class 2 has not considered the cost of remediation alternatives, but all other attributes are significant. Thus, the most valued attribute and level is good water quality followed by health and biodiversity. Class 3 took the cost of remediation alternatives into account when making their choices and the most valued attribute was good water quality. Finally, for Class 4 *Wateruse* was just significant for avoiding *Water Restrictions* or *Cuts,* and *Cost* was carefully considered during the choice experiments. Class 3 and Class 4 are the closest in preferences.

To understand the effect of the drought on people, we need to consider the sample-wide estimates for all classes but only significant variables should be considered. Significance implies that the attribute matters for the respondents, thus, to elicit a value per attribute, at least, the *Cost* variable should be significant. Also, we expect the *Cost* attribute to be negative, indicating that individuals always prefer to pay less rather than pay more. For the rest of the attributes, negative values indicate disutility/harm for the individual. Those strict conditions are met only by classes 3 and 4. Class 1 has a significant *Cost* parameter but it is positive, it may be explained as individuals choosing regardless of the cost in the hope of obtaining improvements in other attributes. In the focus groups and follow-up questions, it was recurrent that, given the difficulty of choosing when you do have not much knowledge about it, choosing the most expensive option is a guarantee that something will be done. That is, people want remediation actions but they are not certain how to choose. Another reason for choosing the option with the highest cost is that individuals have no income restrictions or the proposed amount is too low so it can be overlooked. On the other hand, Johansson and Kriström (2020) adduce reasons why these responses, seemingly outside of economic theory, may make sense, which is that it may be a manifestation that the respondent feels that he/she is already paying too much in taxes and therefore should get the best without paying extra.

Looking at the personality variables, we see that the sign of the *Dependence* variable is negative, i.e., those who score low on this characteristic are more likely to choose other options than the *status quo* in classes 3 and 4, while those who score high are more likely to choose the *status quo* in class 2. As for the variable *Liveliness*, those who score high in enthusiasm and optimism will choose the *status quo* option more likely than those who are less optimistic.
CCNever, again, those who believe that the effects of climate change will never be felt, are more likely to choose the *status quo* option than the rest.
In summary, the *status quo* option is the choice of not applying any remediation or preventing negative impacts from droughts, in other words, it is the expression of not wanting to pay, for whatever reason, that prevents us from extracting a value from the choice experiments.

On the other hand, *Sentimentality* explains class 1 and 4 membership with opposite signs, i.e. those who score high are more likely to be in class 1 while those who score low are more likely to be in class 4. In other words, people who are sensitive to the feelings of others, and with high emotional attachments, (we assume it could be environmental), are more likely to belong to class 1.

From equation (10) we obtain an approximation of the value people place to avoid welfare losses through the *willingness to pay* (WTP). This individual WTP is per attribute increase/decrease (1%/category/unit) per person in table 16. The willingness to pay per person to avoid the loss of 1% of the forested area is 16.82€ while avoiding health impacts on one person is 70.49€ or the loss of a species is 29.98€. Water use restrictions or water quality losses amount to €83.05 and 104.19€ respectively. From these unit values, we can calculate or simulate the impact that a drought can have on a population.

	WTP in €
Area	16.82
Health	70.49
Biodiversity	29.98
Water restrictions	-83.05
Not suitable for drinking	-104.19
Good quality	178.18

Table 16. Willingness to pay to avoid damages for 1%/unit increase/decrease

To calculate an aggregate value, we should consider the percentage of the sample represented by a class and the size of the population applying weights together with a quantification of the effects or a specific drought.

5.4. Stakeholder's perceptions

We interviewed a small group of stakeholders (21), including individuals with business, scientific, and trade union interests, as well as different groups in the Jacetania region. They completed the same survey as the consumer panel. This sample itself is already biased, so we expected that attributes such as cost would not be significant in their choices. The only relevant attributes in the choice were health and biodiversity, the latter being the most important. Restrictions on water use or water quality were also not significant, which was also an expected result since such a situation would be unlikely and therefore not very credible in that part of Spain. Table 17 shows the results for this collective.

Attributes/β	β	Importance
Area	0.023	0.027
Health	0.403*	0.323
Biodiversity	0.255*	0.35
Water restrictions	-0.4321	
Not suitable for drinking	-0.708	0.212
Good quality	1.14	
Cost	0.026	0.089

*Table 17. Stakeholder's choices. * Significance at 1%*

Since these results are not representative, we include this table just for illustration. Unlike the general population, the stakeholder group values biodiversity above all other attributes. Health is a close second but they are the only significant variables. We were surprised with the fact that changes in the forested area were not significant.

6. Some conclusions

Climate change in general and drought, in particular, are of great concern to the population.

Climate change and the fear of drought are causing a lot of discomfort among the population.

In general, the most valued attribute affected for droughts is the good quality and availability of water and the next is health.

There are important differences in the assessment of the effects of drought among different segments of the population.

We have obtained unit values that allow us to quantify the negative impact of drought on non-market goods and services.

Certain aspects of personality and attitudes and values are good predictors of the value individuals place on drought impacts.

Changes in forested area (10% loss) would result in a welfare loss valued at over 110.5 million euros.

In our work we have only included respiratory incidences, but we know that droughts have other health effects that would be interesting to explore in future work.

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8. ANNEX

	Class 1	Class 2	Class 3	Class 4
Net Income				
Up to 900€	0.0964	0.1585	0.3976	0.1505
Between 901 and 1350€	0.1831	0.2295	0.1430	0.3820
Between 1351 and 1900€	0.1860	0.2044	0.2762	0.1285
Between 1901 and 2700€	0.3191	0.2556	0.0684	0.1815
More than 2701€	0.2153	0.1520	0.1147	0.1575
Mean in €	1853.01	1643.1	1240.99	1507.11
Age				
18 - 33	0.2130	0.1642	0.1833	0.2096
34 - 45	0.1706	0.2743	0.2005	0.2546
46 - 54	0.2106	0.1975	0.1779	0.1715
55 - 62	0.1992	0.1881	0.1661	0.1308
63 - 90	0.2029	0.1757	0.2722	0.2334
Mean	49.2380	48.4733	51.2464	48.2821
Sex				
Man	0.5744	0.5276	0.5456	0.5210
Woman	0.4180	0.4721	0.4544	0.4788
Education				
No formal education	0.0000	0.0000	0.0202	0.0000
Primary	0.0300	0.0254	0.0928	0.0474
Secundary	0.3646	0.3812	0.3172	0.3794
Bachelor’s Degree or Diploma	0.2329	0.2577	0.2852	0.1873
University Degree	0.3512	0.2982	0.2260	0.3553
Doctorate	0.0213	0.0374	0.0587	0.0307
Occupation				
Military pólice and civil guard	0.0302	0.0250	0.0203	0.0043
Directors and managers	0.0586	0.0563	0.0765	0.0669
Scientific and intellectual technicians and professionals	0.2683	0.2079	0.2001	0.1949
Technicians, support professionals	0.1226	0.0761	0.0373	0.0985
Accountants, clerical, and other office workers	0.2545	0.3324	0.3078	0.3131
Catering, Personnel, protection, and salespersons	0.0581	0.0689	0.0664	0.0378
Agriculture, livestock, forestry, and fishing sector	0.0072	0.0332	0.0212	0.0000
Craftsmen and skilled workers in manufacturing industries	0.0442	0.0223	0.0560	0.0646
Plant and machinery operators and assemblers	0.0171	0.0174	0.0294	0.0308
Unskilled labor	0.1393	0.1604	0.1852	0.1891

Growth site (less than 5000 inhabitants) Dummy	0.2072	0.2100	0.2556	0.2176