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Assessing public preferences for a wildfire mitigation policy in Crete, Greece

Haleema Misal [a,b,d,*], Elsa Varela [c], Apostolos Voulgarakis [b,d,e], Anastasios Rovithakis [d], Manolis Grillakis [d], Yiannis Kountouris [a,b]

[a] Centre for Environmental Policy, Faculty of Natural Sciences, Imperial College London, Princes Gardens, SW7 1NE, United Kingdom
[b] Leverhulme Centre for Wildfires, Environment and Society, Imperial College London, Department of Life Sciences, London SW7 2AZ, United Kingdom
[c] Georg-August-Universität, Department of Agricultural Economics and Rural Development, Göttingen, Germany
[d] Technical University of Crete, Department of Chemical and Environmental Engineering, Akrotiri Campus, Chania 731 00, Greece
[e] Department of Physics, Faculty of Natural Sciences, Imperial College London, SW7 2BW, United Kingdom

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ABSTRACT

The increased frequency and severity of wildfires in the Mediterranean region generates significant damages in ecosystems and landscapes while harming human populations. Institutional complexities, along with socioeconomic and demographic changes encouraging development into the wildland-urban interface, rural abandonment, and focus on fire suppression, are increasing the vulnerability and flammability of Mediterranean ecosystems. Developing effective strategies for managing wildfire incidence and its aftermath requires understanding of the public preferences for wildfire policy characteristics. Here we elicit public preferences for wildfire mitigation policies employing a stated choice experiment applied in Crete, Greece. A region with typical Mediterranean landscape experiencing significant development and rural-to-urban migration that disrupts existing fire regimes. We estimate conditional logit, mixed logit and latent class models to study the general public's preferences and willingness to pay for limiting wildfire frequency and agricultural land burnt, maintaining landscape features, and managing post-wildfire recovery. Results of our study show that measures to manage post-wildfire damage are consistently valued as the most positive amongst the sampled respondents, achieving values that range between €25.92 in conditional logit model to €46 in one of the latent classes identified. Improving the landscape quality follows in importance, although it shows more heterogeneity in the responses. The latent class approach allowed to identify that those associated with either the agricultural or the tourism sector of the sampled individuals, displayed significantly different preferences for the proposed attributes. Overall, our findings indicate that there is a strong preference amongst the general public to shift current policies based on suppression towards more integrated approaches dealing both with prevention and post-fire management. The outcomes of this study serve to guide decision makers on targeted management plans based on their audience.

1. Introduction

Wildfires in Mediterranean Europe burn on average 4500km^2 every year causing severe ecological, economic and social damages (San-Miguel-Ayanz et al., 2013; Turco et al., 2018). Whilst Mediterranean ecosystems have adapted to fire, socio-economic changes and climate change are contributing to longer and more severe fire seasons, reducing their resilience and making them more vulnerable (Commission, E, et al., 2019). Similarly, drought and heatwaves are expected to increase in frequency due to climate warming, with small variations in future climates leading to substantial changes in ecosystems (Volosciuk et al., 2016; Dupuy et al., 2020; Turco et al., 2018; Brotons et al., 2013).

Greece is severely affected by wildfires, having the highest yearly average fire size amongst Mediterranean countries from 1980 to 2019 (San-Miguel-Ayanz et al., 2022). Over the last two decades, Greece has experienced on average 2000 wildfires annually, with the severity of fires expected to continue to increase, especially in its island regions (Papagiannaki et al., 2019; Georgoulias et al., 2022; Rovithakis et al.,

* Corresponding author at: Centre for Environmental Policy, Faculty of Natural Science, Imperial College London, Princes Gardens, SW7 1NE, United Kingdom.
E-mail address: hm4117@ic.ac.uk (H. Misal).

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2022). Recently wildfires attracted significant policy and public interest following the deadly 2018 Attica wildfires which resulted in over 100 casualties and 1250 ha burnt (Lagouvardos et al., 2019).

Socio-economic factors, such as rural exodus leading to land abandonment as well as the disappearance of traditional land management practices which creates a homogenous fuel dense landscape, give rise to unpredictable and extreme wildfires (Fernandes et al., 2019; Viedma et al., 2015; Rego et al., 2010). These socio-ecological vulnerabilities are especially evident in the mountainous islands of Greece such as Crete with high fuel loads and dispersed populations in difficult to access areas (Colantoni et al., 2020; Mengist et al., 2020) where emergency response times can be longer and less effective (Lal et al., 2011; McLennan and Birch, 2005). But public funding and active fire management tends to focus on areas with higher population density, while social mobility and the desire for second homes further contributes towards the degradation of traditional landscapes, increasing pressure on remote wildland and forest ecosystems (Kizos et al., 2017).

Further strain on remote and island ecosystems in the Mediterranean region comes from the extensive and growing tourism industry. This has exacerbated unregulated costal urbanisation and promoted commercial land use, both of which contribute to the expansion of the wildland-urban interface (WUI), increasing human-caused ignition opportunities (Briassoulis, 2003). Increased activity associated with visitors during the tourist season increases the risk of wildfire ignition due to lack of fire awareness, indirect pressures on the landscape in vulnerable regions, and housing units in close proximity to flammable vegetation (Salis et al., 2021; Vogiatzakis et al., 2020).

At present, wildfire management strategies in Greece focus on fire exclusion with governments responding to wildfire problems by increasing their firefighting budget (Xanthopoulos et al., 2022; Moreira et al., 2011). There is increasing evidence that fire suppression, especially during catastrophic wildfires, has a limited ability to mitigate the risk of major disasters when not used in tandem with preventative tasks (Moreira et al., 2020).

Implementing preventative tasks such as reducing fuel loads through clearing forests, creating fuel breaks, or increasing monitoring activities, are important pathways for mitigating the damages of wildfires (Damianidis et al., 2021). Shifting management policies towards prevention and maintaining landscapes that are naturally wildfire prone such as Crete requires integrated management with the local population (Bertomeu et al., 2022).

This is why decision makers need to understand attitudes and preferences towards the status quo and how to communicate policy proposals (Toman et al., 2006). Economic valuation surveys estimate social benefits for shifts in the current suppression-oriented policies by measuring the change in social welfare that this would produce. This allows a comparison of the costs of current wildfire policies with alternative interventions, therefore contributing towards fair and equitable policy making (Varela et al., 2014a; Soliño et al., 2012). Using the public as agents in this process by institutionalising their preferences can result in stronger government-citizen relations, ensuring greater acceptance for political outcomes (Caddy and Vergez, 2001).

In this paper, we undertake a discrete choice experiment (DCE) survey to ascertain public preferences for a wildfire mitigation policy on the island of Crete. The novelty of this study is that we focus specifically on the preferences of Cretans. And differently from previous studies (Varela et al., 2014a; Alló and Loureiro, 2020; Soliño et al., 2018), we consider a mix of attributes required for an integrative wildfire policy. We simultaneously encompass wildfire-related outcomes such as reduction of wildfires and burnt area, as well as changes leading to more resilient wildfire landscapes, and measures to restore and protect burnt areas. Economic valuation is used here to understand the positive externalities of integrative policy strategies on wildfire management. Incorporating the results of this study into decision making frameworks can strengthen the rationale for improved wildfire policy.

2. Material and methods

2.1. Literature review

Environmental valuation methods are being increasingly used to assess public preferences for changes on wildfire policies. One of the seminal studies on this respect was conducted by Loomis and González-Cabán (1994) which showed that social demand existed for protecting old-growth forests from fires in Oregon, USA. Kaval et al. (2007) use a CVM to assess preferences for a fire risk reduction programme in Colorado, USA, showing that homeowners support adopting a policy that uses prescribed burns to reduce fire risk. A significant number of the studies conducted in the USA focus on assessing the preferences of homeowners for wildfire prevention management since spread settlement in the (WUI) is a salient issue in the region. Loomis et al. (2009) use the CVM to examine homeowners WTP for fuel treatments across three states (California, Florida and Montana) and find positive preferences for the programme. Further model testing found that respondents were more likely to pay for the programme with increasing acreage reduction. Meldrum et al. (2014) use a choice experiment in Colorado to examine homeowners WTP for a cost-sharing programme that clears vegetation around homes. Irrespective of the different population sample examined in these studies, both types of actors (homeowners and landowners) gained utility associated with the hypothetical management programmes. Regmi et al. (2023) use a DCE for a prescribed burning programme in Pennsylvania, results show respondents had a WTP between $11–$19 per acre for the fuel treatment. Further modelling in these studies showed that WTP varied when regressed against independent variables. For example, those with higher incomes and younger respondents were most likely to pay more for the programme.

In a Mediterranean European context, the work by Varela et al. (2014a) and Varela et al. (2014b) in Spain also focus on fire prevention management, more specifically addressing preferences for fuel break management options that differ with respect to fuel break design and landscape integration. Findings show that people would support wildfire prevention structures that are more integrated into the landscape and maintained with low biomass content, either using light machinery or the involvement of local shepherds. More recent studies looking at preventive measures and WTP values associated with these include work by Tabatabaei et al. (2015) who use the CVM to estimate WTP for two forest management options that would reduce intensity of future wildfires by removing beetle killed and dying trees in Colorado. Results showed substantial WTP from respondents, indicating support for active forest management and associated negative externalities such as reduced air pollution and post wildfire water quality.

Forest biomass extraction has also been considered as a form of active wildfire management, aiming to decrease the available surface fuel and reduce further wildfire hazards (Regos et al., 2016). Soliño et al. (2010) assess preferences for a forest-energy policy to reduce forest fires in Galicia, Spain. Results show that households are WTP €38 per year for this programme. A further similar study by Soliño et al. (2012) look at consumer preferences for electricity generated from forest biomass with aims of reducing wildfire risk. Amongst the five attributes presented, the attribute 'decrease in the risk of forest fires (%)' was the highest valued positive externality effect of the programme, highlighting the importance Galician households express on fire risk. Similar results are mirrored in Pinto et al. (2022) who use the contingent valuation method and elicit individuals' WTP to increase installed capacity for production of electricity using forest bioenergy in Portugal. Respondents WTP increased when presented with information on the benefits of biomass energy, most notably with respect to forest fire prevention, demonstrating increased social acceptability for policies that reduce wildfires.

Some valuation studies have addressed wildfires as part of larger assessments on ecosystem management. Riera et al. (2007) assess impacts of climate change on Mediterranean shrublands in Spain. Attributes that affected shrublands included: 'soil erosion', 'fire risk' and

'plant cover'. Results showed welfare loss was highest for 'soil erosion' followed by 'fire risk', highlighting respondents' preference for prevention tasks *e.g.* through forest corridors and wider impacts that catalyse damages of wildfires (soil erosion). Varela et al. (2017) also look at preferences for reducing damages of wildfires indirectly as a result of active management of Aleppo pine forest in Catalonia where attributes relating to wildfires include preferences for reduction in burned area.

Other forms of wildfire management include traditional activities such as resin tapping, a declining activity widely implemented across southern European Mediterranean regions for economic and social reasons which also sees a reduction in forest fires (Moussouris and Regato, 2002). Some studies deal with the recovery of these activities which can produce landscapes that are more resilient to wildfires. Soliño et al. (2018) examine social preferences for several attributes of resin tapping in Spain. Results of the choice experiment showedthat people were most concerned about the risk of forest fires and were willing to pay more to obtain a low risk of fires. Highlighting the extent of benefits derived from traditional wildfire management in relation to forest fires. We expand on such studies and include landscape as an attribute which will allow for traditional activities and tourism to take place whilst reducing wildfire risk.

Our study aims to comphrensively address all aspects of wildfire damaes, from proactive prevention tasks to post-fire issues which are often not prioritised. Previous studies such as Alló and Loureiro (2020) show that citizens significantly value attributes that actively prevent and reduce the impacts of wildfires as well as ndirect methods of reducing wildfire incidence such as planting resistant species, also provide utility to respondents. Additionally, the study conducted by Durán-Medraño et al. (2017) in Galicia, Northern Spain, stands out as one of the few studies to address both preventive and post-fire management measures. The study considered attributes related to monitoring, cleaning, and active forest management to mitigate damages caused by wildfire events. The results reveal that respondents highly value attributes associated with biodiversity loss and post-wildfire damages.

Our study integrates wildfire prevention and post-fire measures by addressing management aspects of the landscape that deal with sustaining economic values. By not limiting the study to coastal, rural or urban areas only, we attempt to operate away from silos and integrate all types of environments affected by wildfires in Crete. Building on previous studies we address the most pressing issues related to wildfire in Crete and remain cognizant of sustaining the cultural and social values associated with our policy and the landscape of Crete. Within the context of wildfire in Greece and Crete in particular, to our knowledge, this is the first economic valuation study undertaken for the assessment of public preferences for a wildfire mitigation policy.

2.2. Study area

Crete is the largest most populous island in Greece, located at the southern edge of the Aegean Sea, at about 160 km from the mainland. The island covers 8336 km^2, accounting for 6.3% of the total Greek land area, with a population of 623 k inhabitants[1] (Hellenic Statistical Authority, G, 2014). Crete has seen an average of 1430 ha/yr of burnt land between 2000 and 2021 as shown in Fig. 1 (a). The percentage of area burnt per year for the prefecture of Chania, Crete (all four prefectures) and Greece is shown in Fig. 1(b) highlighting that Chania is close to the Crete average. Both are within the Greece interquartile range, or even higher for several years, showing that for Crete and Chania, wildfire problem is as important as it is for most of Greece.

Along with its pyrophilic landscape, Crete has steep topography with elevation varying up to 2456 m (Fig. 2 (a)) above sea-level. Its dramatic landscape is characterised by four mountain ranges, with surface water determined by its respective topography and rainfall (Varouchakis et al., 2018). The average rainfall on the island is 878 mm/year exhibiting a decreasing gradient from west to east. It ranges between 440 mm/year on the eastern part of the island to >2000 mm/year on the western mountainous regions (Grillakis et al., 2020).

Fig. 2 (b) illustrates zones of high flooding across the island, these areas are located near roads and settlements as shown in Fig. 2 (c) constituting potential damages to livelihood after a wildfire event. Future rainfall regimes suggest less rainfall but increased intensity of rainfall events and are expected to interfere with soil erosion processes (Grillakis et al., 2020) with both urban and rural/mountain areas of Crete prone to intense flooding (Tichavský et al., 2020). The Water and Land Resources Degradation Index (WLDI) for Crete suggests that low average rainfall coupled with high water demand may significantly affect water and land degradation (Tsesmelis et al., 2022). Degradation of land occurs mainly in areas with high agricultural and tourist activity and with climate change affecting water availability (García-Ruiz et al., 2011), a deficit in water budgets stress agricultural productivity, tourism and threatens the general wellbeing of Cretans (Chartzoulakis et al., 2001; Toth et al., 2018; Kourgialas et al., 2018).

The Cretan landscape is heterogenous, influenced anthropogenically through pastoralism and agricultural activities over the past ten millennia (Blondel, 2006). Land use and land cover (LULC) change owed to agricultural extensification, rural abandonment and intensification accelerated after the 1970s resulting in huge expansions of traditional crops such as olive and citrus groves (Zambon et al., 2018). The olive groves of Crete account for 26.7% of the total olive area cultivation in Greece (213,521 ha) (Kosztra et al., 2019). These carry significant cultural and economic value for the local economy with olive oil production being one of the most profitable crops for farmers in Crete (Stobbelaar et al., 2000) However, such economic and agricultural advancements have had unintended side effects on the ecology of the region.

Land use and land cover changes as illustrated in Fig. 3, highlight the gradual increase in forested areas and olive groves. Intensity of land use has changed as opposed to increasing land use types, primarily in response to subsidies provided through the Common Agricultural Policy (CAP) in the 1980's (Kosmas et al., 2016; Varela et al., 2020). During the 1990's and 2000's vineyards were largely replaced by olive plantations (Panagos et al., 2014). While terraced olive groves traditionally managed in mountainous regions were abandoned and consequently subjected to secondary succession and colonised by trees such as cypress or pine (Grove and Rackham, 1993; Allen et al., 2006). Adoption of unsustainable farming practices and lack of maintenance of olive groves at higher altitudes in Crete has increased soil degradation, and risk of fire, further placing marginal, upland areas at risk of flooding (Karydas et al., 2008; Koutroulis et al., 2016; Allen et al., 2006).

2.3. Attribute selection and description

To elicit public preferences for changes in the wildfire mitigation policy, a DCE was designed considering five key attributes, summarised in Table 1. Attribute and level selection were guided by a review of the related literature, media publications and focus interviews with experts and stakeholders in Crete. The choice experiment was piloted and subsequently revised to reduce communication errors and ensure applicability. The following attributes were used: 'fire frequency, 'agricultural land burnt', 'landscape quality, 'protection post-fire' and 'tax' as the payment vehicle. The experiment assumes that without intervention conditions will deteriorate in the future based on climate modelling.

The first attribute conveyed the expected number of wildfires per year on the island due to climate change and human activities. Respondents were informed that a prescribed management programme was to be implemented by the Greek forestry service to reduce the availability of fuels for wildfires. This would include pruning trees, reducing the biomass in forests in turn allowing for effective fire suppression intending to reduce the number of fires surpassing ≥ 1 ha. Data from the Hellenic Fire Service show that over the past 20 years, Crete has

[1] Based on the 2011 Population Census.

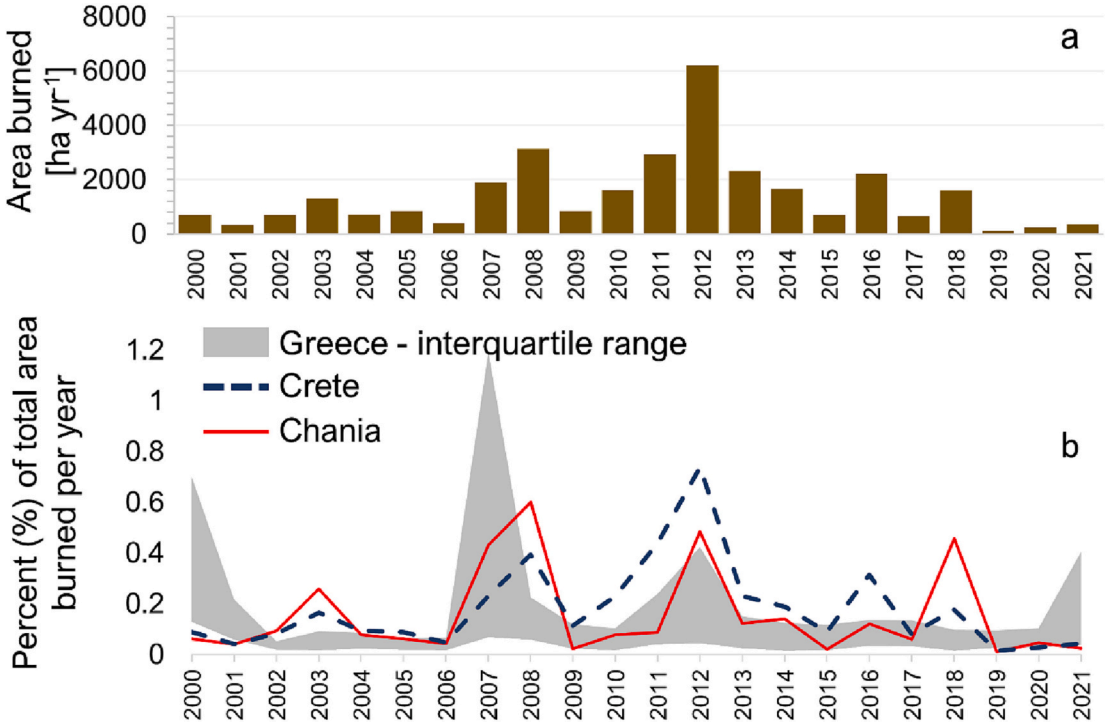

Fig. 1. a) Area burned per year on the island of Crete, in hectares. b) Percent area burned per year in Crete and Chania, comparing to Greece. Shaded area indicates 25th to 75th percentiles (interquartile range) of the burned area percentage amongst different Greek prefectures (NUTS3).

suffered on average 623 non-agricultural fires per year ≥ 1 ha. Depending on the scale and characteristics of the programme, wildfire occurrence in the future will be either above or below the current level. Depending on the intervention, 400, 500 or 600 wildfires would occur on average per year. We chose 800 fires per year as the status quo due to future climate predictions of Crete indicating that wildfire events will increase in the coming years (Rovithakis et al., 2022).

The second attribute focused on reducing the level of agricultural land burnt per year. For the purpose of this paper, levels are presented in hectares but conveyed to respondents in 'stremmas' (1 ha = 10 stremma). The levels started at 50 ha as the lowest number of agricultural land burnt followed by 100 and 200 with 350 ha as the status quo. We explained to respondents that the forestry service will be employed to monitor management of traditional crops such as olives, citrus and vineyards in order to prevent further number of agricultural land burnt per year by non-agricultural fires. Tasks completed by the forestry service include maintaining fuel breaks between crops and cleaning of excess litter that may be used as a source of fuel during a wildfire event.

The third attribute focused on landscape quality. The aim here was to introduce physical interventions such as fuel breaks and firewalls provided by the local government to reduce wildfire incidents. Respondents were informed that if the government could fulfil this through effective and aesthetically pleasing projects it will protect infrastructure in public and private lands with businesses operating in zoned areas. Many of these businesses are tourist related which contributes significantly to the local economy. Three levels were assigned to this attribute : i. 'maintaining all aspects of the traditional and unique Cretan landscape' (displayed as 'full'); this level would include the implementation of soft engineering approaches that align with the natural landscape ii: 'some visible hard intervention' (displayed as 'medium'); involved hard engineering that would be as effective but with some scarring of the aesthetic landscape iii. 'no intervention' included as the status-quo.

The penultimate attribute featured protection against post-wildfire damages. This attribute was binary, with levels 'present' or 'absent'. After a wildfire event, soil erosion may lead to flooding and landslides and well surface run off contaminating drinking water supplies. Similarly, damages to power lines, fallen trees and other infrastructure need to be monitored and mapped. This attribute aimed to increase monitoring through Unmanned Aerial Vehicles (UAV) which can identify and predict top-soil movements in the order of a few centimetres after wildfire events (Alexiou et al., 2021). To reduce the impacts of flooding, the government plans to contract specialist engineers to dredge rivers that manage erosion of watersheds damages by wildfires (Haring et al., 2021).

Finally, to implement these changes, respondents were asked to contribute towards the new policy through a one-time tax payment per household which was set from €10 - €50. We choose a hypothecated tax as the payment vehicle given its familiarity and transparency of costs associated with services from a new policy.

2.4. Survey design

We use an unlabelled discrete choice experiment to understand public preferences for a wildfire mitigation policy in Crete. Unlabelled alternatives were utilised here to help minimise non-trading situations in the experiment (Doherty et al., 2013; Czajkowski and Hanley, 2009). We offered respondents 6 choice cards, with three alternatives each including a status-quo option (Fig. 4) to be consistent with Hicksian welfare theory (Scarpa et al., 2005; Marsh et al., 2011). The full design consisted of 12 choice cards. To minimise respondents' cognitive burden, the design was partitioned in two blocks of 6 choice situations each.[2] The experimental design used for the final combination of alternatives was obtained through an efficient design with a D-error of 0.167.

After obtaining respondents' consent, the rationale of the study was explained to each participant followed by a brief description of each attribute.[3] We also included a cheap talk script before the start of the survey to reduce hypothetical bias (Ladenburg et al., 2010).

[2] Choice cards including survey questions can be provided upon request.
[3] A detailed description of the attributes can be found in Appendix A.

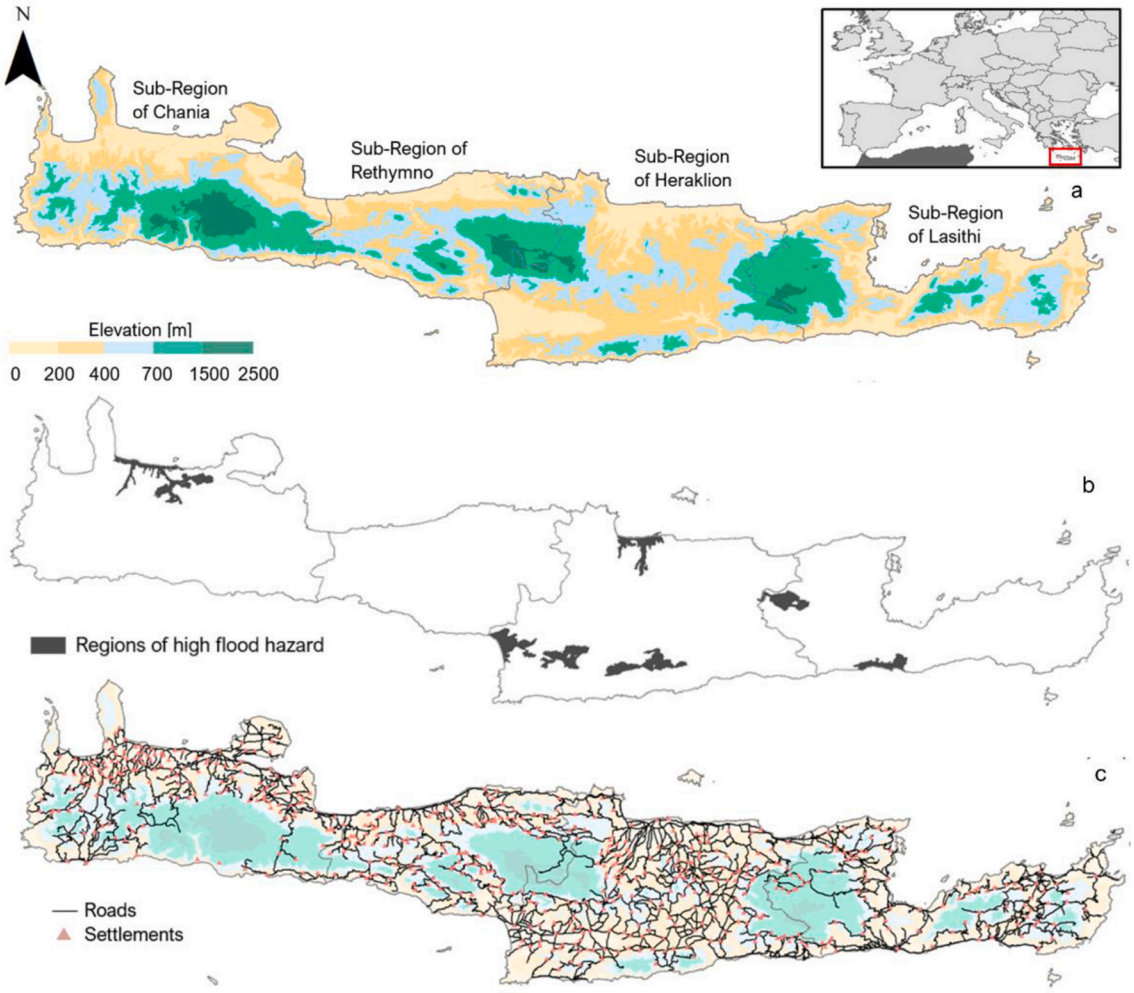

Fig. 2. a) Elevation map of the island of Crete Data source[a] Grey lines depict administrative boundaries, b) zones of potentially high flood hazard[b] c) road networks and existing settlements (cities-towns-villages) with elevation superimposed.[c]
[a]Data source: Copernicus, 2018.
[b]Data source: Greek Ministry of Environment, 2022.
[c]Data source: Region of Crete (https://data.apdkritis.gov.gr/).

Respondents were then presented with the choice cards and instructed to choose their most preferred alternative for each choice instance.

The final survey comprised a total of 39 questions in 5 sections. The first section secured participants informed consent. The second and third part of the survey described the valuation scenario with attributes and presented the choice questions respectively. Finally, Sections 4 and 5 collected attitudinal and sociodemographic information. Attitudinal questions were included to understand respondents' relationship with and exposure to wildfires, to assess the relative importance of each attribute as well as questions that helped to examine further clarity of each attribute. These were broken down into two parts: the first, presented in a binary format asked if each attribute was important during individual respondents' decision making. The second, presented in a scalar format with answers ranging from 'strongly disagree' to 'strongly agree' aimed to understand respondents' attitudes towards fires in Crete. We asked a range of standard socio-demographic questions including age, gender, income, household characteristics amongst others shown in Table 2. The final question asked in Section 5 consisted of one question to identify protest respondents, determined to be those who consistently opted out and why. The question was as follows: *"If you consistently chose the alternative 'Opt-out', could you please tell us why?"*

The following options were available to choose from:

1. *I do not think the management scenarios will be effective (19%)*
2. *The extra cost must be paid by the government from existing resources (1%)*
3. *I am not concerned about wildfire issues (4%)*
4. *I cannot allocate money for this purpose (5%)*

Respondents that consistently chose the status quo option across all the choice sets, were asked a debriefing question to disentangle true zero bidders from protesters. Our differentiation between protestors and valid zero bidders was guided by Mariel et al. (2021). Protesters were respondents that chose the option: "*The extra cost must be paid by the government from existing resources*" (1%) and "*I don't think the management scenarios will be effective*" (19%), while zero bidders would choose the option: "*I am not concerned about wildfire issues"* (4%) and "*I cannot allocate money for this purpose"* (5%). As such, 20% of respondents were classified as zero bidders, whilst 9% were classified as protestors.

We included the protesters in the model estimation since there is not a clear agreement in the literature on how to treat protesters and removing them may leave room for sample selection bias (Meyerhoff et al., 2014). Some guidance does exist on protest results and how to treat them, generally, most practitioners will remove them from the sample, but some opt to. Furthermore, including them as will provide more conservative WTP estimates (Carson and Hanemann, 2005) and

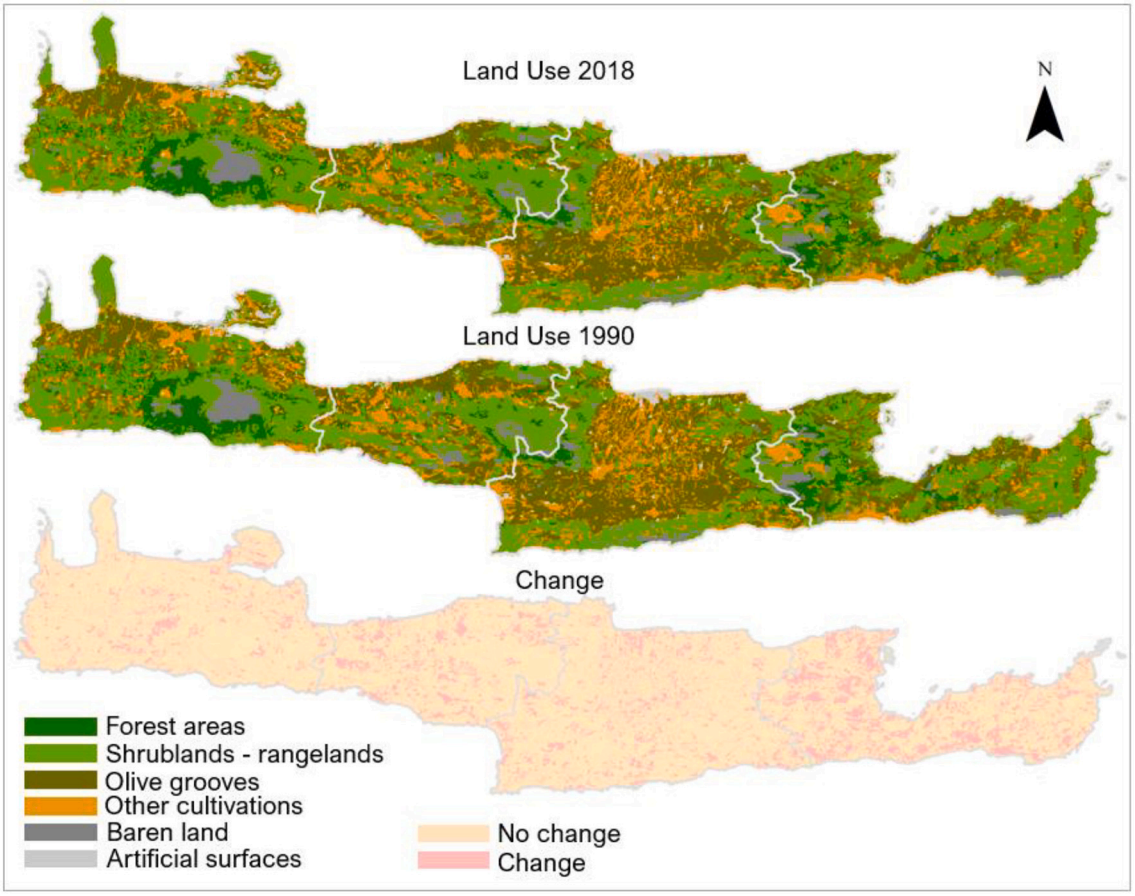

Fig. 3. Major land use types across Crete. Data source: Corine Land Cover 2018 and 1990 (Kosztra et al., 2019).

Table 1
Description of attributes and levels.

Attributes	Levels
Fire Frequency	400,500,600,**800**
Agricultural land burnt (ha)	50,100,200,**350**
Landscape quality	Maintaining all aspects of the traditional and unique Cretan landscape, Some visible hard engineering, **No intervention**
Protection post-fire	Present, **Absent**
Tax	**€0**, €10, €20, €30, €50

when these are used in a policy setting, can allow for transparency (Johnston et al., 2017).

Choice cards were presented before all other questions in case respondents decided to ignore attitudinal and socio-demographic questions. This strategy ensured that choice answers could be used for data analysis.[4] Descriptive statistics of these questions are presented in Table 2.

2.5. Data collection

Previous experiments identified regional differences in preferences for environmental goods and services, particularly between rural and urban samples (Bernués et al., 2014; Domínguez-Torreiro et al., 2013; Campbell et al., 2008; Hassan et al., 2019). To address this, we collected data from a range of rural, urban, peri-urban, coastal, mountainous, agricultural, and touristic areas of the prefecture of Chania. Wildfire occurrence and intensity, the geography (Fig. 2), LULC (Fig. 3) and general trends in burnt area is similar across all prefectures of Crete (Fig. 1 (b)). As such, we were able to generalise results of the study to be representative of Crete, despite data collection only occurring in Chania. The survey was deployed in November 2021 to avoid the tourist season and focus on the local population of the island. The survey was conducted by trained local interviewers in Greek who also provided support in sourcing and targeting representative areas of Crete in Chania. A total of 157 surveys were collected. Fig. 5 below depicts areas that the survey was deployed in.

Table 2 contains a summary of socio-demographic characteristics of the sample. The sample was fairly balanced when it came to gender with males making up a slightly higher percentage (56%) compared to females. Similarly for age, there was no strikingly large age gap amongst respondents, with most respondents between the age groups of '25–39' (32%) and '40–49' (28%) with the smallest group represented by those 63 or above. Undergraduate (36%) and Up to High School (34%) were the most common level of schooling for the sample. A modest number of respondents had at least 1 child (44%). We intentionally conducted the survey outside the tourist season to capture preferences of Cretan people and full-time residents. This strategy was successful as the majority of respondents in our sample were full-time residents (86%) and Cretan (71%). A small majority of our sample were either directly involved or had family members involved in agriculture (37%) and tourism (25%). As with the trends across age, a high subscription of respondents falling to a dominant income group did not exist. Most respondents fell almost evenly across most income brackets, with the exception of 14% falling under €75,000+. The highest number of respondents falling into one

[4] Although this strategy was implemented, we found only 1 respondent who did not answer attitudinal questions. This survey was subsequently discarded as choice cards were left incomplete.

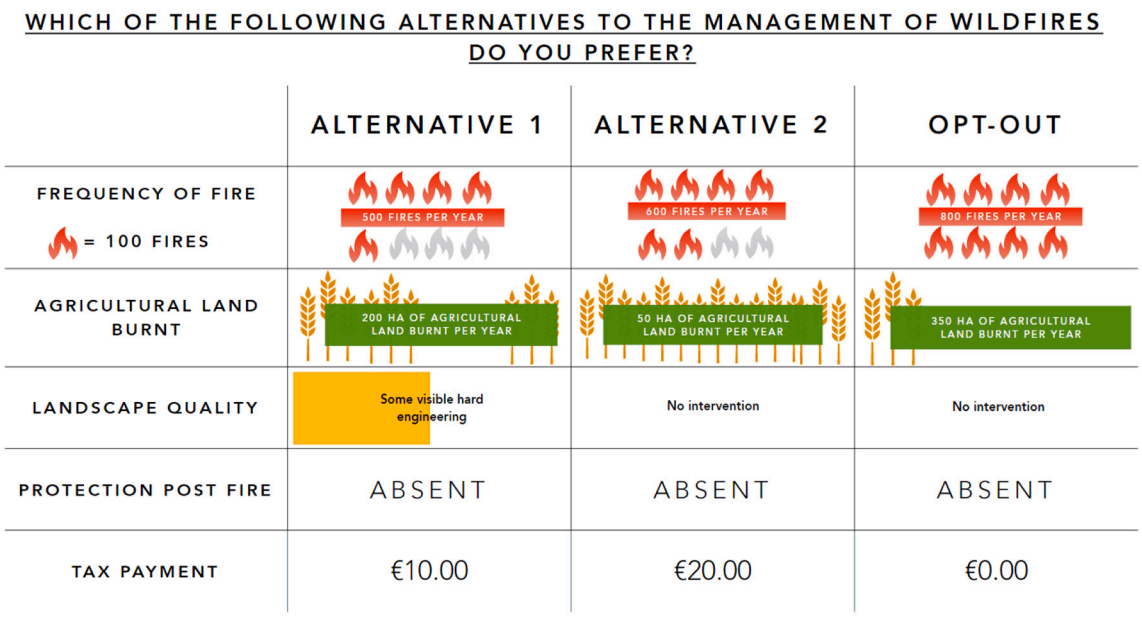

Fig. 4. Example of a choice card.

bracket was between '€5199–€15,999' containing 34% of the population sample.

2.6. Empirical model

This methodology follows Lancaster's characteristic demand theory, whereby consumers derive utility from the component characteristics of a good as opposed to the whole good itself (Lancaster, 1966). An individual's total utility therefore takes the form of the following function:

$$U_{\mathrm{nj}} = V_{nj} + \varepsilon_{nj} \tag{1}$$

where U_{nj} is the total utility of person n amongst a set of j alternatives. Utility depends on observed characteristics of the alternatives, observed characteristics of the decision maker and unobserved characteristics. V_{nj} is the deterministic utility with ε_{nj} as the stochastic element that we assume to be independently and identically distributed (IID). The deterministic component can be broken down as:

$$V_{nj} = \beta x_{nj} + s_n \tag{2}$$

where, x_{nj} is the deterministic component of utility defined by the vector of attributes of the alternative and s_n is the random component of utility. β is the vector of coefficients to be measured.

The variables corresponding to the attributes: 'FreqFires', 'AgriBurnt' and 'Tax' were coded as continuous variables using their original values while 'LandscapeQual' and 'ProtectionPostFire' were dummy coded.

$$U_{ij} = \alpha + \beta_1 \bullet FreqFires + \beta_2 \bullet AgriBurnt + \beta_3 \bullet LandscapeQual + \beta_4 \bullet ProtectionPostFire + \beta_5 \bullet Tax + \varepsilon_{ij} \tag{3}$$

First, we estimated a baseline conditional logit model[5] (CLM) (McFadden, 1973). Although this model is relatively simple in terms of estimation, interpretation of choice probabilities and elasticities, it does suffer from limitations (Sarrias and Daziano, 2017). The model assumes that utility is constant across all respondent and choice occasions and does not account for preference heterogeneity across respondents (Hauber et al., 2016). To remedy this, we extend the model to a mixed logit model (MIXL) which allows for one or more parameters to be randomly distributed. We employed the MIXL to account for preference heterogeneity across the population and relax the Independence of Irrelative Alternatives (IIA) assumption. We use the MIXL as proposed by (Revelt and Train, 1998) as it is a less restrictive model in comparison to the CLM. The model is estimated using the Maximum Likelihood Estimator (MLE).

We calculate willingness to pay for each attribute as:

$$WTP = -\beta_{1-4}/\beta_5 \tag{4}$$

The mixed logit model generalises the CLM by allowing the beta coefficients to be random with the mixing distribution of $f(\beta|\theta)$. A common way to rationalise the MIXL is the random utility model with individual specific coefficients.

We model β_n as a random variable with a density $f(\beta|\theta)$ and integrate over the density of random coefficients to obtain the unconditional choice probability. The choice probability can be expressed as:

$$P_n(i) = \int \frac{e^{V_{ni}(\beta)}}{\sum_{j=1}^{J} e^{V_{nj}(\beta)}} \mathrm{f}(\beta)\, d\beta \tag{5}$$

In the model specification, we assumed that all attributes, except for the cost, follow a normal distribution and are randomly distributed. All non-monetary attributes were assumed to follow a triangular distribution with the cost coefficient following a constrained triangular distribution (Hensher et al., 2015; Daly et al., 2012).

Whilst the MIXL takes into account preference heterogeneity (Train, 2009), we report estimates from a latent class model (LCM) replacing the assumption of continuously distributed heterogeneity with the

[5] To undertake the analysis, we used the **gmnl** package in **R** which estimated several extensions of the conditional logit model (Sarrias and Daziano, 2017).

Table 2
Summary statistics of the socio-demographics of the population relative to the Greek average.

Socio-demographic characteristics	Sample	
	Count	Percent (%)
Gender		
Male	88	56%
Age		
18–24	29	18
25–39	51	32
40–54	44	28
55–62	20	13
63+	13	8
Children		
At least 1 child	69	44
Education		
Up to High School	54	34
Undergraduate	57	36
Postgraduate	46	30
Residency		
Full time	135	86
Seasonal	22	14
Area		
Urban	66	42
Rural	33	21
Sub-urban	58	37
Cretan	111	71
Agriculture	58	37
Tourism	40	25
Income		
€5199 - €15,999	63	39
€15,600 - €31,199	49	31
€31,200 - €74,999	24	16
€75,000+	21	14

assumption from the former with a discrete distribution whereby heterogeneity is captured by membership to a class (Boxall and Adamowicz, 2002; Greene and Hensher, 2003). LCM with 2,3,4 and 5 classes were estimated. The appropriate number of classes were determined by using both the Akaike Information Criterion (AIC) and Bayesian Information Criterion (BIC)[6] (Tein et al., 2013). Asymptotically the AIC may overestimate the number of classes with the BIC preferring fewer classes in smaller sample sizes (Scarpa et al., 2007). Lower values in both criteria suggest better model fit.

Eq. (6) describes the latent class model. Where $P_{n|c}$ is the choice probability that person n, conditional to belonging to class q (q = 1, …Q) chooses alternative j amongst a set of J alternatives is given as:

$$P_{n|c}(j) = \frac{exp\left(x_{i,j}^{'}\beta_c\right)}{\sum_{j=1}^{j} exp\left(x_{i,j}^{'}\beta_c\right)} \quad (6)$$

Table 3
Covariates used for class membership in the LCM.

Variable	Description
GEN	1: Female, 0: Male
EDU	Highest education level (1: undergraduate or higher, 0: otherwise)
CHILD	At least one child (1: yes, 0: no)
AGRI	Is involved in agriculture or has family involved (1: yes, 0: no)
TOUR	Is involved in tourism or has family involved (1: yes, 0: no)
AGE	1: between the ages of 18–49, 0: age 49+

3. Results

3.1. Preferences for wildfire management attributes

Table 4 shows coefficient estimates from the conditional logit model, describing individual preferences for the attributes comprising the wildfire mitigation policy. Coefficient estimates on 'fire frequency', 'agricultural land burnt' and 'tax' attributes are statistically significant and negative, suggesting that respondents are more likely to choose alternatives with lower levels of wildfire occurrence, lower agricultural land burnt and lower price, relative to alternatives with higher levels of those attributes. The positive coefficient on the level full landscape quality indicates that people are more likely to select alternatives aimed at preserving the unique features of Cretan landscape rather than a no-intervention status-quo. Within the same attribute, the coefficient of the level 'medium' is statistically insignificant, suggesting that respondents' utility is not affected when moving from no intervention to medium intervention level. Coefficients on 'protection post-fire' are statistically significant and positive, indicating respondents' preferences for this attribute. The estimated coefficient for the status quo is negative and statistically significant, indicating that *ceteris paribus* people are willing to depart from the status quo to alternative wildfire management scenarios. Finally, the coefficient of 'tax' is negative and highly significant ($P \leq 0.01$), as expected.

Estimates from the MIXL (Table 4) show a similar preference pattern to that of the CLM but identify that there is substantial heterogeneity in

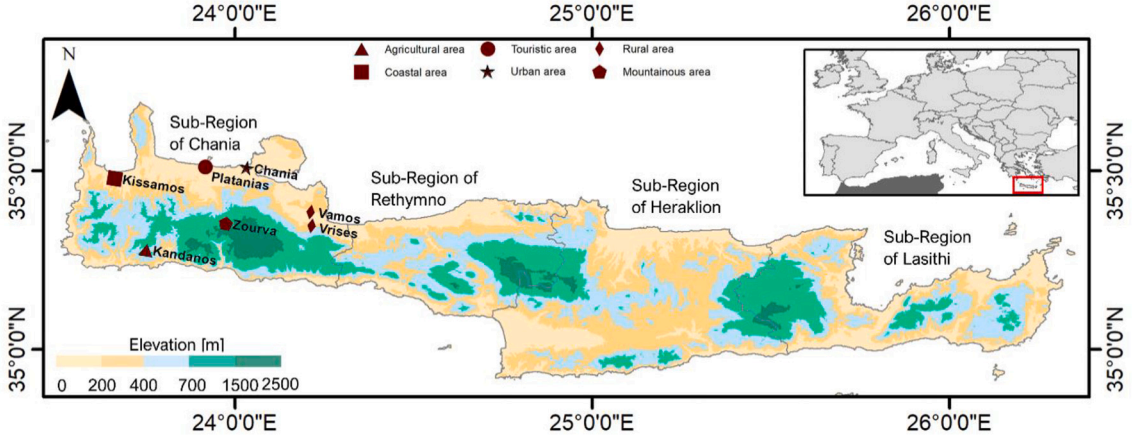

Fig. 5. Areas of Chania prefecture where surveys were deployed.

[6] See Appendix B. for criteria information.

preferences as shown by the significant standard deviations of all coefficients. As such, the status quo option is negative and statistically significant. Protection post fire is the attribute that achieves the highest estimates in this model, following the same pattern observed in CLM, indicating that this attribute is the one that contributes to a higher extent to shape respondents' preferences. Parameter values for 'agricultural land burnt' were very low and close to zero highlighting the disutility associated with more land burnt. Finally, the 'tax' attribute was negative and statistically significant at the 1% level, indicating disutility associated with paying taxes for the hypothetical policy.

Estimates of the LCA are displayed in Table 4 with a description of covariates used in the LCA shown in Table 3 below. In our estimation, the smallest value for both the AIC and BIC favoured 3 classes. At 4 classes, values increased, indicating that adding a fourth segment did not improve model fit (Boxall and Adamowicz, 2002). As a result, a 3-class model was preferred, values corresponding to this are reported in Tables 4 and 5. Class membership was modelled through socio-demographic characteristics.[7] An individual's assignment to each class is modelled using the following independent variables: **GEN**, **EDU**, **CHILD**, **AGRI**, **TOUR** and **AGE** (description shown in Table 3). Beta regression was used to support profiling the members of each class.

Segment allocation for the LCA designates Class 2 as the reference class and represents the largest share of respondents (76%), with class 1 and class 3 by 16% and 8% respectively. The model reveals a considerable degree of heterogeneity between the classes in preferences for various attributes pertaining to the new policy. Socio-demographic variables were modelled to understand class membership for the LCA.

Class 1 were labelled as 'fire conscious' given that the attributes providing utility were most concerned with fire and impacts of fire as opposed to attributes linked to aesthetically pleasing landscapes. The attribute 'landscape quality' at 'medium' level retrieves very high, negative values, whilst the 'full' level is insignificant, indicating disutility associated with this attribute relative to the status quo. The socio-demographics of this class show that membership is made up of majority working age males, that are university educated, with no children and involvement in agriculture but not tourism.

Class 2 can be labelled as 'supporters' with clear preferences for policy proposals that depart from the status quo scenario. Class 2 shows similarities with Class 1 with respect to relative importance of taste parameters in that 'agricultural land burnt' and 'fire frequency' across Crete provide disutility to respondents. Preferences for this attribute indicate a more balanced pattern across attributes with respect to class 1. The socio-demographic characteristics associated with this class show respondents were mostly women, not educated to university level, had children and were involved with tourism.

Class 3 on the other hand could be labelled as 'indifferent' as they displayed no statistically significant parameters across scenarios. In terms of socio-demographic characteristics, this class was represented by educated women of working age with children and were not associated with either the agricultural or tourism sector. This sample bore similar characteristics with both classes but was more aligned with Class 1.

3.2. WTP estimates

As expected, the WTP estimates from the CLM reveal a similar trend to estimated coefficients. 'protection post-fire' displayed the highest WTP amongst all attributes with respondents WTP €34.56 to avoid implement the programme followed by the full 'landscape quality', with a WTP of €15.58 per household. 'agricultural land burnt' was also negative and statistically significant with WTP at -€13.87 for every 10 ha of agricultural land burnt per year showing the disutility experienced when the agricultural land is affected by wildfires, similarly to 'fire frequency, although the disutility experience was lower and amounted -€6.41 for every 100 fires.

Accounting for individual heterogeneity was done through the MIXL model. Results from this model revealed a similar pattern for attribute preferences. 'protection post fire' presented the highest WTP of €37.22. Followed by 'landscape quality' at 'full' with a WTP of €22.64. The disutility produced by wildfires amounts -€5.90 per 100 fires while every 10 ha of land burnt reduce citizens welfare in -€0.19.

Turning to the WTP from the latent class model, respondents in class 1 are WTP €25.92 for protecting against post wildfire damages, while experiencing disutility for the hectares of agricultural land burnt (−€12.37) and for the 'medium' improvement level in the landscape (−€28.75) compared to the status quo of no landscape intervention. 'fire frequency' also produces disutility for the respondents although to a lower extent with -€2.28 for every 100 fires prevented.

WTP attributes for Class 2 were much different the class 1, although they both had the highest WTP for 'protection post fire' (€46.03). This class generated significantly different estimates with respect to Class 1 for 'landscape quality' with positive and significant for both 'full' and 'medium' intervention on the landscape that were in harmony with the traditional Cretan landscape with a WTP of €30.30 and €42.42 respectively. Relating to agriculture, respondents expressed disutility here with -€15.15 for every 10 ha of agricultural land burnt. Reducing the number of fires followed last in preference showing disutility, indicated through -€9.53 to for every 100 fires prevented. Finally, Class 3 was the most dissimilar amongst other classes and the smallest segment. All attributes displayed insignificant coefficients. This is consistent with the estimated coefficients displayed in Table 5 and interactions with WTP estimates.

3.3. Importance of attributes, perceptions and use of fire

To further understand how important each attribute was for respondents, we asked follow-up questions assessing the importance assigned to each attribute during decision making shown in Table 6. Overall, protection of agriculture production for the attribute 'agricultural land burnt' showed the highest level of importance for respondents, with 89% saying 'yes' to this question, followed by 'protection post-fire' (80%), 'fire frequency' (76%). 'landscape quality' (69%) and 'tax' (54%) presented with the lowest importance during decision making.

Wildfires in Crete are complex with many conflicting opinions on who is responsible and how fires should be managed. As such, the second section of question looks to understand public perception of around fire in Crete and responsibilities of fire. These questions were presented on a scale of 1–5 (1 being Strongly Agree and 5 being Strongly Disagree). From the descriptive statistics it is clear that respondents disagree that fire is beneficial for forests, highlighting their understanding of fire and its importance to Cretan forests. There is also a general consensus and confusion on who is responsible for fire protection. Results show that on average, respondents agreed that the government (2.12), society (2.18) and individuals (1.95) have responsibility for fire protection. They also strongly agree that stricter regulations for the use of fire in agriculture and similar work should be introduced (1.81), they also assign importance to protecting traditional agriculture (1.93) which is consistent with model results. Respondents are also worried about fires in Crete (2.01) which may explain negative utilities associated with the status quo option.

With respect to the use of fire, many people do not use fire for agriculture purposes or cleaning vegetation residue (35%) but did have a good understanding of the regulations and instructions for the safe use of fire (69%). Despite not being directly affected by fire (15%), an overwhelming majority of respondents agreed that fires should be prevented instead of suppressed (92%) as well as the use of controlled burning to reduce fuel in forests (75%), indicating agreement that current management for wildfires is not supported by the general public.

[7] Modelled in STATA 14.

Table 4
Estimated coefficients for the conditional logit model, mixed logit model, and latent class analysis.

Variables	CLM	MIXL		Class 1	Class 2	Class 3
	Coefficients (std error)	Coefficients (std error)	Std. dev	Coefficients (std error)	Coefficients (std error)	Coefficients (std error)
Status quo	−0.72** (0.23)	−0.90* (0.35)		−2.26*(1.07)	−1.84*** (0.34)	1.57 (20.07)
Fire frequency	−0.11* (0.04)	−0.18* (0.07)	0.54*	−0.04* (0.21)	−0.12* (0.05)	4.51 (7.71)
Agricultural land burnt	−0.23*** (0.06)	−0.05** (0.00)	0.07**	−2.43** (0.86)	−0.2* (0.08)	0.32 (3.58)
Landscape quality: Full	0.26* (0.11)	0.70** (0.18)	0.04**	−0.26 (0.85)	0.41** (0.13)	8.76 (14.15)
Landscape quality: Medium	0.17 (0.11)	0.45 (0.24)	2.10	−5.66* (2.55)	0.57** (0.18)	−0.8 (74.31)
Protection post fire	0.59*** (0.09)	1.16** (0.17)	1.06**	5.11* (2.54)	0.62*** (0.12)	13.15 (23.12)
Tax	−0.01*** (0)	−0.31** (0.06)		−0.19* (0.08)	−0.01*** (0.04)	−0.41 (0.75)
GEN				−1.21*** (0.11)	0.95*** (0.10)	0.40*** (0.16)
EDU				0.69*** (0.13)	−0.46*** (0.12)	1.01*** (0.17)
CHILD				−1.13*** (0.11)	0.39*** (0.11)	0.20*** (0.16)
AGRI				0.21*** (0.13)	−0.20***(0.12)	−0.74** (0.16)
TOUR				−0.12** (0.15)	0.31*** (0.13)	−0.26*** (0.18)
AGE				0.51***(0.16)	−0.30***(0.14)	0.40*** (0.19)
Class share				16%	76%	8%
Total number of observations				942		
Log Likelihood	−885.57	−774.65			−714.61	

Note: *** ≤ 0.01% significance level ** 1% significance level * 5% significance level.

Table 5
Willingness to pay for the conditional logit model, mixed logit model, and latent class analysis.

	CLM	MIXL	Class 1	Class 2	Class 3
Variables			Coefficients (std error)		
Fire Frequency (€ per 100 fires)	−6.41** (2.97)	−5.90* (2.75)	−2.28** (1.04)	−9.53* (5.32)	−10.79 (13.39)
Agricultural land burnt (€/10 ha)	−13.87*** (4.39)	−0.19** (0.05)	−12.37*** (1.99)	−15.15** (7.25)	−0.77 (8.21)
Landscape quality: Full	15.58** (7.07)	22.64** (6.96)	−1.37 (4.02)	30.30** (13.7)	20.92 (13.76)
Landscape quality: Medium	9.95 (6.91)	14.47 (8.41)	−28.75*** (6.53)	42.42** (21.25)	−1.92 (178.12)
Protection post fire	34.56 *** (8.67)	37.22** (8.52)	25.92*** (5.16)	46.03*** (16.15)	31.39 (59.58)
Class Share			16%	76%	8%
Total number of Observations			942		
Log Likelihood	−885.57	−774.65		−714.61	

Note: *** ≤ 0.01% significance level ** 1% significance level * 5% significance level.

Table 6
Descriptive statistics for attitudinal questions. 'Attribute importance', 'Use of fire' are binary where 1:Yes, 0:No. 'Perception of fire' is on a Likert scale 1–5 Strongly Agree - Strongly Disagree.

Question	Mean	Std
Attribute importance		
'Frequency of fires' was important in my decision making	0.76	0.42
'Agricultural land burnt' was important in my decision making	0.89	0.32
'Landscape quality' was important in my decision making	0.69	0.46
'Protection post-fire' was important in my decision making	0.80	0.40
'Tax' was important in my decision making	0.54	0.50
Perception of fire		
Fires are beneficial to our forests	4.07	1.09
Fire protection is the responsibility of the government	2.12	1.25
Fire protection is the responsibility of society	2.18	1.19
Fire protection is the responsibility of each individual	1.95	1.03
Stricter regulations for the use of fire in agricultural and similar work should be introduced	1.81	1.07
I am worried about fires	2.01	1.25
Protecting traditional agriculture is important to me	1.93	1.11
Use of fire		
Do you use fire for agricultural work or for cleaning vegetation residues?	0.35	0.48
Do you know the regulations and instructions for the safe use of fire?	0.69	0.46
Do you think that fires should be prevented instead of suppressed?	0.92	0.27
Do you think that controlled use of fire can reduce fuel in forests?	0.75	0.44
Have you ever been directly affected by fires?	0.15	0.36

4. Discussion

Up to 90% of all forest fires within the European Union occur in Mediterranean countries (De La Rosa et al., 2008), with Greece already experiencing a disproportionality high number of catastrophic fires (Giannakopoulos et al., 2011) and projected to be one of the countries most vulnerable to climate change (Chrysopolitou et al., 2013; Moreira et al., 2011; Ferrara et al., 2018). While a paradigm shift from suppression-centred policies is needed to integrate active forest management and support the overall reduction of catastrophic wildfire events (Elia et al., 2016; Verkerk et al., 2018), successful policies need to be inclusive of the public concerns (Costa Freitas et al., 2019).

In this study, we assess public preferences for integrative wildfire management through discrete modelling. We find that across all models (CLM, MIXL and LCA) there is an overall support for improved wildfire policy in Crete. This is evidenced by the disutility associated with the

status-quo option and the disutility experienced by the agriculture burnt land and positive estimates of post wildfire protection and landscape preservation. Adopting continuous and discrete modelling approaches allowed for complementary insights on citizens preferences. The LCA helped identify some extreme preference patterns that were further disentangled by the socio-demographic characteristics of classes. Specifically, we observed that respondents in class 1 show very high value of protection post wildfires and display high disutility with agricultural land burnt while landscape quality improvements produced a disutility in them.

Respondents involved in agricultural rather than tourism were more likely to belong to class 1 which we hypothesise may contribute to their expressed preferences. This finding is consistent with previous research demonstrating that farmers tend to prioritise attribute that conoslidate and enhance their economic output (Broch and Vedel, 2012). Martin-Collado et al. (2014) also find that landscape qualities did not provide increased utility in their sample and attribute this finding to the high importance placed on agriculture.

Reducing the frequency of wildfires presented with positive utility consistently across all models but was found to be one of the lowest valued in terms of WTP. We hypothesise that the relatively low disutility estimates are related to the acceptance of wildfires taking place every year in the region. The relative lower importance of this attribute, compared to previous studies such as Bernués et al. (2014) may relate to the inclusion of complementary attributes such as burnt agricultural area, that attracted greater attention from respondents. Although not directly comparable given different levels, the WTP for similar attributes are consistent with those reported inAlló and Loureiro (2020) where residents have a WTP of around €30.60 to reduce 40,000 ha of burned land through forest cleaning activities in Spain. Additionally, Shrestha et al. (2021) report a mean WTP of $41.39 per acre to reduce wildfire risk through prescribed burning.

For Greece in particular, forest experts advocate fire prevention through fuel management techniques as outlined in the study by Mitsopoulos et al. (2015), and agro-forestry as a sustainable land use option to reduce wildfire risk in Mediterranean Europe (Damianidis et al., 2020). We note that the WTP for the attribute 'fire frequency' is substantial across all models with class 2 in the LCA showing a WTP of -€9.53 per 100 fires. This is consistent with similar studies that also show high WTP for such attributes, as given in Couture and Reynaud (2011).

In contrast, class 2 support interventions aimed at improving landscape quality. This finding is plausible, given respondents' association with the tourism industry and expected returns from maintaining tourist attractions. They also recognise the value of improved and integrative wildfire prevention and restoration as a means of securing key public goods related to landscape quality. Previous studies in Mediterranean regions have signaled that there are concerned profiles of respondents that favour landscape programs which maintain traditional Mediterranean features (Tagliafierro et al., 2016).

Furthermore, while the study here does not directly incorporate or account for bequest values. It is worth noting that respondents in class 2 had children which may explain their preference for maintaining aesthetically pleasing landscapes. Bujosa Bestard and Font (2010) found that respondents with children and those who were unemployed were more likely to participate in recreational activities. This may suggest that respondents in class 2, apart from being related to tourism industry may also be more likely to obtain utility from the wildfire mitigation policy associated with non-use values.

Other socio-demographic characteristics associated with class 2 included women who were approaching retirement and not educated to university level. This result is aligned with previous studies showing that women are more likely to accept and adapt to environmental policies (Stern et al., 1993) with parenthood also affecting attitudes towards environmentalism (Milfont et al., 2020). More specifically, this trend is prevalent amongst Greek women, whereby middle-aged women are more likely to change their lifestyle in order to mitigate negative environmental externalities. As they play a more active role in society, Greek women are more likely to be agents of change (Hirschon, 1985). A study by Zabaniotou et al. (2021) on gender consideration for wildfire management after the 2018 Mati fires in Greece highlighted the need for women to be integrated into decision making processes given their increased vulnerability relative to men from the impacts of wildfires. As such, decision makers should therefore adopt a gender sensitive approach to wildfires.

Despite the literature which contributes towards understanding the preferences of class 2 with respect to their gender, we do see that class 3 is similarly made up of women and individuals who have children but with strikingly different taste parameters. Similar studies have found that having children does not seem to have a definitive role in defining preferences either. Varela et al. (2014a) show that having children does not preclude bequeathing attitudes, potentially explaining the results seen here. Rather it seems that the fact that respondents in class 3 are not associated with the agricultural sector or involved in tourism play a more prominent role in explaining respondent allocation to this and the other two preference classes identified.

Protecting agricultural land generates statistically significant coefficients across the models and classes 1,2 of the LCA, but provides more utility to class 1 than class 2. This can be related to the fact that traditional agricultural land such as olive groves, citrus plantations and vineyards are considered vital for economic and cultural prosperity in rural areas (Stougiannidou et al., 2020). In relation to use values, this attribute may be associated to provisioning and regulating ecosystem services which are found to be highly valued in rural Mediterranean environments such as in García-Llorente et al. (2012) on land-use scenarios in south-eastern Spain.

Policies implementing management for post-wildfire hazards are widely supported by Cretans, indicated by strong preference for the attribute 'protection post fire' consistent amongst all classes and models. Similar results are seen in other ecosystems vulnerable to post wildfire flooding such as is the case with lowlands in Crete. Our results align with those of Mueller et al. (2009) who found positive preferences for forest restoration aiming to reduce catastrophic wildfire damages and post wildfire flooding. Durán-Medraño et al. (2017) also find post wildfire damages to be the highest valued attribute in their study on marine and biodiversity losses in Galicia, Spain. Increased awareness of post-wildfire flooding because of recent events may also play a role in the preferences seen here. For example flooding events in Mandara, Attica which killed 23 people (Soulios et al., 2018; Papathanasiou et al., 2012) or on the island of Evia in August 2021 where wildfires were followed by torrential floods and mudslides two months later (Schismenos et al., 2022). Such events highlight the inadequate structures in place for flood protection which may influence public perception of post-wildfire issues (Stamou, 2018). Moreover, these events took place in mountainous regions that are similar to the Cretan landscape, which ring close to home for Cretans.

Finally, we are aware that one of the limitations of our study may reside in the relative low number of survey respondents. However, it should be noted that the current sample size is not uncommon in the literature as previous studies have also reported reduced sample sizes (Regmi et al., 2023; Mavsar et al., 2013; Remoundou et al., 2012). Nonetheless, our results provide valuable insights into the prefereneces and priorties of respondents that point towards positive preferences for protecting the island of Crete from further damages caused by wildfire events. These findings can help inform decision-makers when making policy decision related to wildfire management, particularly which attributes should be priortised as well as providing a better rationale when implementing wildfire management changes.

5. Conclusion

Wildfire management policies in Crete are currently dependent on fire suppression models that largely ignore some of the more complex

socio-ecological processes underpinning wildfire events (Moreira et al., 2020). A paradigm shift in management, which also takes into account public preferences, is urgently needed to allow for a more coordinated response on wildfire damage mitigation in Crete. Achieving this requires a holistic approach, moving away from operating in silos, and seeking to understand the choices that the public would make. This study used environmental valuation methods to estimate the expected welfare impacts from a wildfire mitigation policy in Crete. Overall, our findings indicate that there is a strong preference amongst the general public to move away from current policies based on suppression towards more integrated approaches dealing both with prevention and post-fire management. Additionally, the study shows that engagement with key economic activities such as agriculture and tourism importantly defined citizens' preferences and that respondents place high economic value on plans for protecting against post-wildfire damages and landscape quality.

These results have direct policy implications. Beyond providing decision makers with real-world data that can be used to evaluate new initiatives for wildfire management, this study can help guide decision makers based on the significant determinants of preferences and support indicated for specific attributes. They also show that decision makers seeking to create both effective and popular wildfire management policy should be considering the socio-economic characteristics of households to appropriately target measures.

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Declaration of Competing Interest

There are no conflicts of interest with respect to the authors and the manuscript from external or internal sources.

Data availability

Data will be made available on request.

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Appendix A. Detailed description of each attribute

Frequency of wildfires

Over the past 20 years, on average 623 non-agricultural fires happen every year in Crete. Fire frequency will increase because of climate change with modelling predicting that Crete will experience milder winters and hotter summers increasing the probability of fire weather. The higher the fire weather is the most favourable the meteorological conditional are to trigger a wildfire event. If no measure is implemented, it is expected that fire frequency will increase to 800 incidents a year. A prescribed fire management programme will be implemented by the Greek forest service to reduce the availability of fuel for fires in turn reducing the number of fires happening per year. Depending on the scale and characteristics of the program, wildfire occurrence in the **FUTURE** will be: 300,500,600 and 800.

Agricultural land burnt (ha)

During a wildfire event, olive groves, vineyards, and other **traditional agricultural crops** are damaged leading to a drop in production levels, in turn contributing to a loss for the local and national economy. Every year 256 ha of agriculture land is burnt per year in Crete, with global models suggesting that this will increase further. With your contribution, the forestry service will be able to maintain correct management practices of these crops in order to prevent and reduce further numbers of agricultural land burnt per year by non-agricultural fires. In this study we consider **four** scenarios regarding the preservation of agricultural production from the impacts of wildfires which take on the following values:

Landscape quality

Physical interventions such as fuel breaks and firewalls will be implemented by the local government to reduce wildfire incidents. Engineering such landscape protection measures are expensive and require a lot of thought to stop unsightly intervention and respect the traditional Cretan landscape. Through your contribution, we will be able to implement effective and aesthetically pleasing projects that will protect infrastructure in public and private lands and allow businesses to operate in zoned areas. In this study we consider **three** scenarios regarding the preservation of landscape quality which will be at three levels:

Protection post-fire

Regardless of what we do, wildfire risk can never be eliminated. In this attribute we aim to reduce wildfire risk and post-wildfire damages. After a wildfire event, soil erosion may lead to flooding and landslides and well surface run off contaminates drinking water supplies. Damages to power lines fallen trees and other infrastructure need to be monitored and mapped. This policy will allow for increased monitoring with the use of drones across the island to detect such hazards. and prevent further damage. Similar to wildfires, the risk of flooding cannot be 100% eradicated but what we can do is reduce the risk of a detrimental flood event taking place. The government plans to contract specialist engineers to dredge the rivers to reduce overland flow as well creating flood barriers after a wildfire event to prevent flooding.

Tax

To implement these changes the government requires a one-time tax payment. This will be taken once out of your standard ANNUAL income tax regardless of whether you are a business owner or private individual in addition to your normal ANNUAL income taxes. The government will collect these taxes and distribute them to your local administrative units. Note that this payment will be used exclusively for this study.

Appendix B. Information on the converged latent segment model

Number of classes	Log likelihood at convergence	AIC	BIC
2	−743.9	1517.80	1590.52
3	**−714.61**	**1475.21**	**1586.71**
4	−708.53	1479.05	1629.34

Appendix C. Attitudinal and socio-demographic questions

Questions	Value	Sig
The characteristics for the variable 'Frequency of fires' were important in my decision making	0	Yes
	1	No
The characteristics of the variable 'Agricultural land burnt' were important in my decision making.	0	Yes
	1	No
The characteristics of the variable 'Landscape quality' were important in my decision making	0	Yes
	1	No
The characteristics for the variable 'Protection post fires' were important in my decision making	0	Yes
	1	No
The features for the 'Tax' variable were important in my decision making	0	Yes
	1	No
Fires are beneficial for our forest	1	Strongly Agree
	2	Agree
	3	Neutral
	4	Disagree
	5	Strongly Disagree
Fire protection is the responsibility of the government.	1	Strongly Agree
	2	Agree
	3	Neutral
	4	Disagree
	5	Strongly Disagree
Fire protection is the responsibility of society	1	Strongly Agree
	2	Agree
	3	Neutral
	4	Disagree
	5	Strongly Disagree
Fire protection is the responsibility of each individual	1	Strongly Agree
	2	Agree
	3	Neutral
	4	Disagree
	5	Strongly Disagree
Stricter regulations for the use of fire in agricultural and similar work should be introduced	1	Strongly Agree
	2	Agree
	3	Neutral
	4	Disagree
	5	Strongly Disagree
I'm worried about fires	1	Strongly Agree
	2	Agree
	3	Neutral
	4	Disagree
	5	Strongly Disagree
Protecting traditional agriculture is important to me	1	Strongly Agree
	2	Agree
	3	Neutral
	4	Disagree
	5	Strongly Disagree
Do you use fire for agricultural work or for cleaning vegetation residues?	0	Yes
	1	No
Do you know the regulations and instructions for the safe use of fire?	0	Yes
	1	No
Do you think that fires should be prevented instead of suppressed?	0	Yes
	1	No
Do you think that controlled use of fire can reduce fuel in forests?	0	Yes
	1	No
Have you ever been directly affected by fires?	0	Yes
	1	No
If you chose the third scenario in all the previous questions tell us if you agree or disagree with the following statements:	0	I do not think the management scenarios will be effective
	1	Didn't choose the third scenario
	2	The extra cost must be paid by the government from existing resources
	3	I am not concerned about wildfire issues
	4	I cannot allocate money for this purpose
What is your age	0	18–24
	1	25–39
	2	40–49

(*continued on next page*)

(*continued*)

Questions	Value	Sig
	3	55–62
	4	63+
What is your gender	0	Man
	1	Woman
Main Occupation	0	Employed
	1	Household
	2	Other
	3	Retired
	4	Student
	5	Unemployment
What is the highest level of education you have completed?	0	Elementary
	1	Primary School
	2	High School
	3	Undergraduate
	4	Postgraduate
	5	PhD
Household	0	Homeowner
	1	Renting
	2	Living with parents
Children	0	Yes
	1	No
Residency Status	0	Seasonal
	1	Full-time
Area	0	Urban
	1	Rural
	2	Sub-urban
How many years have you lived in Crete?	0	0–1
	1	1–5
	2	5–10
	3	10+
	4	My whole life
Are you Cretan?	0	Yes
	1	No
Income	0	Upto 5199
	1	5200-10,399
	2	10,400-15,99
	3	15,600-20,799
	4	20,800-25,99
	5	26,00-31,199
	6	31,200-41,599
	7	41,600-51,999
	8	52,00-74,999
	9	75,000-99,999
	10	100,00+
Are you or a member of your household farmers?	0	Yes
	1	No
Are you or a member of your household the owner of a tourism business?	0	Yes
	1	No

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