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An approach to assess actors' preferences and social learning to enhance participatory forest management planning

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ABSTRACT

Forest management planning is often challenged by the need to address contrasting preferences from several actors. Participatory approaches may help integrate actors' preferences and demands and thus address this challenge. Workshops that encompass a participatory approach may further influence actors' opinions and knowledge through social interaction and facilitate the development of collaborative landscape-level planning. Nevertheless, there is little experience of formal assessment of impacts of workshops with participatory approaches. This research addresses this gap. The emphasis is on the development of an approach (a) to quantify actors' preferences for forest management models, post-fire management options, forest functions, and ecosystem services; (b) to assess the impact of participatory discussions on actors' opinions; and (c) to evaluate the effect of social interaction on the actors' learning and knowledge. The methodology involves a workshop with participatory approach, matched pre- and post-questionnaires, a non-parametric test, the Wilcoxon Signed-rank test for paired samples, and a self-evaluation questionnaire.

We report results from an application to a joint forest management area in Vale do Sousa, in North-Western Portugal. Findings suggest that workshop and participatory discussions do contribute to social knowledge and learning about forest management models. Actors debated alternatives that can address their financial and wildfire risk-resistance concerns. Also, during the participatory discussions, actors expressed their interest in multifunctional forestry. These findings also suggest an opportunity to enhance forest management planning by promoting landscape-level collaborative forest management plans that may contribute to the diversification of forest management models and to the provision of a wider range of ecosystem services. However, more research is needed to strengthen the pre- and post-questionnaire approach, giving more time to actors to reflect on their preferences, to improve methods for quantifying social learning and to develop actors' engagement strategies.

1. Introduction

Forest management entails a range of actors with different interests, preferences, and opinions. Consequently, there are distinct ideas about how the forest should be planned and managed (Cowling et al., 2014). The participatory involvement of these actors at an early stage of planning and in all its steps is becoming increasingly important for forest management (Cowling et al., 2014; Martins and Borges, 2007; Reed, 2008). Participatory processes provide information that can help forest managers and decision-makers understand actors' preferences and expectations and thus develop tailored plans and policies, increasing their social acceptance and sustainability (Balest et al., 2016; Carmona et al., 2013; Kangas et al., 2006; Sarvašová et al., 2014). Several studies report the importance of the assessment and integration of actors' interests and concerns in forest management processes (e.g., Borges et al., 2017; Bruña-García and Marey-Pérez, 2018; Maroto et al., 2013; Nordström et al., 2010).

Moreover, the literature reports the application of participatory techniques to assess actors' preferences for forest management and ecosystem services. For example, Sarkissian et al. (2018) explored the stakeholders' preferences to select native tree species according to conservation priority and ecological suitability for reforestation in Lebanon, while Focacci et al. (2017) evaluated stakeholders' preferences for firewood, timber, non-wood forest products, tourism and recreation, hydrogeological protection, landscape contemplation and nature, and air quality conservation, in a case study in Southern Italy. Rossi et al. (2011) evaluated the preferences of forestland owners for selected forest management treatment practices offered under the pro-

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Table 1
Levels of actors' involvement in participatory approaches.

Level of involvement	Description	Participatory techniques (examples)	Pros	Cons
Information	Information provided to actors aiming to assist them in understanding the problem, the alternatives, the opportunities and/ or solutions	• Newsletter and press releases • Reports • Presentations, public hearings • Internet webpage	• Low cost • Limited resources and logistics • Fast to inform large audience	• Lack of new information • Absence of actors' interaction • Controlled disclosure of information
Consultation	Two-way flow of information to gain feedback on analysis, alternatives and/ or decisions and respond feedback	• Interviews • Questionnaires and surveys • Workshop • Cognitive map	• Qualitative and/ or quantitative primary information collected in a short time • Easy to compare data during the analysis	• Only ask for opinions and not involve actors in decision-making • Bias may appear in data if not effectively supported and conducted
Collaboration **Co-decision**	Joint activities with actors engaged in problem solving and the development of proposals Collaboration where there is shared control of decision making	• Workshop with participatory discussions • Focus group • Multicriteria analysis • Scenario analysis • Consensus conference	• Interaction among actors • Depth discussions • Broader perspectives • Boost actors' engagement • Increased consensus and understanding of other actors' points of view	• Limited number of actors • Actors time demand • Need an experienced facilitator with expertise • It can be expensive • Lack of willing to talk openly
Empowerment	Transfer of control of level of decision making	• Workshop • Focus group • Consensus conference	• Give actors the sense of ownership	• Actors not interested in implementing the decision

Adapted from Brescancin et al. (2018); Cowling et al. (2014); Luyet et al. (2012)

gram "Southern pine beetle prevention cost-share" to improve stand health in six states of USA. Kant and Lee (2004) analyzed four forest stakeholder groups preferences for ten aggregated forest values in Northwestern Ontario, Canada.

Engaging actors with different preferences, opinions, and expectations in participatory approaches can enrich forest management planning. Additionally, this collaboration improves the relationships among actors and decision-makers, promoting informed decisions, understanding, trust, and social learning (Blackstock et al., 2007; Reed et al., 2010; Voinov and Bousquet, 2010). Furthermore, actors' collaboration is different according to their level of involvement in participatory approaches. It is a continuum of actor involvement, from passive dissemination of information to active engagement and empowerment (Arnstein's, 1969; Reed, 2008) with pros and cons (Table 1). According to the literature (Howard, 1980; Lafon et al., 2004), participatory approaches that involve active participation (e.g., workshops and focus groups where participants express themselves and participate in discussions) appear to influence actors' opinion, learning and knowledge more than passive participation with indirect involvement (e.g., reading, hearing a lecture, attending meetings without speaking up).

In the list different participatory techniques for actor involvement (Table 1), like questionnaires and surveys, can support forest management planning by gathering qualitative and/or quantitative information about actors' preferences. This technique has several interesting features. Firstly, it is an affordable and expeditious method of collecting data; secondly, it allows actors to remain anonymous, maximizing their comfort and encouraging more sincere responses; thirdly, it is not too time-consuming; and fourthly, its data processing is faster when compared with interviews or multicriteria decision analysis. Thus, a survey questionnaire is an easy application tool that can assist decision-makers to get fast primary data.

Furthermore, the pre- and post-survey technique can help assess the impact of participatory approaches on actors' opinions and knowledge. This technique consists of two stages. An identical survey tool (e.g., questionnaire) is used before (pre-survey) and after (post-survey) a participatory assessment (e.g., meeting, workshop, field demonstration). Afterward, participants' answers to both surveys are statistically compared to quantify the differences and check whether opinion changes took place. According to Smith (1994), actors' opinions and interests do not change rapidly or unpredictably, and yet they may indeed change. Thus, time is needed between the pre- and the post-questionnaire so that participants can think and reflect about the information provided. However, according to some applications in the framework of natural resources management, the period to reflect before post-survey can vary from one day to more than one year.

For example, Upton et al. (2019) applied pre- and post-surveys to confirm the successful impact of a thinning demonstration in imparting knowledge to forest owners. They responded the post-survey 18 months after the demonstration. Lafon et al. (2004) applied this methodology to evaluate the influence of active participation on stakeholders' knowledge and opinions regarding wildlife management. The time interval between the pre- and the post-questionnaire was about one year. Mayer et al. (2017) conducted three participatory workshops, over a four-month period. The authors applied the pre-questionnaire on the first day of the first workshop and the post-questionnaire was administered at the last workshop (after four months). Likewise, they verified that the participatory workshops impacted participants' abilities on modeling and their beliefs on utility and accuracy of water resources systems models. During a five-day workshop, Fatorić and Seekamp (2017) confirmed that policy presentations and value-based deliberations about climate change adaptation of cultural resources not only influenced participants' opinions and understanding but also enhanced their social learning. The authors applied the pre-questionnaire prior the first workshop session (first day) and the post-questionnaire after the last workshop session (fifth day). Canfield et al. (2015) found that a one-day deliberative forum (or workshop) was useful in shifting participants' perceptions about the importance of climate change but did not significantly influence objective knowledge or energy policies to mitigate and adapt to climate change. Participants answered the pre-questionnaire when they arrived at the forum and completed the post-

questionnaire at the end of the event. Ashworth et al., 2013; Ooi and Tan, 2015 and Robles-Morua et al., 2014 also report the use of pre- and post-questionnaires in a one-day workshop. Based on former contacts and interactions with the actors (Marques et al. 2020) we deemed that a one-day workshop would be suitable for this research.

Nevertheless, to our knowledge, the pre- and post-survey methodology has not yet been used in a forest management planning framework to analyze the actors' preferences as well as opinion change and social learning. This research aims at addressing this gap. It is motivated by the fact that the quantification of the actors' preferences can provide a first overview of the actors' perceptions and opinions related to forest management and the provision of ecosystem services. Moreover, assessing the influence of a participatory approach on actors' opinions and social learning can indicate whether in-depth discussions or the application of further participatory techniques are needed to address misunderstandings or the lack of information to support forest management decisions. Furthermore, it can be an opportunity for forest managers and policymakers to assess how actors perceive alternatives to current forest management practices.

This research encompasses thus three objectives. Firstly, it aims at collecting primary data about (a) actors forest management planning preferences for forest management models, post-fire management options, forest functions, and ecosystem services, by a quantitative survey approach (individual quantitative information); and (b) actors opinions and points of view by participatory discussions (group qualitative information). Secondly, it aims at evaluating the impact of the presentations and participatory discussions on the actors' forest management preferences and opinions. Thirdly, it aims at assessing the effect of social interaction during the workshop on the actors' learning and knowledge. The methodology to address these objectives involves a workshop with participatory approach, matched pre- and post-questionnaires and a non-parametric test, the Wilcoxon Signed-rank test for paired samples, and a self-evaluation questionnaire.

2. Material and methods

2.1. Case study area

We applied our approach to a joint forest management area (ZIF) in Vale do Sousa, in North-Western Portugal (Fig. 1). It is a forested landscape extending over 14,840 ha, where eucalypt (*Eucalyptus globulus* Labill), and maritime pine (*Pinus pinaster* Aiton), in both pure and mixed stands, are the predominant species. The forest ownership is mostly private and fragmented into small forest holdings. There are some community areas managed by the local parish councils. The ZIF has 360 forest owners as members. Wildfires have been frequent and severe in Vale do Sousa. Over the period from 2005 to 2017, the area burned extended up to of 14,798 ha in Vale do Sousa (ICNF, 2019). The years with the largest burnt area were: 2005 (5383 ha, 36.3% of the total area) and 2017 (4006 ha, 27.0% of the total area).

Vale do Sousa is characterized by multiple actors' interests and high relevance of economic forest resources. Previous research (Borges et al., 2017; Juerges et al., 2017; Marques et al., 2020) revealed actors' keen interests in wood provisioning, particularly eucalypt pulpwood, as well as in wildfire risk reduction. The multiplicity of decision-makers, as well as the multitude of ecosystem services, make Vale do Sousa an interesting test case for our approach.

2.2. Research design

We implemented pre- and post-questionnaires, i.e., we used identical questionnaires in two steps to assess and analyze the actors' preferences and opinion changes over a full-day workshop. The evaluation of the presence and direction of opinion change enables us to analyze if and how information and discussions during the workshop can influence actors' opinions (Fatorić and Seekamp, 2017; Lafon et al., 2004) as well as social knowledge and learning (Reed et al., 2010).

2.2.1. Questionnaires structure

The questionnaire to implement the pre- and post-survey was were designed based upon a review of previous studies on the characterization of the forest management context in Vale do Sousa (Borges et al., 2017; Juerges et al., 2017; Marques et al., 2020). The pre- and post-questionnaires were divided into three thematic parts, and encompassed a total of nine questions, for an estimated 10-minutes response. It aimed to collect quantitative information targeting the elicitation of preferences. It did not ask for a justification of actor's preferences (qualitative information). However, all lists of Parts II and III allowed actors to add other unlisted features.

Part I collected actors' personal information, such as forest work experience. We also asked actors to indicate, from a list, the type of forest management actor to which they belonged. Next, Part II focused on forest management. It included questions aiming at the elicitation of actors' preferences. Specifically, they were asked (a) to rank six forest management models (FMMs) according to their preferences; (b) to propose a forest area distribution of Vale do Sousa by the FMMs (percentage); (c) to rank ten forest management post-fire options according to their preferences; and (d) to select two preferred forest functions from a list of seven. Part III targeted the elicitation of preferences for ecosystem services, ranking a list of eight by order of importance. In the ranking questions, we asked actors to rank in from "most preferred" to "least preferred".

In addition, we structured a self-evaluation questionnaire using a 5-point Likert scale ("very weak" to "very strong") for an estimated 5-minutes response. This questionnaire directly asks the actors a) to evaluate the level of importance of their participation and other actors in the discussions during the workshop; and b) to appraise whether presentations and discussions influenced their opinion and knowledge.

All the questionnaires were implemented in Portuguese. To prevent questionnaire bias and misinterpretation (Choi and Pak, 2005), we designed and structured all the questions using simple wording, e.g., avoiding ambiguous and complex questions, technical jargon, and uncommon words. Moreover, the questionnaires were pre-tested by three researchers.

2.2.2. Actors

To facilitate the discussion by the actors, the workshop was not announced to the public but restricted to invited actors. Furthermore, we built from past research (Integral Future-Oriented Integrated Management of European Forest Landscapes, 2015) as well as more recent studies (Juerges et al., 2017; Marques et al., 2020) to identify and invite 46 actors representing different interests in forest management (Table 2).

Of the 46 invited actors, a total of 33 actors attended the workshop and completed the pre-questionnaire (71.7%). However, only 24 actors out of these 33 completed the post-questionnaire (Table 2). Nine of 33 actors were not available to participate in the workshop all day. At the end of the day, 21 actors answered the self-evaluation questionnaire. The invited actors comprised a broadly representative sample of interests (Rowe and Frewer, 2000) for forest management in Vale do Sousa (Table 2). Thus, we categorized the actors into four groups according to their interests in forest management (Juerges and Newig, 2015; Marques et al., 2020).

2.2.3. Workshop

Two months before the workshop date, we sent an invitation email to actors, explaining the event objectives and asking to "save the date". One month before the workshop, we contacted actors by phone, reinforcing the invitation, explaining the agenda, and asking for confirmation of attendance. The final agenda was sent three weeks before the workshop. A week before, we called again actors who had not confirmed their participation yet. The workshop was held in November 2017, and it extended

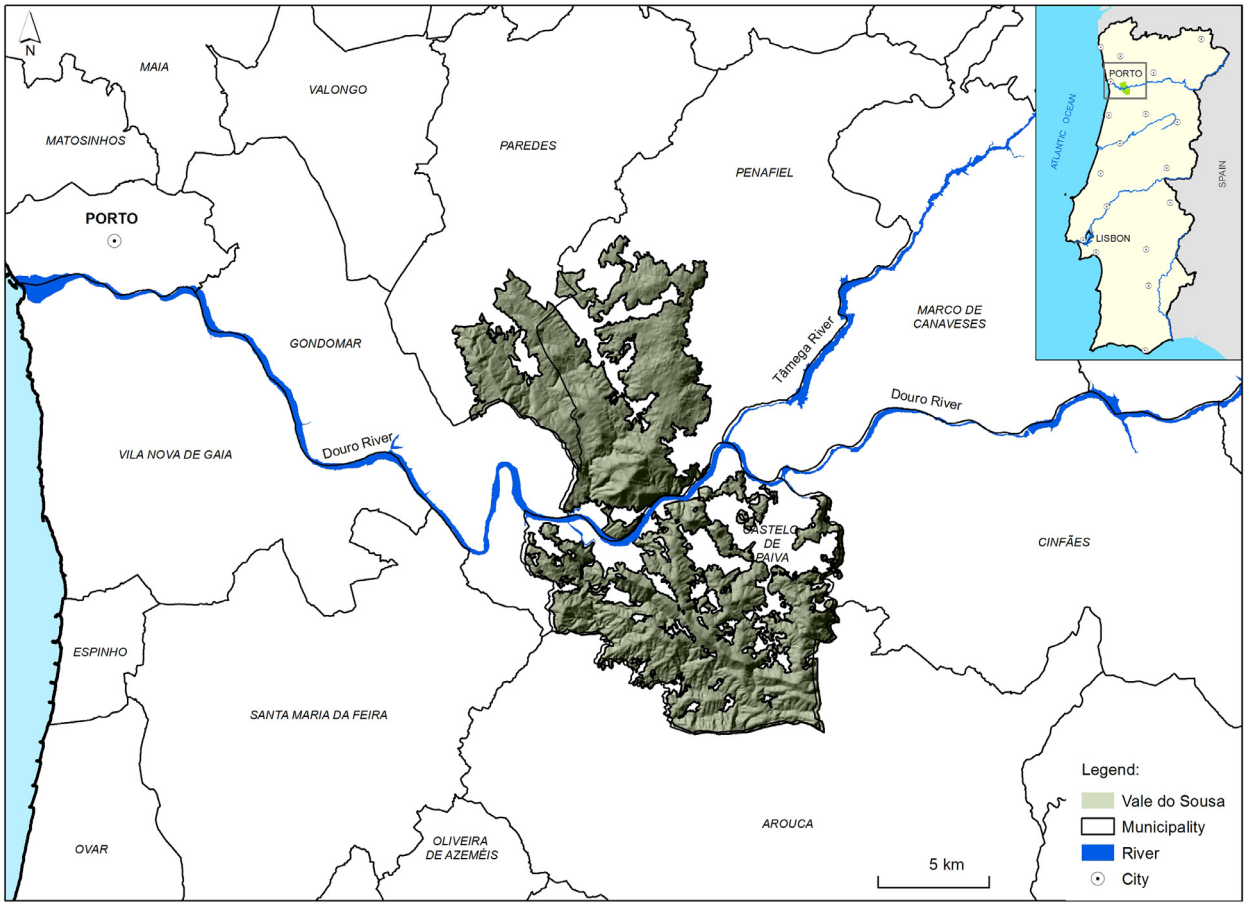

Fig. 1. Location of Vale do Sousa case study area.

Table 2
Identification of the actors invited to the workshop and who answered the questionnaires, categorized by interest group.

Interest group and type of actor	Invited to the workshop	Questionnaire		
		pre-	post-	evaluation
Civil society	***7***	***6***	***4***	***3***
Environmental NGO	4	3	1	2
Forest certification	3	3	3	1
Forest owners	***17***	***12***	***6***	***6***
Forest owners' association	3	3	1	1
Forest owners (non-industrial)	11	7	5	5
Parish council with community areas	3	2	0	0
Market agents	***16***	***10***	***10***	***8***
Biomass industry	1	0	0	0
Forest investment fund	2	1	1	1
Forest services provider	2	1	1	1
Forest services provider and wood buyer	3	3	3	3
Wood industry	4	3	3	3
Wood industry association	4	2	2	0
Public administration	***6***	***5***	***4***	***4***
Forest authority	3	3	2	2
Municipality	3	2	2	2
Total	**46**	**33**	**24**	**21**

over one day in the city of Porto. We chose this location because it is close to Vale do Sousa, about 30 min' drive, and is where most actors live or work.

In order to facilitate the discussion by the actors during the workshop, we set up the tables to create a large U-shape allowing all actors to be able to see at all times (a) each other; (b) the speakers (researchers); and (c) the discussion facilitators. During the workshop, we conducted a pre- and post-questionnaire. We distributed the pre-questionnaire after a welcome message and a brief introduction to the workshop goals and agenda. We stressed that questions focused on forest management in the Vale do Sousa case study area – the pre-questionnaire included a map of it on its last page.

After the actors completed the pre-questionnaire, two presentations were made. The way information is presented can influence decisions and social knowledge. So, speakers (researchers) tried to use simple discourse and presentations. The first presentation focused on actor analysis of the forest management context in Vale do Sousa (Juerges et al., 2017; Marques et al., 2020). It included a characterization of (a) actors interests for forest management and ecosystem services; (b) influential actors in forest management decisions; (c) main conflicts of interests and problems; (d) power resources to influence the forest actors' decisions (Marques et al. 2020). The second presentation characterized the contribution of stand-level FMMs to the provision of ecosystem services available in Vale do Sousa. For that purpose, it included (a) a short description – e.g., regeneration, fuel treatment and thinning options, rotation ages – of current FMMs (mixed maritime pine and eucalypt, mixed eucalypt and maritime pine, pure chestnut and pure eucalypt) and of two proposals of alternative FMMs (pure maritime pine and pure pedunculate oak); and (b) a graphical comparison of the provision of ecosystem

services (e.g., biodiversity, carbon sequestration, cultural services, resin, water quality, wildfires resistance, wood) by each FMM.

Then, two facilitators encouraged a participative discussion of the information provided. The participatory discussions aimed to collect actors' opinions and points of view, i.e. qualitative information, that can complement and support the quantitative information from the pre- and post-questionnaires. The facilitators had previous mediation experience in participatory discussions, and they were knowledgeable about Vale do Sousa forest management issues and actors profiles and interests. They tried to conduct the discussion in an independent, impartial, and unbiased way (Rowe and Frewer, 2000). The facilitators asked actors to speak openly and freely in order to (a) identify different perspectives on forest management in the case study area; (b) check points of view and opinions on the FMMs presented; and (c) discuss the integration of more FMMs that can meet actors' expectations to improve forest management planning. The facilitators aimed a shared understanding of the forest management planning options and opinions and not necessarily a consensus.

The actors answered the post-questionnaire after lunch at the beginning of the afternoon session. At the end of the day, we asked actors to respond to the self-evaluation questionnaire targeting the assessment of their participation as well as of others. We assigned each actor an alphanumeric code to link the actors' pre- and post-questionnaire responses and so that answers were anonymous.

2.3. Data analysis

We conducted a statistical analysis using the software IBM SPSS Statistics, version 25 (Armonk, NY: IBM Corp.), to understand and compare preferences and choices. We estimated statistics only for the 24 matched pre- and post-questionnaires. First, we used descriptive statistics to summarize the actors' characteristics and profiles. Next, we developed a statistical analysis of the frequencies to multiple-choice questions.

Then, we considered ranks as ordinal data and applied statistical tests to identify shifts in rankings as well as to explore whether the differences observed in the sample were statistically significant. We used a 5% value as a reference value for hypothesis testing, meaning we established the inference with an error probability of less than 5%. Since sample size was comparably low and we worked with categorical figures, and as the T-test is used for larger samples with normal distribution, we resorted to the non-parametric Wilcoxon test to assess differences between two repeated measurements (pre- and post-questionnaire). The Wilcoxon Signed-rank test for paired samples states the hypotheses:

H_0: The distribution of the variable values at both times (pre- and post-questionnaire) is equal.

H_1: The distribution of variable values at both times (pre- and post-questionnaire) is different.

When the proof value is higher than 5%, the null hypothesis is not rejected, i.e., there are no statistically significant differences between the two pairs of measures. Otherwise, when the proof value is less than 5% ($\alpha < 0.05$), the null hypothesis is rejected, and the alternative hypothesis is accepted; that is, there are statistically significant differences between two pairs of measures. We ranked the results according to the post-questionnaire. In the case of a tie between the means, we used the standard deviation to rank it (i.e., the mean with lower standard deviation was ranked higher). As the sample size by interest group was very small (four to 10 actors per group) we only applied the Wilcoxon Signed-rank test to the set of 24 matched pre- and post-questionnaires.

3. Results

3.1. Actors' profile

About 54.2% of the actors had professional experience in forestry or had held forest properties for over 20 years (Table 3). Only 8.4% of the actors had less than nine years of experience - they belonged to the group of Market agents. Wood industry actors from the Market agents' group (20.8% of total actors) managed an area larger than 100 ha. Nevertheless, most forest owners manage an area ranging from 2 to 50 ha.

The fragmentation and dispersion of forest blocks are typical in Vale do Sousa. About 50% of forest owners manage less than five blocks. Still, 33.3% manage between 10 and 100 blocks. In the case of Market agents, 30.0% manage more than 150 blocks. Actors manage pure eucalypt (26.7%) and mixed eucalypt and maritime pine (10.2%) FMMs. Most of the actors who manage forest areas stated they willingness to convert the area of maritime pine and eucalyptus stands to other species (e.g., chestnut), in case there is financial compensation.

3.2. Forest management models

In the pre-questionnaire (Table 4), on average, preferences were higher for *Pure maritime pine* (M = 4.88, SD = 1.57) and *Mixed eucalypt and maritime pine* (M = 4.79, SD = 1.91). The lower preference was for *Other forest management model* (M = 2.17, SD = 2.10), with actors identifying as alternative models: "Native mixed forests and Riparian galleries", "Mixed broadleaves stands with cork oak and birch", "Pure poplar", "Mixed stands with red oak", "Broadleaves stands" and "Pure stone pine", each for one actor.

On average, in the post-questionnaire (Table 4), the actors maintain their preference for *Pure maritime pine* (M = 4.88, SD = 1.62), followed by *Pure eucalypt* (M = 4.63, SD = 2.30). The lower preference remained for *Other forest management model* (M = 2.79, SD = 2.55). Four actors listed "Cork oak (pure or mixed with other oaks)", while two actors proposed "Mixed broadleaves", one actor suggested "Native mixed forests and Riparian galleries", and one actor indicated "Pure poplar".

The *p*-value is less than 5% for the differences between the pre- and post-questionnaire for *Other forest management model* (Table 4). Therefore, the null hypothesis is rejected and accepted the alternative hypothesis. The preference for *Other forest management model* increased significantly from the pre- to the post-questionnaire, with statistically significant differences observed (Z = -2.200, $p = 0.028$). While in the pre-questionnaire six FMMs were proposed by six actors, in the post-questionnaire the proposals were more consensual, since four FMMs were proposed by eight actors. The cork oak FMM was proposed by one actor on the pre-questionnaire while it was proposed by four in the post-questionnaire. However, the direction of actors' preferences did not change significantly in the case of the remaining FMMs, since the *p*-value is higher than 5% for the differences between the pre- and post-questionnaire, indicating strong evidence for the null hypothesis.

Regarding the distribution of the area by FMM, in the post-questionnaire, actors associated a higher percentage to *Pure eucalypt* (M = 34.63%, SD = 31.66%) and *Pure maritime pine* (M = 15.46%, SD = 15.68%) (Table 4).

For the *Other forest management model,* in the pre-questionnaire (M = 4.96%, SD = 12.26%), the actors suggested "Native mixed forests, and Riparian galleries", "Pure poplar" and "Mixed broadleaves stand", each by one actor. While in the post-questionnaire (M = 13.92%, SD = 19.47%), four actors proposed "Cork oak", three actors specified "Mixed broadleaves", one actor stated "Native mixed forests and Riparian galleries" and one actor listed "Pure poplar.

From pre- to post-questionnaire, the percentage of forest area associated with the models *Pure eucalypt* (Z = -2.190, $p = 0.029$) and *Other forest management model* (Z = -2.737, $p = 0.006$) increased significantly. By contrast, the percentage of forest area decreased significantly from pre- to post-questionnaire for the models *Mixed eucalypt and maritime pine* (Z = -2.045, $p = 0.041$) and *Pure chestnut* models (Z = -2.333, $p = 0.020$). Actors maintain their preferences about the forest area associated with the remaining three FMMs, since it did not change significantly ($p > 0.05$).

Table 3
Profile of respondent actors by interest group.

Characteristics	All actors (*n*=24)	Interest group			
		Civil society (*n*=4)	Forest owners (*n*=6)	Market agents (*n*=10)	Public administration (*n*=4)
(% of n)					
Experience (years)					
<= 4	4.2	0.0	0.0	10.0	0.0
5 – 9	4.2	0.0	0.0	10.0	0.0
10 – 14	16.7	25.0	16.7	0.0	50.0
15 – 19	20.8	25.0	16.7	30.0	0.0
>= 20	54.2	50.0	66.7	50.0	50.0
Forestland managed (ha)					
< 2	4.2	25.0	0.0	0.0	0.0
[2 - 5[	8.3	0.0	16.7	0.0	25.0
[5 - 20[	16.7	0.0	50.0	10.0	0.0
[20 - 50[	8.3	0.0	16.7	10.0	0.0
[50 - 100[	0.0	0.0	0.0	0.0	0.0
>= 100	20.8	0.0	0.0	50.0	0.0
Not applicable*	41.7	75.0	16.7**	30.0	75.0
Number of blocks					
< 5	20.8	25.0	50.0	0.0	25.0
[5 - 10[	4.2	0.0	0.0	10.0	0.0
[10 - 50[	8.3	0.0	16.7	10.0	0.0
[50 - 100[	12.5	0.0	16.7	20.0	0.0
[100 - 150[	0.0	0.0	0.0	0.0	0.0
>= 150	12.5	0.0	0.0	30.0	0.0
Not applicable*	41.7	75.0	16.7	30.0	75.0
Forest management model (% of the total area managed)					
Pure maritime pine	6.3	0.0	3.3	13.0	0.0
Pure eucalypt	26.7	0.0	35.0	43.0	0.0
Pure chestnut	0.2	0.0	0.0	0.5	0.0
Pure oak stand	1.5	0.0	3.3	1.5	0.0
Mixed of maritime pine and eucalypt	3.1	3.8	2.5	4.5	0.0
Mixed of eucalyptand maritime pine	10.2	12.5	18.3	0.5	25.0
Other forest management model***	7.0	8.8	20.8	0.9	0.0
Shrubs	3.4	5.0	0.0	6.1	0.0
Not applicable*	41.7	75.0	16.7	30.0	75.0

* Actors who do not manage forestland
** Forest Owners' Association
*** Strawberry tree, cork oak, plane trees, walnut tree, red oak, Douglas fir, and cedars.

During the participatory discussions, one actor from the Public Administration group proposed cork oak as an alternative FMM. Several actors expressed their agreement, generating a very participative discussion about the advantages of the cork oak, namely, to provide a regular income, and as a solution for dry areas. In Portugal, the cork oak is used to produce cork. Although, some actors mentioned that it could also be implemented as a coppice system to produce biomass. This option was also discussed for the pedunculate oak, as the rotation age is very long. Actors referred that it is very difficult to convince forest owners plant species with extended rotations, so the coppice system may be attractive as it contributes to anticipate income.

Throughout the discussion, there was a consensus among the actors that the FMMs with extended rotations would be hard to implement in Vale do Sousa due to the occurrence of wildfires (the fire recurrence period is about ten years). Actors agreed about the importance of riparian broadleaves as an alternative FMM for the water lines. Actors emphasized that a riparian FMM can promote discontinuity in the landscape and make it more resistant to wildfires and, at same time, foster the biodiversity in ecological corridors.

Discussions had a strong focus on economic importance of FMMs and how its profitability is paramount to forest owners and managers (e.g. eucalypt and maritime pine FMMs). Forest managers stressed that models should be adjusted for shorten rotations to address the wildfire recurrence period. Actors from the Market Agents group mentioned further that the pine industry prefers wood aged 30-35. In addition, some forest owners reported a high mortality of chestnut stands in Vale do Sousa. So, this FMM does not rank high in their preferences.

3.3. Forest management post-fire options

In the pre- and post-questionnaire (Table 5), the actors' preferences for forest management post-fire options were higher, on average, for *Increasing the diversity of forest species* (pre-questionnaire: M = 8.88, SD = 2.59; post-questionnaire: M = 9.00, SD = 2.36) and *Waiting for natural regeneration* (pre-questionnaire: M = 7.50, SD = 3.04; post-questionnaire: M = 7.21, SD = 3.08).

In the pre-questionnaire for the question *Converting the existing forest management model* (M = 4.29, SD = 3.81), actors suggested eleven conversion options. Two actors proposed "Planting other broadleaves" while the options "Forest stands with shrub mosaics (e.g., strawberry tree)", "FMM for nature conservation", "Modeling at landscape scale with areas for production, conservation, and ecological corridors", "Agroforestry mosaics with mixed broadleaves stands", "Grazing, mixed profitable and multi-purpose forest stands", "Forestland consolidation (parceling)", "Coercing landowners to join in reforestation", "Model that includes professional management", "Recreational and cultural services" and "Coppice stands" were proposed each by one actor. As to the question *Other post-fire option* (M = 2.71, SD = 3.17) actors proposed seven options: "(Re)establishing native mixed forests", "Restoring and planting cork oak", "Poplar stand in riparian areas", "Decreasing the area of monoculture forests", "Following the requirements of the forest certification process", "Creating road and divisional network appropriate to the scale and size of the property" and "Other uses (ex.: agriculture)" each by one actor.

The same number of conversion options were proposed in the post-questionnaire for the question *Converting the existing forest management*

Table 4
Pre- and post-questionnaire results and differences of preferences for forest management models and its area distribution (n=24). Rank according to the post-questionnaire.

	Pre-questionnaire		Post-questionnaire		Pre- and post-questionnaire differences				Z	p-value
					Variation		95% Confidence interval			
	Mean (SD)	Rank	Mean (SD)	Rank	Mean (SD)	Rank	Lower	Upper		
Forest management model (7 to 1)										
Pure maritime pine	4.88 (1.569)	1	4.88 (1.624)	1	⇨ 0.00 (0.978)	⇨ 0	-0.413	0.413	-0.144	0.886
Pure eucalypt	4.38 (2.481)	6	4.63 (2.300)	2	⇧ 0.25 (1.622)	⇧ 4	-0.935	0.435	-0.926	0.354
Mixed maritime pine and eucalypt	4.71 (1.517)	3	4.50 (1.745)	3	⇩ -0.21 (1.615)	⇨ 0	-0.473	0.890	-0.216	0.829
Mixed eucalypt and maritime pine	4.79 (1.911)	2	4.42 (1.998)	4	⇩ -0.38 (1.408)	⇩ -2	-0.220	0.970	-1.144	0.253
Pure chestnut	4.54 (1.719)	4	4.33 (1.633)	5	⇩ -0.21 (1.474)	⇩ -1	-0.414	0.831	-0.715	0.474
Pure pedunculate oak	4.46 (2.021)	5	4.33 (1.993)	5	⇩ -0.13 (1.329)	⇨ 0	-0.436	0.686	-0.203	0.839
Other FMM	2.17 (2.099)	7	2.79 (2.553)	7	⇧ 0.63 (1.439)	⇨ 0	-1.233	-0.017	-2.200	**0.028***
Area distribution by forest management model (% of the area)										
Pure eucalypt	27.04 (31.706)	1	34.63 (31.662)	1	⇧ 7.58 (18.094)	⇨ 0	-15.224	0.057	-2.190	**0.029***
Pure maritime pine	13.33 (14.257)	4	15.46 (15.682)	2	⇧ 2.13 (11.543)	⇧ 2	-6.999	2.749	-1.220	0.222
Other FMM	4.96 (12.256)	7	13.92 (19.473)	3	⇧ 8.96 (17.102)	⇧ 4	-16.180	-1.737	-2.737	**0.006****
Pure pedunculate oak	12.58 (13.237)	6	11.33 (13.014)	4	⇩ -1.25 (6.180)	⇧ 2	-1.360	3.860	-1.076	0.282
Mixed maritime pine and eucalypt	12.92 (13.413)	5	8.71 (11.745)	5	⇩ -4.21 (13.022)	⇨ 0	-1.290	9.707	-1.417	0.157
Mixed eucalypt and maritime pine	14.75 (16.971)	2	8.50 (12.090)	6	⇩ -6.25 (14.161)	⇩ -4	0.270	12.230	-2.045	**0.041***
Pure chestnut	14.42 (15.197)	3	8.25 (9.013)	7	⇩ -6.17 (13.477)	⇩ -4	0.476	11.857	-2.333	**0.020***

* significant at $p < 0.05$; ** significant at $p < 0.01$; SD – standard deviation; ⇧ increase; ⇩ decrease; ⇨ no variation

Table 5
Pre- and post-questionnaire results and differences of preferences for forest management post-fire options (n=24). Rank according to the post-questionnaire.

	Pre-questionnaire		Post-questionnaire		Pre- and post-questionnaire differences				Z	p-value
					Variation		95% Confidence interval			
	Mean (SD)	Rank	Mean (SD)	Rank	Mean (SD)	Rank	Lower	Upper		
Forest management post-fire option (11 to 1)										
Increasing the diversity of forest species	8.88 (2.593)	1	9.00 (2.359)	1	⇧ 0.12 (2.133)	⇨ 0	-1.026	0.776	-0.040	0.968
Waiting for natural regeneration	7.50 (3.036)	2	7.21 (3.078)	2	⇩ -0.29 (1.706)	⇨ 0	-0.429	1.012	-0.611	0.541
Planting pure chestnut	6.75 (2.524)	5	7.04 (2.255)	3	⇧ 0.29 (1.756)	⇧ 2	-1.033	0.450	-0.885	0.376
Planting pure pedunculate oak	7.38 (2.810)	3	7.00 (2.621)	4	⇩ -0.38 (1.813)	⇩ -1	-0.391	1.141	-0.963	0.335
Planting pure maritime pine	7.13 (2.007)	4	6.83 (2.648)	5	⇩ -0.29 (2.440)	⇩ -1	-0.739	1.322	-0.753	0.452
Planting mixed maritime pine and eucalypt	6.38 (2.337)	8	6.58 (2.412)	6	⇧ 0.21 (2.570)	⇧ 2	-1.294	0.877	-0.453	0.651
Planting mixed eucalypt and maritime pine	6.54 (3.050)	6	6.58 (2.977)	6	⇧ 0.04 (2.386)	⇨ 0	-1.049	0.966	-0.029	0.977
Maintain existing forest occupation	5.04 (3.316)	9	5.54 (3.203)	9	⇧ 0.50 (3.776)	⇨ 0	-2.095	1.095	-0.390	0.697
Planting pure eucalypt	6.50 (2.919)	7	6.25 (3.287)	8	⇩ -0.25 (2.400)	⇩ -1	-0.764	1.264	-0.690	0.490
Converting the existing FMM	4.29 (3.805)	10	5.08 (3.966)	10	⇧ 0.79 (3.489)	⇨ 0	-2.265	0.682	-1.204	0.228
Other post-fire option	2.71 (3.169)	11	1.58 (1.840)	11	⇩ -1.13 (2.833)	⇨ 0	-0.071	2.321	-2.032	**0.042***

* significant at $p < 0.05$; SD – standard deviation; ⇧ increase; ⇩ decrease; ⇨ no variation

model (M = 5.08, SD = 3.97) namely: "Other broadleaves", "Mixed broadleaves", "Cork oak", "Native mixed species (or in combination with interesting exotic species)", "Native and riparian forest", "Mixed maritime pine to pure maritime pine", "Maritime pine revolutions of 25 to 30 years old at most", "Model for nature conservation", "Profitable and sustainable forest species", "Forestland consolidation (parceling)", "FMM that includes professional management", each for one actors. However, for the question *Other post-fire option* (M = 1.58, SD = 1.84), actors proposed three options: "Pastures, agriculture and others", "Poplar stand in riparian areas", and "Any sustainable FMM", each by one actor.

The preference for *Other post-fire option* decreased significantly from the pre-questionnaire to the post-questionnaire, with statistically significant differences observed (Z = -2.032, p = 0.042). However, there was no significantly shift in the direction of the actors' preferences for the remaining forest management post-fire options, from pre- to post-questionnaire (p> 0.05).

According to actor analysis of the forest management context in Vale do Sousa (Juerges et al., 2017; Marques et al., 2020), wildfire risk was considered as the problem that can influence most forest management decisions. During the participatory discussion session, forest managers reinforced the importance of this problem in their decisions. Some forest owners have reported that this situation has discouraged them from investing in forest management. They also argued that, due to the high recurrence of wildfires, their forest management post-fire options are related to low-cost options (e.g. waiting for natural regeneration). However, forest managers were consensual in the preference for species diversification and for a multifunctional forest that may allow them to (a) reduce wildfire risk; and (b) promote diversify of its forestry revenues.

3.4. Forest functions and ecosystem services

Actors selected *Wood production* (M = 91.67%, SD =28.23%) as the most important forest function in the pre-questionnaire (Table 6), followed by *Cultural services promotion* (29.17%, SD = 46.43%). Regarding the question *Other forest function* (M = 8.33%, SD = 28.23%) one actor identified "Forest jobs creation and maintenance".

In the post-questionnaire (Table 6), *Wood production* (M = 75.00%, SD = 44.23%) ranked also first, followed by *Water quality protection* (M = 33.33%, SD = 48.15%). As to the question *Other forest function* (M = 12.50%, SD = 33.78%), the answers included "Water cycle regulation" and "Fire prevention", each by an actor. However, the preference for the function *Wood production* decreased significantly from the pre- to the post-questionnaire (Z = -2,000, p = 0.046). For the remaining forest functions the observed differences were not statistically significant (p > 0.05) since actors' preferences did not shift significantly from pre- to post-questionnaire.

On average, in the pre-questionnaire (Table 6), the preferred ecosystem services was *Wood* (M= 5.63, SD = 2.86), followed by *Water Quality* (M = 5.33, SD = 2.12). The most preferred ecosystem service is the same in the post-questionnaire (M = 6.42, SD = 2.47), while *Biodiversity* (M = 5.38, SD = 1.72) ranks second. Even so, the observed differences from pre- to post-questionnaire were not statistically significant (p > 0.05) for all the ecosystem services. Actors did not significantly change the direction of their opinion and maintained their preferences for ecosystem services.

The graphical comparison of ecosystem service indicators by FMM raised several questions about the possibility of ecosystem services, in addition to wood, being profitable. Some actors were unaware of this possibility (e.g. carbon market). Furthermore, actors from Public Administration and Civil Society interest groups stressed the importance of diversifying the forest functions and ecosystem services to contribute for a sustainable forest management. However, the provision of non-market services in the case study area depend on the possibility of attracting payments for them.

3.5. Evaluation of actors' participation in the workshop

Of the 21 actors who responded to the questionnaire, 33.3% had never been involved in participatory approaches, while 14.3% had already been involved more than ten times, 42.9% had been involved in two to five participatory approaches, and 9.5% only once. All actors confirmed their willingness to participate in future participatory approaches.

The results (Fig. 2) highlight that about 85.7% of the respondents rated *Other actors' participation in discussions* as of strong to very strong importance. It reveals the value of social interaction to share points of view and opinions. *Actor learning during the workshop* was also highly rated (85.8% strong to very strong importance), indicating that the information available and the discussions contributed to actor's understanding and knowledge.

Regarding the evaluation of their participation, around 71.4% of the actors indicated that they had been able to clearly share their ideas and opinions during the workshop. Although, the rating of their *Participation in discussions* was somewhat lower, about 66.6% considered it strong to very strong. Less than half of the actors (42.8%) indicated strong to very strong importance to changes in initial opinion because of the discussion. It means that the remaining actors considered that they slightly changed their initial opinion (57.1%). No actor rated any of the items as of very low importance. Only 4.8% of actors rated as of low importance some questions (*Actor ideas and opinions clearly shared* and *Actor participation in discussions*).

The workshop discussions and the actors' comments in the evaluation questionnaire revealed that most actors considered that this approach contributed to (a) their learning from the information provided; (b) their discussion with actors who had different preferences in forest management, and (c) their understanding of other actors' opinions and points of view.

4. Discussion

This approach was not intended to model actors' opinions. Moreover, we did not aim to reach a consensus on FMMs, forest management post-fire options, forest functions, or ecosystem services to be considered in forest management planning. The objectives were to quantify actors' preferences, identify alternative FMMs and capture the multiplicity of actors' points of view. The findings can support ZIF managers better orient forest management planning. Also, we sought to understand if the workshop environment leads actors to change their opinion and promotes social knowledge and learning. The main advantage of this approach is the ease of application and its time and data processing cost effectiveness.

4.1. Actors preferences and opinion change

In general, actors' preferences and opinions regarding current forest management did not change significantly since the observed differences are not statistically significant (p > 0.05). Also, the actors' evaluation of their participation in the workshop confirmed that most of them did not strongly change their opinion. However, results highlight some opinion shifts from pre- to post-questionnaire that may be due to the workshop participatory discussions and are noteworthy.

The main actors' preferences for FMMs were first for *Pure maritime pine* and second for *Pure eucalypt*. In addition, actors assigned a higher percentage of area to the *Pure eucalypt* model, which increased significantly from pre- to post-questionnaire, followed by *Pure maritime pine*. These results confirm and strengthen the current preference of forest managers for these two FMMs. Besides, these species occupy most of the area in Vale do Sousa. According to the actors opinions during workshop discussions, the preferences for *Pure eucalypt* and *Pure maritime pine* FMMs are based on (a) the income that can be obtained in the short term

Table 6
Pre- and post-questionnaire results and differences of preferences for forest functions and ecosystem services (n=24). Rank according to the post-questionnaire.

	Pre-questionnaire		Post-questionnaire		Pre- and post-questionnaire differences					
					Variation		95% Confidence interval		Z	p-value
	Mean (SD)	Rank	Mean (SD)	Rank	Mean (SD)	Rank	Lower	Upper		
Forest function (frequency of yes, %)										
Wood production	91.67 (28.23)	1	75.00 (44.23)	1	-16.67 (38.07)	0	0.59	32.74	-2.000	**0.046***
Water quality protection	20.83 (41.49)	4	33.33 (48.15)	2	12.50 (33.78)	2	-26.77	1.77	-1.732	0.083
Biodiversity promotion	20.83 (41.49)	4	29.17 (46.43)	3	8.33 (40.82)	1	-25.57	8.91	-1.000	0.317
Soil protection	25.00 (44.23)	3	25.00 (44.23)	4	0.00 (0.00)	-1	na	na	0.000	1.000
Cultural services promotion	29.17 (46.43)	2	20.83 (41.49)	5	-8.33 (40.82)	-3	-8.91	25.57	-1.000	0.317
Carbon sequestration	12.5 (33.78)	6	16.67 (38.07)	6	4.17 (20.41)	0	-12.79	4.45	-1.000	0.317
Non-wood forest products production	8.33 (28.23)	7	12.50 (33.78)	7	4.17 (20.41)	0	-12.79	4.45	-1.000	0.317
Other forest function	8.33 (28.23)	7	12.50 (33.78)	7	4.17 (20.41)	0	-12.79	4.45	-1.000	0.317
Ecosystem service (8 to 1)										
Wood	5.63 (2.856)	1	6.42 (2.466)	1	0.79 (2.226)	0	-1.732	0.148	-1.699	0.089
Biodiversity	5.29 (1.488)	3	5.38 (1.715)	2	0.08 (1.586)	1	-0.753	0.586	-0.215	0.830
Wildfires resistance	5.04 (2.476)	5	5.13 (2.092)	3	0.08 (1.998)	2	-0.927	0.760	-0.024	0.981
Water quality	5.33 (2.120)	2	5.04 (2.156)	4	-0.29 (2.177)	-2	-0.627	1.211	-0.952	0.341
Soil erosion protection	5.17 (2.078)	4	4.92 (2.062)	5	-0.25 (1.939)	-1	-0.569	1.069	-0.394	0.694
Carbon sequestration	4.25 (2.172)	6	4.38 (2.163)	6	0.13 (1.569)	0	-0.788	0.538	-0.257	0.797
Cultural services	4.13 (1.918)	7	3.96 (2.331)	7	-0.17 (2.278)	0	-0.795	1.129	-0.344	0.731
Resin	2.92 (2.448)	8	2.42 (2.205)	8	-0.50 (1.978)	0	-0.335	1.335	-1.222	0.222

* significant at $p < 0.05$; SD – standard deviation; na – not applicable; ⇧ increase; ⇩ decrease; ⇨ no variation

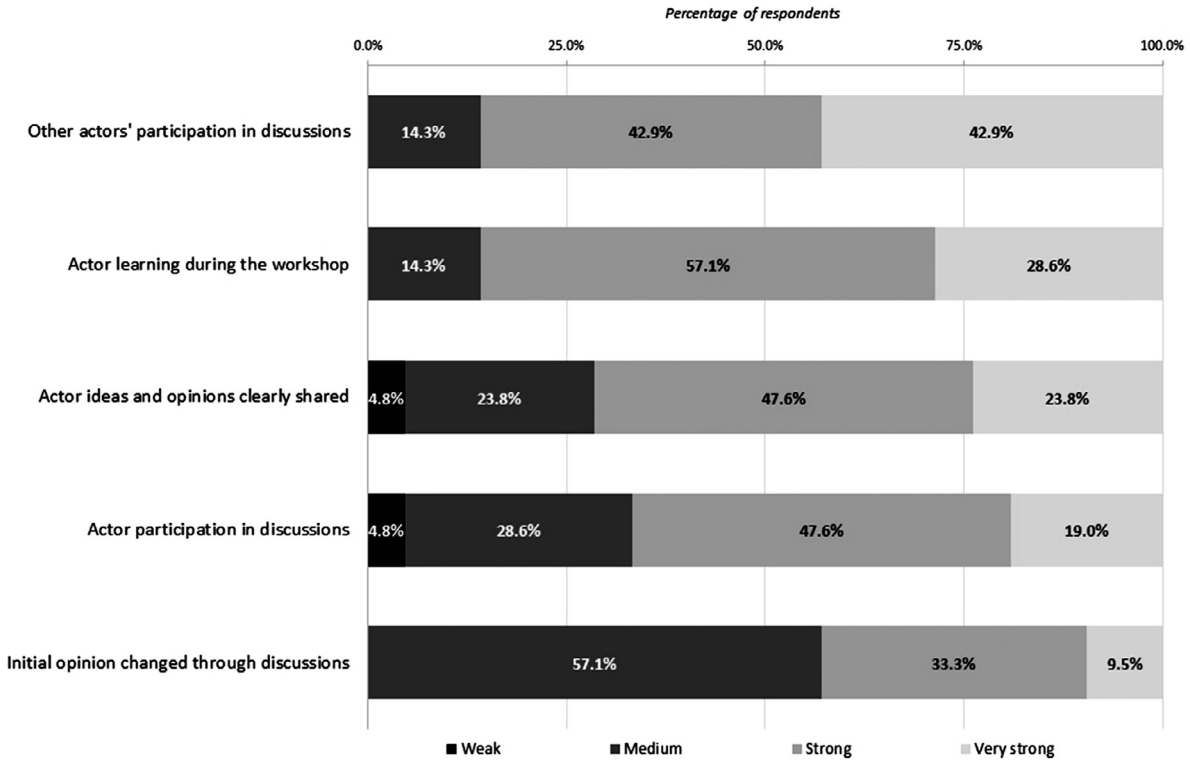

Fig. 2. Aggregate results (n=21) of actors' perceptions about their and others' participation in workshop discussions, measured on a 5-point Likert-scale ("very weak" to "very strong" importance).

(e.g., eucalypt is harvested every 10-12 years and maritime pine at 35-50 years); (b) the wildfire recurrence period (about ten years); and (c) the market demand. Throughout discussions actors stressed that FMMs with extended rotation ages are not attractive to forest owners and managers. Further, actors from the Market Agents group stated that market demand for pine wood is less than 35 years. Therefore, actors required an adjustment of the *Pure maritime pine* and *Pure pedunculate oak* models to shorten the rotation age and anticipate revenues.

During the discussions, some forest owners reported a high mortality of trees of *Pure chestnut* model. This situation can be caused by ink disease (*Phytophthora cinnamomic*) or by chestnut cancer (*Endothia parasitica* And & And). This sharing of information may explain the actors' opinion shift on the area to be allocated to this model. The preferences for *Pure chestnut* decreased significantly from pre- to post-questionnaire, changing from the third preferred FMM to the least preferred.

Most forest owners and managers depend on the forest economic returns, directly or indirectly. During the workshop discussions, actors reinforced that one of the most important concerns is the profitability of forestry investment. Moreover, actors revealed the importance they assign to the diversification of income sources and to the evenness of revenue flows. According to the actors, in Vale do Sousa, these economic criteria depend on the *Wood production,* classified as the most important forest function while *Wood* is the preferred ecosystem service. These findings reinforce the preference of actors for *Wood* provisioning in Vale do Sousa, as reported by Borges et al. (2017), Juerges et al. (2017), and Marques et al. (2020).

To achieve a profitable and multifunctional forest, that can minimize the wildfire problem, during participatory discussions, actors debated the inclusion of two alternatives FMM: (a) cork oak (pure or mixed); and (b) riparian broadleaves. Discussions about these alternative models may have led to the actors' opinion shift since the preference for *Other forest management model* increased significantly from the pre- to the post-questionnaire. In the pre-questionnaire the cork oak FMM was proposed by a single actor while in the post-questionnaire it was proposed by four actors. In addition, forest managers emphasized that wildfires may dissuade them from choosing species with longer rotation age. Actors stressed that the cork oak FMM may be an adequate alternative to respond to concerns (namely with income even flow and with losses due to wildfires) that influence forest management decisions in Vale do Sousa. Besides the cork oak regularity of income (every nine years), the actors also highlighted the cork oak's excellent ability to regenerate in the post-fire conditions in Vale do Sousa.

Another notable opinion shift, from pre- to post-questionnaire, was a significant decrease in preference for the forest function *Wood production*. This opinion change may be related to the information that speakers (researchers) presented about the range of available ecosystem services and forest functions in Vale do Sousa. The graphical comparison of the available ecosystem services by FMM brought a new vision and helped promote discussions about the possibility of diversifying forest functions and ecosystem services as this may contribute to decrease losses by wildfires. Also, some actors stressed the importance of diversify the forest functions for a sustainable forest management.

Despite the fact that actors continue to consider *Wood production* as the most important forest function, the decrease in their preference evidence a willingness to change current forest management practices. In fact, during the participatory discussions, actors expressed their interest in a multifunctional forestry. It appeared that actors are available to consider alternative FMMs and to diversify the forest functions and ecosystem services in forest management planning. Forest managers interested in profitable forests were not opposed to alternative FMMs (e.g. riparian broadleaves), forest functions (e.g., water quality protection), or ecosystem services (e.g., biodiversity) since they can receive payments for that forest management change.

These findings suggest an opportunity for ZIF managers to enhance forest management planning, since there is an openness of the forest managers to accept changes to the current forest management practices. This reveals that if more information is provided about scenarios involving changing social demand, market fluctuations and wildfires re-

currence, actors may adjust their preferences to better address the new challenges.

4.2. Actors knowledge and social learning during the workshop

An evaluation questionnaire should complement the pre- and post-questionnaire approach to assess (a) the quality of workshop and participatory approach and discussions; (b) the interaction between actors; (c) actors self-learning and knowledge. Most actors stated that they viewed themselves as having learned during the workshop, increasing their knowledge in a social context. Moreover, the actors acknowledged that with the participatory discussions they better understand the points of view of other actors regarding forest management. Also, they highlighted the increased knowledge of opportunities and alternatives to diversify forest functions, ecosystem services and FMMs, that they may consider in forest management planning.

Thus, there is evidence that in our approach the participatory discussions contributed to social learning, confirming the findings by Reed et al. (2010) and Voinov and Bousquet (2010). Most actors did play an active role during the workshop; they discussed forestry issues and learned with social interaction. Furthermore, the workshop also demonstrated its utility in improving the relationships between actors. Some evidence of this social learning was the interactions after the workshop, with questions and requests for more information related to the workshop discussions. For example, two forest owners, one actor from wood industry association and another from forest certification contacted us to ask for more information about the alternative FMMs and the assortment of ecosystem services in Vale do Sousa. Another example was the contact by an actor from the forest authority with whom we discussed the improvement of the cork oak FMM proposed during the workshop discussion session.

The results from the application of pre- and post-questionnaire to actors' preferences for forest management, can be compared to other similar studies in natural resources management. As demonstrated by this research, the participatory approach that involves social interaction between actors can (a) impact their knowledge and learning (Fatorić and Seekamp, 2017; Mayer et al., 2017; Upton et al., 2019); and (b) in some situations, can contribute to actors opinion change (Canfield et al., 2015; Lafon et al., 2004).

4.3. Participatory approach limitations and future improvements

The application of this approach provided valuable information that may be used by future research. We identified five issues to address. Firstly, the time available for the actors to interact with researchers and to discuss among them might be extended to support further their reflections and the learning process. This would be influential to examine further whether in forest management planning, opinions change quickly or if, as Smith (1994) points out, actors' opinions and interests do not change rapidly or unpredictably.

In this framework, in future research, we might apply the same questionnaire in four steps, to quantify and confirm the impact of the workshop and participatory discussions in a long-time frame. In the first step, we would send the pre-questionnaire by email or mail to the actors one week before the workshop so that they could examine it comfortably without the workshop social environment time constraint. In the second step, actors would answer the pre-questionnaire in the first session of the workshop. In the third step, actors would respond the post-questionnaire at the end of the workshop. And in the fourth step, we would send the post-questionnaire by email or mail to the actors one week after the workshop, so that they have more time to absorb, reflect and think about all the information provided by the speakers (researchers) and the participatory discussions. Thus, we can compare a pre-questionnaire and two post-questionnaires and assess the effect of participatory discussions and social interaction in actors' initial opinion, according to the time given for reflection (on the day and one week later).

The drawback of this four steps approach can be a low response rate as outside the workshop environment since it may be more difficult to ensure actors' commitment and availability. In addition, it may be challenging to ensure that a suitable number of the same actors answer the three questionnaires so that we may get matched questionnaires. In order to circumvent potential shortcomings of the four steps approach, the questionnaires should be sent to a wide range of stakeholders, ensuring diversity and representability of interest groups. In addition, follow-up work with the actors will be necessary in the first and fourth steps. Researchers should contact actors, by phone or in person, to motivate them to answer the questionnaires, emphasizing the importance of their participation in the study.

Secondly, in future research the structure of the questionnaires might be adjusted to explore further the actors' points of view. Although actors could add other unlisted features, they had little time to justify their preferences and explain their perceptions. Also, not all actors feel comfortable to freely express their opinions in participatory discussions. Thus, in future research, we may add a field to each question for actors to express themselves anonymously, without restrictions that the social environment may impose on them.

Thirdly, future research should address further the weak participation of some actors in the discussion and the need to strengthen their involvement. Therefore, we should identify the most passive or shy actors and enhance their participation so that they can present and share their ideas and opinions. Fourthly, future research should address the fact that actors with the same interests or from the same entity or interest group may speak to each other and agree on some responses to the questionnaires. So, to guarantee individual and independent responses, actors' seats are distributed in advance, ensuring that actors sitting side by side have different interests. Moreover, before starting to fill up the questionnaire, the researcher can reinforce that the answers are individual.

Fifthly, future research should develop strategies to ensure sufficient actors for statistical analysis, assuring the representativeness of interests. We identified and invited 46 actors representing the diversity of interests in forest management in Vale do Sousa. Actors were categorized into four groups, according to their interests in forest management (Juerges and Newig, 2015; Marques et al., 2020): civil society, forest owners, market agents and public administration. Knowing at the outset that not all actors would be available to participate in the workshop, we invited more actors (46 actors) than we thought it would be interesting to have present (30 to 35 actors). Although 13 actors were not available to attend, those who participated in the workshop were representative of the four interest groups from Vale do Sousa. However, only 24 actors were available to attend the full day workshop. So, further research is needed to develop and explore strategies for engaging more actors in the participatory approaches. This will be influential to draw more information from the perspective of each group.

5. Conclusions

This study provides information about actors' preferences and points of view to support landscape-level forest management planning. It is the first evaluation of actors' preferences for FMMs, forest functions and ecosystem services for Vale do Sousa. Our findings reveal the importance of involving actors to discuss alternatives to current forest management practices.

Vale do Sousa forest management planning encompassed four FMMs and three species, eucalypt, maritime pine and chestnut. In the workshop, researchers proposed two alternative FMMs (*Pure maritime pine* and *Pure pedunculate oak*), that were well accepted by the actors. However, they asked for an adjustment to these FMMs to shorten the rotation age and anticipate revenues. An important outcome from this participatory approach was the inclusion of two new alternative FMMs - *Cork*

oak and *Riparian broadleaves* - in forest management planning in Vale do Sousa. During participatory discussions actors considered that these two models are suitable for Vale do Sousa as they meet their economic goals (income flow) and environmental concerns (biodiversity and wildfire protection). Due to discussions, actors changed their opinion about these alternative FMMs, and their preference for them increased significantly from pre- to post-questionnaire. With this participatory approach, we went from four to eight FMMs, thus contributing to diversify the forest management options in Vale do Sousa.

The integration of actors' preferences and participatory discussions outcomes from this study in ZIF forest management planning can (a) facilitate its social acceptance and implementation; (b) the development of more consensual forest management plans; and (c) contribute to enhance actors' knowledge and learning. The proposed approach can be easily applied or replicated in other ZIF or forest management areas. This systematic collection of information (quantitative from questionnaires and qualitative from participatory discussions) may be useful to support ZIF managers, when developing collaborative forest management plans, or policymakers, when designing effective forest policy programs that can address the actors' demands and preferences. Moreover, comments by actors reported in the self-evaluation questionnaire confirmed that they found the workshop and participatory discussions useful. This approach enables actors to enhance their knowledge about the range of FMMs, forest functions and ecosystem services that can promote a multifunctional and sustainable forestry.

The survey of actors' preferences for forest management using pre- and -post-questionnaires is a useful, practical, low-cost, and straightforward way for evaluating their opinions and perceptions. However, further research can improve this approach by (a) giving actors more time to reflect in their preferences and choices (before and after workshop); (b) asking actors to justify their preferences in questionnaires so we can better understand their opinion change; (c) assessing the social learning using an evaluation questionnaire with more questions to quantify it; (d) extending the workshop to a broader interest groups; and (e) developing strategies to attract more actors and motivate them to participate in the workshop throughout the day.

This research was developed in the framework of a participatory process that is being developed with actors with interests in forest management of Vale do Sousa. In the next stage of the process we will take advantage of the actor analysis research (Juerges et al., 2017; Marques et al., 2020) and the results from this workshop with a participatory approach to develop further the assessment of actors' preferences applying other participatory techniques in the framework of multiple criteria decision analysis.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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References

Arnstein, A., 1969. A ladder of citizenship participation. J. Am. Inst. Plan. 26, 216–233.
Ashworth, P., Einsiedel, E., Howell, R., Brunsting, S., Boughen, N., Boyd, A., Shackley, S., Van Bree, B., Jeanneret, T., Stenner, K., Medlock, J., Mabon, L., Ynke Feenstra, C.F.J., Hekkenberg, M., 2013. Public preferences to CCS: how does it change across countries? Energy Procedia 37, 7410–7418. doi:10.1016/j.egypro.2013.06.683.
Balest, J., Hrib, M., Dobšinská, Z., Paletto, A., 2016. Analysis of the effective stakeholders' involvement in the development of National Forest Programmes in Europe. Int. For. Rev. 18, 13–28. doi:10.1505/146554816818206122.
Blackstock, K.L., Kelly, G.J., Horsey, B.L., 2007. Developing and applying a framework to evaluate participatory research for sustainability. Ecol. Econ. 60, 726–742. doi:10.1016/j.ecolecon.2006.05.014.
Borges, J.G., Marques, S., Garcia-Gonzalo, J., Rahman, A.U.U., Bushenkov, V., Sottomayor, M., Carvalho, P.O., Nordstrom, E.M., Nordström, E.-M., 2017. A multiple criteria approach for negotiating ecosystem services supply targets and forest owners' programs. For. Sci. 63, 49–61. doi:10.5849/FS-2016-035.
Brescancin, F., Dobšinská, Z., De Meo, I., Šálka, J., Paletto, A., 2018. Analysis of stakeholders' involvement in the implementation of the Natura 2000 network in Slovakia. For. Policy Econ. 89, 22–30. doi:10.1016/j.forpol.2017.03.013.
Bruña-García, X., Marey-Pérez, M., 2018. Participative forest planning: How to obtain knowledge. For. Syst. 27, 1–11. doi:10.5424/fs/2018271-11380.
Canfield, C., Klima, K., Dawson, T., 2015. Using deliberative democracy to identify energy policy priorities in the United States. Energy Res. Soc. Sci. 8, 184–189. doi:10.1016/j.erss.2015.05.008.
Carmona, G., Varela-Ortega, C., Bromley, J., 2013. Participatory modelling to support decision making in water management under uncertainty: two comparative case studies in the Guadiana river basin. Spain. J. Environ. Manag. 128, 400–412. doi:10.1016/j.jenvman.2013.05.019.
Choi, B.C.K., Pak, A.W.P., 2005. A catalog of biases in questionnaires. Prev. Chronic Dis. 2, 1–13.
Cowling, P., DeValue, K., Rosenbaum, K., 2014. Assessing Forest Governance. A Practical Guide to Data Collection, Analysis, and Use. PROFOR and FAO. Washington DC.
Fatorić, S., Seekamp, E., 2017. Evaluating a decision analytic approach to climate change adaptation of cultural resources along the Atlantic Coast of the United States. Land Use Policy 68, 254–263. doi:10.1016/j.landusepol.2017.07.052.
Focacci, M., Ferretti, F., De Meo, I., Paletto, A., Costantini, G., 2017. Integrating stakeholders' preferences in participatory forest planning: a pairwise comparison approach from Southern Italy. Int. For. Rev. 19, 413–422. doi:10.1505/146554817822272349.
Howard, G.S., 1980. Response-Shift Bias. A problem in evaluating interventions with pre/post self-reports. Eval. Rev. 4, 93–106.
ICNF 2019. Defesa da Floresta Contra Incêndios. Incêndios Rurais: mapas. Instituto da Conservação da Natureza e das Florestas. Retrieved from www2.icnf.pt/portal/florestas/dfci/inc/mapas (accessed September 17, 2019).
Integral Future-Oriented Integrated Management of European Forest Landscapes, 2015. Reference to reports and research papers available in http://www.integral-project.eu/project-outcomes.html (html).
Juerges, N., Krott, M., Lundholm, A., Corrigan, E., Masiero, M., Pettenella, D., Makrickienė, E., Mozgeris, G., Pivoriūnas, N., Lynikas, M., Brukas, V., Arts, B., Hoogstra-Klein, M., Laar, J. van, Borges, J.G., Marques, M., Carvalho, P.O., Canadas, M.J., Novais, A., Mendes, A., Sottomayor, M., Pinto, S., Brodrechtova, I., Smreček, R., Bahýľ, J., Bošela, M., Sedmák, R., Tuček, J., Lodin, I., Başkent, E.Z., Karahalil, U., Karakoç, U., Sari, B., 2017. Internal Report on actors driving forest management in selected European countries. ALTERFOR project. Reference to reports and Research Papers available in https://alterfor-project.eu/
Juerges, N., Newig, J., 2015. How interest groups adapt to the changing forest governance landscape in the EU: a case study from Germany. For. Policy Econ. 50, 228–235. doi:10.1016/j.forpol.2014.07.015.
Kangas, A., Laukkanen, S., Kangas, J., 2006. Social choice theory and its applications in sustainable forest management-a review. For. Policy Econ. 9, 77–92. doi:10.1016/j.forpol.2005.02.004.
Kant, S., Lee, S., 2004. A social choice approach to sustainable forest management: an analysis of multiple forest values in Northwestern Ontario. For. Policy Econ. 6, 215–227. doi:10.1016/j.forpol.2004.03.005.
Lafon, N.W., Mcmullin, S.L., Steffen, D.E., Schulman, R.S., 2004. Improving stakeholder knowledge and agency image through collaborative planning. Wildl. Soc. Bull. 32, 220–231.
Luyet, V., Schlaepfer, R., Parlange, M.B., Buttler, A., 2012. A framework to implement Stakeholder participation in environmental projects. J. Environ. Manag. 111, 213–219. doi:10.1016/j.jenvman.2012.06.026.
Maroto, C., Segura, M., Ginestar, C., Uriol, J., Segura, B., 2013. Sustainable Forest Management in a Mediterranean region: social preferences. For. Syst. 22, 546–558. doi:10.5424/fs/2013223-04135.
Marques, M., Juerges, N., Borges, J.G., 2020. Appraisal framework for actor interest and power analysis in forest management - Insights from Northern Portugal. For. Policy Econ. 111, 14. doi:10.1016/j.forpol.2019.102049.
Martins, H., Borges, J.G., 2007. Addressing collaborative planning methods and tools in forest management. For. Ecol. Manag. 248, 107–118. doi:10.1016/j.foreco.2007.02.039.

Mayer, A., Vivoni, E.R., Kossak, D., Halvorsen, K.E., Morua, A.R., 2017. Participatory modeling workshops in a water-stressed basin result in gains in modeling capacity but reveal disparity in water resources management priorities. Water Resour. Manag. 31, 4731–4744. doi:10.1007/s11269-017-1775-6.

Nordström, E.M., Eriksson, L.O., Öhman, K., 2010. Integrating multiple criteria decision analysis in participatory forest planning: experience from a case study in northern Sweden. For. Policy Econ. 12, 562–574. doi:10.1016/j.forpol.2010.07.006.

Ooi, P.C., Tan, M.T.T., 2015. Effectiveness of workshop to improve engineering students' awareness on engineering ethics. Procedia - Soc. Behav. Sci. 174, 2343–2348. doi:10.1016/j.sbspro.2015.01.898.

Reed, M.S., 2008. Stakeholder participation for environmental management: a literature review. Biol. Conserv. 141, 2417–2431. doi:10.1016/j.biocon.2008.07.014.

Reed, M.S., Evely, A.C., Cundill, G., Fazey, I., Glass, J., Laing, A., Newig, J., Parrish, B., Prell, C., Raymond, C., Stringer, L.C., 2010. What is social learning? Ecol. Soc. 15, 10. doi:10.5751/ES-03564-1504r01.

Robles-Morua, A., Halvorsen, K.E., Mayer, A.S., Vivoni, E.R., 2014. Exploring the application of participatory modeling approaches in the Sonora River Basin, Mexico. Environ. Model. Softw. 52, 273–282. doi:10.1016/j.envsoft.2013.10.006.

Rossi, F.J., Carter, D.R., Alavalapati, J.R.R., Nowak, J.T., 2011. Assessing landowner preferences for forest management practices to prevent thesouthern pine beetle: an attribute-based choice experiment approach. Forest Policy Econ. 13 (4), 234–241. doi:10.1016/j.forpol.2011.01.001.

Rowe, G., Frewer, L.J., 2000. Public participation methods: a framework for evaluation. Sci. Technol. Hum. Values 25, 3–29. doi:10.1177/016224390002500101, T4 - A Framework for Evaluation M4 - Citavi.

Sarkissian, A.J.A.J., Brook, R.M.R.M., Talhouk, S.N.S.N., Hockley, N., 2018. Using stakeholder preferences to select native tree species for reforestation in Lebanon. New For. 49, 637–647. doi:10.1007/s11056-018-9648-2.

Sarvašová, Z., Dobšinská, Z., Šálka, J., 2014. Public participation in sustainable forestry: The case of forest planning in Slovakia. IForest 7, 414–422. doi:10.3832/ifor1174-007.

Smith, T.W., 1994. Is there real opinion change? Int. J. Public Opin. Res. 6, 187–203. doi:10.1093/ijpor/6.2.187.

Upton, V., Ryan, M., Heanue, K., Dhubháin, Ní, 2019. The role of extension and forest characteristics in understanding the management decisions of new forest owners in Ireland. For. Policy Econ. 99, 77–82. doi:10.1016/j.forpol.2017.09.016.

Voinov, A., Bousquet, F., 2010. Modelling with stakeholders. Environ. Model. Softw. 25, 1268–1281. doi:10.1016/j.envsoft.2010.03.007.