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D10_D3.2_Perceptions and expectations of forest owners and managers

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1 LITERATURE REVIEW 4

1.1 Introduction 4

1.2 Methodology of the review of the forest managers and owners' perceptions and expectations 7
1.2.1 Using Google Scholar as a search engine for systematic reviews 7
1.2.2 Method for identifying the relevant literature about perceptions 8

1.3 Literature results on forest managers and owners' perceptions 12
1.3.1 Forest managers and forest owners perceptions 12
1.3.2 Limitations of the studies on perceptions and expectations 15

1.4 Conclusions from perceptions and expectations literature review 16

2 SURVEY ON THE FOREST OWNERS' AND MANAGERS PERCEPTIONS AND EXPECTATIONS – DATA COLLECTION PROTOCOL 18

2.1 The context and the purpose of the interviews/questionnaires 18

2.2 The consent to participate to the survey 19

2.3 The WP3 questionnaire description 20
2.3.1 How looks the questionnaire? 20
2.3.2 How will the data be used? 20
2.3.3 Confidential and proprietary 20
2.3.4 Online Questionnaire 21
2.3.5 Target groups 21
2.3.6 Procedure of the first questionnaire implementation 22
2.3.7 Reporting and justification of delayed submission of the deliverable D3.2 24
2.3.8 Structure of the questionnaire 26

3 RESULTS FROM PRETESTING THE QUESTIONNAIRE 32

3.1 Sample profile 32

3.2 Forest manager's perceptions of climate change 32

3.3 Forest managers' perceptions of measures for climate change adaptation and mitigation 34

3.4 Comparison of the results from pre-testing with other existing studies 36

4 RESULTS FROM THE SURVEY ON FOREST OWNERS' AND MANAGERS' PERCEPTIONS AND EXPECTATIONS ON CLIMATE CHANGE (28.11.2023) 40

4.1 General perceptions about climate change 40
4.1.1 How the impact of climate change is perceived by forest owners and managers? 40
4.1.2 How the future effects ofclimate change are perceived by forest owners and managers? 41
4.1.3 How do the respondents situate themselves on the interpretation of climate change origins? 43
4.1.4 Estimating the level of concern on different forest-related issues under climate-change context 43
4.1.5 Perceived vulnerabilities and risks 45

4.1.6 Quantifying the effect of climate change on forest ecosystem provisioning 46

4.2 Opinions on mitigation policies and strategies 47
4.2.1 Opinions on strategies for mitigations 47
4.2.2 Estimating the impact of mitigation measures 49

4.3 Opinions and preferences about forest management adaptation to climate change at stand level ..51
4.3.1 Which is the main forestry system the respondents implement in their forests 51
4.3.2 Reasons for changing forest management in the past 52

5 CONCLUSION 55

5.1 Literature findings 55

5.2 Limitations in studying perceptions and attitudes over adaptation and mitigation and precautions in the design of the survey 55

5.3 Pretesting the questionnaire 56

5.4 The results of the survey (N=98) 56
5.4.1 A better sampling will allow a better differentiation amongst the European bio-geographical regions 56
5.4.2 There are clear perceptions of climate change effects as changing temperature and precipitation regimes 57
5.4.3 Belief in climate change varies, there is potential for non-adaptation/ non-mitigation 57
5.4.4 How climate change will affect the ecosystem provisioning 57
5.4.5 Opinions on strategies for mitigation place on the top the promotion of woody biomass as an energy source, but there are contrasting views 58
5.4.6 Motivation of decisions to change forest management taken in the past decade 59

6 REFERENCES 60

1 Literature review

1.1 Introduction

One of the WP3 objectives is to provide a meta-analysis of environmental, socioeconomic, technical, political, and legal/administrative barriers and opportunities of forest-based mitigation and adaptation strategies at the regional scale, as identified in past projects, available macro-economic data and sociological analysis.

Task 3.1: Framing patterns of forest-based mitigation and adaptation (Months: 1-6; Lead: USV; Participants: I4CE) addressed this objective through a literature review and an analysis of the existing macro-economic data, e.g., forest productivity, forest investments and/or forest inventory data. The results (materialised in D3.1) will provide input to WP1 and WP4 concerning barriers and opportunities of mitigation and adaptation strategies at the regional scale, and the factors that may help or hamper the strategies of carbon stocking in long-life projects.

Our reviewing methodology was based on a literature study dealing with forest-based mitigation and adaptation and on a synthesis work on core literature that addresses the perceptions of forest managers and forest owners.

Adapting European forest management to climate change involves consideration of institutional factors and options. The pattern of ownership, the level of policy creation, and the nature of forest commodities and services are all important elements impacting adaptation (Bouriaud *et al.* 2015). Stakeholder participation in forest management planning, the expected inadequacy of present management approaches, and the presence of adaptation barriers all generate opportunities for adaptation (Bussotti *et al.* 2015). Overcoming path dependency and behavioral barriers can be accomplished by encouraging local self-government processes and incorporating external stakeholders in forest and climate change policy adaptation (Sousa-Silva *et al.* 2018). Furthermore, when several decision-making levels are involved, climate change belief systems and political engagement play key roles in explaining adaptation (Nelson *et al.* 2016).

In a top-down decision-making process, private forest owners confront perceived climate change risks in addition to other risks (Coșofreț and Bouriaud 2022). The decision to adapt to climate change is influenced by both objective and subjective elements, such as the owners' and property's qualities, as well as their perception of climate change and its consequences. Forest ecosystems are vulnerable to climate change, and knowing its consequences and hazards is critical for making educated decisions (Freer-Smith *et al*. 2007). In Austria, where small-scale private forest owners manage a significant portion of the forest area, tailored approaches are needed to influence the decision-making processes of female forest owners (Pröbstl-Haider *et al.* 2020). Private forest insurance can be used as a means to fund resilience and adaptation, with the insurance decision impacting forest management practices (Loisel *et al.* 2019, 2020).

Continuous cover forestry (CCF) is gaining interest in Europe as a forest management strategy that promotes species and structural diversity. However, there is limited information

on the extent of CCF adoption and the knowledge gaps and challenges hindering its wider use. A survey across 33 European countries estimated that between 22% and 30% of European forests are managed through CCF, although data are lacking (Mason *et al.* 2021). The main knowledge gaps include uncertainties related to climate change, forest resilience, mechanized harvesting, and economic implications of CCF. Major obstacles include limited awareness and competence in CCF among forest owners and professionals, high ungulate populations damaging natural regeneration, and a lack of experience in transforming plantation forests (Pommerening and Murphy 2004). In the UK, where CCF is relatively new, efforts have been made to improve knowledge on thinning interventions and stand structure through simple models and hybrid gap models (MacKintosh 2013). The implementation of CCF in Sitka (Alaska) spruce forests faces technical challenges and cultural resistance (Mason 2015). Retention forestry, including habitat trees and dead wood, is being practiced in uneven-aged, continuous-cover forestry in temperate regions of Europe, with potential for further development (Gustafsson *et al.* 2020).

Local actor groups in Southwestern Europe interpret natural forest regrowth on abandoned land differently (Frei *et al.* 2020). The study of interviews done in France and Spain reveals three narratives: a rural fatalism narrative, a pro-forest management story, and a pro-nature narrative. These tales have their own problem descriptions and solutions for natural forest restoration. Regional subtleties and land use variables impact local actor groups' perceptions. Natural forest regrowth serves symbolic roles ranging from lost territory to reclaimed land. When assessing trade-offs and opportunities, it is critical to evaluate the local situation, and management and governance approaches should take into account the cultural ideas that form the actor group view. Different social actors at various levels of the policy-making process have competing positions and perceptions towards nature protection, sustainable forest management, and biodiversity integrity (Blondet 2015). However, in general local people in the field do not consider climate change as a relevant issue for them, as they have not noticed significant signs of environmental change in their surroundings (Thomas *et al.* 2022). On the other hand, private forest owners in France have already implemented adaptation strategies to climate change, such as early harvest, thinning, and irregular silviculture, with the decision to adapt being influenced by both objective and subjective variables (Andersson *et al.* 2017). The implementation of adaptation strategies, such as assisted migration, varies between countries like Canada and France due to factors such as differing strategies, concerns about geoengineering and economic arguments, and the lack of information flow between research and foresters (Sansilvestri *et al.* 2016). Effective communication and a clear understanding of common goals and expectations are crucial for successful science-stakeholder interactions in the forestry sector (Stephens *et al.* 2010, Jönsson and Swartling 2014).

Three main kinds of uncertainty influence forestry regeneration decisions under climate change-related uncertainties and dangers (Schou *et al.* 2015). First, the perceived time horizon before there is an assurance about the outcome influences decision-making. Ex--ante, forest managers who anticipate extended periods of climate change uncertainty may make suboptimal decisions. Second, the distribution of impacts across alternative outcomes influences decision-making. The more skewed the belief distribution, the more ex-ante decisions will be made (Yousefpour and Hanewinkel 2016). Lastly, the subjective probability

assigned to each outcome plays a role in decision-making. Forest managers' beliefs about the likelihood of different outcomes will influence their decisions (Albert *et al.* 2015).

The perception of forest owners and managers of the threats posed to forests by abiotic and biotic pressures is critical for understanding what strategies and approaches are being used to mitigate their effects and what options could be proposed if no action is taken (Sousa-Silva *et al.* 2018, Vincenti *et al.* 2020). A large number of studies have focused on understanding the perspectives of forest owners and forest managers on climate change, as well as their willingness to make changes in forest management practices to promote forest ecosystem adaptation to future climate conditions (Lawrence and Marzano 2013, van Gameren and Edwin Zaccai 2015, Heltorp *et al.* 2016, Sousa-Silva *et al.* 2018, Hengst-Ehrhart 2019, Pröbstl-Haider et al. 2020, Deuffic *et al.* 2020, Thomas *et al.* 2022). Sansilvestri *et al*. 2020 evaluate the capacity of forestry stakeholders about climate change and the top-down policies in different forest-socioecological systems.

Values, knowledge, trust, risk perception, desired outcomes, past hardships, and beliefs all play a role in forest management decision-making (Aubin *et al.* 2011, Hajjar and Kozak 2015). But forest socioecological systems, such as economic, political, cultural and ecological characteristics can play an important role in both mitigating climate change and adapting to local communities (Sansilvestri *et al.* 2020). In another case, the adaptation to climate change is not a priority in Swedish forestry, and business-as-usual techniques are encouraged due to economic motivations and industry demand for timber (Andersson and Keskitalo 2018). It has been discovered that the prevailing view among private owners of small forest properties that are not continuously managed by experts is to let natural dynamics in forest ecosystems guide self-regulatory processes without intervening (Mostegl *et al*. 2019).

Although the concepts of sustainability, adaptive capacity, and resilience are interconnected, their application in efforts to adapt areas to new conditions creates great obstacles, because it is unclear which situations favor these system features (Sansilvestri *et al.* 2020). Nevertheless, foresters feel constrained by too many restrictions, due to options limited for their own forest (Sansilvestri *et al.* 2020). Furthermore, despite abundant biodiversity, forest productivity remains poor due to adverse environmental circumstances. It is critical to comprehend and investigate the adaptation logic that drives and shapes business-as-usual to develop transformative adaptive measures and strategies related to climate change on long-term impacts (Andersson and Keskitalo 2018). In Central European countries, for example Austria, current and future forest managers are sensitive to changes in ecological processes caused by climate change, concerning disturbances of tree mortality (Seidl *et al.* 2016). On the other hand, in Germany, small private forests contributed to a national strategy on biological diversity, but their perceptions of biodiversity conservation affect their management techniques, which can serve as ecologically valuable stepping-stones towards landscape-scale biodiversity protection. Moreover, the policies aiming to integrate biodiversity conservation into forest management should consider the engagement of local forest owners as their perceptions of conservation impacts affect their management approaches (Joa and Schraml 2020). Forestry professionals in southwest Germany perceive climate change as a significant risk, with concerns about extreme hazards, water scarcity, and changes in climatic zones. They see the potential for forestry to mitigate climate change as low but view adaptation strategies as helpful (Yousefpour and Hanewinkel 2015).

Small-scale private forest owners play a crucial role in the European Natura 2000 conservation network. They perceive regulating and cultural services as more important than provisioning ecosystem services and have a multifunctional perspective on their forests (Tiebel *et al.* 2021). However, forest owners with Natura 2000 sites have a stronger focus on resource use and do not perform conservation measures more frequently than those without (Tiebel *et al.* 2021). Moreover, this ownership group has more negative nature conservation attitudes (Joa and Schraml 2020). To effectively implement the Natura 2000 scheme, it needs to be more strongly adapted to the demands of small-scale private forest owners, including increasing participation and establishing a results-based incentive scheme for conservation measures (Belin *et al.* 2005). Considering the perspectives of small-scale private forest owners in forestry decision-making can strengthen sustainable forest management that integrates nature conservation and resources use (Pröbstl-Haider *et al.* 2020).

1.2 Methodology of the review of the forest managers' and owners' perceptions and expectations

The different methods for reviewing literature and identifying relevant projects are described in the following subsections.

1.2.1 Using Google Scholar as a search engine for systematic reviews

Google Scholar was created by Google Inc., a private company, but it is open to the public and aims to summarize all electronic references on a topic. It supports both quick and advanced searches. The results of an advanced search can be limited by title words, authors, source, date of publication, and subject areas (Falagas *et al.* 2008).

The sample selection of pertinent studies impacts a review`s conclusion, validity, and explanatory power. Rigorous evidence identification is crucial for systematic reviews and meta-analyses (evidence syntheses) (Gusenbauer and Haddaway 2020). There is a dearth of comprehensive, empirical performance ratings and limited recommendations for search engines and bibliographic databases to use for systematic searches (Adriaanse and Rensleigh 2013, Haddaway *et al*. 2015, Moed *et al*. 2016, Martín-Martín *et al*. 2018, Gusenbauer and Haddaway 2020). According to Becher and Trowler (2001), there is a direct connection between the disciplines (territories of knowledge) and those who develop them (scientific tribes); between the social characteristics of academic communities and the epistemic properties of the various kinds of scientific knowledge. For this reason, the cognitive (the disciplines themselves) and social (the community) domains must be considered in any analysis of a discipline. What is practiced by individuals who cultivate a discipline is a discipline (Martín-Martín *et al*. 2018). When specifically looking for recognized articles Google Scholar (GS) can identify the majority of the evidence in the systematic review case studies examined. Yet, compared to typical academic citation databases or grey literature identification techniques, GS can find a sizeable amount of new grey literature (Haddaway *et al*. 2015). Grey literature is considered as those documents not published by

commercial publishers which includes academic theses, organisation reports, government papers and may prove to be quite influential in syntheses e.g. (Haddaway *et al*. 2015, Haddaway and Bayliss 2015, Yasin *et al.* 2020). According to Haddaway *et al.* (2015), between 8 and 39% of full-text search results are classed as grey literature. Moreover, GS results are displayed in relation to the times of user visits, not to another index of publication quality (Falagas *et al.* 2008). According to research, GS's indexing and ranking of academic papers must be improved further. Nonetheless, this platform provides viable avenues for searching and disseminating research that would otherwise languish in journal collections. GS allows researchers to inform their research, improve future research, expand scholarly networking for collaborations, and market their research (Zientek *et al.* 2018). GS is extremely precise for exploratory searches conducted by a user who is only interested in a few relevant results on the first page of search engine results (Gusenbauer and Haddaway 2019).

1.2.2 Method for identifying the relevant literature about perceptions

According to Navon (1977), perceptual processing is viewed as a unified process in which both the *"where"* and *"what"* questions are answered while the scene is structured. In most real-world situations, the human perceptual processor's task is not only to account for given input, but also to choose which part of the surrounding stimulation is worth receiving, attending to, and processing. In our research analysis the questions of *"where"* and *"what"* **refer to the analysis of the publications at the European level about how forest managers and forest owners perceive climate change with its impact on forests**.

Because perception is essentially dynamic, there is frequently only time for partial analysis due to the constant change in input. In that case, a general idea of structure is more valuable than a few isolated details (Navon 1977). Perceptual processing, as stated by Palmer (1975) and Norman and Bobrow (1976) and supported by a large body of empirical evidence, must be both **input-driven and concept-driven.** Thereby, **perception** is viewed as a two-way process in which hypotheses about what a stimulus might be interacting with what the stimulus is to determine what the stimulus is ultimately perceived to be.

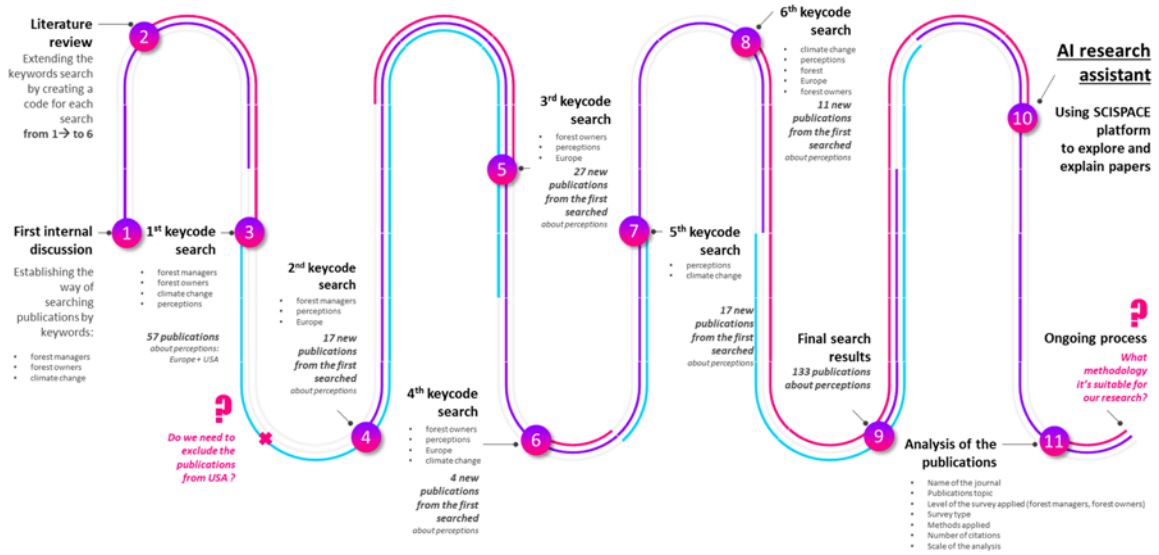


Figure 1 Identifying relevant literature about perceptions in forestry by main keywords

Following the steps proposed by Biesbroek *et al*. (2015), we used GS as the main search engine for the literature review. Thus, the keywords about perceptions related to climate change, such as ”forest managers”, ”forest owners”, ”climate change”, ”Europe”, ”forest”, and ”perceptions” were the main inputs for identifying the primary publications e.g. articles, and grey literature.

The keywords were used in different order and the searches were coded as (see Figure 1):

1. **Code 1** for the keywords ”forest managers”, ”forest owners” ”climate change” with **57 publications** resulted;
2. **Code 2** for the keywords ”forest managers”, ”forest owners”, ”climate change”, ”perceptions”, with **17 new publications** resulting from the first search with Code 1;
3. **Code 3** for the keywords ”forest owners”, ”Europe”, ”perceptions”, with **27 new publications** resulted;
4. **Code 4** for the keywords ”forest owners”, ”perceptions”, ”Europe”, ”climate change”, with **4 new publications** resulted;
5. **Code 5** for the keywords ”perceptions”, ”climate change”, with **17 new publications** resulted;
6. **Code 6** for the keywords ”climate change”, ”perceptions”, ”forest”, ”Europe”, ”forest owners”, with **11 new publications** resulted.

We established this method because we observed that at every search other new publications resulted, when changing word’s order. Thus, a final number of 133 publications were selected for review, and they were introduced in a database by using Microsoft Excel® structured as follows:

1. Publication ID: (year, authorship, Title);
2. Journal name;
3. Subject type of the publication: forest managers / forest owners / stakeholder perceptions / general analysis / public perceptions / review;
4. Geographic region: Europe-wide, USA, Global;

5. Main topic of the publication: climate change / forest management / forest ecosystem services / forest certification / bioenergy / decision-making / Natura 2000 / conservation;
6. Survey type: online questionnaire / interviews / field survey / mixed approach
7. Methods used: exploratory analyses / context analysis / landscape visualisation / comprehensive discourse analysis;
8. Number of citations – the most cited publications are those with general analysis about perceptions of climate change or about public perceptions, either at the Global level or those from the USA.
9. Keywords.

Among the 133 papers selected for review, 54 of them were about forest owners' perceptions, followed by 25 about stakeholder perceptions in which the research is done from different actors' perspectives including forest owners, forest managers level, or both. Furthermore, 20 of them analyse the perceptions of forest managers, and 13 are included in the same publication forest owners and forest managers perceptions. Only 4 of them analyse the perceptions from the private forest owners association perspective. The rest of the 17 publications are either literature reviews, general analysis, public perceptions and surveys made with national representatives. From 133 publications 23 of them have been published in Forest Policy and Economics Journal, and 10 in national journal from Scandinavia subregion in Northern Europe. Journals such as Forests, Global Environmental Change, Environmental Science & Policy, Small-scale forestry, Environmental Management, Land Use Policy, Climate change and Ecosystem Services were also journals with important publications about forest owners' and forest managers' perceptions.

The review analysis was focused on Europe, overall European-wide-based publications are 33, and all the individual countries from Europe have been classified as European regions. Therefore, in Central-West we identified 25 publications, in Central-East 12 publications, in South-West 4 publications, in South-East 3 publications and in the Northern region 27 publications. Besides these situations, we identified other publications from Europe in which the research was made together with other continents. If taking into account these steps, the reviewing was made for 109 articles at the European level.

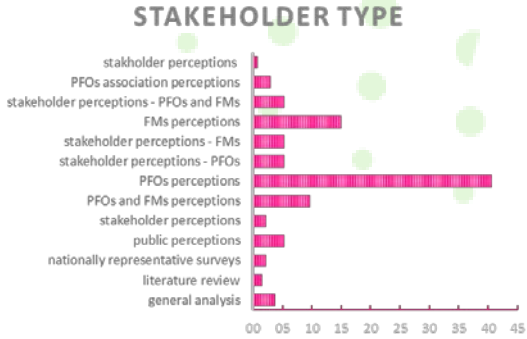


Figure 2 Publications identified by stakeholder type for analyzing the perception of climate change

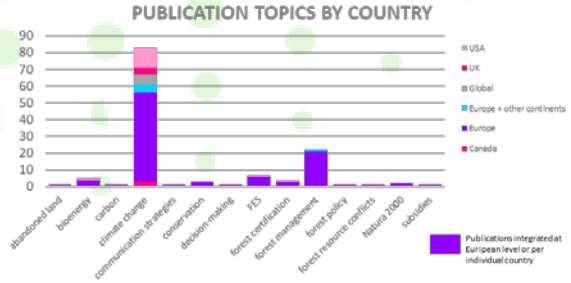


Figure 3 Publications identified by main topics found in the title

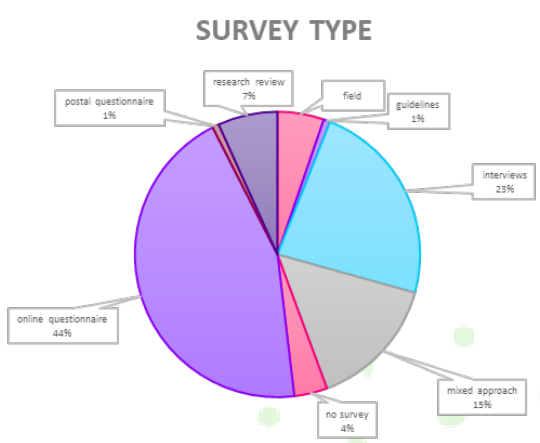


Figure 4 Publications identified by the method applied using different surveys

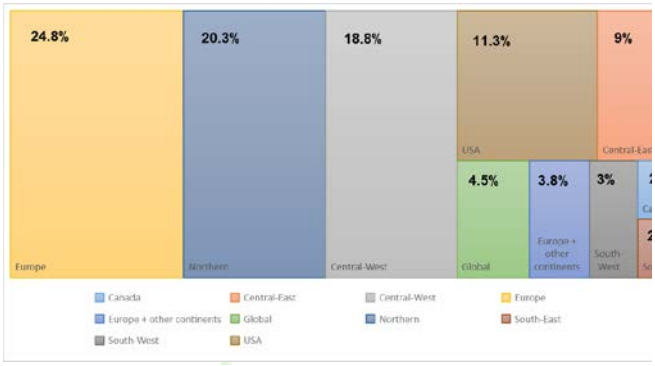


Figure 5 Publications identified by the range of research

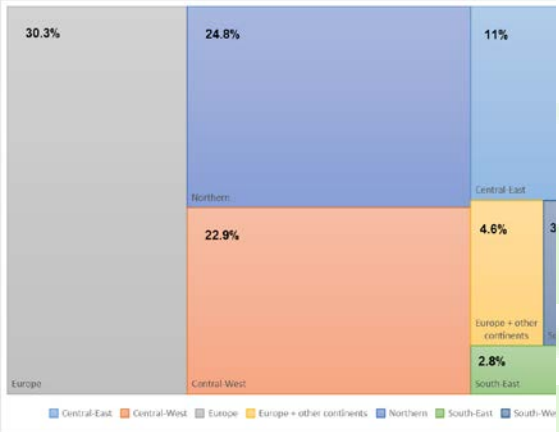


Figure 6 Publications identified at the European level

1.3 Literature results on forest managers' and owners' perceptions

1.3.1 Forest managers' and forest owners' perceptions

Following the described methodology, the perceptions on barriers and opportunities for implementation of mitigation and adaptation measures in forestry in Europe are described in a summarized way in this chapter. We also paid special attention to the studies published on the following topics:

- Perceptions on the need to increase the adaptive capacity to climate change;
- Perceptions on the need to maintain or preserve the ecosystem services, and
- Perceptions on the need to adapt forest management practices under different scenarios.

1.3.1.1 Forest owners' perceptions

The results were summarized according to the main topic of the publications and the range of the studies. Thereby, the main perceptions of forest owners are described as:

1. Planned adaptation – when forest owners anticipate climate change;
2. Accidental adaptation – when forest owners can be motivated by other reasons while being unaware of the need to adapt forest management.

Increasing the forest management practices that enhance the adaptive capacity to climate change

According to the findings, some forest owners are already taking adaptive measures (van Gameren and Edwin Zaccai 2015, Sousa-Silva *et al.* 2018), or they show a great need to adapt forest management practices for climate change adaptation (Sousa-Silva *et al.* 2016), or they are aware of climate change impacts and its effects (Pröbstl-Haider and Haider 2013, Mostegl *et al.* 2019). Technical forestry actions predominate among them, such as choice of plantations, stand structure, or measures taken against drought risks being so-called interventionist measures, and the passive measures are those about natural processes such as natural regeneration and maintaining the cover (van Gameren and Edwin Zaccai 2015). On the other side in some countries e.g. France, Belgium Portugal, Netherlands and Estonia there is a lack of technical knowledge and information for adapting the management of their forest to climate change (Sousa-Silva *et al.* 2018). The focus of future research is to improve the communication of adaptation challenges and strategies for climate change (Sousa-Silva *et al.* 2016). Pröbstl-Haider *et al*. (2020) highlighted some significant differences in gender perceptions. Thus, females prefer environmental and human-centered forest management practices.

Many countries already developed adaptation strategies and action plans (Sousa-Silva *et al.* 2018) to increase the acceptance of new strategies (Mostegl *et al.* 2019). In some cases the mobilization of forest owners remains the most crucial task, especially when it comes to harvesting methods of so-called "utility-oriented forest owners", and applying long-term

approaches with a focus on the strategy of so-called ”recreation-oriented forest owners” (Mostegl *et al.* 2019). Eriksson (2018) says that advice and economic policy incentives are more effective among forest owners.

Maintaining or preserving the ecosystem services

Timber, carbon sequestration, hydrological regulation and recreation are all provided by forests, and according to MEA (2015), these are defined as ecosystem services. Since the early twentieth century, management models aimed at improving multiple societal functions to promote sustainable forest management have been developed in Europe (Pistorius *et al*. 2012).

Forest owners and managers play an important role in the provision of forest ecosystem services (FES) because they make the majority of forest planning and management decisions. (Torralba *et al*. 2020). Their management decisions are largely rooted in personal values and perspectives, which go beyond economic profit and combine several other aspects like their personal preferences, past experiences, cultural identities and social norms (Hugsson and Ingemarson 2004, Urquhart *et al*., 2012, Maier and Winkel 2017).

The most challenging is to provide multiple forest ecosystem services or functions, and this is the case of cultural ecosystem services (CES). The lack of policy support mechanisms for these types of ecosystem services has many reasons. At the level of the EU, one of the most common reasons is due to different shared competencies in policy sectors. On the second side, the cultural ecosystem services are addressed only to the environmental context which enhances the power asymmetries between economic-oriented policy stakeholders and environmental-oriented policy stakeholders (Schleyer *et al*. 2015, Bouwma *et al*. 2018). According to Torralba *et al*. (2020), it was analysed the relationship between different groups of landowners to their management and attitudes towards cultural ecosystem services. The results showed that the most used CES are for hunting.

Forest policy must consider that forest ownership entails more than just economic values and that current forest ownership structures, as well as the diverse goals of owners, are important factors for the diversity of forest ecosystem services that should be recognized and preserved (Joa and Schraml 2020).

Adapting forest management practices under different scenarios

Regional biodiversity protection rules, along with low forestry income, force most foresters to do the bare legal minimum in terms of forest management (Sansilvestri *et al.* 2020). In the German case, the private forest owners are implementing conservation practices, such as maintaining the deadwood in their forests with positive benefits from the formation of humus (Joa and Schraml 2020). For mobilizing energy wood and fostering energy wood entrepreneurship, the NIPFs preferred subsidies and guaranteed markets above tax reduction.

A thesis published in 2020 (Brèteau-Amores, 2020) pays attention to the issue of forest decline due to climate change. Face to the drought-induced risk of forest dieback, four types of adaptation strategies were tested from an economic perspective and compared (Brèteau-Amores, 2020; Brèteau-Amores *et al*., 2022): incremental (reduction of rotation length and reduction of stand density), transitional (composition diversification and structure diversification) and transformational (species substitution) management-based adaptation as well as a market-based adaptation (index-based insurance). The findings suggest that

combining different management-based adaptation strategies appeared as a relevant way to adapt forests, but not all the adaptation options appear to be effective, or feasible.

1.3.1.2 Forest managers' perceptions

Increasing the forest management practices that enhance the adaptive capacity to climate change

Forest managers are seeking information on adaptive forest management strategies to address climate change impacts on forests (Jönsson *et al.* 2015), but forest professionals perceive climate change as a significant influencer on forest ecosystems with its impacts on forests including changes in forest composition, increased frequency and severity of disturbances, and changes in forest management practices (Soucy *et al.* 2021). Forest managers are challenged to develop adaptive strategies to manage forests under climate change, and they recognize the need for adaptation strategies to promote sustainable forest management in the face of climate change impacts (Soucy *et al.* 2021). These strategies include resistance options, resilience options, response options, and realignment options (Johnston and O'Shaughnessy, 2002). Moreover, they are reluctant to change their practices without persuasive evidence of consequential changes in forest health or productivity (Innes 1994). Forest managers in Hungary have varying attitudes towards climate change and adaptation (Jandl *et al.* 2019, Jankó *et al.* 2022). Studies revealed that generally, the perceived legitimacy and usefulness of climate change science increased, with regional-scale hydrologic knowledge being regarded as the most beneficial (Blades *et al.* 2016).

Maintaining or preserving the ecosystem services

The implementation of the ecosystem services approach faces challenges (Crook *et al.* 2021, Mann *et al.* 2021), including the lack of a clear, widely adopted approach to considering ecosystem services in management. There is a need for the development of management-relevant methods for describing and quantifying ecosystem services (Crook *et al*. 2021).

There is a deep divide in opinion regarding species choice for adaptation activities, with commercial advisors looking to new exotics but being inhibited by the absence of markets, while small-scale owners rely more on native genetic diversity (Ambrose-Oji *et al.* 2020). Forest genetic resource management is viewed as an approach to adapting forests to climate change. European forest owners and managers have expressed a willingness to actively manage forest genetic resources (FGR) to increase the resilience of forest ecosystems to climate change. The major hazards to forests, according to them, are pests and diseases, windstorms, and drought (Vincenti *et al.* 2020).

Adapting forest management practices under different scenarios

Many private-sector forest managers and experts are sceptical about the necessity for adaptation and believe that the future is unpredictable, particularly in terms of tree disease rather than climate change (Lawrence and Marzano 2014).

However, more evidence of the benefits of active adaptation and mitigation management of FGR is required, as is a better understanding of forest owners' and managers' attitudes and motivations (Vincenti *et al.* 2020). Improving communication and demonstrating potential climate change adaptation solutions will most likely be the most successful technique for

promoting their acceptance (Sousa-Silva *et al.* 2016). Forest managers can use scientific knowledge and a participatory approach to assess the importance of climate-smart forestry for management planning at the stand and management unit levels (Bowditch *et al.* 2022). Based on contextual factors the timber supply is analysed from four scenarios' points of view: business as usual, efficiency and reforms, ecology, and climate change mitigation, and builds six forest-management programs to describe the behavior of state forest managers and private forest owners in each scenario. Because of the substantial amount of middle-aged and premature stands in contemporary forests, all four scenarios resulted in increased timber supply. The scenario analysis demonstrates that relaxing legislative constraints not only increases long-term contributions to economic well-being but also allows for more even age-class distributions (Mozgeris *et al.* 2019).

In forest management, there is a lack of adaptive activity on both the stand and business levels in response to climate change (Hengst-Ehrhart 2019). Therefore, awareness-raising campaigns and forest consultation can be tailored to take into account the individual viewpoints of target groups to promote the application of adaptive measures.

1.3.2 Limitations of the studies on perceptions and expectations

Some studies conducted in a specific region may not be generalizable to other regions or countries (Lawrence and Marzano 2014, van Gameren and Zaccai 2015, Blade *et al.* 2016, Sousa-Silva *et al.* 2016, Mozgeris *et al.* 2019, Deuffic *et al.* 2020, Vincenti *et al.* 2020, Ambrose-Oji *et al.* 2021, Soucy *et al.* 2021), or either the sample is relatively small (Lawrence and Marzano 2014, Blade *et al.* 2016, Sousy *et al.* 2021, Matilainen *et al.* 2019).

Other studies did not explore the potential barriers to implementing climate change science in forest management decisions beyond organizational barriers (Blade *et al.* 2016, Vincenti *et al.* 2020), or did not consider the potential influence of social and political factors on the use of climate change science in forest management decisions (Blade *et al.* 2016). On the other case, Hengst-Ehrhart (2019) focuses on the intention to use adaptive measures rather than actual implementation, the results may not fully reflect the activities taken by forest owners and managers. Moreover, some of the studies are only focused on the perceptions, intentions, beliefs and attitudes of forest managers (Lawrence and Marzano 2014, Blade *et al.* 2016, Vincenti *et al.* 2020) and did not measure actual behaviour change, or either relies on self-reported perceptions which may be subject to biases and inaccuracies (van Gameren and Zaccai 2015, Sousa-Silva *et al.* 2016, Matilainen *et al.* 2019, Deuffic *et al.* 2020, Vincenti *et al.* 2020, Soucy *et al.* 2021). The lack of proper forest roads is seen as the most significant obstacle to mobilizing energy wood from private forests (Halder *et al.* 2017). Some studies do use only qualitative methods and do not provide a comprehensive analysis (Matilainen *et al.* 2019, Soucy *et al.* 2021) of the economic or policy implications of climate change impacts on the forest industry (Soucy *et al.* 2021).

Forest professionals have faced barriers to effective adaptation, such as the complexity of information and lack of knowledge of understanding of climate change impacts (Fernandez and Agricultural 2008, Morin *et al*. 2015, Sousa-Silva *et al.* 2016, Sousa-Silva *et al.* 2018, Vincenti *et al.* 2020). The forest owners' social networks currently serve only a minimal function of sharing knowledge of climate change and adaptation (André *et al.* 2017). Forest

managers and private forest owners will follow forest management programs, which may not always be the case in practice (Mozgeris *et al.* 2019).

1.4 Conclusions from perceptions and expectations literature review

Forest ownership is shifting among new forest owners in Europe, with a shift toward more diversified values and purposes. These new owners are no longer financially reliant on their trees and frequently prefer amenity functions over production ones (Matilainen *et al.* 2019). It is critical to understand how these new forest owners see their ownership to better satisfy their requirements and provide suitable services (Dhubháin 2011). Overall, the decision-making process of private forest owners regarding climate change adaptation is complex and influenced by various factors, including perceived risks and available insurance options. Worldviews, disbelief in science or policy suggestions, and woodland size all influence the intention to change forest management and use species diversification as an adaptation method (Mostegl *et al.* 2019).

Climate change workshops effectively delivered scientific information, and the credibility of climate change increased (Blades *et al.* 2016). Croatian and Serbian private forest owners have shown positive attitudes towards energy wood production from their forests, despite perceiving barriers such as underdeveloped markets, low prices, and fragmented forest properties (Halder *et al.* 2017).

Forest policies and management objectives may need to change to reflect the effects of climate change on forest productivity (Nelson *et al.* 2016). Forest management system adaptation requires revising assumptions, upgrading institutions, and changing practices to reduce vulnerability and enhance resiliency, or promoting sustainable forest management in the face of climate change, such as diversifying forest products, improving forest health, and enhancing public education and outreach (Soucy *et al.* 2021). Forest professionals have diverse viewpoints about climate change, but the majority support adaptation and recognize the importance of adaptation concepts. Regression models revealed that usefulness, credibility, and organizational hurdles all predicted the desire to use climate change science (Blades *et al.* 2016). According to Lawrence and Marzano (2014), the potential trade-offs or conflicts between different management objectives (e.g. economic vs. ecological) could affect the feasibility or attractiveness of specific adaption measures. Some findings reveal that diverse approaches of (not) integrating climate change into forest management are observable in a sample of private forest owners who can be classified as adapters or non-adapters (van Gameren and Zaccai 2015), and these findings are useful for understanding real adaptive processes and if are relevant for decision-making since they highlight some adaptive capacity strengths and shortcomings. Moreover, forest stakeholders see forest dieback as visible evidence of climate change (Deuffic *et al.* 2020). They believe that forest dieback has accelerated in recent decades as a result of rising temperatures and intense weather occurrences. However, stakeholders cannot agree on whether climate change is a precipitating or aggravating element. Stakeholders can be classified into three types based on their adaptive strategies: proactive, reactive, and wait-and-see forest owners. These profiles differ in terms of investment capacity, economic reliance, emotional attachment to

forests, knowledge level, and ability to access actionable information through participation in institutional networks.

Further research is needed to better understand the effectiveness of boundary objects and organizations in facilitating the use of climate change science in forest management decisions (Blade *et al.* 2016), and to evaluate the influences of individuals on forestry decision-making related to climate change (e.g. in Sweden) with private forestry ownership (André *et al.* 2017). According to Vincenti *et al*. (2020), more efforts should be made to understand the attitudes and motivations of European forest owners and managers to better personalize advice on effective strategies to combat the negative consequences of climate change.

2 Survey on the forest owners' and managers' perceptions and expectations – data collection protocol

2.1 The context and the purpose of the interviews/questionnaires

Working Package 3 (WP3) – Socio-institutional patterns of innovative forest-based mitigation and adaptation strategies is part of the INFORMA project and aims to provide a meta-analysis of environmental, technical and institutional barriers and opportunities of forest-based mitigation and adaptation strategies in **identifying the EU forest owners' and forest managers' expectations**, **by linking the stakeholders' preferences and options on forestry and forestry scheme with the harvesting and wood industry patterns** and providing policy recommendations with sociological, institutional and economic drivers by **drawing an innovation roadmap.**

Task 3.2 with the title "Voicing forest managers and owners perceptions, needs and expectations on forest-based mitigation and adaptation measures" was planned to be developed during months 3 to 12, leaded by USV and with I4CE and UPV as participants.

T3.2 provides an **ex-ante evaluation of forest-based mitigation and adaptation scenarios** (addressing objective 2), in investigating at a regional scale existing perception about climate change effects on forests, opinions on forest management strategies and measures for climate change mitigation/adaptation and expressed needs towards science-based information about alternative mitigation/adaptation strategies. The ex-ante evaluation is planned to be reached through questionnaires addressed to a representative sample of forest owners and managers from different bio-geographical regions, to assess to what extent are forestry practitioners aware of climate change and what adaptation strategies they know or practice (D3.2). Their answers will help to feed up the scenario definition on WP4 (milestone 6) and clarify the multiple levels at which the stakeholders act.

The data collection aims to obtain accurate and valid data that can be used to answer the research question about the forest owners' and forest managers' perception of climate change effects on forests.

The WP3 questionnaire is based on the ex-ante evaluation and is intended to reach a representative sample of forest owners and managers from various biogeographical regions to assess the extent to which forestry practitioners are aware of climate change and what adaptation strategies they know or practice. The responses will be used to feed into the scenario design for WP4 - Development and Impact of Sustainable Forest Management Alternatives, as well as to clarify the various levels at which stakeholders act.

The questionnaire aims to identify forest owners and forest managers from the forestry sector within all the countries involved in the INFORMA project to obtain comprehensive data about their perceptions of climate change and their opinions regarding forest management strategies while expressing their needs for alternative mitigation/adaption strategies in correlation to the perceived future risks.

More information about the project can be found by accessing the link: https://informa-forests.eu/.

2.2 The consent to participate in the survey

The USV department specialised in research ethics approved the development of this survey through the Accord nr. 151/18.08.2023, following the request made by Laura Bouriaud according to the national and internal administrative procedures (Claim and documents sent on 31st of July 2023).

To comply with GDPR requirements, the first page of the online survey is available here:

https://docs.google.com/forms/d/1ljPAk_M-HHQ5nFGOSFjcsd5UAFftjEomNoDlPy7j8MI/viewform?ts=64aec1b0&edit_requested=true

It contains the following statements:

You are invited to participate in a research study about the forest owners' and managers' perception of climate change and lessons learned in forest management adaptation to climate change.

We adhere to the EU General Data Protection Regulation (2016/679, GDPR), national legislation, and the regulations and judgments of authorities. The information you will share with us if you participate in this study will be kept completely confidential to the full extent of the law. All the type of information eventually being collected (IP, e-mail address) will be de-linked from survey data.

The answers will be anonymously codified and all the data collected will be presented in aggregate form that will keep respondents anonymous throughout the reporting process.

Participation in this survey is voluntary.
By completing this survey, you are consenting to participate in this study.

If you have any questions about the data obtained from your side as part of the INFORMA project (https://informa-forests.eu/), please contact Laura Bouriaud: at laura.bouriaud@usm.ro.

Fulfilling the questionnaire is expected to take between 20-30 minutes.

2.3 The WP3 questionnaire description

2.3.1 How does the questionnaire look like?

The survey is carried out online and has been created on an online platform (Google Forms. The duration for filling up the questionnaire is expected to be between 20-30 minutes. The questionnaire is designed by chapters, such as:

- **General perceptions about climate change**
- **Perceptions about climate change's impact on forests**
- **Opinions on strategies for mitigation**
- **Opinions and preferences about forest management adaptation to climate change at stand level**
- **Changes in forest management at stand level in the last 10 years.**

All the questionnaire answers will be anonymously codified.

2.3.2 How the data will be used?

All information gathered will be used solely for research purposes. The questionnaire will be bilingual, created first in English and then translated into the national languages of the countries participating. The parties involved will ensure the security of the obtained data, including the use of secure servers with password-protected access. All data will be presented in aggregate form, and respondents will be kept anonymous throughout the reporting process. While anonymised data are no longer considered personal data and non-personal data will be retained in a research database with appropriate metadata about the goal and methods of its collection in the spirit of research transparency and re-use. The database will be credited in the research articles that arise from their study, and the rights to free use will be granted. The entire process plays an important role in ensuring high-quality, consistently collected, and open-science data.

2.3.3 Confidential and proprietary

We adhere to the EU General Data Protection Regulation (2016/679, GDPR), national legislation, and the regulations and judgments of authorities. In particular, the respondents have the right to: be informed about how their data is being used; to refuse the use of their personal data for research at any time; and to request that their personal / identifying data be fully erased from the records. The research team members will review all the answers and will gather all the information needed only for the project's purposes. All the records will be kept and secured during the entire project and at least 3 years after the project's achievements.

If you have any questions about the data obtained from your side as part of the INFORMA project, please contact Laura Bouriaud: at laura.bouriaud@usm.ro

2.3.4 Online Questionnaire

There will be a two-stage survey in INFORMA's WP3: a questionnaire and an interview. Both will collect primarily quantitative data.

The first stage (online questionnaire) targets different groups and covers a broad set of questions. It has been implemented starting with July 2023 as part of Task 3.2: Voicing forest managers' and owners' perceptions, needs and expectations on forest-based mitigation and adaptation measures (Months: 3-12; Lead USV; Participants: I4CE, UPV) on a representative sample of forest owners and managers from different EU bio-geographical regions, to assess to what extent are forestry practitioners aware of climate change and what adaptation strategies do they know or practice. Moreover, partners can use them to encourage evidence-based dialogue with target groups. The first questionnaire is included in the Appendix to this Methodology.

Beyond that, the second stage (interview) will be done as part of Task 3.3: Assessing barriers and opportunities of innovation up-taking in practice (Months: 36-46; Lead: USV; Participants: UPV) to provide a post-evaluation of simulated adaptation strategies by a quantitative survey on a sample of forest managers and owners (addressing objective 2), with the aim to identify barriers and opportunities of the proposed innovative schemes, and therefore to improve the probability of innovation up-taking in practice. The interviews will aim to identify what are the major factors that account for the success or failure of forest adaptation in each region, starting from the results obtained in local scale simulation of forest management alternatives (WP4) and from the new forestry schemes proposed in WP5 (**D3.3**, milestone 16).

The WP3 leader (USV) will provide the questionnaire to partners and will undertake the interviews. Initial results will be available before the end of August, but a reminder will be sent at the beginning of September and USV will start with interviews in September if needed to complement the collected information.

2.3.5 Target groups

A representative sample of forest owners and managers from different EU bio-geographical regions, email-based.

For the first questionnaire, 50 completed questionnaires per country (requires sending online questionnaire link to at least 100 people). The proportion of target groups within countries depends on national circumstances. In total, at least 400 completed questionnaires need to be completed.

For the second survey stage, we estimate a number of 5 to 15 completed interviews per country.

2.3.6 Procedure of the first questionnaire implementation

a. Common template for the questionnaire is provided by USV as a Google Form link in English and as a Word format;

b. if needed, the WP3 leader (USV) will provide the partners with translations of the questionnaires into their own languages, and the partners will provide their corrections on the translation;

c. an online tool for the questionnaire is provided by WP3 and the questionnaire link was sent to partners on 10th of August 2023

d. partners reach out to the target groups at the national level and ensure a timely response rate to the online questionnaire (end of August). In case conducting the questionnaire online is not feasible, partners can also decide to carry out the survey face-to-face.

Initial planning: Deadline for the first round of survey done, including first analysis of raw data: 30.09.2023

Suggestion of the text accompanying the email to forest owners and managers:

Dear colleague,

Climate change is affecting our forests. As a forest practitioner, you certainly have experience with changing conditions of forest management. You have also expectations to receive science-based information about mitigation and adaptation strategies. In the project INFORMA we try to address these expectations in building scenarios that include also your perceptions and preferences.

Thus, we kindly ask you to help us voicing forest owners' and managers' expectations on forest-based mitigation and adaptation measures by answering the online questionnaire below:

Email text sent on 10.08.2023:

Dear colleagues,

As discussed in the Vienna meeting (3GM), during this month we should proceed with the first sending of the WP3 questionnaire.

The WP3 survey target is represented by forest practitioners (owners and managers), whom we consider the best placed to observe the changing conditions in forestry today and to have expectations, and therefore the ability to implement or not mitigation/adaptation measures. The results from WP3 should provide qualitative data to inform WP4 scenarios.

The questionnaire (English version attached) is translated with 'DeepL' in French, German, Catalan, Spanish and Dutch. Therefore, please check first the accuracy of translation in fulfilling the questionnaire as a test and let us know (ramona.scriban@usm.ro and laura.bouriaud@usm.ro) if there are major problems.

If all is fine with the link provided, please distribute the link **next week** via email to the networks that you consider the most appropriate for reaching forest practitioners.

To reach a minimum of 50 to 70 responses per country, we think that a reminder has to be sent.

Please find here below the link to the different versions of the questionnaire and a suggestion for a short accompanying text:

1. English: https://forms.gle/meTxAy8wUczRdkKr8
2. Dutch: https://forms.gle/q1bxzA2hhyE7e9Kg9
3. German: https://forms.gle/FcwQ4EWC7ShAKSJN7
4. Spanish: https://forms.gle/RDFf6fZMyFMHBiBdA
5. French: https://forms.gle/jA3c4XFfmEmmXcN5A
6. Finish: https://forms.gle/9mTm95Kz381DzZc17
7. Catalan: https://forms.gle/kQN2bjnbJvrwbq2VA

Dear colleague,

Climate change is affecting our forests. As a forest practitioner, you certainly have experience with changing conditions of forest management. You have also expectations to receive science-based information about mitigation and adaptation strategies. In the project INFORMA we try to address these expectations in building scenarios that include also your perceptions and preferences.

Thus, we kindly ask you to help us voicing forest owners' and managers' expectations on forest-based mitigation and adaptation measures by answering the online questionnaire below: https://forms.gle/meTxAy8wUczRdkKr8

Klimaatverandering heeft invloed op onze bossen. Als bosbeoefenaar hebt u zeker ervaring met de veranderende omstandigheden van bosbeheer. U verwacht ook wetenschappelijk onderbouwde informatie te ontvangen over mitigatie- en adaptatiestrategieën. In het project INFORMA proberen we aan deze verwachtingen te voldoen door scenario's op te stellen die ook uw percepties en voorkeuren omvatten.

Daarom vragen we u vriendelijk om ons te helpen bij het verwoorden van de verwachtingen van boseigenaren en -beheerders over bosgebaseerde mitigatie- en adaptatiemaatregelen door de onderstaande online vragenlijst te beantwoorden: https://forms.gle/q1bxzA2hhyE7e9Kg9

Der Klimawandel wirkt sich auf unsere Wälder aus. Als Forstpraktiker haben Sie sicherlich Erfahrung mit den sich ändernden Bedingungen der Waldbewirtschaftung. Sie haben auch Erwartungen, wissenschaftlich fundierte Informationen über Abschwächungs- und Anpassungsstrategien zu erhalten. Im Projekt INFORMA versuchen wir, diese Erwartungen zu erfüllen, indem wir Szenarien entwickeln, die auch Ihre Wahrnehmungen und Präferenzen einbeziehen.

Daher bitten wir Sie, uns bei der Beantwortung des nachstehenden Online-Fragebogens zu helfen, damit wir die Erwartungen von Waldbesitzern und -bewirtschaftern in Bezug auf waldbasierte Abschwächungs- und Anpassungsmaßnahmen formulieren können: https://forms.gle/FcwQ4EWC7ShAKSJN7

El cambio climático está afectando a nuestros bosques. Como profesional de los bosques, seguro que tiene experiencia con las condiciones cambiantes de la gestión forestal. También espera recibir

información científica sobre estrategias de mitigación y adaptación. En el proyecto INFORMA intentamos responder a estas expectativas construyendo escenarios que incluyan también sus percepciones y preferencias.

Por ello, le pedimos que nos ayude a expresar las expectativas de los propietarios y gestores forestales sobre las medidas forestales de mitigación y adaptación respondiendo al siguiente cuestionario online*:* https://forms.gle/1W2jfekWKSqFGRKf6

Le changement climatique affecte nos forêts. En tant que praticien forestier, vous avez certainement l'expérience des conditions changeantes de la gestion forestière. Vous vous attendez également à recevoir des informations scientifiques sur les stratégies d'atténuation et d'adaptation. Dans le cadre du projet INFORMA, nous essayons de répondre à ces attentes en élaborant des scénarios qui tiennent compte de vos perceptions et de vos préférences.

Nous vous demandons donc de bien vouloir nous aider à exprimer les attentes des propriétaires et gestionnaires forestiers concernant les mesures d'atténuation et d'adaptation basées sur la forêt en répondant au questionnaire en ligne ci-dessous : https://forms.gle/jA3c4XFfmEmmXcN5A

Ilmastonmuutos vaikuttaa metsiimme. Metsäalan ammattilaisena sinulla on varmasti kokemusta metsänhoidon muuttuvista olosuhteista. Sinulla on myös odotuksia saada tieteellisesti perusteltua tietoa ilmastonmuutoksen hillitsemis- ja sopeutumisstrategioista. INFORMA-hankkeessa pyrimme vastaamaan näihin odotuksiin laatimalla skenaarioita, joissa otetaan huomioon myös sinun käsityksesi ja mieltymyksesi.

Pyydämmekin teitä ystävällisesti auttamaan meitä ilmaisemaan metsänomistajien ja metsänhoitajien odotuksia metsäpohjaisista lieventämis- ja sopeutumistoimista vastaamalla alla olevaan verkkokyselyyn : https://forms.gle/9mTm95Kz381DzZc17

2.3.7 Reporting and justification of delayed submission of the deliverable D3.2

WP3 Leader is responsible for reporting, in close collaboration with I4CE, UPV and partners. As announced in the Vienna meeting (3GM) on May 2023, we have postponed the deadline for this deliverable from 31.07.2023 to 30.09.2023 as to have the questionnaire checked by representatives of the WP4, but also as to obtain the administrative authorization for undertaking the survey (ethical commitment compulsory for European financed projects).

The deadline for reporting on the first stage survey was 30.09.2023. Since the number of answers on 30.09.2023 was unsatisfactory, there was a second reminder to the partners to proceed with the sending of the questionnaires to their forest-related professional network (email sent on 10.10.2023). Version 1.0 of the Deliverable on 30.09.2023 contained only the results of the literature review, the data collection protocol and the results of pre-testing the questionnaire on a sample of 87 forest engineers and technicians from Romania.

Table 1. Situation of the responses received

Country/ Language	No. of answers on 10.10.2023	No. of answers on 13.11.2023	No. of answers on 28.11.2023	No. of answers on 3.12.2023	Link questionnaire
Spanish	8	13	13	14	https://forms.gle/WSm5ooFTTBT8NPXc7

Catalan	12	12	12	12	https://forms.gle/ZCC98JqcBhRpxsxj8
English	4	4	5	5	https://forms.gle/FefS9U1vWEFK9hs16
Dutch	0	6	6	6	https://forms.gle/D3UEmWmeFmH2NSDi9
French	0	1	1	1	https://forms.gle/recWZugcjq8hV9Wd6
Finnish	0	10	10	10	https://forms.gle/CrAWABSXy6P3cgG5A
German	0	0	0	0	https://forms.gle/G2ZMyA47gf52MM2R9
Romanian*	0	21	51	52	https://forms.gle/9uzGVqD2GHuJaVnK8
Total	**24**	**67**	**98**	**100**	

*The Romanian questionnaire includes also 3 answers from the Republic of Moldova. The Romanian version of the questionnaire was addressed as a Google Doc link (N=39) and as a Word document returned fulfilled by email (N=12).

Version 2.0 of the Deliverable on 4.12.2023 contains the data analysis of the responses received until 28.11.2023 on a number total of 98 questionnaires.

2.3.8 Structure of the questionnaire

Forest Managers' Opinion survey
on climate change's impact on the forest ecosystem services supply[1]

A. General perceptions of climate change

Q1. Which one of the following statements fits best your opinion? *(one option only, please):*	
	Climate change will affect into a little extent the forests in my region
	Climate change will affect into a moderate extent the forests in my region
	Climate change will affect into a significant extent forests in my region
	It is not clear yet how climate change will affect the forests in my region
	I do not know, have no idea

Q2. In your opinion, for your region, in the next 50 years climate change will manifest as:					
	Certainly yes	*Probably yes*	*Probably not*	*Certainly not*	*Don't know/ can't say*
Temperature above normal regime					
Temperature below normal regime					
Significant changes in the temperature regime (alternance of the periods with above normal and below normal temperature)					
Decrease of precipitation quantity (waterfall)					
Increase in the precipitation quantity (waterfall)					
Increased impacts of flooding					
Increased impact of drought					
Significant changes in the precipitation (alternance of periods with above normal and below normal precipitation)					
Significant changes in forest soil moisture					
A higher occurrence rate of catastrophic climate events					
Other:					

Q3. In your opinion, the global warming over the past decade is due to *(one option only, please):*	
	Only natural causes, which cannot be controlled by man
	Only human activity (industrial development, pollution, population growth, etc.)
	Both human activities and natural causes (natural and anthropogenic)
	I do not know

Q4. Is there any event or any of your recent phenomena if have observed in your region that you consider a consequence to climate change? *Give an example, please.*

[1] Contact person: Prof. Univ. Dr. Ing. Laura Bouriaud, Universitatea Ștefan cel Mare din Suceava, Romania, laura.bouriaud@usm.ro. Study carried out within the frame of EU financed Informa project (https://informa-forests.eu).

B. Perceptions about climate change's impact on forests

Q5. To what extent do you feel concerned about the following issues?					
	Not at all concerned	*Rather concerned*	*Concerned*	*Very concerned*	*Extremely concerned*
I feel concerned about future damage from insects and/or diseases					
I feel concerned about the risk of large-scale disturbances that may affect the forests in my region					
I feel concerned about the game populations in excess threatening the regeneration of my stands					
I feel concerned about the impacts of climate change on forests					
I feel concerned about the negative public perception of timber harvesting					
I feel concerned about the risk of lower timber production due to climate change					
I feel concerned about the risk of biodiversity loss in forests due to climate change					

Q6. In your perception, which of the following vulnerabilities and risks are likely to affect the forests of your region in the next decades?					
	Don't know/ can't say	*Certainly not*	*Probably not*	*Probably yes*	*Certainly yes*
Forest diseases and pests					
Incidence of forest fires					
Incidence of windfall					
Forest decline/dying stands					
Replacement of some forest species by other forest species					
Difficulties in achieving natural regeneration of stands					
Decline of the forest productivity					
Other:					

Q7. In your perception, how the climate change will affect the provisioning of the ecosystem services from the forests you manage/ you own/you're advising?					
	Don't know/ can't say	*Certainly not*	*Probably not*	*Probably yes*	*Certainly yes*
Forest overall timber production will be lower					
There is a serious risk of biodiversity loss					
The stands will no longer provide the same level of protective functions					
Climate change will increase climate-related disturbances such as forest fires, drought stress and pest outbreaks.					
Climate change will increase the					

uncertainty on the economic revenue of the forests (i.e. increase the discount rate).					

Q8. Is there any other serious threat for the stability/resilience of forests in your region, other than climate change?

Q9. According to your personal experience, has the process of forest regeneration characteristics changed in the last 10 years?

C. Opinions on strategies for mitigation

Q10. In your opinion, which are the three measures / policies that you consider most appropriate for climate-change mitigation? *(only three options, please):*

	Promoting woody biomass as an energy source
	Promoting biological fuel
	Increase the carbon sequestration in forests
	Promoting solar and wind energy
	Promotion of hybrid/electric motor vehicles
	Development of micro-hydropower plans
	Promoting the cascade use of wood and wood recycling
	Increase the carbon sequestration in long-life wood-based products
	Other: _____

Q11. In your opinion, which of the following measures have a potential positive impact in mitigating the effects of climate change?

	No impact	*Weak impact*	*Middle impact*	*Strong impact*	*Very strong impact*
Developing crops outside of forest areas for woody biomass production					
Replace forest area with crop/shrubland/grassland area to increase water availability downstream.					
10% strict protection of national forests (without any extraction of wood)					
30% protection of national forests through active conservation (little extraction of wood)					
Restrict the access to areas in danger of a forest fire during summer, to avoid human-induced triggers of forest fires.					
Improve the forest infrastructure for rapid reaction in case of severe disturbances					
Decrease the harvesting age (shorter rotation)					
Increase the harvesting age (longer rotation)					
Increase the frequency of interventions and the quantities extracted at once					
Decrease the frequency of interventions and the quantities extracted at once					
Converting to uneven-aged forest					
Converting to continuous forest cover					
Converting the sylvicultural system to high-quality logs production					

Q12. In your opinion, in which way the forests you are managing/you own/you're advising could

contribute the best to climate change mitigation? *(only three options, please)*	
	In improving the carbon sequestration in aerial forest biomass and in the forest soil
	In improving the carbon sequestration in the forest soil
	In securing biodiversity refugia (species diversity, uneven-aged stands, dead wood, gene pool,..)
	Inefficiently use of resources (water, light, nutrients) for one cubic meter of wood produced
	Supplying high-quality wood products for long-life carbon stocking
	Supplying high quantities of energy wood for substituting fossil-based energy
	Contributing to local microclimate mitigation
	In reducing the severity of climate-induced disturbances to reduce the risks (e.g. forest fires, floods) associated with climate change
	Other, if any:

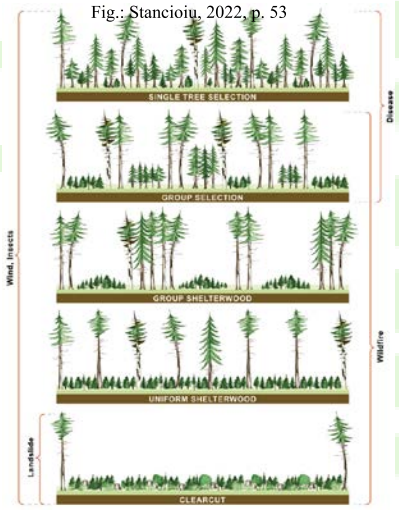
D. Opinions and preferences about forest management adaptation to climate change at stand level

Q13. Which are the three main species dominating the forests in the area you manage/you own/you're advising?

Q14. Which are the main types of the forests you manage/you own/you're advising?
e.g. *even-aged/uneven-aged; broadleaved/coniferous; pure stands/mixtures/admixtures; natural forests/plantation forest.*

Q15. Which is the main* sylvicultural system practiced to regenerate the stands in the forests you manage/you own/you're advising?
**The system is applied in at least 70% of the stands*
Please compare with the figure provided to select one option from the above 5 options:

Fig.: Stancioiu, 2022, p. 53



	Single tree selection
	Group selection
	Group shelterwood (irregular or strip-based)
	Uniform shelterwood
	Clearcut
	Other: Seed tree system and High forest with reserves system; coppice system; if other, *please describe*

Q15A. For the selected sylvicultural system to regenerate the stand, please describe:

I. Which criteria are used to decide the time of cutting (age, diameter, basal area or other criteria)?

II. How much is extracted at once if several interventions are practiced?

III. Does the removals ratio differ between tree species in a mixed stand?

IV. is the first regeneration cut intended to extract in priority rather a) weak trees; b) bad quality trees; c) dominant trees; d) Random extraction; e) all dimensions (*please select the appropriate answer)*

V. What is the time lag between the interventions?

VI. How long is the overall regeneration period?

VII. To which extent (%) the planting is practiced or needed after the cutting?

Q16. If windfall or severe drought is likely to occur with higher intensity in the forests from your region, which would be the adaptive forest management that you would like to opt for the forest you manage/you own?
Please note the preferences on a scale from 0- not preferred at all, to 5 – the most preferred option.

	Increase the intensity or frequency of interventions to extract trees
	Decrease the number of interventions or their intensity
	Promote in forest regeneration other species, less vulnerable to windfall or drought
	Keeping current management orientation and practices
	Implementing selection cuttings with long regeneration periods (20 to 40)
	Implement management practices that reduce timber revenue but increase the stand's resilience
	Promoting mixed forests
	Harvest stands at lower rotation ages than currently practiced
	Practice the retention of old or dead trees
	Use additional resources (irrigation, fertilizers, weed controls) to secure the plants' development
	Reduce or renounce planting in favour of the natural regeneration
	Leave a fraction of the harvested trees in the forest to generate dead wood to increase ecosystem function
	Other: _____

E. Changes of the forest management at stand level in the last 10 years

Q17. How has the regeneration of your forests changed in the last decade?
(only one option, please)

	I have increased the share of natural regeneration
	I have increased the share of planting
	I have tried to increase the share of natural regeneration, but I needed to complement it with planting up to …%.
	I have not changed anything

Q18. Have you changed your species selection criteria for planting trees in the latest decade?
(multiple options)

	I have chosen my seedlings based on wood productivity
	I have chosen my seedlings based on non-woody product productivity (e.g. production of *Tuber melanosporum*).
	I have chosen my seedlings to anticipate various risks climate-change-related (drought, insects, etc.)
	I have chosen my seedlings to introduce local species coming from other populations
	I have chosen my seedlings to address selection criteria for EU / country-level existing incentives
	I have not changed anything

Q19. Have you changed your logging method/sylvicultural system/regeneration cut in the latest decade?

Q20. Have you made changes related to nature conservation measures in the forest you manage/own in the latest decade? *(e.g. increase the retention of old or dead trees, classify woodlots as protected areas)*

Q21. Whenever you have changed forest management in the last decade, how important were these aspects in your decision to change?

	Not at all	*Rather*	*Import*	*Very*	*Extremely*

	important	*important*	*ant*	*important*	*important*
I wanted to achieve the goals of the forest management plan					
I wanted to benefit from new machinery and/or technology: logging equipment, drone inventories, etc.					
I had to address the consequences of a natural disaster (drought, flooding, disease, etc.)					
I wanted to prevent the impacts of a natural hazard (drought, flooding, disease)					
I wanted to reduce management costs					
I wanted to benefit from governmental incentives					
I did it at the request of my relatives or neighbours					
I did it on the advice of a forest engineer or a forest company					
Easier access to my woodlots has contributed to changing my practices					
I intend to benefit from the opportunity of carbon credits markets					
Other reasons than those above:					

Q22. A. From your experience with changes in forest management, are there any advice or warnings that you would like to provide to forest managers or owners?

Q22. B. What kind of changes in forestry to adapt it to new climatic conditions are important to know and understand?

Q22. C. Have you experienced any kind of obstacles in implementing these changes?

F. Complementary data

Q23. To which category do you belong?

	Central forest administration (central governmental agencies and structures)
	Local forest administration (local governmental agencies and structures)
	Forest manager, managing mainly public forests
	Forest manager, managing mainly private forest
	Individual private forest owner
	Representative of a private forest owner's association
	Another type of forest owner:
	Entrepreneur in forestry (forest contractors, private firms, harvesting companies, etc.)
	NGO / civil society /academic
	Forest consultant
	Other

Q24. How many years of experience working in the forestry/forest sector do you have?

3 Results from pre-testing the questionnaire

3.1 Sample profile

The target group was the staff of several forestry offices, most of them private, but also some forest owners or their representatives, as well as people from other institutions or private companies in the forestry sector (NGO, management, logging agents). The questionnaire was tested in fall 2022.

The study was based on 87 responses. Respondents were between 21 and over 50 years of age (age category: 21-30 years, 12 respondents (14%); 31-40 years, 23 respondents (26%); 41-50 years, 23 respondents (26%); over 50 years, 29 respondents (33%), represented by Figure 5.1.1. These individuals have experience in the field: most of them have experience between 11-20 years (32%), between 1-10 (31%), and over 20 years (37%). 98% of the respondents have forestry education. The majority of people are employed as engineers, foresters or district managers (88%), and the remaining 12% are forest representatives or owners, forest technicians, representatives of forest management companies, NGOs or managers of forestry companies.

3.2 Forest managers' perceptions of climate change

63% of respondents believe that climate change is fairly obvious, 24% believe that climate change is an undeniable reality, and the remaining 13% do not believe in the existence of climate change, by arguing that it cannot be proven or simply exists but cannot affect us directly.

In a later question we have scored nine issues to see what foresters predict might happen in the next 50 years:

- 86% believe there will be changes compared to the current climate, 14% believe there will not be changes;
- 83% think that the average temperature will increase, and 17% do not think so or do not comment;
- 77% think that the average temperature will not decrease, 13% think it may decrease and 10% think it is likely to decrease;
- 91% believe that there will be extreme temperature variations, 8% believe that there will not, and only 1% cannot say anything about this;
- 64% believe that average rainfall will decrease, 36% do not;
- 68% say average rainfall will not increase, 14% cannot say, and 18% think *average* rainfall will increase;
- 69% believe that the hydrology will essentially change (reduced flows, fewer springs), 31% say this is unlikely;
- 76% believe that the trend of catastrophic events (floods, droughts, hailstorms) will increase, the rest say no or cannot say for the moment;

- More than half believe that the local climate will be substantially altered by desertification or aridisation, and the other half believe that the local climate will not be altered.

Foresters (70%) believe that global climate warming over the last 10 years is due to both human activity and natural causes, 28% believe that human activity alone is driving this through industrial development, population growth, pollution, and 2% believe that this is due to strictly natural causes that are beyond human control.

57% of the respondents are aware of climate change phenomena and 43% are not, also 34% of them believe that these effects of climate change on the forest cannot be mitigated by human intervention, but 66% of them believe that their activities can mitigate these phenomena.

Of the 57% of people who said they knew of cases of recent phenomena that they considered to be facts of climate change, they gave the following examples:

- lack of snow in November and December; milder winters;
- the shifting of the seasons;
- decreasing river flows, flooding, rising summer temperatures, drought;
- drying up of springs: 3 out of 9 per 1000 ha - Bihor;
- extreme events from heatwaves to hail;
- increased fruiting period of quercineae due to prolonged drought and unfavourable climatic phenomena, prolonged late droughts, excessive drought during autumn, heavy rains during flowering;
- drying out of the fir tree due to long-term moisture deficit in the soil;
- decline in quercineae;
- unpredictable and unexplained appearance of pests; unexplained drying of trees;
- due to the drought, vegetation fires have been more frequent and aggressive;
- windthrow;
- a change (extension) in the altitude range of some tree species such as beech;
- significant decrease in the flow of the Duruitoare waterfall in the Ceahlău Massif;
- the Solești reservoir, Vaslui county, which is expected to dry up in the coming years.

Several of those who completed the questionnaire told us about personal experiences or difficulties they have had recently in managing the areas they are responsible for and which they link to phenomena triggered by possible global climate warming:

- much rarer fruiting in *Quercus* species, (from 4-6 years to 10-12 years) which makes natural regeneration of these stands impossible;
- drying phenomenon in *Quercus* species;
- the emergence of pest attacks that previously did not cause damage, the increase in average temperature and long periods of drought cause some pests to change their

biology and have more generations per year or shorten their life cycle from 2 years to one year (e.g. *Agrillus Bigutatus* in Quercineae);

- poor fruiting and high periodicity in Quercineae, oak wilt, high interspecific competition of species better adapted to moisture deficits, lime vs oak and beech in lowland and hill areas, ash vs oak, beech vs fir and spruce in hill and mountain areas), in general, the advance of species into the upper range in search of moisture and more favourable conditions;
- In mixtures of resinous and beech, where resinous trees are the majority, beech is much easier to establish without the intervention of foresters, resulting in almost pure beech stands;
- Natural regeneration has declined, as has the quality of regeneration, and plantings need to be supplemented;
- The coniferous trees migrate to higher areas and their place is taken by beech;
- the drying phenomenon present in some young spruce stands which is not caused by the presence of hypids;
- drying phenomena in more and more *Quercus* forests located between the Siret and Prut rivers;

Drying and fruiting seem to be a problem in several areas for Quercineae, and the most nominated effect is the altricial growth of species, particularly beech, but also unexpected insect attacks.

3.3 Forest managers' perceptions of measures for climate change adaptation and mitigation

When asked if they believe that the national forest policy is appropriate to mitigate the negative impacts of climate change on Romania's forests, foresters responded as follows: 57% - Yes, but some aspects of the policy and its implementation should be improved, 30% - No, the current policy needs to be fundamentally changed, 10% - Yes, the current policy is appropriate and well implemented, 3% - Yes, the current policy is appropriate but poorly implemented. The conclusion from this question is that respondents do not trust the current policies or even their implementation, believing that both the implementation and the policies need to be changed.

We then listed five policy guidelines that could have a greater impact in adopting forest management to climate change, and these are the results: 28% believe that intensification of silvicultural work (more repeated and stronger interventions in stands) is one of the preferred measures, 24% believe that there is no possible option that could mitigate climate change, 23% believe that keeping the current forest management orientation is sufficient even if other climate change impacts occur, 17% want larger-scale development of forests in protected natural areas (with the possibility of harvesting timber under certain conditions), and 8% are in favour of larger-scale forest conservation (with no or little timber extraction).

In the respondents' opinion, stopping illegal logging, adapting forest management to the form of ownership, increasing the intensity of interventions through care and management works would have a strong/very strong impact on preventing climate change effects.

Moderate impact would be on energy crops, protection of primary forest structure and reduction of the rotation age. Large-scale forest conservation, conversion of stands to woodland gardening and increasing forest accessibility have little or no effect in preventing climate change effects.

Regardless of forest type, forests are considered relatively and slightly vulnerable to the effects of climate change.

Depending on the forest formation they manage, foresters have proposed different forest works and intensities for these and also tree species that would be preferable in regenerating stands, all of which are considered suitable to reduce the vulnerability of the forest to climate change. For example, for beech, selective felling with a regeneration period between 10 and 20 years was chosen with a strong intensity of 16-25% of volume. The species proposed to decrease vulnerability are beech, oaks and various hardwoods.

Selective clearcuts with a regeneration period between 10-20 years with moderate intensity 6-15% of volume and strong intensity of 16-25% of volume have been chosen for oak-based stands. The species proposed for these forest formations are beech, oaks, larch, Douglas fir and various hardwoods.

For spruce mixtures, continuous regeneration hardwoods have been proposed with a moderate intensity of 6-15% of volume and with many beech, spruce, and fir proposed for regeneration.

For spruce trees, opinions are divided and we have no conclusion on the proposed treatment, with foresters making this choice: 15% clearcut, 15% clearcut with artificial regeneration, 15% strip clearcuts based on natural regeneration, 15% selective clearcuts with regeneration period up to 10 years, 12% selective clearcuts with regeneration period between 20 and 30 years, 25% selective clearcuts with regeneration period between 10 and 20 years, 3% strip clearcuts based on natural regeneration.

Interventions regardless of the work are preferably moderate 6-15% of the volume and strong 16-25% of the volume. To decrease the vulnerability of spruce forests, it is recommended to regenerate/forest with beech, spruce, fir and mountain pine.

Foresters believe that the following activities that they carry out daily can intensify climate change:

- logging without taking into account weather conditions, or with old or non-adapted machinery used in logging
- forest protection works where chemicals are used
- consumption of firewood in low energetic efficiency
- too frequent use of the car as a means of transport for work purposes
- clear-cutting on large areas
- use of unsuitable species
- intense, non-rational logging where the forest does not allow it

They also consider that afforestation, regeneration, afforestation of degraded land, removal of dry trees, conservation of habitats, protection of trees left over during the logging process, increasing the accessibility of the forest floor, promoting natural regeneration, promoting the use of low-impact technologies (cableways), ensuring that economic operators comply

precisely with environmental protection rules, contribute to reducing the vulnerability of forests to the effects of climate change.

95% of forest workers would voluntarily implement any measure to prevent/stop the effects of climate change if certain activities were properly carried out/documented.

3.4 Comparison of the results from pre-testing with other existing studies

We have compared the results of this pre-testing with the results available from the following studies:

- R. Sousa-Silva *et al*, "Adapting forest management to climate change in Europe: Linking perceptions to adaptive responses", *Forest Policy and Economics*, vol. 90, 2018, pp. 22-30, ISSN 1389-9341, https://doi.org/10.1016/j.forpol.2018.01.004.
- Mutu M., Bouriaud L., Nichiforel L., Drăgoi M., Duduman C., Palaghianu C., "Forest engineers' perceptions of vulnerabilities and risks of forest ecosystems in the context of climate change" *Bucovina Forestière,* vol. 14(1), 2014, pp.51-59, http://www.silvic.usv.ro/z_2014_bf_1_palaghianu.pdf

This pre-testing and the other two studies are based on the same approach to the topic of climate change effects on forests and on the opinion of foresters on the vulnerability of forests, the phenomenon itself, its impact and the strategies to prevent and mitigate negative effects on forests. All these factors analysed are of interest to find out the level of awareness and identify and implement procedures that can ensure the resilience and development of forests in the future.

From the point of view of the sample chosen: the research conducted in 2018 was applied in 7 European countries (Belgium, Estonia, France, Netherlands, Portugal, Romania and Slovakia) including Romania with 1131 respondents, while the present study received responses from 87 people being conducted at national level. The 2014 survey was also conducted only in the country but included only 3 counties (subnational division) where 76 foresters were questioned. The Europe-wide survey takes a more general approach with differences in climate, differences in forest background and the fact that many foresters have already had to deal with the effects of climate change in their work. Specifically, 56% of all respondents were reported to be aware of the risks through experience and are already looking for remedial solutions.

From the point of view of people's perceptions of climate change, the article by R. Sousa-Silva *et al*. (2018) shows that 91% of respondents were aware of the existence of the phenomenon, and in the case of the present research, 93% of respondents believe more or less in the impact of climate change. The article published in 2014, compared to the current study, did not investigate the awareness of the phenomenon, basing the study mainly on the effects of climate change and the expected degree of its intensity. Thus, about 37% of respondents expected moderate impacts in Romania, and only 12 (16%) out of the total 76 respondents considered that the effects of climate change on Romania could be major. This survey carried out 8 years later, reports similar findings for a similar question. Specifically, 44% of respondents now believe in moderate effects and only 7% in major effects.

The current case study primarily examines foresters' views on climate change trends over the next 50 years. In this context, it is mainly observed that a range of approximately 65% to 90% of foresters expect: changes in the current climate with temperature increases, extreme temperature variations, decreases in average precipitation and hydrological changes. Increased incidence of catastrophic climate events is an outlook also analysed in the 2018 survey, where 70% of respondents expect this effect in the future, and in the current case study, where the percentage is 76% of surveyed foresters. In addition to these issues, foresters are concerned about the actual effects of climate change on forests in the future.

Risks/Possible effects of climate change on forests	This study 2022	Mutu *et al.* 2014	Sousa-silva *et al.* 2018
Increasing attacks by forest pests	73%	22%	60%
Facilitating the development of plant pathogens	68%	20%	
Increasing frequency of forest fires	60%	22%	
Increased frequency of windthrow	65%	39%	
Increased drying of stands	64%	45%	
Increased risk of extinction of certain plant or animal species	46%	13%	
Decreasing production capacity of stands	44%	14%	
Decreased forest protection capacity (floods, landslides)	40%	21%	
Increasing replacement of forest species	66%	33%	55%
Decreased natural regeneration capacity of stands	39%	26%	17%

The differences between the two Romanian studies and the European one come from the way of approaching the subject in question. While the research carried out in the country is based on prevention and investigates the risks and vulnerabilities of the forest, the article published by R. Sousa-Silva *et al*. develops the analysis both by observing expectations about the future and by investigating extreme climate events already experienced by foresters. Thus, in the seven countries surveyed, up to the time of the questionnaire, foresters had largely encountered climate change events such as storms, drought, fires, extreme precipitation and heat waves in their work. Thus, they expect the effects of climate change on forests in the future to bring: extreme events, insects and diseases, changes in species composition and changes in tree growth and soil fertility. By comparison, in this survey conducted in 2022 in Romania, 57% of respondents are unaware of global warming phenomena. However 70% believe that the global warming process is due to both natural causes and human activities and 66% say they believe in the power of human intervention to

mitigate the negative effects of climate. The result of a question asked in the 2014 article reveals that there is then a belief that there can be a positive effect of climate change on forests in Romania, i.e. increasing the importance of forests in society with 47 out of 76 answers, only 9 foresters believing that there can be no positive effects.

A common principle of this research is forest policy and management in the context of climate change. In the study undertaken by R. Sousa-Silva *et al*., the awareness of the need to adapt to climate conditions of 885 foresters by country (France, Portugal, Belgium, Slovakia and their average) and their status as forest owners, private and state foresters are analysed in particular, while also investigating how many of them have already adapted. The results show an average of 54% aware of the need to adapt compared to 36% who have already adapted. In terms of position, forest owners are in the majority. The analysis continues with cross-country comparisons of the degree of adaptation and the reasons for limiting adaptation to climate change. The main constraints identified, listed according to how often limitations are encountered, are: lack of technical knowledge, lack of information, lack of conviction, lack of financial possibilities and very rarely, lack of autonomy. This information has not been analysed in this paper, as the case study is based on the analysis of forest adaptation and management through certain forest management strategies and state involvement with national forest policies, similar to the 2014 article.

In terms of state implications, 58% of the foresters surveyed believe that the national forestry policy is appropriate to mitigate the negative effects of climate change on forests in Romania, but that some aspects of policy and implementation should be improved. However, 30% of respondents believe that the current policy needs to be fundamentally changed. Correspondingly, the 2014 article investigating threats to forest stability in Romania highlighted that most foresters are concerned about such issues as: political influence in administration and control (65%), inconsistency of forest legislation (50%), failure to adapt legislation to form of ownership (37%) and illegal logging (30%).

By proposing possible orientations in this study, it was observed that about a quarter of the foresters consider that there are no mitigation options for climate change, a quarter bets on keeping the current orientation and a third quarter that considers a possibility of intensifying silvicultural work. In comparison with the 2018 article, a similarity is observed in that R. Sousa-Silva *et al*. present the three possible approaches to forest adaptation to climate change in a theoretical part presenting directions and strategies for forest management adaptation. These approaches are: no intervention, reactive adaptation (on the fly) and planned adaptation. The category of "no action" although not questioned in this article, is named as the majority observation of the authors. It can be quantifiably proven, however, by the current case study, which identified this perception in about half of the Romanian foresters surveyed (52%).

These results are worrying, as the literature considers that action needs to be taken on adaptation to climate change, and especially early action through the planned adaptation strategies approach. The results of the 2018 article thus propose as a solution the planting of species that would grow faster under the predicted climate conditions, information that could help spread the trend towards the implementation of effective measures. However, the research had not yet presented a concrete solution. Thus, the importance of the contribution of local experts who can provide additional (often overlooked) information on the impacts of climate change and fill the knowledge gaps in this area at the European level is stressed. In parallel, the results of the questionnaire in this paper reveal that from the perspective of foresters, regardless of forest formation, forests are considered relatively and less

vulnerable to the effects of climate change. In this context, to reduce the vulnerability of the stand to risk factors, different types of forestry works were proposed, with specific work intensities depending on *the* forest formations (see Table 5.5.2). In terms of management measures, the 2014 study mainly promotes 3 solutions for the risk of increased insect attacks raised by climate change. 78% of the respondents surveyed consider the promotion of deciduous-woody mixtures as a reliable practice, 47% favour the procedure of promoting other, more resistant species in forest regeneration, and 39% favour a forest management measure that supports the exploitation of stands at lower ages than at present.

The present case study also examined the views of foresters on the degree of impact of climate change prevention policies. The results show that the general opinion is that the strongest impact would be on policies to:

- Stopping illegal logging;
- Increasing the intensity of interventions through care and management work;
- Adapting forest management to the form of ownership.

By comparison, the article by Sousa-Silva *et al*. gives the example of a policy in France, which in 2011 launched a national climate change adaptation plan. It mainly proposed adaptive capacity-building measures, including for the forestry sector, to step up research and development efforts, to collect and widely disseminate ecological data and to ensure impact monitoring. However, for any broad implementation, national governments need to provide an appropriate institutional framework with supporting policies and funding mechanisms. Romania is given as an example in this context, where decision-making in local forest management is often hampered by regulatory obstacles, as forest policy as such is based on a set of strictly imposed rules, leaving little room for local expert involvement in decisions on adaptation measures and their practical implementation. This was also noted from the fact that many foresters interviewed in the 2014 article saw political influence and inconsistency in forest legislation as possible threats to forest stability. Returning to the European level article, another positive example of policy-oriented research is the online GIS platform introduced in 2011 in Slovakia to support foresters with a free flow of information. It provides guidance and support to define the timing and location of forest management options based on continuously updated information about the state of forests and is specified for use in state and private forests. In contrast to the current case study, the 2018 article considers that the nature of forest ownership plays a key role in determining the course of climate change adaptation actions.

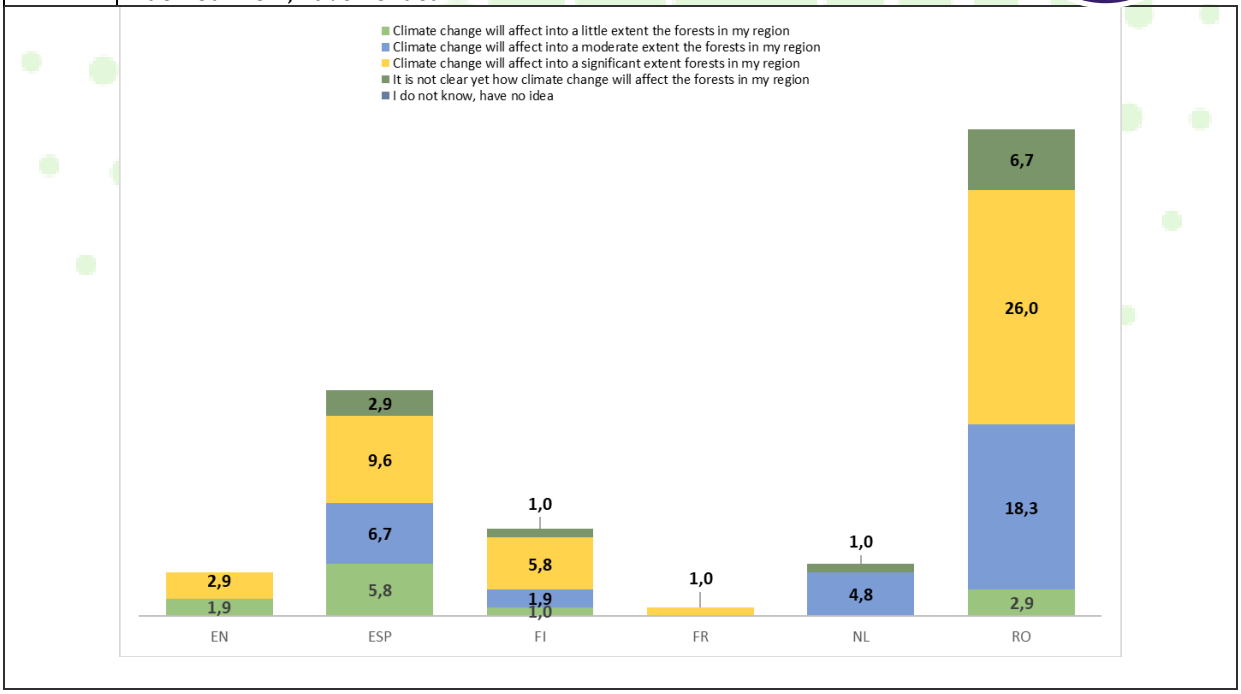
4 Results from the survey on forest owners' and managers' perceptions and expectations on climate change (28.11.2023)

4.1 General perceptions of climate change

4.1.1 How the impact of climate change is perceived by forest owners and managers?

Q1. Which one of the following statements fits best your opinion? *(one option only, please):*	
	Climate change will affect into a little extent the forests in my region
	Climate change will affect into a moderate extent the forests in my region
	Climate change will affect into a significant extent forests in my region
	It is not clear yet how climate change will affect the forests in my region
	I do not know, have no idea

Q1



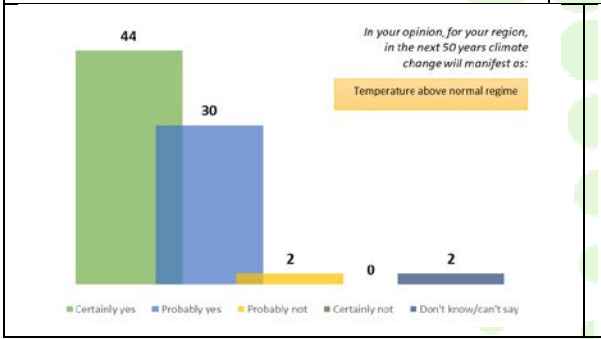
The number of answers received did not allow yet to answer clearly how climate change will affect the forests in each of the bio-geographical regions analysed. Only for Romania the answers suggest that the dominant perception is that forests will be affected to a significant or moderate extent, while responses from Spain (both questionnaires) tend to show a

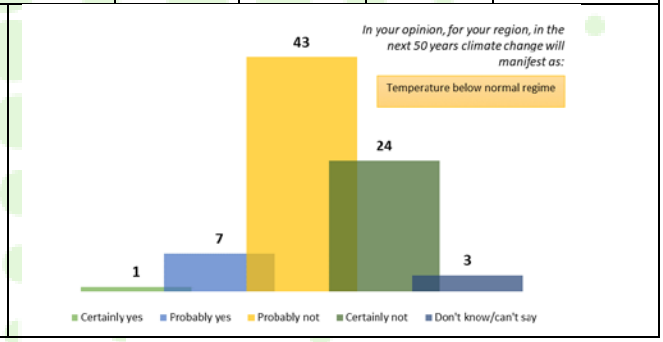
balanced situation between those considering that the forests will be affected and those considering that there is not clear yet how the climate change will affect the forests.

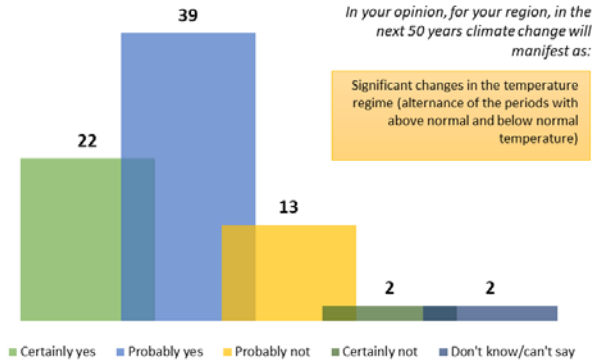
4.1.2 How the future effects of climate change are perceived by forest owners and managers?

Q2. In your opinion, for your region, in the next 50 years, climate change will manifest as:					
	Certainly yes	*Probably yes*	*Probably not*	*Certainly not*	*Don't know/ can't say*
Temperature above normal regime					
Temperature below normal regime					
Significant changes in the temperature regime (alternance of the periods with above normal and below normal temperature)					
Decrease of precipitation quantity (waterfall)					
Increase in the precipitation quantity (waterfall)					
Increased impacts of flooding					
Increased impact of drought					
Significant changes in the precipitation (alternance of periods with above normal and below normal precipitation)					
Significant changes in forest soil moisture					
A higher occurrence rate of catastrophic climate events					
Other:					

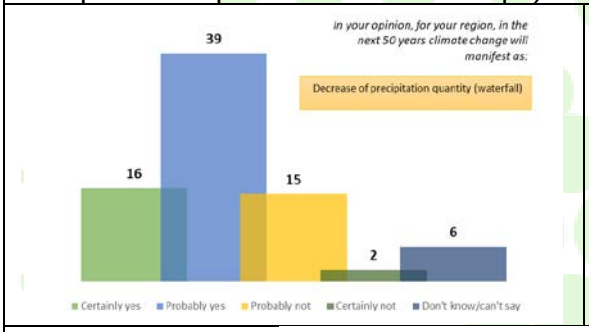
Q2

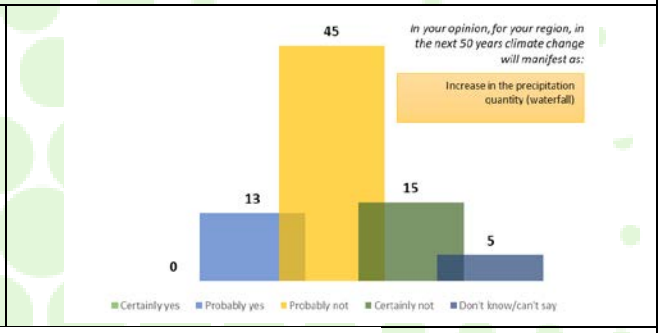


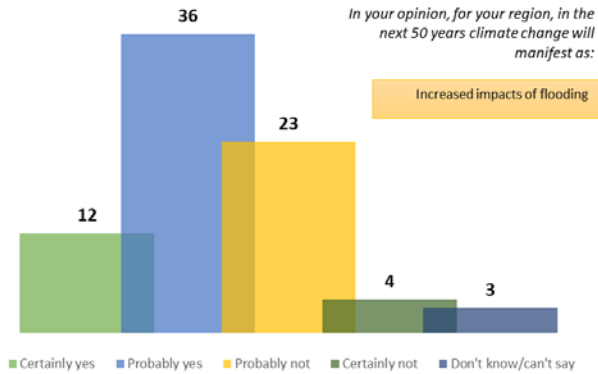




The answers show that climate change is perceived to change the temperature regime in the sense of increased temperature (74%), but with also the possibility of having temperature below the normal regime (8%). We remark on the low number of those without an opinion on this issue.
The perception is maintained also, but less affirmative on the next questions that figure out the changing temperature amplitudes. A significance test is needed to better understand what means this difference (perhaps driven by the high number of answers from South Europe as compared with North Europe).





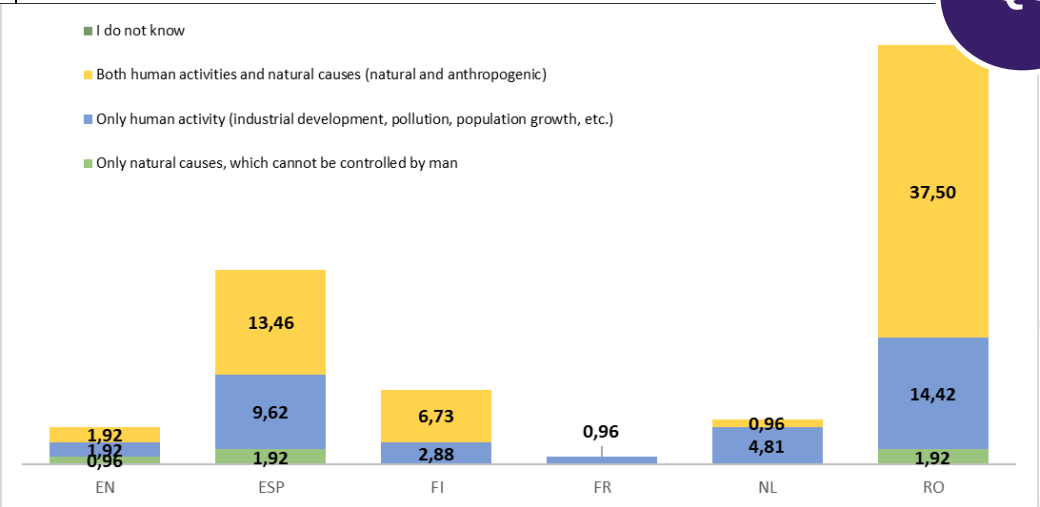


Changes in the precipitation regime are perceived in a similar way to the changes in the temperature regime. In the forest owners' and managers' opinion, in their regions there will be probably a decrease in the precipitation quantity (55%), and most likely (60%) not an increase in the precipitation regime. One third however agree that probably in their regions they will assist in an increased impact of flooding.

4.1.3 How do the respondents situate themselves on the interpretation of climate change origins?

Q3. In your opinion, the global warming over the past decade is due to *(one option only, please):*	
	Only natural causes, which cannot be controlled by man
	Only human activity (industrial development, pollution, population growth, etc.)
	Both human activities and natural causes (natural and anthropogenic)
	I do not know

Q3

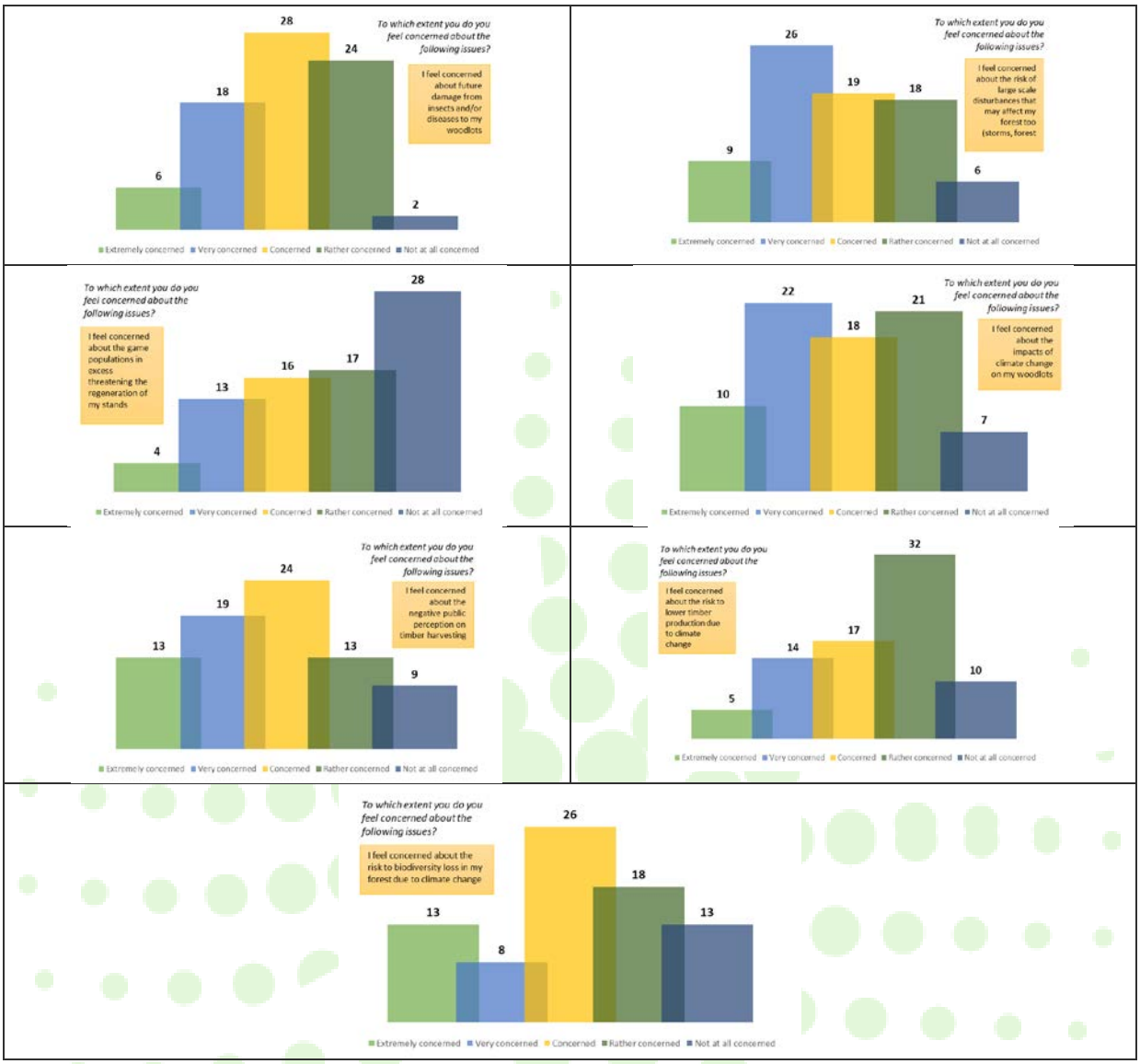


For several regions, the "middle-convinced climate change" believers seem to overpass by two the of "true climate change" believers. If the respondents believe that climate change is due to both human activities and natural causes, the tendency to undertake adaptation and mitigation actions will be lower than in the case of belief in only human-induced climate change.

4.1.4 Estimating the level of concern on different forest-related issues under climate-change context

Q5. To what extent do you feel concerned about the following issues?					
	Not at all concerned	*Rather concerned*	*Concerned*	*Very concerned*	*Extremely concerned*
I feel concerned about future damage from insects and/or diseases					
I feel concerned about the risk of large-scale disturbances that may affect the forests in my region					
I feel concerned about the game populations in excess threatening the regeneration of my stands					
I feel concerned about the impacts of climate change on forests					
I feel concerned about the negative public perception of timber harvesting					
I feel concerned about the risk of lower timber production due to climate change					
I feel concerned about the risk of biodiversity loss in forests due to climate change					

Q5



The most stressful worries for the sample analysed (98 respondents very concerned and concerned) are:
- insect damage (46%);
- disturbances (45%);
- negative public perception of harvesting (43%);
- climate change (40%);
- biodiversity loss (34%);
- lower production (31%);
- game population (29%).

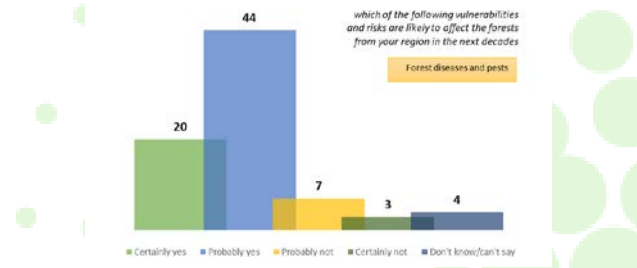
The direct biotic and abiotic factors raise the biggest concern, while the climate change impact is less worrying than the public perception.

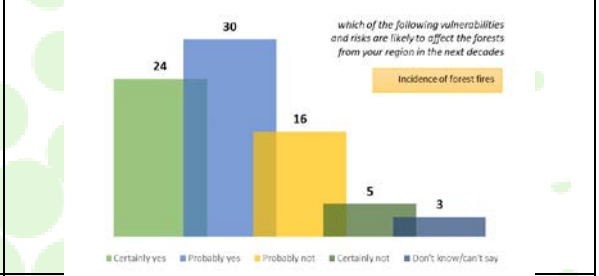
4.1.5 Perceived vulnerabilities and risks

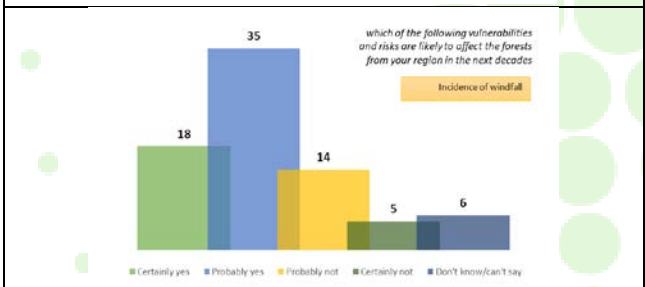
This question is intended to assess the estimated impact of different factors as compared with the level of individual concerns expressed in the previous question (Q5).

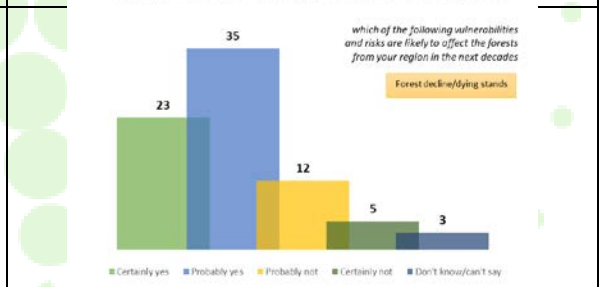
Q6. In your perception, which of the following vulnerabilities and risks are likely to affect the forests of your region in the next decades?					
	Don't know/ can't say	*Certainly not*	*Probably not*	*Probably yes*	*Certainly yes*
Forest diseases and pests					
Incidence of forest fires					
Incidence of windfall					
Forest decline/dying stands					
Replacement of some forest species by other forest species					
Difficulties in achieving natural regeneration of stands					
Decline of the forest productivity					
Other:					

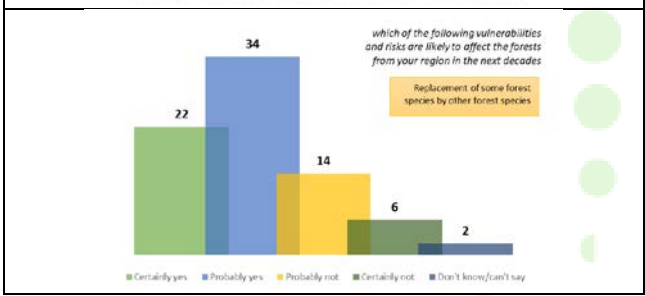
Q6

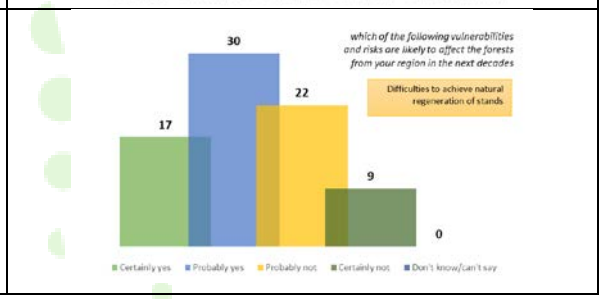


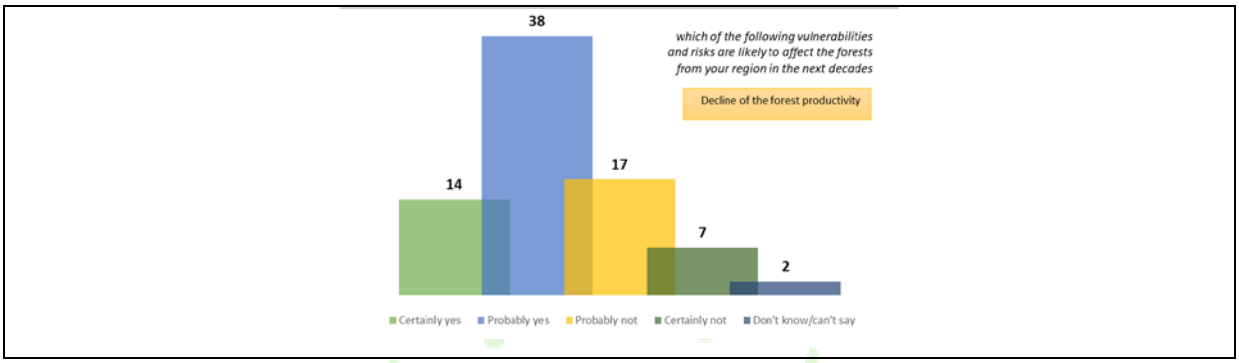












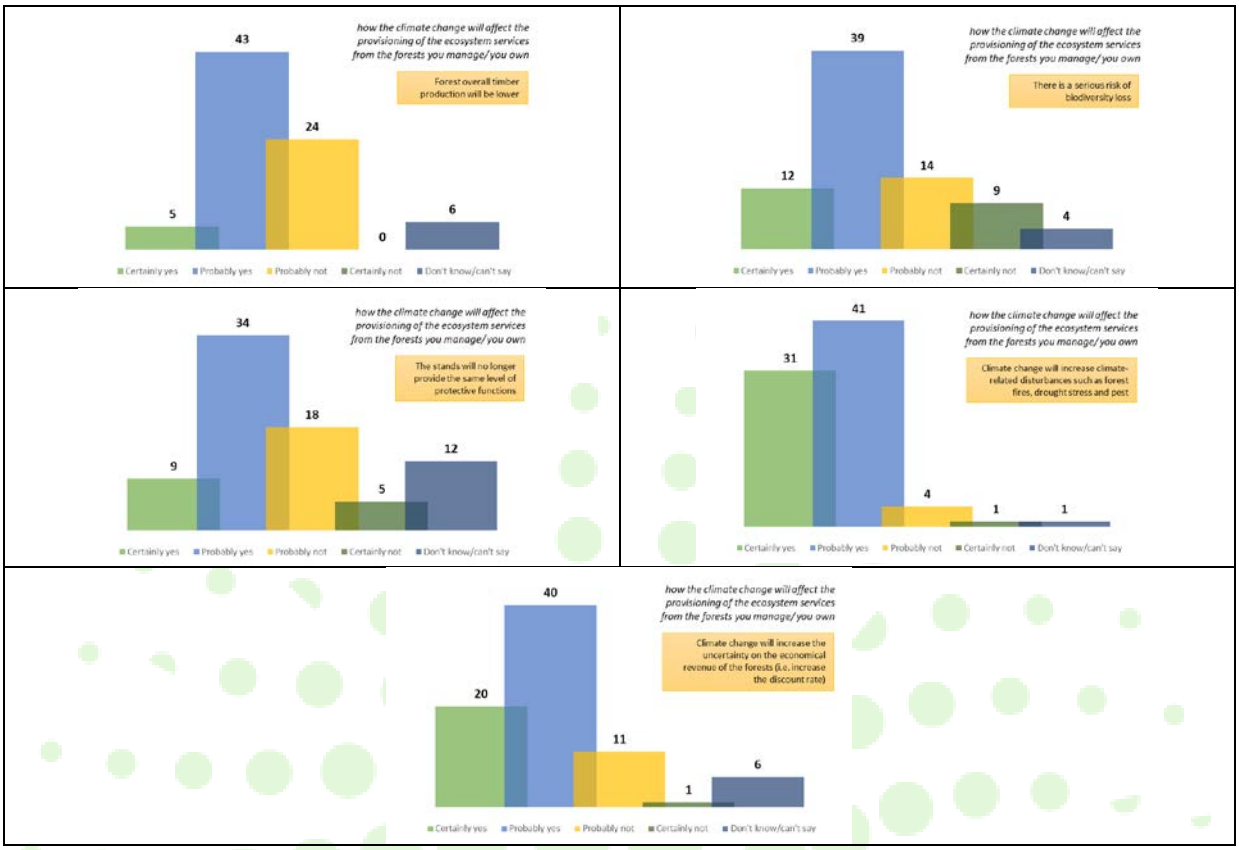
The vulnerabilities perceived as being sure (certainly yes) (certainly yes and probably yes) are:
1. Incidence of forest fires (24%); (54%)
2. Forest decline/dying stands (23%); (58%)
3. Replacement of forest species (22%); (56%)
4. Forest diseases and pests (20%); (64%)
5. Incidence of windfall (18%); (53%)
6. Difficulties on natural regeneration of stands (17%); (47%)
7. Decline of the forest productivity (14%); (52%).

If considered a certain level of incertitude (adding probably yes), the main vulnerability perceived is again the forest diseases and pests, followed by forest decline. Therefore, there is a serious concern about forest health amongst the respondents, a result appearing also from the previous question.

4.1.6 Quantifying the effect of climate change on forest ecosystem provisioning

Q7. In your perception, how the climate change will affect the provisioning of the ecosystem services from the forests you manage/ you own/you're advising?					
	Don't know/ can't say	*Certainly not*	*Probably not*	*Probably yes*	*Certainly yes*
Forest overall timber production will be lower					
There is a serious risk of biodiversity loss					
The stands will no longer provide the same level of protective functions					
Climate change will increase climate-related disturbances such as forest fires, drought stress and pest outbreaks.					
Climate change will increase the uncertainty on the economic revenue of the forests (i.e. increase the discount rate).					

Q7



The answers to this question have a higher rate of „probably yes" answer due to difficulties in anticipating the effects of climate change in ecosystem services provisioning, but overall the respondents identified higher impacts on climate-change-induced disturbances (72%), on forest economic revenues (60%) and biodiversity (51%). For almost one quart of respondents the timber production will not be lower – but these results have to be consolidated with a better representativity of answers from North Europe.

4.2 Opinions on mitigation policies and strategies

4.2.1 Opinions on strategies for mitigations

Opinions on strategies for mitigations (Q10) give different priorities according to the region. Thus, t**he most important measures/policies for climate change mitigation were:**

Romania

1. **Promoting solar and wind energy**
2. Increase the carbon sequestration in long-life wood-based products
3. Promoting woody biomass as an energy source

Finland

1. **Increase the carbon sequestration in forests**

2. Increase the carbon sequestration in long-life wood-based products
3. Promoting solar and wind energy

Netherland

1. **Promoting solar and wind energy**
2. Promotion of hybrid/electric motor vehicles
3. Promoting the cascade use of wood and wood recycling

Spain

1. **Promoting woody biomass as an energy source**
2. Promoting the cascade use of wood and wood recycling
3. Promoting biological fuel

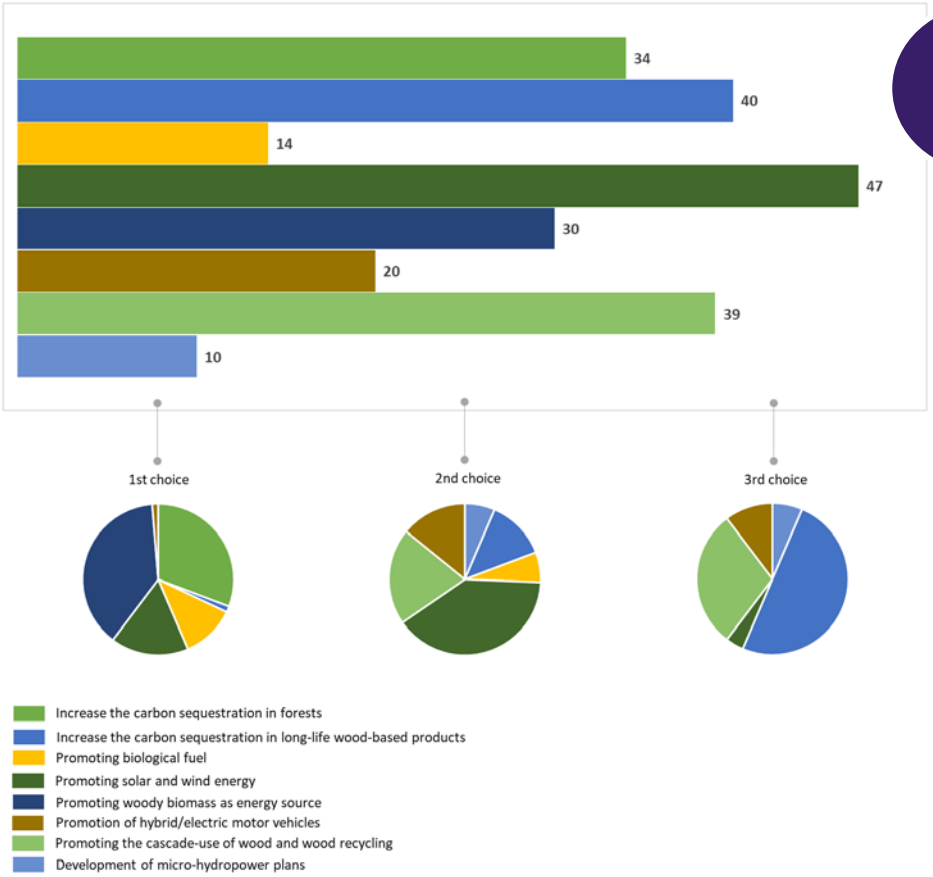
We have to remark that, except Finland, and Spain, for all the other regions the forest-related mitigation measures are in second position only, after solar and wind energy.

Measures / policies that are most appropriate for climate-change mitigation. The total number of options expressed, irrespective of the order of the options, indicates the following priority:

1. promoting solar and wind energy (47%)
2. increase the carbon sequestration in long-life wood-based products (40%);
3. increase the carbon sequestration in forests (39%);
4. promoting the cascade use of wood and wood recycling (34%);
5. promoting woody biomass as an energy source (30%).

When combining all the answers and considering the priority level, the first three options are:

1. promoting woody biomass as an energy source;
2. promoting solar and wind energy;
3. increase the carbon sequestration in long-life wood-based products.



Q10

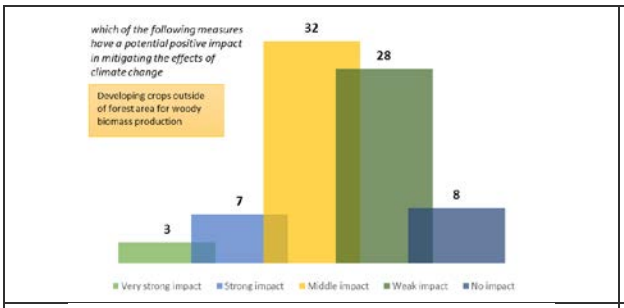
An interesting point is that the increase in the carbon sequestration in forests is mentioned by respondents, but it never gets a first-priority rank.

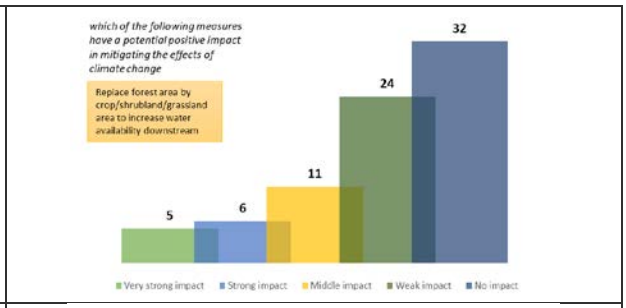
With a higher number of answers, we can also analyse the regional-dependency of the preferred mitigation measures.

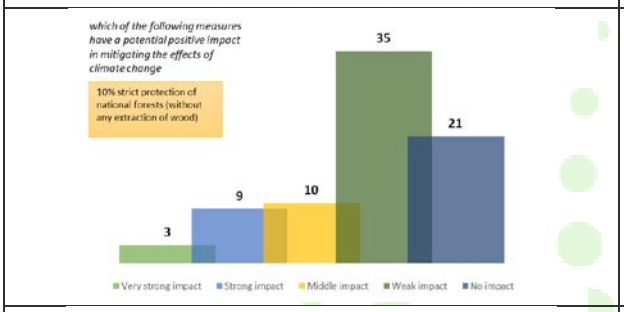
4.2.2 Estimating the impact of mitigation measures

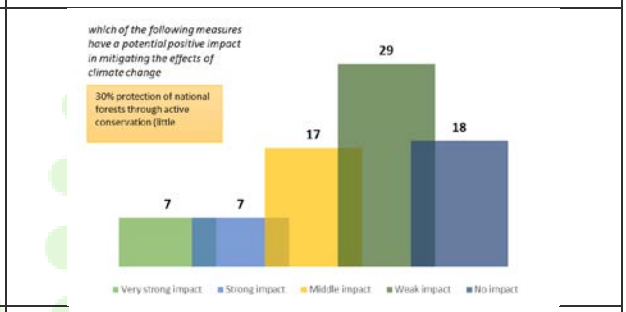
Q11. In your opinion, which of the following measures have a potential positive impact in mitigating the effects of climate change?					
	No impact	*Weak impact*	*Middle impact*	*Strong impact*	*Very strong impact*
Developing crops outside of forest areas for woody biomass production					
Replace forest area with crop/shrubland/grassland area to increase water availability downstream.					
10% strict protection of national forests (without any extraction of wood)					
30% protection of national forests through active conservation (little extraction of wood)					
Restrict the access to areas in danger of a forest fire during summer, to avoid human-induced triggers of forest fires.					
Improve the forest infrastructure for rapid reaction in case of severe disturbances					
Decrease the harvesting age (shorter rotation)					
Increase the harvesting age (longer rotation)					
Increase the frequency of interventions and the quantities extracted at once					
Decrease the frequency of interventions and the quantities extracted at once					
Converting to uneven-aged forest					
Converting to continuous forest cover					
Converting the sylvicultural system to high-quality logs production					

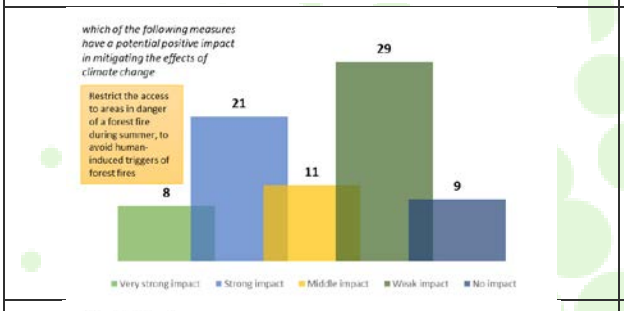
Q11

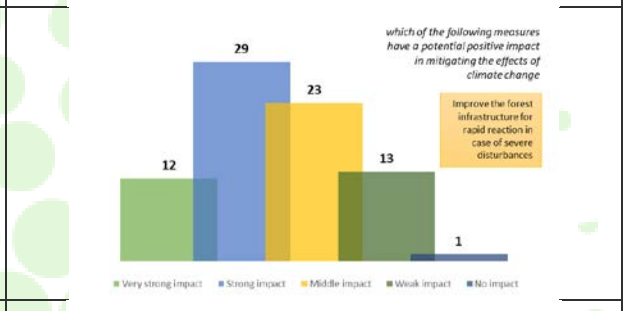

which of the following measures have a potential positive impact in mitigating the effects of climate change
Developing crops outside of forest area for woody biomass production
3
7
32
28
8
Very strong impact
Strong impact
Middle impact
Weak impact
No impact

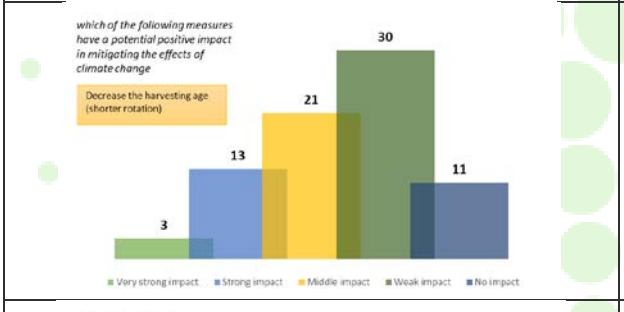

which of the following measures have a potential positive impact in mitigating the effects of climate change
Replace forest area by crop/shrubland/grassland area to increase water availability downstream
5
6
11
24
32
Very strong impact
Strong impact
Middle impact
Weak impact
No impact

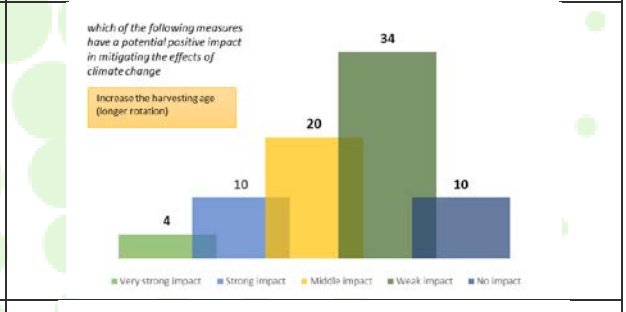

which of the following measures have a potential positive impact in mitigating the effects of climate change
10% strict protection of national forests (without any extraction of wood)
3
9
10
35
21
Very strong impact
Strong impact
Middle impact
Weak impact
No impact

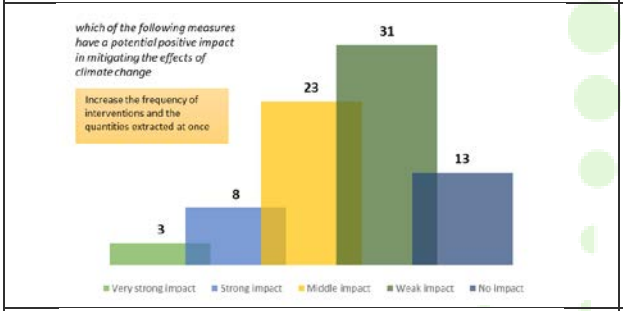

which of the following measures have a potential positive impact in mitigating the effects of climate change
30% protection of national forests through active conservation (little
7
7
17
29
18
Very strong impact
Strong impact
Middle impact
Weak impact
No impact

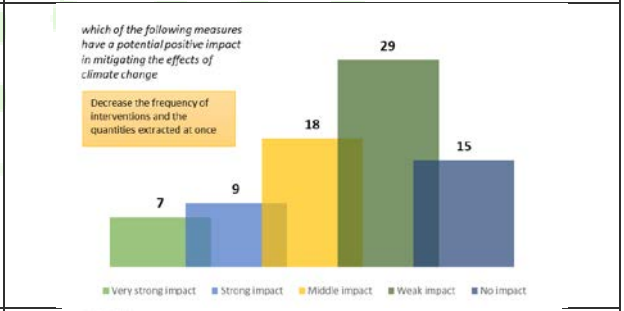

which of the following measures have a potential positive impact in mitigating the effects of climate change
Restrict the access to areas in danger of a forest fire during summer, to avoid human-induced triggers of forest fires
8
21
11
29
9
Very strong impact
Strong impact
Middle impact
Weak impact
No impact

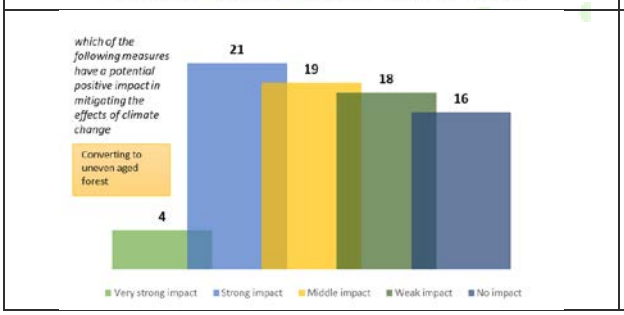

which of the following measures have a potential positive impact in mitigating the effects of climate change
Improve the forest infrastructure for rapid reaction in case of severe disturbances
12
29
23
13
1
Very strong impact
Strong impact
Middle impact
Weak impact
No impact

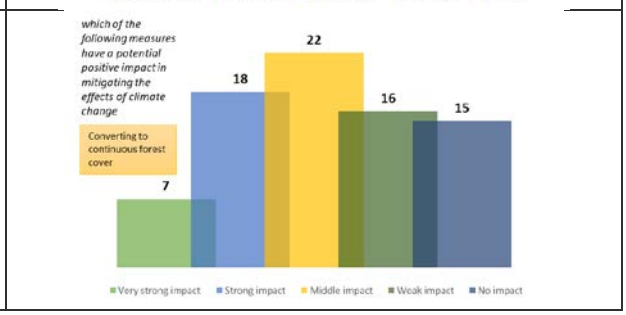

which of the following measures have a potential positive impact in mitigating the effects of climate change
Decrease the harvesting age (shorter rotation)
3
13
21
30
11
Very strong impact
Strong impact
Middle impact
Weak impact
No impact


which of the following measures have a potential positive impact in mitigating the effects of climate change
Increase the harvesting age (longer rotation)
4
10
20
34
10
Very strong impact
Strong impact
Middle impact
Weak impact
No impact


which of the following measures have a potential positive impact in mitigating the effects of climate change
Increase the frequency of interventions and the quantities extracted at once
3
8
23
31
13
Very strong impact
Strong impact
Middle impact
Weak impact
No impact


which of the following measures have a potential positive impact in mitigating the effects of climate change
Decrease the frequency of interventions and the quantities extracted at once
7
9
18
29
15
Very strong impact
Strong impact
Middle impact
Weak impact
No impact


which of the following measures have a potential positive impact in mitigating the effects of climate change
Converting to uneven aged forest
4
21
19
18
16
Very strong impact
Strong impact
Middle impact
Weak impact
No impact


which of the following measures have a potential positive impact in mitigating the effects of climate change
Converting to continuous forest cover
7
18
22
16
15
Very strong impact
Strong impact
Middle impact
Weak impact
No impact

"Weak" and "no impact" cumulated (%) give us an idea about the belief the proposed measures are efficient or not.

Respondents are not at all convinced about the impact of measures to replace forest areas with crop/shrubland/grassland areas to increase water availability downstream (56%), 10% strict protection of national forests (without any extraction of wood) (56%) and about 30% protection of national forests through active conservation (little extraction of wood) (47%).

We did not obtain a clear option on the impact of converting to uneven-aged forestry and restricting access to areas in danger of a forest fire during summer, to avoid human-induced triggers of forest fires, in both cases we have had a balanced representation of the impact, that may be a representation of regional differences to be further investigated.

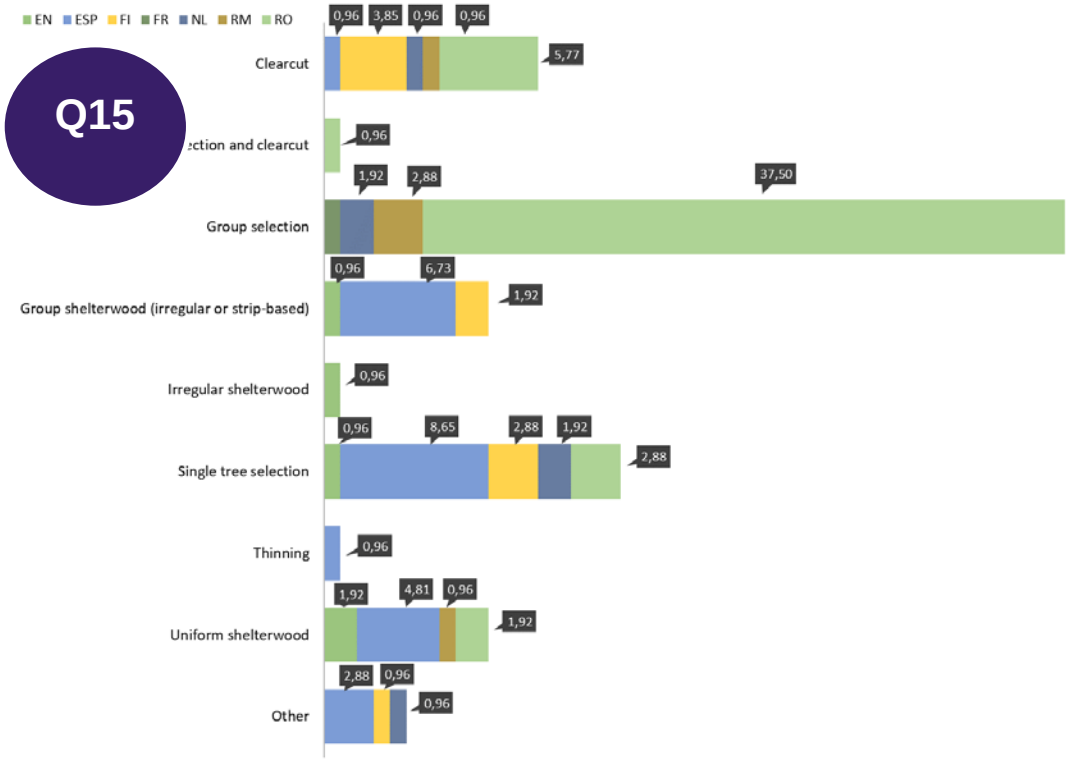
Respondent was indecisively convinced about the use of developing woody crops outside of forests to supply energy needs (32% appreciate a middle impact, while 28% say no impact).

We can observe a tendency to say that improving the forest infrastructure for rapid reaction in case of severe disturbances has an impact, and a tendency to say that decreasing the harvesting age (shorter rotation) or increasing the harvesting age (longer rotation) has no impact (the same situation also for increase the frequency of the interventions and decrease the frequency of the interventions). For these options, the graphs suggest a normal distribution of answers that has to be statistically analysed, but as a preliminary guess, conservative attitudes seem to dominate, resulting from the fact that neither longer rotation nor shorter rotation was not considered to have an impact on climate change adaptation/mitigation.

4.3 Opinions and preferences about forest management adaptation to climate change at stand level

4.3.1 Which is the main forestry system the respondents implement in their forests

Applied forestry systems in the respondents' regions



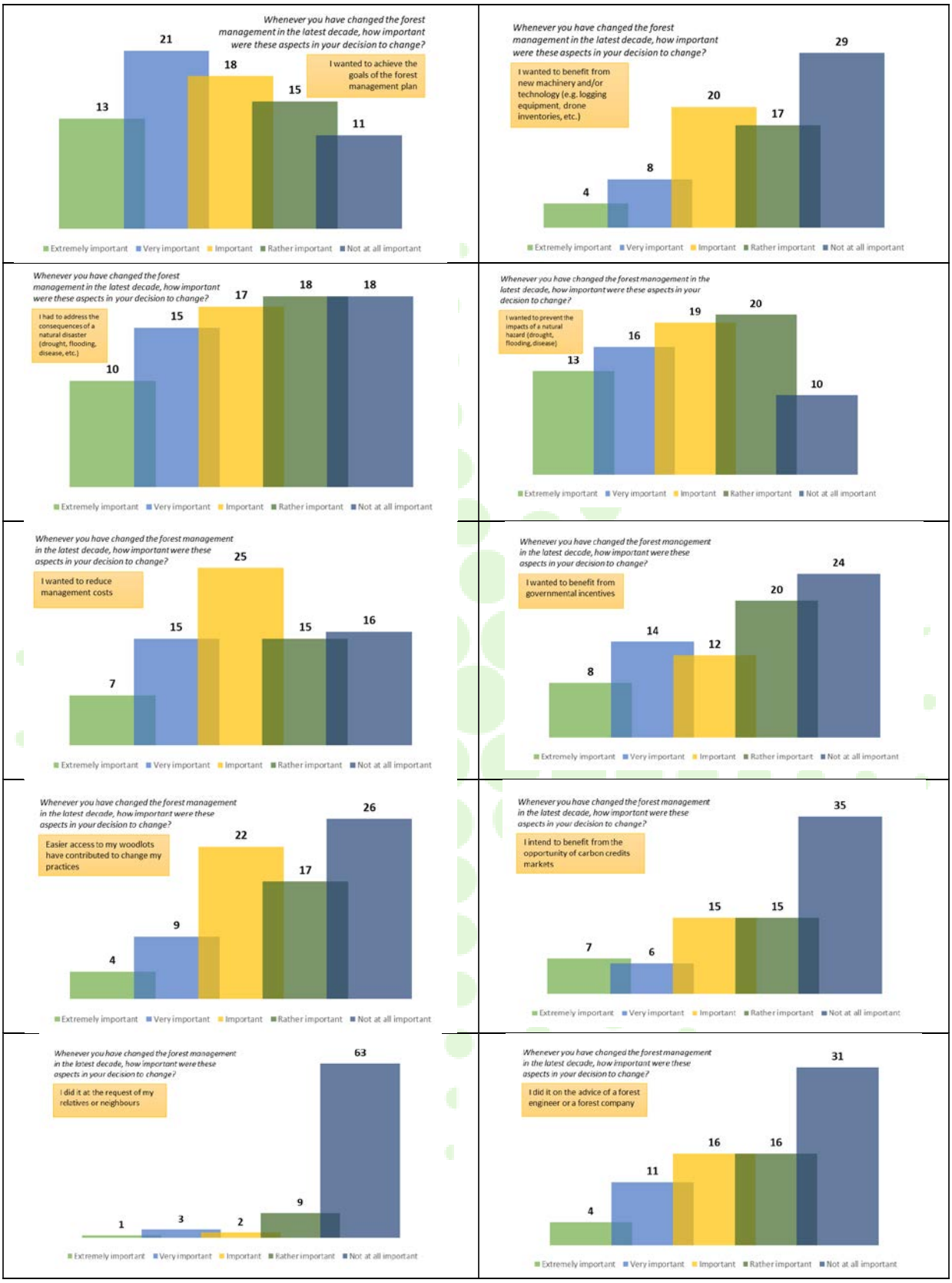
We can observe a huge variety of forestry systems in place, therefore the interpretation of forest managers' and owners' perceptions and attitudes has to consider this variety of applied forestry systems.

4.3.2 Reasons for changing forest management in the past

Q21. Whenever you have changed forest management in the latest decade, how important were these aspects in your decision to change?

	Not at all important	*Rather important*	*Important*	*Very important*	*Extremely important*
I wanted to achieve the goals of the forest management plan					
I wanted to benefit from new machinery and/or technology: logging equipment, drone inventories, etc.					
I had to address the consequences of a natural disaster (drought, flooding, disease, etc.)					
I wanted to prevent the impacts of a natural hazard (drought, flooding, disease)					
I wanted to reduce management costs					
I wanted to benefit from governmental incentives					
I did it at the request of my relatives or neighbours					
I did it on the advice of a forest engineer or a forest company					
Easier access to my woodlots has contributed to changing my practices					
I intend to benefit from the opportunity of carbon credit markets					
Other reasons than those above:					

Q21



The reasons that determined the decision to change the forest management in the past decade were:

1. Implementing the forest management plan which represented a very important and important reason for 52% of the respondents;

2. Dealing with the consequence of a natural disaster: 42% or preventing a disaster: 48%.

3. Improving the economic condition: reducing management costs – 47%, but only 34% to obtain governmental subsidies (perhaps a different availability of them has to be considered) and the reason for new machinery- 32% and easier access to woodlots 35%.

Carbon credits account as a changing reason for only 28% of the respondents.

Therefore we can deduce that planning is important when implementing changes in an equal important with the climate-induced disaster. This suggests different approaches to implementing changes in forestry and perhaps different ways to act to trigger a change, according to the local conditions.

It appears that changes were not modified as a consequence of close relationships (only 15% of respondents reacted following the request of relatives or neighbours). Advice from forest engineers or companies had a higher role (31% was important).

5 Conclusions

5.1 Literature findings

Forest ownership is shifting among new forest owners in Europe toward more diversified values and purposes, including a preference of amenity functions over production ones.

The decision-making process of private forest owners/forest managers regarding climate change adaptation is complex and influenced by various factors, including perceived risks and available insurance options.

Forest policies and management objectives may need to change to reflect the effects of climate change on forest productivity and forest ecosystem provisioning.

Forest professionals have diverse viewpoints about climate change, but the majority support adaptation and recognize the importance of adaptation concepts.

The potential trade-offs or conflicts between different management objectives affect the feasibility or attractiveness of specific adaption measures.

Forest owners and managers can be classified as adapters or non-adapters, or proactive, reactive, and wait-and-see. However, stakeholders cannot agree on whether climate change is precipitating or aggravating the forest dieback manifestation they perceived. According to Vincenti *et al*. (2020), more efforts should be made to understand the attitudes and motivations of European forest owners and managers to better personalize advice on effective strategies to combat the negative consequences of climate change.

5.2 Limitations in studying perceptions and attitudes over adaptation and mitigation and precautions in the design of the survey

Respondents' opinions on how the national forestry policy/forest management planning decision deals with the negative effects of climate may be very contrasting, according to the position they have on the forest decision-making process, e.g. studies did not explore the potential barriers to implementing climate change science in forest management decisions beyond organizational barriers (Blade *et al.* 2016, Vincenti *et al.* 2020), or that did not consider the potential influence of social and political factors on the use of climate change science in forest management decisions (Blade *et al.* 2016). **The place and role of individual respondents should then be considered in the results interpretation**.

While investigating threats to forest stability, it may be that there are many other threats that are perceived by stakeholders as being more important that climate change, **thus the survey should consider these perceptions on another risk than climate change**.

Some studies conducted in a specific region may not be generalizable to other regions or countries (Lawrence and Marzano 2014, van Gameren and Zaccai 2015, Blade *et al.* 2016, Sousa-Silva *et al.* 2016, Mozgeris *et al.* 2019, Deuffic *et al.* 2020, Vincenti *et al.* 2020, Ambrose-Oji *et al.* 2021, Soucy *et al.* 2021), or either the sample is relatively small (Lawrence and Marzano 2014, Blade *et al.* 2016, Sousy *et al.* 2021, Matilainen *et al.* 2019). The comparative analysis is likely to have a higher qualitative contribution to the topic of perceived strategies for adaptation and mitigation than a quantitative one.

In the other cases, studies focused on the intention to use adaptive measures rather than actual implementation, the results may not fully reflect the activities taken by forest owners and managers did not measure actual behaviour change, or either rely on self-reported perceptions which may be subject to biases and inaccuracies. **A conceptual model of behaviour is needed to put together intentions, perceptions and actual changes implemented**.

Some studies do use only qualitative methods and do not provide a comprehensive analysis (Matilainen *et al.* 2019, Soucy *et al.* 2021) of the economic or policy implications of climate change impacts on the forest industry (Soucy *et al.* 2021). For example, forest managers and private forest owners will follow forest management programs, and they will not be interested/allowed to change forest management. **Data analysis should deal with this limitation.**

5.3 Pretesting the questionnaire

About a quarter of the foresters in pretesting the questionnaire in Romania consider that there are no mitigation options for climate change, a quarter think that is enough to keep the current orientation and a quarter consider that there is possible to intensify silvicultural work. Thus the questionnaire should be place not only for planned/proactive adaptation but also for reactive adaptation and for no intervention/no reaction attitudes. There were questions modified to let place to ‘no option’ and to clarify the wording. The Lickert scale was used whenever possible to avoid further codification of answers to open-ended questions.

5.4 The results of the survey (N=98)

5.4.1 A larger sampling will allow a better differentiation amongst the European bio-geographical regions

At this moment, the number of answers received can be considered as **not enough to undertake an analysis of potential regional differentiation of answers received**. For example, it is not yet clear how climate change will affect the forests in each of the bio-geographical regions analysed. Only for Romania the answers suggest that the dominant perception is that forests will be affected to a significant or moderate extent, while responses from Spain tend to show a balanced situation between those considering that the forests will

be affected and those considering that there is not clear yet how the climate change will affect the forests.

5.4.2 There are clear perceptions of climate change effects as changing temperature and precipitation regime

Climate change is perceived as a change in the temperature regime (higher) and precipitation regime (decrease in the quantity of precipitations). The answers show that climate change is perceived to change the temperature regime in the sense of increased temperature (74%), but with also the possibility of having a temperature below the normal regime (8%). We remark on the low number of those without an opinion on this issue. A significance test is needed to better understand what means this difference (perhaps driven by the high number of answers from South Europe as compared with North Europe).

Changes in the precipitation regime are perceived in a similar way to the changes in the temperature regime. In the forest owners' and managers' opinion, in their regions there will be probably a decrease in the precipitation quantity (55%), and most likely (60%) not an increase of the precipitation regime. One third however agree that probably in their regions they will assist in an increased impact of flooding.

5.4.3 Belief in climate change varies, there is potential for non-adaptation/ non-mitigation

There is a huge variation in human-induced or natural-induce origin of climate change. For several regions, the "middle-convinced climate change" believers seem to overpass by two of the "true climate change" believers. If the respondents believe that climate change is due to both human activities and natural causes, the propensity to undertake adaptation and mitigation actions will be lower than in the case of belief in only human-induced climate change.

5.4.4 How the climate change will affect the ecosystem provisioning

The most stressing worries for the sample analysed (98 respondents) are: 1) insect damage (46%); 2) disturbances (45%); 3) negative public perception of harvesting (43%); 4) climate change (40%); 5) biodiversity loss (34%); 6) lower production (31%); 7) increase in the game population (29%). Concern with climate change **comes only in fourth place**, after the concern about the negative public perception of forest harvesting, which confirms the hypothesis that there are perhaps threats that are most worrying that climate change.

The vulnerabilities perceived as being sure (**certainly yes**) (certainly yes and probably yes) are: 1) Incidence of forest fires (**24%**); (54%); 2) Forest decline/dying stands (**23%**); (58%); 3) Replacement of forest species (**22%**); (56%); 4) Forest diseases and pests (**20%**); (64%); 5) Incidence of windfall (**18%**); (53%); 6) Difficulties on natural regeneration of stands (**17%**); (47%); 7) Decline of the forest productivity (**14%**); (52%). If considered a certain level of incertitude (adding 'probably yes' answers), the main vulnerability perceived is again the

forest diseases and pests, followed by forest decline. Therefore, there is a serious concern about forest health amongst the respondents, a result appearing also in the previous question.

The answers to the question "how climate change will affect the ecosystem provisioning" have a higher rate of „probably yes" option, due to difficulties in anticipating the effects of climate change in ecosystem services provisioning. Overall the respondents identified higher impacts on forest integrity due to disturbances (72%), on forest economic revenues (60%), and on biodiversity (51%). For almost one quart of respondents the timber production will not be lower as a result of climate change, but these results have to be consolidated with a better representation of answers from North Europe.

The comparison between the most stressing worries for the forest owners and managers and the strongest vulnerabilities perceived suggests that insect damage are the most stressing issue and the strongest vulnerability perceived with a high degree of probability, yet the answers received suggest that the respondents do not necessarily link this phenomenon (insects attacks and forest dieback) to the indirect effects of climate-change (finding already presented in the literature).

5.4.5 Opinions on strategies for mitigation place on the top the promotion of woody biomass as an energy source, but there are contrasting views

Opinions on strategies for mitigations give different priorities according to the regions, but we would need more answers to do a statistically meaningful analysis. Overall, when combining all the answers and considering the priority level accorded to each option, the first three options are: 1) promoting woody biomass as an energy source; 2) promoting solar and wind energy; 3) increasing the carbon sequestration in long-life wood-based products.

"Weak" and "no impact" cumulated (%) give us an idea about the belief the proposed measures are efficient or not. Respondents are not at all convinced about the impact of measures to replace forest areas with crop/shrubland/grassland areas to increase water availability downstream (56%), about the impact of putting 10% of forests in strict protection (without any extraction of wood) (56%) or about 30% protection of national forests through active conservation (little extraction of wood) (47%). We did not obtain a clear option on the impact of converting to uneven-aged forestry and about restricting access to areas in danger of a forest fire during summer, to avoid human-induced triggers of forest fires. In both situations, we have had a balanced representation of the impact, which may be a representation of regional differences to be further investigated.

Respondents were indecisively convinced about the use of developing woody crops outside of forests to supply energy needs (32% appreciate a middle impact, while 28% says no impact). This contrasts with the answers to the best policy for mitigating climate change (putting on first place promoting woody biomass for energy), therefore a deeper analysis is needed to understand which factors explain this apparent contradiction (it can be a regional difference as well, but also it can express a concern of forest managers and owners of not losing wood energy market opportunity, if energy crops are to be developed outside of the forest area).

We can observe a tendency to say that improving the forest infrastructure for rapid reaction in case of severe disturbances has an impact, and a tendency to say that decreasing the harvesting age (shorter rotation) or increasing the harvesting age (longer rotation) has never impact (the same situation also for increase the frequencies of the interventions and decrease the frequencies of the interventions). For these options, the graphs suggest a normal distribution of answers that has to be statistically analysed, but as a preliminary guess, conservative attitudes seem to dominate, resulting from the fact that neither longer rotation nor shorter rotation was not considered to have an impact on climate change adaptation/mitigation.

5.4.6 Motivation of decisions to change forest management taken in the past decade

The reasons that determined the decision to change the forest management in the past decade were:

1. Implementing the forest management plan which represented a very important and important reason for 52% of the respondents;

2. Dealing with the consequence of a natural disaster: 42% or preventing a disaster: 48%.

3. Improving the economic condition: reducing management costs – 47%, 34% obtaining governmental subsidies (perhaps a different availability of them has to be considered), introducing new machinery- 32%, easier access to woodlots 35%.

Carbon credits account as a changing reason for forest management for only 28% of the respondents.

It appears that changes were not implemented as a consequence of close relationships (only 15% of respondents reacted following the request of relatives or neighbours), but rather that advice from a forest engineer or company had a higher role (in 31% of cases their advice was important).

Therefore we can deduce that planning is important when implementing changes in an equal manner to climate-induced disasters and disturbances. These findings suggest 1) that different approaches to trigger changes in forestry are needed, 2) that economic and market-related motivations were not the main drivers of changes implemented up to now by the respondents, and 3) an important place in triggering a change remains the forest management planning and the experts' advice.

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