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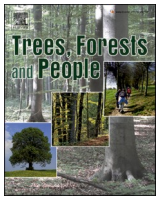

Identifying key actors, barriers and opportunities to lead a transition towards sustainable forest management: an application to the Basque Country, Spain

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ABSTRACT

The forestry sector is essential for achieving a transition towards sustainability because of the opportunities associated with the transformation of their management and practices. However, forest plantation management is characterised not only by ecological interactions but also by the complex dynamics that arise from the interaction of multiple actors, their knowledge and worldviews, and how actors can overcome barriers and lobby for their values and interests to be represented in policies and management. We illustrate this via a case study: the Basque Country in Spain. Drawing on 33 qualitative in-depth semistructured interviews conducted in 2022 and 2023 with a wide variety of forestry actors, we aim to a) identify who the potential actors are that can trigger a change toward sustainable forest management, b) explore actors' interactions and knowledge interchange that can foster a transformation toward sustainable forest management, and c) understand the opportunities and barriers that the main actors face to achieve sustainable forest plantation management. Our results show that a) those who may have the ability to induce a change in the forestry sector of the Basque Country are landowners, rangers and private sector companies; b) mutual learning happens in the day-to-day practices of forest plantation management while academic knowledge does not reach policy and practice; and c) barriers are related to managerial, political and individual dimensions that impair the way towards "close to nature" management and a "circular bioeconomy", such as a perceived lack of supporting policies and knowledge, as well as increasing land abandonment. Opportunities to pose a potential way forward are, among others, forest plantations of native species providing high-quality timber, and opening access to additional markets, such as the ones funding the diversity of contributions that forest plantations may bring to people. Collaboration to overcome barriers for small-scale forest plantation management and actions to promote a stronger feeling of attachment to natural forests and forest plantations are essential to achieve sustainable forest management in the Basque Country.

1. Introduction

The forestry sector has great potential to contribute to conserving nature and humans. Well-managed forests play a key role in the sequestration and storage of carbon for the mitigation of climate change impacts (Pan et al., 2013). They are also vitally important habitats for biodiversity (Thompson et al., 2009) and provide a wide range of cultural, recreational (Felipe-Lucia et al., 2018), ecological, social and economic benefits to society, such as timber production (Mengist and Soromessa, 2019). The maintenance and improvement of these functions constitute a fundamental part of sustainable forest management (Schmid et al., 2021).

A large share of the EU's forests has been actively managed for centuries, in many cases, primarily for timber production, although with substantial regional variation (Winkel et al., 2022). To meet the world's timber demand, since the 19th century, European forestry has often adopted a model of growing production through intensive management practices aimed at increasing tree growth and management efficiency while simplifying and homogenising stand age structure and species composition (Betts et al., 2021). Forest plantations in Europe have been predominantly managed as monospecific, even-aged plantations with exotic species, and clearcutting with a low level of tree retention has been the dominant management regime (FAO, 2020). Owing to the negative impacts of such intensive forest management on biodiversity,

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habitat quality, soils, water and nutrient cycling, landscape and nature's contributions to people, alternative forest management approaches have been developed but have received less attention (Puettmann et al., 2015). For example, alternatives such as soil retention systems and continuous cover forestry have been shown to mitigate the negative effects of clear-cutting regimes on soil erosion (Fedrowitz et al., 2014), and the use of mixed stands has been proven to increase resistance to natural disturbances (Jactel et al., 2017). However, there is still a lack of knowledge on how forest management can be broadly more sustainable in its practices and in specific European regions (Moreaux et al., 2022).

The new European Union (EU) forest strategy for 2030 under the umbrella of the EU Green Deal (European Commission and Directorate General for Environment, 2023) established as guidelines of sustainable forest management a change towards "close to nature" management in a "circular bioeconomy" to mitigate climate change and biodiversity crises. "Close to nature" refers to an ecosystem-oriented approach to forest management that fosters forests composed of several tree species, age classes and life cycle stages to provide not only timber and nontimber materials but also biodiversity conservation and nonmaterial benefits (Larsen et al., 2022). "Circular bioeconomy" refers to a biobased economic model that prioritises forest resource conservation and sustainable supply chains of forestry products, such as using sustainably managed forest material to make consumer goods and industrial bioproducts (Birner, 2018). Most of the studies to date on sustainable forest plantation management have focused on single and predominantly technological or economic aspects (McEwan et al., 2020). However, any shift in forest plantation management practices is not only an ecological or technological one but also a complex social process.

First, views of how forests and plantations should be sustainably managed may vary widely among different actors (i.e. rightholders, stakeholders, knowledge holders) managing forest plantations and in diverse territories. It is also not clearly defined who has the capacity, responsibility and opportunity to turn towards sustainable management of forest plantations (Larsen et al., 2022). In social-ecological theoretical frameworks, the central role that actors who can trigger a change could play in forest plantation management is broadly acknowledged, as they represent the actors through whom the necessary transformative actions toward sustainable forest management might be achieved (Andriamihaja et al., 2021). Thus, which actors can trigger a transformation in forest plantation management and how they can attain more sustainable management remain critical research questions and gaps.

Second, the changes that these individuals or institutions can generate in forest plantation management and practices are determined by their relationships and knowledge about the forest and its management and their capacity to obtain new knowledge and distribute it; it is assumed that actors with more relationships and knowledge interchange can make more significant changes (Borgatti and Cross, 2003). Knowledge that has the power to trigger changes is generally constructed through interactions and relationships operating in specific contexts and situations (West et al., 2019). In this sense, social relations can play an important role in the generation of knowledge among forest actors and in their processes that lead to management decisions (Ruseva et al., 2014; Brugnach et al. 2021). Decisions about forest plantation management determine the capacity of forested lands to provide climate, biodiversity, and economic and social benefits. Therefore, understanding the relationships that forest plantation management actors have with their territory, their collaborative or conflicting interactions, who they talk to and whom they turn to for advice related to management practices is essential and still not sufficiently studied.

Third, it is widely recognised that barriers and opportunities to practise sustainable forest management define the decision-making contexts of individuals who drive practices and actions (Topp et al. 2022). How to overcome barriers and which opportunities have opportunities to advance a transition towards sustainable forest management in a given social-ecological context has been recognised as one of the most relevant knowledge gaps in forest management research (Konczal et al. 2023).

We aim to fill these three abovementioned research gaps. Next, we examine and respond to the question of how actors' interactions and relationships, knowledge and perceived barriers and opportunities shape the functioning of the forestry sector and management strategies to achieve sustainable forest plantation management. We first identify the potential actors that can lead to the transformation of forest plantation management and then map their knowledge interchanges and social relations networks to understand which knowledge and relations actors have (new ideas, innovations, social networks, etc.) that can support a transition towards sustainable forest management. Third, we explore the main barriers they face to do so. This is illustrated by a case study in the Basque Country in Spain, where to the best of our knowledge, no previous research in these fields has been conducted. Finally, we suggest how to overcome barriers and highlight potential pathways addressing the important challenges to the forestry sector in the Basque Country that can also be applied elsewhere.

2. Methods

2.1. Case study

The Basque Country is located on the north coast of Spain and includes the provinces of Araba, Bizkaia and Gipuzkoa (Fig. 1). This territory has a very diverse climate, with a predominantly Atlantic climate in the northern part and a transitional Mediterranean climate in the southern part. There are pastures for livestock and forests for timber production in the northern part of the territory, whereas extensive crops dominate the territory in the southern part (Loidi et al., 2011). For centuries, the exploitation of natural forests (e.g., oak and beech) in the Basque Country has been carried out steadily, for example, through a traditional practice locally referred to as "trasmocho", where several branches from a tree are pruned and used, for instance, as firewood without removing the entire tree. However, the growing demand for forest products by the modern economic system led to the establishment of exotic tree plantations for productive purposes in the last century (e.g., *Pinus* and *Eucalyptus* genera) (Michel-Rodríguez, 2003). Most forest plantations are concentrated in the northern part of the territory, in Bizkaia and Gipuzkoa, whereas most native forests that are not used for production purposes are found in Araba (HAZI, 2022).

Oak forests (*Quercus robur*) once occupied large areas in the Basque Country; today, they are reduced to isolated locations due to pressure on their habitats and the value of their timber in the past, which caused them to be intensively felled (Loidi et al., 2011). However, oak trees are still found in so-called Atlantic mixed forests, which are heterogeneous mixtures of hardwoods that, in the absence of harvests and other disturbances, often give space to the long-term dominance of the oak species. Atlantic mixed forests currently occupy 38,138 ha, mostly as a consequence of the abandonment of pastures or felled pine forests. Among the forest plantations used for production, Monterey pine (*Pinus radiata)* is the species that occupies the largest area (102,488 ha, accounting for 25.9% of the total forested area) (HAZI, 2022). Eucalyptus trees are increasingly planted and currently cover an area of 25,316 ha, mainly in Bizkaia. It is estimated that their annual increase is approximately 1,000 hectares, especially for the species *Eucalyptus nitens*.

According to most updated information publicly available Gobierno Vasco, 1994), most forest plantations are located on small private properties. Private forest owners in the Basque Country are in charge of a total of 131,553 ha of managed forest plantations, with an average plot size of 6.1 ha per owner. A smaller share of the forest plantations is managed by public administrations and private companies. By the beginning of the current management plan for the three Basque provinces (Gobierno Vasco, 1994), publicly managed forested land covered an area of 141,986 ha, with a much larger average plot size of 253.5 ha. Approximately 69% of this publicly managed land is located in Araba

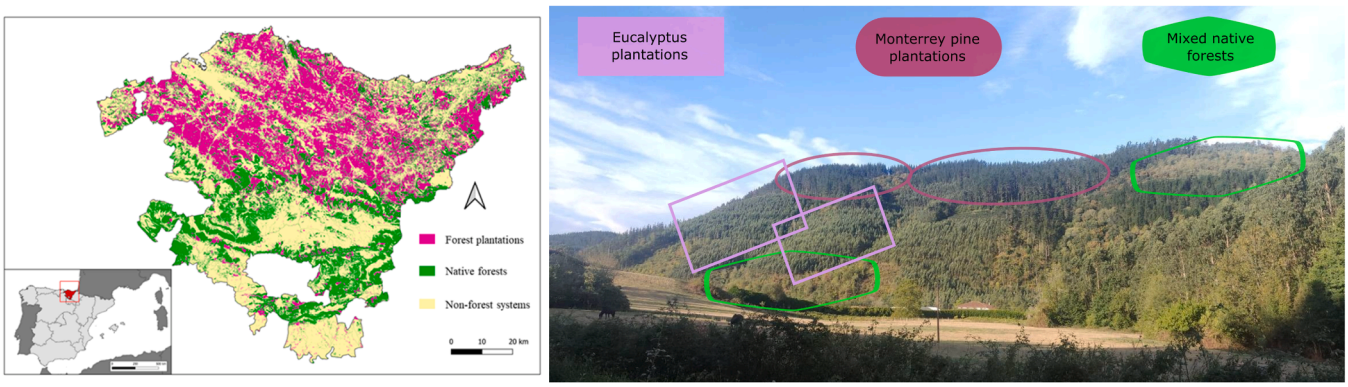

Fig. 1. Basque Country forest plantation distribution (left) and species composition (right). Map source: Unai Ortega. Photo credit: Céline Moreaux.

Province. Most of the Atlantic mixed forests in the Basque Country are in this public domain and are managed by local administrations, such as village councils, or collectively by traditional associations of local people. However, the current state of health of the forests in the Basque Country, particularly forest plantations, is critical because of the interplay of native forest fragmentation, intensive management practices on plantations, and climate change-related pressures. On the one hand, forest coniferous plantations have, in recent decades, increasingly suffered from diseases and pests such as the fungus *Mycrosphaerella Dearnessii* (brown spot needle blight, locally called *banda marrón*) and the pine processionary moth (*Thaumetopoea pityocampa*). These are particularly prevalent in monoculture coniferous tree plantations. These diseases have caused a significant loss of harvestable timber and revenues for landowners and private sector companies. On the other hand, the intensification of forest management practices (such as clear-cut harvests on steep slopes, subsoiling or ripping of forest soils for site preparations, and shorter rotations in eucalyptus and pine plantations) results in significant environmental damage, such as erosion, soil compaction and losses at accelerated rates, decreased biodiversity and the spread of introduced diseases to native forests (Gartzia-Bengoetxea et al., 2009). Given this, society has begun to worry about the damage to the environment that can be caused especially by exotic forest plantations. This has been reflected in the large number of initiatives that have arisen in the territory to recover exotic forest plantations into native forests.

2.2. Data collection

We conducted in-depth semistructured interviews with 33 actors in Araba, Bizkaia and Gipuzkoa, representing regional (n=2; RG) and local (n=2; LG) government forestry technicians, rangers (n=4; R), landowners (individual private, collective public and private owners) (n=10; PICP), consultancies related to forest plantation management (n=2; C), forestry-related private sector companies (n=4; PC), forestry (n=2; PPA) and business (n=2; BA) associations, public or private institutions supporting forest research and knowledge about plantation planning and management (n=1; A), and forest conservation organisations (n=4; FC). We followed a snowball sampling strategy to identify relevant actors, where interviewed actors were asked to suggest and provide contact details of other actors they considered relevant to be included in the research (Leventon et al., 2016). This approach is especially important in our case study, as access to some relevant actors in the forestry sector of the Basque Country is only possible if they are contacted via a person in whom they trust, owing to social tensions about the future of the forestry sector in the region. This is also particularly relevant, as they are interviewed about sensitive issues such as relations, conflicts and individual perspectives. The snowball started with actors with whom the authors of the research had a personal relationship, most of whom were individual private landowners. Our sample was balanced in relation to the number of actors that were interviewed in each of the areas that could have a say in the forestry sector in the Basque Country: governmental bodies shaping the forest management practices through setting the legal framework, rules and enforcement; public or private institutions and associations technically supporting the management, practices or manufacturing wood into commercial products; private companies, landowners and their associations who shape forest plantation management practices in their day-to-day practice; and actors that engage with approaches to forest management (such as “close to nature” approaches). We acknowledge that our sample cannot be representative for private landowners as they account for over 20,000 people in the Basque Country (Gobierno Vasco, 1994).

All interviewed actors participated on a voluntary basis. They were first informed that the aim of the study was to better understand the forestry sector in the Basque Country. Free, prior, and informed consent was secured orally or by signing a consent form in one of the two official languages (Spanish and Basque), which clarified the study aim, voluntary participation, confidentiality, and procedure for withdrawal from the study. The interviews were conducted between May 2022 and May 2023.

The in-depth semistructured interviews lasted approximately 1–2 h each (see details about the questions in Appendix A). The questions were open-ended and were used to gather information from actors in the forestry sector in the Basque Country and their individual role in it. Furthermore, we enquired details about the forestry management practices that actors performed and envisioned for the future, limits, barriers, needs and opportunities to achieve the preferred forestry management practices, as well as the knowledge that actors use and may need in forest plantation management (technical and traditional knowledge gaps). Finally, we asked in the interviews about relationships with other actors (with whom actors relate to which degree, in which form they relate and how the relationship is perceived) and their perceptions of the multiple benefits that the forestry sector provides to the Basque society. Interviews were conducted face-to-face in the forest plantation (n=7), government office (n=2) or informal settings (such as the community centre or bar of the nearest village) (n=7), whereas others were conducted online (n=11) or by phone (n=6), depending on what was most convenient and comfortable for the interviewed actor. The interviews were conducted in Spanish or Basque.

2.3. Data analyses

2.3.1. Who are the potential actors that can trigger a change towards sustainable forest management?

We developed a social network analysis (SNA) from detailed information about the relationships between actors gathered in the in-depth semistructured interviews. Social networks are an aggregation of mutual interactions made up of a relational structure of the actors and their respective interrelationships (Bodin and Crona, 2009). This structure

examines the roles and relationships of the actors and allows us to identify who could be a potential actor that could leverage a transformation toward sustainable forest management. Actors with a greater number of relations are the key actors that can trigger a change (Andriamihaja et al., 2021). SNA was performed via the igraph library (Csárdi et al., 2023) in RStudio (version 2022.12.0.353). The actors were grouped into predefined groups: regional governments (RG), local governments (LG), rangers (R), RStudio Team (2020) landowners (individual private, collective public and private owners) (PICP), forest plantation management consultancies (C), forestry-related private sector companies (PC), forestry associations (PPA), business associations (BA), public or private academic or research institutions supporting forest research and knowledge about plantation planning and management (A), and forest conservation organisations (FC). The types of relationships were coded as positive, negative or neutral, according to the responses of the interviewed actor. We produced a diagram illustrating relationships between actors for each type of relationship (positive, negative or neutral). In building the diagram, we considered the number of interactions of each actor (actors with more relationships are represented with larger circles) and the number of interactions occurring between actor pairs (the most related pair of actors are represented with a larger relationship arrow).

2.3.2. *What kind of knowledge do actors use and cogenerate to foster a transformation towards sustainable forest management?*

We developed an actor-linkage matrix of knowledge interchanged from the detailed information about knowledge interchange between actors obtained in the in-depth semistructured interviews. These matrices display actors in the rows and columns of a grid so that the knowledge interchanges (what knowledge they interchange) and interrelations between them (who interchange knowledge) can be described (Biggs and Matsaert, 1999; Reed et al., 2009). The actor-linkage matrix of interchanged knowledge has been graphically displayed in a Sankey diagram (SankeyMATIC; 2023 SankeyMATIC code is atgithub.com/nowthis/sankeymatic; produced by Bogart (2023); d3.js version 7.x, Canvg 3.0.9).

2.3.3. *Opportunities and barriers that actors face in pursuing sustainable forest management*

During in-depth semistructured interviews, the actors were given space to articulate their perceptions of the current state of the forestry sector in the Basque Country and their barriers, limitations, opportunities and needs. On the basis of this dialogue, actions that could enable or constrain the functioning of the sector were identified via open coding (Strauss and Corbin, 1998). For this purpose, the narratives from each interview were broken down into statements containing information on opportunities (enablers) or barriers (constraints) that actors observed about the sector. These statements were used to first identify categories of broad concepts, such as market and management, policies and personal motivations, which were then further subcategorised into more concrete actions (Bergman, 2010). The coding was adjusted throughout the process to increase homogeneity within each category and subcategory as well as heterogeneity across them (Ayala-Orozco et al., 2018). Finally, we recorded the frequency with which each barrier and opportunity was mentioned by the actors. The results from the coding were also used to identify actions that may act as both current barriers and potential opportunities, as well as actions that may cause conflicts in the functioning of the forestry sector in the Basque Country. Actors' narratives and hence the results obtained from the analysis can be strongly influenced by their political and sociocultural context (Zafra-Calvo et al., 2020). While the interviews were anonymised during the open coding to limit interpretation bias by the researchers (Neuman, 2014), cultural and political factors such as power dynamics, traditions, languages, etc., that shape the actors' realities were carefully taken into consideration.

3. Results

3.1. *Who are the potential actors that can trigger a change towards sustainable forest management?*

Our results concerning the key actors who may trigger a change in the forestry sector of the Basque Country show that a) landowners (individual and collective private, public and their associations), b) rangers and c) private sector companies, are those who may have the ability to bring about this change. The social network analysis clustered the actors into two general groups of more intensive interactions and relationships. On the one hand, landowners of any type and their associations, private companies and rangers have stronger bonds and frequent interactions. On the other hand, we also find a significant but smaller number of interactions between regional and local governments, business associations, forest conservation initiatives and actors supporting the generation of technical knowledge and innovation.

Most of the actors know each other and interact through working relationships (Fig. 2). The majority of the interactions and relations between actors are good or neutral, but sometimes there could be some tensions, especially among high-interacting actors. In this sense, we find that there are some tensions in the relationship of the government with consultancies and forest conservation initiatives when they may have different visions about an issue at stake. Rangers, landowners and private companies could also have differences regarding day-to-day management practices in forest plantations, commonly in trying to balance the tension between economic profit, enforcement of regulations and choice of management practices. The regional government is the main nexus between actors in both clusters with respect to tensions and interactions because of its role in elaborating policies and providing economic incentives and disincentives.

3.2. *What kind of knowledge do actors use and cogenerate to foster a transformation towards sustainable forest management?*

The results of the actors' linkage matrix reveal the main channels of knowledge interchange, as well as important gaps (Fig. 2). Most of the knowledge interchange and mutual learning occur in the day-to-day practices of forest plantation management. Landowners, rangers and private companies interchange knowledge about which species to plant and why, when and how to perform day-to-day management practices; expenses and revenues; the market and workforce; subsidies; and legal frameworks that shape forest management. In peer-to-peer and informal conversations with trusted individuals, visions, motivations and opinions about policies and political dynamics are also expressed. Individual landowners, as well as rangers and private companies, tend to rely on experiential knowledge or learning by doing, although some landowners consult the media and internet to look for more technical information about which species to plant and general trends in the forestry sector. Experiential and observational knowledge that comes from natural observation is also employed by forest conservation actors, who mostly interchange knowledge about these experiences with rangers. Importantly, there is a strong bond and experiential knowledge interchange among landowners and between peer members in the case of rangers or forest conservation actors.

A third of the actors highlighted that academic and innovative technical knowledge about forest plantation management and practices is very siloed in the region and that actors generating this kind of knowledge are neither able to provide usable and timely knowledge to the challenges that the sector faces in their daily management nor support a change in their strategic vision. Actors generating technical knowledge and innovation in the Basque Country (e.g., knowledge about how to tackle pests) interchange technical knowledge with the regional government and provide targeted information requested to private landowners' associations, for instance, about carbon markets. However, consultancies, collective landowners and private companies

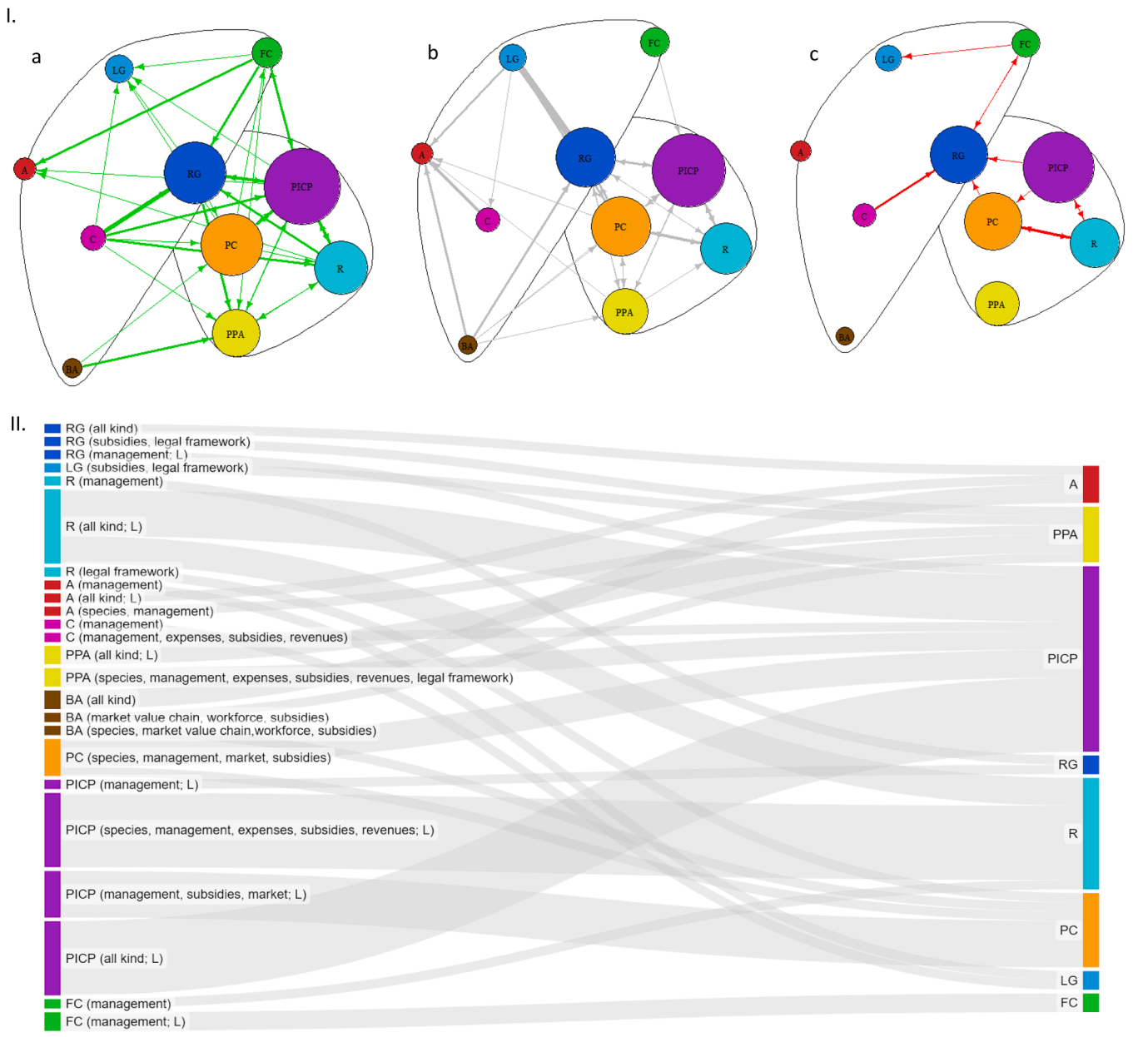

Fig. 2. Actor relations (I; a: good relations, green arrows; b: neutral relations, gray arrows; and c: bad relations, red arrows) and knowledge interchange streams (II) in the forestry sector of the Basque Country. Actors are abbreviated as regional (RG) and local (LG) governments; rangers (R); proprietors (individually private, collective public and private) (PICP); forest plantation management consultancies (C); forest-related private sector companies (PC); forestry (PPA) and business (BA) associations; public or private institutions supporting forest research and knowledge about plantation planning and management (A); and forest conservation organisations (FC). The social network analysis (I) clusters them according to the number of relationships between the actors. The size of each circle indicates the number of relations that the actors have, and the size of the arrows indicates the number of interactions between the two actors. The colours have been assigned randomly. The Sankey diagram (II) represents who to whom knowledge is interchanged between actors. Details about the kind of knowledge interchanged with other (s) are in brackets. "L" indicates that both actors mutually expressed knowledge exchange and learning from each other. The width of the arrow means that there were more actors that pertained to this category who mentioned that they interchanged knowledge.

rely on academic and technical knowledge, although due to the lack of internal knowledge exchange, this knowledge is provided by academic or technical actors outside the Basque Country (e.g., by interchanges with other regions that are more advanced in forest plantation management, individual training or working experiences in other regions). Actors also highlighted the lack of technical innovation and the difficulty in accessing the data and knowledge held by academics and technical support bodies in this regard. Importantly, most of the technical staff of the government are not dedicated to updating or sharing technical knowledge but rather to processing administrative queries such as subsidies or fines.

In addition, experiential, technical or academic knowledge does not necessarily reach the forums where policy decisions are taken in an effective manner. Although the government is in charge of updating policies, several nongovernmental actors revealed their perception that regional and local governments are not fully open to listen to and learn from the experiences of other actors.

3. 3. Opportunities and barriers that actors face to pursue sustainable forest management

We identify three dimensions of barriers and opportunities expressed

by the interviewed actors in the forestry sector in the Basque Country: a practical dimension related to the market and management, a policy dimension and a dimension related to actors' personal motivations. Several themes within these dimensions are named by different actors both as a form of ongoing barrier to the functioning of the sector as well as a potential opportunity for improvement of the current situation (Fig. 3): a) timber quality and market demands, b) environmental impacts, c) small-scale management, d) sustainable management policies, e) identity/connection, visions and f) management intensity.

The market and management dimension outlines the regional and international economic circumstances, illustrated by a wide diversity of economic barriers and opportunities. First, we identified poor timber quality in native and nonnative forest plantation species as an important barrier. On the one hand, seven actors (n=7) named the currently poor timber quality of nonnative plantation species (BA, C, FC, PICP) as a barrier, together with high external labor costs (PPA) and a lack of professional workforce (BA, PC). On the other hand, six other actors (n=6) considered the low timber quality of native species (PC, R) as a barrier as well, in addition to the current lack of a consolidated market for these native species (A, FC, PPA, RG). The strongest opportunities we identify to counter both of these barriers were proposed as a set of initiatives by a total of 15 actors (timber quality and market demands) (n=15): improving timber quality (C, FC, PICP); meeting the demand for certified timber and km0 timber (BA, PC, RG); taking advantage of rising timber prices (BA, PPA); providing innovative start-ups (C); establishing infrastructure for more effective plantation management and access to markets (PPA, RG); and finally creating a market for carbon credits for forest plantations, biomass and payments for contributions to the societies of native and nonnative species (BA, FC, LG, PC, PICP, PPA, RG). The latter is a proposed bioeconomic concept that has gained considerable traction in the Basque Country in recent years.

Furthermore, approximately one-third of the actors (n=10) were worried about environmental impacts. They named the impoverishment of soils, lack of water and the loss of native species (PICP, R, RG), as well as lower plantation health and productivity due to climate change (e.g., droughts) and pests as other key barriers for the functioning of the sector (PICP, PC). In response, four actors (n=4) suggested the promotion of native species plantations (C, FC, PC) and penalties for environmental damage caused by intensive timber plantations (FC).

Small-scale management is another theme that we identify as a barrier and opportunity for the sector. It is named by six actors (n=6), as the intensive management of plantations at small plot sites is challenging for more profit, jointly with the loss of traditional management (PICP, PC, R). The establishment of collaborations is highlighted as an opportunity to overcome these barriers (n=2) (BA, PICP). Next, seven actors (n=7) stated that both the lack of adaptation to new management models and uncertainties and the lack of capacity to coordinate and dialogue make the forestry sector rigid and inhibit necessary changes (C, FC, PICP, R, RG). We cannot identify a perceived opportunity to match this concern. Finally, a general opportunity for the sector was seen by two actors (n=2) in using forest plantations as a form of investment for current owners who live in cities and may delegate forest management to private companies (A, PICP). However, some small private landowners are concerned that such exploitation practices may degrade the land and produce unsustainable forest plantation management.

The policy dimension refers to the policies and governance frameworks in which the sector is embedded and which influence the capacity for lobbying, leveraging power dynamics and determining developments within the sector. Given the frequency of actions, barriers clearly outweighed opportunities in terms of importance given by the actors. First and foremost, seven actors (n=7) suggested that the current public policies do not support the Basque forestry sector as a productive economic sector but rather are designed to serve urban citizens' demands of recreation in forested places (A, BA, PC, PICP, PPA). This conflicts with the perception of four other actors (n=4) that public policies do not foster the use of native species and seed banks to bring back more native forest plantations and landscapes that will require more investments and long-term planning opportunities (C, FC, PC,

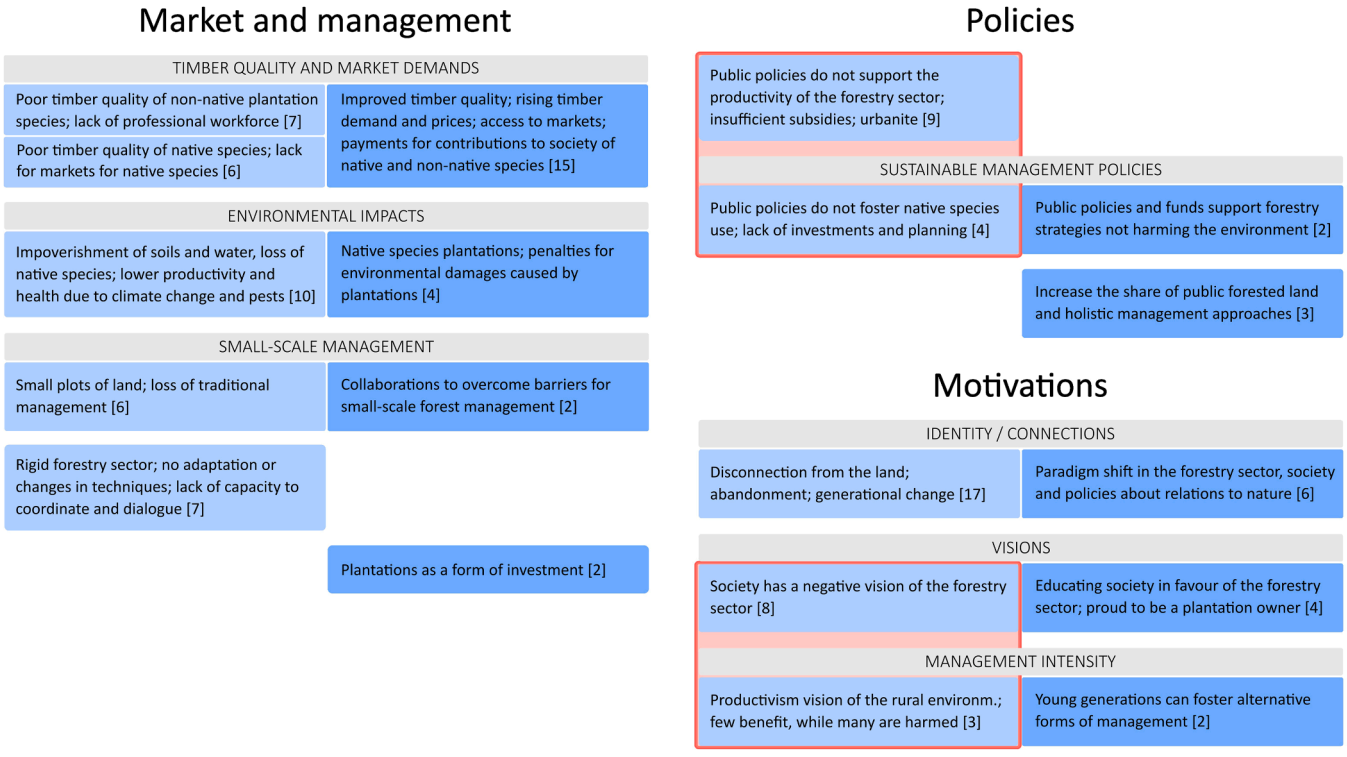

Fig. 3. Opportunities (in dark blue) and barriers (in light blue) of the forestry sector in the Basque Country. Several actions within these categories were named both as a form of ongoing barrier and as a potential opportunity to improve the current situation (light gray boxes). Fundamental differences in the vision of how to achieve sustainability also arose within two of the dimensions (red boxes; paired).

PICP). An opportunity to overcome this second barrier was mentioned in the form of support for public funding schemes for forest management that do not harm the environment, such as "close to nature" forestry (C, FC) (n=2). These two actions constitute the theme of sustainable management policies. Another policy-related suggestion made by three actors (n=3), who also address the barrier of small-scale management, was to increase the share of public forested land and holistic management approaches (FC, PICP, R).

Finally, the dimension of personal motivations summarises the visions and interests of the actors to engage (with each other) in the sector and to implement actions. The main barrier, which was mentioned by half of all respondents (n=17), was a deep disconnection from the land and high rates of rural abandonment in general and of forestry particularly, in the Basque Country (BA, C, FC, LG, PC, PICP, PPA, R, RG). Actors mentioned that this is partially rooted in forest plantations not being part of the identity of the Basque people but rather being an economic source of revenues. They also see generational change as a reason for this disconnection, where sons of formerly rural citizens who moved to cities change their vision of forestry along with their lifestyle. In contrast, six actors (n=6) called for a paradigm shift in the forestry sector, policies and society concerning our relationships with nature, forests and land towards more sustainable management (BA, FC, PC, R), which we identify as an opportunity to counter this barrier and concern (identity/connections).

The open coding analysis revealed two further barriers within this last dimension, which were in direct conflict with each other, as they reflected two contradictory perceptions of a shared reality. Some actors (n=8) expressed that a negative vision by society in the Basque forestry sector is an important obstacle to its further development (A, PC, PICP, PPA, RG). In contrast, three actors (n=3) perceived that the forestry sector embodied an excessive productivism vision of the rural environment, which benefits few, who enrich themselves with the exploitation of the land and nature and leaves many deprived of nonmaterial contributions such as soil and biodiversity, water purification, physical and mental health, inspiration, etc. (FC). For each of the two barriers, a matching opportunity is identified. For the former concerning visions, actors (n=4) proposed educating society and creating awareness in favour of the forestry sector (BA, PC) and fostering an inner motivation to feel proud of being a forest or plantation owner (PPA). For the latter, in relation to the theme of management intensity, actors (n=2) expressed hope in the young generations, who could search for and foster alternative forms of management, species planted, etc., to resolve the environmental and economic challenges of the sector (PC, PICP).

4. Discussion

4.1. Who are the potential actors that can trigger a change towards sustainable forest management?

Our results show that a change in forest management can be triggered by balancing a) the decisions of landowners about, e.g., the species planted and the rotation length; b) the responsibility of rangers in advising and enforcing what should/can be done according to rules and policies; and c) private sector companies' commitment to the day-to-day management of forest plantations. These key actors have also been identified as essential figures in forest management decisions in other Global North countries, such as the United States of America (Ruseva et al., 2014). In addition, our results further highlight the important role of governments at all levels, consultancies, bodies of scientific and technical knowledge generation, and forest conservation and business associations to support changes towards sustainable forest management in the Basque Country. Governments can contribute by developing policies and rules; consultancies and bodies of scientific and technical knowledge generation by providing the knowledge and innovation needed; and associations of forest conservation and businesses by supporting new paradigms and patterns of forest management.

4.2. What kind of knowledge do actors use and cogenerate to foster a transformation towards sustainable forest management?

Our study highlights the gap that currently exists for usable scientific and technical knowledge to reach key actors within the forestry sector in the Basque Country. Scientific knowledge may signal to new native species to plant and "close to nature" management support approaches, and technical innovation may help to overcome machinery and business challenges. The knowledge-to-action gap and lack of relations between academia and landowners might be based on a lack of channels or willingness to communicate and trust (Morford et al., 2003). Literature also suggests that information seeking and learning are main reasons for landowners talking to other actors (Ruseva et al., 2014) and a frequent limitation to transition towards sustainability, in other European countries (Sousa-Silva et al., 2018; Hernández Morcillo et al., 2022). Improving cocreated knowledge and exchange of experiences might therefore be a critical bridge to jointly identify and improve locally adapted strategies to address sustainable forest management. Relationships, when based on trust and honest knowledge exchange, could facilitate the transition towards sustainability while addressing conflicting views and interests (Blicharska et al., 2020).

4.3. Opportunities and barriers that actors face to pursue sustainable forest management

The challenge of achieving sustainable forest plantation management is significant, as it is also shown in the results of the analysis of barriers and opportunities. In addition, landowners, rangers, companies and even the same individual in different contextual situations and times may hold different visions about how to attain the change towards "close to nature" management and a "circular bioeconomy" business approach.

Our results show that landowners, especially their associations, are primarily concerned with the abandonment of land and associated forestry practices; lower plantation health and productivity due to climate change and pests; and the choice of tree species to plant to ensure high production, good timber quality and economic benefits. Moreover, landowners recognise that soils, water quality and landscapes may suffer from intensive management practices, such as nonnative monoculture plantations under short rotations combined with clear cuttings and the use of heavy machinery. Small plot sizes, an issue also reported by private forest owners in other parts of Europe (Tiebel et al., 2022), are among the challenges presented here (see also Martinez de Arano and Lesgourgues, 2014). Considering the perspectives brought up by these actors, the ongoing challenging situation could be a unique opportunity to strengthen sustainable forest management, as highlighted in studies in other European countries (Sousa-Silva et al., 2016; Roitsch et al., 2023).

Rangers are essential actors in land management in general and sustainable forestry in particular, as they address the challenge of how to implement and enforce policies and rules in day-to-day management (Maier and Winkel, 2017). Our in-depth interviews show that rangers often share concerns with other actors, which indicates close relationships, interactions and knowledge exchanges between them and these actors. These concerns include, for instance, the impoverishment of soils and lack of water availability—shared with private landowners—as well as the current lack of monetary profitability of native species and the difficulty in managing small plots of land—shared with landowners and private companies. Rangers are also represented in the diverse group of actors reporting the most frequently named barriers and opportunities outlined in the results. These are the rigidity of the forestry sector, the lack of knowledge exchange and the disconnection of landowners from the land on the one hand (barriers), and the need for a paradigm shift in our relationship to nature and forest plantations on the other hand (opportunity). In addition, rangers can play a pivotal role in bridging and brokering knowledge between decision makers, such as the policy and technical staff of local and regional governments, and experiential

or technical knowledge holders, such as landowners and private companies (Sagor and Becker, 2014; Lawrence et al., 2020).

According to our results, the strongest focus of private companies with respect to barriers and opportunities lies in the primary importance of the market dimension for them. From a professional perspective, they share concerns about timber prices, species profitability, and the creation of revenues in highly spared and small forestry plantations. The need to and concerns about restructuring business models and developing new commercial products and contributions to society has also been highlighted by private companies in other European countries, such as Finland, especially in relation to how to adapt their companies to "circular bioeconomy" and sustainability (Näyhä, 2019). Simultaneously, as individuals, they recognise the value of native forests, e.g., for recreation or mushroom gathering. They highlight the societal need for timber products (infrastructures, biomass) and urge policies and society to support the economic use of the forest. As it has been found in other places such as Canada, actors are able to pressure a company indirectly via other actors on whose resources the company is dependent (Henriques and Sharma, 2005), then ensuring public and political support is not trivial in company operations. As in other European countries (Freer-Smith et al., 2019), private companies and landowners share concerns in relation to barriers to the sector, which are primarily founded on their perceived lack of profitability and markets for native species, small forest properties, and low productivity and increasing health problems due to climate change.

4.4. Pathways towards sustainable forest management in the Basque Country

Hence, considering the mentioned concerns of the key actors that need to be addressed and that social-ecological systems in Europe are undergoing major transitions promoted by the EU Green Deal, it could represent an opportunity for change towards sustainable forest management in the Basque Country. Therefore, the following question arises: What could be a potential opportunity or pathway to sustainable forest management in the Basque Country? We suggest a potential path that can sum up several pieces of what actors mentioned: promotion of native species producing good timber quality that can be used by innovative start-ups businesses and can open the door to alternative carbon markets while protecting biodiversity. An available and targeted well-trained workforce in the machinery used and business innovations are essential, as has also been noted in other places (McEwan et al., 2020). Finally, political commitment is critically needed to support long-term incentives for landowners to transition from nonnative to native species in forest plantations while maintaining high-quality timber production and opening new markets and opportunities for small start-up companies.

Some initiatives that are compatible with and aligned with sustainable forest management, as described in the EU Green Deal, are already in place in the Basque Country, such as common pool native oak forests traditionally managed for household firewood, mushrooms or hunting by landowners or nature-centred social enterprises or consultancies. Although not exempt from challenges (Górriz-Mifsud et al., 2018), other initiatives are forest plantations that are managed by collaborative or cooperative social enterprises and consultancies who aspire to nature-centred management. These initiatives are currently not necessarily key actors, as per our results, but their role is essential in triggering a change towards sustainable forest management, as it has been in other places in Europe (Keeton et al., 2013).

We think that a renovated vision of forest plantations based on "close to nature" management can be a sustainable source of income and an important opportunity to make Basque society proud and engage in the sector with new landowners, as it has also been successfully suggested in other European regions (Niskanen et al. 2007). New forms of governance through organisations and associations of landowners could also arise, especially emerging from landowners with a more social and environmental view of how healthy and sustainably managed forests can contribute to society in general while providing welfare to rural areas (Feliciano et al., 2017; Weiss et al. 2019). In this sense, new visions and mainstream knowledge about practices that suit "close to nature" approaches, such as those focused on conserving naturally regenerated shrubs and soils or promoting native species to be planted, are needed if we want to trigger a transformation toward sustainable forest management (Vadell et al., 2022). It may be led by trusted collective or cooperative groups of landowners or individuals, private companies or supporting consultancies, but all will need to contribute (Huff et al., 2015). In addition, new start-up companies that are emerging in the context of a "circular bioeconomy" and increase demand for sustainable products resulting from current societal change will also be important in reconnecting the rural economy and urban society and promoting change (D'Amato et al., 2020).

This may be an initial step in enlarging a "circular bioeconomy" in the region, as new start-up and innovative companies' creation is one of the ten important factors that can potentially drive the development of a forest-based bioeconomy in the Basque Country (Barañano et al., 2022). However, it is essential that the bioeconomy deprioritises economic growth when there is a risk of exceeding the limits of sustainable resource extraction and causing lasting environmental degradation (Birner, 2018) and turns to more comprehensive considerations of social-ecological contexts and the integration of local actors and alternative practices such as "close to nature" in the management of forest plantations to contribute to a transition towards sustainability in European countries (Friedrich et al., 2023). Specifically, in the case of Basque Country, concerns have been focused on the accelerating use of fast-growing, nonnative tree species such as Eucalyptus and Monterey pines for the production of short-lived products such as paper, packaging material and pallets and the documented environmental damage associated with these monocultures (Elosegi et al., 2020; Gartzia-Bengoetxea et al., 2021). Therefore, it must be carefully considered whether this opportunity can be pursued to assist the forestry sector in a truly sustainable transition. Concerning potential markets, attention needs to be devoted to the expansion of carbon farming practices (forest plantation management practices that "aim to enhance the carbon sequestration potential of forests and soils as well as avoiding or reducing greenhouse gas emissions"), to ensure that rewarded management practices are directed to for instance diversify forest plantation structure and composition, extend rotation periods, reducing harvesting intensity, or improve agroforestry management, as it has been recently recommended by the European Forest Institute according to EU policies (Chiti et al., 2024).

Overall, policy enablers are also necessary to support or trigger change (Sotirov et al., 2017; Brouwer et al., 2018). Three broad types of political response for future pathways to sustainable forest management in the Basque Country can be considered: to reject change and resist, to accommodate sustainable forest management and propose reforms, or to adopt and demand revolutionary or radical change for more sustainable forest management (Rantala and Primmer, 2003). Which one of these three options the government of the Basque Country may support will actually foster or hamper the transition towards sustainable forest management in the region. As a bridging actor, other actors relate to them frequently, either the private sector companies and their businesses associations, landowners' associations, researchers and consultancies or forest conservation initiatives. A closer exchange and dialogue directly with society to mutually understand values and necessities could open the path to remunerate certain contributions provided by landowners and forest plantation managers such as educational projects, water conservation projects, food forests or agroforestry (Palacios-Agundez et al., 2013; Lazdinis et al., 2019).

5. Conclusion

Knowing who may attain a transition towards more sustainable

forest management is a critical question that may be solved by performing social relations, knowledge gaps and narrative analyses of barriers and opportunities in a given territory collectively with all relevant actors. First, in our case in the Basque Country, our research identified as key actors, private companies, rangers and landowners. Further research is needed to identify who may lead a change towards sustainable forest management in other European regions to conform a diverse and plural network map of actors that can lead the transition towards sustainable forestry in Europe. The snowballing approach may also miss some important information and evidence that subsequent studies in the Basque Country may clarify. Second, as networks and knowledge are dynamic and relational, there is a need to also look into them over time to reach, in a coproduced process, any transition towards sustainable forest management. Third, poor timber quality, lack of clear policies and an increasing disconnection from the forest plantation and land by the landowners and following generations represent barriers to the identified key actors – private companies, rangers and landowners. Planting native species of high-quality timber, access to alternative markets and funding (such as the one provided for the contributions that forest plantations may bring to the quality of life of people), more support for "close to nature" management and innovative start-up companies, a well-trained workforce able to nurture a truly "circular bioeconomy", increasing collaboration to join efforts, and actions to promote a stronger feeling of pride and attachment to forest plantations and their sustainable management are suggested as potential pathways towards more sustainable forest management. These initial suggested pathways can also be completed and assessed in the future to ensure that sustainable forest and plantations management is achieved in Europe.

Positionality statement

The concept of sustainability can be contested, as what needs to be sustained, why and for whom can be individually and collectively context-specific. We would like to state our position here as well because who is performing the research and how an issue at stake is conceptualised depends on who is defining the problem and their visions about possible solutions. We are two European men and two European women, two of them originally from the Basque Country. One of us has a close family member who owns a forest plantation and one of us has a background in nature conservation. Two of us work in social-ecological systems and sustainability science approaches while the other two are closer to forestry sciences. All this shaped the snowballing process to identify actors and how they have been characterised, how the in-depth semi-structured interviews were conceived and developed, how co-authors related with actors as well, and how sustainability and the qualitative analysis were conceived. The research was approved following ethical review at the Basque Center for Climate Change (BC3).

Declaration of generative AI and AI-assisted technologies in the writing process

During the preparation of this work the authors used Curie in order to proofread the English. After using this tool/service, the authors reviewed and edited the content as needed and take full responsibility for the content of the publication.

CRediT authorship contribution statement

Noelia Zafra-Calvo: Writing – review & editing, Writing – original draft, Formal analysis, Data curation, Conceptualization. **Unai Ortega:** Writing – review & editing, Writing – original draft, Formal analysis, Data curation. **Unai Sertutxa:** Writing – review & editing, Writing – original draft, Formal analysis, Data curation. **Céline Moreaux:** Writing – review & editing, Writing – original draft, Formal analysis, Data curation.

Declaration of competing interest

Authors declare no competing interests.

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Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.tfp.2024.100727.

Data availability

Due to the sensitive nature of the questions asked in this study, in-depth semi-structured interviews respondents were assured, according to the Free, Prior and Informed Consent signed, that raw data would remain anonymous and confidential and would not be shared.

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