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The Forest Sector in EU Member States' National Recovery and Resilience Plans: a preliminary analysis

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ABSTRACT

The role of forests in reaching the environmental policies targets of the European Union (EU) is being increasingly recognised. Consequently, investing in the forest sector takes on a fundamental role. Different funding opportunities are already in place in the EU, but there are some limitations in accessing them. New funding opportunities arose more recently. To support the recovery process of Member States (MS) after the Covid-19 pandemic, the EU is making significant efforts through NextGenerationEU, funding MS after the European Commission (EC) approval of the National Recovery and Resilience Plans (NRRPs). No specific guidelines are present to finance the forest sector. The aim of this paper is to investigate how the forest sector has been taken into account in the NRRPs through an analysis of the contents of 26 NRRPs. Financial investments in the sector by action types have also been analysed. Finally, commonalities and differences between MS have been extracted by means of a cluster analysis.

Results show that the majority of MS dedicate a portion of their funds to the forest sector and there were no investments in the sector in only four countries. One-third of MS have foreseen a dedicated portion of the funds to the sector. The forest-related themes most represented in the NRRPs are: biodiversity protection, climate adaptation, forest-based ecosystem services management, climate mitigation, rural development and innovation. The cluster analysis identifies three MS clusters, giving evidence about the MS behaviour in a non-ordinary funding situation. The first one is characterised by more traditional countries, while in the other two clusters innovation plays an important role. The second cluster orients innovation towards wood-related products, while innovation in the third cluster is addressed to support forest multifunctionality.

Results can support national and European decision-makers to plan national strategies, funds allocation, or to act at European level knowing which are the priorities given by the different MS.

1. Introduction

Forests represent around one-third of Europe's total land and have expanded by 9% in the last 30 years (FOREST EUROPE, 2020; Korhonen and Stahl, 2020).Their relevance at European level is being increasingly recognised. Indeed, forests provide several goods and services, known as ecosystem services (ES), needed for the welfare of the whole society (García-Nieto et al., 2013; Orsi et al., 2020). Global changes on the one hand are making forests less resilient, negatively affecting ES provision (Mina et al., 2017; Chirici et al., 2019; Ferrara et al., 2019; Forzieri et al., 2021) and, on the other hand, they create a need for investments to adapt forests to ensure the provision of ES and meet the climatic mitigation targets. Under the umbrella of the European New Green Deal of the European Union (EU), presented in 2019, different policies have been developed with the common aim to "*protect, conserve and enhance the EU's natural capital, and protect the health and well-being of citizens from environment-related risks and impacts*" (EC, 2019). Forests are considered important resources within the European Climate Law (EC, 2021a) – which set specific carbon removal targets for the Land Use, Land-use Change and Forestry (LULUCF) sector in April 2023[1] – and the European Climate Pact,[2] due to their role in carbon removal. This role has been reaffirmed in the Sustainable Carbon Cycles Communication (EC, 2021b), where the potential of forests has been expanded by illustrating their ability to provide co-benefits in carbon-removal

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[1] https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32023R0839.

[2] https://climate-pact.europa.eu/index_en.

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projects. In the Circular Economy Action Plan (EC, 2020a), forests are mentioned as strategic to support the bio-based sector, improving wood usage in constructions, and to achieve carbon neutrality.

In recent years, other European policies, directives, and regulations have been established in line with the objectives of the European New Green Deal. Similarly, the relevance of forests is evident in these policies. Forest protection, for instance, is at the basis of the EU Biodiversity Strategy for 2030 (EC, 2020b). Furthermore, under the Farm to Fork Strategy (EC, 2020c) forests are considered important mainly in relation to agroforestry practices. Furthermore, within this strategy, the implementation of sustainable near-natural forest management, along with some agricultural practices, is encouraged to improve the prevention of negative agricultural impacts and to limit forest deforestation. More recently, the role of forests in ensuring sustainable energy production, favouring the bioenergy transition, has been clearly defined within the REPowerEU plans (EC, 2022a). Finally, forests are the centre of the new EU Forest Strategy for 2030 (EC, 2021c), where different facets of the forest sector have been considered relevant: from the support of socio-economic functions, which are of predominant importance in rural areas; to the boosting of a forest-based bioeconomy; to the restoration, expansion and protection of forests to face climate change, improving forest resilience, multifunctionality and enhancing biodiversity. Finally, in summer 2023 the European Parliament adopted the Nature Restoration Law[3] aimed at restoring degraded European ecosystems to improve carbon storage and other ES provision, to decrease the impact of natural disasters by improving ecosystems resilience, and to support the achievement of the EU's climate objectives. Within this law, forests are among the ecosystems that urgently need to be restored.

Considering the role of the forest sector within all the mentioned recent EU policies, the importance of investing in forestry results evident. Despite this, public funding is scarce (EIB, 2022) and in some countries bureaucratic issues have been seen as the greatest barrier to the use of the European Fund for Rural Development in the forest sector (EC, 2018). In the second pillar of the new rural development policy, in many MS the main source of financing for the forest sector, the 2020 agreement on multiannual financial framework foresees a 19% decrease in budget allocation. Broader funding programmes, such as LIFE,[4] Interreg,[5] Horizon Europe[6] and PRIMA,[7] can contribute to channelling resources to the forest sector, although projects should be aligned with the objectives of those programmes and participants should respect eligibility conditions, while transversal capacities, scientific knowledge and networks are also requested to participate.

In 2020, a funding opportunity arose after the Covid-19 pandemic. The pandemic forced all countries to innovate and develop urgent approaches to cope with that situation (Azoulay and Jones, 2020; Kapoor et al., 2021; Patrucco et al., 2021). The EU made significant efforts to support, also financially, economies to face pandemic-related challenges. With the establishment of the NextGenerationEU programme, the EU aimed to support the recovery of Member States (MS) from the negative economic and social impacts caused by the health emergency. It did so by establishing the Recovery and Resilience Facility (RRF), with the intention of providing a clear direction in which this recovery must tend, transforming the EU into a greener, healthier and more digital economy and society. The relevance of the facility's measures is considerable. Indeed, it is the first time after the "European Recovery Program" of 1948, known as the Marshall Plan, that some European countries, in these cases the EU MS, receive economic and financial support to recover from a disruptive event. The RRF aims to support, through the National Recovery and Resilience Plans (NRRPs), both the digital and green transitions, helping Europe to reach its targets for climate neutrality in 2050. The NextGenerationEU programme complements the European New Green Deal through its desire to stimulate an ecological transition of the MS.

In light of the mentioned role of the forest sector for the development of bioeconomy, green jobs, with the provision of ES, it could be expected that the sector would have a significant place in the NRRPs. NRRPs can represent additional sources of funding in addition to the ones already in place at national level (FOREST EUROPE, 2020; Haeler et al., 2023).

Scientific research exploring the role of NRRP funds on environmental issues is not yet represented in the literature. Some papers describe the NRRP of single MS in detail (e.g., Filippini and Vinceti, 2021; Fabbrini, 2022; Ottone and Barbieri, 2022; Prontera and Lizzi, 2023) and a paper compares the behaviour of two different MS (Kotseva-Tikov and Dvorak, 2022). The relation between SDGs and NRRPs has also been investigated (Perchinunno et al., 2023; Passaro et al., 2023). Concerning NRRPs, there are no papers that analyse the forest sector. Being aware of the relevance of forests in current European challenges, this research contribution aims to provide an initial understanding of the role of the forest sector within the NRRPs. To reach this main objective, the research questions addressed in this paper are the following: (i) Are NRRPs currently integrating the forest sector? (ii) What key forest-related themes emerge from the NRRPs and could these themes describe commonalities and differences among MS? (iii) What is the ratio of RRF resources that each MS has reserved for the forest sector?

To try to answer these questions, the NRRPs of the MS have been analysed. Section 2 describes the structure and function of the NRRPs. The methodology used in the paper is described in Section 3. Section 4 presents the main findings, and Section 5 discusses them. Finally, a brief conclusion is depicted in Section 6.

2. Structure and functioning of National Recovery and Resilience Plans

Financing for implementation of the NRRPs are provided by the RRF. The purpose of the Facility is "*to mitigate the economic and social impact of the corona virus pandemic and make European economies and societies more sustainable, resilient and better prepared for the challenges and opportunities of the green and digital transitions*".[8] The RRF sets out six relevant European policy areas structured in six pillars. It "*makes €723 billion (at prices of 2022) in loans and grants available to support reforms and investments undertaken by Member States*"[9] to contribute to the relevant policy areas. The six pillars of the RRF are: green transition; digital transformation; smart, sustainable and inclusive growth; social and territorial cohesion; health, and economic, social and institutional resilience; and policies for the next generation.

The possible allocation of funds to MS varies depending on different factors related both to pre-pandemic economic data (e.g., population in 2019, average employment rate in 2015–2019) and considering the effects of Covid-19 on them (e.g., GDP loss in the 2020–2021 period) favouring both vulnerable countries and those that were more affected by the Covid-19 pandemic (Pfeiffer et al., 2021). RRF funds are made available to MS through grants (non-repayable financial contributions) and loans. To request them, MS must justify the request in relation to the reforms planned and presented within their NRRPs. Additionally, for loan requests, they must highlight higher financial needs required to perform additional reforms and investments (EC, 2021d).

The RRF funds started in 2020 and last until 2026. MS can benefit from the RRF funds by submitting their NRRPs to the European

[3] https://environment.ec.europa.eu/topics/nature-and-biodiversity/nature-restoration-law_en.

[4] https://cinea.ec.europa.eu/programmes/life_en.

[5] https://www.interregeurope.eu/.

[6] https://research-and-innovation.ec.europa.eu/funding/funding-opportunities/funding-programmes-and-open-calls/horizon-europe_en.

[7] https://prima-med.org/.

[8] https://ec.europa.eu/info/business-economy-euro/recovery-coronavirus/recovery-and-resilience-facility_en.

[9] Ibid.

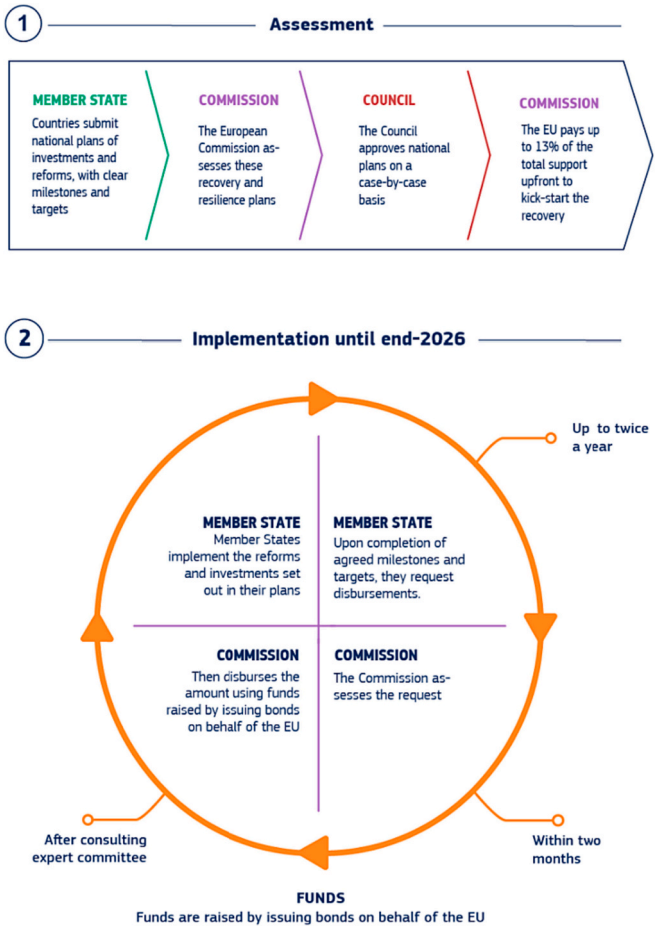

Fig. 1. Process of NRRPs approval and funds disbursement. From: https://ec.europa.eu

Commission (EC). The plan has to contain the reform and investment programme that the MS will implement to support a green transition and make their economy and society more resilient. The plans must be implemented by the end of 2026. After the EC approves the NRRP, MS see a first funds injection, up to 13% of the total, and the remainder is provided after the achievement of the declared milestones and targets. To monitor the implementation of NRRPs, the EC supervises the verification of the achievement of the milestones and targets declared by the MS. The process of approval of NRRPs and funds disbursement is illustrated in Fig. 1.

The planned investments and reforms of the NRRPs must consider the country-specific recommendations, presented by the Council to each MS to address their challenges, and address the seven flagship investment areas identified by the Commission.[10]

The structure of the NRRP is the following (EC, 2021e): an initial part describes the general objective of the plan, the main challenges faced by the country, and how by addressing these challenges through the NRRP it contributes to the six pillars of the NextGenerationEU. The main part of the NRRP is represented by the description of planned reforms and investments, also considering the country-specific recommendation of the EC. Reforms and investments are grouped into different components. Each component is focused on a specific need or challenge. Within each component, milestones and targets are jointly proposed with a timeline. The achievement of milestones and targets is a condition for payment to MS. Finally, for each component, MS should provide an estimation of its total costs, justifying them. The last section of the NRRP is characterised by the description of its impacts considering the plans as a whole.

3. Material and methods

This research is based on the analysis of case studies from selected and comparable EU countries. The countries have been selected based on the submission of the NRRP to the EC. Not all the countries submitted their NRRP at the same time. The research of NRRPs was conducted from May 2021 to September 2021 using the dedicated EC website.[11] During the mentioned period, the NRRPs (hereinafter "plans") have been continuously uploaded to the EC website, making them available for public consultation.

After collection of the plans, the documents were analysed, both deductively and inductively, using the content analysis method (Mayring, 2004). Because almost all of the plans were presented to the EC in the national languages, a first issue arose. The authors have knowledge of 5 EU languages (English, Italian, French, Spanish and Portuguese). To validate the content analysis method, the analysis started from the plans that were written in these languages (i.e., Irish, Danish, Cypriot, Maltese, French, Luxembourgish, Belgian, Italian, Spanish and Portuguese).

Plans have been screened using keywords to check if they mention forestry and forest-related themes. Keywords have been translated using the Google neural machine translation system, a framework that uses an artificial neural network to improve the translation results of the Google multilingual translation services: Google Translate. Scientific studies demonstrate that Google Translate's accuracy in translating European languages is good (Aiken and Balan, 2011) and its accuracy improved about 34% from 2011 to 2019 (Aiken, 2019). Keywords selected were: "*forest**", "*silviculture**", "*wood**", "*biomass*", "*tree**", and "*ecosystem service**". Although the authors are aware that the selected keywords do not reflect all aspects of forestry and forest-related themes, they were sufficient to identify whether the plans addressed forestry and forest-related themes and to identify the relevant parts of the plans for in-depth content analysis.

To deal with language barriers, only the relevant text of the plans has been translated. With relevant text, we indicate the chapters of the plans where at least one keyword was found. For translation, the same software used to translate the keywords has been used. The software ensures the translation of large portions of texts from all different languages into English. After the relevant texts of the documents have been translated, two different analyses have been implemented.

Firstly, a qualitative analysis was performed. Relevant texts have been analysed to understand whether the forest sector was explicitly, implicitly, or not mentioned in the plans. With explicit mention is intended when at least one forest-related theme has a dedicated chapter, subchapter, or investment section within the plans. Differently, forest sector has been considered as implicitly mentioned in the plans when it is embedded as part of sections, chapters, or subchapters focussing on other sectors. Both explicit and implicit mentions can be present in the same plan. No mention means that forest-related themes are not present in the text, either explicitly or implicitly. The relevant texts have then been analysed inductively with the aim of identifying the forest-related themes present within the plans. In line with the methodology for Inductive Category Formation proposed in Mayring (2004), the relevant texts were carefully read line by line, and a forest-related theme associated to each section of the texts. Forest-related themes were formulated using few words and being able to summarise the forest-related themes described in the text. Different sections of the text that are characterised by a close topic, were categorised under the same forest-related theme. If the forest topic presented in the text analysed did not fall under the themes already constructed, a new theme was formulated.

[10] https://ec.europa.eu/commission/presscorner/detail/en/IP_20_1658.

[11] https://ec.europa.eu/info/business-economy-euro/recovery-coronavirus/recovery-and-resilience-facility_en.

Table 1
Presence of explicit, only implicit, or no mention of the forest sector within the EU NRRPs.

Type of mention	Definition	Countries
Explicit	At least one forest-related theme has a dedicated chapter, subchapter, or investment section within the plans	Belgium, Cyprus, Czechia, Finland, France, Germany, Greece, Portugal, Romania, Slovenia, Sweden
Only implicit	Forest-related theme embedded as part of sections or chapters/subchapters focusing on other sectors	Bulgaria, Croatia, Denmark, Estonia, Hungary, Italy, Latvia, Lithuania, Poland, Slovakia, Spain
None	Forest-related themes are not present in the text either explicitly or implicitly	Austria, Ireland, Luxembourg, Malta

After no new themes were found and after verifying that no overlaps were present among them, the themes identified were checked by going through the texts again.

Furthermore, data on the number of investments and budgets allocated to the forest sector were collected and analysed to investigate the financial relevance of the forest sector within the plans. For most of the plans in which the forest sector was explicitly mentioned, this information is available. To understand the ratio of the declared fund dedicated to forests by each country, information was considered about the total amount of investments planned.[12] The European disbursement is divided into grant and loan. For the total investment calculation, the two different funding instruments, when present, have been considered jointly. The data analysed have been computed by dividing the funds dedicated to the forest sectors by the total amount of the declared investment of the country. When the specific funds allocated to the forest sector were expressed in local currencies, different from Euros, it was necessary to convert them into million Euros to homogenise the data. The currencies exchange was done on 14th January 2022 considering the exchange rate of that day.

In a second phase a quantitative analysis has been implemented. The analysis allowed to detect and highlight if common patterns are present on how forest-related themes have been integrated in the different plans. To accomplish this objective, Hierarchical Clustering on Principal Components (HCPC) has been run. A dataset describing the presence or absence of forest-related themes within the plans has been created. Both implicit and explicit mentions have been considered. The presence of forest-related themes has been coded as 1, while their absence has been coded as 0. HCPC allows an agglomerative hierarchical clustering to be performed based on the result of a principal component method. When dealing with qualitative dichotomous data, the Multiple Correspondence Analysis (MCA) has been computed as principal component method. MCA computation allowed relationships patterns of the variables considered to be analysed (Abdi and Valentin, 2007). Computed MCA variables are gathered in different dimensions, explaining data variations. Dimensions extraction is based on the eigenvalues, or inertia, and on the related percentage of inertia (Husson and Josse, 2014). Cluster analysis was later performed based on the basis of the dimensions derived from the MCA. The dimensions used have been established considering those with a proportion of explained variance $>1/J$, with J representing the total number of variables under consideration (Husson and Josse, 2014).

The outcomes of the HCPC allow the clusters to be described according to the significance of the variables under analysis. The Manhattan distance has been used in clustering. For each variable, the analysis provides the following data:

- *Global*: percentage of cases (MS) present within the cluster out of the total cases that present the variable under analysis;
- *p.value*: significance of the variables within the cluster ($\alpha < 0.05$);
- *v.test*: test statistic. If v.test $>|2|$ the variable is significantly different from 0. The higher |v.test| value, the higher is the variable contribution in characterising the cluster.

The HCPC was performed by using the "FactoMineR" R packaging (Le et al., 2008).

4. Results

4.1. Forest relevance within the National Recovery and Resilience Plans

As already mentioned in the previous section, countries selection was conducted in a specific time span (May–September 2021). Only The Netherlands did not present its plan in the period considered because of the occurrence of national elections (in March 2021) and the subsequent time needed to form the new government.[13] The Dutch NRRP was submitted to the EC on the 8th July 2022.[14] This results in the analysis of 26 plans out of the 27 MS, excluding the Dutch one.

The forest sector has been explicitly and/or implicitly mentioned in all the plans analysed. More specifically, in all countries that present an explicit mention of the forest sector, implicit mentions in parts of the plans dealing with other sectors or ecosystems have also been observed. This led to the distinction of countries between those that explicitly mentioned the forest sector (first row of Table 1) and those that only implicitly mentioned it (second row of Table 1). Only in four countries (i.e., Austria, Ireland, Luxembourg, Malta) explicit or implicit mentions of the sector were not found. The other countries are homogeneously distributed between those who have at least an explicit mention of the sector and the countries that only implicitly mention it.

Among the countries that mention forests explicitly it is possible to observe very different rationales from one country to another. France and the Czech Republic, for instance, insist on the importance of adapting forest ecosystems to climate change, while Germany focuses on the promotion of wood-based construction as part of a bioeconomy development. Slovenia underlines the importance of improving the national wood value chain to facilitate the transition to a circular bioeconomy. Cyprus, Portugal and Greece clearly identify the prevention and combating of forest fires as a priority that seems logical for countries exposed to this climate-related risk in the Mediterranean region.

The outcome of the Inductive Category Formation allowed twelve forest-related themes present within the plans to be identified, considering both explicit and implicit mentions within the relevant texts. Table 2 describes the forest-related themes. The descriptions allow the different themes identified to be clearly distinguished, underlining their specificities.

Observing the presence of forest-related themes within the different countries, the ones more represented are: biodiversity, climate adaptation and forest ecosystem services (FES), followed by climate mitigation, rural development and innovation.

[12] https://ec.europa.eu/info/business-economy-euro/recovery-coronavirus/recovery-and-resilience-facility_en.

[13] https://www.europarl.europa.eu/RegData/etudes/BRIE/2022/739275/EPRS_BRI(2022)739275_EN.pdf.

[14] https://commission.europa.eu/business-economy-euro/economic-recovery/recovery-and-resilience-facility/recovery-and-resilience-plan-netherlands_en.

Table 2
Forest-related themes derived from plans analysis.

Forest-related theme	Abbreviation	Description	# of countries
Circular bioeconomy	*CirBioec*	Introduction of wood products in different sectors (e.g. for construction and industrial uses) considering the whole product lifecycle, from its harvesting to its application (and recycling)	8
Green revolution/ecological transition	*EcolTrans*	Recognition of the importance of forestry (forest ecosystem services, wood and non-wood forest products) to build a sustainable and resilient economy	6
Green jobs	*GJ*	Forestry is seen as a favourable sector to sustain the increase of green jobs	7
Rural development	*RD*	Actions that positively impact rural areas through forest-based solutions	10
Climate action (adaptation)	*ClimAd*	Make forest ecosystems more resilient to climate change (including forest fires and natural hazard prevention) and increase the resilience of territories and people through forest-based solutions (ecosystem-based adaptation)	14
Climate action (mitigation)	*ClimMit*	Forests and wood products as carbon sinks	11
Biodiversity	*Biodiv*	Actions addressed to support and improve forest biodiversity and biodiversity in forests	17
Sustainable forestry	*SF*	Improvement and increasing adoption of sustainable forest management practices	9
Forest Ecosystem Services (FES) provision/enhancement	*FES*	Willingness to improve or address forest management for FES provision and enhancement	12
Urban nature-based solution	*UNBS*	Forest-related solutions implemented in urban areas	5
Gender balance and women inclusion	*GenB*	Commitment to make forestry a fairer sector	2
Innovation	*Innov*	Willingness to introduce innovative practices and technologies within different forest-related activities	10

Finally, the analysis of the budget dedicated to the forest sector allowed its financial relevance within the plans to be understood. The calculated ratio between the investment dedicated to the forest sector and the total amount of planned investments is described in Table 3. Several countries are not present in the table. This does not mean that they do not dedicate any funds to the forest sector. On the contrary, these countries address part of the plan's funds to the sector, but the specific amount is not derivable because it is embedded in an investment section that includes other sectors. Table 3 presents the countries where a portion of the plan's funds has been explicitly dedicated to the forest sector.

The table highlights that when forest-related interventions are integrated into the plans, they benefit from 7.5% to 0.2% of the plans' budgets. The two countries that dedicate most of the plans' funds to forestry are Sweden and Romania, with >7 and 5% of the budgets respectively. The other countries show a proportion between 2.3% and 0.2%. In the case of Sweden, the State is planning to establish new protected areas through the purchase of forest properties and compensating local forest owners who will lose the ability to manage their forest for economic purposes (Sweden RRP, 2021). This policy has significant costs given the opportunity costs of forest exploitation. In Romania, forest cover accounts for 29% of the land, while the optimal percentage is considered 40% (Romanian RRP, 2021). Plans are in place to restore forests that have been degraded mainly due to illegal logging and climate change. A negative impact on forest health and management has also been due to the changes of ownership occurring in the country since 1989 (Scriban et al., 2019). Restoration and afforestation projects, combined with actions to improve forest health and adapt to climate change, have been introduced within the Romanian plan (Romanian RRP, 2021).

4.2. Countries' behaviour in including forestry in the NRRPs

The HCPC analysis has been implemented to assess whether, analysing the different countries, some clusters capable of highlighting their different behaviour in including the forest sectors within their plans come out.

From MCA computation, it emerges that 4 dimensions have a proportion of explained variance >1/J (see Section 3). In our case, J is equal to 12 (number of variables considered) and represents the number of forest-related themes found through the Inductive Category Formation. These 4 dimensions (described in Annex 1) explain 68.23% of the total variance and have been used to compute the cluster analysis. Subsequently, our computation revealed the presence of three different clusters, described in Table 4. The first cluster comprises Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Greece, Hungary, Italy, Poland, Romania, Spain and Sweden. The second cluster is formed by Estonia, Germany, Latvia and Lithuania. Finally, the third cluster is composed by Finland, France, Portugal, Slovakia and Slovenia.

The forest-related themes (variables) that were significant in describing the clusters (with $\alpha < 0.05$) were, in order of significance: circular bioeconomy, innovation, biodiversity, sustainable forestry, climate mitigation, and FES provision/enhancement.

The first cluster is characterised by the absence of some forest-related themes such as innovation, circular bioeconomy and climate mitigation (Table 4). Instead, clusters 2 and 3 are determined by the presence of significant themes in the plans. The second cluster, indeed, is characterised by countries with the presence of an innovation theme in their plans and the absence of biodiversity and FES provision/enhancement themes. The third cluster is described by the presence within the plans of circular bioeconomy, sustainable forestry, innovation and climate mitigation themes.

The first two dimensions derived from the MCA have been used for the graphical representation of the cluster analysis (Fig. 2). They have been chosen because they have a higher eigenvalue, meaning a lower heterogeneity of the variable within the dimensions, and because they are capable of explaining the highest variance proportion, jointly explaining 45.71% of the total variance.

The outcomes of the cluster analysis reveal an interesting picture of the different behaviours present at European level in relation to forest-related themes in the countries' plans.

A first distinction between the clusters can be made considering that clusters 2 and 3 share innovation as a forest-related theme. These two clusters present an attitude in innovating that does not characterise cluster 1. A further distinction can be made between clusters 2 and 3. Cluster 2 is characterised by the absence of themes such as biodiversity and FES, while cluster 3 is characterised by the presence of circular bioeconomy, sustainable forestry and climate mitigation themes (Table 4Table 4).

Taking into account the analysed text, the results show that in cluster 2 innovation is more focused on improving wood-related processes, productions, and small and medium enterprises (SME). Indeed, Lithuania stressed the topic of start-up and support of SMEs, while Latvia introduced innovation as necessary to improve wood-related products, technologies and processes. The concept of social innovation is also presented in the Latvian plan and is addressed to increasing forest sector productivity and resource efficiency. Finally, the Estonian plan underlines the necessity to introduce new technologies to valorise bioresources, being efficient and improving products' value-added, as well as the importance of incentivising SME to support them in

Table 3
Ratio of NRRP funds allocated to the forest sector.

Country	Financed actions	NRRP funds dedicated to forests (million €)	Total country's NRRP fund (million €)*	Ratio of NRRP funds dedicated to forests to total country's NRRP funds
Sweden	Compensation for restrictions on land use of valuable forests	244.5	3300	**7.41%**
Romania	Afforestation	1500	29,180	**5.14%**
Portugal	Landscape transformation of vulnerable forest territories	270	16,600	**2.35%**
	Fuel management lanes – primary network	120		
Slovenia	Construction of the centre for seed, nursery, and forest protection	6.18	2505	**2.17%**
	Greater wood processing for a faster transition to a climate-neutral society	48		
Finland	Climate action in the land use sector	30	2100	**1.43%**
Greece	National reforestation plan	224	30,500	**0.73%**
France	Adaptation of forests to climate change and forest restoration	150	39,400	**0.38%**
Germany	Investment for the development of wood sustainable building	70	25,600	**0.27%**
Czech Republic	Investment in built forests resistant to climate change	0.35	7100	**0.18%**
	Water retention in forests	12.2		

* From: https://ec.europa.eu/info/business-economy-euro/recovery-coronavirus/recovery-and-resilience-facility_en.

Table 4
Forest-related themes characterising the clusters.

Cluster	Forest-related theme	Global	p.value	v.test
1	Innov = 0*	54.54	0.0000201	4.26
	CirBioec = 0	63.64	0.0000281	4.19
	ClimMit = 0	50	0.044	2.01
2	Biodiv = 0	22.73	0.000684	3.4
	Innov = 1	45.45	0.028708	2.19
	FES = 0	45.45	0.028708	2.19
3	CirBioec = 1	36.36	0.002127	3.07
	SF = 1	40.91	0.004785	2.82
	Innov = 1	45.45	0.009569	2.59
	ClimMit = 1	50	0.017544	2.38

* "0" corresponds to the absence of the theme within the plan, while "1" corresponds to its presence.

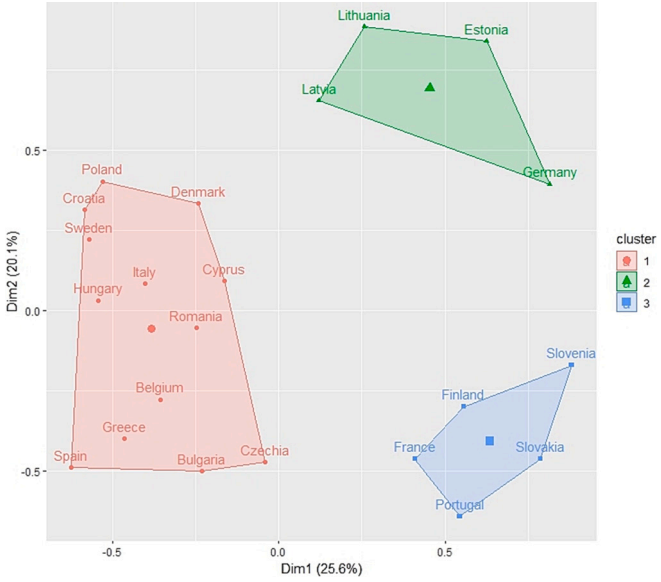

Fig. 2. Clustering of Member States according to the forest-related themes included in the NRRPs.

innovating. Innovation results as being mainly addressed to the improvement of products and amelioration of processes and related technologies, depicting a clear attention to a traditional view of the forest sector oriented mainly towards providing FES. Less attention is paid to more environmental components, represented by the absence of biodiversity and FES (regulating and cultural FES) themes in this cluster.

Instead, in cluster 3 innovation involves a larger spectrum of actions dealing with FES. In Finland, for instance, innovation in forest management is addressed towards precision forestry, also with the aim of supporting an improvement in carbon sequestration. Portugal pays more attention in adopting innovation to fight forest fires and ameliorate bio-based products. Slovakia declares its willingness to introduce novel strategies to decarbonise its economy, as well as Slovenia that, in addition, intends to innovate to reduce the negative environmental impacts of supply chains and to support SMEs. Cluster 3 reveals greater attention to the environmental and multifunctional aspects of the forest sector. Whether we consider the principal topics that received attention in the last EU strategies (e.g., New Green Deal, Biodiversity Strategy, Forest Strategy, Farm to Fork Strategy), they have been well addressed by the plans of the countries presented in this cluster.

The interpretation of cluster 1 is less clear than the other two. This cluster is characterised by the absence of certain themes such as innovation, circular bioeconomy and climate mitigation. Observing the other themes present in the plans of the countries belonging to this cluster (Annex 2), it is possible to notice how there are some themes that have been well addressed, like biodiversity, FES, and rural development. Climate adaptation is more represented than the climate mitigation theme. Climate adaptation is intended as improving forest resilience (Table 2), having a greater impact on local communities and consequently on rural development and biodiversity at the local level, themes that also have a high frequency in the plans of the countries of this cluster. In the light of these results, it is possible to characterise this cluster as indicatively formed by countries that have an inward-looking orientation and will face current challenges with a more national perspective.

Taking into account the main priorities of policy actions of the MS belonging to the clusters, with a focus on the different role of innovation, the three clusters can be characterised as follows.

Cluster 1 – Traditional and inward-looking countries.

Cluster characterised by countries that do not explicitly mention innovation within their forest sector and that allocate plan funds to actions or strategies that impact more on the local/national scale than on the larger/global scale.

Cluster 2 – Innovative countries supporting a more traditional forestry.

Cluster characterised by countries willing to innovate through plans' funds. This innovation is directed to support of the more traditional FES: provisioning of wood-related FES, improving their production and innovating processes and technologies.

Cluster 3 – Innovative countries supporting forest multifunctionality.

Cluster characterised by countries willing to innovate through plans' funds. This innovation is addressed to support forest multifunctionality: regulating and cultural FES. The environmental component of the forest sector is more present in this cluster, underlying the cluster's multi-sectoral attention.

5. Discussion

This study highlights whether and how the forest sector has been introduced and considered within the NRRPs of the EU Member States. Although the RRF did not indicate to MS to specifically dedicate part of the funds to the forest sector, in almost all MS reforms and investments, a share of funding involves forest resources. This is a clear indication of the recognition of the importance of the forest sector in achieving the EU environmental objectives and making Europe more resilient, sustainable and ready for a green transition. The relevance of the forest sector is also underlined by the presence, in half of the plans, of a specific component of the budget allocated to the sector (Table 1). This information can support and integrate the analysis of the use of EU public funds in the forest sector already present in the literature (e.g., FOREST EUROPE, 2020; Haeler et al., 2023). In the remaining half of the plans, the high intersectoral potentiality of the forest sector, also having a key role in other sectors beyond forestry, is appreciated. Indeed, in these plans, forest actions have been introduced only within measures that have a broader and expanded vision of nature-related solutions involving different sectors, a trend seen also in other policy instruments at European level (Lier et al., 2021).

Among the countries that do not mention forests at all, Austria, Luxembourg and Ireland are forest rich countries (FAO, 2020). In the case of Malta, the forest cover is 1.1% and the forest sector is not relevant (FOREST EUROPE, 2020), so it is not surprising that forest measures have not been included in its plan. Considering the case of the other three countries, some explanations can be hypothesised. In 2020, the Austrian National Council adopted a forest fund planning investment of 350 million Euros, among the largest packages of measures for domestic forests in the country.[15] The economic measures from NRRP could support other more demanding sectors that are not already, or not sufficiently, covered by national policy instruments. A similar explanation can be provided in considering Luxembourg. In recent years, a national system to support forestry has been established, making the NRRP funding less urgently needed. Indeed, the Wood Cluster[16] was established in 2016. The Wood Cluster is a wood-based innovation platform that aims to connect and establish partnerships among the actors in the value chain. Also in this case, NRRP funds have been allocated to sectors with higher needs. Finally, Ireland also has already established different funds supporting forests through the European Investment Bank. From the Irish Sustainable Forestry Fund[17] in 2015, Ireland received 12 million Euros addressed to biodiversity improvement and the establishment of the Sustainable Land Management Silva Fund,[18] a 30 million Euros fund to accelerate sustainable forest management in the country. The absence of forest-related themes within its plan could be understood as an already sufficient presence of resources available at national level for the sector.

Concerning the specific forest-related themes that emerged from the NRRPs' analysis, we identified 12 different themes, which describe the multifunctionality of forests and forest management objectives (Elands and Wiersum, 2003). These themes are strictly related to the environmental targets present in EU policy instruments. When considering the policy targets analysed in Lier et al. (2021), the forest-related themes found in the NRRPs completely match with them. Instead, within the forest-related themes there are some additional ones not included in the policies analysed in the mentioned paper (i.e., gender balance and women's inclusion, green jobs, rural development, urban nature-based solution). On the one hand this underlines how the EC through the RRF has been capable of maintaining and reinforcing the main environmental objectives of EU policies already in place. On the other, some of the new themes not already present in the policy targets analysed in Lier et al. (2021), are highlighting an enlargement of the policy impacts on environmental-related topics and consequently the willingness of the EU to expand its policy targets. Indeed, in approving the different plans, the EC also approved the themes and actions present within them, supporting different lines of action.

The more relevant themes (i.e., biodiversity, climate adaptation, FES, climate mitigation, rural development and innovation) are in line with the policies present at European level that are often considered as interconnected (see Section 1).

Although climate mitigation is mentioned in several plans, it seems that the more relevant priority is on the need to adapt forests to climate change, and to promote forests as a way to build more resilient landscapes, also considering the increased occurrence of natural hazards and extreme events (Seneviratne et al., 2021). In recent years, a visible decrease has been identified in carbon storage capacity by forests (EEA, 2023). This has also been attributed to the higher occurrence of natural disturbances (such as wildfires, droughts, storms, insects, etc.) exacerbated by climate change. Hence, improving forest resilience means drastically reducing carbon emissions, decreasing the effects of these disturbances and consequently improving the mitigation capacity of the ecosystem.

Forest innovation in bioeconomy is an emerging topic of interest in the plans that is in line with the efforts to promote such fields at EU levels (e.g., through the Circular Bioeconomy Alliance,[19] Knowledge Centre for Bioeconomy,[20] and research programmes from the Joint Research Centre[21]). Innovation results as being a relevant forest-related theme in the NRRPs. Several MS clearly mention the willingness to introduce some innovative approaches to their forest sector. The innovation theme addresses a wide variety of topics: from technological innovation to support precision forestry and improve energy efficiency, to social innovation to sustain the sector productivity increase. The relevance of innovation at European level is demonstrated by its fundamental role in supporting the achievement of the EU climatic environmental targets and in tackling environmental challenges to increasingly moving towards bioeconomy (EC, 2022b). Considering the presence of some of the less represented forest-related themes, an interesting case is that of green jobs. Indeed, despite the role of the forest sector in the creation of green jobs being well known (UNECE and FAO, 2020), this theme has been mentioned in <50% of plans. This underrepresentation is not a surprise, but not mentioning this topic within the plans does not mean that there is no interest in the issue. Indeed, the adoption of green policies often acts already per se as a stimulus to greening the economy, and consequently it has a catalytic effect in reshaping the economic system and the labour market creating new (green) job positions (OECD, 2017; Silva and Schweinle, 2022).

To understand the financial relevance of the forest sector within the plans, the ratio between the total national NRRP funds and the funds

[15] https://info.bml.gv.at/en/topics/forests/10-measures-for-austrias-forests.html#:~:text=The%20Forest%20Fund%20Act%20was,over%20the%20past%20few%20years.

[16] https://www.luxinnovation.lu/cluster/luxembourg-wood-cluster/.

[17] https://www.eib.org/en/projects/pipelines/all/20150605.

[18] https://www.slmpartners.com/ireland.

[19] https://efi.int/cba.

[20] https://knowledge4policy.ec.europa.eu/bioeconomy_en.

[21] https://publications.jrc.ec.europa.eu/repository/handle/JRC120324.

dedicated to forest-related actions has been analysed. Given that the RRF did not explicitly address actions towards the forest sector, the presence of one third of countries that have foreseen a dedicated portion of their plans' funds to it highlights the MS's recognition of forestry in supporting the European green transition. Considering the financed actions (Table 3), they are connected to the following topics: improve forest resilience to climate change, extreme events and natural hazards; increase forest cover to improve forest mitigation capacity; increase forests protection to preserve biodiversity. This result confirms the priority of actions that will tackle the main environmental challenges that forests and society are currently facing. Moreover, it reflects the direction that the EC is supporting through the establishment of the RRF, confirming that this has been transposed by the MS.

The identification and analysis of forest-related themes and, for the MS in which it is present, the rate of funds dedicated to the sector is important information for policymakers or practitioners. Knowing which are the possible allocations of NRRPs funds can support a projection of actions in their strategic planning.

Within the last analysis implemented that considered MS behaviour in including certain forest-related themes in their plans, three clusters have been identified (Fig. 2). The clusters partially reflect the characteristics of the forest sector of the countries, once an additional funding source enters in their policy scenario. For instance, in the Baltic republics (belonging to cluster 2, "*Innovative countries supporting a more traditional forestry*"), the forest-based economy, focused on wood-related production, has a fundamental role, a role that makes these countries important players in the EU forest-based bioeconomy, also thanks to their capacity in innovating the wood-based industry (Hetemäki, 2020).

To fully understand the MS belonging to the different clusters, a detailed analysis and exploration of the context and forest profile of each country is needed. This gives the space for future researches for more in-depth country-specific analysis.

As a final reflection, more connected to the ongoing phase of implementation of NPPRs than to the design of the plans, is related to the role played in the process by some key organizations of the sector active in Europe, such as (among others) ForestEurope,[22] the European Forest Institute (EFI),[23] the Confederation of European Forest Owners (CEPF),[24] and the European State Forest Association (EUSTAFOR).[25] The role of such organizations could be more active in monitoring and comparing the areas of policy action and allocation of the NPPRs funds to investments impacting forests and the forest sector, providing a critical analysis of this newly-activated policy instrument.

This lack of critical scrutiny by stakeholders' organizations partly explains some of the limitations of the present study. Some of them lie in the methodology used (Section 3): dealing with the different plans, presented in different languages, made their comparison a complex exercise. Indeed, because of the lack of experts who know the different idioms of the EU, the use of a translation software has been necessary. Despite the high accuracy of the software used, some nuances linked to the specificities of the MS have not been possible to identify. The limitation in comparing texts in different languages also relies on the identification and selection of the keywords to screen them. Indeed, the keywords used have been initially tested in 5 different languages. Despite the diversity of the languages, 4 of them are Romance languages and share many semantic fields of their words. The other language is English, the one shared among scientists in investigating forests and the forest sector, thus ensuring a correct translation and interpretation from English to the other four known languages. Instead, for the other different languages, the translation from English could be less precise or not capable of gathering all the possible expressions to refer to the keywords.

[22] https://foresteurope.org/.
[23] https://efi.int/.
[24] https://www.cepf-eu.org/.
[25] https://eustafor.eu/.

Also the results of the analysis concerning the financial relevance of the forest sector within the plans show a partial picture. This is caused by the aggregation of most of the expenditure headings foreseen by the different MS. To have an overall picture on the funds that will be addressed to the European forest sectors through the NRRPs, further studies will be necessary, at the end of the financing period, surveying the MS and analysing which have been the total expenditures, isolating the actions addressed directly to forests and the forest sector.

This study aimed to implement a preliminary comparative analysis among the NRRPs. This lays the foundations for further in-depth analyses for the single MS. Indeed, climatic regions, forest types, forest managements, forest sector, and its importance within the economy of each county vary a lot across the EU (Nabuurs et al., 2015). Interpretation of the results of this study can benefit from considering the differences and commonalities of the MS on these aspects and the different challenges faced by forests across the EU. Such considerations to sharpen the analysis could form part of further research efforts if relevant.

6. Conclusions

This research represents a first attempt to understand if and how the forest sector has been considered by the NRRPs and if and to what extent public funds from the RRF were dedicated to the sector. Furthermore, based on the forest-related themes observed within the NRRPs, this research has explored similarities and different approaches among MS in including the forest sector in their plans.

The analysis reveals that the forest sector was included in the majority of plans. Only in 4 MS, out of 26, no mention of forests was found. As detailed in Section 5, this could be connected to the lack of forests at the country level (as in the case of Malta) or to the presence of other funds that are already satisfactory in meeting the needs of the sector (as in the case of Austria, Ireland and Luxembourg).

Analysing the extent to which the RRF has funded the forest sector, the paper highlights that in one third of the plans a specific share of the budget of the plans has been dedicated to the sector. In the rest of the cases, the funds have been embedded in actions involving other sectors. The total amount of money dedicated to the sector varies from country to country. Despite this, the financed actions have some commonalities and are addressed at measures aimed at increasing forest cover, enhancing forest resilience and improving biodiversity protection. The highest portion of the NRRPs' funds to forest investments have been allocated by Sweden and Romania, the former to protect forests to improve biodiversity and, the latter, to support afforestation projects.

Analysing the NRRPs documents, 12 different forest-related themes have been extracted by the content analysis. The themes were found to be in line with the main European policies objectives: biodiversity protection, and climate adaptation and mitigation. New themes, not yet clearly addressed by EU policies already in place, have emerged from our analysis: gender balance and women's inclusion in forestry and urban nature-based solutions. Among the less represented themes there is the green job, despite the high attention it has received at European level. The establishment of policies that spur a green transition (such as the NextGenerationEU, but also the New Green Deal) is already per se a stimulus for the labour market.

Finally, the current study depicts a first attempt to cluster the MS according to the forest-related themes in their NRRPs. Three different clusters have been identified in relation to the role and relevance of the innovation issue. Among countries open to larger investments in innovation, a further characterisation of the clusters has been done in relation to forest management objectives. In one group of countries, innovation is addressed more to wood-related products and the wood-based industry, supporting a transition towards bioeconomy, while, in a second group, it is addressed more to regulating and cultural FES supporting forest multifunctionality and the European ecological transition.

Because this study focuses only on the strategies coming from the NRRPs, the outcomes of the research and specifically, of the cluster analysis, do not pretend to characterise the whole policies of the EU MS but want to describe how NRRP funds are allocated considering the contingent needs for investing in a non-ordinary area of policy action.

The outcomes of this contribution can support national decision-makers to predict possible future financial options in forest-related investments. For European decision-makers it can be useful to understand MS behaviour and forecast possible impacts on the establishment of future policies or financing sources addressed to the forest sector. Moreover, the results of the analysis could help identify tailor-made recommendations at country level on how to better integrate forests in NRRPs, while promoting regional or sub-regional cooperation between EU MS with similar geoclimatic conditions. This effort may also be positive in view of the implementation of the EU forest strategy and to address some of the challenges ahead at EU level. Indeed, it is proven that more than half of EU countries are exposed to desertification and land degradation (EU, 2018), and forests surely have a role to play to counterbalance this trend. While the UN Decade on Ecosystem Restoration has started, the EU has an opportunity to bring a significant restoration contribution to the world. To maximize positive impacts, all financing solutions should be seized and NRRPs funding represents a very relevant opportunity going forward that can serve as a reference to define some lessons learnt for future financing programmes.

CRediT authorship contribution statement

Giorgia Bottaro: conceptualisation, data curation, methodology, writing – original draft, writing – review & editing. **Ludwig Liagre:** conceptualisation, data curation, methodology. **Davide Pettenella:** conceptualisation, methodology, supervision, writing – review & editing.

Declaration of competing interest

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

Data availability

The data (National Recovery and Resiliance Plans) are publicly available in the European Commission website

Appendix A. Annexes

Annex 1

Description of the four dimensions derived from the MCA.

Dimension 1				Dimension 2				Dimension 3				Dimension 4			
Variable*	Coord	R^2	p-value	Variable	Coord	R^2	p-value	Variable	Coord	R^2	p-value	Variable	Coord	R^2	p-value
CirBioec_1	1.204	0.478	4.36E-09	Biodiv_0	1.415	0.4104	3.1E-05	UNBS_0	0.406	0.307	6.078218e-05	EcolTrans_1	1.012	0.228	0.0021
Innov_1	0.907	0.421	1.95E-06	ClimAd_0	0.967	0.3405	0.0001	GenB_1	2.005	0.379	1.535582e-03	RD_0	0.547	0.197	0.0032
ClimMit_1	0.708	0.358	0.0002	FES_0	0.739	0.3036	0.0006	GenB_0	−0.200	0.379	1.535582e-03	GenB = 1	1.596	0.287	0.0166
SF_1	0.676	0.289	0.0064	SF_0	0.458	0.2508	0.008	UNBS_1	−1.381	−0.307	6.078218e-05	GenB = 0	−0.160	−0.287	0.0166
RD_0	0.406	0.226	0.0382	GJ_0	0.307	0.2163	0.0359					RD_1	−0.657	−0.197	0.0032
RD_1	−0.487	−0.226	0.0382	RD_0	0.399	0.1967	0.0421					EcolTrans_0	−0.380	−0.228	0.0021
SF_0	−0.468	−0.289	0.0064	RD_1	−0.478	−0.1967	0.0421								
ClimMit_0	−0.708	−0.358	0.0002	GJ_1	−0.658	−0.2163	0.0359								
Innov_0	−0.756	−0.421	1.95E-06	SF_1	−0.661	−0.2508	0.008								
CirBioec_0	−0.688	−0.478	4.36E-09	FES_1	−0.616	−0.3036	0.0006								
				ClimAd_1	−0.552	−0.3405	0.0001								
				Biodiv_1	−0.416	−0.4104	3.1E-05								

Annex 1 shows only the significant variables and levels determining the dimensions. Variables have been sorted according to their contribution to the dimension (Coord). The value of R^2 indicates the correlation between variable and dimension, *p*-value has been calculated for $\alpha < 0.05$.

* The link between the abbreviation of the variable and corresponding forest-related themes is given in Table 2.

Annex 2

Clusters description according to the forest-related themes present in the Member States' NRRPs.

Cluster	*Country*	CirBioec	EcoTrans	GJ	RD	ClimAd	ClimMit	Biodiv	SF	FES	UNBS	GenB	Innov	Tot number of themes
1	*Belgium*			x		x		x		x	x			5
	Bulgaria			x	x	x	x	x		x				6
	Croatia				x			x						2
	Cyprus					x	x	x						3
	Czech Rep.		x		x	x	x	x	x	x				7
	Denmark						x	x			x			3
	Greece			x	x	x		x		x				5
	Hungary				x	x		x						3
	Italy				x			x		x	x		x	5
	Poland				x					x				2
	Romania					x		x	x		x			4
	Spain				x	x		x	x	x		x		6
	Sweden		x					x		x		x		4
2	*Estonia*	x	x				x						x	4
	Germany	x		x			x		x				x	5
	Latvia		x			x							x	3
	Lithuania	x											x	2
3	*Finland*	x				x	x	x	x	x			x	7
	France	x			x	x	x	x	x	x			x	8

(*continued on next page*)

Annex 2 (*continued*)

Cluster	*Country*	CirBioec	EcoTrans	GJ	RD	ClimAd	ClimMit	Biodiv	SF	FES	UNBS	GenB	Innov	Tot number of themes
	Portugal	x		x	x	x	x	x	x	x			x	9
	Slovakia	x	x	x		x	x	x	x	x	x		x	10
	Slovenia	x	x	x		x	x	x	x				x	8
	Tot	8	6	7	10	14	11	17	9	12	5	2	10	

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