NEGEM

Quantifying and Deploying Responsible Negative Emissions in Climate Resilient Pathways

Final Report of Stakeholder Survey

Horizon 2020, Grant Agreement no. 869192

Number of the Deliverable	Due date	Actual submission date
5.6	**31.03.2024**	**31.03.2024**

Work Package (WP): 5 – Public and Stakeholder Assessment

Task: 5.2 – Stakeholder Perceptions of NETP

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Dissemination level: Public

Call identifier: H2020-LC-CLA-02-2019 - Negative emissions and land-use based mitigation assessment

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 869192

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Document history

V	Date	Beneficiary	Author/Reviewer
1.0	2024-03-15	UCAM	David Reiner, Lucrezia Nava, Zeynep Clulow/ Alica Evatt and Anniina Lampinen
1.1	2024-03-29	UCAM	David Reiner, Lucrezia Nava, Zeynep Clulow, Meijuan Pan

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Statement of Originality
This deliverable contains original unpublished work except where clearly indicated otherwise. Acknowledgement of previously published material and of the work of others has been made through appropriate citation, quotation or both.

Executive Summary

There is a growing consensus that our ability to meet an ambitious temperature target rests on the rapid scale up of negative emissions technologies and processes (NETPs). Yet current deployment lags significantly behind the levels that are needed to be consistent with global net-zero targets. Since most NETPs, particularly technology-based options, which are expected to have the highest negative emissions potential, are costly to deploy, there is a need for strong support from public and private sector actors to coordinate, incentivize and fund deployment, at least in the early stages of upscaling. Therefore, expert stakeholder attitudes towards NETPs are critical to understand since they anticipate the realistic potential for future deployment trends and ultimately influence deployment trajectories.

A rich and growing literature assesses the costs, benefits and potential trade-offs associated with different NETPs. Most analyses assess trade-offs from a techno-economic or biodiversity perspective and highlight the different design challenges, costs and environmental implications of different options. Yet as NETPs are rolled out, it has become evident that stakeholders often hold divergent perspectives. Moreover, there is growing evidence that some of this dissensus stems from divergent assessments about the acceptability of different trade-offs posed by different options. Deliverable 5.3, for example, showed that stakeholder preferences for different characteristics can hinder dialogue and obstruct agreement on NETPs. Similarly, deliverable 5.4 showed that expert assessments about key NETP attributes such as deployment costs and resource use are associated with divergent assessments about the scalability and economic feasibility of NETPs. Crucially, stakeholder attitudes towards NETPs and the trade-offs they pose do not necessarily mirror techno-economic assessments as attitudes often reflect a diverse range of socio-ethical, cultural concerns and factors such as values, ethics perceptions and national conditions.

Since experts are likely to play an influential role in shaping early deployment and long-term upscaling potential, a key objective of this deliverable is to better understand stakeholder attitudes towards the trade-offs posed by different NETPs and the relative importance of key concerns that shape these trade-offs. In this way, this work seeks to improve understanding of how different expert stakeholders solve trade-offs and formulate their opinion on the acceptability of different NETPs.

To explore these dynamics, we invited stakeholders from our large (3500+) database of experts consisting of individuals who have an interest in EU climate mitigation policy and work in relevant fields of environmental NGOs, public agencies, multilateral organizations and academia. A total of 399 respondents participated in and 223 completed our online survey, which included a series of questions designed to gauge attitudes towards NETPs as well as potential attitudinal drivers and socio-demographic variables.

The survey included a section that incorporated questions for facilitating conjoint analysis – a method that involves presenting respondents with hypothetical scenarios that vary in attributes to investigate how individuals make trade-offs and prioritize different attributes – of expert attitudes towards different NETP projects. Respondents were asked to rate their preferences towards different NETP configurations by choosing between five pairs of *hypothetical* projects that varied in terms of five key attributes - namely: (i) type of NETP (technology vs. nature-based carbon storage; (ii) carbon storage permanence (how long the captured CO2 is safely stored from 10 to 1000 years); (iii) cost per ton of captured CO2; (iv) project proponent (environmental NGO vs. energy/ oil and gas company) and (v) impact on resources (different levels of energy and water use vs. impact on land, food security and biodiversity). Importantly, as some of the attribute combinations that made up the different NETP projects do not (currently at least) exist as implementable technologies or practices (e.g.

a project that involves nature-based storage and 1000 years permanence), respondents were asked to decide between hypothetical projects rather than specific technologies or practices that are already in deployment.

The main results provide somewhat encouraging signs that experts generally hold similar views on the relative importance, and in most cases, ideal characteristics of the key attributes that make up different (hypothetical) NETP options. The pooled results indicate that experts give precedence to the permanence of carbon storage and prefer options that provide high permanence (1000 years). This is closely followed by resource use and impact, with most experts expressing a preference for options that involve high energy and water and low impact on land, food security and biodiversity. These patterns held regardless of sector (private sector of environmental NGO), organizational geographical scope and geographical country grouping, with the exception of experts recruited from outside the Western hemisphere (Africa and Asia), who prioritized resource impact over permanence. Our cluster analysis also suggested that knowledge about different NETPs is associated with prioritization of carbon storage permanence, which suggests that better knowledge and information could potentially increase support for more permanent (technology-based) NETPs that are easier to quantify and govern.

We can draw several policy implications from our findings. First, because expert stakeholders tend to agree to afford precedence to storage permanence and resource impacts of NETPs, configurations that possess this optimal pair of attributes are likely to enjoy broad support from key stakeholders. Given the current status of technological development and operational facilities, these findings suggest that, when combined with non-land intensive storage such as permanent CCUS outputs, CCS-based options (particularly DACCS which benefits from location-autonomy) are likely to be key options in the short-term until, perhaps, technologies that are better contenders in terms of these key attributes emerge such as ocean-based carbon removal.

We also find that, irrespective of sector, experts tend to be more supportive of NETPs projects that are proposed by environmental NGOs as opposed to energy/ oil and gas companies. This suggests a potential strategy for increasing social acceptability: involvement of environmental NGOs through activities such as, for example investment, consultation or endorsement. This strategy could help build trust in NETPs among key organizations and, potentially, other important stakeholders such as national publics.

While our analysis reveals significant consistency across expert stakeholders, the disaggregated results of the geographical analysis also uncover important divergences that are suggestive of distinct regional (and possibly national) attitudes towards trade-offs associated with different NETPs. The most important divergences were seen in relation to the type of NETP, with some geographies preferring nature-based as opposed to technology-based solutions, and the importance of resource impact/use, particularly outside the Northern hemisphere among Asian and African respondents. While the small sample sizes of subgroups only provide limited grounds for comparing European attitudes with other geographies, these findings suggest that attitudes towards NETPs are likely to be shaped by distinct national conditions such as experiences with analogue technologies/ activities, geophysical resources, economic development and social values. Collectively, these results make a strong case for a flexible approach that can be tailored to accommodate regional and national conditions.

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1. Introduction

Negative Emission Technologies and Practices (NETPs) have gained significant attention as a crucial component of climate change mitigation strategies due to the necessity of achieving deep decarbonization and the potential for overshoot. These technologies, which aim to remove greenhouse gases from the atmosphere, include approaches such as bio-energy with carbon capture and storage (BECCS), direct air carbon capture and storage (DACCS), and afforestation or reforestation. However, the successful implementation of these technologies faces various challenges and risks that need to be addressed (see also Deliverables 3.3, 3.5, 3.7 and 3.8). Cobo et al. (2023) emphasize the importance of sustainable scale-up of NETPs and highlight the need to focus on specific areas to ensure their successful implementation. This underscores the necessity of strategic planning and targeted efforts to overcome the challenges posed by negative emission technologies. Fuss et al. (2018) highlight the costs, potentials, and side effects of negative emissions technologies, emphasizing the need to balance the benefits and risks associated with NETPs.

As stakeholder perceptions play a crucial role in shaping the feasibility and acceptance of NETPs, understanding stakeholder perceptions regarding the risks and benefits associated with each NETP is essential for facilitating effective decision-making and policies that are able to navigate these complexities (Deliverables 5.2 and 5.3). Studies such as those by Fridahl and Dixon (2021) and Cox et al. (2022) emphasize the importance of considering public perceptions and risk assessments of carbon removal technologies to address potential challenges and enhance societal acceptance. While an increasing body of research is delving into stakeholder perceptions regarding NETPs, a core challenge emerges from the inherent advantages and disadvantages that accompany each available technology or practice. This complexity hinders straightforward assessment, as NETPs exhibit variability across multiple dimensions that involve trade-offs (see Deliverable 2.2 and 5.2). For example, afforestation, although more cost-effective, offers lower CO_2 storage permanence compared to DACCS, which, despite its higher permanence and cost, involves substantially higher energy demand. Direct engagement with stakeholders to discern their perceptions on various NETPs necessitates an analysis of these trade-offs. However, what remains unclear for extrapolating stakeholder perceptions towards both existing and potential future NETPs is the identification of which dimensions (such as cost, permanence, or resource use) are more influential drivers of different groups of stakeholders' perceptions. Our research thus aims to explore which features of NETPs are most valued across different stakeholder profiles and seeks to understand the relative importance of these dimensions in shaping stakeholder preferences and perceptions of NETPs initiatives.

In particular, we focus on five dimensions across which different NETPs vary widely. The first dimension is the cost per ton of CO_2 captured associated with these technologies, a key factor determining their widespread adoption and deployment. A recent expert elicitation (Deliverable 5.4) underlines how experts expect the cost of BECCS ($/ton CO_2 captured) to decrease only marginally in the next 25 years, while the cost for DACCS is expected to decrease more rapidly. However, DACCS cost is expected to remain over 250 ($/ton CO_2 captured) in 2050, a value significantly higher than other available NETPs (Deliverable 7.2) and the carbon market price.

A second dimension is linked to the permanence of the CO_2 captured. Some NETPs like reforestation and soil carbon sequestration pose risks of reversal that need to be carefully considered in climate change mitigation strategies. Studies such as Schwartz et al. (2020) and Piffer et al. (2021) analyse reforestation dynamics in Latin America and the Caribbean and underscore the risk of reversal associated with reliance on natural forest regeneration for carbon sequestration. By contrast, other NETPs such as CCS-based options can store carbon for thousands of years (Deliverable 2.2).

A third relevant dimension is the type of storage, which can be biological or geological. Biological storage is likely to present co-benefits and contribute to ecosystem restoration and biome preservation, and sustainable economic activity (Deliverable 3.3). However, biological storage might also present risks associated with slow rate of sequestration, which introduces accounting difficulties, and limited capacity - risks that are less salient for geological storage (Deliverable 2.2).

The fourth dimension is resource use—some technologies are land-intensive, while others require significant water or energy. For instance, research by Realmonte et al. (2019) assesses the role of DACCS in IPCC-compliant deep mitigation pathways, highlighting the considerable sorbent production and energy input required for scaling up DACCS. Additionally, Chiquier et al. (2022) address the challenges related to the limited availability of land and biomass supply for NETPs, particularly BECCS, which can hinder the feasibility of achieving carbon dioxide removal objectives.

The last dimension refers to the proponent of the project: the diversity in project management, ranging from private sector to public or NGO-led initiatives, presents further trade-offs, as underlined by Deliverable 5.3, which highlights potential mistrust between different stakeholder groups as an important factor in influencing perceptions and social acceptability.

Given that each NETP displays distinct characteristics and levels across the five highlighted dimensions—cost, CO_2 permanence, storage type, resource use, and project proponent—and considering the inherent trade-offs, no single NETP emerges as superior across all dimensions. Furthermore, the perception of what constitutes an optimal trait varies among stakeholders, emphasizing the complexity of evaluating NETPs solely based on their technical and economic characteristics. To truly comprehend stakeholder perceptions of NETPs, it is essential to understand how different stakeholders prioritize these dimensions and their preferred levels within each. Consequently, we propose conducting a conjoint analysis study; a research method designed to deconstruct and rank the preferences of participants by presenting them with a series of options that vary across a set of defined dimensions. Conjoint analysis offers several benefits in research on decision-making processes. It allows researchers to understand the relative importance of different attributes, predict choices, and simulate market scenarios effectively (Ryan & Farrar, 2000). By analysing preferences and trade-offs, conjoint analysis helps in designing effective policies, developing targeted interventions, and optimizing product features based on consumer preferences (Marshall et al., 2010). This approach enables us to gauge the trade-offs stakeholders are willing to make between different characteristics of NETPs. Through this method, we aim to extrapolate nuanced insights into the preferences of key stakeholder groups, shedding light on the relative importance they place on each dimension of NETPs and their desired levels within these dimensions. This, in turn, will provide a more grounded understanding of how different stakeholders perceive the value and viability of various NETP options, guiding the development and implementation of these technologies in alignment with stakeholder expectations and preferences. The methodology used in our study is described next.

2. Methods

Conjoint analysis is a methodology widely used in social sciences, policy research, and energy research to understand preferences, decision-making processes, and policy design. This method involves presenting respondents with hypothetical scenarios or product profiles that vary in attributes, allowing researchers to analyse how individuals make trade-offs and prioritize different features. Hainmueller et al. (2014) highlight the application of conjoint analysis in understanding multidimensional choices through stated preference experiments, emphasizing its relevance in practical issues such as policy design. For instance, Poortinga et al. (2003) discuss its application in understanding household preferences for energy-saving measures, highlighting its role in shaping energy policies based on consumer preferences. The methodology enabled the researchers to assess the relative importance of different attributes, such as cost, environmental impact, and convenience, in energy-related decision-making processes.

The first step in conducting conjoint analysis is attribute selection, where researchers identify and define the relevant attributes that characterize the products, services, or policies under study. These attributes can include features, characteristics, or levels that are essential for decision-making. In our case, we included the five dimensions highlighted in the introduction. Figure 1 presents the five attributes we selected for this study, together with their levels, as they were presented to the stakeholders participating in our study.

Each project consists of five aspects (varying in their levels):

1. Type of NETP: NETPs vary in their storage. Options are:
a) Nature-based solutions (biological storage of the captured CO2, into plants or soil): These include afforestation/reforestation and soil carbon sequestration, among others.
b) Technology-based solutions (geological storage of the captured CO2 as minerals): These include bioenergy with carbon capture and storage, and direct air capture with carbon storage, among others.

2. Permanence: for how long is the CO2 captured safely stored? Options are:
a) 10 years
b) 100 years
c) 1000 years

3. Cost: The cost per ton of CO2 captured also varies by NETP. Options are:
a) €50 per ton of CO2 captured
b) €100 per ton of CO2 captured
c) €200 per ton of CO2 captured

4. Proponent: The primary proponent of the project (e.g. publishing favorable press releases and reports about the project, investing in the project). Options are:
a) An environmental NGO
b) An Energy/Oil&Gas company

5. Impact on resources: NETPs vary on their resource use.
a) Energy and water use (high or low): indicates whether the project requires significantly more, or less, energy and water per ton of CO2 compared to most other removal methods
b) Impact on land, food security and biodiversity (high or low): indicates whether the project requires significantly more, or less, land per ton of CO2 compared to most other removal methods.

Figure 1. Attributes and levels

In the following step, researchers develop hypothetical product profiles or scenarios, combining different levels of the selected attributes to simulate various options for evaluation by the respondents. Survey design plays a pivotal role in conjoint analysis, as it involves crafting surveys that effectively present these profiles to respondents, allowing for a systematic comparison of preferences (Hainmueller et al., 2015). Following survey deployment, data collection occurs through participant responses, offering insights into how individuals prioritize different attributes and make decisions based on the scenarios presented (Hainmueller et al., 2014). Respondents encounter varied combinations of potential projects and are prompted to either make choices or rate their preferences, shedding light on their preference structures and the trade-offs they are willing to make among the attributes. In our study, we presented respondents with five pairs of potential NETP projects that differed across the predefined five dimensions. It is worth emphasizing that some of the attribute combinations that comprised the different NETP projects do not (currently at least) exist as implementable technologies or practices (e.g. a project that involves nature-based storage and 1000 years permanence). Therefore, respondents were asked to choose between hypothetical projects rather than operational technologies or facilities. Each participant evaluated ten hypothetical projects, organized into five pairs. Initially, respondents were asked to imagine being allocated resources by their organization to support an NETP project of their choosing and to select the project they were more inclined to support from each pair. This dual response structure ensured that respondents had to choose a preference from two hypothetical projects in each round of the conjoint experiment by indirectly rating the relative importance of trade-offs between the specified five key project dimensions. Subsequently, to assess the actual support for the chosen project, we inquired whether they would indeed allocate resources to it, requiring a simple yes or no answer. Figure 2 illustrates the options and queries presented to stakeholders, providing a concrete example of our survey methodology in action.

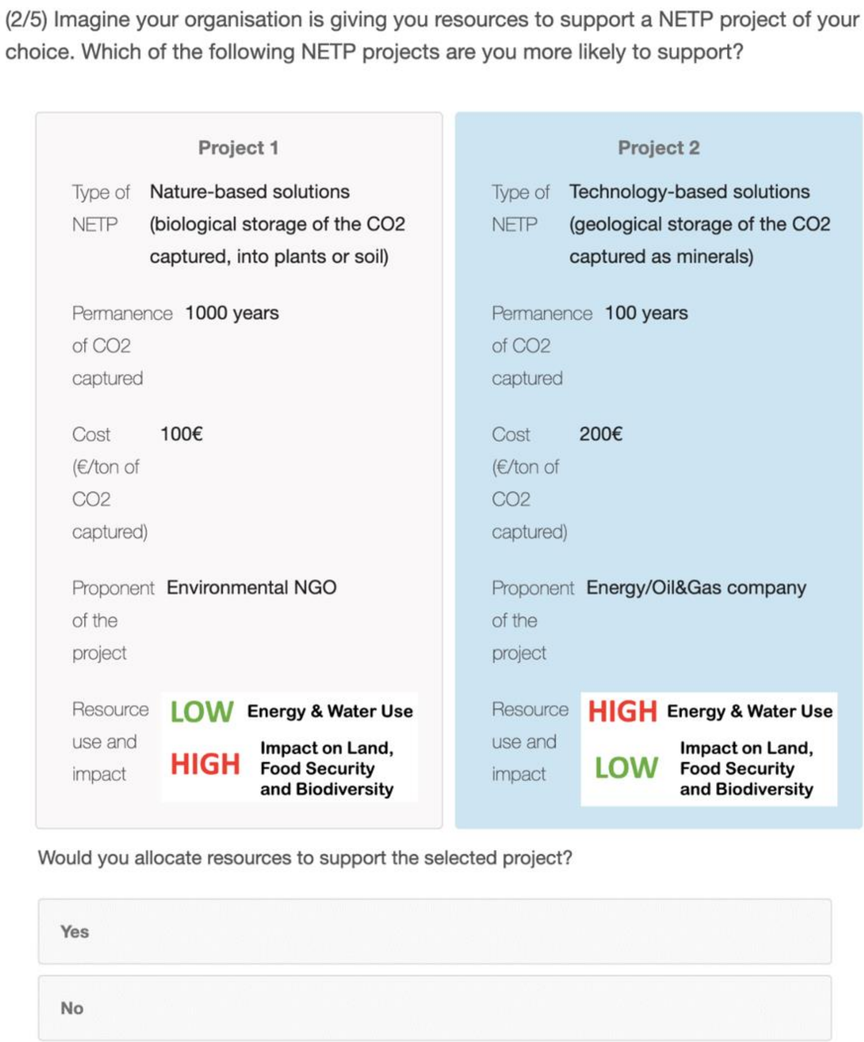


Figure 2. Sample display card

The questionnaire incorporated demographic queries regarding both the organization (covering aspects like sector, industry, geographic scope and location, size) and the respondent (age, gender, educational background, role and experience within the organization and sector, personal values, and political orientation). These questions are crucial for segmenting respondents into distinct groups to explore how preferences vary among them. Additionally, at the survey's outset, we asked respondents to rate their expertise in various NETPs on a five-point scale, ranging from “never heard of it” to “I am an expert on it”. This covered technologies such as DACCS, BECCS, afforestation/reforestation, soil carbon sequestration, enhanced weathering, and ocean alkalinisation, aiming to assess respondents' familiarity with these concepts and potentially exclude those unaware of any NETPs, as our focus was on capturing existing perceptions rather than hypothetical ones.

To recruit respondents, we first identified a set of stakeholders relevant to our study. An extensive internet search helped compile a database of 399 environmental NGOs, 144 public agencies, 383 private sector organizations, and 44 multilateral organizations, including research institutes. Our inclusion criteria prioritized a significant presence in Europe—even for those headquartered elsewhere—and an interest in European Union climate mitigation policies, whether due to sectoral involvement, like climate organizations or energy sector companies, or through a demonstrated commitment to Carbon Dioxide Removal (CDR) deployment, evidenced by reports, public statements, or media coverage. We selected a few knowledgeable and interested members from each organization (if possible), considering their expertise, interest, decision-making capacity (e.g., senior policy officers for NGOs, CEOs for CDR developers, carbon capture experts/project managers/sustainability managers for larger companies), and geographic location. This process yielded a database of over 3500 stakeholder contacts, with distribution as follows: 31% from NGOs, 20% from the private sector, 24% from public agencies, and the remaining 25% from multilateral organizations.

We conducted a pilot survey with 350 stakeholders to refine the survey design, questions, and methodology based on feedback, enhancing the main study's clarity, relevance, and efficacy. Following some minor adjustments, we extended invitations to the remainder of our stakeholder list. The final survey garnered 319 responses, representing a 9% overall response rate.

The data collected through the survey were subsequently analysed using statistical techniques to estimate the relative importance of each attribute and to calculate the utility or preference scores for different levels of these attributes, as per the methodology described by Green & Srinivasan (1978). This step is crucial for deciphering the decision-making processes of stakeholders, enabling predictions of choices based on attribute preferences, and extracting meaningful insights from the survey data. The outcomes of this conjoint analysis, detailed in the following section, shed light on stakeholder perceptions, revealing their preferences and the trade-offs they are willing to make, based on the framework proposed by Jaeger et al. (2001).

3. Key findings

3.1 Basic Results

3.1.1 Demographic information of samples

Figure 3 offers insights into the demographics and experience levels of respondents. In terms of age distribution, the majority fall within the 35 to 64 age range (69.6%), with the highest percentage in the 35 to 44 category (26.6%). Gender distribution shows a significant majority of males, comprising 64.8% (119) of respondents. When it comes to industry experience, a slight majority had more than 10 years of experience

(53.3%), followed by those with 1 to 5 years (23.9%) with less than 5% have less than one year's experience. Regarding organization size, over half of respondents come from organizations with 1 to 99 employees.

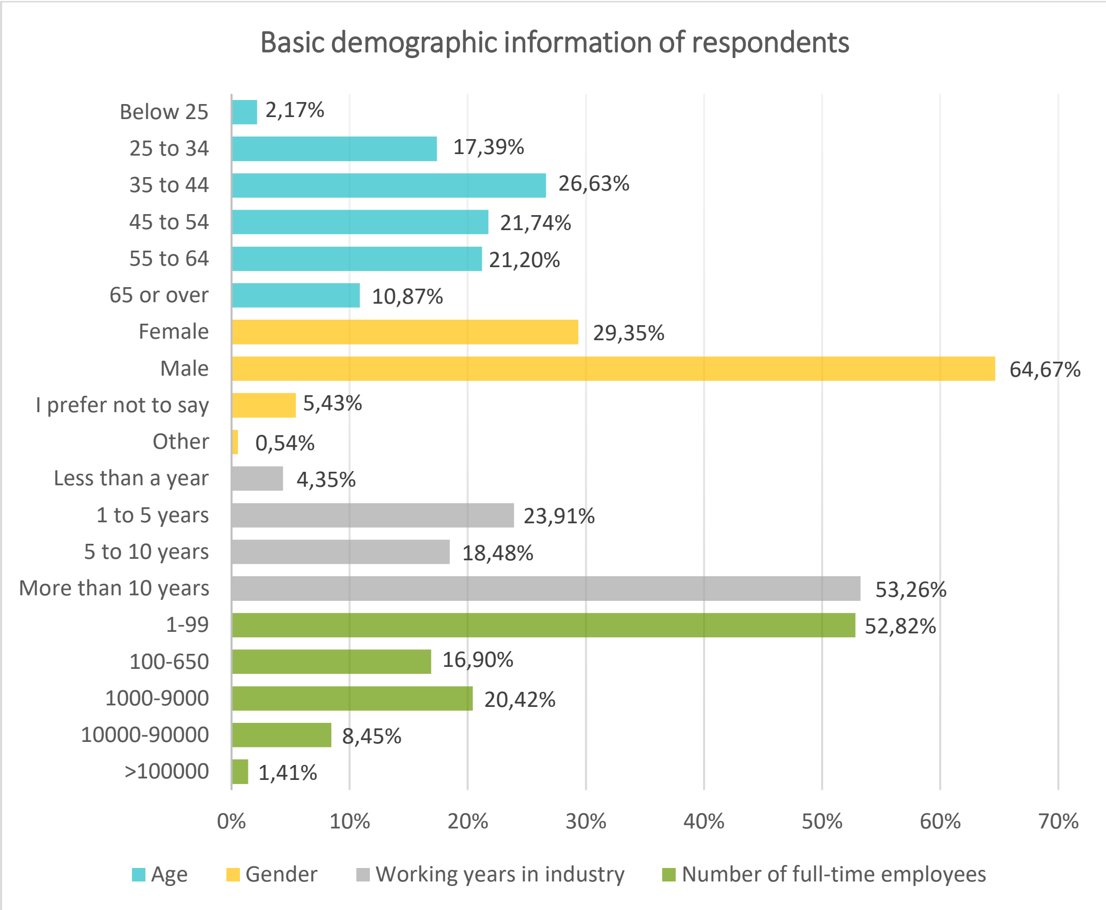


Figure 3. Basic demographic information of respondents

Figure 4 illustrates the educational and professional backgrounds of respondents. In terms of their roles within the organization: senior management or director constitute the largest portion (21.9%), followed closely by those of academic or researcher, is 21.3%. The academic discipline of respondents (based on the field of their highest degree) was most commonly engineering and technology (23.23%), followed by natural sciences (16.9%) and environmental studies & forestry (16.0%). This suggests a strong presence of STEM (Science, Technology, Engineering, and Mathematics) backgrounds among the surveyed individuals, particularly in more technical and managerial roles.

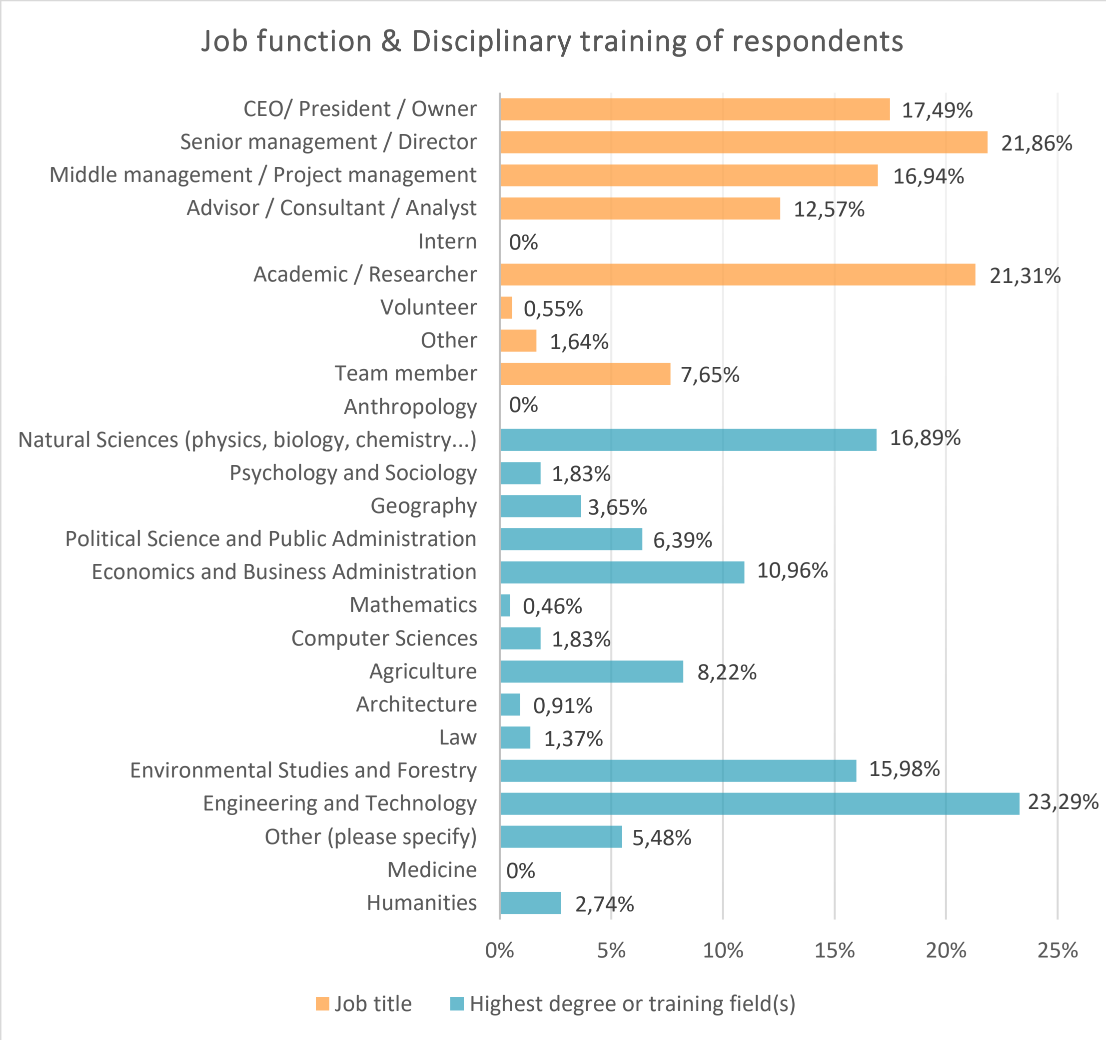
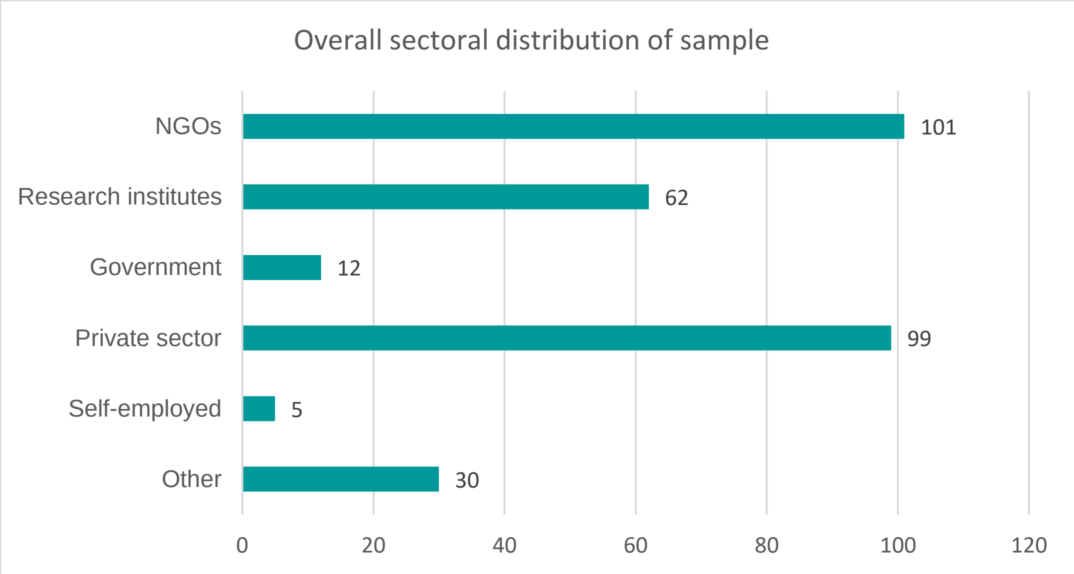


Figure 4. Job title and highest degree or training fields of respondents

The top part of Figure 5 illustrates the sample distribution by sector. We consciously tried to seek a relatively even balance between NGOs and the private sector. As seen in Figure 5, our survey was able to roughly achieve this balance with responses from 101 participants affiliated with environmental NGOs, 99 from the private sector, 62 from research institutes, 12 worked in government positions, and 5 were self-employed. Additionally, 30 respondents are associated with diverse organisations, including industry or professional associations, trade unions, and consulting firms. Within the private sector, 25 respondents were employed by carbon dioxide removal providers or developers, 18 were involved in the energy, oil, and gas sector, 18 in agriculture, fisheries, and forestry, 7 in financial services, with the remainder working in other industries.

The bottom of Figure 5 also provides details of respondents' affiliations or industries. Carbon dioxide removal developer/provider, along with agriculture, fisheries, and forestry, are the most represented sectors, each comprising around 18-26% of respondents. The energy industry (including the oil & gas sector) was well represented, with 18.6%. Overall, the data highlights a diverse range of industries among respondents, with a significant focus on sectors related to energy, and carbon dioxide removal development.



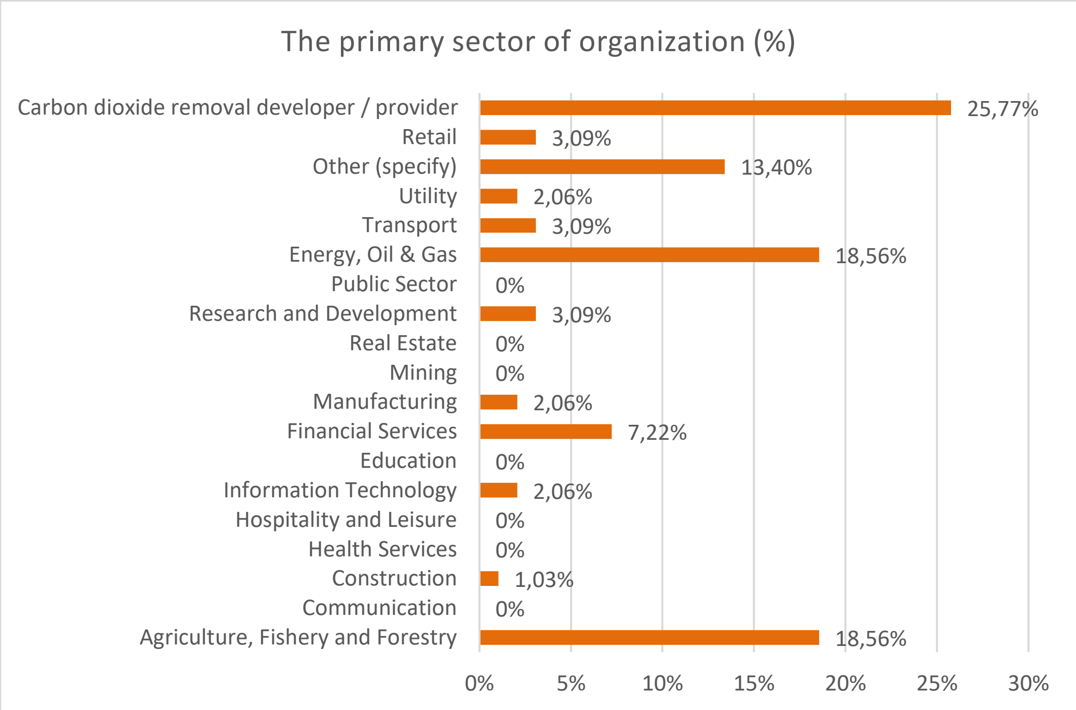


Figure 5. Sectoral distribution of sample

Regarding the geographic distribution of respondents, as shown in the left pane of Figure 6, the United Kingdom is the most represented country with 43 stakeholders (15.5% of responses), followed by Belgium with 35 respondents (12.6%), the United States with 24 (8.6%), Germany with 21 (7.6%), Finland and the Netherlands each with 13 (4.7%), and Sweden with 12 (4.3%). The rest of the respondents hailed from a variety of countries, including Austria, Albania, Argentina, Australia, Belarus, Bosnia and Herzegovina, Bulgaria, Canada, Colombia, Costa Rica, Croatia, Cyprus, Czech Republic, Denmark, Estonia, France, Georgia, Greece, Hungary, India, Indonesia, Ireland, Italy, Latvia, Lithuania, Luxembourg, Montenegro, Nigeria, Norway, Poland, Portugal, Romania, Saudi Arabia, Serbia, Slovakia, Slovenia, Spain, Switzerland, and North Macedonia. Taken together, however, the clear majority of respondents (over 60%) were from the EU-27.

The right pane of Figure 6 reveals the geographic scope of organizational operations/activities. A notable portion, almost 38%, are primarily concerned with national-level initiatives, a slightly smaller portion, just under 37%, are primarily global organisations and over a quarter operate at the European level. This distribution suggests a balanced distribution of institutions across various geographic scales.

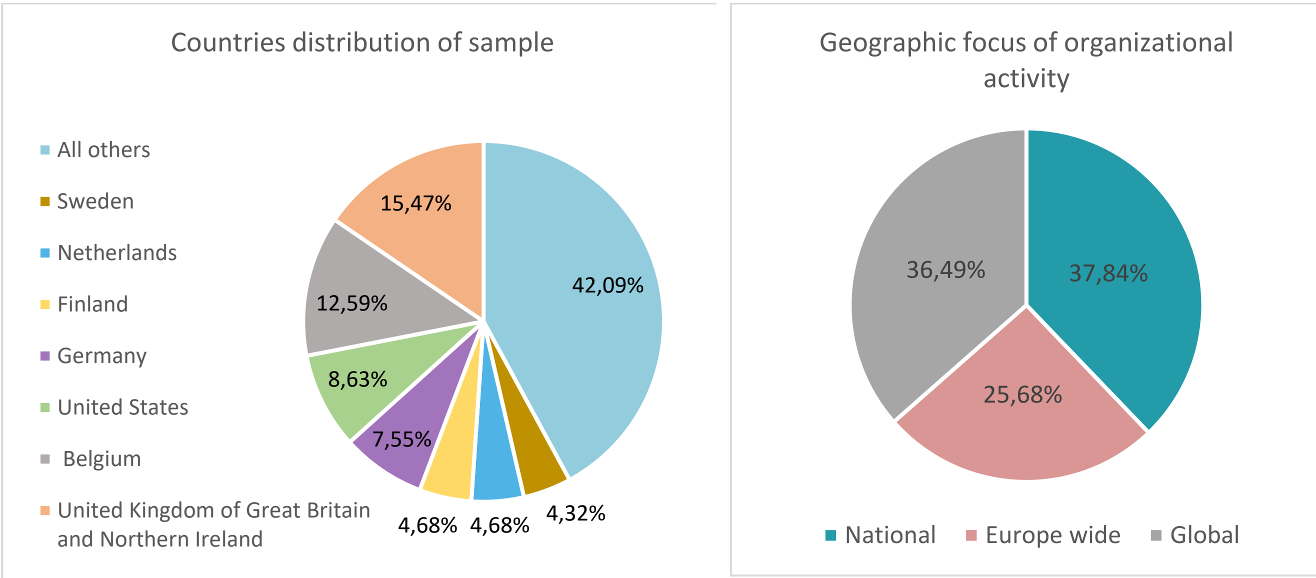


Figure 6. Geographic distribution of sample

Figure 7 shows a large majority of respondents (83%) favor higher levels of government involvement in the economy. Only a small percentage (1%) would support a minimal role for state intervention and a relatively small fraction (16%) position themselves in a more balanced or neutral perspective on the role of government in the economy. These findings highlight a predominantly interventionist inclination among the respondents regarding the level of state involvement in economic affairs. It is noteworthy that roughly a third of respondents are from the private sector so even a majority of these stakeholders favor a strong role for government,

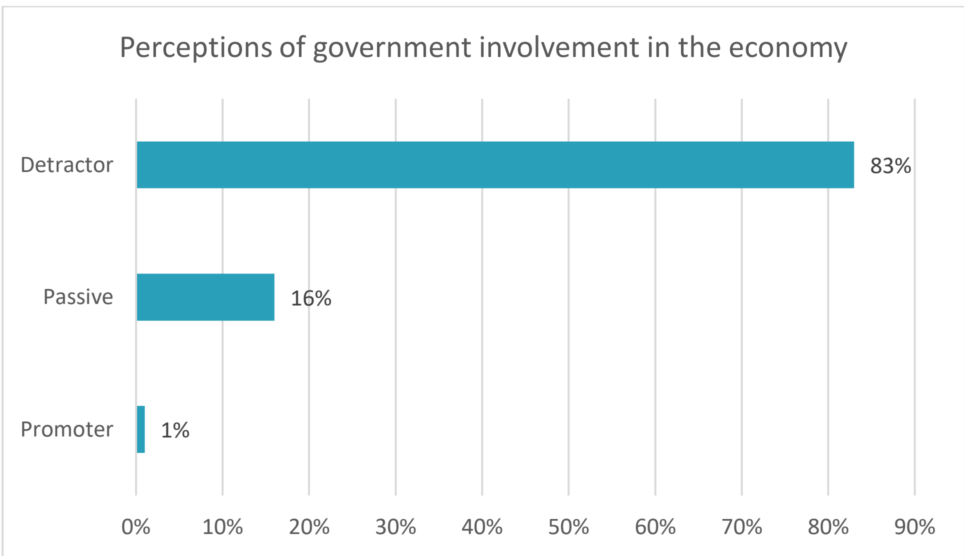


Figure 7. Perceptions of government involvement in the economy

Figure 8 presents respondents' ratings of various moral values, ranging from opposition (-1) to supreme importance (7). Notably, values related to equality, peace, social justice, and environmental stewardship receive high ratings, with substantial percentages rating them as very important or of supreme importance. On the other hand, values associated with social power, wealth, authority, and self-indulgence tend to receive lower importance ratings, with large percentages indicating opposition or minimal importance. This suggests a prioritization of altruistic, community-oriented, and environmentally conscious values among the respondents, while values associated with dominance and personal gain are comparatively less valued.

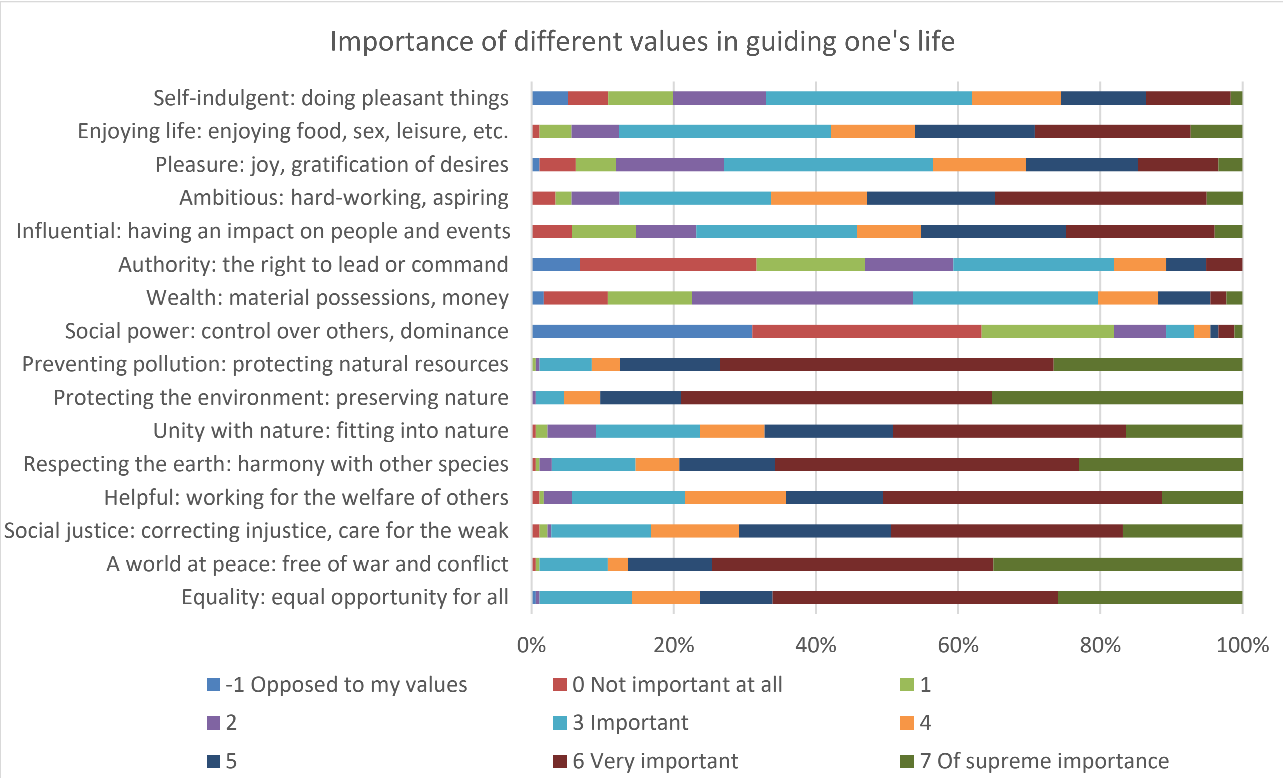


Figure 8. Importance of different values in guiding one's life

3.1.2 Knowledge about NETPs

Figure 9 shows that most stakeholders reported a moderate to high level of familiarity with the various NETPs, beginning with a particularly strong understanding of afforestation/reforestation, where the median response was "I know a lot about it". This was followed, in descending order of familiarity, by BECCS, DACCS, and soil carbon sequestration, for which the median response was "I know a moderate amount about it". Knowledge was reported to be significantly lower for enhanced weathering and ocean alkalinization, with respectively 44% and 46% of respondents admitting to a very limited understanding of these practices. It is worth emphasizing that these stakeholders were included in our database precisely because they were more likely to have a view on NETPs and those who responded would be expected to be even more likely to have a view on the subject. Hence, there is selection bias at play and so we would caution against interpreting any results as being representative of stakeholder views on any of these subjects although, given the relatively large sample size, it is at least indicative of the views of informed stakeholders.

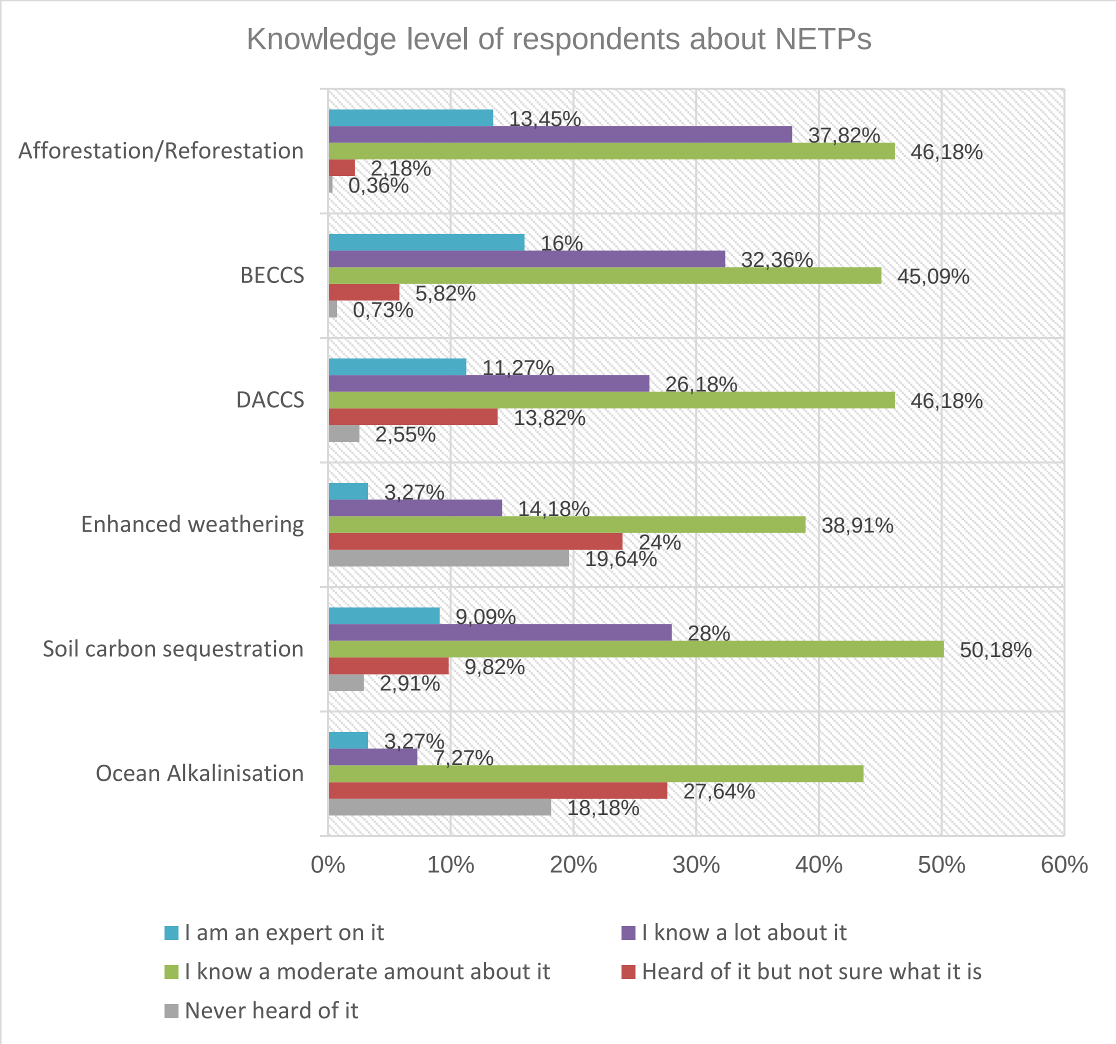


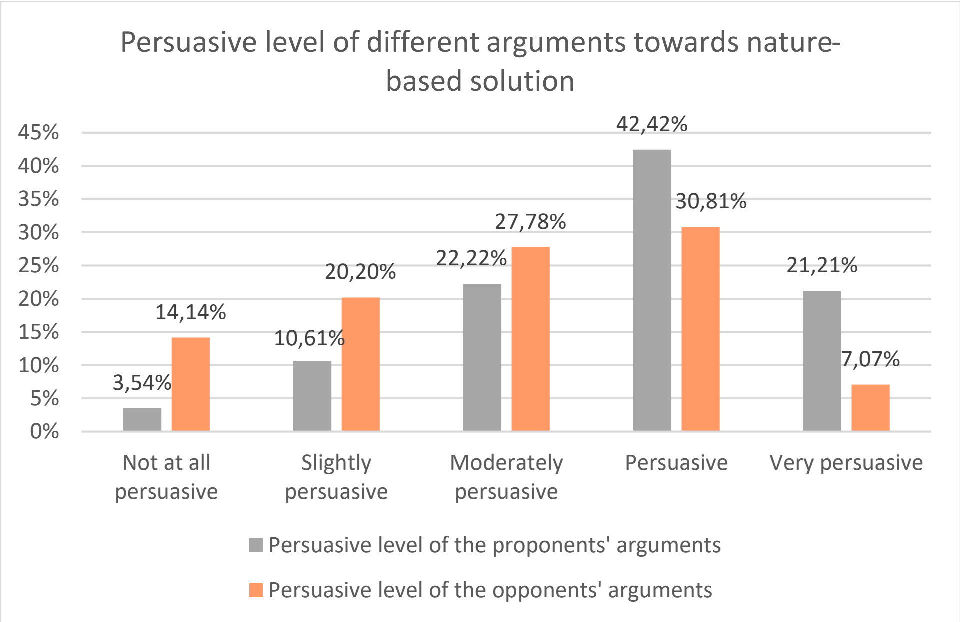
Figure 9. Knowledge level of respondents about NETPs

3.1.3 Attitudes towards two types of projects

- **Vignette Nat Moral**

The top of Figure 10 presents respondents' perceptions of the persuasive levels of arguments made by proponents and opponents of nature-based solutions projects, specifically focusing on afforestation/reforestation or soil carbon sequestration. Proponents argue that such projects restore ecosystems damaged by human activities and are affordable and community-friendly, while opponents raise concerns about the difficulty of measuring and maintaining captured CO2 and the risk of overcounting emissions. Respondents find proponents' arguments moderately to very persuasive (85.85% combined), with a majority leaning towards the persuasive end (42.4%), while opponents' arguments are deemed less persuasive overall (65.7% combined moderately to very persuasive).

Additionally, the bottom of Figure 10 illustrates respondents' likelihood of supporting levels when proponents is either energy oil & gas company or environmental NGO. When the proponent is an environmental NGO, 39.39% of respondents express being likely to support such a project, with an additional 32.32% indicating they might support it, and 8.08% suggesting they would always support it. Conversely, only 2.53% state they would never support the project when advocated by an environmental NGO, reflecting a higher level of support compared to when the proponent is an energy oil & gas company.



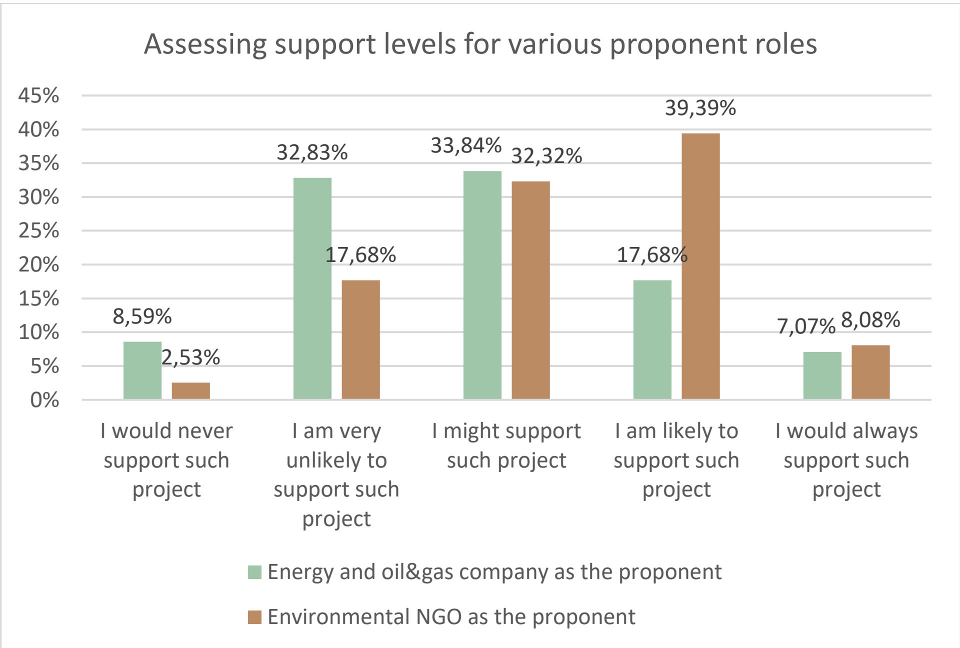


Figure 10. Attitudes towards Vignette Nat Moral

- **Vignette Nat Sci**

The top of Figure 11 examines respondents' perceptions regarding the persuasive levels of arguments presented by proponents and opponents of nature-based solutions projects, specifically focusing on afforestation/reforestation or soil carbon sequestration. Proponents advocate for the restoration of biodiverse landscapes and the relatively lower cost of capturing CO_2 compared to other solutions, while opponents highlight concerns about the limited permanence of captured CO_2 and the risk of reversibility due to natural or artificial causes. Respondents find proponents' arguments moderately to very persuasive (80.77% combined), with a majority leaning towards the persuasive end (39.56%), while opponents' arguments are deemed slightly less persuasive overall (67.59% combined moderately to very persuasive).

Respondents were asked to rate their likelihood of supporting a nature-based solutions project sponsored by either a major environmental NGO or a company in the energy and oil & gas sector (as shown in the bottom of Figure 11). Results indicate that when the proponent is a major environmental NGO, 38.46% of respondents express being likely to support such a project, with an additional 32.42% indicating they might support it, and 9.89% suggesting they would always support it. Conversely, when the proponent is an energy and oil & gas company, only 17.03% state they are likely to support the project, with a significantly higher percentage (37.36%) expressing being very unlikely to support it.

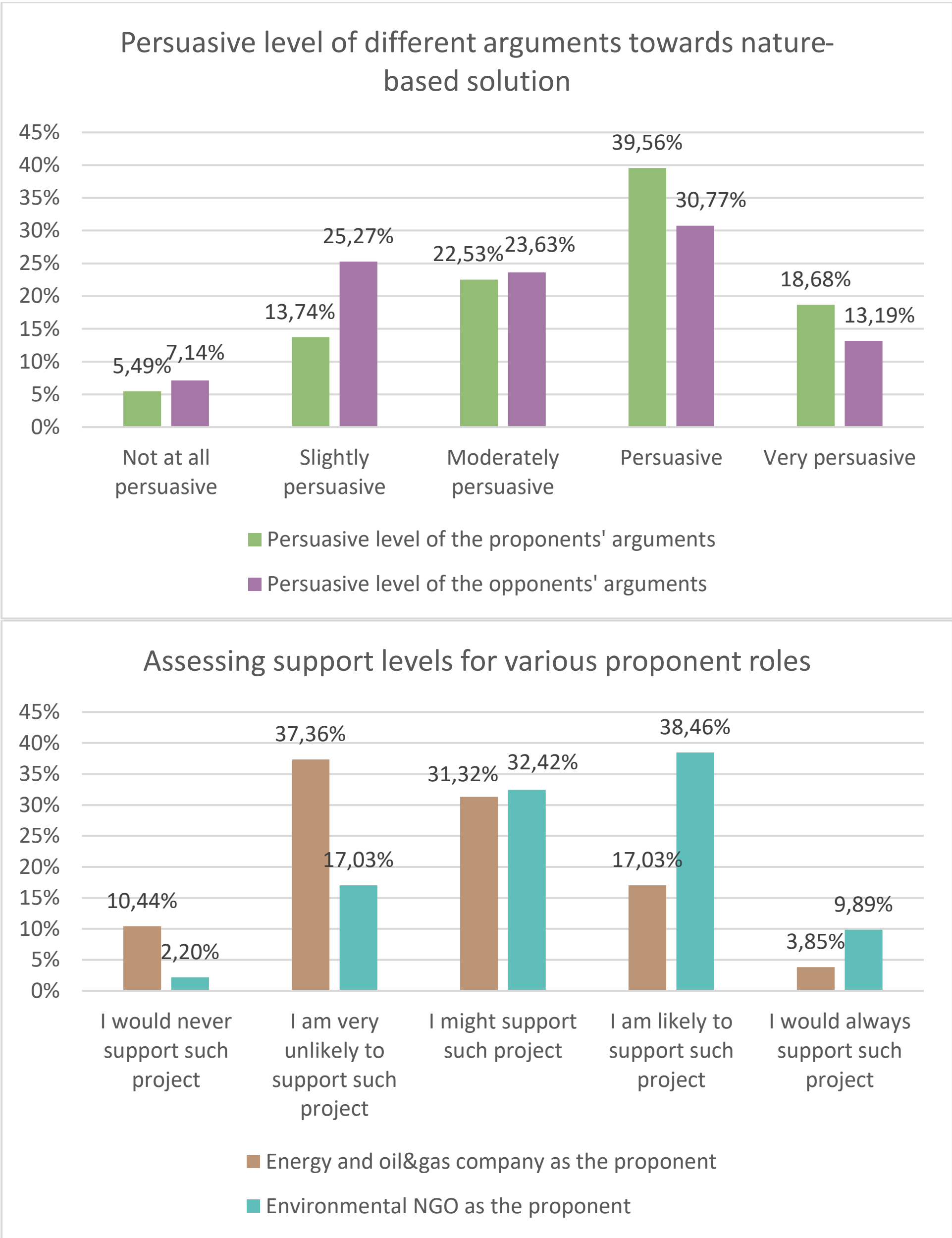


Figure 11. Attitudes towards Vignette Nat Sci

- **Vignette Tec Moral**

The top of Figure 12 delves into respondents' perceptions regarding the persuasive levels of arguments put forth by proponents and opponents of technology-based solutions projects, specifically focusing on bioenergy with carbon capture and storage and direct air capture with carbon storage. Proponents argue that these projects effectively capture and permanently store CO2, ensuring greater transparency and accountability. However, opponents raise concerns about the high burden placed on local resources, particularly electricity and land, and the significant uncertainty regarding the risk and future costs of these technologies. Respondents find both proponents' and opponents' arguments moderately persuasive overall), with a majority leaning towards the persuasive end (35.5% for proponent and 31.7% for opponents).

The bottom of Figure 12 reveals differing levels of support based on the proponent. When the proponent is a major environmental NGO, 31.7% of respondents indicating they might support such a project, with an additional 29.5% express being likely to support it. When the proponent is an oil & gas company, only 20.2% state they are likely to support the project, while a significantly higher percentage (30.6%) indicate they might support, with 30.05% expressing being very unlikely to support it.

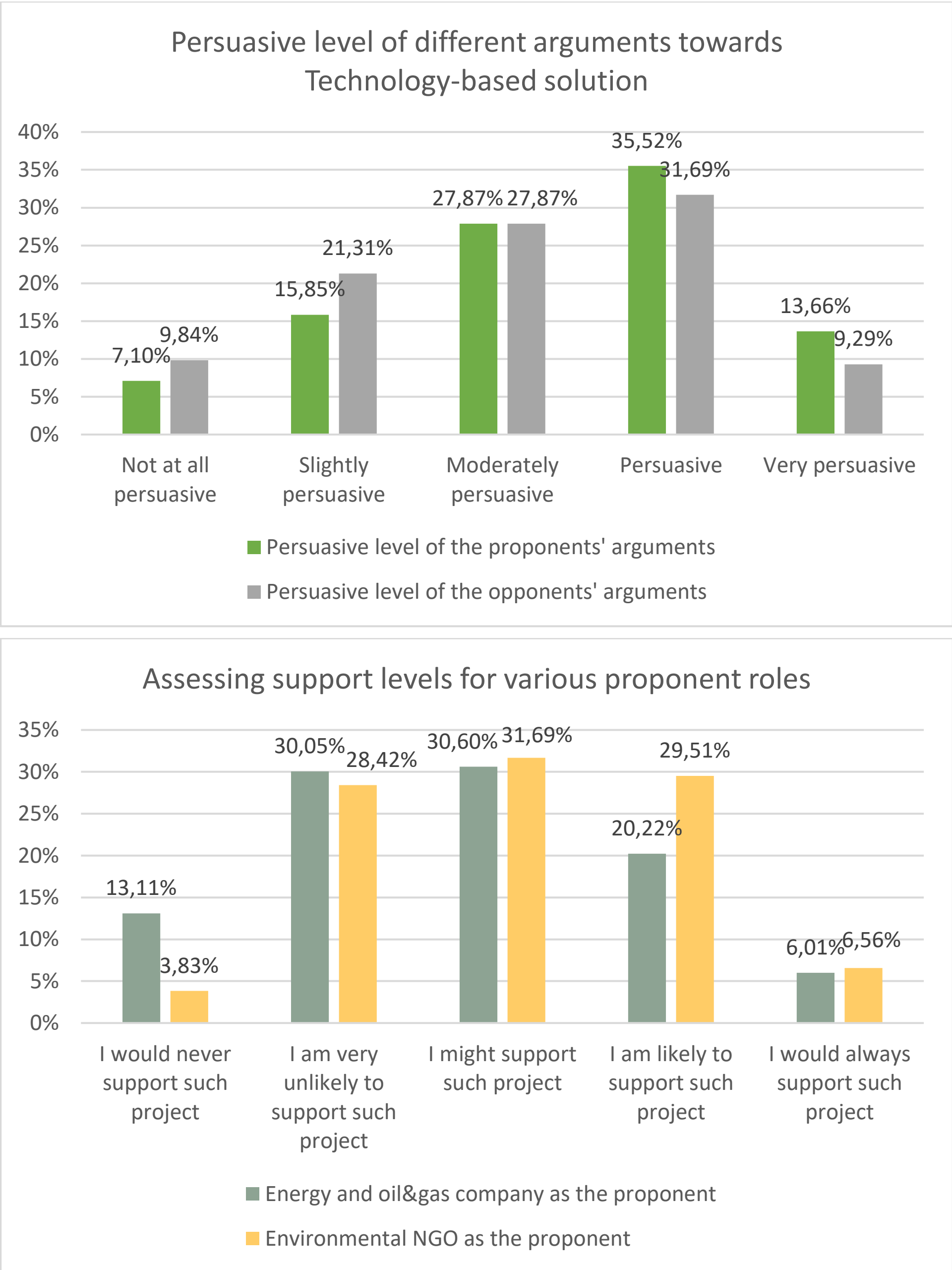


Figure 12. Attitudes towards Vignette Tech Moral

- **Vignette Tech Sci**

The top of Figure 13 examines respondents' perceptions regarding the persuasive levels of arguments presented by proponents and opponents of technology-based solutions projects, specifically focusing on bioenergy with carbon capture and storage and direct air capture with carbon storage. Proponents argue that these projects effectively capture and store CO2 for thousands to millions of years, highlighting their long-term benefits. Conversely, opponents raise concerns about the high cost (both in financial and energy terms) and the low technology readiness level for these technologies. Respondents find both proponents' and opponents' arguments moderately persuasive overall, with a slight majority leaning towards the persuasive end (34.97% for proponent and 30.6% for opponents).

The bottom of Figure 13 depicts when the proponent is a major environmental NGO, 33.33% of respondents express they might support the project, with an additional 28.42% indicating they are likely to support it and 27.32% suggesting they are very unlikely support it. Conversely, when the proponent is an energy and oil & gas company, only 18.58% state they are likely to support the project, with a notably higher percentage (34.43%) indicating they might support it, while 28.42% express being very unlikely to support it.

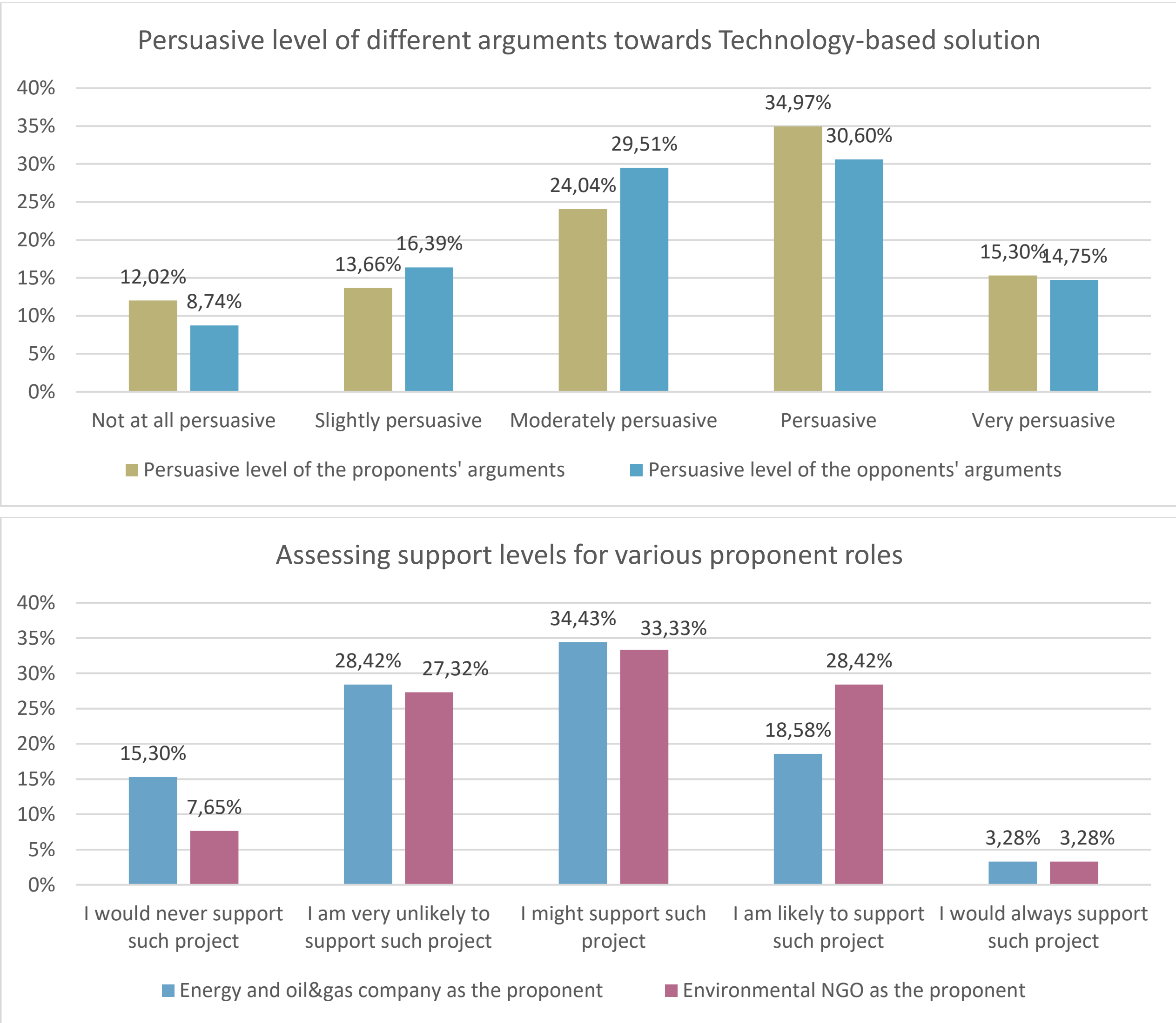


Figure 13. Attitudes towards Vignette Tech Sci

3.1.4 Mechanisms

Figure 14 indicates respondents' perceptions of the alignment of certain beliefs with their organization's stance on fighting climate change, rated on a scale from 3 (least aligned) to 1 (most aligned). The majority (54.4%) believe that the economic argument – emphasizing the high cost of climate change compared to mitigation investments – is the least aligned with their organization's beliefs. Conversely, a significant fraction (51.9%) finds the ecological perspective – emphasizing the need to live within planetary boundaries and preserve biodiversity – to be the most aligned with their organization's beliefs. Meanwhile, a sizable proportion (40.5%) also sees the moral imperative of preserving the planet for future generations as strongly aligned with their organization's stance on climate change.

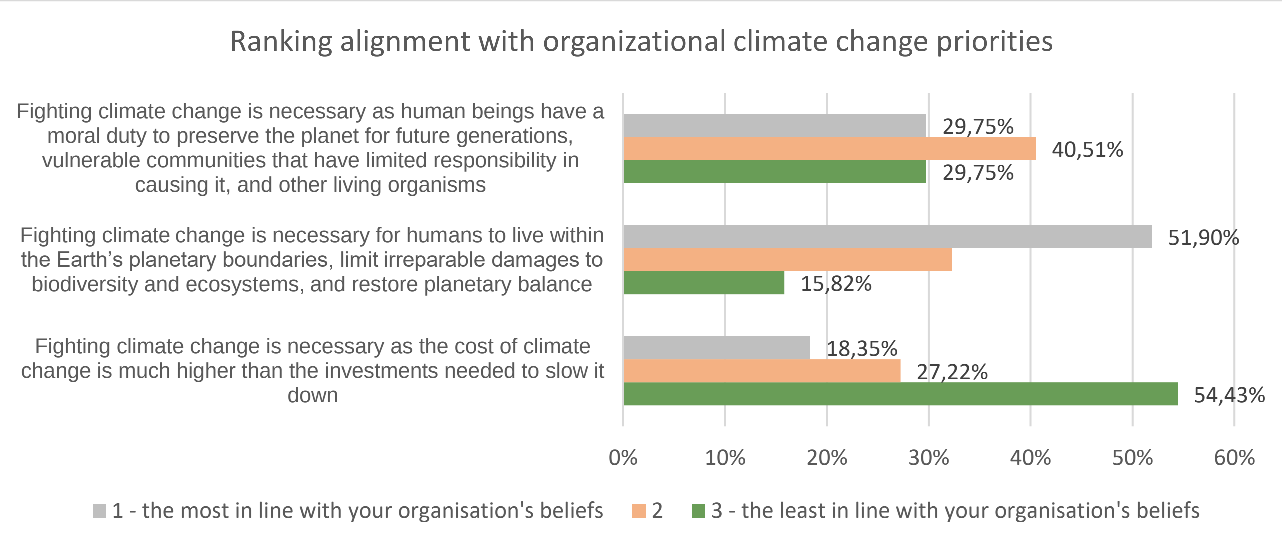


Figure 14. Ranking alignment with organizational climate change priorities

Figure 15 presents respondents' rankings of various organizational objectives based on their perceived value within their organizations, ranging from 1 (most valued) to 9 (least valued). Among the listed objectives, moral integrity emerges as the most highly valued (25.8%), followed closely by logic (15.9%), efficiency (14.3%) and fairness (14.3%). Innovativeness also holds considerable importance at 12.1%. Growth and compassion are ranked lower, with compassion in particular (almost 30% ranking it as the least valued objective), and growth also ranking as being of relatively low value (27.5%). Of course, many respondents come from NGOs, which helps explain the low priority given to growth.

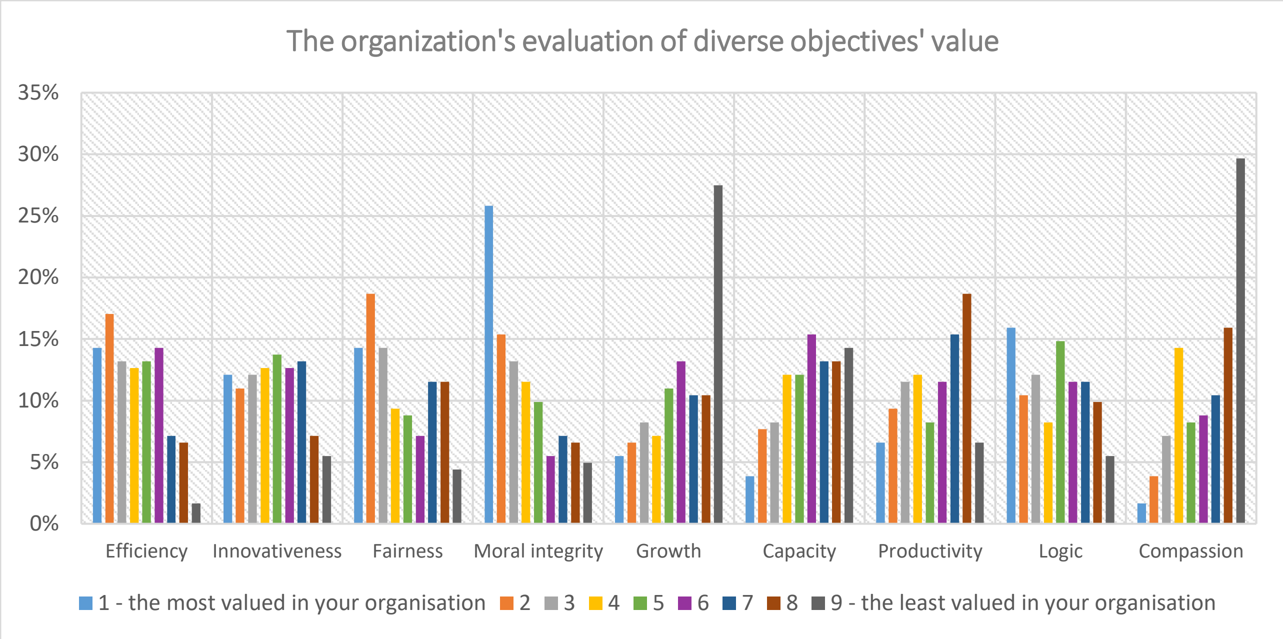


Figure 15. The organization's evaluation of diverse objectives' value

Figure 16 reveals varying degrees of agreement among respondents regarding their organization's efforts with regard to the environment. While a significant portion agrees or strongly agrees that their organization encourages eco-friendly behavior (73.6%), promotes biodiversity protection (71.8%), contributes to saving resources and energy (78.3%), and takes action to reduce pollution (72.5%), there are notable concerns regarding measuring the impact of organizational activities on the natural environment, with 67.7% expressing disagreement or strong disagreement. These results suggest a generally positive perception of the environmental efforts underway within the organizations surveyed, albeit with room for improvement in environmental impact measurement practices.

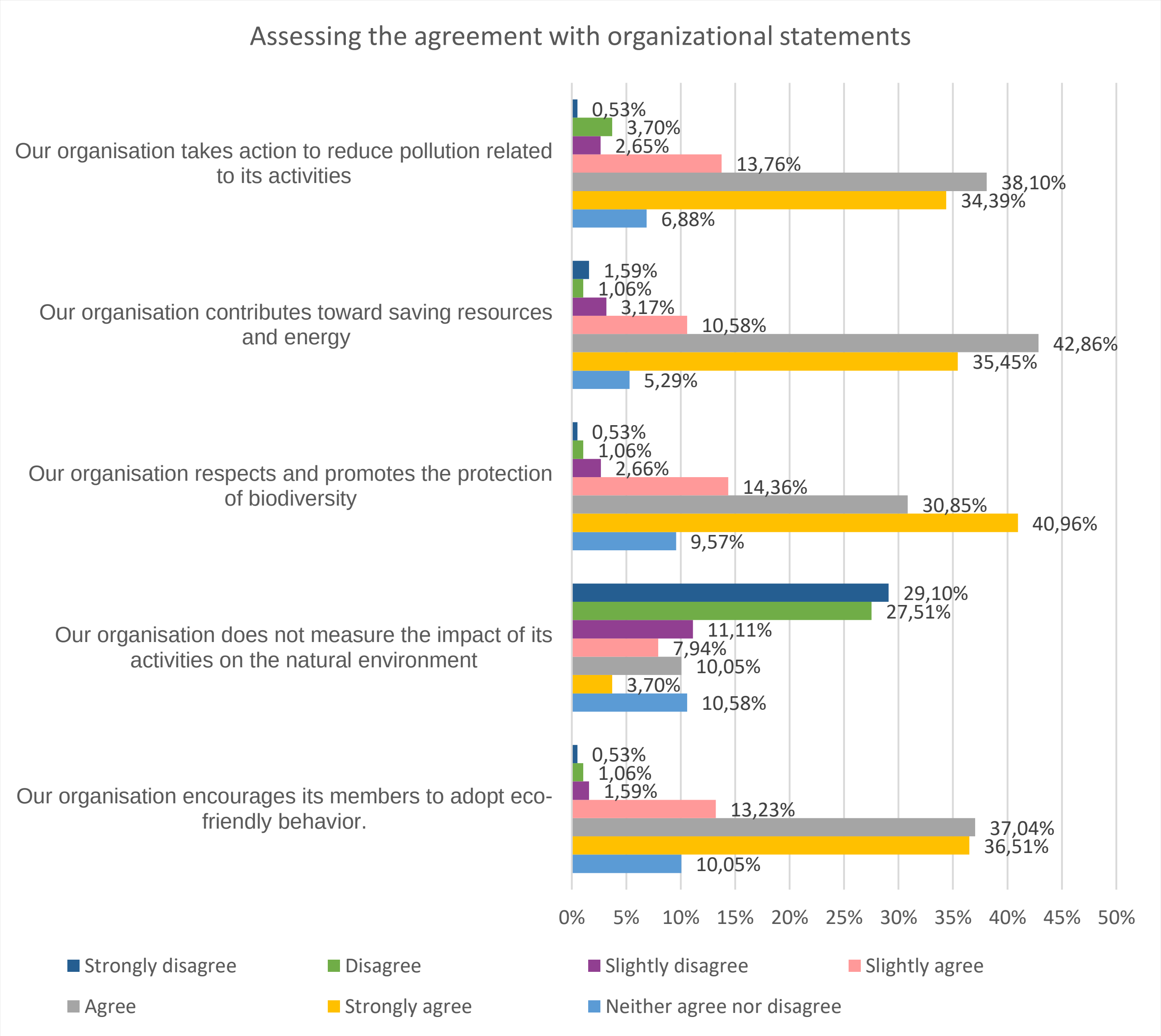


Figure 16. Assessing the agreement with different organizational statements

3.1.5 Trust in Stakeholders

Figure 17 sheds light on views of stakeholders' perceived influence and perceived expertise regarding NETPs. Scientists are considered the most likely to influence organizational beliefs on NETPs, with 66.1% ranking them highest in influence, while 84.8% believe scientists are most likely to have expertise on NETPs. Conversely, the general public is regarded as the least likely to influence organizational beliefs, with 45.4% ranking them lowest, and also the least likely to have expertise, with 84.2% ranking them lowest. Unlike expertise, almoat 5% of respondents did list the public as the single most important influence on their organisation. The private sector and NGOs rank relatively high in both influence and expertise, indicating a recognition of their importance in shaping organizational perspectives and knowledge on NETPs.

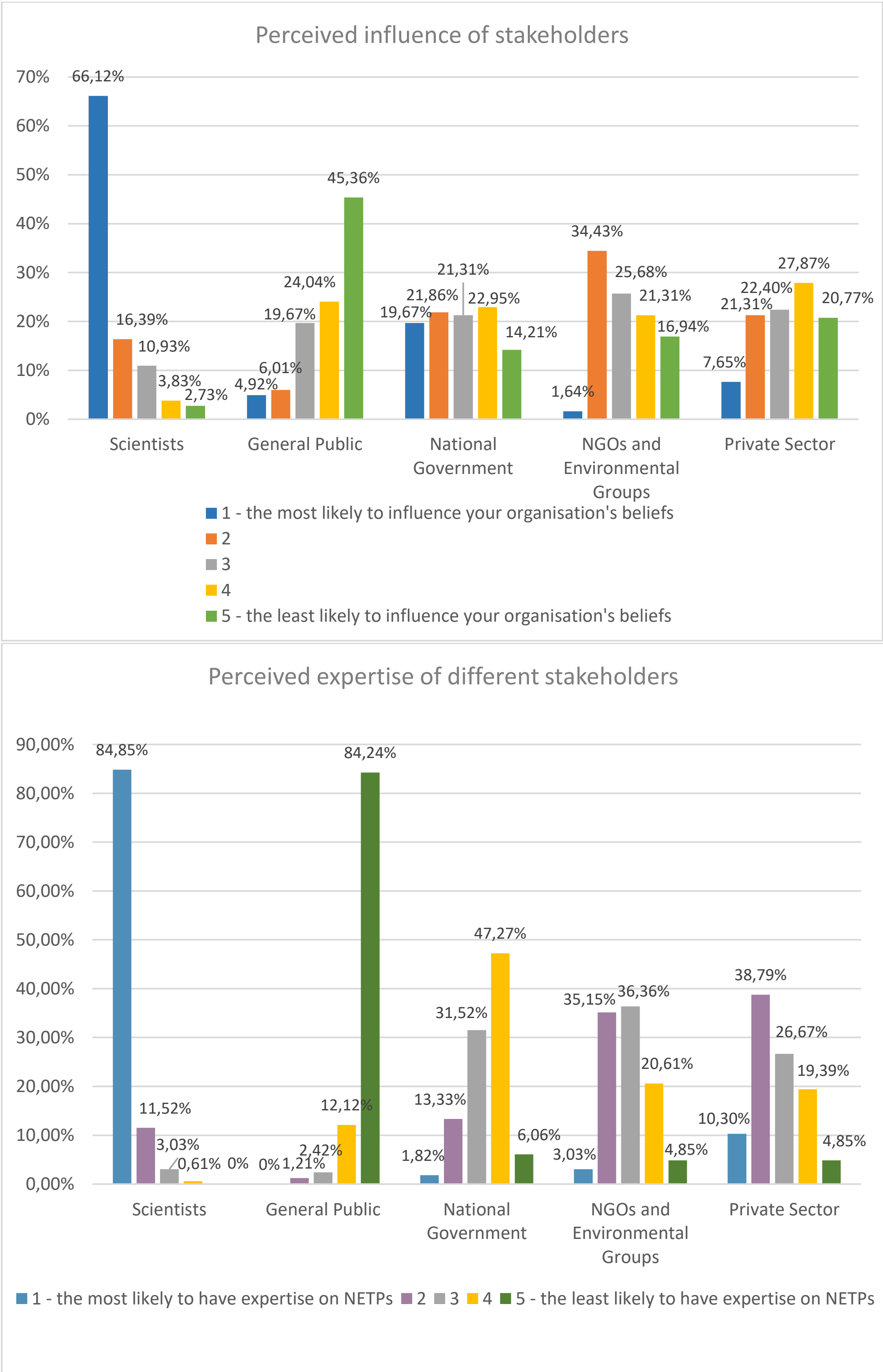


Figure 17. Perceived influence and expertise of stakeholders

3.1.6 Public decision-making about NETPs

The top pane of Figure 18 illustrates respondents' attitudes towards public involvement in the development of NETPs, measured on a scale from -3 (Not at all desirable) to +3 (Very desirable). Results show that a large majority of respondents find it desirable to inform the public about the development of NETPs, with 55% rating it as very desirable. Similarly, allowing the public to express their opinions and decide together with the public about the development of NETPs also receive significant support, with 89% and 65% respectively rating these options as desirable (scores from 1 to 3). Conversely, a notable proportion of respondents (38%) find it undesirable to exclude the public from decision-making about the development of NETPs, with 21% rating this option as not at all desirable (-3).

The bottom of Figure 18 presents respondents' views on the need for public involvement in the development of NETPs, rated on a scale from -3 (Not at all necessary) to 3 (Very necessary). Results indicate a strong consensus on the importance of informing the public about NETPs development, with almost 97% rating it as necessary (scores from 1 to 3), and a majority (57%) considering it very necessary (score 3). Similarly, allowing the public to express their opinions and deciding together with the public are also viewed as necessary by the majority of respondents, with two-thirds and one-third rating these options as necessary or very necessary respectively. Conversely, excluding the public from decision-making is deemed unacceptable by most respondents, with only a small fraction (16.2%) considering it necessary or very necessary. These findings underscore a strong preference for public engagement and participation in shaping the development of NETPs

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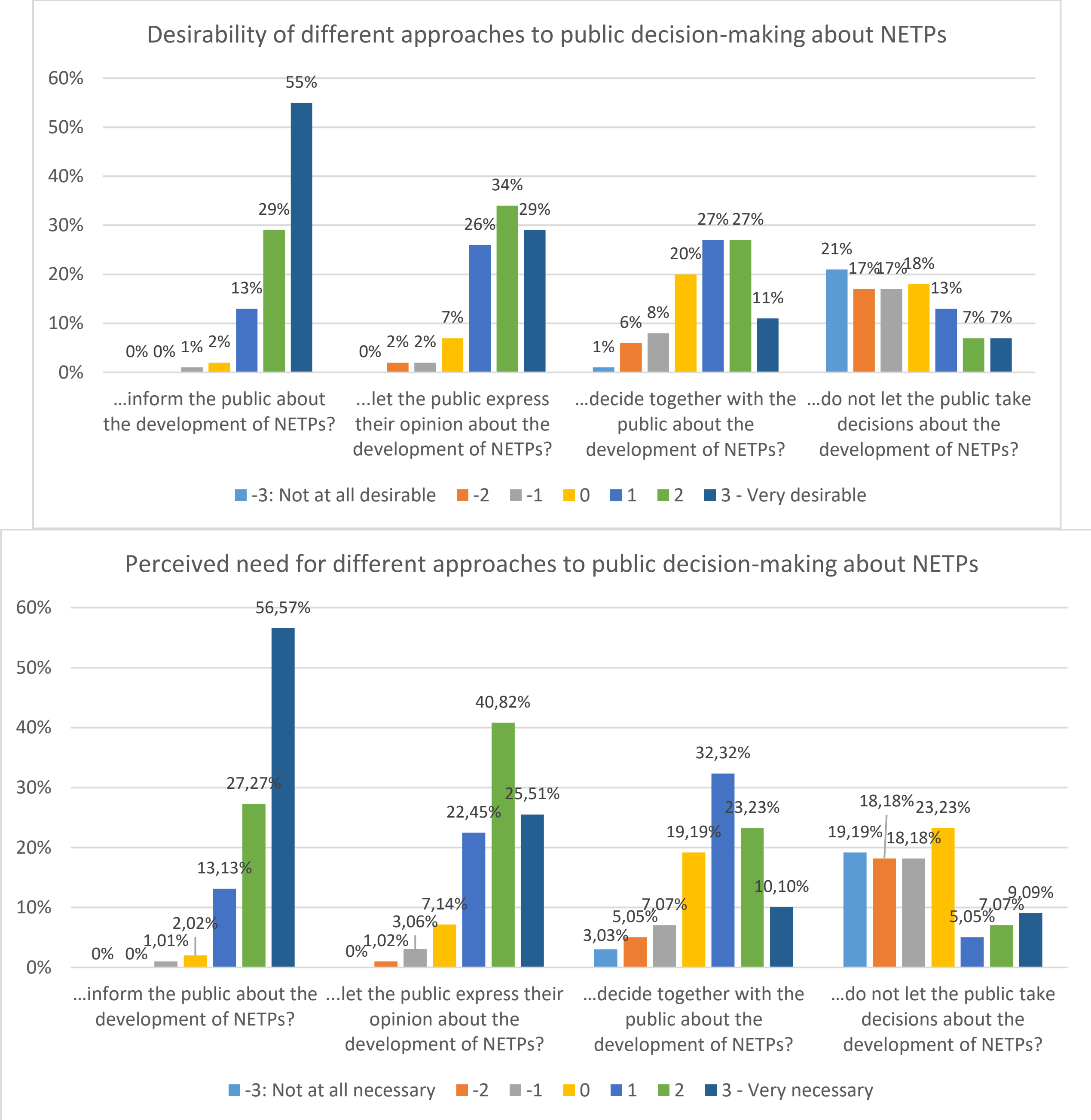


Figure 18. Desirability and perceived need for different approaches to public decision-making about NETPs

3.1.7 Policy instruments

Figure 19 explores respondents' preferences for various instruments aimed at facilitating the implementation of NETPs. The three most desirable instruments include public financial support for deployment (15.7%), carbon taxes (15.5%), and markets for carbon certificates (15.1%). Additionally, the most desirable instrument overall is carbon taxes and standards (26.6%), followed by market for carbon certificates (19.6%) and public financial support for investments (15.6%). These results suggest a preference for policy measures that incentivize carbon reduction in general and provide financial support for NETP implementation, reflecting a desire for both regulatory and economic incentives to drive deployment as part of a wider effort.

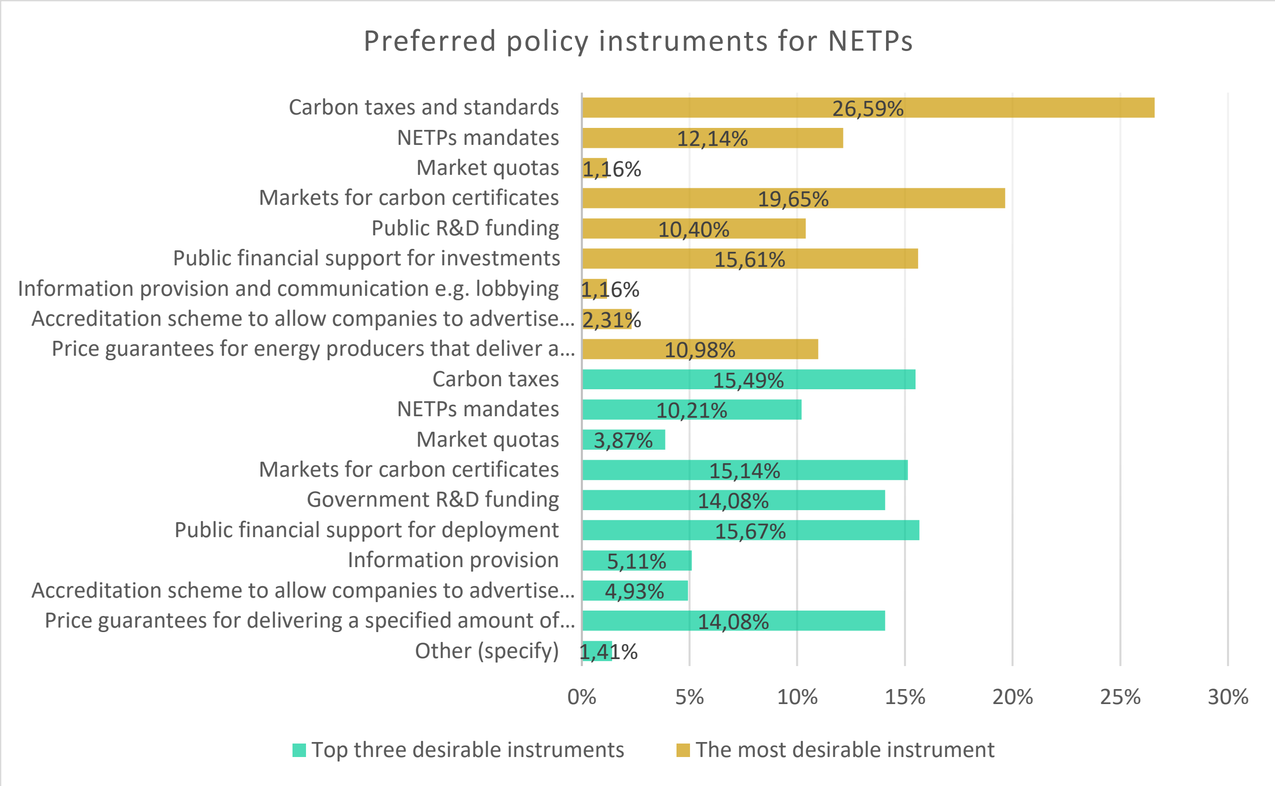


Figure 19. Preferred policy instruments for NETPs

3.1.8 International Fairness

Figure 20 presents respondents' perceptions regarding which types of countries should take the lead in implementing NETPs and their perceived capabilities for doing so. Regarding responsibility for taking action, countries that have emitted the most CO_2 in the past were seen as the most responsible (57%), followed by countries currently emitting a lot of CO_2 (53%). Conversely, in terms of capability, respondents ranked countries with more income and wealth as the most capable (61%) of supporting NETP deployment. These findings indicate a nuanced understanding among respondents of both historical responsibility for emissions and practical implementation capabilities.

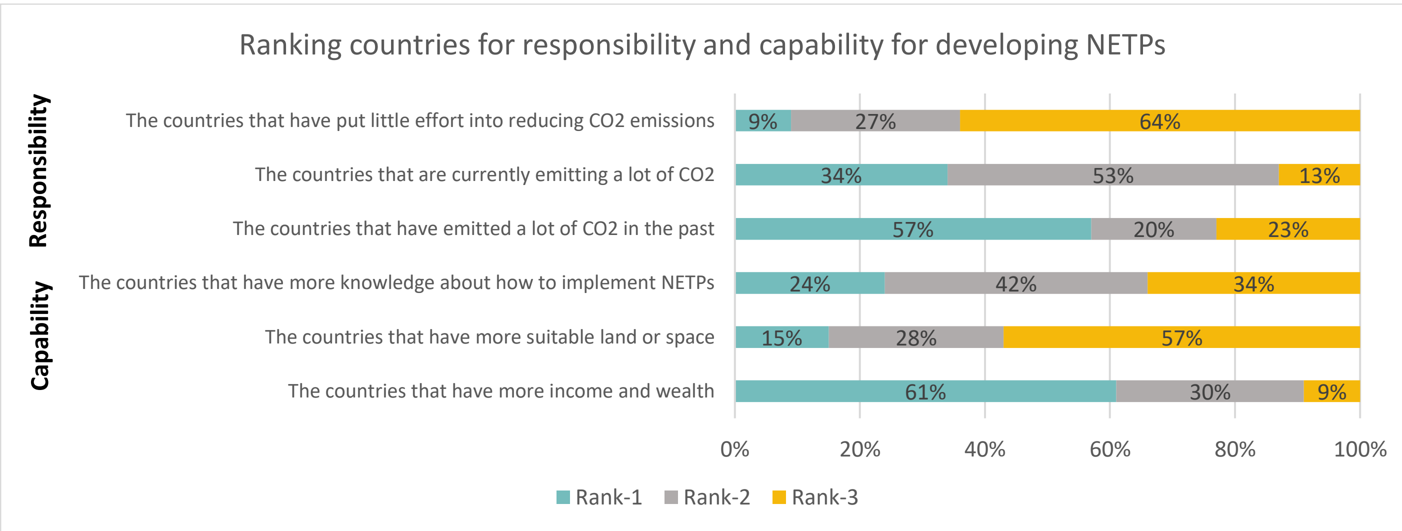


Figure 20. Ranking countries in terms of their responsibility and capability for NETPs

Figure 21 highlights respondents' perspectives on how a country's CO_2 emissions should be calculated for purposes of determining the responsibilities that different countries should have in implementing NETPs. While 12% advocate calculating emissions per country and 23% favor calculating emissions per person, more respondents (33%) suggest using a combination of both measures. Additionally, 32% suggest considering other metrics such as GDP or historical emissions. These results indicate a diverse range of opinions, with a significant portion of respondents advocating for a mixed approach that incorporates multiple factors to assess countries' responsibilities in addressing climate change through NETPs implementation.

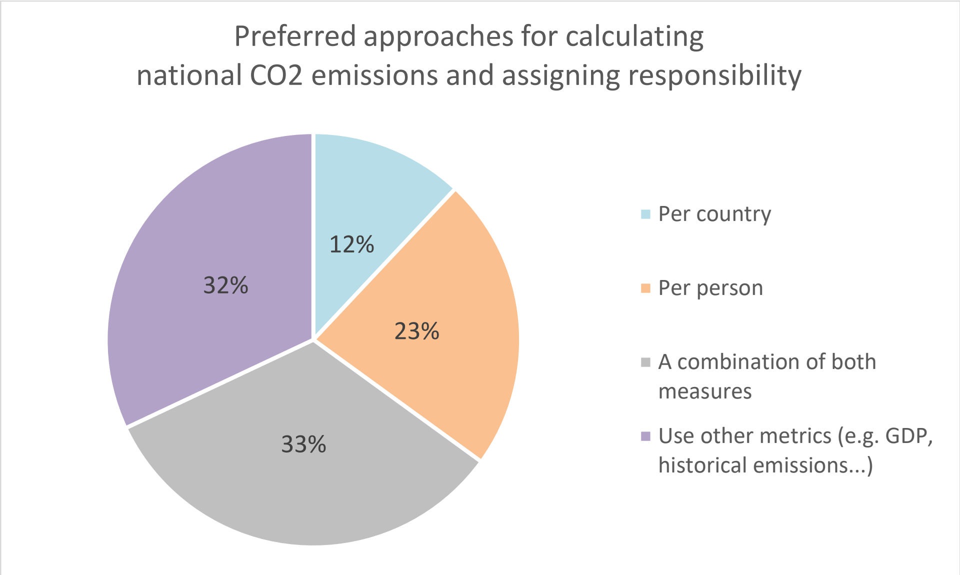


Figure 21. *Preferred approaches for calculating national CO_2 emissions for purposes of assigning responsibility* for implementing NETPs

3.2 Conjoint Results

3.2.1 Pooled Conjoint Results

In this section, we delve into the principal outcomes derived from the conjoint analysis. Initially, we present a broad overview of the results without delineating stakeholder segments, laying the foundation for our analysis. Following this, we investigate sectoral distinctions, placing particular emphasis on the differing preferences between NGOs and private sector entities, thereby uncovering nuanced insights into their respective valuation of NETPs' attributes. Subsequently, our exploration extends to the impact of geographic scope and location, distinguishing between local and global organizations, as well as comparing preferences across various European and global regions, to discern regional trends and differences in priorities. Finally, we employ a clustering approach among our respondents, grouping stakeholders with similar preferences to identify and examine any differences across their dominant demographic characteristics. This structured examination not only highlights general trends and sector-specific priorities but also underscores the influence of geographical and demographic diversity influencing stakeholder preferences towards NETPs. The results are based on 223 responses, as some of the responses were not complete or were excluded for not fulfilling our sampling criteria.

Figure 22 illustrates the preference weightings for each dimension, quantifying the impact of each attribute on the respondent's selection of a preferred NETP project. The scores, which sum to 100, represent the percentage significance of each attribute in the decision-making process. As shown in the figure, the permanence of the CO_2 captured dominates the decision-making process, accounting for nearly 40% of the weight. This is followed by resource use and impact at approximately 22%, cost at 16%, the type of NETP at 12.4%, and finally, the project proponent (10.2% of the weight). This hierarchical representation of attribute importance offers a nuanced insight into the criteria that stakeholders prioritize when evaluating NETP projects, underscoring the relevance of CO_2 permanence above other considered attributes.

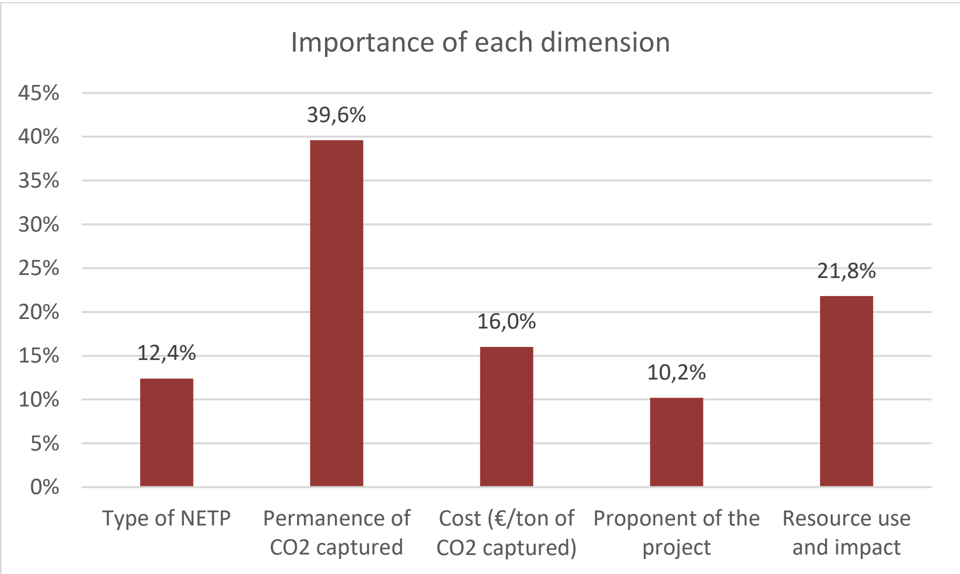
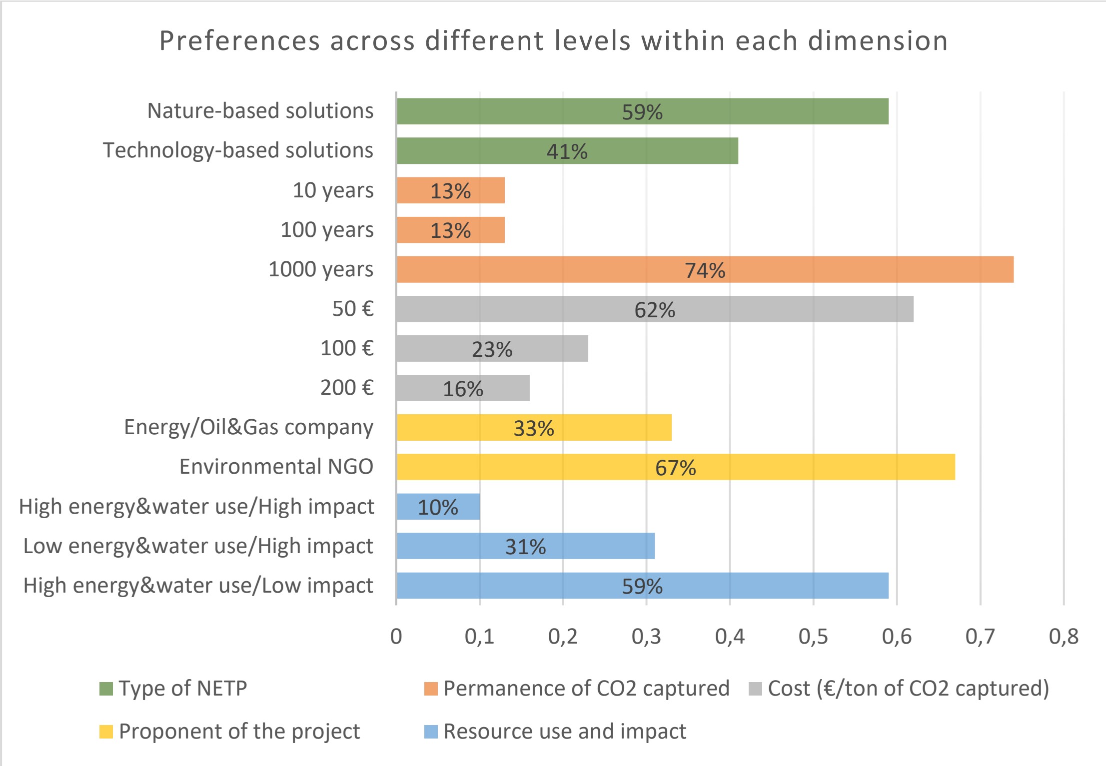


Figure 22: Importance of each dimension

Figures 23 describes respondents' preferences across different levels within each attribute dimension. It highlights a slight preference for nature-based NETPs, which utilize biological storage, over technology-based solutions that employ geological storage, when other dimensions are held constant. By the same token, most technology-based solutions tend to demonstrate much greater permanence, and it also shows a clear preference for higher CO2 permanence levels, emphasizing the value stakeholders place on long-term carbon capture. As expected, stakeholders prefer options with lower costs, again with all other attributes constant. The figure also reveals a distinct preference for projects proposed by environmental NGOs, as opposed to those by energy or oil and gas companies, despite this dimension being less influential in the overall decision-making process. Finally, it depicts preferences related to resource use; notably, high water and energy use with low land impact is favored by 59% of respondents over the alternative of low energy and water use with high land impact, which is preferred by only 31%. This figure collectively demonstrates how varying levels within each dimension influence stakeholder preferences for NETP projects.



Fi*gure 23. Preference across different levels with*in each dimension

The combination of these preferences leads us to delineate the optimal NETP project, based on respondents' preferences, as depicted in Figure 24. The optimal NETP project uses nature-based solutions, has a permanence of over 1000 years, a cost of 50 euros per ton of CO_2 captured, is proposed by an environmental NGO and uses high energy and water but has low impact on land. We acknowledge that the optimal bundle of attributes derived from our analysis does not correspond to any existing NETPs project in its entirety. Nonetheless, the distribution of preferences for each dimension, as illustrated in Figure 22, facilitates a deeper understanding of which features within the optimal bundles are prioritized—namely, the permanence of CO2 capture and the utilization of resources—and which are deemed less critical, including the type of NETPs storage and the identity of the proponent. Drawing on these insights, it can be inferred that stakeholders, on average, would rather compromise on the type of NETP storage and the project proponent, while they would be more reluctant to compromise on permanence and land use. For instance, we can deduce that stakeholders would tend to favour a hypothetical "Project 1", a technology-based NETP that offers relatively high permanence and cost, proposed by a company, and utilizes water and energy resources while minimizing land use impacts, over a "Project 2" that involves nature-based solutions, presents lower permanence and greater land use implications, even when proposed by environmental NGOs and at a lower cost. This is because Project 1, reflecting the characteristics of many DACCS projects, matches the preference for high permanence and low impact of land that is considered a priority by stakeholders in their decision-making process, while Project 2, which aligns with some afforestation projects, matches stakeholder preferences on less prioritized dimensions like type of NETP and project proponent. This rationale allows for the assessment of various existing and potential future NETP projects.

Type of NETP	Nature-based solutions (biological storage of the CO2 captured, into plants or soil)
Permanence of CO2 captured	1000 years
Cost (€/ton of CO2 captured)	50€
Proponent of the project	Environmental NGO
Resource use and impact	High energy & water use / Low impact on land, food security & biodiversity

Figure 24. Optimal bundle

3.2.2 Conjoint Results by Sector

This section delves deeper into the conjoint analysis results by highlighting the variation in preferences among different stakeholder groups. Specifically, we scrutinize the distinctions between private sector stakeholders (73 responses) and those associated with environmental NGOs (66 responses). Figure 25 delineates the significance attributed to each dimension by NGO and private sector respondents, respectively. While both groups prioritize permanence as the paramount dimension, private sector respondents assign it even greater importance, accounting for 42% of their decision-making process, as opposed to 35% for NGO stakeholders. Conversely, NGO members attribute more significance to resource use and impact (23.6% vs. 20.2%) and the choice of project proponent (12.7% vs. 7.7% for the private sector). Additionally, while keeping all other dimensions constant, cost is slightly more pivotal for private sector stakeholders, though there appears to be no marked difference between the two groups in terms of the weight they place on the type of NETP and its storage options.

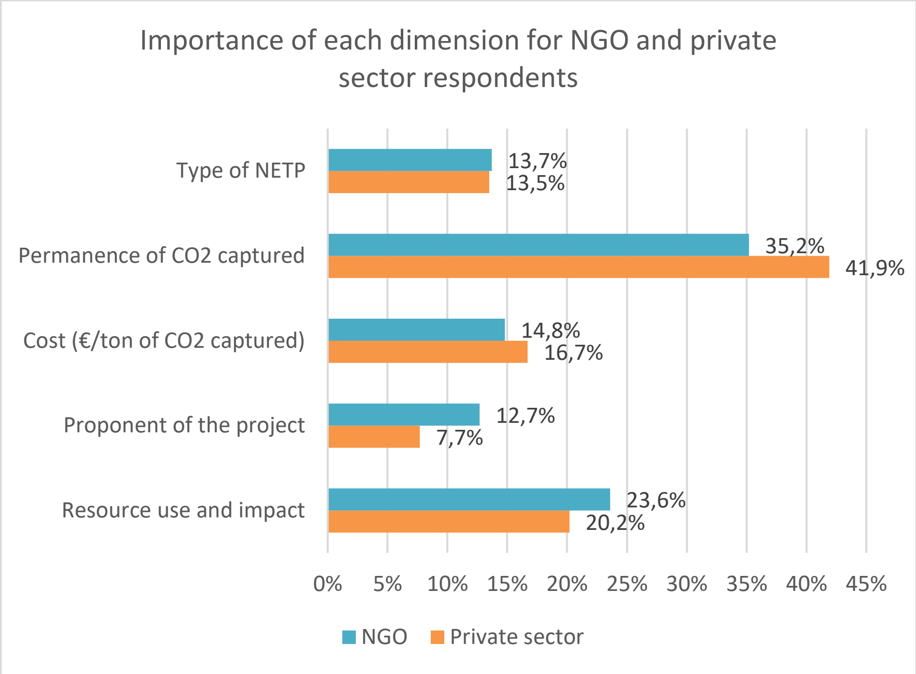


Figure *25*. Importance of each dimension for NGO and private sector respondents

Figure 26 compares the preferences for the different levels within each dimension for NGO and private sector respondents. We can see that both stakeholder groups prefer nature-based solutions over technology-based ones, but this preference is much stronger for NGO respondents (73% versus 57% of preference). Higher permanence is favoured by stakeholders in both groups, but such preference is stronger for private sector respondents (where 81% of respondents favoured the highest permanence, 1000 years, compared to only 68% for NGOs respondents). Lower cost is favoured by stakeholders in both groups (keeping other dimensions constant), but, even in this case, this preference is stronger for private sector respondents (where 69% of respondents favoured the lowest cost, 50 euros per ton of CO_2 captured, compared to only 49% for NGOs respondents). Having an environmental NGO as a proponent is favoured by stakeholders in both groups (keeping the other dimensions constant), but not surprisingly this preference is stronger for NGO respondents (where 74% of respondents favoured environmental NGOs as project proponents, compared to 64% for private sector respondents). Additionally, the data reveal only a marginal difference in the resource use and impact dimension, with a majority in both groups favouring projects that utilize high energy and water but have a low impact on land, over those with low energy and water use but high land impact (and notably over projects with both high energy and water use and high land impact).

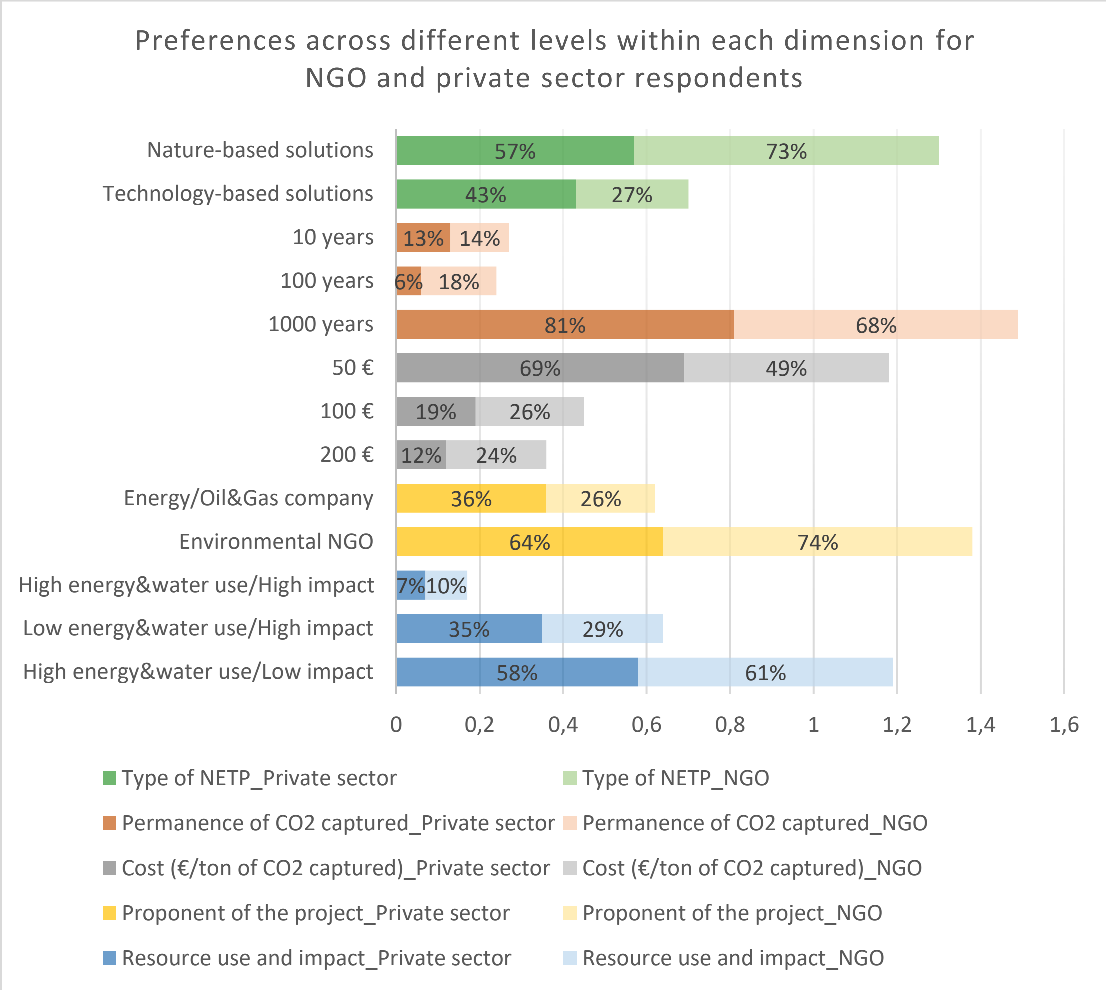


Figure 26. Preferences across different levels within each dimension for NGO and private sector respondents

Interestingly, despite variations in the strength of their preferences, both groups concur on the optimal level for each of the five dimensions examined in our study. Thus, both groups predominantly prefer nature-based solutions that offer higher permanence and lower cost, are proposed by an environmental NGO, and involve high energy and water use with minimal land impact. This consensus across stakeholder groups on the optimal bundle of attributes, represented in Figure 24, indicates a strong and uniform preference for these characteristics in NETPs across sectors.

3.2.3 Conjoint Results by Geographic Scope and Location

In this section, we delve into how preferences vary according to the geographic scope and location of organizations. We compare the views of stakeholders from global organizations to those affiliated with national-level entities. Additionally, we segment responses according to the geographic location of these organizations, analysing differences across various European regions as well as other world regions. This approach allows us to understand how the geographic context influences stakeholder perceptions and preferences towards NETPs. Figure 27 represents the importance of each dimension for global organizations (86 responses) and local organizations (81 responses) respectively.

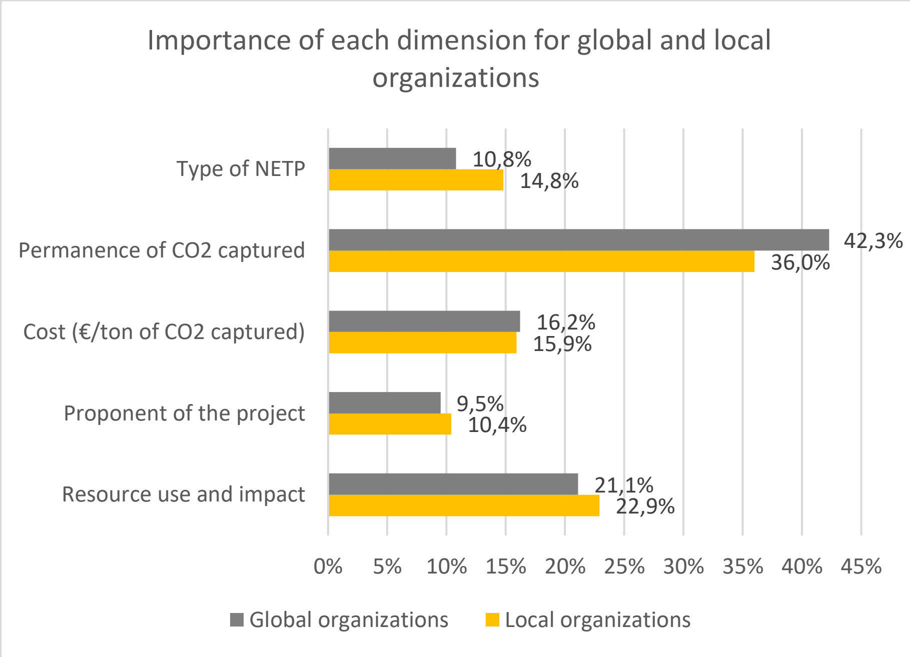
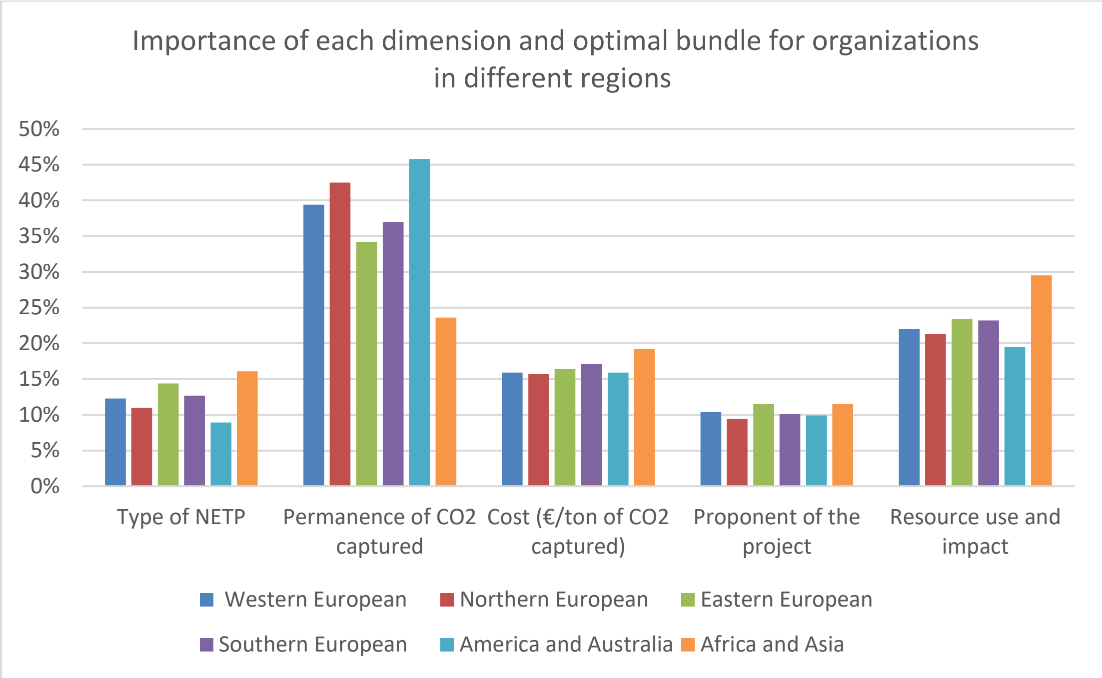


Figure 27. Importance of each dimension for global and local organizations

While both groups prioritize permanence when all other dimensions are held constant, global organizations attribute a higher importance to this dimension (42.3% of the weight compared to 36% for local organizations). Conversely, local organizations assign relatively more importance to the type of NETP, possibly indicating a 'not-in-my-backyard' effect for technology-based NETP projects. Interestingly, the preferred level within each dimension remains consistent across the geographic scope of the organizations, with the optimal bundle for both groups aligning with the one depicted in Figure 24. **This consistency suggests a strong robustness in stakeholder preferences regardless of the organization's geographic scope.**

Additionally, we explore variations in preferences among organizations based in different European regions. Figure 28 shows the importance assigned to each dimension and the optimal bundle as per the 98 respondents from organizations in Western Europe (including the United Kingdom, France, Germany, Ireland, Austria, Switzerland, the Netherlands, and Luxembourg). Given that this group is the most represented in our sample, their preferences and results unsurprisingly echo the general findings presented in section 3.2.

However, notable differences arise when examining other geographic areas within Europe. Figure 28 highlights both the relative significance of each dimension and the optimal attribute bundle for the 33 respondents from organizations situated in Northern Europe, encompassing countries like Finland, Iceland, Norway, Denmark, and Sweden. Among this cohort, the dimension of permanence stands out as particularly crucial, claiming a more significant portion of decision-making weight at 42.5% compared to other European regions. Intriguingly, while the nature of the NETP (whether technology-based or nature-based) holds less sway in the overall decision process for this group, their preference distinctly leans towards technology-based solutions over nature-based ones, even when other dimensions remain unchanged. This trend highlights Northern European stakeholders' inclination towards approaches that eschew reliance on natural carbon sinks, possibly reflecting a concern over the balance between optimizing natural carbon sequestration capacities and preserving other ecosystem services, such as biodiversity. Moreover, in Finland and Sweden, the forest industry is a powerful stakeholder and they have expressed concern that carbon sequestration will be prioritized in Nordic forests, leading to negative impacts on the industry.



Type of NETP	Nature-based solutions (Western/Eastern/Southern European organizations; America and Australia organizations)
	Technology-based solutions (Northern European organizations; Africa and Asia organizations)
Permanence of CO2 captured	1000 years
Cost (€/ton of CO2 captured)	50
Proponent of the project	Environmental NGO
Resource use and impact	High energy &water use / Low impact on land, food security & biodiversity

Figure 28. Importance of each dimension and optimal bundle for organizations in different regions

In contrast, the preferences of the 29 respondents from organizations based in Eastern Europe—including countries like the Republic of North Macedonia, Serbia, Croatia, Poland, Latvia, Estonia, and Lithuania—differ slightly. While permanence of CO2 captured remains the most crucial dimension in their decision-making process, these respondents place relatively more importance on the other dimensions than their Western and Northern European counterparts. As illustrated in Figure 28, the optimal bundle for Eastern European respondents aligns more closely with that of Western European respondents, indicating a shared preference for nature-based solutions, unlike stakeholders in Northern Europe. This suggests nuanced regional variations in prioritizing NETP attributes, with Eastern Europeans showing a broader consideration beyond mere permanence.

Figure 28 presents the data from 19 stakeholders associated with organizations in Southern Europe, covering countries such as Italy, Spain, Greece, and Cyprus. This group appears to place a greater emphasis on cost, which accounts for more than 17% of the total weight in their decision-making process. This increased focus on cost compared to other geographic areas may reflect lower per-capita incomes and the limited public budgets prevalent in these regions. The optimal bundle, in this case, aligns with Western European stakeholders.

When comparing the preferences of respondents based in Europe with those from outside Europe, Figure 28 reveals that the 27 respondents from organizations located in North America, South America, or Australia place the greatest emphasis on the permanence dimension, which accounts for nearly 46% of the decision-making weight. They also place relatively less importance on the type of NETPs. Even in this comparison, the optimal bundle preferred by these respondents aligns with that of Western European stakeholders, indicating a shared priority on the permanence of CO2 capture across diverse geographic regions.

Lastly, Figure 28 presents the importance of each dimension and the optimal bundle for respondents from organizations located in Asia or Africa, noting that this group comprises only 5 respondents in our sample. Therefore, the representativeness of these responses should be approached with caution. Intriguingly, for these respondents, permanence is not deemed the most critical dimension, accounting for just 23.6% of the decision-making weight. Instead, the most significant factor is resource use (accounting for 29.5%), particularly emphasizing low impact on land as highlighted in their optimal bundle. This preference may suggest a recognition of the potential adverse effects of land acquisition practices in these geographic areas and a version of the traditional food versus fuel dilemma (Tomei & Helliwell, 2016). In this case, the tradeoff is between allocating land for NETP projects versus ensuring food security for local populations. Additionally, there is a preference for technology-based solutions over nature-based ones among these stakeholders, possibly indicating a hesitance to exploit natural resources for carbon sequestration.

All in all, our findings highlight a significant geographic variability in the importance attributed to various dimensions of NETP projects, as well as in the preferred levels of these dimensions among different stakeholders. This variability is influenced by both the geographic location of the stakeholders and the geographic scope of their organizations. These insights are crucial for policymakers, underscoring the need to consider geographic context when designing and implementing policies related to NETPs.

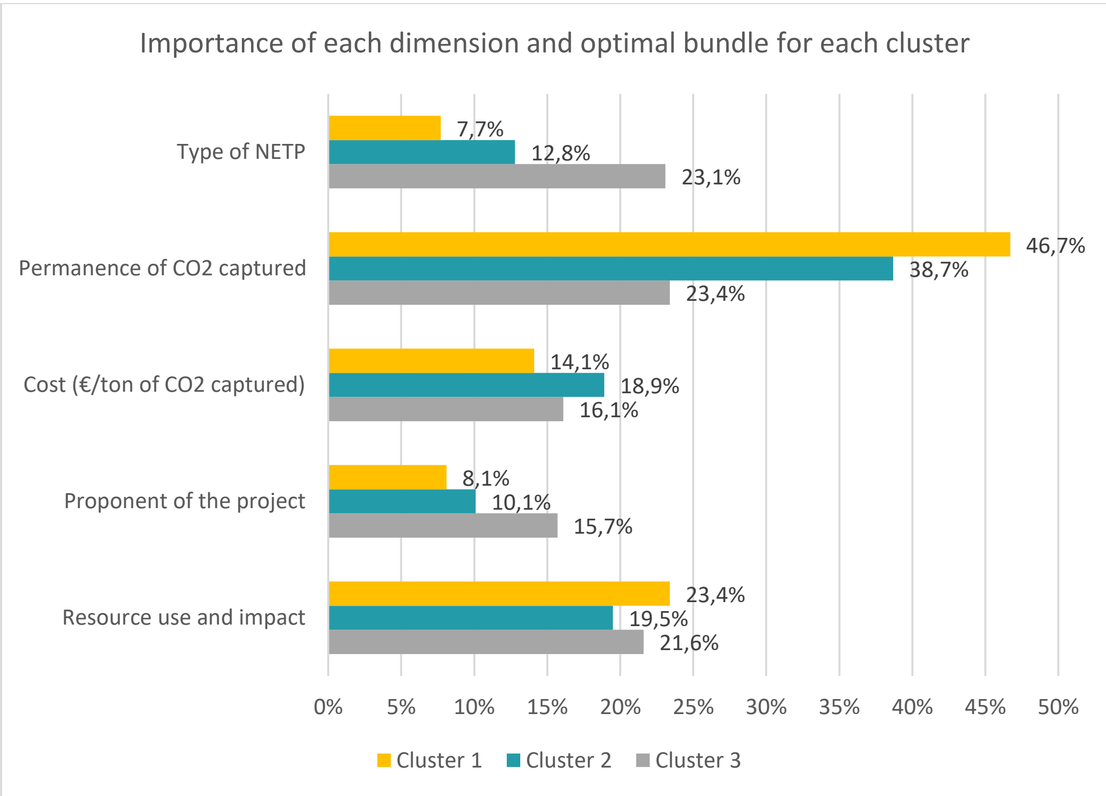
3.2.4 Conjoint Results by Clusters

In this subsection, we delve into the analysis of stakeholder preferences through a different lens—clustering. Moving beyond the traditional segmentation based on single characteristics such as stakeholder type or geographic scope, this approach enables us to consider multiple demographic attributes simultaneously. Our clustering analysis reveals three main groups of stakeholders who exhibit similar response patterns in the conjoint analysis. For each cluster, we have identified and extrapolated the most prevalent demographic characteristics. This multidimensional analysis offers a nuanced understanding of stakeholder preferences, enriching our insights into the complex landscape of opinions and priorities surrounding NETP projects.

Figure 29 displays the preferences for Cluster 1, the most sizable group with 90 respondents. These individuals assign the greatest importance to the permanence of CO_2 sequestration, which constitutes 46.7% of their decision-making weight, and also prioritize resource use—particularly valuing low impact on land, which accounts for 23.4%. Their preferred bundle matches the general results, reflecting this cluster's large size and its representativeness of our overall sample. Demographically, Cluster 1 predominantly consists of individuals from the private sector in global organizations based in Western regions, who possess a moderate level of knowledge about various NETPs. The most common age range within this cluster is 35 to 44 years, with many holding senior management positions in their organizations.

Figure 29 also showcases the preferences of Cluster 2, which comprises 77 respondents. Like Cluster 1, these participants emphasize the importance of CO_2 sequestration permanence, contributing 38.7% to their decision-making weight, and resource use, with a particular focus on low land impact at 19.5%. However, they attribute greater significance to cost (18.9%), type of NETPs (12.8%), and project proponent (10%) compared to the first cluster. Their preferred bundle leans towards technology-based solutions, diverging from Cluster 1's preference for nature-based solutions. Demographically, Cluster 2 mainly includes individuals from the private sector in nationally focused organizations based in Western regions, with a moderate to high knowledge level of various NETPs. Unlike Cluster 1, the most frequent age range in this cluster is 55 to 64 years, and many occupy research-oriented positions within their organizations, underscoring a more technical background.

Finally, Figure 29 illustrates the preferences of Cluster 3's respondents. These stakeholders distribute their importance more evenly across dimensions compared to the other clusters. The permanence of CO2 sequestration, the type of NETPs—with a preference for nature-based solutions—and resource use, favoring a low impact on land, each command a weight ranging from 21.6% to 23.4% in their decision-making process. The significance they place on cost and the project proponent is also relatively high, at around 15%. This distribution suggests that these stakeholders value all dimensions considerably. Contrary to expectations, their preferred bundle leans towards solutions with lower permanence and higher costs. Demographically, Cluster 3 is mainly composed of individuals from European NGOs with a national focus, possessing moderate to low levels of knowledge about various NETPs. The predominant age range in this cluster is 35 to 44 years.



	Pane (a) - Cluster 1	Pane (b) - Cluster 2	Pane (c) - Cluster 3
Type of NETP	Nature-based solutions	Technology-based solutions	Nature-based solutions
Permanence of CO2 captured	1000 years	1000 years	10 years
Cost (€/ton of CO2 captured)	50 €	50 €	200 €
Proponent of the project	Environmental NGO	Environmental NGO	Environmental NGO
Resource use and impact	High energy &water use / Low impact on land, food security & biodiversity	High energy &water use / Low impact on land, food security & biodiversity	High energy &water use / Low impact on land, food security & biodiversity

Figure 29. Importance of each dimension and optimal bundle for each cluster

Through the lens of these three distinct clusters, our analysis unveils diverse stakeholder groups within the NETP discourse, each with unique preferences and priorities shaped by a blend of demographic characteristics, organizational affiliations, and knowledge levels. This nuanced understanding emphasizes the complexity of stakeholder perspectives on NETPs and underscores the importance of tailoring communication and policy approaches to effectively engage with the varied segments of the stakeholder population.

4. Conclusions and policy recommendations

As our ability to meet an ambitious temperature target rests increasingly on substantial deployment of NETPs, rapid scale up should be crucial. Yet current deployment scales – particularly for newer technologies that have the highest potential capacity to deliver negative emissions – lag significantly behind Paris-compliant levels. While some of this undoubtedly stems from important technical, economic and commercial challenges – especially in for technology-based NETPs which face high (short-term) deployment costs – deployment is also obstructed by key stakeholder attitudes. In particular, given that substantial coordination, governance, and financial support is needed to initially drive roll-out, it is likely that upscaling, in the short-term at least, will require significant public and corporate involvement. In this context, expert assessments about the desirability and optimal role of different types of NETPs and the underlying value afforded to key attributes that make up these options (geological vs. biological storage of captured carbon, storage permanence, cost, project proponent and resource use and impact) are likely to be influential drivers of deployment trajectories. Our analysis of expert stakeholder attitudes towards NETPs raises several important policy implications for upscaling efforts.

4.1 Carbon storage permanence and resource impacts

The pooled results of the conjoint experiment showed that expert stakeholders were most likely to be supportive of NETPs projects if they provided permanence carbon storage (of 1000+ years). While secondary to carbon permanence, stakeholders also assigned substantial weight to the resource use and impact of the NETP project and were generally more supportive when a project used high energy and water and had low impact on land, food security and biodiversity. Although such a technology (high permanence and low land impact) has not been developed, these results suggest important insights for potential NETPs options that could emerge at different time horizons. In the near-term, out of existing operational facilities and pipeline projects, the optimal bundle results suggest that the (current) best contender might be CCUS-based options which involve some sort of permanent non-land-based storage medium such as cement to bypass the undesirable land impact. While, hypothetically, both BECCS and DACCS could be combined with utilization options that facilitate non-land based storage, the relative location-autonomy of DACCS offers an important advantage in this regard. In contrast, nature-based solutions which are both land-intensive and offer non-permanent carbon storage are likely to be viewed least favorably. However, given the significant investment in NETPs R&D and technological learning rates, it is possible that technological development could result in the emergence of novel NETP options that offer both permanent and non-land intensive negative emissions. For example, advances in the storage permanence potentials of ocean-based carbon dioxide removal options could present more permanent, low-land, but water-intensive carbon storage options that align with the optimal bundle identified in this study.

4.2 Sectoral consensus

The sectoral analysis revealed that stakeholders who work in different sectors hold largely similar views towards NETPs and afford similar weight to the different attributes that make up NETPs. In particular, we found that respondents from the private sector and NGOs gave primacy to carbon storage permanence and resource use and impact, which suggests that configurations that possess this optimal pair of attributes are likely to attract widespread support from experts. This somewhat encouraging finding diverges from past research, which, although scarce, tends to suggest that attitudes towards NETPs differ more widely across different sectors compared to our study. For example, Romanak et al.'s (2021) expert elicitation analysis find that business actors tend to view BECCS more favorably compared to environmental NGOs, which tend to be opposed. Similarly, qualitative analyses of stakeholder attitudes towards DACCS (Erans et al., 2022) and NETPs more broadly (Clulow & Reiner, 2022) are suggestive of wider divergences. Therefore, in contrast to most studies, our results suggest that configurations which offer permanent carbon storage and non-land intensive negative emissions could help resolve potential trade-offs presented by different NETPs and reduce, rather than widen attitudinal gaps between expert stakeholders. The potential for certain attribute bundles to reduce, rather than widen gaps between expert stakeholders could prove to be a critical advantage for upscaling in comparison to a more polarized hypothetical scenario where different stakeholders had strong conflicting attribute preferences (e.g. environmental NGOs gave most importance to resource use the private sector prioritizes costs).

4.3 Environmental NGOs and trust-building

Although not a primary attribute for most stakeholders, our results suggested that respondents from both the private sector and environmental NGOs were more supportive of NETPs projects when they were proposed by environmental NGOs as opposed to energy/oil and gas companies. This finding coheres with past research, which suggests that a lack of trust in the private sector (even among individuals working in the private sector) can often constrain the social feasibility of greenhouse gas removal technologies (Cox et al., 2020a). The obvious policy implication is that involvement by environmental NGOs in NETPs projects could help increase social acceptability among experts. More broadly, experience with other potentially controversial technologies such as wind energy, GMO food and fracking suggest that involvement by trusted actors such as environmental NGOs are often critical for building support among other key stakeholders such as consumers (Biresselioglu et al., 2020) and national publics (Cox et al., 2022; Rayner, 2010).

4.4 A tailored approach

While our analyses showed that stakeholders across Europe tended to agree that carbon storage permanence and low-land use/impact are the top two priorities for NETPs projects, our disaggregated analysis of smaller geographical samples highlighted some important nuances across different groups of countries.

First, while not a top priority attribute for any of the geographical samples analyzed, a small number of country groups (namely North Europe and Africa and Asia) preferred technology-to-nature-based solutions. Past research suggests that a preference for technological based solutions might be attributable to higher deployment of and familiarity with related or analogue technologies. This might apply, for example, to North Europe, which includes some of the leading countries in CCS deployment globally such as Denmark and Norway (Xenias & Whitmarsh, 2018). However, most of our results suggest the very opposite may be true as stakeholders in most geographies that deploy high shares of NETPs and other decarbonization technologies (such as West Europe and America and Australia) tend to prefer nature-based solutions. As proposed by past research, the preference for nature over technology-based solutions might reflect an effort to counter-balance GGR options where deployment has followed a faster trajectory (Karimi, 2021). Similarly, on the other end of the spectrum, the strong preference for technological solutions among stakeholders based in Asia and Africa might stem from negative experiences and distrust of past nature-based mitigation activities under schemes such as the CDM and REDD+ (Aggarwal & Brockington, 2020).

While past and existing deployment might explain some of the geographical variation in attitudes towards different types of NETPs, geophysical/resource constraints are also likely to play a role. Indeed, we found that stakeholders around the world rated resource use/impact as the most (Africa and Asia) or second most (all other regions) important NETP attribute. This coheres with past research on relevant technologies, which shows that stakeholder attitudes across Europe are closely associated with geophysical characteristics such as land availability (Karimi, 2021). In relation to DACCS and BECCS, land availability for storage appears to be a critical attitudinal driver as suggested, for example, by high support in Norway and Finland, where storage is seen as much more available, in contrast to Germany, where land is a constraining factor (Karimi & Komendantova, 2017).

Furthermore, and while noting that our analysis included a disproportionately small number of stakeholders from Africa and Asia, our results revealed that, unlike respondents from Europe and America and Australia, experts from the global South rated resource use and impact as the top priority, over carbon storage permanence and all other attributes that make up the bundle. While most past analyses of NETPs attitudes do not engage with southern perspectives, the handful of studies that do find that developing country perspectives are much more critical of land-intensive NETPs. The recent study by Jaschke and Beirman (2022), for example, suggests that multinational companies (MNCs), NGOs and policymakers from the global South are significantly more opposed to BECCS and afforestation/ reforestation (AR) compared to their northern counterparts. As suggested above, while this valuation is likely a reflection of the adverse effects of past climate mitigation initiatives on local/national resources, the prioritization of resource trade-offs over other key attributes could also be rooted in different national or regional visions of climate ethics and global justice frameworks for distributing responsibility for negative emissions. Indeed, it is increasingly recognized that visions of equitable solutions for allocating carbon dioxide removal quotas are likely to vary widely across different countries (Peters & Geden, 2017; Pozo et al., 2020). Therefore, and given the critical role that developing countries are likely to play in hosting many key NETPs, our results underline the importance of engaging with stakeholders from the global South with a view to understand nationally or regionally-specific concerns and tradeoffs that are likely to give rise to divergent perspectives towards what might be perceived as (in)just frameworks for governing NETPs globally. More broadly, the attitudinal nuances exhibited between different geographies in our analysis underline the importance of national experiences with related energy technologies, resource endowments and values in shaping stakeholder perspectives towards NETPs and acceptable trade-offs. Therefore, the results of this study suggest that upscaling efforts are likely to be more successful if they are flexible and accommodate divergent national conditions.

4.5 Knowledge and the value of carbon storage performance

Our cluster analyses provide some indication that knowledge about NETPs is associated with prioritization of carbon storage permanence. While all clusters rated permanence as the most important attribute, there were important differences in the relative weight given to this attribute across clusters with divergent (self-declared) levels of knowledge of various NETPs. Respondents with moderate to high knowledge (clusters 1 and 2) tended to give higher ratings of the permanence attribute whereas, by contrast, respondents who rated their NETPs knowledge as low (cluster 3) gave notably less – around half – the level of importance to permanence. **These findings suggest that more knowledge about NETPs (and presumably greater understanding about the carbon cycle, rationale for carbon removal and the importance of carbon storage permanence) could potentially increase support for CDR options that offer permanent carbon storage**. By the same token, more knowledge might reduce support for less permanent nature-based options such as AR and soil carbon sequestration (SCS). This could prove critical for social acceptability among national publics and local communities, as information campaigns about the potential of long-term carbon storage in meeting climate targets could garner support for key NETPs. While public awareness of NETPs is still low, experts working in the European climate/energy industry increasingly assert that public education and knowledge sharing around energy transition and DACCS, in particular, are crucial for meeting national climate goals and upscaling (Bates et al., 2023; Koukouzas et al., 2022).

4.6 Social feasibility modelling

While a rich literature considers the tradeoffs associated with NETPs, most of these analyses are based on techno-economic assessments of different options (Fuhrman et al., 2019; Fuss et al., 2018). Our analysis identifies a number of divergences among expert stakeholders, which, even among this relatively select profile of respondents, suggests that perceptions of NETPs tradeoffs can vary widely. This gives rise to an important policy implication: as discussed above, since it is widely accepted that experts (especially from the private and public sectors) are expected to play an important role in at least initially driving upscaling, expert predictions and attitudes towards NETPs are likely to have an important bearing over deployment trajectories and our long-term ability to meet Paris-compliant targets. Indeed, deliverable 5.4, for example, argued that expert uncertainty was a major barrier for investment in NETPs. Therefore, the attitudinal divergences analyzed by this study suggest that expert stakeholder attitudes should be incorporated as (social) feasibility parameters into techno-economic assessments of deployment predictions and climate modelling.

5. Limitations and suggestions for future research

This work provides insights into attitudes towards NETPs and the trade-offs that are associated with different options among European expert stakeholders. Yet, due to the limited scope and length of this report, our analysis is inevitably limited in some respects.

First, while our sample includes experts from around the world, in accordance with the scope of this study, most respondents were based in Europe. Yet our results showed that opinions on trade-offs raised by different NETPs varied (sometimes widely) among even this relatively select group of respondents. These divergences, coupled with our comparison of European attitudes against our smaller samples from non-European geographies, suggest that attitudes towards NETPs are likely to vary even more widely as the geographical scope of analysis expands. **Therefore, our findings highlight the need for more research into attitudes towards NETPs and perceived optimal bundles from different parts of the world, particularly the global South**. Wider geographical analyses are likely to identify different attributes that need to be considered alongside or possibly even instead of some of the attributes considered in this study such as, for example, integrability with existing infrastructure, potential to increase/reduce energy access, and cultural values and visions of justice.

Similarly, in accordance with the scope of this deliverable, our analysis focused on expert stakeholder attitudes. Yet, as discussed above, other stakeholders are likely to be influential in shaping the social acceptability of NETPs. Notably, and as demonstrated by other related technologies such as CCS, national publics, while largely unaware at present, are expected to play a critical role in deciding the fate of individual projects and deciding which proposals eventually go on to become and remain operational. Therefore, a potential angle for future research is to compare attitudes across expert and public stakeholders to compare their attitudes towards trade-offs raised by negative emissions options.

Relatedly, our results are suggestive of some associations between knowledge of NETPs and attitudes towards hypothetical projects and trade-offs. While we were not able to examine the association in this report, our results suggest that further research should be conducted to understand the potential linkages. Moreover, with upscaling, awareness and knowledge about climate change and options for addressing it (including NETPs) is likely to rise, both among expert stakeholders and publics. It would be interesting to study whether knowledge is associated with consistent or divergent attitudes across different stakeholders, which could help set accurate expectations about the potential attitudinal consequences of information campaigns on different stakeholders. Recent research in this space identifies a need for greater understanding of local attitudes to assess which attributes shape attitudes among host communities at subnational levels. Though limited research has been done on this, early findings suggest that different attributes relating to expected local co-benefits and adverse effects are likely to be most important for localities. This is particularly relevant for the NETPs that our findings suggest are viewed more favourably by experts (options that deliver high permanence and low land use such as, potentially, DACCS and BECCS with non-land based CCUS) as these options do not necessarily provide clear benefits, and on the contrary, might be associated with potential adverse research impacts for local communities. Past studies suggest that the absence of (expected) local benefits is likely to be a critical factor for determining the social acceptability of key technology-based NETPs (Cox et al., 2020b; Scott-Buechler et al., 2023). Therefore, there are strong reasons to expect that the attitudes of our expert stakeholders are likely to diverge in important respects from local stakeholders.

Another caveat is that the conjoint experiment in our study did not compare NETPs against behavioural options or other classical mitigation options such as improving energy efficiency for decarbonisation. Doing so would have required a different (broader) set of attributes and, as suggested by past research on stakeholder preferences between NETPs and classical mitigation (Cox et al., 2020b; Perdana et al., 2023), would likely reveal that different attributes (including some that are non-specific to NETPs) influence attitudes towards NETPs and the wider portfolio of options for meeting net zero targets.

As understandings of key stakeholder attitudes towards NETPs improve and social feasibility is increasingly regarded as an important determinant of upscaling, there are obvious grounds for exploring the processes and channels through which stakeholder attitudes influence actual deployment. Recent studies have started addressing these sorts of questions, including, for example, project deliverable 5.4, which explores the potential implications of expert expectations about future DACCS and BECCS costs and scalability against net-zero compliant benchmarks.

6. Deliverables considered

In preparing this report, the following deliverable/s have been taken into consideration:

D#	Deliverable title	Lead Beneficiary	Type	Dissemination level	Due date (in MM)
2.2	Interactions and trade-offs between nature-based and engineered climate change solutions	UOXF	R	Public	17
3.3	Global assessment of NETP impacts utilising concepts of biosphere integrity	PIK	R	Public	36
3.5	Literature assessment of ocean-based NETPs regarding potentials, impacts and trade-offs	PIK	R	Public	24
3.7	Global impacts of NETP potentials on food security and freshwater availability, scenario analysis of options and management choices	PIK	R	Public	36
3.8	Report on comparative life-cycle sustainability assessment of NETPs for impacts on human health, ecological functions and resources	PIK	R	Public	24

5.1	Measuring Social License to Operate for Different NETPs	UCAM	R	Public	18
5.2	Stakeholder views on the business case for NETPs	UCAM	R	Public	24
5.3	Stakeholder views on NETP governance	UCAM	R	Public	18
5.4	Final Report on Expert Elicitation for NETPs	UCAM	R	Public	36
7.2	Extended MONET-EU	ICL	R	Public	17

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Appendix

A.1. Qualitative comments from respondents on survey

1. I found interesting to work on these answers. This is not always easy as I had the feeling that some questions on technical cases were similar from one panel to the other. As a summary on the involvement of the different actors I think that the role of private sector is important to find the right ways to remove and we should not separate too much the mitigation actions and removal actions as they use sometimes same technologies; Also, a question: to which an obligation of removal should be decided? Suppose an industrial actor which does not emit anymore CO2 or GHG. Should it be constrained by a removal obligation and trade? At last, what is the role of NGOs in this business: advocacy or demonstration projects? Some NGO's can show the way but the real work will be insured by public support, R&D and real demonstration projects by industry in order to be able to deploy these technologies.
2. My company is developing scalable liquid air energy storage and regeneration to enable global power grids to be completely decarbonised. Our new technology also incorporates CO2 capture from the processed air at negligible additional cost. When fully implemented this will not only solve the problem of enabling global power grids to depend fully on renewables but also achieve the IPPC target of extracting 10 gigatons of CO2 from the atmosphere per year to repair the climate. Why is this solution not offered in your survey?
3. Quite a lot of questions on other things than NETPs...
4. Ambiguous complex and biased questions. Costs and resource use in particular are exaggerated for the different strategies, and some in bold font. The survey is clearly designed to elicit positive views about nature-based solutions, and lacks any serious mention of the fact that they are almost impossible to measure and verify.
5. very interesting questions!
6. Focus on Ecosystem based approaches that involves participation of local communities over large corporations
   (1) Criteria for supporting carbon removal project should focus on scalability, security of permanence 10, 50, 100, ..., impact, growth and business opportunity (2) Developed countries and countries with high knowhow in technologies and their implementation should focus on implementing those technologies; Regarding the climate change development, we need a complementary approach of all technologies, but prioritizing them after scalability hence cost and rewards; (3) Different policies are possible, important is that there is a future business case, because from a market point of view, subsidies won't be the future; (4) Technologies must replace conventional technologies to become a business as usual;
7. I'm not sure that there should be responsibility for implementing CDR. Instead, we should limit or tax emissions, and those who can afford to pay for it should, and those who can profitably implement (with regard to other externalities) should do so. It will be a global industry, or at least it's hard to see how if developed it will not be. Moral responsibility is a different question.
8. It is very regrettable that BECCS and DACCS are conflated in the questions, these two technologies have very different risk profiles and maturity.
9. Some of the options would depend on context and which NET technology is in focus. Thus, a bit hard to focus. Also, not straight forward with a climate policy on NET since the value of negative emissions will benefit all but the cost will be taken by the actor who contribute with the negative emissions (at least if individual actors)

10. Question regarding NETP decision making and involving public is not clear. Desired by whom? EC, lobiyists, political parties or multinational investment companies... Please take in consideration current changed geopolitical situation that is lacking realistic global climate consensus. In this context, EU (and the west) should invest in technologies that are also beneficial to economy (forestry, biomass and soil solutions) and decrease or substitute use of fossil fuels. This is not a part of your study questions! Substitution of materials, local self-sufficient communities, investing in social-general well-being of society, human values. Economy and the market decision makers are not prepared to decrease consumption. Only decisions on individual level can be promoted and be expected. There are no projects and incentives on the topic of promotion of human values. Climate and the earth cannot be saved by more greedy people doing business as usual and not taxing where we should and could. We must start supporting green cost-effective solutions chosen by responsible humane individuals. How do I buy eco-friendly product if I do not know it's CO2 impact or substitution effect. Are electric cars really that green if electricity is not calculated and not green? Is using wood in limits of forest increment with increasing growing stock really pollution? A lot is misunderstood at top level of decision making. Or is it?
11. There is a huge difference between BECCS and DACCS in terms of the energy balance: while BECCS can be applied in energy-limited settings, DACCS can be sensibly implemented only in energy-abundant settings. As our energy supply is >80% fossil-dependent, emission reduction should be preferred to DACCS, while BECCS can be done straightforwardly within the limitation of sustainable biomass production. Messing up the two options in the survey is problematic in my view.
12. I do not think the question about "features of the countries from most responsible to least responsible for implementing NETPs" is well founded. I don't think there is a responsibility to implement NETs linked to current or historical emissions, but rather to capabilities (knowledge, financing, etc.)
13. Promotion of Photosynthesis in Oceans, i.e., cultivation of Diatom Algae in Oceans, is not mentioned as a nature-based solution. Growing Diatom Algae in Oceans is similar to afforestation / reforestation on land, so it ought to have been mentioned.
14. This survey claimed to be "a research project to inform European policymakers about the realistic potential and risks of deploying carbon dioxide removal (CDR) in European climate policy." In reality it is a survey about perceptions, and not about the reality of realistic potentials and risks. There are real risks with some NETs at scale, and each approach has advantages and disadvantages. The public perception of those risks and the understanding of the potential is very different from what informed people know to be the case. This is a huge flaw in the survey. The results can legitimately be used to inform communication on policy, but the results should not be used to inform policy. For that, you should speak in detail with experts about their technologies. --- Additionally, NETs should be considered an opportunity, not a responsibility. Who pays for the carbon removal is a different question - should it be the country/individual who is emitting the most carbon now, or has emitted most historically? Think of carbon removal as garbage collection. We all need to stop putting garbage in the atmosphere, and everyone needs to pay their fair share for their garbage collection. That will mean that the countries/companies/individuals who have emitted the most should pay the most. This is a huge opportunity for historically disadvantaged groups/countries to provide carbon removal services and reap the gains with that service.
15. The implementation of negative emissions technology is an opportunity. The questions should be asked about who should fund them - who should be responsible for paying for creating and operating negative emission technology. All countries, companies and all individuals have a responsibility to get to net zero - NETs are one tool that they can help mitigate for very hard-to-abate emissions.
16. European wide initiative to support start-ups for carbon removal.
17. Feel free to add Improved Forest Management (IFM) to the nature-based solution methods

18. We should work on the development of clean and green energy technologies to reduce carbon foot prints throughout world. Set goals and work relentlessly.
19. For me it's not just about CO2 per person, but should be the CO2 associated with the goods consumed and not just the CO2 produced in a certain country. I think developed countries inhabitants should be held responsible for the emissions they create by consuming goods that are produced in the developing world
20. The selection questions about allocating resources to hypothetical scenarios make little sense, as many of them had no real-world analogues. Decisions about deployment should be based on other factors than the ones listed, such as cost-effectiveness and co-benefits.
21. Many of the options did not align with my knowledge of GHG reduction technologies and methods. I had to force myself to choose answers on the basis of "which of the options offered is the least daft"
22. Very indicative questions in this survey!
23. Some questions such as the selection of project were hard to decide on the basis of given information when the risk is not quantifiable.
24. the examples seemed infeasible at times, could not think of a real life (real NET) example that would match the proposed combo of permanence, price, type.