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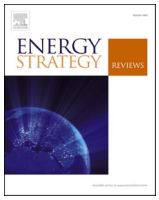

Policy support platforms on climate change mitigation and adaptation: An assessment framework

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ABSTRACT

While numerous platforms have been developed to support climate action, structured evaluations of their design remain limited. This paper presents a novel assessment framework for evaluating climate change mitigation and adaptation policy platforms. The framework includes 43 criteria that are structured around nine design requirement categories, including transparency, ease of use, interactivity, and accessibility. It is applied to ten policy platforms developed under the EU Horizon 2020 programme. Results show that while most of the examined platforms perform strongly in transparency, communication of complex information, and education, they consistently underperform in areas such as active maintenance, security, and accessibility. These findings highlight key areas for improvement by platform developers and funders. In parallel, they demonstrate the framework's flexibility and value as both an evaluation tool and a design guide for future platforms.

1. Introduction

Given its prominent role in informing climate action globally, climate change mitigation and adaptation (CCMA) research is becoming increasingly abundant, complex, and data intensive [1]. Whether it is the thousands of mitigation scenarios modelled by Integrated Assessments Models (IAMs) in recent years [2] or the high spatial resolution provided by climate impact studies (e.g., Ref. [3]), these results can often be difficult to follow and comprehend by non-experts [4]. This is especially critical for policymakers who might not be familiar with the technical intricacies of climate models or datasets, yet often need to make urgent decisions based on these results. If they do not understand the results from the models, they may not use them [5] or misinterpret them. While many policymakers rely on experts to help them translate scientific advice into actionable policy [6], they still need to be part of participatory processes in CCMA research to ensure its relevance and legitimacy [7]. Major assessments such as the reports of the Intergovernmental Panel for Climate Change (IPCC) have recognised this need by providing summaries for policymakers; still, the language [8] and visuals [9] used can be challenging for non-experts.

In order to increase the usability of CCMA research, numerous online platforms have been developed in the last decades to inform policy making on climate action and wider sustainability [10]. Whether called decision support tools, decision aids, climate data platforms, interactive web tools, climate services, or policy platforms, they usually act as intermediaries between data producers and policymakers [11]. Prominent functionalities include learning modules that allow policymakers to make sense of the concepts and complexities of CCMA research, case studies to learn about best practices that have worked elsewhere, and interfaces to explore different climate action scenarios. The latter is usually achieved through interactive scenario explorers that allow users to experiment with different CCMA options, for example, decarbonisation policies, energy mixes, and adaptation methods, and receive real-time feedback on impacts and trade-offs [12–14].

While hundreds of such platforms exist, covering different spatial scales and specialised CCMA topics such as energy, finance, and equity [15], evaluations of their use and effectiveness are relatively scarce [16]. What is more, despite the existence of studies on evaluations of specific policy platforms [17–20] and recommendations on their design [11,21], most studies are platform-specific and there is currently no evaluation framework that can be generalisable enough to be widely adopted by the CCMA community. This is in contrast to guidelines for better climate data visualisations which have been more actively used, e.g., within the IPCC community [9].

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One potential issue is that platform assessments may require time and multiple interactions with the target audience. Many platforms are developed as part of wider CCMA projects such as those funded by the EU Horizon program, often leaving little time for evaluation if there is no explicit requirement by the funders [22]. Additionally, many platforms are designed without a specific target audience in mind, subsequently affecting the applicability and relevance of evaluation methods. For instance, while the SENSES climate scenarios toolbox specifically targeted policymakers and finance experts [23], the popular Scenario Explorer of the IPCC's Sixth Assessment Report did not report such intentional design [24], leading to uncertainty in terms of which evaluation method to use. Another potential issue is that older evaluation methods may not cover the breadth of functionalities that policy platforms now offer. For instance, the evaluation methodology by Wong-Parodi et al. (2014) evaluates the consistency of user decisions which may not apply to platforms used as learning aids, while the survey script of Bessette et al. (2016) mainly focuses on energy-related tools.

In response to these challenges, this study introduces a novel, comprehensive, and easy-to-use evaluation framework designed to systematically assess the design quality of CCMA policy platforms. Unlike existing fragmented or tool-specific evaluations, this is the first framework to integrate 43 criteria across nine key design dimensions, such as transparency, interactivity, and accessibility, and to apply them uniformly across multiple real-world platforms.

The study pursues two main aims.

1. To identify and synthesise key design requirements for CCMA platforms based on a review of academic and grey literature.
2. To apply these requirements in a structured evaluation of ten policy platforms developed under the EU Horizon 2020 programme.

Horizon 2020 provided a good sample of such platforms as it was the largest public-funded research programme of the EU between 2014 and 2020—a period that covered the launch of the Paris Agreement and the European Green Deal—and funded many climate-related projects that resulted in policy-relevant platforms. Section 2 outlines the methodology for selecting these platforms and identifying platform requirements, which are categorised in Section 3. Section 4 details the application of the framework to the selected platforms, and Sections 5 and 6 present findings, implications, and directions for future research. Overall, the framework is intended to guide platform developers, funders, evaluators, and policymakers in assessing and improving the design and long-term impact of CCMA platforms.

2. Methodology

2.1. Identification of design requirements for policy platforms

The Scopus database was used to identify typical design requirements of CCMA policy platforms. Since this research was focused on investigating what set of overall design requirements can be derived from the literature with the end-user of the different policy platforms in mind, the literature review was focused on user requirements, features, or needs. The search encompassed decision support tools, decision support systems, as well as similar names, that specifically addressed environmental or climate change-related issues.

Specifically, we searched within the title, abstract, and keywords of papers using the query ("user* feature*" OR "user* requirement*" OR "user* need*") AND "decision support tool*" OR "decision support system*") AND (environmental OR "climate change*") and found 83 papers. Titles and abstracts were reviewed to verify suitability for the goals of this research. As a result, 51 papers were excluded as they vaguely mentioned user needs or requirements. The remaining 32 papers were selected for screening. From them, 19 papers were excluded as they assessed decision support tools in unrelated areas, such as food packaging, or briefly addressed user needs and requirements without offering comprehensive discussions on them. The literature review resulted in 13 papers for in-depth analysis. Four additional articles were added based on snowballing from the 13 papers, resulting in a list of 17 articles. In addition to scientific literature, grey literature was also searched for relevant information on user requirements and requirements for climate change mitigation and adaptation policy platforms (or decision support tools). The Google search engine was used to explore results related to user needs and decision support tools, which led to the inclusion of four records derived from grey literature. The results of the search process are summarised in Figure A1 in the Appendix.

Each of the 21 information sources from scientific and grey literature mentioned earlier from was individually examined to identify requirements or user needs relevant to this research. In order to identify such requirements, a process based on the thematic synthesis technique was used. Thematic synthesis aims to develop analytical themes via a descriptive synthesis and identify relevant explanations for a review question [25]. Thematic synthesis entails systematically coding data to produce descriptive and analytical themes grounded in the data [26], typically proceeding in an iterative fashion, beginning with an initial review of each document, followed by the identification of relevant segments, labelling of segments, and finally translating the codes derived from these segments into meaningful themes [25].

The implementation of the thematic synthesis mentioned earlier involved a three-step procedure. The first step involved a comprehensive assessment of each scientific or grey literature source and, whenever a potential requirement or user need was detected, a "requirement" code was assigned to the corresponding text excerpt. The Lateral web platform [27] was used in the initial step to streamline the process of identifying requirements in the consulted literature due to its capabilities of facilitating the organisation, reading, and identification of codes (or concepts) in source materials. In the second step, the codes assigned in the previous step, along with the information source (i.e., authors) and the exact text excerpts, were exported to Excel for further analysis. They were then systematically evaluated in order to assign relevant codes that would meaningfully describe each text excerpt labelled generically as "requirement" in the previous step. The third and final step involved conducting an analysis of the tailored codes assigned in step two to identify significant themes that could categorise various codes into groups of requirements. The objective of this final stage was to identify clusters of codes that were internally consistent (i.e., addressing the same topic) while also being comprehensive enough to reduce the number of clusters to a manageable amount of requirements. The themes identified in step three were used to generate the proposed requirements. The codes assigned in step two, along with the text excerpts, were used as input to determine the criteria for each requirement. Table 1 illustrates the application of this procedure using selected instances from the referenced literature.

2.2. Identification of policy platforms for assessment

The European programme Horizon 2020 (H2020) was chosen as a source for the identification of CCMA policy platforms for assessing using the proposed framework, for three reasons. First, due to its relevance, as it was the EU's primary research and innovation programme that ran from 2014 to 2020 and had a funding budget of nearly €80 billion, making it the largest EU research and innovation programme of its time [28]. Second, due to the period covered by the H2020 programme, which included the signing of the Paris Agreement in 2015 and the adoption of the European Green Deal in 2019. Finally, given that most of the projects funded by the H2020 programme were already completed or nearing completion by the time this study was conducted, it makes it more likely to identify policy platforms already fully developed in the H2020 programme than in its successor Horizon Europe.

The EU Commission's Community Research and Development Information Service (CORDIS) was investigated to identify relevant climate change mitigation and adaptation policy platforms related to the

Table 1
Examples of codes used to derive requirements and criteria used in the proposed framework.

Source	Text reference	Step 2 code *(input for criteria list)*	Step 3 code *(requirement)*
Hewitt and Macleod (2017)	"[The application] will aim to be credible, with transparency in the information and methods used"	Credibility and reliability of information	Transparency & Credibility of information
McIntosh et al. (2011)	"Be open and honest about system weaknesses and areas in need of improvement, including model uncertainties and assumptions"	Clear communication of tool's limitations, uncertainties or assumptions	
Palutikof et al. (2019)	"[The tool] is authoritative: gives guidance that has been developed, reviewed and approved by experts"	Credibility and reliability of information	
Calvo et al. (2021)	"Accessibility: Discipline and rules that guarantee that websites and technologies are designed and developed so that people with disabilities can use them independently from their capability limitations: auditory, visual, cognitive, physical, or neurological"	Accessibility & Usability	Accessibility & Portability
Hewitt and Macleod (2017)	"[The tool/software] should work on touch devices like mobile phones, tablets and larger touch tables"	Mobile compatibility	
	The tool/software Should be free at the point of use.	Free-of-charge	

H2020 programme. The entire dataset of H2020 projects was downloaded on 26/03/23 as an Excel file from the CORDIS platform [29]. The CORDIS project dataset was filtered to identify relevant projects using the following criteria: **(i)** selection of projects within the sub-programmes "3.5. Climate action, environment, resource efficiency and raw materials", "3.3. Secure, clean and efficient energy", or unspecified (blank); **(ii)** projects with an end date prior to 2023; **(iii)** projects whose objective descriptions contained terms from three distinct keyword groups. The first group focused on the intended output and included terms such as "support tool", "platform", "web tool", or similar. The second group related to the thematic focus, using terms such as "transition", "pathways", "adaptation", "mitigation", and "energy transition". The third group targeted the intended users of the platform and included terms like "policymakers", "decision-makers", "policymaking", and relevant variants. Projects were included if they resulted in a publicly accessible, web-based policy platform with a primary focus on climate change mitigation or adaptation.

By following the steps mentioned above, a list of ten projects involving CCMA policy platforms was identified for assessment: SENTINEL [30], COACCH [31], SOCLIMPACT [32], EUCalc [33], INNOPATHS (DPET) [34], CD-LINKS (Climate Policy Database) [35], Era4CS (Senses Toolkit) [36], Paris Reinforce (I^2AM PARIS platform) [37], PLACARD [38], EnerMaps [39]. All platforms were assessed between April 2023 and June 2023. The assessments were conducted by the first author following a structured scoring guide based on the predefined criteria outlined in Section 3 and under the supervision of all other authors. While the use of multiple evaluators would have reduced the subjectivity of this assessment, we note that the point of the application is not to provide a strict scoring system for these ten platforms, but to uncover insights and recommendations for improvement. Nevertheless, future applications may benefit from involving multiple evaluators to improve replicability.

3. Design requirements for CCMA policy platforms

Based on the thematic analysis of Subsection 2.1, nine groups of design requirements were developed. A set of criteria were derived from the scientific and grey literature discussed in the previous section, to support the assessment of each design requirement. Each criterion was proposed to support as much as possible an objective assessment of different policy platforms. Table 2 presents the list of requirements and criteria proposed in the framework, and each requirement is further discussed in the next subsections. Table A1 in the Appendix provides an overview of references of policy platform requirements identified in the literature. It is noted that not all these requirements and criteria are applicable for all platforms, given the variety of target users (e.g., high-level policymakers, expert advisors) and the breadth of information in the climate domain that needs to be communicated. For instance, a scenario-exploring tool that is primarily intended for experts (that are, subsequently, advising policymakers) may not need an extensive educational module. Therefore, the framework is intended to be flexible and adaptable. Users should tailor the framework based on the platform's purpose, target audience, and expected functionalities by removing criteria that are not relevant. A practical example of such adaptation is shown in the application of the framework in Section 4.

3.1. Transparency and Credibility of Information

"Transparency and Credibility of Information" refers to characteristics of policy platforms that are related to how open they are about the limitations and assumptions of their data sources and models (if available), if they are associated with credible organisations and partners (e.g., the consortium responsible for the tool's development), and how well they communicate their intended purposes and targeted user groups. Transparency and credibility of information concepts were identified in eight of the articles reviewed. In a review of the available literature on Environmental decision support systems (EDSS), McIntosh et al. [40] identified that the representation of uncertainty related to results obtained was one of the success criteria for EDSS to support science and engineering analysis successfully. According to the authors, being honest and open about model assumptions and uncertainties is a best practise if one wants to improve user perception of credibility and trust [40]. Similar findings were also observed by Ref. [41] in a study of EDSS for land and freshwater management in Scotland. The authors identified twelve principles for developing tools to support environmental decision-making related to land and freshwater management as a result of a workshop engagement involving stakeholders with expertise in outcomes-based environmental management. Workshop participants emphasised the importance of dealing honestly with uncertainty about the tool's outputs in order to trust the information provided by the decision-support tool, as well as the tool being transparent and upfront about its intended purpose and what it can and cannot do [41].

The credibility of the tool's data sources and the organisation(s) or people who created it was also emphasised in the literature. One of the critical requirements derived from interviews with expert groups and river basin managers in Belgium, according to Ref. [42] is the need for the available data on the decision-support tool to be detailed and include both the source of the information and uncertainty levels. The need for a tool to be authoritative was identified by Ref. [43] as the most common

Table 2
Proposed framework of requirements and criteria for the assessment of policy platforms.

Transparency and Credibility of Information
TC.1 The tool clearly specifies its intended objective or purpose.
TC.2 The tool clearly specifies its intended users.
TC.3 The tool is developed or affiliated with credible sources, and this information is clearly stated.
TC.4 The tool clearly communicates data sources used in models, policies or recommendations provided.
TC.5 The tool openly communicates its limitations.
TC.6 The tool openly communicates uncertainty and assumptions associated with its models.
TC.7 The tool clearly specifies whether it was co-created with its intended users, ideally providing evidence of doing so (e.g., reports documenting workshops)
Ease of Use
EU.1 The tool clearly displays buttons, menus and options available for users in its graphical user interface (GUI).
EU.2 The tool provides a menu/section where the user can learn how to use the tool and the available functionalities.
EU.3 The tool provides brief outputs that are easier to understand and use (e.g., policy briefs, main takeaways).
EU.4 The tool's screens are free of excessive visual clutter that can make it difficult for users to understand the information being presented.
EU.5 The tool provides clear explanations or visible help for users to understand its functionalities (e.g., abbreviations, glossary, expanded explanations).
EU.6 The tool provides visualisations that contain all the information necessary for users to understand them (e.g., axes titles, legends, units of measure).
EU.7 The tool includes mechanisms to check and validate user input before model execution or output generation. This includes features such as mandatory field checks, format validation, and real-time user feedback.
Flexibility of Use
FU.1 The tool allows users to use it for different needs/reasons (e.g., run models, better understand topics).
FU.2 The tool allows users to modify parameters or underlying logic of the models provided.
FU.3 The tool is able to generate tailored results/recommendations based on input specified by the user.
FU.4 The tool provides different levels of detail regarding spatial and temporal scales (e.g., different locations and end year).
FU.5 The tool allows users to continue their analysis in the future, save scenarios or export results.
FU.6 The tool allows users to access previous analyses or scenarios (e.g., access to saved history, import files).
Accessibility and Portability
AP.1 The tool is intuitive and easy to navigate when accessed via mobile phones or tablets.
AP.2 The tool provides free/open access to all its functionalities.
AP.3 The tool is at least partially natively accessible in languages other than English.
AP.4 All of the tool's functionalities are accessible through a website.
AP.5 The tool passes online accessibility tests (assessed via Lighthouse accessibility test).
AP.6 The tool can be accessed from multiple locations worldwide (assessed via Uptrends availability test).
Education and Awareness
EA.1 The tool provides resources to help users better understand the topics covered in the tool.
EA.2 The tool provides additional resources to help users learn and be more aware of the topics covered by the tool (e.g., videos, MOOCs, articles).
EA.3 The tool provides recommendations of similar tools or platforms that users may be interested in exploring.
EA.4 The tool provides examples of successful policies or benchmarks that can help promote policy transfer and evidence-based policymaking.
EA.5 The tool provides results or recommendations without imposing a standard on what is the "right thing to do".
Communication of Complex Information
CI.1 The tool provides brief resources that synthesise complex information in a more easily digestible format (e.g., summaries, policy briefs).
CI.2 The tool provides resources to help users better understand the information provided (e.g., tooltips in charts, explanations of scenarios).
CI.3 The tool provides resources to summarise and clarify the results of models/analyses (e.g., ranges, intervals, concept descriptions).
Data Visualisation and Interactivity
DV.1 The tool provides visual graphical resources for presenting information (e.g., charts, maps, tables).
DV.2 The tool provides graphical visualisations with easily distinguishable elements that do not require users to constantly refer to legends or additional explanations.
DV.3 The tool provides interactive visual graphical resources for presenting information (e.g., charts, maps, tables or others that users can select, filter, zoom in on).
Actively Maintained and Supported
AM.1 There is evidence that the tool is still being maintained (e.g., recent posts, version updates).
AM.2 The tool provides clearly visible options for users to contact someone if they encounter a bug, have questions, or need more information.
AM.3 There is evidence that the tool has been updated with data, policies or other relevant information from recent years as they become available.
Security and Privacy
SP.1 The tool allows users to interact with it without having to provide personal data (e.g., email addresses).
SP.2 The tool passes online cookies and data transfer for GDPR compliance tests (assessed via 2gdpr online EU cookie law checker).
SP.3 The tool passes online safety and security tests (assessed via SSLTrust safety and security check).

survey answer for the question asking about the key features that would make a climate risk management tool useful for coastal decision-makers, where the concept of authoritative involved being developed, assessed, and approved by experts. Additional references to the theme of information transparency and credibility were found in Refs. [44–47]. Lastly, co-creation activities with target audiences are often deemed essential for designing impactful CCMA platforms [7,16]. While it is difficult to assess the quality of the potential co-creation activities that took place in the design of a platform and whether these have meaningfully informed the development, criterion TC.7 is still added to emphasise the importance of co-creation, especially for new platform developers.

3.2. Ease of use

In a broader sense, "Ease of Use" refers to how intuitive a tool is for users who are unfamiliar with it. Six scientific and three grey literature sources were used to identify concepts related to usability. Clar and Steurer [48] found that in a review of two online support tools (Adaptation Wizard in the UK and Klimalotse in Germany), both tools were simple to use and produced outputs that were usually simple to apply. They also emphasise that Klimalotse does not target users with specific knowledge of adaptation policies, instead offering modules ranging from basic understanding to advanced support. According to the results of the authors' interviews, this characteristic of Klimalotse was perceived as a benefit because users who are unfamiliar with it but interested in learning more about it can find value in the tool's provided step-by-step introduction [48]. McIntosh et al. [40] highlight as a best practise recommendation for the development of DSS that one action to improve adoption of decision-support tools is to present the tool to the user in a simple fashion in order to minimise complexity and having a design for ease of use of a tool, e.g., by having a user interface (UI) adaptable to different user types and with adequate help functionalities available. This has been formalised in the framework through criterion EU.7, which assesses whether a platform prevents users from submitting incomplete or incorrect data inputs, such as mandatory field checks (e.g., ensuring required fields are completed), format validation (e.g.,

numeric ranges or data types), and real-time user feedback (e.g., error or warning messages when input is invalid).

Fürst et al. [49] also identified self-explanatory UI as a critical condition for users accepting and using the tool. The availability of help features (tutorials on how to use the tool, help boxes) [46] (p. 206) was also one of the main recommended features derived from workshop sessions with representatives from various levels of government and organisations in the Gulf of Mexico. The International Organisation for Standardisation also specifies error protection (the level at which users are prevented from making errors while using a tool) and operability (the level at which a system has attributes that make it easy to use) as sub characteristics of a software product's usability [47]. Still on the grey literature, a user-friendly tool was designated as a must-have requirement in deliverable D 7.3 ("Report on requirements for user-centric tools") of the H2020 ICARUS project [50].

3.3. Flexibility of use

"Flexibility of Use" refers to a tool that offers users a variety of options. This could include allowing users to learn about topics or concepts, run custom simulations and scenarios, and receive recommendations. Flexibility of use concepts were discovered in 12 sources (9 scientific, 3 grey literature). According to Ref. [44], respondents to an end-user survey suggested enhanced flexibility of Decision-Support Tools (DST), such as providing customised outputs based on user needs, to maximise DST's practical relevance. Schlobinski et al. [51] identified several user requirements of analysts (decision--makers or people supporting decision-makers) of a climate change adaptation tool for city planners and managers, some of which relate to having the flexibility to use a decision-support tool in a variety of ways. Being able to export model results and visualisations for use with external applications and manipulate system elements such as input parameters, boundary conditions and input models for scenarios were all considered to be requirements for the analysts [51]. Editing and extending model logic, as well as being able to import data sources, were also suggested as relevant criteria to assess DSS by Hewitt and Macleod [41], while McIntosh et al. [40] recommended developing a DSS that "can be used to solve multiple environmental problems" (p.1400).

From the consulted grey literature, flexibility (the extent to which a system can be used for contexts beyond the initial specifications) was identified in the ISO/IEC 25010 quality-in-use model [47], and the ability to perform 'what-if' and 'scenario' analyses was suggested by Ref. [52] as a relevant factor to alleviate perceptions that a DSS does not take into account local specificities or does not meet the needs of users.

3.4. Accessibility and portability

"Accessibility and Portability" refer to how easy and portable the policy platform is to use on mobile phones and tablets, whether the tool is open-access and web-based, freely accessible from all over the world, and how accessible it is for people with various disabilities. Accessibility and portability references were found in 9 examples of consulted literature (6 scientific and 3 grey literature). The International Organisation for Standardisation identifies three accessibility and portability-related characteristics or sub-characteristics of the ISO/IEC 25010 product quality model: portability, availability, and accessibility. The ability of a system or product to be transferred from one environment to another (software or hardware) while maintaining the same effectiveness and efficiency is referred to as portability. Availability, on the other hand, refers to the degree to which a system or product is accessible and operational whenever it is needed [47]. Accessibility refers to the level at which a system can be used by users with the widest range of capabilities and particularities to achieve specific goals in specific contexts of use [47]. Alternatively, as Calvo et al. [53] put it, accessibility refers to guidelines that ensure that websites and other technologies are "designed and developed so that people with disabilities can use them independently from their capability limitations: auditory, visual, cognitive, physical, or neurological" (p.12).

Portability was also mentioned by Hewitt and Macleod [41] as one of the criteria for EDSS, as well as a must-have requirement for the user-centric tools for the ICARUS H2020 project [54]. Fürst et al. [49] identified availability as a relevant characteristic when stating that users identified "broad accessibility for users at any time and any place" (p. 946) as one of the most important attributes of support tools. Being easily accessible via a web-based platform was also mentioned as a relevant feature of decision-support tools in several studies [41,46,49,54], usually in conjunction with the desire for a free and open access tool. Whereas it is evident that accessibility, availability, and portability are important as individual platform requirements, they are not necessarily grouped in the literature. For instance, ISO/IEC 25010 defines accessibility as part of usability while portability is given as a separate category. Still, they are grouped in the context of this assessment framework, mainly to keep the number of requirements manageable, and since only one criterion refers to portability (AP.1). Nevertheless, the framework can be adapted in the future to split these requirements and add further criteria.

3.5. Education and awareness

"Education and Awareness" refers to aspects of policy platforms that improve user understanding by providing learning material such as detailed explanations of concepts or even Wikis and Massive Open Online Courses (MOOCs). This requirement also includes functionalities that help users discover case studies and success stories on climate change mitigation or adaptation. Schumacher et al. [44] identified the need for policy platforms to provide resources to improve users' knowledge (e.g., video, courses, tutorials, webinars, and similar) when discussing how a lack of experience with decision-support tools may make users less interested in using the tools, so providing training functionalities would be of interest. Clar and Steurer [48] also discuss how one of the critical features of the UK climate tool Adaptation Wizard is that it provides training and educational services such as workshops, which the authors found in only six of the 88 tools on climate change adaptation that the authors evaluated. The study in Ref. [55] highlights that the use of EDSS systems for learning purposes may support changes in the mental conceptualisations of world-systems, but other findings suggest that the improved learning provided by such tools does not automatically lead to actual behaviour changes by their users [56]. Additionally, while educational resources can complement and expand the applications of policy platforms, they are not always necessary, especially if the target audience (see criterion TC.2) prefer simple and straightforward functionalities. Still, basic information on the tool's topics and tutorials on its use are deemed important in most cases (see EA.1).

Discovering and accessing real-world case studies from policymakers or organisations in other locations is another important aspect of education and awareness. These needs were mentioned several times in the literature. According to Ref. [57], one of the updates made to the German Klimalotse online tool in response to user feedback was the availability of "real-world case studies illustrating how other municipalities dealt with the tasks, as well as exemplar documents from municipalities and template documents" (p.566) [52]. found similar results, with participants interviewed favoured seeing examples of how others solved similar problems. The authors also state that sharing best practices and lessons learned can assist users in determining which climate change adaptation option is best suited to their specific situation [52]. It is noted that not all case studies have to be about success stories, as users can also learn from what went wrong and understand how to avoid potential failures. Some of the local policymakers interviewed by Ref. [48] pointed out that they expect knowledge exchange not only from researchers to policymakers but also between policymakers. Peer-learning between policymakers can potentially complement and

contextualise the top-down knowledge delivery from academics, increasing, thus, the significance of platforms that can support such lesson-sharing.

3.6. Communication of complex information

"Communication of Complex Information" refers to a policy platform's ability to produce understandable results that can be applied in more practical ways. This trait is consistent with the BellagioSTAMP's sixth principle: effective communication. The BellagioSTAMP is made up of eight guiding principles for measuring and assessing progress towards sustainability [58]. Bartke and Schwarze [45] proposed a criterion called practicality based on requirements identified by users of sustainability assessment tools (SATs), which includes aspects such as how quickly and easily methods in the tool can be used and understood; whether detailed documentation is required to use a specific tool; and whether the results produced by the platform are easy to assess and understand. In another study [52], policymakers perceived the BalticClimate Toolkit as too detailed and expressed a preference for more concise information, suggesting that it may be necessary to provide them with succinct documentation containing only the most essential information, such as policy briefs or key takeaways. Similar findings involving the importance of presenting information in a more condensed, attractive, or easy-to-digest manner were discovered in various sources [40,41,48,54,59].

3.7. Data visualisation & interactivity

"Data visualisation and interactivity" refers to the availability of visual graphical elements (e.g., different types of charts, maps, tables and other visualisations) as well as how the information is presented (e.g., choice of colour, angles, brightness, gradients and similar) and how interactive the available elements are (e.g., if users can zoom in and out, visualise data labels, filter selections, and so on). Hewitt et al. [59] found that the COLLAGE tool's interactive functionalities, including the real-time presentation of renewable energy targets through charts, introduced a gamification element that stimulated user engagement with the tool. This interactivity was deemed crucial in capturing the interest of stakeholders and inspiring them to experiment with the platform. This finding contrasts the limited interactivity offered by the APoLUS tool, which only features a basic graphic interface operating within the R environment and a few command-line operations [59]. Calvo et al. [53] identified the inclusion of interactive elements that allow users to filter out non-relevant information or emphasise particular details for decision-making as a significant factor in enhancing user experience and decreasing cognitive load associated with climate data visualisations. Similar observations were also found in Ref. [51] when discussing that to analyse outcomes from multiple scenarios in a model effectively, the capability to visually represent model results is required, and also in Ref. [52] when arguing that an "overall text-heavy representation acts as repellent and does not help to arise interest and concern as has been found in the case of the BCT (BalticClimate Toolkit)" (p.62).

3.8. Actively Maintained and Supported

This requirement emphasises the maintenance of decision-support tools such as supporting them with the most recent scientific findings and updated functionalities as well as having an active community of users. Based on the consulted literature, these needs are mentioned as important to keep users interested in a particular tool and ensure that information is still seen as trustworthy. According to Ref. [52], due to the dynamic nature of climate-change-related scientific knowledge, it is critical to consistently incorporate and update the most recent scientific discoveries into decision-support tools, or risk losing users' interest or trust in the information presented. This is also consistent with the findings of [49], who found that the availability of real-world conditions and the most up-to-date knowledge was a feature that participants valued in an optimal support tool. Similar references were found in Ref. [41], where the authors propose that active maintenance, preferably through a large and open user community, is an important criterion for an EDSS. The authors add that this is important for distinguishing between projects that are still being maintained and those that are not, and they also recommend that a tool be designed to be updateable with new information as it becomes available as a general principle for application development [41]. [42–44,60] also identified requirements or user needs related to ongoing support, continuous improvement, long-term access, or availability of very recent data.

3.9. Security and privacy

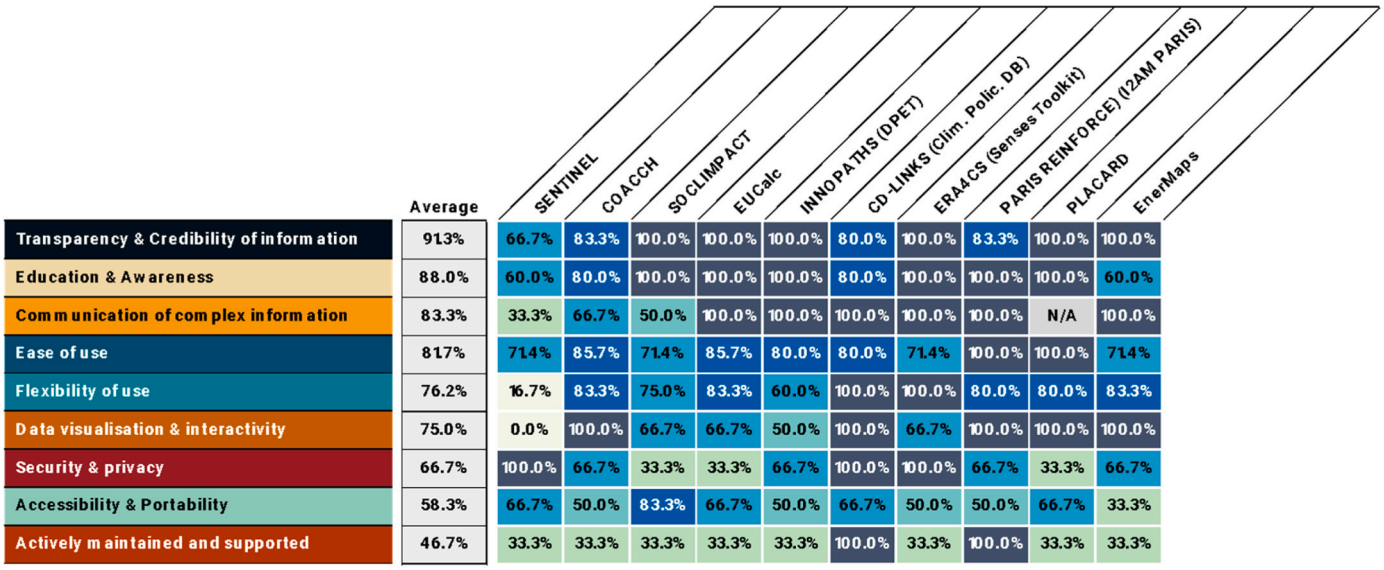
These requirements were mostly derived from recommendations from the ISO/IEC 25010 System and software quality models from the International Organization for Standardization. The international standard defined under the Product quality model is the security and confidentiality sub-characteristic relevant to this research. Security refers to the extent to which a system safeguards information and data, whereas confidentiality is related to the extent to which a system restricts data to be accessible solely by those authorised [47]. Security and privacy requirements or user needs were not explicitly identified in other sources of information. However, this requirement group was included due to the topic's relevance to the EU. On May 25, 2018, the General Data Protection Regulation (GDPR), the "strongest privacy and security law in the world" [61], was put into effect. The GDPR law increased protection for personal data by imposing that websites, for example, obtain clear consent to process personal data, making it available for users the "right to be forgotten" [61], among several other measures. It is noted that, while these indicators provide a general sense of user data protection, they do not constitute a full technical security audit. More detailed assessments, such as those based on cybersecurity standards (e.g., OWASP), would require specialised expertise and are beyond the current scope. Future research may incorporate such approaches for a deeper evaluation of platform-level risks.

4. Application of the framework

4.1. Overview of the application

The proposed framework described in Table 2 was applied to ten examples of CCMA policy platforms, which are identified as described in Subsection 2.2. Each criterion was assessed using a binary scoring scheme ('met' or 'not met'). A detailed explanation of how policy platforms perform against each characteristic and a full evaluation for each policy platform is provided in Section A2 in Appendix. Figure 1 depicts the results (on the requirements level) of the assessment performed. The percentages shown in Fig. 1 for each policy platform and requirement are calculated by comparing how many criteria were successfully met within each requirement to the total number of criteria applicable to that requirement. For instance, the Sentinel platform score of 66.7 % for "Transparency and Credibility of Information" refers to the four criteria it successfully meets out of six applicable criteria for that requirement, as described in Table 2 criteria TC1 through TC6. Similarly, the COACHH score of 83.3 % for Flexibility of use indicates that the COACCH policy platform successfully met five out of six criteria for that group.

A specific criterion may not always be applicable to a given policy platform. In such cases, a "N/A″ mark is assigned to that criterion-platform pair. For example, the INNOPATHS (DPET) received a "N/A″ for one criterion under "Flexibility of use" (FU.2) because it is not a scenario-building or simulation tool, and thus that criterion is not directly applicable to that platform. In that case, the score of 60 % for "Flexibility of use" in INNOPATHS (DPET) refers to three criteria being successfully met out of five applicable criteria (rather than six because



	Average	SENTINEL	COACCH	SOCLIMPACT	EUCalc	INNOPATHS (DPET)	CD-LINKS (Clim. Polic. DB)	ERA4CS (Senses Toolkit)	PARIS REINFORCE) (I2AM PARIS)	PLACARD	EnerMaps
Transparency & Credibility of information	91.3%	66.7%	83.3%	100.0%	100.0%	100.0%	80.0%	100.0%	83.3%	100.0%	100.0%
Education & Awareness	88.0%	60.0%	80.0%	100.0%	100.0%	100.0%	80.0%	100.0%	100.0%	100.0%	60.0%
Communication of complex information	83.3%	33.3%	66.7%	50.0%	100.0%	100.0%	100.0%	100.0%	100.0%	N/A	100.0%
Ease of use	81.7%	71.4%	85.7%	71.4%	85.7%	80.0%	80.0%	71.4%	100.0%	100.0%	71.4%
Flexibility of use	76.2%	16.7%	83.3%	75.0%	83.3%	60.0%	100.0%	100.0%	80.0%	80.0%	83.3%
Data visualisation & interactivity	75.0%	0.0%	100.0%	66.7%	66.7%	50.0%	100.0%	66.7%	100.0%	100.0%	100.0%
Security & privacy	66.7%	100.0%	66.7%	33.3%	33.3%	66.7%	100.0%	100.0%	66.7%	33.3%	66.7%
Accessibility & Portability	58.3%	66.7%	50.0%	83.3%	66.7%	50.0%	66.7%	50.0%	50.0%	66.7%	33.3%
Actively maintained and supported	46.7%	33.3%	33.3%	33.3%	33.3%	33.3%	100.0%	33.3%	100.0%	33.3%	33.3%

Fig. 1. Application of the assessment framework to ten CCMA policy platforms across nine design requirement categories. The percentages shown for each policy platform are calculated by comparing how many criteria were successfully met within each requirement to the total number of criteria applicable to that requirement.

one was understood to be non-applicable). This approach of assigning "N/A″ when non-applicable and adjusting the calculation was introduced to avoid penalising some platforms for not providing functionalities that were never intended to be provided (for example, modelling and simulation functionalities for tools that were not built for that). If more than half of the criteria within a given requirement were assigned a "N/A″ mark, the entire group received a "N/A″ mark, as in the case of the "Communication of Complex Information" in the PLACARD tool. It is also noted that criterion TC.7 on co-creation was not evaluated in any of the platforms since it was added afterwards.

4.2. Application results

"Transparency and Credibility of Information" scored the highest average among the tested policy platforms (91.3 %), as most platforms communicated assumptions and uncertainties related to the information presented. "Education and Awareness" scored the second highest average (88.0 %), where most platforms provided resources to enhance learning or awareness of the topics addressed in the platform (e.g., video resources, courses, workshops, articles or similar). "Communication of Complex Information" was third (83.0 %), as most assessed platforms provided brief resources such as summaries or key takeaways to synthesise complex information in a digestible format. "Ease of Use" had the fourth highest score (81.7 %), as most platforms provided an overview of what functionalities are available and instructions or tutorials on how to use them. "Flexibility of Use" was fifth (76.2 %), as many tools offered features that can adapt to different user needs, for instance filters to customise the information shown in a tool. "Data Visualisation and Interactivity" was close behind (75 %), since many platforms provided users with both visual graphic elements and interactive ones, allowing them to apply different zoom levels, filter or otherwise interact with.

For the majority of the examined platforms, the lowest scores were found for the last three requirements of the assessment framework. On "Security and Privacy" (66.7 %), many platforms presented problems in terms of GDPR compliance (e.g., clearly notifying users when and how cookies are used) while others having safety issues (e.g., expired SSL Certificates). "Accessibility and Portability" presented the second lowest average score (58.3 %), as even though the platforms were accessible via a mobile phone, the user experience was often severely compromised (e.g., users would frequently need to scroll up and down, or some visualisations would be visually overloaded). Finally, "Actively Maintained and Supported" was the requirement in which the policy platforms had the lowest overall score (46.7 %), since in only three tools there is evidence that the tool is currently in use by, for instance, recent posts, version updates, or social media activity. Figures A.2 and A.3 in the Appendix include boxplots and descriptive statistics, illustrating the variation in performance of the different platforms.

5. Discussion

5.1. Significance of the evaluation framework

This paper identified design requirements for policy platforms related to climate change mitigation and adaptation, and evaluated a number of existing policy platforms using these requirements. The literature review on CCMA policy platforms identified 43 design criteria grouped in nine platform requirements: "Transparency and Credibility of Information", "Ease of Use", "Flexibility of Use", "Accessibility and Portability", "Education and Awareness", "Communication of Complex Information", "Data Visualisation and Interactivity", "Actively Maintained and Supported", and "Security and Privacy". To the best of our knowledge, this represents one of the first efforts to integrate such a broad and diverse set of evaluation dimensions into a single, generalisable framework that can be applied across CCMA policy platforms. Although such evaluations already exist in the literature for specific platforms (see, e.g., Refs. [17–20]), prior studies have typically focused on individual platforms or isolated aspects (e.g., visual design, usability, or co-creation). This framework aims to be a user-friendly tool for systematically evaluating platform performance, making it accessible to researchers, platform developers, funders, and other stakeholders. For example, it can be used to assess whether a platform effectively communicates complex climate data through user-friendly visualisations and whether it supports accessibility for a wide range of users.

This framework offers valuable insights that extend beyond the evaluation phase, as it can also serve as a guide during the development and improvement of CCMA platforms. For example, developers can use the framework during the design phase to incorporate features such as interactive data visualisations or adaptable user interfaces, ensuring platforms are accessible and meet user needs. By integrating these design requirements early in the planning process, developers can create more effective and user-friendly CCMA policy platforms that better support decision-making processes in climate change mitigation and

adaptation. Note that the design requirements identified through the literature review pertain to policy platforms in the domain of climate change. Hence, depending on the field considered, additional requirements might be introduced, and adjustments might need to be made. Some examples of policy platforms from different domains include platforms on health [62] and economy [63,64].

5.2. Insights from the evaluated platforms

The proposed assessment framework was applied to ten policy platforms on climate topics developed in the EU-funded Horizon 2020 programmes. The results from the framework application indicate that the evaluated policy platforms performed very well in some of the design requirements in the proposed framework. For instance, six of the ten evaluated platforms received a score of 100 % for "Transparency and Credibility of Information", "Communication of Complex Information", and "Education and Awareness". "Data Visualisation and Interactivity" was another characteristic that received 100 % from 50 % of the platforms and less than 50 % from one (Sentinel). Multiple criteria were deemed non-applicable due to the inaccessibility of the modelling tool when the Sentinel platform was evaluated in this study, thus not performing well in many of the characteristics.

Despite the positive results in certain design requirements, the evaluated platforms consistently underperformed in some areas. "Actively maintained and supported" is a key example, with only two platforms receiving 100 % and the remaining eight platforms receiving no more than 50 %. Only three of the ten platforms investigated showed signs of being used or updated (e.g., recent posts, version updates, social media activity, or others). Only two platforms (I2AM PARIS and Climate Policy Database) showed signs of having been recently updated with new data, projects, or policies. In contrast, platforms like SENTINEL and EUCalc lacked evidence of recent maintenance, updates, or user support (at the time of the evaluation), resulting in low scores in this category.

These findings suggest that the majority of evaluated platforms do not receive regular updates or maintenance, potentially hindering their effectiveness and relevance in supporting policy development and decision-making processes. Platforms that are not regularly updated may become less relevant or trustworthy for policymakers. Moreover, if the website that hosts a policy platform becomes inaccessible even periodically, policymakers may be hesitant to use it because there is no guarantee that it will be available in the future. It is noted that these are only assumptions based on the low scores found in the maintenance category, as we cannot assume that platforms with low scores are not used at all without looking at their web traffic or similar indicators. Also, these platforms may have been useful in the context and duration of the project that made them (e.g., in workshops with stakeholders) and they can still be used as a static reference, even without new data or software updates. Still, since these tools are made in the context of (primarily) public-funded projects, their lack of longevity is worrying and should be addressed by funders and developers.

Connecting completed projects with new projects is one method for ensuring that knowledge generated in EU projects is kept alive, as shown in both platforms that received 100 % in the "Actively maintained and supported" requirement. Specifically, the I^2AM PARIS platform was funded by three ongoing Horizon Europe projects (IAM COMPACT, DIAMOND, and TRANSIENCE) after the end of the PARIS REINFORCE project and, similarly, the Climate Policy Database was linked to ELEVATE, CD-Links and ENGAGE projects. This could be a viable solution if projects are logically linked, such as research approach, objectives, universities, research organisations involved, or researchers. Another option would be for organisations that incentivise research and provide funding (for example, the European Commission in the case of H2020 and Horizon Europe) to allocate specific budgets for the long-term maintenance of developed policy platforms and, eventually, have solutions in place for the migration of such platforms to other domains or the eventual decommissioning of the tools.

The "Security and privacy" requirement is another example in which policy platforms performed poorly. Only three policy platforms received the maximum score of 100 % for this requirement, while the remaining seven platforms received up to 67 %. Compliance with GDPR regulations regarding cookies and data transfer was the criteria within security and privacy in which the assessed platforms performed the worst (70 % failed). This implies that the current policy platforms developed within the EU may not fully adhere to the security and privacy standards set forth by GDPR regulations, potentially leaving user data vulnerable to breaches or mishandling.

Another low-scoring design requirement is "Accessibility and portability", with the majority of platforms scoring between 50 % and 66 %. This was primarily attributed to multiple platforms failing the Lighthouse accessibility tests and lacking being at least partially accessible in other languages. Only Sentinel and the Climate Policy Database passed all accessibility tests, and only SOCLIMPACT and PLACARD were partially available in other languages. This underscores the fact that the platforms are not adequately designed to accommodate individuals with various disabilities, and the importance of addressing accessibility concerns within the design and development of policy platforms.

Based on the proposed assessment framework, these results highlight areas in which projects involved in the development of policy platforms consistently deliver on high standards (such as transparency, flexibility of use, education and awareness, and communication of complex information). This suggests that effective systems are already established to address these specific requirements. On the other hand, the findings also highlight important warnings that future policy platforms should be aware of, as they can jeopardise the usefulness and added value of a support tool. Building on these findings, we propose the following recommendations to enhance future development and funding of climate policy platforms. First, funders should incorporate long-term maintenance requirements into project design and funding mechanisms, for example, by mandating sustainability plans, enabling handovers to other institutions, or connecting related platforms across projects. Second, developers should adopt inclusive design principles by following accessibility guidelines, ensuring that platforms are useable across devices and for users with varying needs. Third, security and privacy features must be integrated from the outset. These steps can help ensure that platforms not only meet technical standards but also build trust, support diverse users, and remain relevant over time.

5.3. Limitations

This paper has several limitations that need to be discussed. Firstly, although design requirements for policy platforms are identified from the literature, there is limited understanding of how policymakers perceive such tools and what requirements they consider important in a policy platform. This represents an important knowledge gap, as various policy platforms have already been developed or are in the process of being developed as part of major international programmes to address climate change mitigation and adaptation. However, it is still unclear whether such platforms meet the needs of policymakers when it comes to climate change mitigation and adaptation. Furthermore, even if some platforms have been reportedly co-created with stakeholders [e.g., see Ref. [65] for I^2AM PARIS], it is often difficult to generalise insights from such participatory processes to benefit new platforms. Therefore, it is recommended to study more generally how policymakers on different levels (local, regional, national, etc.) in the EU perceive the usefulness of such platforms and what qualities or characteristics of a policy platform are valued by these users.

Secondly, and, related to the first limitation, the design requirements are not ranked in terms of importance. This study intended to collect criteria from the academic literature in a comprehensive evaluation framework and showcase its applicability in 10 platforms resulting from a major research program. Thus, it is assumed that platform developers and users would subjectively rank the requirements and criteria

depending on the priorities of their platform, the target audience, the context of its use, etc. However, one could argue that some criteria are more important than others, for instance, the criteria related to active maintenance and support (e.g., AM.1), as a tool that is not well maintained may not be useable at all by policymakers. Similarly, there can be trade-offs between criteria; for instance, creating a platform with many different functionalities (i.e., high Flexibility of Use) can result in complex tools that are not easily useable by the main audience (i.e., low Ease of Use). While identifying trade-offs and understanding the significance of different requirements are beyond the scope of this paper, it should be further studied in the future, potentially through case analysis and stakeholder engagement methodologies such as expert interviews, formal expert elicitation, or Delphi panels.

Thirdly, when evaluating policy platforms, two design requirements identified in the literature are not explicitly studied in the paper. The first requirement includes characteristics that are intrinsically dependent on user perception and judgment (e.g., whether users perceive a system as being suitable for their needs, whether a set of functions fulfils all specified tasks and user objectives, and so on). Because of their subjective nature, these were not considered in the proposed framework for assessing H2020 CCMA policy platforms. Alternative criteria could be devised to evaluate the use of a platform, such as by using web analytics data to measure the platform's traffic. Nonetheless, approaches like these may easily become platform-specific as they need a way to meaningfully discern passive visitors from active users, e.g., by measuring how many users have pressed a specific button or visited pages beyond the homepage. Since our goal was to create a practical framework to act as a checklist for platform developers in general, we avoided including such potentially complicated criteria, but we would still recommend studying them in future research. The second requirement consists of technical characteristics, which include how fast the platform is in terms of calculations, how the data is stored, technical architecture, etc. Technical characteristics are important in evaluating software and decision support tools, but they are beyond the scope of this study. Further research can focus on more technical aspects of policy platforms and on evaluating the full lifecycle of a platform from development to use and to closure.

Lastly, only a selection of projects from Horizon 2020 are evaluated using the assessment framework, excluding other EU-funded programmes such as Horizon Europe or even platforms developed by non-EU programmes or institutions. Consequently, it is not possible to comment on how well platforms from other programmes perform against the design requirements. Platforms developed in other regions, by private-sector actors, or within different institutional frameworks may prioritise different design choices or face other constraints. As such, the conclusions drawn from the case study mostly apply to public-funded CCMA platforms developed within the priorities and requirements of the Horizon 2020 programme. Nonetheless, the framework itself can be applied to other climate change mitigation and adaptation-related projects, as well as both existing and future platforms. In future research, it can be useful to expand the application of the proposed framework to evaluate platforms from other programmes and provide a more comprehensive understanding of performance against design requirements. This could also be coupled with a more systematic literature review using protocols such as PRISMA to expand the assessed literature and identify potentially missing criteria. In addition, it would be interesting to evaluate platforms from various countries or regions (e.g., US, Australia, and developing/emerging countries) in order to test broader applicability and uncover potential cultural similarities, framings, or even biases in their design. Ideally, platform evaluations should be performed by multiple reviewers to reduce their inherent subjectivity and improve the generalisation of the results. Similarly, a sensitivity analysis could be performed to assess the robustness of the evaluations, e.g., how sensitive the final scores are to different weighting schemes or missing criteria.

6. Conclusion

This paper presents a novel and systematic framework for evaluating climate change mitigation and adaptation (CCMA) policy platforms. The framework is structured around nine core design requirement categories, including transparency, interactivity, and accessibility. Unlike previous evaluations that were often fragmented or tool-specific, this framework enables consistent comparisons across diverse platforms and supports both post-development evaluation and forward-looking design. The framework was applied to ten policy platforms developed under the EU Horizon 2020 programme. The results show that platforms generally performed well in areas such as transparency, communication of complex information, and education and awareness. In contrast, the lowest scores were observed in active maintenance and support, accessibility and portability, and security and privacy. The findings underscore the importance of upholding these characteristics throughout the lifecycle of CCMA policy platforms. Platforms that are not regularly updated or easily accessible may become less relevant or trustworthy from policymakers' perspective, potentially hindering their effectiveness in informing climate action and decision-making processes.

Future research should apply the framework to platforms developed outside of Europe to test its relevance across different policy, cultural, and funding contexts. The framework could also be refined by incorporating expert input to rank or weight the criteria based on their relative importance in different use cases. Such expert-driven adjustments would help tailor the framework for specific user groups or decision-making contexts. Finally, future studies could integrate usage data, such as website traffic, feature engagement, or user retention to evaluate platform performance in practice. This would allow researchers to explore whether higher-scoring platforms are more actively used or have greater influence in decision-making.

CRediT authorship contribution statement

Alexandre Curley: Conceptualization, Methodology, Investigation, Visualization, Writing. **Georgios Xexakis:** Conceptualization, Supervision. **Anneke Zuiderwijk:** Conceptualization, Supervision, Writing. **Ellen Minkman:** Conceptualization, Supervision. **Özge Okur:** Conceptualization, Supervision, Writing.

Declaration of competing interest

The authors declare no competing interests.

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APPENDIX

A.1Details on the literature review for the identification of design requirements

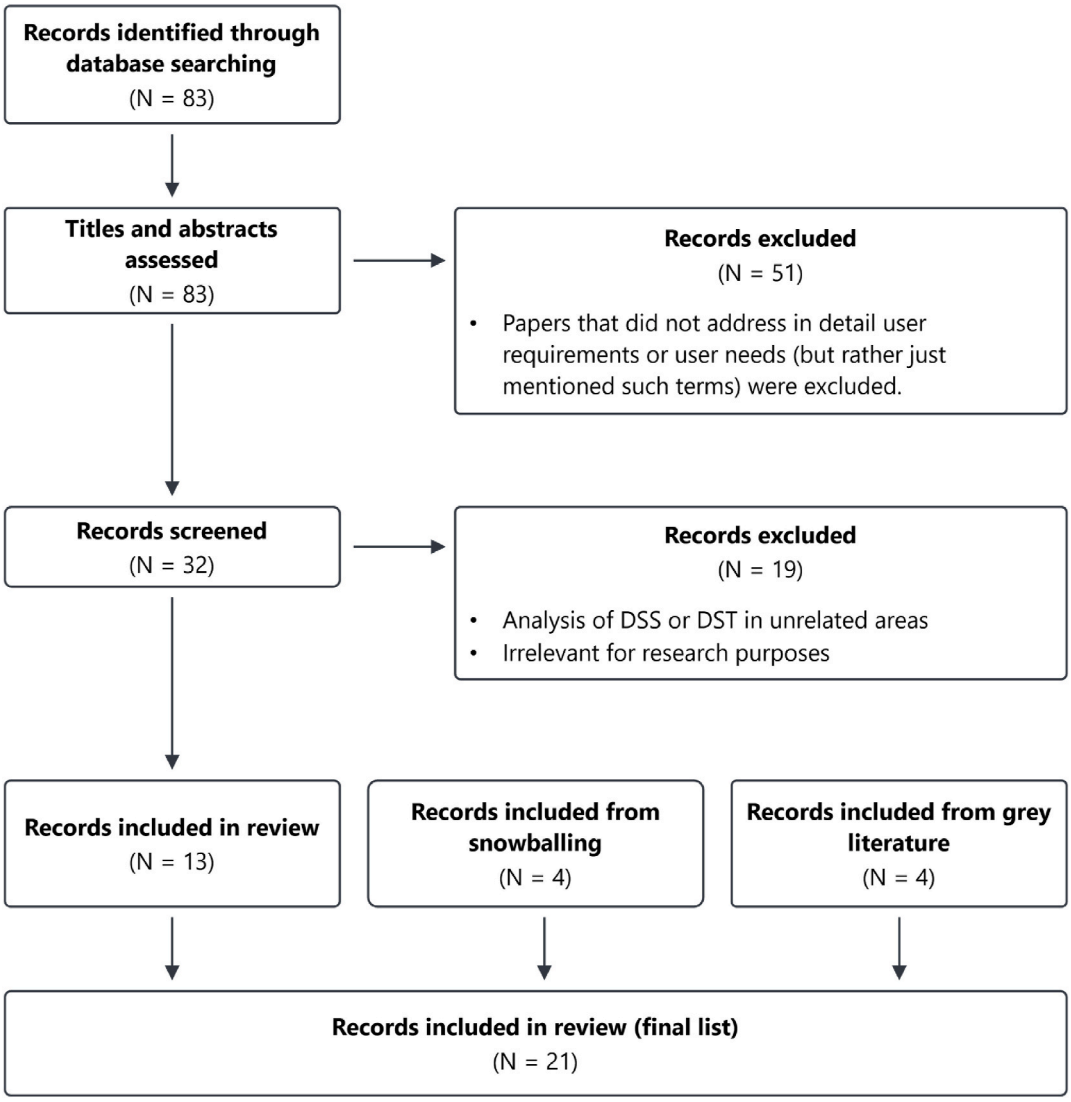

Fig. A1. Literature review process

Table A1
Overview of references of policy platform requirements identified in the literature (✓ indicates that one or more references for that requirement were identified in that source)

Source	Transparency & Credibility of information	Ease of use	Flexibility of use	Accessibility & Portability	Education & Awareness	Communication of complex information	Data visualisation & interactivity	Actively maintained and supported	Security & privacy
Fürst et al. (2010)		✓		✓				✓	
McIntosh et al. (2011)	✓	✓	✓		✓	✓			
Schlobinski et al. (2011)			✓				✓		
Broekx et al. (2012)	✓		✓					✓	
Bartke and Schwarze (2015)	✓		✓			✓			
Hewitt and Macleod (2017)	✓		✓	✓	✓	✓		✓	
Szimba et al. (2017)			✓	✓					
Clar and Steurer (2018)		✓			✓	✓			
Haβe and Kind (2019)					✓ ✓				

(*continued on next page*)

Table A1 (*continued*)

Source	Transparency & Credibility of information	Ease of use	Flexibility of use	Accessibility & Portability	Education & Awareness	Communication of complex information	Data visualisation & interactivity	Actively maintained and supported	Security & privacy
Palutikof et al. (2019)	✓							✓	
Webb et al. (2019)					✓			✓	
Hewitt et al. (2020)				✓		✓	✓		
Schumacher et al. (2020)	✓		✓		✓			✓	
Calvo et al. (2021)				✓			✓		
Collini et al. (2022)	✓	✓	✓	✓					
González and Connell (2022)		✓	✓						
Roth et al. (2014)			✓		✓	✓	✓	✓	
International Organization for Standardization (2011)	✓	✓	✓	✓	✓		✓		✓
Aristotle University of Thessaloniki et al. (2018)		✓		✓		✓			
MS10: Validated Requirements for the ICARUS DSS (2016)		✓	✓	✓			✓		

A.2. Detailed results on the application of the framework

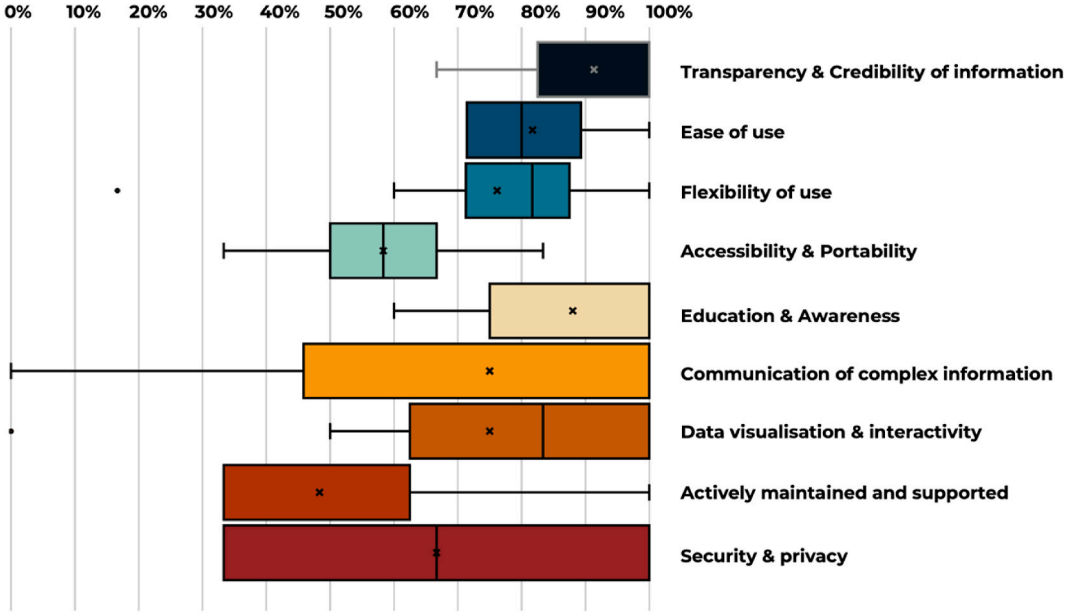

Fig. A2. Boxplot of the assessment results for the 10 policy platforms of Section 4

	Min	25%	50%	75%	Max	IQR [1]	Range [2]
Transparency & Credibility of information	66.7%	83.3%	100.0%	100.0%	100.0%	16.7%	33.3%
Ease of use	71.4%	71.4%	80.0%	85.7%	100.0%	14.3%	28.6%
Flexibility of use	16.7%	76.3%	81.7%	83.3%	100.0%	7.1%	83.3%
Accessibility & Portability	33.3%	50.0%	58.3%	66.7%	83.3%	16.7%	50.0%
Education & Awareness	60.0%	80.0%	100.0%	100.0%	100.0%	20.0%	40.0%
Communication of complex information	33.3%	66.7%	100.0%	100.0%	100.0%	33.3%	66.7%
Data visualisation & interactivity	0.0%	66.7%	83.3%	100.0%	100.0%	33.3%	100.0%
Actively maintained and supported	33.3%	33.3%	33.3%	45.8%	100.0%	12.5%	66.7%
Security & privacy	33.3%	41.7%	66.7%	91.7%	100.0%	50.0%	66.7%

Legend:
- Best score for that metric
- Intermediate score for that metric
- Worst score for that metric

[1] Interquartile range (IQR) is a measure of statistical dispersion and refers to the difference between Q3 (75%) and Q1 (25%),

[2] Range provides an indication of the statistical dispersion of a dataset and refers to the difference between the largest and smallest values.

Fig. A3. Descriptive statistics of the assessment results for the 10 policy platforms of Section 4

A.2.1. Transparency & Credibility of information

Transparency and Credibility of Information scored the highest average among the tested policy platforms (91.3 %). Six out of the ten assessed platforms were assigned with the perfect score of 100 %. The Sentinel platform received the lowest score for this requirement (66.7 %) due to not providing clear specifications of limitations related to each model on their web pages (TC.5), as well as not clearly communicating assumptions and uncertainties related to the different models available (TC.6). Climate Policy Database and I^2AM PARIS were other policy platforms that failed to meet all the criteria within Transparency & Credibility of information, both of them not clearly specifying who the intended users of each platform are (TC.2).

A.2.2. Education and awareness

Education and awareness scored the second highest average (88.0 %). Similar to Transparency and credibility of information, six platforms also scored 100 % for this requirement and four did not meet some of the criteria. Sentinel and EnerMaps failed to provide recommendations of similar tools or projects that the user can benefit from (EA.3), which was a common theme across the platforms (e.g., by referencing synergies or sister projects). COACCH and Enermaps failed to offer examples of successful policies or best practices from other places that can help promote policy transfer and evidence-based policymaking (EA.4). Climate Policy Database failed to meet criterion EA.2 by not providing additional resources to enhance learning or awareness of the topics addressed in the platform (e.g., video resources, courses, workshops, articles or similar). Finally, Sentinel was assessed as not meeting criterion EA.5 due to the inaccessibility of the modelling tool.

A.2.3. Communication of complex information

Communication of complex information received an average score of 83.0 %, making it the third best performing requirement among the platforms on average score. All assessed platforms were considered to meet CI.1 by providing brief resources such as summaries or key takeaways to synthesise complex information in a more easily digestible format. Similar to previous sections, Sentinel was assessed as not meeting CI.2 and CI.3 due to the inaccessibility of the modelling tool. COACCH failed to provide resources to help users understand the results of analyses (e.g., ranges, intervals, concept descriptions etc) as described in CI.3 as the charts and maps produced as outputs of analyses do not provide easily identifiable additional explanations regarding what is considered "worst", "best" or "medium" uncertainties regarding the different assessed impacts. Finally, SOCLIMPACT failed to meet criterion CI.2 due to the fact that some output documents provided are standalone files that do not clearly explain all the terms. Therefore, the user needs to access additional resources within the tool itself or outside the tool to have a better understanding of such concepts or terms.

A.2.4. Ease of use

Ease of use was the requirement with the fourth highest average score (81.7 %). I^2AM PARIS and PLACARD scored 100 % for this requirements, while the other eight platforms failed to meet one or more criteria within ease of use. In terms of the ease of navigating through the tools, Climate Policy Database and EnerMaps failed to provide a section or menu where users can learn how to use the tools and what functionalities are available (EU.2), and the web interface of the Senses Toolkit sometimes did not make it clear for users to understand in which menu or submenu they were in (EU.1) since the tool does not have fixed headers with navigation options for the user to the same extent as other platforms. The Senses Toolkit, DPET and Sentinel also depicted some heavily dense menus, failing to meet criterion EU.4 (tool's screens free of excessive visual clutter, which can make it difficult for users to understand the information being presented). Criteria EU.6 and EU.7 did not apply to DPET and Climate Policy Database because they are not simulation or scenario-based tools, and thus the display of model results or similar outputs is not applicable to them.

A.2.5. Flexibility of use

Flexibility of use scored an average of 76.2 %, being positioned as the fifth best performing requirement. Climate Policy Database and the Senses Toolkit emerged as the best performing platforms regarding flexibility of use, both scoring 100 %. Both the Climate Policy Database and the Senses Toolkit allow users to use the tool for a variety of needs, customise searches by using multiple filters or criteria, as well as download results or searches or access past analyses by saving the URL for future consultations or sharing with others. Sentinel obtained the lowest average score regarding flexibility of use due to the fact that most of the criteria considered within this requirement were not able to be assessed due to the inaccessibility of the Sentinel modelling tool. The DPET platform also obtained a lower score for this requirement due to the fact that, even though the tool provides several customisation features for users to take advantage of while using the platform, it does not allow users to download results of analyses or retrieve past consultations or share them via URLs, making both tools failing to meet criteria FU.5 and FU6.

A.2.6. Data visualisation & interactivity

Data visualisation & interactivity was the sixth best performing requirements with an average of 75 %. Five platforms obtained the highest score for data visualisation & interactivity (COACCH, Climate Policy Database, I^2AM PARIS, PLACARD, and EnerMaps). All these platforms provide users with not only visual graphic elements but also interactive ones which allow users to select parts of such elements, apply different zoom levels, filter or otherwise interact with. As the Sentinel platform was not accessible when assessed, this platform received a score of 0 % for this requirement. The DPET platform also obtained a lower score for this requirement due to the fact that, even though the tool provides plenty of graphical visualisations, they are not clearly distinguishable (e.g., slightly stronger or weaker tones of green, yellow and blue mean different things, making users potentially having to frequently refer back to legends, tooltips or glossary to understand how to use the tool), resulting in the failure to meet criterion DV.2. Similarly to the DPET, the Senses Toolkit also failed to meet criterion DV.2 due to the fact that some visualisations have different shading or borders, making users potentially needing to refer to legends multiple times to understand such visualisations. SOCLIMPACT and EUCalc failed to meet criterion DV.3 (tool offers interactive visual graphical elements), as in both tools users are not able to dive deeper into visualisations or charts by using, for example, filters or zoom options.

A.2.7. Security & privacy

Security & privacy obtained an average score of 66.7 %, which positions it as the third requirement with the lowest average score. Sentinel, the Climate Policy Database and the Senses Toolkit were the only platforms that scored the maximum score of 100 % for this requirement. Two online tests were used to support the assessment of criterion SP.2 (platform passes cookies and data transfer for GDPR compliance tests) and SP.3 (tool passes Website Safety & Security Checks). For SP.2, the website [66] was used as a proxy for how well each policy platform complies with EU GDPR requirements. For SP.3, the website [67] was used to assess the safety and security of each policy platform website. Regarding compliance with EU GDPR requirements, only Sentinel, Climate Policy Database and the Senses Toolkit were able to pass all the tests performed, with the rest of the platforms usually presenting problems involving cookies installed during the loading of pages not being strictly necessary or some cookies being installed during the loading of the pages without prior consent by users. As for safety aspect, EUCalc and PLACARD failed to pass the safety and security check performed by SSLTrust. The EUCalc Transition Pathways Explorer presented a warning that the SSL Certificate has expired (which is visible for users by the fact that the website has an http protocol instead of https). The main website of PLACARD, in turn, also presented issues with the SSL certificate when tested using SSLTrust.

A.2.8. Accessibility and portability

Accessibility and portability presented, on average, the second lowest average score among the assessed policy platforms (58.3 %). This requirement was also the only one in which none of the ten platforms scored the maximum score of 100 %. On the positive note, all of the ten policy platforms assessed met criterion AP.2 (platforms offer free/open access to all of its functionalities) and only Sentinel – due to the inaccessibility of the modelling tool – failed to pass AP.4 (platform provides access to its functionalities in full via a website). On the other hand, criteria AP.3 (platform is at least partially natively accessible in some other language beyond English) and AP.5 (platform passes accessibility tests) were the ones with the highest number of platforms (80 %) failing to meet them, followed by AP.1 (tool provides an intuitive and easy navigation when accessed via mobile phones or tablets) with 70 % of the assessed platforms.

Regarding the accessibility levels when using mobile devices (criterion AP.1), most platforms were considered to not meet this criterion because, even though the platforms were accessible via mobile phones, the user experience was often severely compromised (e.g., users would frequently need to scroll up and down or laterally, or some visualisations would be visually overloaded when accessed via a smartphone). For the criterion AP.5, the Google Lighthouse accessibility test was executed in order to assess the accessibility of each policy platform website. This test assesses factors such as colour contrast, semantic HTML, keyboard navigation, and screen reader compatibility to ensure that the website is accessible to users with disabilities. Based on this test, only two platforms (Sentinel and Climate Policy Database) were able to achieve a score considered to be good. The main issue with the other platforms were related to background and foreground colours of different screens within the platforms not having sufficient contrast ratio, which can make it hard for users with some kind of visual impairment to visually interact with the platforms. In order to support the assessment of AP.6 (tool passes availability tests), the website [68] was used as a proxy for this criterion because it can send requests to a specified website and check each response from over 40 checkpoints worldwide. All platforms assessed (with the exception of EnerMaps) passed the tests performed by uptrends, meaning that they are available for users across several locations worldwide.

A.2.9. Actively maintained and supported

Actively maintained and supported was the requirement in which the policy platforms depicted the lowest overall score, with an average of only 46.7 %. The Climate Policy Database and I^2AM Paris were the only platforms that scored the maximum score of 100 %, with all others scoring 33.3 %. On the positive note, all platforms (with the exception of Sentinel) successfully met criterion AM.2 (tool provides a menu or option for users to contact someone in case of a bug, question, suggestion or request for additional information). On the negative note, eight platforms (80 %) failed to meet criterion AM.3 (the tool indicates that it has been recently updated, by means of recent data, policies, content or similar) and 7 platforms failed to meet criterion AM.1 (there is evidence that the tool is currently maintained by, for instance, recent posts, version updates, or social media activity).

Data availability

Data will be made available on request.

References

[1] S. Jain, et al., Are we at risk of losing the current generation of climate researchers to data science? AGU Adv. 3 (4) (2022) 1–9, https://doi.org/10.1029/2022AV000676.

[2] C. Guivarch, et al., Using large ensembles of climate change mitigation scenarios for robust insights, Nat. Clim. Change 12 (5) (2022) 428–435, https://doi.org/10.1038/s41558-022-01349-x.

[3] B.A. Bastien-Olvera, et al., Unequal climate impacts on global values of natural capital, Nature 625 (7996) (2024) 722–727, https://doi.org/10.1038/s41586-023-06769-z.

[4] R. McMahon, M. Stauffacher, R. Knutti, The unseen uncertainties in climate change: reviewing comprehension of an IPCC scenario graph, Clim. Change 133 (2) (2015) 141–154, https://doi.org/10.1007/s10584-015-1473-4.

[5] M.C. Lemos, C.J. Kirchhoff, V. Ramprasad, Narrowing the climate information usability gap, Nat. Clim. Change 2 (11) (2012) 789–794, https://doi.org/10.1038/nclimate1614.

[6] K. Jagannathan, et al., A research agenda for the science of actionable knowledge: drawing from a review of the most misguided to the most enlightened claims in the science-policy interface literature, Environ. Sci. Pol. 144 (September 2022) (2023) 174–186, https://doi.org/10.1016/j.envsci.2023.03.004.

[7] C. McGookin, et al., Advancing participatory energy systems modelling, Energy Strategy Rev. 52 (January) (2024), https://doi.org/10.1016/j.esr.2024.101319.

[8] D.V. Budescu, H.H. Por, S.B. Broomell, M. Smithson, The interpretation of IPCC probabilistic statements around the world, Nat. Clim. Change 4 (6) (2014) 508–512, https://doi.org/10.1038/nclimate2194.

[9] J. Harold, I. Lorenzoni, T.F. Shipley, K.R. Coventry, Communication of IPCC visuals: IPCC authors' views and assessments of visual complexity, Clim. Change 158 (2) (2020) 255–270, https://doi.org/10.1007/s10584-019-02537-z.

[10] G. Wong-Parodi, K.J. Mach, K. Jagannathan, K.D. Sjostrom, Insights for developing effective decision support tools for environmental sustainability, Curr. Opin. Environ. Sustain. 42 (2020) 52–59, https://doi.org/10.1016/j.cosust.2020.01.005.

[11] R.H. Moss, Assessing decision support systems and levels of confidence to narrow the climate information 'usability gap, Clim. Change 135 (1) (2016) 143–155, https://doi.org/10.1007/s10584-015-1549-1.

[12] L. Costa, et al., The decarbonisation of Europe powered by lifestyle changes, Environ. Res. Lett. 16 (4) (2021), https://doi.org/10.1088/1748-9326/abe890.

[13] P. Allen, T. Chatterton, Carbon reduction scenarios for 2050: an explorative analysis of public preferences, Energy Policy 63 (2013) 796–808, https://doi.org/10.1016/j.enpol.2013.08.079.

[14] G. Xexakis, E. Trutnevyte, Model-based scenarios of EU27 electricity supply are not aligned with the perspectives of French, German, and Polish citizens, Renew. Sustain. Energy Transit. 2 (July) (2022) 100031, https://doi.org/10.1016/j.rset.2022.100031.

[15] Overview of 100+ Climate Data Platforms | World Resources Institute." Accessed: October. 25, 2024. [Online]. Available: https://www.wri.org/data/overview-100-climate-data-platforms.

[16] S. Elsawah, et al., Scenario processes for socio-environmental systems analysis of futures: a review of recent efforts and a salient research agenda for supporting decision making, Sci. Total Environ. 729 (2020) 138393, https://doi.org/10.1016/j.scitotenv.2020.138393.
[17] M. Gong, et al., Testing the scenario hypothesis: an experimental comparison of scenarios and forecasts for decision support in a complex decision environment, Environ. Model. Software 91 (2017) 135–155, https://doi.org/10.1016/j.envsoft.2017.02.002.
[18] J. Bessette, Douglas L and Campbell-Arvai, Victoria and Arvai, "Expanding the reach of participatory risk management: testing an online decision-aiding framework for informing internally consistent choices,", Risk Anal. 36 (5) (2016) 992–1005.
[19] G. Wong-Parodi, B. Fischhoff, B. Strauss, A method to evaluate the usability of interactive climate change impact decision aids, Clim. Change 126 (3–4) (2014) 485–493, https://doi.org/10.1007/s10584-014-1226-9.
[20] G. Xexakis, E. Trutnevyte, Are interactive web-tools for environmental scenario visualization worth the effort? An experimental study on the Swiss electricity supply scenarios 2035, Environ. Model. Software 119 (2019) 124–134, https://doi.org/10.1016/j.envsoft.2019.05.014. May.
[21] M. Hegarty, The cognitive science of visual-spatial displays: implications for design, Top. Cogn. Sci. 3 (3) (2011) 446–474, https://doi.org/10.1111/j.1756-8765.2011.01150.x.
[22] J.C. Arnott, C.J. Kirchhoff, R.M. Meyer, A.M. Meadow, A.T. Bednarek, Sponsoring actionable science: what public science funders can do to advance sustainability and the social contract for science, Curr. Opin. Environ. Sustain. 42 (2020) 38–44, https://doi.org/10.1016/j.cosust.2020.01.006.
[23] C. Auer, et al., Climate change scenario services: from science to facilitating action, One Earth 4 (8) (2021) 1074–1082, https://doi.org/10.1016/j.oneear.2021.07.015.
[24] AR6 scenarios database, Accessed: Oct. 25, 2024. [Online]. Available, https://pure.iiasa.ac.at/id/eprint/18399/.
[25] D.S. Cruzes, T. Dybå, Recommended steps for thematic synthesis in software engineering, in: International Symposium on Empirical Software Engineering and Measurement, 2011, pp. 275–284, https://doi.org/10.1109/esem.2011.36, 7491.
[26] E. Nicholson, T. Murphy, P. Larkin, C. Normand, S. Guerin, Protocol for a thematic synthesis to identify key themes and messages from a palliative care research network, BMC Res. Notes 9 (1) (2016) 1–5, https://doi.org/10.1186/s13104-016-2282-1.
[27] Lateral - streamline your research workflow, Accessed: Oct. 25, 2024. [Online]. Available, https://www.lateral.io/.
[28] European Commission, HORIZON 2020 in Brief, 2014, https://doi.org/10.2777/3719.
[29] "data.europa.eu." Accessed: October. 25, 2024. [Online]. Available: https://data.europa.eu/data/datasets/cordish2020projects?locale=en.
[30] SENTINEL: sustainable energy transitions laboratory." Accessed: Oct. 25, 2024. [Online]. Available: https://sentinel.energy/.
[31] Scenario explorer." Accessed: Oct. 25, 2024. [Online]. Available: https://www.scenarioxplorer.coacch.eu/.
[32] Soclimpact - project to fight against climate change in EU islands." Accessed: Oct. 25, 2024. [Online]. Available: https://soclimpact.net/.
[33] "eucalc." Accessed: Oct. 25, 2024. [Online]. Available: http://tool.european-calculator.eu/intro.
[34] Innopaths - decarbonisation policy evaluation tool." Accessed: Oct. 25, 2024. [Online]. Available: http://innopaths-pet.niceandserious.com/#/.
[35] CD-LINKS – linking climate and development policies – leveraging international networks and knowledge sharing." Accessed: Oct. 25, 2024. [Online]. Available: https://www.cd-links.org/.
[36] Senses Toolkit." Accessed: Oct. 25, 2024. [Online]. Available: https://climatescenarios.org/toolkit/.
[37] I2AM PARIS." Accessed: Oct. 25, 2024. [Online]. Available: https://www.i2am-paris.eu/.
[38] Connectivity hub." Accessed: Oct. 25, 2024. [Online]. Available: https://connectivity-hub.placard-network.eu/?resource=false&teaser_resource=false.
[39] EnerMaps." Accessed: Oct. 25, 2024. [Online]. Available: https://lab.idiap.ch/enermaps/.
[40] B.S. McIntosh, et al., Environmental decision support systems (EDSS) development - challenges and best practices, Environ. Model. Software 26 (12) (2011) 1389–1402, https://doi.org/10.1016/j.envsoft.2011.09.009.
[41] R.J. Hewitt, C.J.A. Macleod, What do users really need? Participatory development of decision support tools for environmental management based on outcomes, Environ. MDPI 4 (4) (2017) 1–20, https://doi.org/10.3390/environments4040088.
[42] S. Broekx, et al., Web-based decision support to set up cost effective programs of measures for multiple water aspects. iEMSs 2012 - Managing Resources of a Limited Planet: Proceedings of the 6th Biennial Meeting of the International Environmental Modelling and Software Society, 2012, pp. 2841–2849.
[43] J.P. Palutikof, et al., Overcoming knowledge barriers to adaptation using a decision support framework, Clim. Change 153 (4) (2019) 607–624, https://doi.org/10.1007/s10584-018-2177-3.
[44] J. Schumacher, et al., Bridging the science-policy gap – toward better integration of decision support tools in coastal and marine policy implementation, Front. Mar. Sci. 7 (October) (2020) 1–18, https://doi.org/10.3389/fmars.2020.587500.
[45] S. Bartke, R. Schwarze, No perfect tools: trade-offs of sustainability principles and user requirements in designing support tools for land-use decisions between greenfields and brownfields, J. Environ. Manag. 153 (2015) 11–24, https://doi.org/10.1016/j.jenvman.2015.01.040.
[46] R.C. Collini, et al., Utilizing an end-user driven process to identify and address climate-resilience tool needs in the U.S. Gulf of Mexico, Coast. Manag. 50 (2) (2022) 197–214, https://doi.org/10.1080/08920753.2022.2022975.
[47] ISO/IEC25010, Systems and Software Engineering-Systems and Software Quality Requirements and Evaluation (SQuaRE)-Product Quality Model, vol.2023, 2023. Switzerland.
[48] C. Clar, R. Steurer, Why popular support tools on climate change adaptation have difficulties in reaching local policy-makers: qualitative insights from the UK and Germany, Environ. Policy Govern. 28 (3) (2018) 172–182, https://doi.org/10.1002/eet.1802.
[49] C. Fürst, C. Lorz, H. Vacik, N. Potocic, F. Makeschin, How to support forest management in a world of change: results of some regional studies, Environ. Manag. 46 (6) (2010) 941–952, https://doi.org/10.1007/s00267-009-9360-2.
[50] Integrated Climate forcing and Air Pollution Reduction in Urban Systems, MS10: Validated Requirements for the ICARUS DSS, 2020.
[51] S. Schlobinski, R. Denzer, S. Frysinger, R. Güttler, T. Hell, Vision and requirements of scenario-driven environmental decision support systems supporting automation for end users, IFIP Adv. Inf. Commun. Technol. 359 (AICT) (2011) 51–63, https://doi.org/10.1007/978-3-642-22285-6_6.
[52] B. Toolkit, G.B. Sea, Decision Support Tools as Instruments to Facilitate Climate Change Adaptation the Case of the BalticClimate Toolkit for Adaptation in the German Baltic Sea Region, 2011.
[53] L. Calvo, I. Christel, M. Terrado, F. Cucchietti, and M. Pérez-montoro, "Users' Cognitive Load," pp. 1–16..
[54] Integrated Climate forcing and Air Pollution Reduction in Urban Systems, D7.3 Report on Requirements for User-Centric Tools, 2020.
[55] R.L. McCown, Changing systems for supporting farmers' decisions: problems, paradigms, and prospects, Agric. Syst. 74 (1) (Oct. 2002) 179–220, https://doi.org/10.1016/S0308-521X(02)00026-4.
[56] K.B. Matthews, M. Rivington, K. Blackstock, G. McCrum, K. Buchan, D.G. Miller, Raising the bar? – The challenges of evaluating the outcomes of environmental modelling and software, Environ. Model. Software 26 (3) (Mar. 2011) 247–257, https://doi.org/10.1016/J.ENVSOFT.2010.03.031.
[57] C. Haße, C. Kind, Updating an existing online adaptation support tool: insights from an evaluation, Clim. Change 153 (4) (2019) 559–567, https://doi.org/10.1007/s10584-018-2166-6.
[58] L. Pintér, P. Hardi, A. Martinuzzi, J. Hall, Bellagio STAMP: principles for sustainability assessment and measurement, Ecol. Indic. 17 (2012) 20–28, https://doi.org/10.1016/j.ecolind.2011.07.001.
[59] R.J. Hewitt, C. de Boer, J. Flacke, Participatory development of digital support tools for local-scale energy transitions: lessons from two European case studies, Glob. Transit. 2 (2020) 138–149, https://doi.org/10.1016/j.glt.2020.07.003.
[60] R. Webb, D. Rissik, L. Petheram, J.L. Beh, M. Stafford Smith, Co-designing adaptation decision support: meeting common and differentiated needs, Clim. Change 153 (4) (2019) 569–585, https://doi.org/10.1007/s10584-018-2165-7.
[61] The general data protection regulation - consilium." Accessed: Oct. 25, 2024. [Online]. Available: https://www.consilium.europa.eu/en/policies/data-protection/data-protection-regulation/.
[62] EU health policy platform - EU health policy platform." Accessed: Oct. 25, 2024. [Online]. Available: https://webgate.ec.europa.eu/hpf/.
[63] OECD digital economy policy platform." Accessed: Oct. 25, 2024. [Online]. Available: https://depp.oecd.org/.
[64] Doing business." Accessed: Oct. 25, 2024. [Online]. Available: https://archive.doingbusiness.org/en/doingbusiness.
[65] WP3-Ongoing stakeholder dialogue," 2020. [Online]. Available: https://www.paris-reinforce.eu/.
[66] Check website cookies for GDPR compliance and site pages for SSL encryption." Accessed: Oct. 25, 2024. [Online]. Available: https://2gdpr.com/.
[67] Free website safety & security check | SSL tools." Accessed: Oct. 25, 2024. [Online]. Available: https://www.ssltrust.com.au/ssl-tools/website-security-check.
[68] Website uptime test: check website status | uptrends." Accessed: Oct. 25, 2024. [Online]. Available: https://www.uptrends.com/tools/uptime.