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Current needs for climate services in West Africa: Results from two stakeholder surveys

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ABSTRACT

Climate services have been criticised in the past for their tendency to only disseminate results from climate research, rather than to seek to understand and tailor to the needs of their target audiences. Two surveys have been conducted within two projects, ISIpedia and CLIMAP, to assess users' needs for climate and climate impacts information of all countries (with a foremost focus on West Africa) and for Senegal.

The joint analysis of the results showed that climate and climate-impact information is very relevant for West African respondents' activities but a number of barriers prevent existing climate services from fully fulfilling the role they could play in this respect. Consistently across both surveys, the respondents highlighted the irrelevance or the incompleteness of the information that current climate services provide, which is mostly related to the lack of high-resolution information or high uncertainties, as the biggest barriers. Both surveys showed that the lack of training to understand the provided information is also an important barrier, which calls for the organisation of capacity-building activities to ensure the uptake of the information by their target audiences.

Overall, the survey responses demonstrated the importance of stakeholder engagement to ensure the usefulness of climate services in West Africa. In addition, appropriate integration of the existing climate services within the national contexts as well as their dissemination within the ecosystem of information portals and products appear to be essential to ensure their effectiveness.

Practical Implications

Even if global emissions are held to levels compatible with the Paris Agreement, global warming is still likely to trigger a cascade of effects with substantial risks for impacts on natural and human ecosystems and on sectors, such as health and agriculture. The risks are particularly high in developing countries in West Africa where climate is already highly variable, which threatens food security, and adaptation capacities are low. The assessment of such risks in the next decades as well as the evaluation of adaptation and resilience measures mainly rely on the climate simulations, such as those generated within the Coupled Model Intercomparison Project, and on impact simulations from a range of coordinated sectoral and cross-sectoral modelling communities. The resulting knowledge on climate and impact projection data and scientific publications plays an important role in informing decisions on climate risk reduction and adaptation. There are, however, major obstacles that limit access to the use of this information in decision-making processes. These limitations include: a mismatch between the high complexity of the models outputs made available (format, size) and the lack of advanced IT skills of users, inappropriate spatial and temporal scales of the information provided in scientific publications or reports, uncertainty and its communication (and implications), and a lack of common understanding and vocabulary between researchers and users. Climate services were established to address this gap between science and practice and to respond to the needs of decision-makers for information on climate change and its impacts.

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While the use of climate services would be particularly relevant to support decision-making in West Africa to limit potential negative effects of climate change, several issues complicate the development and the use in the region. These originate from the critical climate and climate-impact data scarcity, the low performance of climate and climate-impact models, as well as limited capacity of both providers and users of climate services and the multitude of infrastructure issues. To bridge the climate service gap in West Africa, two initiatives, CLIMAP and ISIpedia, were recently launched to engage stakeholders in the use of climate and impacts projections in the region. Both projects aim to develop online portals delivering climate information: more specifically, CLIMAP will provide climate projections designed especially for the agriculture sector in Senegal (http://retd1.teledetection.fr/climap/proj/), and ISIpedia will provide worldwide country-level sectoral and cross-sectoral information, starting with a focus on West Africa (https://isipedia.org).

Two surveys were conducted to seek input from relevant stakeholders, including those in West Africa, which will then inform the content and design of the respective portals. They aimed to better understand the needs of users and provide guidelines for effectively communicating climate and climate-impact information in the region. The surveys demonstrated that climate and climate-impact information is very relevant to West African respondents' activities. This information is already being used for a diverse range of activities among the respondents, mostly to help develop adaptation plans but less to inform operational activities or decision-making (e.g. providing subsidies or fertilizers to farmers, dimensioning of engineering structures, internal planning of portfolio deployment for an insurance company or bank). However, a number of barriers prevent existing climate services from fully fulfilling the role they could play. The respondents identified the irrelevance or the incompleteness of the information these services provide, which is mostly related to the lack of high-resolution information or high uncertainties, as the most important obstacle. The lack of training to understand the provided information was also raised by the respondents as an important barrier, which calls for capacity-building activities to ensure the effective uptake of information offered by climate services.

The overall results strongly support the need for an effective engagement between the providers and the users of climate services in order to address many issues with current climate services in West Africa highlighted by the surveys. The stakeholder engagement process should go beyond the collection of user input for the design of climate services and incorporate capacity-building of both users and providers of climate services. This includes improved knowledge about climate impacts and a better understanding of how to take advantage of provided tools to access that knowledge. In particular, an effort is needed to improve how to interpret fundamentally uncertain information for robust decision-making on the user's side and to enhance knowledge exchange, translational science and understanding of the decision and policy-making process as practiced by their intended users on the provider's side. Moreover, it is only through dedicated and continued stakeholder engagement that the provision of climate services can be meaningfully and sustainably anchored in the reality of the targeted user groups and countries, e.g. by identifying key regions or time horizons for which information on climate and climate impacts is required, involving local partners who can help sustain the use of the services on the ground, and even beyond the project's lifetime. Finally, the funding environment for climate services is also critical to ensuring their effectiveness, such as the consolidation of already established initiatives, securing their long-term sustainability and facilitating the alignment of complementary but parallel efforts.

1. Introduction

1.1. Climate services: bridge the gap between science and practice

For over two decades, scientists have been accumulating evidence that the increase in anthropogenic greenhouse gas emissions has led to significant changes in climatic conditions, globally and locally. The recent Intergovernmental Panel on Climate Change reports (IPCC, 2018, 2019) highlight that even if global warming is limited to levels compatible with the Paris Agreement, a cascade of effects on natural and human systems, with substantial risks for impacts on ecosystems, health and agriculture, will be unavoidable. For instance, in food-insecure regions of West Africa, a number of recent studies have estimated that increasing greenhouse gas emissions will likely reduce mean crop yields and increase year-to-year variability (Sultan and Gaetani, 2016; Sultan et al., 2010; Knox et al., 2012; Roudier et al., 2011) even under the most optimistic scenarios where global warming does not exceed 1.5 °C, let alone 2 °C (Faye et al., 2018; Parkes et al., 2018, 2017). Future projections used in these studies mainly rely on the climate simulations generated within the Coupled Model Intercomparison Project (CMIP, Taylor et al., 2012) and on the impact simulations from a range of coordinated sectoral and cross-sectoral modelling communities, such as the global Agricultural Model Intercomparison Project, AgMIP, and its branch for regional assessments in West Africa, CI-WARA. Recent progresses on impact assessment have been advanced within the global inter-sectoral impact modelling community, ISIMIP, that has been contributing consistent and comprehensive climate-impact projections to the scientific community through coordinated input of common climate, socioeconomic and other sector-specific data such as land-use into participating models (Frieler et al., 2017; Warszawski et al., 2014; www.isimip.org). The resulting knowledge on climate and climate impact projections, in the form of data and scientific publications, is a valuable asset for informing decisions on climate risk reduction and adaptation.

Although data and many publications produced by many of these modelling communities are publicly available, there are major obstacles that limit access to, reliance on and use of this information in decision-making processes. These limitations - or barriers- include, amongst others, a mismatch between the high complexity of the model outputs made available (format, size) and the basic IT skills of users, technicalities of the outputs that render their interpretation and application difficult, the lack of relevant and usable information on the associated limitations and uncertainties, inappropriate spatial and temporal scales of the information provided in scientific publications or reports and those at which decision-making takes place, and a lack of common understanding and vocabulary between researchers and end-users (Hansen, 2002).

Climate services were established to bridge this gap between science and practice and to respond to the needs of decision-makers for information on climate change and its impacts. In 2009, the World Meteorological Organization (WMO) adopted the Global Framework for Climate Services (GFCS) to strengthen existing initiatives and develop new infrastructure where needed, providing climate information in a way that assists individual and organisational decision-making in all sectors affected, at global, regional and local scales (WMO, 2014). The notion of climate services has rapidly reached the top of the research and research-funding agendas worldwide as well as appearing on the policy agenda, identified as an important instrument of climate change adaptation and mitigation by the Paris Agreement and the Sustainable Development Goals (Jones et al., 2015). However, according to Lourenco et al. (2016), the focus of most climate services activities and discussions is dominated by the cut-and-dry provisioning and dissemination of climate observations and modelling, rather than understanding and tailoring to users' needs. The first step for an effective

climate services should be identifying potential users[2] and their needs (Vaughan and Dessai, 2014) to translate useful information from producers of climate services into usable information as required by users (Lorenz et al., 2017; Lemos and Morehouse, 2005). In some geographycal, political and economic contexts, it could be challenging (see Carr et al., 2019 for a review), for there is a diversity of users within sectors as well as among researchers and practitioners (Skelton et al., 2019) and political and economic constraints which make users' needs do not turn into actions (Lorenz et al., 2017).

It is important to note that, in their broad definition, climate services encompass the contextualization of long-term (several years) climate projections as well as short-term (some days) meteorological information (Tall et al., 2018). However, in this paper, we only focus on the first type of climate services.

1.2. The challenge of climate services in West Africa

While many countries in the world are developing their own national climate services, they have reached different levels in their implementation (WMO, 2014). Currently in West African countries most attention is paid to early stages of climate service development, such as the focus on ensuring appropriate data management and the fully operational provision of weather and seasonal forecasts (Dinku et al., 2018; Hansen et al., 2019). External incentives, such as guidelines from the WMO and USAID as well as funding from international programs (e.g. Hydromet Africa), are aligned with this need for a focus on weather and seasonal forecasts. Additionally, climate services are generally managed by National Meteorological Agencies, such as the Agence Nationale de l'Aviation Civile et de la Météorologie (ANACIM) - which is the IPCC focal point institution in Senegal or the Société d'Exploitation et de Développement Aéroportuaire, Aéronautique et Météorologique (SODEXAM) in Côte d'Ivoire, whose primary mandate deals with weather forecasting and is complemented only relatively recently by future climate modelling.

Moreover, as discussed by Tall et al. (2018), several interrelated challenges complicate the development of climate services in the region. First, Africa critically lacks climate data as it has a weather, climate and hydrology observation network in a nascent stage, with only 1/8 of the required density and less than 300 weather stations with signs of deteriorating quality according to WMO standards (World Bank, 2017). As a result, data to calibrate and validate climate models are significantly scarcer in comparison to Europe or North America. This leads to the second challenge, namely the fact that state-of-the-art climate models in both CMIP3 and CMIP5 exercises show low performance in simulating past observed variability of rainfall in West Africa, and have considerable uncertainties in future climate change scenarios (Biasutti, 2013). These eventually cascade down to higher uncertainties for climate impact projections, as impact models use climate model simulation results as an input. Impact models also often exhibit lower performance because most of them are initially developed for temperate areas, which does not systematically suit West Africa. Moreover, a multitude of infrastructure issues constitute a third challenge. The poor internet network of some countries, their limited computation and computer storage facilities and the restricted access to scientific literature of their research institutions all hinder the access to state-of-the-art climate information and its derived knowledge and products that could help in the context of climate risk management and adaptation.

[2] In this paper we will use the definition of Skelton et al. (2019) for the term 'user'. *'It refers to all people, regardless of their sectoral, academic, or professional affiliation, who have interacted with climate scenarios, (…), often also applying data into their work.'*

1.3. Two climate information portals: CLIMAP & ISIpedia

In an attempt to address the needs for climate services in West Africa, two initiatives, CLIMAP and ISIpedia, were recently launched and have engaged stakeholders in the development of portals. The CLIMAP portal, on one hand, will deliver climate and climate-impact information in Senegal and is funded by the French Ministry for an Ecological and Solidary Transition, the NERC/DFID Future Climate for Africa programme and by the French Development Agency. The ISIpedia portal, on the other hand, will be delivering climate-impact information for individual countries and a number of sectors (health, agriculture, water, biodiversity, energy, etc.) based on the results from ISIMIP. It is funded by the pan-European intergovernmental initiative JPI-Climate. Both portals target members from (sub)national governmental or administrative bodies, NGOs, private companies, international organisations or environmental consultants that may use this information for their activities, such as adaptation planning, outreach, lobbying, strategic and operational planning, as well as researchers. It is worth noting that none of these portals will provide weather or seasonal forecasts. Both initiatives each conducted a survey to ensure that the delivered information is relevant and user-friendly to the targeted stakeholders, including those in West Africa. By analysing both survey results, this paper aims to better understand the needs of users of climate and climate-impact information in order to provide guidelines for designing appropriate climate web portals and thereby effectively communicating this information in the region.

This paper offers an overview of the key findings regarding barriers and needs of the targeted stakeholders in the context of climate service provision. Section 2 lays out methodologies of both surveys. Section 3 analyses the results by focusing on stakeholders' main barriers to the use of and needs for climate services. The results support discussions in Section 4 about the broader technical, organisational and institutional implications for developing climate services that appropriately serve practitioners and decision-makers.

2. Methodology

2.1. Survey descriptions and target audiences

Each project created an online survey aiming to better understand the future user groups of the portal, their current use of climate(-impact) information and their needs in terms of information content and design. An overview and comparison of the components of both stakeholder surveys can be found in Table 1. The text of both surveys with different scopes and questions, as communicated to the survey participants, can be found in the Supplementary Material.

2.2. Survey analysis

In this article, questions from the ISIpedia and CLIMAP surveys are referred to as QI and QC, respectively. Although the scope of both survey questions extended beyond the questions discussed in this study, i.e. preferred file type, importance of given features and functions, only the questions relevant for the comparison between the two surveys were analysed in this study. Three key topics offering comparable results were identified to feed into a relevant discussion: i) frequency of use of climate services, ii) barriers to the use of climate services (with four subcategories), iii) time horizons of interest (Table 2). The full questionnaires can be found in the supplementary information section.

2.2.1. Matching of the two surveys

Although both surveys address the three above-mentioned topics, the structure and wording of the questions (and possible answers) were not always directly comparable. Therefore, the main challenge was to match and merge the questions and answers from both surveys in an adequate way. In some cases, like the answers for frequency of use of

Table 1
General details for both conducted surveys.

	CLIMAP Survey	ISIpedia Survey
online survey tool	Online on www.esurveycreator.com, (commercial version used)	Online on www.surveymonkey.com, (commercial version used)
language	French	English, with translations in French, Spanish & Chinese
date	21 December 2017 to 20 January 2018	open 12 March to 9 April 2018
# of questions	35 questions (34 close-ended questions, 15 of which also including an open-ended field "other"; and 1 open-ended question)	27 questions (19 close-ended, 17 of which also included an open-ended field "other"; and 8 open-ended ones)
Sections	1. User description 2. Climate services use 3. Knowledge about climate projections 4. Climate projections use 5. Needs and interest for a climate data web portal	1. General information 2. Access and use of climate-impact information 3. Design and content of the ISIpedia platform 4. Climate-impact indicators 5. Further contact
Selection of potential survey recipients	Short list of institutions (companies, universities, government agencies, development banks) located in Senegal or working on Senegal with a specific person to contact	Stakeholder mapping based on tapping into Climate Analytics stakeholder networks and online databases such as the UNFCCC focal point and non-party stakeholder lists
# of respondents	57	131 usable responses, 23 from West Africa
Remarks	A link to the World Bank climate portal is provided at the beginning of the survey to give an example	Also includes questions about further development of the ISIpedia project

climate or climate-impact information: "daily", "weekly", "monthly", "very rarely or never", this was straightforward. However, for the question on the barriers encountered during the use of climate services, it was necessary to divide the answers into four common categories (see Table 2). Within these questions, answer options specific to one survey for frequency of use and time horizons were still kept to capture the scope of the answers.

The main structural difference between the two surveys was the question format. Although all of the questions from both surveys analysed for this study were multiple-choice (i.e., had set answer choices

Table 2
Topics or thematic areas from the two surveys which are addressed in this analysis, along with the specific question and relevant possible answers from both the CLIMAP and ISIpedia surveys that address each topic (and sub-topic). "Relevant answer choice" specifies only the common or equivalent possible answer from both surveys.

Topic (label used in the article)	CLIMAP questions (translated from French)	ISIpedia questions	Comments on the merging procedure
Frequency of use for climate services (Fig. 2)	QC16: How often do you use climate projections for your professional activity?	QI8: How often do you use climate-impact information?	4 identical types of answers: daily, weekly, monthly, very rarely or never (*épisodiquement*)
Barrier to use of climate services: Cost & infrastructure (Fig. 6)	QC22: What are the two main problems in climate projections use? Relevant answer choices: 1) Internet connection speed for downloading	QI13: What are the main barriers you have encountered to making use of climate-impactinformation? Relevant answer choices: 1) Inconsistent or unstable Internet connection 2) Cost of accessing information or data	
Barrier for use of climate services: Irrelevance or incompleteness of information (Fig. 5)	QC22 (see above) Relevant answer choices: 1) Products are not adapted to my needs 2) issues with data completeness and promptness 3) results uncertainty is too high	QI13 (see above) Relevant answer choices: 1) lack of relevant information on a particular topic 2) missing sectoral or cross-sectoral information 3) Lack of information for the relevant time horizon 4) lack of information for the spatial scale needed 5) lack of high-precision or high-accuracy information	
Barrier: User friendliness (Fig. 8)	QC22 (see above) No relevant answer choices	QI13 (see above) Relevant answer choices: 1) Not available in a specific language 2) user-unfriendly online services (e.g. due to a lack of a mobile app)	Language was not a possible choice in this question (QC22) of the CLIMAP Survey. However, to QC5 that asked to share user experiences of a specific climate information portal ("What are the two main issues using the World Bank portal?"), 7 people responded that having the portal only in English was an issue
Barrier: Capacity (Fig. 7)	QC22: Relevant answer choices: 1) Lack of skills to analyse the data	QI13: Relevant answer choices: 1) Lack of training to understand or use the information or data found	
Relevant Time-Horizon (Fig. 4)	QC29: For which time horizons would you like to have climate projections?	QI14: For which time horizons is climate-impact information most relevant to your work?	Common possible answers are: "Horizon 2050"and "by 2050" "Horizon 2100" and "by 2100"

that survey respondents selected), the ISIpedia survey allowed respondents to select an unlimited number of choices while the CLIMAP survey allowed respondents to select only up to two options for each question, or one in the question asking about the purposes of use of climate(-impact) information in order to focus on respondents' top choices.

Another key difference was the definition of "climate information" considered in both surveys. ISIpedia will be a platform delivering sectoral and cross-sectoral climate information on the impacts of climate change, and therefore the survey conducted for this project focused on this type of information. It almost always used the term "climate-impact information" which was defined in a "definition box" at the bottom of each survey page (Supplementary Material). The CLIMAP survey, on the other hand, mostly considered specific types of climate information, namely the data and information derived from climate variables (such as temperature and precipitation). For the chosen questions analysed, the CLIMAP survey the term "climate projections", which, despite its narrower meaning, this paper referred to as "climate information."

2.2.2. Comparison of the two survey results

For each topic mentioned in Table 2, three groups of survey respondents were compared: i) all ISIpedia survey respondents (which includes respondents from all continental regions other than Oceania; n = 131), ii) ISIpedia West African survey respondents (n = 23), and iii) CLIMAP Senegal survey respondents (n = 57). In order to ensure comparability between the surveys, we focused on analysing the responses from groups ii) and iii), although we show answers from all groups. In general, for the topics or subtopics analysed, the number of respondents who selected a specific answer was divided by the total number of respondents (i.e., 131 for ISIpedia global, 23 for ISIpedia-WA or 57 for CLIMAP) to obtain percentages. It is important to note that not all participants answered every question and thus the figure percentage numbers to some questions do not add up to 100%. In case a question was skipped by some respondents, the percentages of those who did so were also indicated in the figures by the column "No answer".

In an attempt to better anticipate potential users of climate(-impact) information, the respondents to both surveys were characterised by their organisational type and current purpose of climate service use. The ISIpedia survey included a question (QI2) that asks respondents to identify their own organisational type with 7 possible answers. On the other hand, the CLIMAP survey only collected the names of respondents' institutions, and therefore the provided institutions were classified using the answer choices of QI2 and assigned up to 2 organisation types for better comparison. A cross-analysis resulted in the total numbers of 146, 25 and 65 responses respectively for i) ISIpedia global, ii) ISIpedia West Africa (WA) and iii) CLIMAP as some respondents could choose (in the ISIpedia survey) or were assigned (in the CLIMAP case) multiple organisation types. Consequently, the percentages were derived from dividing the number of responses from each organisation type by these totals for each panel.

A similar cross-analysis was conducted, this time by correlating the respondents' purposes of climate service use against their frequency of climate service use, their barriers and the frequently used time horizons. Then, the number of responses to each answer choice was divided by the total number of responses to each purpose in order to explore potential purpose-specific preferences.

3. Results

3.1. Profile of the respondents

3.1.1. Organisation type

Fig. 1 shows the organisation types to which the survey respondents said they belong (ISIpedia) or to which they were ascribed a posteriori (CLIMAP). The structures of ISIpedia-WA and CLIMAP were relatively similar. However, CLIMAP had more respondents from international or supranational organisations whereas more ISIpedia respondents identified themselves as being from academia or a research institution. Out of 23 West African ISIpedia survey respondents, no one indicated that they belonged to "private company" or "consultancy" and out of 57 CLIMAP survey respondents, no one was assigned to the panel "consultancy." It is also important to note that 95% of the CLIMAP survey respondents (n = 57) have an education degree equal or above Master's degree (information not available for ISIpedia) and 52% hold a PhD. With 10 West African respondents to the ISIpedia survey originating from Senegal and eight of them having declared that they are interested in the topic "Agriculture" (which is the focus of the CLIMAP portal), there is potentially some overlap between the two survey panels. Nevertheless, this cannot be checked as responses were anonymous. The broader focus of the ISIpedia portal, which will cover a higher number of sectors, is likely reflected in the institutional profile of the respondents. It is also important to keep in mind that the interpretation of the survey answers is affected by the limited size of the panels, especially in the case of ISIpedia-WA.

3.1.2. Purpose of use of climate-impact information

The breakdown of the respondents' climate service use purposes further helped identify the current users of climate services. Among the ISIpedia survey respondents from West Africa, the overwhelming majority (91%) uses climate-impact information to "[support] the development of adaptation strategies and plans" (Fig. 2). Notably, this answer was selected by all members of "(sub)national government or administrative bodies" and "academic and research institutions" (44% and 24% of the ISIpedia-WA panel, respectively), and at least half of the respondents from other organisation types (Table S2), which may reveal a widespread potential of climate services for adaptation strategies and plans, regardless of the organisational type. In parallel, the biggest portion (26%) of the CLIMAP survey respondents indicated that their purpose for using future climate projections is "vulnerability studies", which is consistent across different organisational type except for "private company" (see Table S3, note that only one purpose could be selected in this survey). To interpret this specific result, it is important to mention that in Senegal, as well as in other West African countries, the conduction of such studies is notably often also done in the context of the "development of [national or territorial] adaptation strategies and plans" via a participatory process that can involve many actors affiliated with different organisations or institutions dealing with issues related to climate change. For example, in Senegal the development of the National Implementation Strategy (Stratégie Nationale de Mise en Oeuvre, SNMO) of the UNFCCC in 1999 was preceded by a series of vulnerability analysis (Noblet, 2018). More generally, the conduction of participatory approaches to assess a country's climate vulnerability was recommended in the UNFCCC annotated guidelines (UNFCCC LDC Expert Group, 2002), and was effectively done by most West African countries in the process of developing their National Adaptation Programmes of Action (NAPA). Chouinard et al. (2017) and Visman et al. (2017) reported that such setups favour information exchanges between scientists and stakeholders that allow to provide a better vulnerability assessment and adaptation option identification, which helps improve the decision making processes. It is noteworthy that the percentage of ISIpedia respondents who declare using climate-impact information to "support […] adaptation strategies and plans" drops to 55% when considering the global answers, almost equal to the share using it as "input for academic research" (56%); but this can be related to the much higher proportion of researchers in this panel (39%, followed by employees from (sub)national government and administrative bodies, international/supranational and non-profit or non-governmental organisations at 16, 16 and 14%, respectively).

Other common uses of climate-impact information for West African ISIpedia respondents include "public outreach and awareness" (57%), "input for academic research" (52%) and "lobbying decision makers" (48%). The high percentages for these different choices indicate that

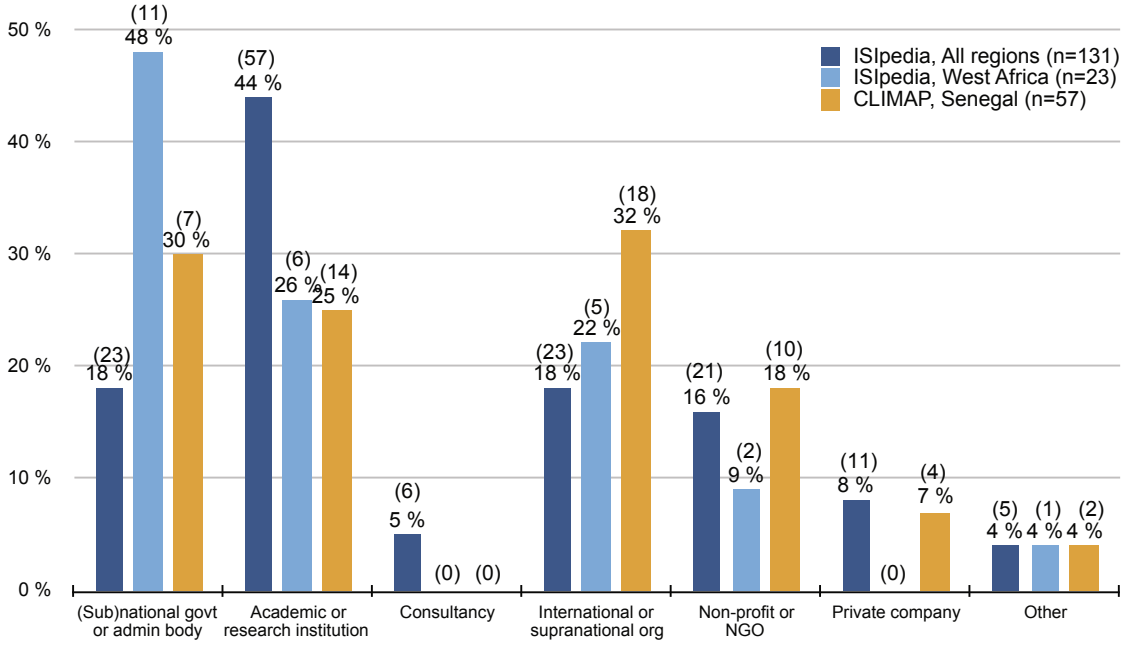

Fig. 1. Panel breakdown of organisation type of respondents, for each survey.

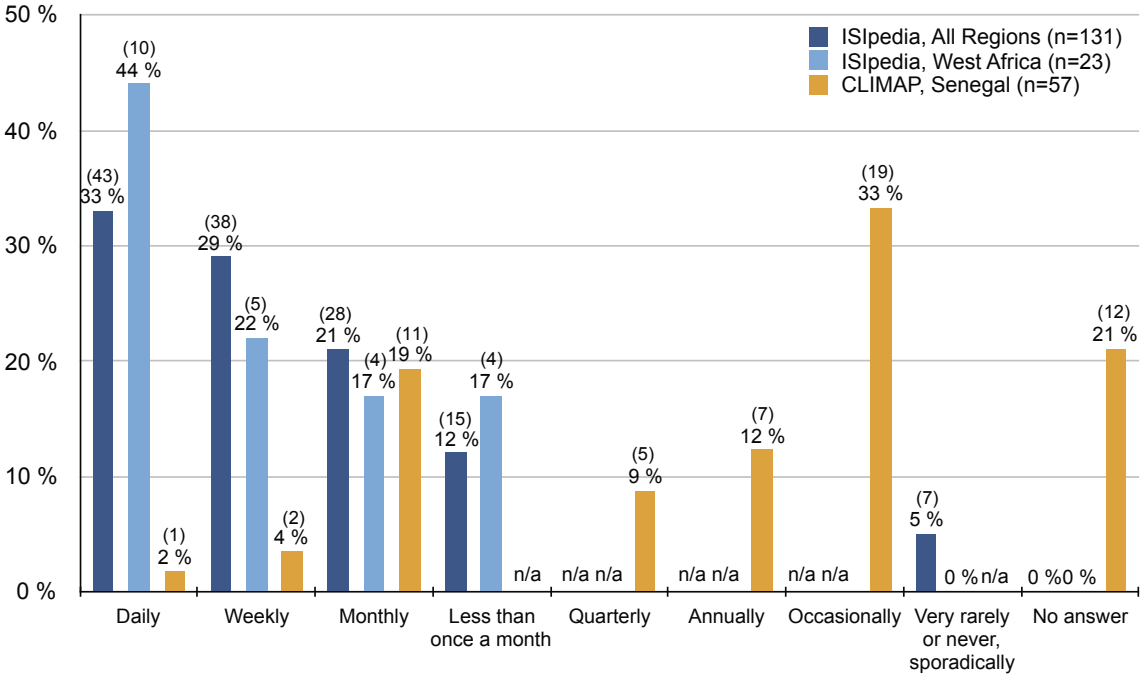

Fig. 2. Purposes for using climate-impact information by ISIpedia survey participants (QI7, up) and climate projections by CLIMAP survey participants (QC13, bottom).

many respondents use climate information for diverse purposes. For example, out of the 11 respondents who identified themselves as members of "(sub)national government or administrative bodies", 5 (45%) selected "input for academic research" and "lobbying decision makers", and 6 (55%) selected "public outreach" as well (see Table S3).

The combined answers of Figs. 1 and 2 as well as Tables S2-3 therefore suggest that the panels of West African (in the case of ISIpedia) or Senegalese (in the case of CLIMAP) respondents consist mostly of staff members from governments, international organisations, research institutions, and to a lesser extent from NGOs who contribute to the development of national or territorial adaptation strategies and plans via participatory processes. It is relevant to note that the National Adaptation Plans (NAPs) have two main objectives: 1) to reduce vulnerability to the impacts of climate change and 2) to facilitate the integration of climate change adaptation into relevant policies, programmes and activities, also called mainstreaming (UNFCCC, 2002). Our results overall strongly suggest that the West African respondents from both surveys mostly pursue the first of these objectives as well as the integration of climate change adaptation into relevant policies when taking part in participatory vulnerability assessments, but also simultaneously contribute to the whole mainstreaming objective via broader programmes and activities by collectively advancing research, communicating to the public and alerting about the impacts of climate change at a higher political level, similarly to what has been reported

from other participative approaches (Chouinard et al., 2017, Visman et al., 2017).

The use of climate-impact information for operational activities is less widespread among our survey respondents as "organisational strategic development and economic planning" was the least selected answer choice in the ISIpedia survey (by only 30% of the respondents). This also appears to be consistent with the CLIMAP survey results where respondents selected "decision-making" (14%), "risk management and asset protection" (9%) and "dimensioning of engineering structures" (5%) less. A likely reason for this finding is the organisational types of respondents, as nobody from the ISIpedia-WA panel identified themselves as from "private company" or "consultancy" (Fig. 1), while two of the four CLIMAP respondents from a "private company" selected "decision-making" and 25% selected "dimensioning of engineering structures", but none of them selected "vulnerability studies" (Table S3). It is therefore possible that the use of climate(-impact) information for operational activities would have been selected more if more staff members from private companies or consultancies had responded to the surveys. Nevertheless, it is still worth noting that while all of the ISIpedia-WA respondents working for "(sub)national government or administrative bodies" declare that they are using climate(-impact) information to "support the development of adaptation strategies and plans", only 27% of them (3 respondents) perceive that they are also using it to make strategic decisions or economic planning (Table S2). Similarly, among the CLIMAP respondents belonging to "(sub)national government or administrative bodies", "international or supranational organisations" and "not-for-profit or non-governmental organisations" (17, 18 and 10 respondents, respectively), "vulnerability studies" was selected at least twice as often as "risk management or asset protection", "decision-making", or "dimensioning of engineering structures" (Table S3). This suggests that the mainstreaming step as part of the second objective of the NAP development process has so far had limited reach in the decision-making (including economic) spheres in West Africa, as noted by Kok and Coninck (2007) for general policy and development planning worldwide, Agrawala and van Aalst (2008) for six developing countries, or more specifically by Noblet et al. (2018) or Alhassan and Hadwen (2017) in the case of Senegal and Ghana.

3.2. Current and potential use of climate and climate-impact information

3.2.1. Frequency of use and level of satisfaction with climate and climate impact information

The results of the ISIpedia survey indicate a high frequency of use of *climate-impact information* globally, with 62% of respondents using it daily or weekly and a similar share in West Africa (66%, see Fig. 3). On the contrary, the CLIMAP survey indicates a lower frequency of use of *climate projections*, with a majority of survey respondents using them occasionally (33%), monthly (19%) or annually (12%). This is a rather consistent pattern across respondents of all three panels irrespective of their organisation types or of their purposes when using this information (Tables S4–9), which is not so surprising given that many respondents belong to several organisation types or indicated several purposes of use. The differences between the CLIMAP and ISIpedia-WA panels are limited – at least in terms of organisation types to which the respondents belong and their purposes of use of climate(-impact) information (see Section 3.1) – and each panel has a limited size, which in general makes it difficult to interpret the differences in frequency of use between the two survey respondents in light of their organisations. However, it can partly be attributed to the way the question was asked, since the term "climate-impact information" used in the ISIpedia survey is catch-all, while the term "climate projections" mentioned in the CLIMAP survey is more specific and technical, which can imply access to a specific data infrastructure or use of data analysis techniques.

The relatively low frequency of use of climate projections of the CLIMAP respondents, nevertheless, does not imply a low relevance of such information for their activities, as overall 25% and 33% of the respondents indicated that climate projections are "very important" and "important", respectively, to improve those activities (QC21, see Fig. S1 in the Supplementary Material). It is worth noting that one of these two answers was selected by at least half of the respondents for each organisation type identified in the CLIMAP survey panel (Table S10). In parallel, only 14% of the respondents judged that their level of access to climate projections is "satisfactory" or "very satisfactory" (QC14, Fig. S2) and only 18% declared their level of satisfaction while using them as "satisfactory" (0% describe it as "very satisfactory", QC20, Fig. S3). Notably, the main interest of the CLIMAP survey respondents consisted of sectoral data such as agricultural yields or water resources (54% of the responses to QC24, in addition to another 5% referring to sectoral issues in the additional "other" field, see Fig. S4) rather than purely climatic information (40%, only one answer possible for this question). This clearly contrasts with their lower current use of sectoral variables (32%, QC18, Fig. S5), compared with that of climatic variables like precipitation (70%) or temperature (54%; 3 choices were possible for this question). The general dissatisfaction of the CLIMAP survey respondents with accessing and using climate projections, as well as the discrepancies between the type of information they are looking for and the one they are currently using, therefore suggests a need for more appropriate climate services to fill the gap between their potential use of climate information and their actual one (as shown on Fig. 3 and described above).

3.2.2. Time horizons of interest

Both surveys show a strong interest in projections to 2050 (44% in the CLIMAP survey and 61% among the ISIpedia-WA panel, see Fig. 4). 2050 was the most and the second most selected answers to the corresponding question in the CLIMAP and ISIpedia survey respectively (both among the global and West African respondents to the latter). Especially, it was the top choice for the employees from academic and research institutions of all three panels (Tables S11–13), thereby illustrating the high attention paid to this time horizon in current climate and climate-impact research. Consistently with this result, with 53% (39 responses) it was also the second most selected answer among the ISIpedia-G respondents that declared using climate(-impact) information as an input for academic research (Table S14). The meaningfulness of cross-analyses with the mentioned purposes of using this information (described in Section 3.1.2) is unfortunately limited in the case of the ISIpedia-WA panel because of its limited size. With 42%, the share of CLIMAP survey respondents which selected 2050 is twice as high as for the second favourite time horizon among those who use climate projections for "vulnerability studies", i.e. to support adaptation planning at the national or territorial level (see Section 3.1.2). This is consistent with the fact that 2050 is a time horizon that is often included in climate policy documents in Senegal. For example, the concrete case of its Intended Nationally Determined Contribution (INDC) and its sectoral Nationally Determined Contributions (NDCs) show that although these documents focus on 2035, the entire 2021–2050 timeframe was considered during their elaboration (NDC of fisheries sector, 2016; NDC of flooding sector, 2016).

The focus on 2035 in many Senegalese policy documents, such as the long-term economic development strategy called the Emerging Senegal Plan (Plan Sénégal Émergent) and the climate policies that were aligned with it (e.g. INDC, sectoral NDCs), is reflected in the fact that 2030 was the second-most selected time horizon among the CLIMAP respondents (40%), including those who declared using climate projections for "vulnerability studies" (note that 2030 was not an answer choice in the ISIpedia survey). This more imminent time horizon was predominantly chosen for the purposes of "Elaboration of plans and advocacy documents", "Decision-making" and "dimensioning of structures" (although only 3 persons selected the latter purpose, and among those 2050 was selected equally often, see Table S16). Moreover, it was the most selected answer among the representatives of "(sub)national government or administrative bodies" (41%, see Table

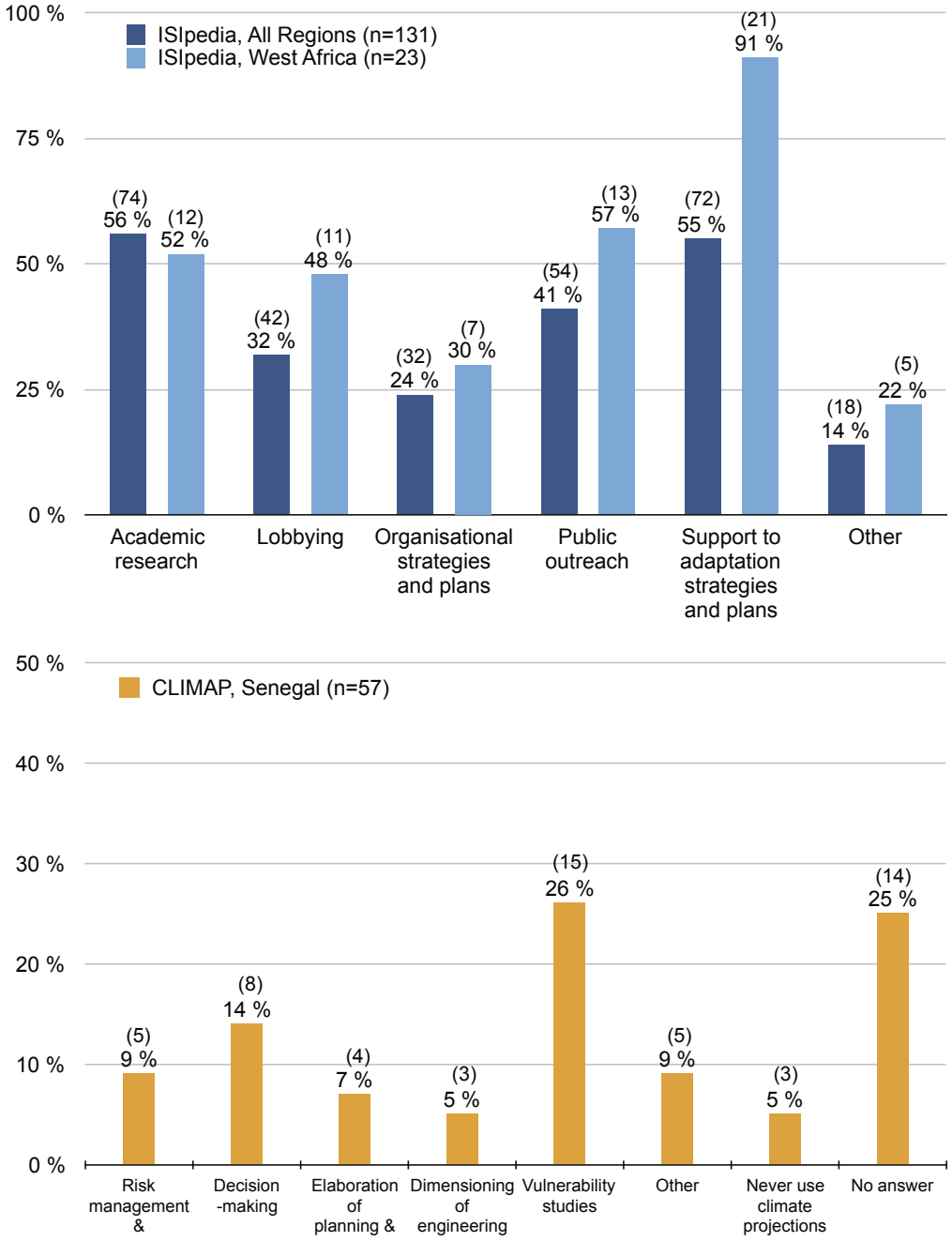

Fig. 3. Frequency of use of climate-impact information (QI8) by ISIpedia survey participants, and of climate projections (QC 16) by CLIMAP survey participants.

S13), as well as "not-for-profit or non-governmental organisations" (60%). Notably, the ISIpedia survey indicates a high relevance of information provided for the current period, with 78% of survey respondents from West Africa selecting this answer option. Here, we stress that different scopes of the term "climate information" used in the two surveys complicated the cross-analysis as the term "climate projection" used in the CLIMAP survey did not include the current period. However, the high share of its respondents who selected the closest time horizon possible in the future (2030, 40%) may also illustrate that they prefer information on climate projections that is as near-term as possible. Consistent with this interpretation, most remaining possible answer options of the ISIpedia survey ("up to one year in the future", "in 1–5 years", "in 5–10 years" and "in 10–20 years") were selected by between 26% and 35% of the respondents from West Africa and appear to be especially important for the respondents from "international or supranational organisations" (Table S12). Globally, the respondents who declared using climate-impact information for "organisational strategic development and economic planning" selected "in 1–5 years", "in 5–10 years" and "in 10–20 years" more often than "2050", while these four options were about equally as important for those who mentioned using it to "[lobby] decision-makers" (Table S14). These preferences therefore suggest that providing more of such information for near-term timescales may favour its applicability for operational activities, i.e. facilitate the mainstreaming objective mentioned in Section 3.1.2.

"The historical period" was selected by 44% and 37% of the ISIpedia survey respondents in West Africa and worldwide, respectively, with relatively similar percentages across organisation types and purposes of use. Furthermore, "2100" appears to be also important as it was selected as often as "2040" by the CLIMAP survey respondents (11%), and

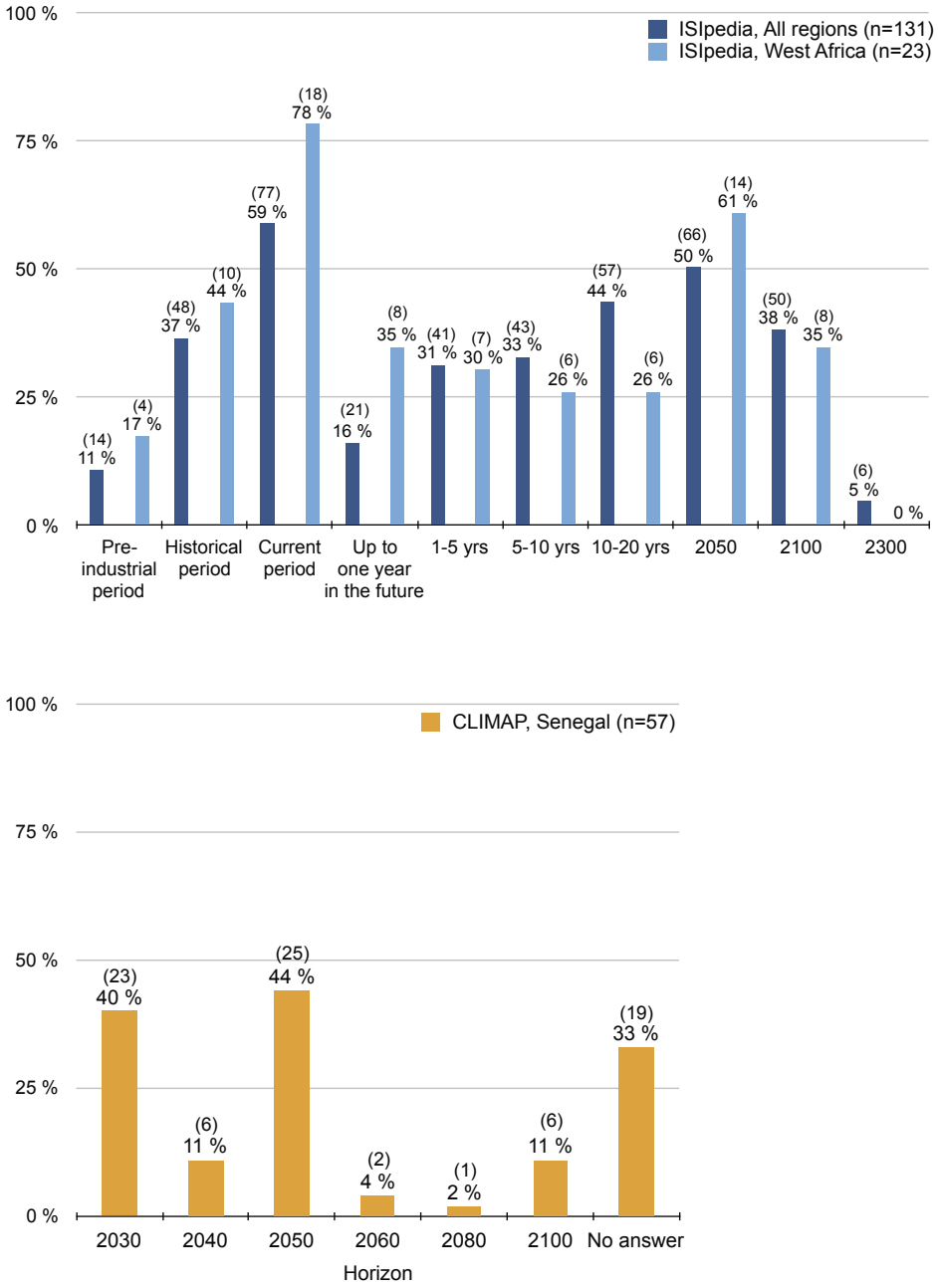

Fig. 4. Relevancy of suggested time horizons for climate-impact information from ISIpedia survey respondents (QI14, up), and time horizons for climate projections that CLIMAP survey respondents are most likely to use (QC17, bottom).

as often as "up to one year in the future" (35%) among the ISIpedia panel. Other answer options were selected much less, with "2060" and "2080" getting at most 4% in the CLIMAP survey, while "the pre-industrial period" was selected by only 17% of the respondents among the ISIpedia-WA panel (Fig. 4).

Overall, the preferences expressed by the panel of respondents from both surveys reveal an interest in the provision of climate(-impact) information for several time horizons reflecting the different purposes revealed in Section 3.1.2: the time horizons included in policy documents (consistent with the fact that climate(-impact) information is mostly used among the respondents to support the development of national and territorial-level adaptation plans), the current period and the coming years (roughly, 1–20) for several organisation types but especially for strategic and economic planning, and by 2050 (especially for research purposes).

3.3. Limitations of available climate services in West Africa

3.3.1. Irrelevance or incompleteness of the existing information

The irrelevance or incompleteness of the existing information on climate or climate impacts were selected as the most important barriers to the use of such information by the respondents from both surveys. The "too high uncertainty in the results" (i.e. the spread among climate models projections) specifically stands out in this category: this is indeed the "main problem for using climate projections" that was most selected by CLIMAP respondents (33%, Fig. 5). This is the case for those from "academic or research institutions", "international or supranational organisations" and "not-for-profit or non-governmental organisations", as well as those using climate projections for the "dimensioning of structures", "vulnerability studies" and the "elaboration of plans and advocacy documents". Similarly, in the ISIpedia survey the

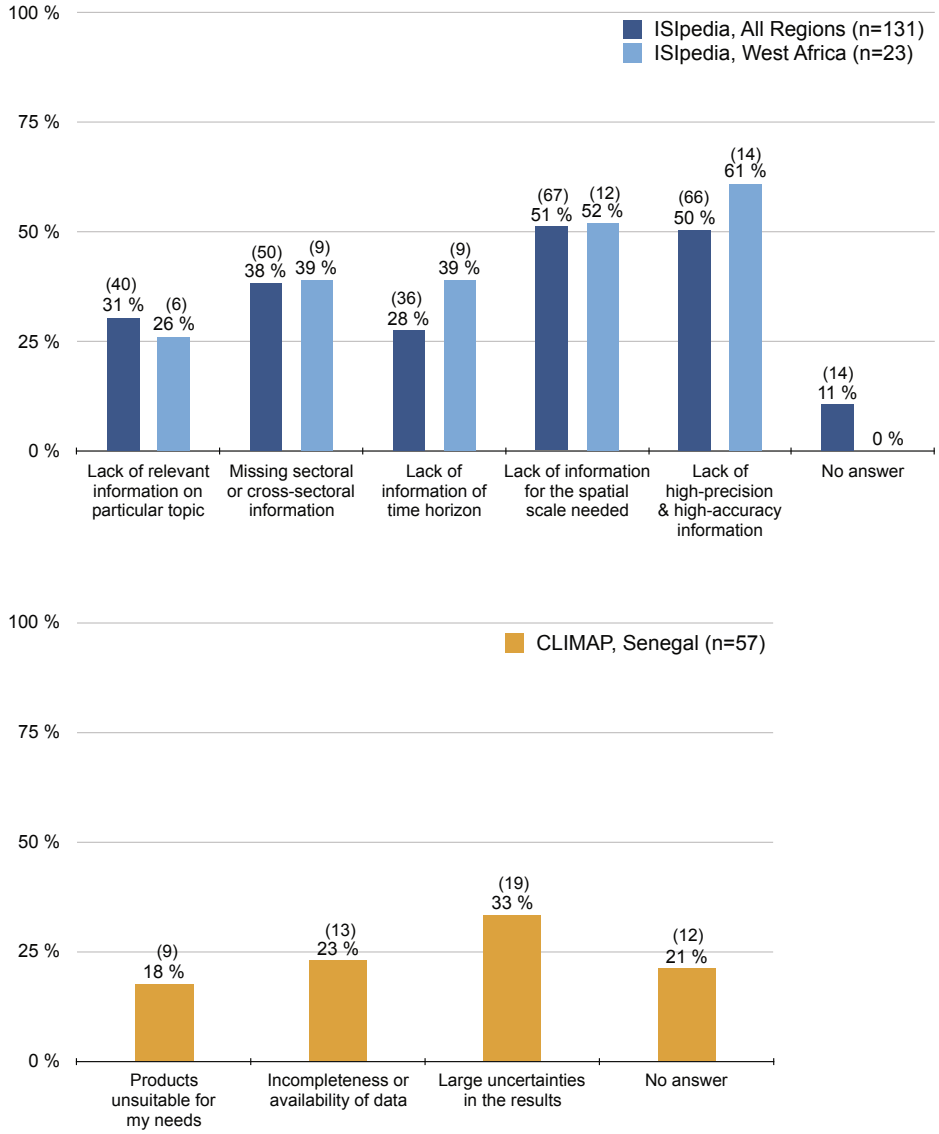

Fig. 5. Main barriers to using climate-impact information (in the case of the ISIpedia survey) or climate projections (for CLIMAP) that are related to its irrelevance or incompleteness, according to the ISIpedia (QI13, up) and CLIMAP survey respondents (QC22, bottom).

"lack of high-precision or high-accuracy information" was the top choice for the "main barriers to making use of climate-impact information" among West African respondents (61%), and the second-most globally. This percentage is similar throughout the various categories of organisations that responded to the ISIpedia survey, making up between 45% and 65% and between 50% and 82% of responses globally and in West Africa, respectively (except for NGO employees, see Tables S17 and S18). The formulation of the latter answer option is a bit broader than the "too high uncertainty in the results", as it can, for example, refer to the lack of spatial accuracy. Since information on climate and climate impacts typically comes from models running at a resolution of roughly 0.25-3°, it indeed gets more uncertain as one focuses on features of this spatial scale. The inadequacy of the spatial resolution of existing information also specifically emerges as an important barrier, with the "lack of information for the spatial scale needed" being the most selected answer by respondents of the ISIpedia survey, and the second most-selected among those originating from West Africa (Fig. 5). Typical model outputs may thus not be able to address some needs of the respondents to the ISIpedia survey who operate at the "subnational" (24%), "local" (20%) or "watershed" (9%) scale (QI4, see Fig. S6). Similarly, for the CLIMAP respondents having climate projections only at the country scale, as provided on the World Bank portal on which they were invited to comment, appeared to be a problem (QC5). This is clearly in line with their expressed needs in terms of spatial resolution that are very diverse (QC28: 19% for country level, 19% for regional level, 12% for sub-regional level, 21% for municipality level, 26% for any specific coordinate point, see Fig. S7).

Other important barriers that are in the "irrelevance or incompleteness of the existing information" category can be a lack of "information for the relevant time horizon," "on a particular topic," or "sectoral or cross-sectoral information," as these were selected by at least a quarter of all West African respondents, with similar numbers globally (Fig. 5). The latter choice is also highlighted in the results of the CLIMAP survey, which indicate a need for sectoral variables, i.e., not only about climate but also about water resources, agriculture, etc. (Fig. S4). "[In]completeness or [un]availability of data" and more broadly "products unsuitable for my needs" are also mentioned as problems for 23% and 18% of the respondents to the CLIMAP survey respectively, which corresponds to the third and fourth most selected answers (out of five). The favoured time horizons for the respondents that use climate(-impact) information for strategic and economic planning had led us to suppose that providing it for more near-term

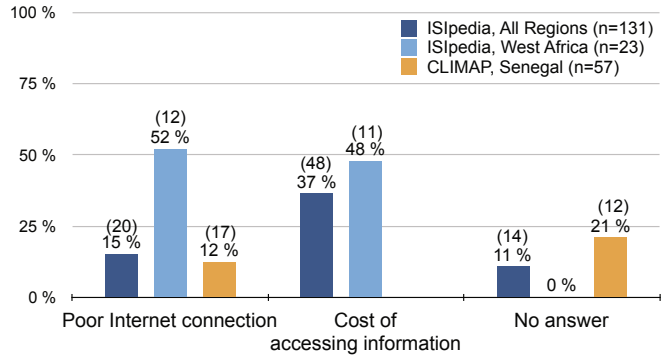

Fig. 6. Main barriers to using climate-impact information (in the case of the ISIpedia survey) or climate projections (for CLIMAP) that are related to cost and infrastructure, according to the ISIpedia (QI13, up) and CLIMAP survey respondents (QC22, bottom). Note that it was not possible to select an answer related to the cost of accessing climate projections in the CLIMAP survey.

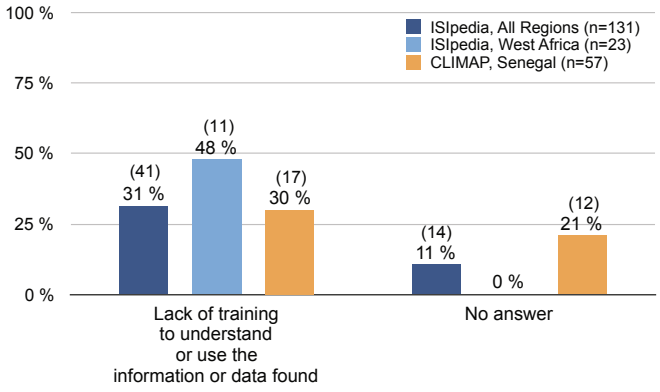

Fig. 7. Main barriers to using climate-impact information (in the case of the ISIpedia survey) or climate projections (for CLIMAP) that are related to the capacity to use the provided data or information, according to the ISIpedia (QI13, up) and CLIMAP survey respondents (QC22, bottom).

timescales may favour its applicability for operational activities (Section 3.2.2). However, "lack of information for the relevant time horizon" is only the sixth choice among the 32 ISIpedia-G respondents who selected "organisational strategic development and economic planning" as a purpose, suggesting that from a global perspective, the mainstreaming of climate adaptation planning into operational activities is not primarily limited by the lack of information for the relevant timescales (Table S22). This answer option scores higher among the ISIpedia-WA panel (Table S23), but the low number of West African respondents (seven) that selected this purpose prevents from drawing a robust conclusion on the specificities of West Africa on this point.

3.3.2. Cost and infrastructure

Strikingly, an "inconsistent or unstable Internet connection" was mentioned three times more often as a barrier to accessing climate-impact information among the West African respondents to the ISIpedia survey (52%, see Fig. 6) than globally (15%), making it the second most selected answer to the corresponding question in the region. It is interesting to note that only 15% of the respondents to the CLIMAP survey selected "Internet connection speed for download" as a barrier for accessing climate projections. This could relate to the particular case of Senegal, which had already developed "one of Africa's most extensive and modern telecommunications infrastructures" by 2012 according to statistics from the private sector, and exhibited Africa's eighth highest Internet penetration rate in May 2019 with 58% (https://www.internetworldstats.com). Additionally, the lower rate of selection for this barrier in the CLIMAP survey may partly be due to the design of the question, which allowed only selection of two answers among the suggested barriers. Overall, these results seem to indicate that the quality of the Internet connection can constitute a hindrance to the provision of information by climate services in West Africa, and that in this respect, the specifics of each country need to be considered.

Almost half of the responses to the ISIpedia survey originating from West Africa (11) reported cost as a barrier to accessing climate-impact information (this was not an answer option in the CLIMAP survey), including seven of the 11 employees from "(sub)national or administrative bodies" and two of the five working for "international organisations" (Table S21). Therefore, their answers likely refer to the costs of hiring paid consultants to gather the required information. The provision of free climate services in the region could address this issue, if scientific information is successfully made openly available for the public in a usable, accessible and legitimate form, i.e. through addressing current issues and barriers to the uptake of climate(-impact) information.

3.3.3. Limited capacity to understand or use the information provided on results of climate services

The "lack of competency to deal with data" (30%) was the second most chosen problem while using climate projections by the CLIMAP survey respondents (Fig. 7). Importantly, this number would have likely been higher if the proportion of respondents holding an educational degree at least equal to the master level would have been lower, i.e. closer to the typical proportion among "(sub)national government and administrative bodies" in West African countries. This result, along with the fact that almost half of the ISIpedia survey respondents from West Africa selected "lack of training to understand or use the information or data found" as a barrier (18% more than the global average), points to an essential need for appropriate online and offline capacity-building activities to accompany the provision of information on climate and climate impacts, and thus promoting their uptake by the targeted users. It re-emphasises that strong attention should be paid to including such activities in the stakeholder engagement component of projects that aim at developing climate services for non-experts. More specifically, on the scope of these activities, 56% of the CLIMAP survey respondents answered that the types of capacity-building activities that they would most "need to understand and use climate projections" would be on "basics of climate modelling" (QC34, see Fig. S8). This being the most selected answer, together with the 35% of respondents that selected "basics of agricultural and hydrological modelling," reflects the priority needs for training to help the targeted users of climate services in Senegal acquire the basic domain knowledge about climate and climate-impact information, and the tools to derive it. Answers to questions QC9-12 further illustrate this point, with 37% of the respondents rating their level of knowledge of climate models as "average" and 32% as "low" (Fig. S9). They declare being less familiar with climate scenarios and even less with bias correction and downscaling methods (with "low" becoming the most selected answer, see Figs. S10–12). In contrast, capacity building focusing on technical skills on "statistical treatment" (37%), "cartography (GIS software)" (23%), and "database management" (19%) tends to be less needed. This may indicate the relatively higher knowledge of the participants about these aspects, or the fact that the products they have access to are delivered in a format that requires little or easy processing.

3.3.4. User [Un-]Friendliness

In comparison to the other above mentioned barriers, the user-unfriendliness of online climate services appears to be less important as it was selected by only 30% of the West African respondents of the ISIpedia survey (although this figure is higher than the global average, 12%, see Fig. 8). Nevertheless, the fact that climate-impact information is "not available in a specific language" is perceived as a barrier by 35%

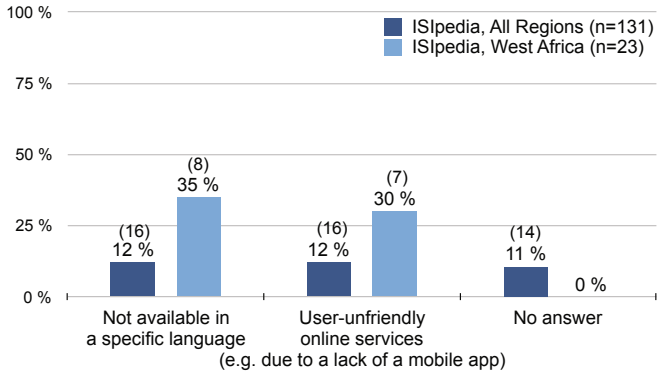

Fig. 8. Main barriers to using climate-impact information (in the case of the ISIpedia survey) or climate projections (for CLIMAP) that are related to their user-unfriendliness, according to the ISIpedia (QI13, up) and CLIMAP survey respondents (QC22, bottom). There was no relevant possible answer for this category in the CLIMAP survey.

of the West African respondents to the ISIpedia survey, i.e. a substantially higher number than the mean for all respondents globally (12%). This figure is even amplified when looking specifically at the answers from respondents using climate-impact information as "input for academic research" (Tables S22 and S23). Therefore, the results from the ISIpedia survey point at the importance of developing climate services in other languages (primarily French, presumably) in West Africa. The CLIMAP survey which was conducted in French did not offer the possibility to back this finding directly as it did not suggest language as a possible problem while using climate projections. However, 7 respondents underlined as an open comment that language was one of the main issues they faced while trying to use the World Bank portal (in English, QC5).

4. Conclusion and discussion

We analysed the results of two surveys independently conducted by the projects CLIMAP and ISIpedia, each of which assessed the needs for climate and climate-impact information of a targeted group of potential users. Both projects ultimately aim to create online portals that deliver climate(-impact) information: CLIMAP will provide climate projections designed especially for the agriculture sector in Senegal and ISIpedia will provide country-level sectoral and cross-sectoral information globally, starting with West Africa. Both surveys share a similar survey structure and a similar composition of panel respondents, composed of staff members from governments or territorial administrations, international organisations, research institutions, and to a lesser extent from NGOs as well as a few from private companies. They primarily use climate(-impact) information to support the development of national or territorial adaptation plans (an answer option that was selected by 91% of the West African ISIpedia survey respondents) via participatory approaches that invite various types of stakeholders. Thereby, they also simultaneously contribute to the mainstreaming of climate change adaptation by contributing to research activities, communicating them to the public and alerting about the impacts of climate change. Importantly, their use of climate(-impact) information for strategic operational (e.g., economic) planning is perceived to be limited, although this could be due to the under-representation of employees from private companies and consultancies in the panels.

We found that information on climate, and furthermore on climate impacts, is very relevant for the activities conducted by the West African survey respondents but there is still a significant gap between their current use of such information and the potential role it could play in their work. For example, 58% of the CLIMAP survey respondents revealed that climate projection information is important or very important for their work, especially within the context of the development of adaptation strategies and plans (an answer option that was selected by 91% of the West African ISIpedia survey respondents), but currently only 18% of them are satisfied with the usage. Further survey results indicated that the West African respondents prefer climate(-impact) information for the near-term future (about 1–10 years), especially for strategic, operational planning, or that corresponding to specific policy-relevant time horizons (e.g. 2030 in Senegal), while further specific time horizons are also of interest to those in the academic and research sphere (e.g., 2030 and 2050). Finally, we showed that the respondents currently face a number of barriers that are responsible for the gap between their current and potential use of climate services that will be discussed in more detail.

Overall, appropriate stakeholder engagement is key to tackle the reported barriers to the use of climate and climate-impact information. This study examines the results of two projects' first steps in the stakeholder engagement process for designing climate web portals responsive to expectations and needs of users in West Africa. These surveys enabled the ISIpedia and CLIMAP teams to better understand the current users of climate services and their needs for climate information, and more importantly allowed for a co-development process between producers and users. Several extensive reviews have documented the necessity for climate services providers to engage in a two-way collaborative, iterative, interactive and durable process to improve the effective generation and utilisation of climate information to inform decision-making and support adaptation to climate change, particularly in developing countries and Africa (Vincent et al., 2018; Bremer et al., 2019). This communication, which can take the form of regular stakeholder workshops for instance, is a necessary step in the design of climate services platforms to understand the requirements of their users, to test if these have well been taken into account, and more generally to regularly receive user feedback (Bettencourt, 2011).The design of relevant portals delivering climate and climate-impact information in Senegal (CLIMAP) and in West Africa (ISIpedia), will thus require – and has already involved – not only a work to fit to users' needs and expectations as identified in the surveys, but also a continuous effort of collaboration and communication between climate information producers and users through dedicated workshops. These will thus allow to check whether the user input has been appropriately taken into account into the design of climate services along their development.

Furthermore, the purpose of the stakeholder engagement process should not be limited to this latter goal, but also include the conduction of capacity-building activities providing basic knowledge about climate impacts and the tools to study them, or the provision of support on how to interpret fundamentally uncertain information for robust decision-making. Both the ISIpedia and CLIMAP surveys indeed show that the lack of understanding of climate(-impact) information is one of the most important barriers which limits its use in the respondents' activities (Section 3.2.3). This issue has been highlighted by almost half of the ISIpedia survey respondents from West Africa, and this number is likely underestimated since both panels include a high proportion of respondents with a high educational degree (PhD, Master). These results thus indicate that ensuring the relevance of climate services not only requires providing relevant information, but also addressing the need for capacity-building and to organise communication activities to accompany this provision of relevant, usable, legitimate and credible information. Further responses to the CLIMAP survey highlight the preferences of the Senegalese respondents for capacity-building activities that provide basic domain knowledge about how climate(-impact) information is obtained and processed (e.g., such as on climate, agricultural or hydrological modelling). As stressed by Vincent et al. (2017) in their study focusing on Malawi, an investment in capacity building and assistance to climate services (e.g. trainings, scholarships, summer schools, technical support, massive open online courses) could even prove more cost-effective for donors than funding vast amounts of information that remains unused because of a lack of knowledge.

Moreover, another important barrier to the use of climate and climate-impact information that was expressed in the two surveys is related to the irrelevance or incompleteness of the existing information, such as its uncertainty, its coarse spatial resolution or the lack of relevant time horizon and/or sectoral information. Scientific efforts aiming to deliver information on a wider number of sectoral variables may partly address this barrier. As discussed by Goosen et al. (2013), sectoral variables give better support in the design of adaptation strategies, therefore rendering the CLIMAP and ISIpedia portals highly relevant for users, as both services aim to provide sectoral information. However, other aspects, including high spatial resolution, precision and accuracy in information, prove more difficult to address. Increasing spatial resolution to reach the scale demanded by some survey respondents (regional, sub-regional or even municipality levels) while keeping a reasonable precision level indeed appear to be far beyond their capabilities of most current climate and climate-impact models. This indeed points to a strong need for model development and refinement of downscaling techniques by considering new methodologies for example based on machine learning (Knüsel et al., 2019), which is out of our study scope. In order to effectively facilitate the uptake of climate(-impact) information and to avoid a misuse of the information for example in the context of adaptation planning, procedures should also be implemented that do not rely on detailed and certain projections but include scoping adaptation options to identify low-risk, robust ones and to challenge these with currently available climate change projections (Nissan et al., 2019; Hallegatte, 2009). The interactive and durable stakeholder engagement activities mentioned above can also help achieve these objectives by allowing the identification of case studies to elaborate on later during dedicated capacity-building activities, in order to illustrate how the portals providing climate(-impact) information can be used (for example for adaptation planning). This is particularly what the ISIpedia project plans to work on once its portal is online.

Understanding the institutional complexity and articulating our climate services offer within the institutional framework are key for sustainable climate services (Bettencourt, 2011). Endorsement of a project by key national institutions or more generally climate-impact information users is crucial to ensure usefulness in activities in a given country, e.g. policy processes, and therefore its perennity. In Senegal, the CLIMAP initiative established strong links with ANACIM which is the IPCC focal point, with an important role in the NAP in Senegal and close contacts with key relevant stakeholders in each sector. The connection to ANACIM is perceived as key to ensure the continuation of the platform beyond the CLIMAP project lifetime. This is especially true as funding activities to maintain, update, improve a platform delivering climate(-impact) information or communicate its results to other sectoral users remains challenging, since the multiple funding incentives rarely support consolidation and effective delivery of existing climate services and government budgets are generally hardly available for multi-sectoral climate information systems (Bettencourt, 2011). Therefore, there is a need, while developing such web portals, to (i) define a clear sustainable business model in order to maintain the portal in the future and add new climate runs and/or analyses (it can be completely free and funded by the government or donors, or free for public actors such as academics and not for private companies etc…) and (ii) assess the added value of such services for different types of actors. This could be used as an argument to prove to governments/donors that investing in long-term climate services is valuable. This assessment of the impacts of climate services use has already been done in several papers (see e.g. Vaughan et al. (2019) for a review in Africa) but only for short term (daily to seasonal) climate services. There is to our knowledge, no similar studies focusing on long-term climate services such as CLIMAP or ISIpedia. There is therefore a real need to build a methodology to assess the added value of such portals' use and to demonstrate that value.

Last but not least, the development of the CLIMAP and ISIpedia portals are just two initiatives among a myriad of projects aiming to develop climate services (see e.g. Swart et al. (2017) for a non-comprehensive list of existing initiatives). In the near future, several new climate portals will be created with various e.g. focus areas or data types. For instance, the coming 6th IPCC report will include a web atlas in order to visualize climate results in a more interactive way, the Building Resilience in the Indian Ocean[3] project will also design such a web portal with new high resolution data on small islands; a CORDEX-Africa Impact atlas is also under development at the Climate System Analysis group of the University of Cape Town[4]. As a result, there exists a high risk of funding redundant projects and thus of duplication of efforts, which calls for an assessment existing initiatives by all involved actors (funders, scientists, climate services developers and users) in order to identify strategies for increasing the complementarities among these climate service outputs and portals in a manner that enhances the utility and reduce the confusion of the intended users. This outlines the need for coordination among projects aiming to develop climate services and identifying an appropriate coordinating body is not without challenges. Although, the GFCS appears to stand out as a natural candidate to endorse it, this would require an important extension of its area of responsibility.

A less top-down, nonetheless welcome approach, would imply that the persons working on different climate services projects focusing on similar areas and/or topics directly coordinate in order to benefit from each other's feedback, but also to identify ways of collaboration. This is what happened between the CLIMAP and ISIpedia teams who decided (i) to share all their surveys results with each other, (ii) to communicate jointly about their stakeholder processes and (iii) to provide on the final version of each portal a link to the other. This is fundamental as a non-expert user could wonder why results from both websites are not exactly the same.

Nevertheless, we acknowledge a few caveats to our analysis and suggest readers to take precautions when interpreting the presented results and applying them in different contexts. The two survey results were based on a limited number of respondents (57 and 23 respectively for the CLIMAP and ISIpedia surveys) and do not represent all possible climate information users despite our efforts to diversify the respondents pool in terms of sectors as well as organizational types. We also acknowledge the possible overlap of respondents in the two surveys as they were conducted separately. However, despite our attempt to account for the overlapping cases, we were not able to because the survey respondents remained anonymous for ethical obligation. Lastly, as discussed above, the mismatch of the time horizons that "climate information" of the two surveys provide made it difficult to draw a definite conclusion regarding their preferred time horizons. However long-term projections remain a crucial information for the development of adaptation strategies and plans as assessed by 91% of the West African ISIpedia survey respondents.

Declaration of Competing Interest

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

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[3] http://commissionoceanindien.org/axes-strategiques/environnement-durable-et-changement-climatique/changement-climatique/activites-en-cours/projet-brio/?fbclid=IwAR1HeZZU1v7lV7Sj9SXSuDbGieIPnkM1HYpkZ8rJey6qa6IA-hBal6SLXd4.

[4] http://www.csag.uct.ac.za/cordex-africa/cordex-africa-impacts-atlas/prototype-impacts-atlas/.

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Appendix A. Supplementary data

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