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Abstract

The widely recognized increase in greenhouse gas emissions is necessitating adaptation to a changing climate, and policies are being developed and implemented worldwide, across sectors, and between government scales globally. The aim of this paper is to reflect on 1 of the major challenges: facilitating and sharing information on the next adaptation practices. Web portals (i.e., websites) for disseminating information are important tools in meeting this challenge, and therefore, we assessed the characteristics of select major portals across multiple scales. We found that there is a rather limited number of case studies available in the portals—between 900 and 1000 in total, with 95 that include cost information and 195 that include the participation of stakeholders globally. Portals are rarely cited by researchers, suggesting a suboptimal connection between the practical, policy-related, and scientific development of adaptation. The government portals often lack links on search results between US and EU websites, for example. With significant investments and policy development emerging in both the US and EU, there is great potential to share information via portals. Moreover, there is the possibility of better connecting the practical adaptation experience from bottom-up projects to the science of adaptation.

Introduction

The seriousness of climate change impacts on socioeconomic and environmental systems has forced governments around the world to consider how to best adapt to the more frequent extreme weather-related risks and changing climatic conditions cost-effectively. Adaptation needs are related to the protection of human health (e.g., disaster risk reduction), ecosystem services (such as adapting agricultural practices and policies), and human infrastructure (e.g., protecting cities against flooding). Restricting the average global temperature increase to no more than 2^{o}C during this century relative to preindustrial times remains the official mitigation policy benchmark, per the UN 'Copenhagen Accord' from COP15, and is the point of departure for the 2015 COP 21 Meeting in Paris to lessen the serious and dangerous impacts of climate change (http://unfccc.int/2860.php).

The window for restricting the rise in global surface temperature to this limit, however, is closing rapidly. The United Nations Environment Programme (UNEP) (2013) estimates that meeting the 2^{o}C target with the fewest costs would mean that emissions in 2050 should be 41% and 55% below such levels in 1990 and 2010, respectively. By 2020, global emissions should be reduced by 17±3 $GtCO_2$. However, the global reduction pledges do not amount to this—at best, the emission gap would be 6 $GtCO_2$. The COP21 agreement concludes that the current intended CO2 emission reductions in 2030 will result in annual global emissions of 55 GtCO2 (paragraph 17), which needs to be lowered further to 40 GtCO2 to meet the 2^{o}C target in 2030. Hence, Anderson and Bows (2011) found that there is now little or no chance of maintaining the rise in global mean surface temperature at or below 2^{o}C, despite repeated high-level political statements to the contrary. Betts et al. (2011) concluded that their best estimate is that a 4^{o}C rise in global temperature, compared with preindustrial levels, will occur in the next 50–60 years. It is therefore increasingly evident that climate change adaptation is becoming progressively important on a global scale to protect against potentially more extreme and frequent weather events and risks (e.g., the recent

hurricanes Bopha (Pablo), Sandy, and Haiyan) and gradually changing climatic conditions, such as agriculture under a potential 4^{o}C scenario (New et al. 2011).

In light of the above, adaptation to climate change is becoming increasingly important from humanitarian and economic points of view. Adaptation can in essence be seen as the societal reaction to climate change in coping with current or anticipated climate changes in relation to extreme weather events—such as increased rainfall, scarcer water resources, and more frequent storms—and gradual changes in, for example, new disease and pest patterns and ecosystem service provision (Adger et al. 2007). The UNFCCC (2015) has defined adaptation as adjustments in ecological, social, or economic systems in response to actual or expected climatic stimuli and their effects or impacts. It refers to changes in processes, practices, and structures to moderate potential damage or to benefits from opportunities that are associated with climate change (http://unfccc.int/focus/adaptation/items/6999.php) Autonomous adaptation will occur, but the advancement and application of science in the areas of climate, its impacts, society, and economics should enable proactive science-based planning of adaptation to climate change that cost-effectively minimizes environmental, social, and economic disruption. There is hence a need for sound data and information-sharing to support decisions that increase adaptive capacity. Adaptation planning is thus a knowledge-intensive process (Juhola and Westerhoff 2011).

There is a burgeoning database industry in the areas of climate change research and adaptation, particularly as climate change research enters the 'big-data' and 'big-science' realms across the globe (Editorial Nature CC. 2012). Decision makers are therefore generally faced with ever-growing sources and amounts of information, especially in adaptive management, in which the value of information is a very important steering tool (Keisler et al. 2013). Data are being shared globally via adaptation web portals (i.e., websites) (Carroll & Lambat, 2013), with the goal of sharing and linking knowledge and facilitating adaptation measures. In 2015, the European Environment Agency published a report providing an overview of European adaptation portals

(EEA, 2015) in terms of their challenges and strengths. Moreover, portals have been developed by individual projects, authorities, various communities, and even interested individuals.

It is not self-evident that the knowledge delivery corresponds to the perceived needs of those preparing adaptation actions. Adaptation consists of at least 5 general components: observation, assessment of impacts and vulnerabilities (risks), planning, implementation, and monitoring and evaluation of adaptation measures. Effective involvement and engagement of stakeholders and management of knowledge for adaptation are vital in supporting all adaptation activities at each step in the process. Under the Cancun Adaptation Framework, relevant multilateral, international, regional, and national organizations; the public and private sectors; civil society; and other relevant stakeholders are invited to undertake and support enhanced action with regard to adaptation at all levels (http://unfccc.int/focus/adaptation/items/6999.php). It is clear from this development that an accurate assessment of the risks, effective planning that involves the stakeholders (participation), and cost-effective measures are key for successful adaptive planning. However, the usability of such knowledge arguably depends on the extent to which it can be applied to a local context and scale and, thus, the degree to which the stakeholders—as key implementers and knowledge users and providers—can participate in both the knowledge generation and decision-making processes. The extent to which cost assessments and stakeholder participation are considered and reported in key online tools and knowledge portals is investigated in this paper.

Our aim is to provide a brief presentation of selected knowledge portals that have been set up to support adaptation. To this end, we seek to assess the number of case studies (e.g., adaptation in a city in which the measures, processes, and results are presented) available in the portals, with a focus on critical decision support-relevant information—namely, cost assessments and stakeholder participation—in the implementation of the adaptation plans as key components of successful adaptation planning. We selected major portals primarily from the US and EU and used them as an entry to state- and country-specific portals. Lastly, we included 3 international portals (see Table 1).

We then examine a selection of online portals from different jurisdictions and discuss their general use and content.

A uniform motivation underlying the establishment of portals is that policy development around critical societal and environmental issues, such as climate change, should be based on sound science and an informed democratic process for decision making (OECD 2002). Adaptation is needed in virtually all sectors; there are, however, serious scientific gaps and challenges with regard to the delivery of decision-relevant science to the decision-makers. One of the areas in which there is a knowledge gap is the field of adaptation case studies, in which there has been little comparative and evaluation research (Moss et al. 2013). Moss et al. (2013) note that a number of portals with adaptation lessons are emerging (e.g., those in this paper) but that a particular challenge in academic research on adaptation is learning from adaptation practices in thus contributing to a cumulative adaptation science and, by extension, science-based adaptation policy- and decision-making. Hence, for climate change adaptation and national strategies to fulfill this requirement of enhanced resilience, there is a strong need to share (e.g., via the internet) policy-relevant information, such as economic analyses of adaptation measures, and involve the local community whose lives are being affected by the measures taken. Viner and Howarth (2014) also point toward the problem that the academic community is not effective in including practitioners in the systematic review of evidence and note that the lack of integration hinders full and realistic assessments of available evidence, thus illustrating a disconnect between science and practitioners as a barrier in the area of adaptation development.

In terms of the value of information in an adaptive management context, which climate change adaptation often is, information about costs and participation is critically important for cost-effective adaptation planning, as outlined by the UNFCCC above. Such information is quantitatively accessible via adaptation portals containing case studies that address these experiences and was therefore our focus point in the present paper.

Results:

We examined the direct links to scientific knowledge of the portals, as indicated by hits and citations in Google Scholar and Web of Science, to quantify the suggestions by Moss et al. (2013) and Viner and Howarth (2014) on the lack of connection between practitioners and academics. We used the total number of case studies that reported an analysis of costs and stakeholder participation as indicators of decision-relevant contents and valuable/useful information (Keisler et al. 2013) in an adaptive management context (Table 1).

Some of the webpages were not assessable by Alexa, as they were subpages of larger organizations web portals (USEPA, EEA, WHO, and UNFCCC). In terms of global ranking, the portals were not very high overall. Another indicator of the use of the portal is provided by the information on the number of sites that link to it. The UKCIP, Georgetown, and weADAPT have the highest number of links in, whereas the portals from California, Denmark, and Finland have the fewest. The Google Scholar hits suggest that the US EPA, UKCIP, and weADAPT are the most well-known sites in the scientific community, but overall, the portals get few references in the literature. This was confirmed by the search in Web of Science, which did not provide a single reference to any of the portals. In terms of the adaptation case study content, CAKEX has the largest database and the most studies that address costs and stakeholder participation. There is most likely an overlap with the Georgetown database, as the portals crosslink. In Europe, the Climate-Adapt portal appears to contain most studies that are relevant with regard to costs and participatory approaches, although other portals have more case studies, such as UKCIP. Among the more project-oriented portals, weADAPT contains 21 and 16 studies on costs and stakeholder participation, respectively.

Cases with cost information and participatory approaches constituted a small proportion of the total number of case studies in the portals. However, neither the number of cases nor their

content seemed to affect the Google Scholar hits. This suggests that most users of the portals look for other information than what is provided in the case descriptions. There were no explicit links between the US and EU portals. This may reflect the view that adaptation has been considered to be highly geographically context-specific in terms of the local social, economic, environmental, and political conditions.

The patterns that emerged from the comparison of the portals (Table 2) probably have many explanations. In terms of sites linking to the portals, small countries scored low, as one would expect, due to language. The scholarly references to the portals were highest for the US EPA and UKCIP—they are, of course, also older and more academically established than most of the other sites. A detailed analysis of references to these portals in the literature is beyond the scope of this paper, but a preliminary examination suggested that 1 reason for scholars to refer to the portals was that they can contain specific documents that may be difficult to retrieve from other places. For example, Wheeler (2008) referred to "State climate action plans: http://www.epa.gov/climatechange/wycd/stateandlocalgov/state_action.html." Another reason for citing portals was their role as a repository for specific tools or models. For instance, Berry et al. (2002) referred to "UKCIP Technical Report. UKCIP, Oxford. http://www.ukcip.org.uk/model_nat_res/model_nat_res.html." Moreover, Kirchhoff et al. (2013) explained how UKCIP is a recognized successful boundary/interface between science and practice.

As the US Climate Data Initiative (CDI) is under development, the current primary information portals on adaptation in the US are: Georgetown Climate Center, US EPA (2 webpages), and the Climate Adaptation Knowledge Exchange. There is also a portal with a map that shows how cities and states are adapting (or becoming more resilient) to their individual vulnerabilities. The map is not a comprehensive compilation of every city plan or action but rather highlights concrete adaptation actions and examples of what both large and small US cities are doing to adapt to a changing climate (http://www.c2es.org/us-states-regions/policy-maps/adaptation). Portals that have included content that has been used directly in scientific work

have received more scholarly references than those that contain, for example, case descriptions or practical advice on how to carry out adaptation.

Overall, our analysis suggests that the academic use of the portals—e.g., case study content—remains somewhat limited, thus quantitatively confirming the qualitative observations by Moss et al. (2013) Viner and Howarth (2014) that integration of practitioners' research and academic research could be improved, at least from an academic point of view. The databases that the portals include are probably used primarily by the decision makers and stakeholders who have also been perceived to be the main audience for the portals.

The limited impact of portals thus far in this context is not surprising. As far back as the late 1970s, Weiss (1979) coined the phrase the 'problem of little effect,' in which policy-relevant knowledge is generated but not picked up by decision-making processes. It might be that demand for the information they contain may be limited, because adaptation planning is still in its infancy (Ford et al 2011). Another factor might relate to the perceived usability of the data in relation to the needs of decision makers and stakeholders (Frazy et al 2013) in terms of perceived robustness, data format, value of information, and fit with the adaptation context. The low academic use of the portals might also suggest a low profile of these portals—in that they are not developed with researchers as the target audience and that the researchers have not been aware of them in general—as well as the limited number of other websites linking into them.

Further research into the use and value of portals is needed to concretely determine what is driving the patterns we have observed in this paper. Such research is vital to ensure that the portals are appropriately targeted to the needs of decision makers to enable them to fully utilize and share knowledge and experience for more robust and inclusive adaptation planning. In addition, it is obvious that it takes time for a portal to establish itself as an important source of information. Persistence in developing and maintaining the portals is therefore crucial. The community-based portals, such as CAKEX and weADAPT, have a clear strength in that a large group can contribute

to the development. Portals that function as repositories of specific methods and official documents are also likely to be able to attract the attention of a broad user community, including decision makers, practitioners at many levels, and researchers.

Concluding reflections

There is clearly a need for better information-sharing in adaptation, especially with regard to high-value information in support of decision- and policy making in implementation and participation and the economics of adaptation. Further, there is a need to connect practice-oriented research from real-world case studies and policy making to scientific research in adaptation. It is also necessary to share adaptation information on a global scale—certainly between the EU and US—by linking portals as a starting point, for instance. Similarly, regions and countries that are prone to drought and flooding could also benefit from combining or linking, as can nations with similar socioeconomic and political status.

We have presented the portals that cover key elements of the impact of climate change, vulnerability, and adaptive capacity, with a focus on the currently most relevant ones. It is an additional and active research step to render the portal salient for those who may need information in drafting and implementing policies or in planning and executing measures that improve adaptive capacity locally or regionally (Kirchoff et al. 2013). There is an obvious potential for conducting interesting comparative analyses of the content, development, and use of portals between countries and, in particular, across the Atlantic and for sharing lessons and link resources between the EU and US—especially in light of the ongoing Climate-ADAPT and Climate Data Initiatives (https://www.data.gov/climate/) in the EU and US, respectively.

Moreover, it is clear that effective, empirical, and science-based adaptation is needed, considering the current CO_2 emission gap and therefore increasing adaptation needs and the relatively few case studies addressing core decision-relevant information, such as cost information

and applicability/participation experiences in the field of adaptation (Kirchhoff et al. 2013). It is our hope that this paper can further facilitate coverage of the scientific gaps identified by Moss et al. (2013) and Viner and Howarth (2014) by identifying the largest clusters of case studies available globally.

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Table 1: Analysis of climate change adaptation portals. Data on sites linking in and Google Scholar (November 2014).

>>> Insert Table 1

* UKCIP and UNFCCC are approximate, as the exact number is difficult to determine precisely from the website.

Table 1.

Portal	Total # adaptation case studies	# Adaptation case studies with cost and participation	Sites linking in	Google Scholar hits
US: climate change: http://www.epa.gov/climatechange/	0	0	NA	3 420
US: adaptation: http://www.epa.gov/climatechange/impacts-adaptation/adapt-tools.html	0	0	NA	0
US: California: http://cal-adapt.org/	0	0	62	13
US: George Town: http://www.georgetownclimate.org/adaptation/clearinghouse	170	29+69	140	3
US: CAKEX: http://www.cakex.org/	307	27+94	152	84
EU: http://climate-adapt.eea.europa.eu/	66	18+13	NA	34
EU: UK: http://www.ukcip.org.uk/	~150*	0+1	254	835
EU: Denmark: http://en.klimatilpasning.dk/	34	0+0	87	55
EU: Finland: https://ilmasto-opas.fi/en/	8	2+2	53	67
WHO: http://www.who.int/topics/climate/en/	0	0	NA	18
United Nations: http://unfccc.int/adaptation/items/4159.php	~100*	0+0	NA	39
weADAPT: http://weadapt.org/	68	21+16	80	111