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Abstract: Climate change and it's societal response in the form of mitigation and adaptation strategies have potentially very large impacts in different sectors, especially on regions with a high vulnerability. Climate change will greatly affect agricultural and natural ecosystems and urban centers. The scale and complexity of the interactions represent a challenge for policy makers, researchers and the public at large. It is the role of the policy maker at different levels of government to facilitate and encourage adaptation and to achieve the level of transparency needed to obtain the public support for taking far-reaching measures. The European Climate Adaptation Platform Climate-ADAPT supports Europe in adapting to climate change by providing information and knowledge on expected climate change, current and future vulnerability of regions and sectors; letting users learn from each other's national and transnational adaptation strategies, adaptation case studies and potential adaptation options and, guidance on how to plan for adaptation. The platform was developed through an intensive collaboration with stakeholders, climate adaptation experts, a steering committee and the donor in 1.5 years. Different groups provided feedback at different time intervals ranging from bi-weekly teleconferences to quarterly workshops. The close collaboration promoted buy-in, an ongoing commitment of users and donors and several champions promoting the platform. In the first three months of the project a scoping document and a software concept were created using semi-structured interviews and wire-frames. During the development phase evolutionary prototypes were used to elicit feedback in the form of comments, paper sketches and story boards to be implemented in the following increment. In this process insights changed, new tools were conceived and some early ideas were dropped.

Keywords: Climate change adaptation; software development; user involvement; requirement analysis; evolutionary prototyping

1. INTRODUCTION

1.1 The challenge

Climate change has potentially very large impacts on regions with high vulnerability. These impacts could occur in many different sectors of society and greatly affect agricultural, natural ecosystems and urban centres. Also societal response to climate change in the form of mitigation and adaptation strategies will affect our environment and our societies in many ways. The scale and complexity of the interactions between society and the environment represent an unprecedented challenge for policy makers, researchers and the public at large. In
this complex situation with potentially high impacts and relatively large uncertainties, it is the role of the policy maker at different levels of government to facilitate and encourage adaptation strategies based on sound and state-of-the-art knowledge.
An improved design and implementation of cost-efficient adaptation policies and plans protecting vulnerable regions from adverse climate change impacts, requires a high level of sharing of knowledge, data and information between: 1) societal sectors, environmental themes and scientific disciplines; and 2) researchers, policy makers and practitioners. Both are essential in order to develop innovative solutions, to speed up the innovation process by sharing best practices and learning-by-

doing and to achieve the level of transparency needed to obtain the public support for implementing far-reaching measures.
This paper describes the development process of a highly promoted IT platform providing a single intuitive and structured access point to the many different sources available, enabling filtering through information and supporting the discovery and use of knowledge, based on relevant questions.

1.2 User involvement in software development

A software development methodology is a prescriptive model that establishes the order in which a project specifies, reviews and performs its activities. It primarily exists to co-ordinate people involved in the development of the software: programmers, designers, project coordinators, donors and users (Cockburn, 2000). Many development methods exist, ranging from very strict design-implement-test-deliver phased approaches to styles that embrace change. Change is often based on advances in understanding. These so-called 'agile' methods can adapt by executing many short iterations of the design-implement-test-deliver phases. At the end of each iteration users provide feedback to plan the following iteration (Verweij et al., 2010).
A functional design is a formal documentation of what an application should do and how an application should function in interaction with a user. It is a reference for the implementation. Within the User Centered Design approach (Raskin, 2000) usability requirements drive the features and technical development by studying the usefulness with the intended users. Prototypes of interface design can be used to test usability with users. Prototypes can be incomplete versions of the software product, but may as well be screen designs in a software presentation tool, or even hand drawn sketches on paper (Sefelin et al., 2003). They allow users to evaluate developers' proposals for the interface construction of the product by actual testing, rather than having to interpret and valuate the design based on descriptions. The main objective of a prototype is to find out if the developers are on the right track and to further feed requirement discussion (Verweij et. al., 2010). In general a prototype is an inexpensive way to try out ideas so that as many issues as possible are understood before the real implementation is made (Tate, 2005).
'Wire frames' are prototypes addressing the layout of a screen and deal with information, structure, relationships between information and flow between screens. They are a graphical means of communication to further feed discussion on structure and information. Wire frames do not address aesthetics. During the user feedback/design phase in an agile method new wire frames might be added for new functionality, or existing ones might be revised.

2 METHOD

2.1 Development method

At the start of the project the platform to be developed was derived and conceptualized from the mission statement: '*The European Climate Adaptation Platform aims to support Europe in adapting to climate change*'. This definition allows to have as many interpretations as individuals contributing to the development. Further evolving of understanding and political dynamics will likely result in priority shifts. Therefore the development method should support stepwise refinement of functionalities and climate adaptation content.
An iterative software development method was developed (see Figure 1) based on evolutionary prototyping (McConnell, 1996; Verweij et al., 2010). Evolutionary prototyping acknowledges that we do not understand all the requirements at the onset of a project and builds only those that are well understood (Davis, 1992):

- *Scoping* – clarify aims and objectives and define boundaries of the project
- *Define sounding boards* – to organize user involvement from the targeted communities and to gain support and political acceptance
- *Develop the software concept*
    - *Inventory of key issues and concepts* – by studying background material, semi-structured interviews (Wilson, 2013) and sounding board workshops
    - *Group, relate and prioritize the concepts* – during workshops
    - *Develop wire frames* – propose alternative wire framed solutions, discuss and interactively change during workshops

- *Development iterations*
  - *Develop a version* – design, develop and test software together with gathered and incorporated data
  - *Deliver the version*
  - *Elicit feedback* – from the sounding boards
  - *Plan another iteration* – based on the feedback

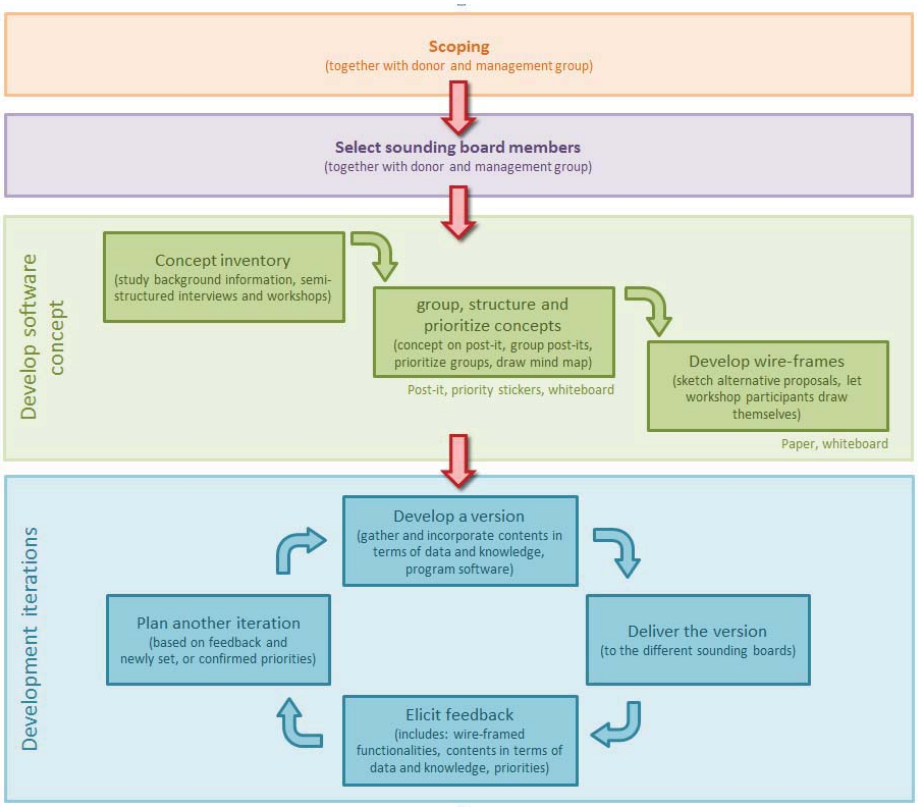

Figure 1 – development method distinguishing the four main sequential phases '*Scoping*', '*Select sounding board members*', '*Develop software concept*' and '*Development iterations*'. Both last two phases contain sub-phases, while the last depicts iterations of the sub-phases.

2.2 User groups

Climate-ADAPT is primarily aimed at European and national policy makers and civil servants, but also at regional and local decision makers and land managers, business and to some extent even the interested public. As such, the platform has to deal with a large group of stakeholders and users with a different cultural, institutional and disciplinal background. In order to obtain input from the targeted communities and to gain support and political acceptance, a number of user platforms were identified together with the donor:

- *User group* – its task was to support development, act as a source of information and provide feedback on iterations;
- *Working group* – it included national experts with representatives from each EU Member State. The group met every 4 months for a one day meeting to ensure Member State acceptability
- *Steering group* – consisting of national politicians with representatives from each Member State. The group met every half year to gain acceptance and support;
- *Management group* – consisting of Members of the European Commission: the donor, experts and the future maintainer. Irregular meetings were organized to monitor progress, provide feedback, organize contacts and set priorities.

The software development conceptualisation started by a 'validation and *alignment*' workshop in which all of the groups were represented.

3 RESULTS

3.1 CLIMATE-ADAPT platform

CLIMATE-ADAPT is single intuitive and structured access point to the many different digital sources available. It structures the information, creates relevant links between them, enables filtering through information and supports the discovery and use of knowledge based on relevant questions. CLIMATE-ADAPT is kept up to date with quality checked information on:

- Expected climate change in Europe
- Current and future vulnerability of regions and sectors
- National and transnational adaptation strategies
- Adaptation case studies and potential adaptation options
- Tools that support adaptation planning

Early software conceptualisation was strongly, but not solely based on learning from others, such as the Biodiversity Information System for Europe[1] and the national portals from Denmark[2], United Kingdom[3] and Germany[4].

3.2 Structure of website content

During the scoping phase a non-complex, climate adaptation familiar structure for information was created together with the donor and the management team. The structure distinguished between: observations & scenarios; vulnerability assessment; adaptation measures; national adaptation plans and strategies and; EU sector policies. The EU, national and trans-boundary levels were identified as relevant geographical scales. From the information types the following were recognized as important: documents, datasets and databases, maps, indicators, tools, graphs and multimedia.
During the following meetings new content was identified, the structure was extended (glossary, community support, links to international organisations, etc. were added), and cross links were determined (see Figure 2 for an overview of the structure).

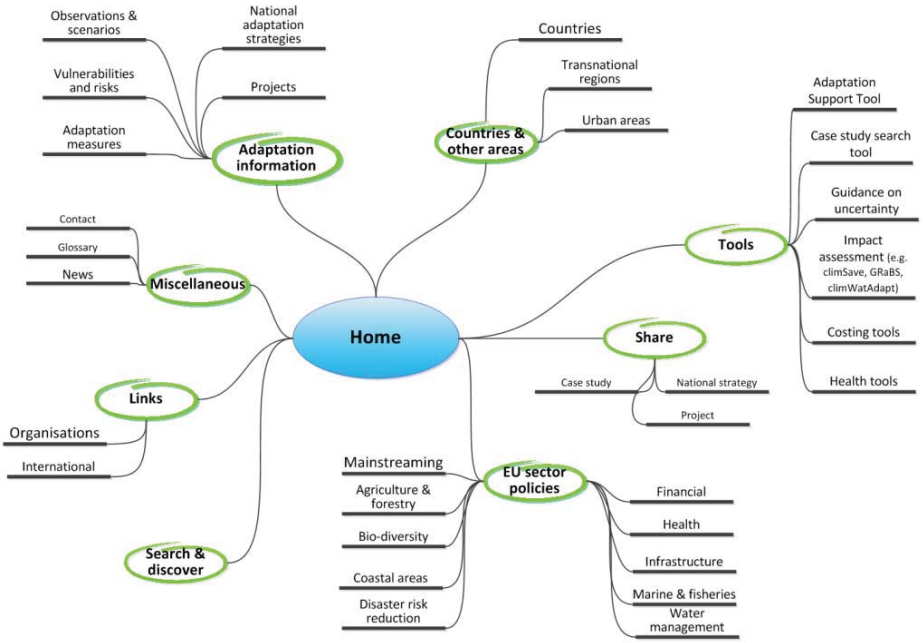

Figure 2 – Mind map diagram depicting the structure of the CLIMATE-ADAPT platform.

[1] http://biodiversity.europa.eu/ , retrieved 2011
[2] http://www.klimatilpasning.dk/ , retrieved 2011
[3] http://www.ukcip.org.uk/ , retrieved 2011
[4] http://www.anpassung.net , retrieved 2011

3.3 No explicit user roles

While the platform was initially directed towards civil servants working on the development and implementation of strategies in the interaction with the EU policy agenda (governmental policy makers and agencies, boundary organisations and research projects) regional, local and cities were recognized as targeted users as well during the many meetings with the *working group* and *steering group*.
In the process of the identification of different user types it was assumed that they all would have different questions to be answered by the platform. This assumption was understood as a user entering the platform by identifying his/her role and getting information corresponding to that role. Soon however, the assumption was dropped. Interviews revealed that users experienced the role identification as too restrictive. It also turned out that different user types were asking very similar questions and expected largely overlapping answers from the platform.
During the content development phase relevant questions were inventoried and prioritized. The high priority questions were grouped in tools and put on the homepage of the platform. All web pages were first drafted on paper, then –when accepted by the user and management group- drawn in a wire framing software package and subsequently presented at the working group and steering group meetings. The final platform homepage with the high level grouped questions can be seen in figure 3.
Some identified key questions were: Why adapt to climate change? How to plan for adaptation? How is the climate changing? What are risks and vulnerabilities in sectors and regions? Are there also opportunities? What adaptation options are available and how to decide what options to include? What are costs and benefits? What can be learned from others, both on a national and local level? What policies and strategies exist per sector and per country, region, or city? The questions were grouped by topic (e.g. '*sector policies*', '*countries, regions and cities*') and structured in tools like the '*Adaptation Support Tool*' a guidance tool for users that are new to adaptation, and the '*case study finder*', a tool aimed at users who want to learn from others' experiences, or to share their information –like case studies and projects- with others.

Figure 3 – screen impression of CLIMATE-ADAPT homepage with important tools capturing high level questions, such as: '*new to adaptation?*', '*What are European countries doing?*', '*Find case studies*' and '*Share you information*'. The top horizontal menu reflects the main structuring of information within the platform

3.4 Tools

From the onset of the project 'tools' were identified as crucial in adapting to climate change. However, interpretation of the concept what the tools should be varied greatly, e.g.: running complex and data intensive simulation models, rules-of-thumb (like 'add x% more broad-leaved trees in a city to lower the summer temperature by y degrees'), a synthesis of results from various climate projection models, process guidance, trend indicator factsheets, maps, cost benefit software packages, summaries of costs benefit analysis, etc.
During an early workshop with participants from all sounding boards and representatives from national climate portals a tool inventory was made to converge on the understanding and prioritization of tools. The identified tools were placed within a matrix with the axis 'complexity' and 'data intensity'.
Low complexity tools received a higher priority. Data intensive tools were considered acceptable only if their output were communicated with low complexity. Two of the tools, 'Guidance on how to plan for adaptation' (later called '*Adaptation Support Tool*') and 'map visualisation of indicators' were given top priorities. On contrary the simulation models and interactive computational decision support systems were assigned lowest priority.
The '*case study finder*' was conceptualized as a tool by the donor, the working group and the steering group which wanted to include the local level and management options. During several face-to-face sessions with the management group wire frames were created on which basis a throwaway prototype (McConell, 1996) working with real-world data was developed. The throwaway prototype was demonstrated to the donor and the user group and tuned further with wire frames before it was put in the evolutionary prototype.

3.5 Maintenance and quality assurance

According to the tender specifications the European Commission was responsible for the future maintenance of CLIMATE-ADAPT. During the development iterations automatic and organisational procedures for maintenance were developed, such as:

- automatic checks for links to other websites and hiding from the users these that are no longer valid. Marked items are updated or removed permanently manually by reviewers;
- assigning reviewers to check uploaded content by CLIMATE-ADAPT users before publishing it to the public and;
- assigning editors and experts to synthesise policy texts;

managing reviewers.

3.6 User group involvement

The user group consisted out of 12-15 scientific experts, individuals closely involved in the development of national portals, international networks and existing sector solutions. It had bi-weekly tele-meetings of 1.5 hours. The user group was disbanded after several meetings. The reason was that, although enthusiastically and with best intentions attended and facilitated, it became a platform for communicating visions, conceptual discussions and of competition of expertise. Subsequently, the management group replaced the user group.

3.7 Monitoring progress by the donor

Each half year a progress report was produced as a formal delivery to the donor. The report included implemented functionalities, data, meetings and resources used. Progress on implementation was informally monitored very closely by the donor and management team during bi-weekly tele-meetings in which live demonstrations were commented, advised upon and the next iteration was planned.

3.8 Current usage

The CLIMATE-ADAPT website was launched during a high level event in April 2012 after which the number of website views peaked. After a few months the website visits stabilized. More recently, the monthly average over the first five months of 2014 was 20.000 page views from 3700 different users. The top viewed pages are (from high to low): home page, Member State (mostly Spain and Germany),sector policies (including mainstreaming), the Adaptation Support Tool and the Case Study Finder tool.

4 DISCUSSION AND CONCLUSION

4.1 User group

Since the user group did not provide the tangible feedback required to stimulate and steer development it was replaced by the management group. Possible causes of dis-functioning of the user group are: too large group; shortages of the selected communication medium tele-meeting software instead of sitting together with a white-board and paper for sketching-; lack of personal familiarity; wrong group composition / group dynamics; competition between members; cultural differences; lack of good facilitation.
The management group included the donor and consisted out of a small number of people including several champions. The group physically met at irregular intervals in which wire frames were drawn and discussions on specific topics were organized. The meetings were characterised by mutual professional appreciation: a good atmosphere for open, creative and constructive collaboration. The tele-meetings organized between the physical ones were a weak reflection of the physical meetings and tended to get flatter the longer the physical meeting took place.
A small user group that meets physically, and in which individuals value and credit each other for their professional contributions is a required condition for a well-functioning process. Political issues are very important, but should be better discussed in other fora.

4.2 Short development iteration

Literature advices to do short development iterations (every 2-3 weeks). Due to institutional settings of the donor the project was forced into 6 months iterations. The project team considered this long period as a potential risk of spending a lot of resources and developing in a undesired direction and therefore the period was – informally- reduced to 6 weeks. When the user group was replaced by the management group, feedback was given every two weeks. Although the short iterations were still informal the donor was fully aware how the project was progressing and was able to steer the development in directions it could not have otherwise. It proved very useful to have many meeting to converge ideas and to manage expectations on what was possible to develop in what time. Sometimes development went faster than expected, sometimes it went slower. We are happy to have a management team that was willing and able to put in the time as it did.
Although it might not be possible to have short iterations in some institutional settings we still highly recommend to have many informal meetings in order to provide the donor with steering capabilities and to manage expectations.

4.3 Wire frames

To explicate team's interpretations many wire frames were drawn, discussed and redrawn during the sessions. The wireframes varied from overall website structure, homepage setup, tool layout and search and filter functions. Alternative wire frames were drawn to explicate alternative visual variants for users to choose between, make their own combinations and stimulate them to come up with solutions of their own. Without wire-frames we would have spent much time on developing (prototype) software implementations. Because of the time and energy spent the developers would have been far less willing to make amendments. This would have been frustrating to both the sounding boards and the developers. We consider the use of wire frames as an absolute must in complex software project.

4.4 Champions

We were lucky to have political as well as scientific champions within the team who took care of profiling and marketing of the platform. The champions opened up doors to gain the support needed to have the required input from individual- and networks of experts and the commitment of politicians to make CLIMATE-ADAPT a success. Moreover, the champions created a creative and constructive attitude within the team and solidarity over the bigger network.

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