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The Development of an EDSS: Lessons Learned and Implications for DSS Research

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Abstract

The Solar and Wind Energy Resource Assessment (SWERA) project is focused on providing renewable energy (RE) planning resources to the public. Examples include wind, solar, and hydro assessments. SWERA DSS consists of three major components. First, SWERA 'Product Archive' provides for a discovery DSS upon which users can find and access renewable energy data and supporting models. Second, the 'Renewable Resource EXplorer' (RREX) component serves as a web-based, GIS analysis tool for viewing RE resource data available through the SWERA Product Archive. Third, the SWERA web service provides computational access to the data available in the SWERA spatial database through a location based query, and is also utilized in the RREX component. We provide a discussion of various design decisions used in the construction of this EDSS, followed by project experiences and implications for EDSS and broader DSS research.

1. Introduction

Environmental management and protection issues have become core to public policy goals with the increased awareness of citizens, corporations, and governments toward the conservation of environmental resources. This was also reflected in the 2010 United Nations Summit on Climate Change. As such, the significance of renewable energy (RE) will continue to grow as a viable and sustainable source of energy. Solar, wind, and hydropower RE sources can be harnessed in homes, factories, and multitude of other applications.

A critical component of planning for RE development is determining the optimal location for RE plant, i.e., which locations would be most viable for a particular RE plant. This is accomplished through collecting and analyzing data assessing the RE potential for a particular location, also referred to as RE assessments. Accordingly, the ability to access and analyze RE assessments at a various levels of granularity is a major factor to making informed decisions. However, such data is not necessarily available to planners and decision makers at the level of detail and quality to meet their planning needs. Moreover, even in cases where the data is available, it is not necessarily in a readily usable format. Environmental Decision Support Systems (EDSS), a domain-specific class of Decision Support Systems (DSS), can go long ways toward facilitating access to relevant RE assessments and support data visualization and analysis tools.

EDSS are concerned with the management and access of environmental data (such as meteorological, solar radiation, wind, and species) and computational decision models that operate on such data for assisting decision makers in solving decision problems. EDSS are distinguished from general Environmental Information Systems (EIS) in that the decision model component is an integral aspect of EDSS. Decision models for representing the decision problems can be of varied types including optimization, statistical, and simulation [1]. Solutions provided by decision models provide decision alternatives in solving the formulated decision problem. In case of RE assessments, examples of such decision models include the HOMER model [2, 3] – an optimization model to evaluate the economic and technical feasibility of RE sources, the Hybrid2 software model [4] – a probabilistic and time series model used for long-term performance and economic evaluation of RE sources, and the RETScreen model [5] – a spreadsheet based decision tool to perform RE project feasibility analysis. These models exist as standalone applications, and rely on the decision makers to provide relevant input parameters and environmental data sets to generate model solutions.

In this paper, we describe the development of "Solar and Wind Energy Resource Assessment" (SWERA) DSS which focuses on providing renewable energy planning resources to RE planners and decision makers. Examples include wind, solar radiation, and hydro assessments. The goal of SWERA DSS is to extend the data storage and access functionality of SWERA to incorporate decision support capabilities.

The rest of the paper is organized as follows. Section 2 discusses related work in DSS and EDSS

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areas. Section 3 presents a description of the SWERA DSS system. Section 4 summarizes the project experiences in developing SWERA DSS. Following this, Sections 5 and 6 discuss implications for distributed DSS research and broader DSS research respectively. Finally, Section 7 concludes the paper.

2. Related Work

Given the vast amounts of environmental data, EDSS have a key role to play in utilizing this data to help environmental decision makers reach informed decisions [6]. EDSS has seen grassroots developments over the past few decades, often under the broader terms such as Environmental Management Information Systems (EMIS) or EIS. Examples of such applications can be seen in [7].

EDSS may follow the general framework for DSS proposed by Sprague and Carlson [8]. In this framework, a DSS is comprised of a dialog, database and modeling components. The dialog component represents the user interface of the system. The database component can be an internal, external (relying on an underlying EMIS to provide the necessary data), or hybrid system (where parts of the data are stored in an EMIS or in other problem specific information systems, and result data are internally stored inside the EDSS itself). The modeling component accommodates the modeling needs of the decision maker by incorporating a variety of environmental management tools and techniques such as renewable energy (RE) assessment, life cycle assessment (LCA), material flow accounting (MFA), life cycle costing (LCC), and multi-criteria analysis (MCA) common to environmental management and auditing.

Building EDSS for supporting resource assessments is nontrivial, given the computational horsepower needed due to large data sets as well as the architectural complexity associated with heterogeneous tools and data existing across multiple disciplines (such as economics, hydrology, and geology). Further, variety of methodologies [9] such as optimization, multicriteria decision analysis, Bayesian analysis, simulation, are often relevant for dealing with differing aspects of the problem. Jakeman, Letcher, and Norton [10] discuss ten iterative steps in development and evaluation of environmental models.

Resource assessment methodologies of RE resources for varying contexts have been proposed by researchers. Multicriteria decision approach [11, 12] has been used in assessing wind energy plants [13], concentrated solar thermal technologies [14], and wave energy conversion [15]. Along similar lines, a case study study on GIS-based assessment of wind energy systems for spatial planning has been reported by Aydin, Kentel, and Duzgun [16]. Seager, Miller, and Kohn [17] emphasize the need for research in developing LCA techniques that will appropriately assess the impacts of RE, particularly with respect to change in land use, which has received little attention thus far. In sum, a common thread noted from the extant literature on RE assessments is the regional nature of such efforts. There is certainly a lack of large-scale EDSS which can provide access to environmental data and decision models at national or international levels in a uniform manner.

3. Development of SWERA DSS

Renewable Energy and “Going Green” have become key concerns in today’s economy. This type of energy, however, is not viable in all locations around the world. In fact, some locations may be limited to only some forms of renewable energy usage, while some may be further limited to none. Implementations of large-scale RE technologies are needed to incorporate this type of energy into a form that society can use. The decision to implement such technology in regions around the world can be a costly endeavour in terms of the effort to design, construct, and implement a working renewable energy resource energy plant of any kind. Accordingly, access to reliable region-specific RE assessment is vital to understand whether candidate locations are viable or cost effective to implement such a plant. These assessments are dependent on two key factors: amount of energy expected from the renewable resources under consideration, and the ability of the RE technology to maintain a balance between energy production and consumption [1, 18]. Such assessments are subject to accessibility of high-quality data about RE resources such as wind and solar radiations.

3.1. SWERA Project

The SWERA project was initiated in 2001 to achieve the above objective, with funding from the United Nations Environment Programme (UNEP) and Global Environmental Facility (GEF) along with more than 25 collaborating organizations around the world. The initial pilot project focused on 13 countries. With the success of the pilot project [19, 20], the project was expanded in 2006 into a full-fledged programme with objectives to provide high quality information on RE resources for countries and regions around the world, along with the support tools needed to apply these data in making decisions on RE policies and investments.

Another main focus of SWERA was to act as a sharing centre for countries and organizations. Through the project, government agencies are able to share information with interested parties. Industry personnel, public and private investors, lawmakers, researchers, and any other concerned parties are able to access this shared information and incorporate it within their research and decision making tasks.

3.2. SWERA Decision Support System

The SWERA DSS consists of three major components. The first component, termed as "Product Archive" tool, provides access to RE data and tools provided by data providers in partner organizations. The second component, termed as "Renewable Resource EXplorer" (RREX) is a Geographic Information System (GIS) based analysis tool for viewing RE resource data available through SWERA data archive. The third component is the SWERA web service, which provides computational access to spatial data available to SWERA. These components are discussed below in greater details.

3.2.1 Product Archive Component. The overall goals of the Product Archive component (refer Figure 1) are two-fold. The first goal is to allow project sponsors, government agencies, and other data providers the ability to share their RE data sets, maps, tools, methodology and results (in the form of PDF articles) and any other information (generically termed as 'products') publicly through the SWERA system. The second goal is to allow all end-users to search and access this shared information. The Product Archive component supports the data providers with the ability to upload and make their data and metadata information available to other end users through a form-based interface. The form-based interface requires providing a contributing organization, a data provider, along with further information about the product (data set or tool) itself and relevant metadata. The information required conforms to the information specified through the Open Geospatial Consortium (OGC) specification for spatial data metadata records. This facilitates search and discovery for the end users as well as enables the users to understand the product in enough details so as to use it in a meaningful manner.

The Product Archive component also allows for all end-users to search the existing archive. Products may be searched based on product type, geographical location, or energy type (wind, climate, etc.). Upon finding a product item, additional information about it is displayed and the user can choose to download it.

From a development standpoint, the overall development has been done using PHP as the main programming language, along with Javascript. SWERA uses Typo3, as a content management system (CMS) for the creation and management of data for the overall website. A Typo3 CMS extension has been implemented to develop the SWERA Product Archive. At the backend, a MySQL database stores the information associated with Typo3 CMS as well as metadata information used to index the products available in the SWERA Product Archive.

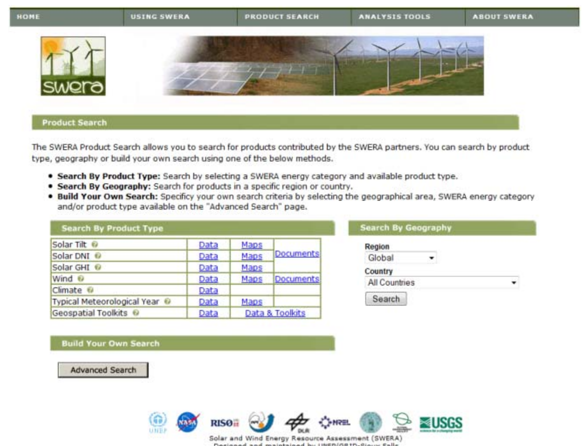

Figure 1. SWERA DSS Product Archive

3.2.2 Renewable Resource EXplorer Component. The Renewable Resource EXplorer (RREX) component serves as a web-based, GIS analysis tool for viewing RE resource data available through the SWERA Product Archive. Users can perform additional analysis by selecting specific point locations through the user interface.

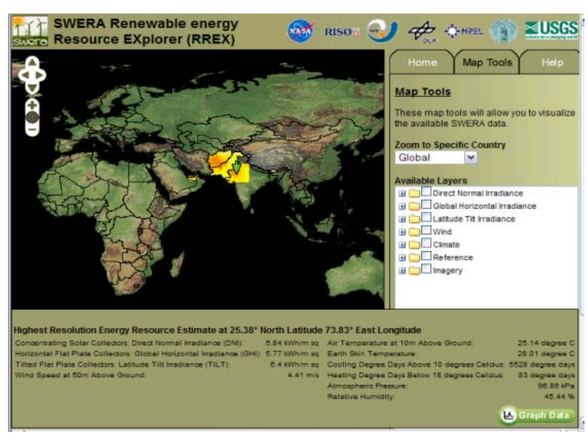

Figure 2. SWERA DSS RREX: Mapping Window

RREX has been built mainly using PHP, Javascript, and AJAX. Additionally, the following open source tools have been used. The open source OpenLayers Javascript library is used for displaying map data in browsers. OpenLayers implements industry-standard methods for geographic data access, such as the OpenGIS® Web Mapping Service (WMS) and Web Feature Service (WFS) protocol standards put forth by the Open Geospatial Consortium (OGC). RREX also uses the ka-Map javascript API as a tiling component. In this way, faster performance for visual display of spatial data is achieved through cached images. The cached images are recreated upon new data uploads on the SWERA Product Archive. AJAX provides for a much smoother interaction when requesting data for specific spots specified on the map. RREX also provides for the selective display of other image layers on the main mapping window through the "Map Tool" menu (refer Figure 2). Essentially, these image layers are associated with specific data sets (e.g., DNI NREL Moderate Resolution) in the Product Archive.

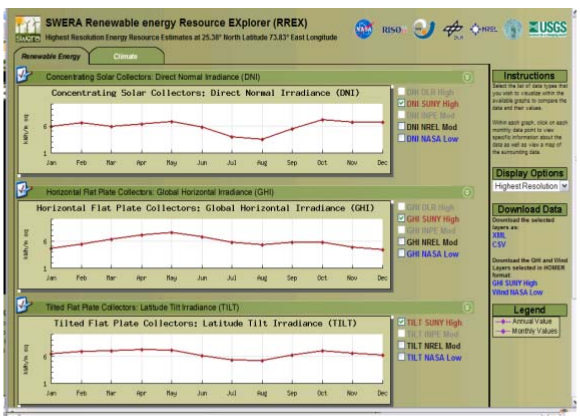

Figure 3. SWERA DSS RREX: Graph Popup

For each location selected on the main mapping window, a popup window displaying corresponding 'Graph Data' allows for a location-specific analysis. Line graphs on the graph display are dynamically built based upon the information retrieved from the location selected on the main mapping window (refer Figure 3). For each plot point on a graph that has monthly data values recorded, a dynamic link to a mapping feature is provided at the bottom of the screen. This new screen displays additional analysis that can be done at a zoomed in location of the point that was originally selected along with a time series display of data over the course of 12 months at that location (refer Figure 4). All of the information that is being presented on the graphing window is also downloadable through links displayed on that window in multiple formats, namely CSV, XML, and with applicable data sets compatible with the HOMER modeling tool. The graphing is done using JPGraph (a graph creating library for use with PHP), along with PHP, AJAX, and JavaScript. The spatial data displayed on the graphing window is retrieved from a PostGreSQL database, while JPGraph is used to display the graphs. Map images used for displaying monthly averages from the time series data are retrieved using a WMS call to the SWERA Map Server. WMS allows retrieval of georeferenced maps through HTTP calls. SWERA has implemented this specification into all the layers that are currently being used in the RREX application. The WMS `getCapabilities` URL has been made available publicly (refer Figure 5), so end users can retrieve georeferenced map data for use in their own applications through an OGC WMS client.

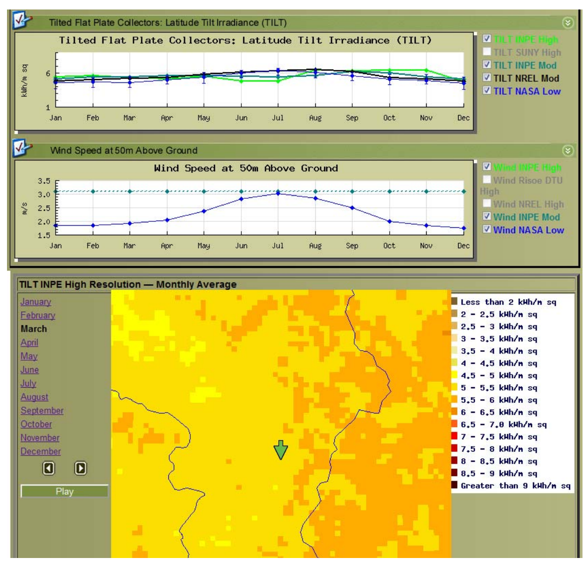

Figure 4. SWERA DSS RREX: Graph Popup displaying spatial and temporal data

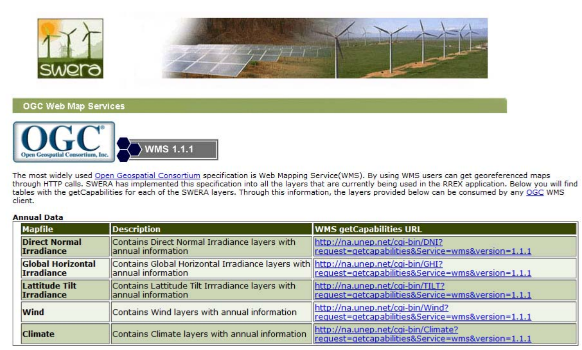

Figure 5. SWERA Implementation of OGC Web Map Services (WMS)

3.2.3 SWERA Web Service. The SWERA web service provides computational access to the data available in the SWERA spatial database through a location (latitude and longitude) based query. The SWERA Web Service is based on the Representational State Transfer (REST) approach. All parameters are sent in through the request URL. This approach was taken for simplicity and the fact that this approach would be easier to implement in another application for the collection of data from the web service. The web service has been developed in PHP. It pulls its information from the PostGreSQL database. Other than the location coordinates, additional optional parameters may be specified in the request URL, such as groups, resolutions, annual values, monthly values, and/or individual layers. An 'Interactive Form' has been developed to allow users to construct request queries for the web service (refer Figure 6). The request URL is dynamically changed (implemented using Javascript) upon selecting different web service parameters. The SWERA web service can output information into three different types of formats. The first is an XML based representation. The second is a comma separated values (CSV) version based upon the XML version. The final format is a HOMER model compatible format. This is also an XML based representation, but it is formatted for consumption by the HOMER model and only retrieves specific information that HOMER needs in its analysis (refer Figure 7).

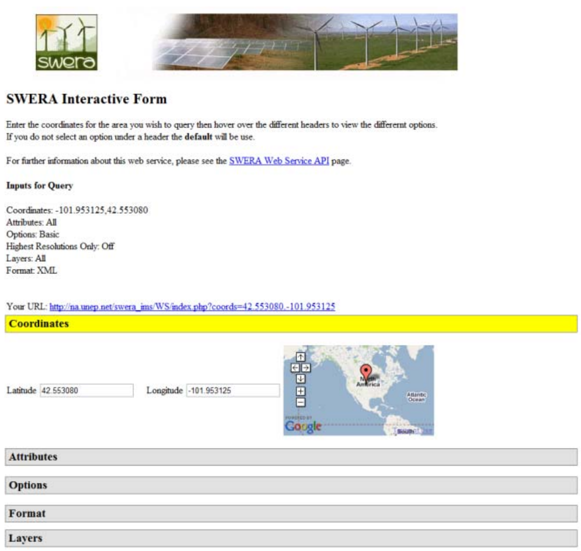

Figure 6: SWERA Web Service Interactive Form

3.2.4 SWERA Users. The SWERA user profile includes users with a wide range of technical knowledge and requirements for renewable energy information. Users can access reports and maps, use the Renewable energy Resource EXplorer to interactively map and query the SWERA database, or can download the assessment data as GIS data or as point data. By providing this layered access to information we hope to reach consumers, policy makers, investors, developers, electric utilities, educators, and researchers. We monitor the user community through the download of products from the SWERA database. Total downloads (Figure 8a), downloads by organizational type (Figure 8b), and downloads by use category (Figure 8C) have been tracked since October 2008. These are tracked through a minimally invasive survey when downloads are requested. The impact of the first major releases of the new user interface becomes notable in mid 2008.

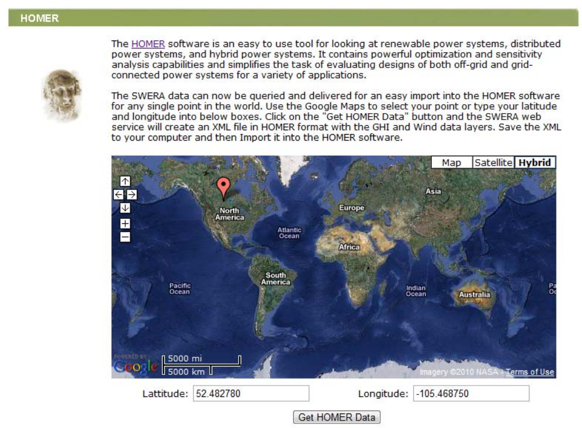

Figure 7: Accessing SWERA data in HOMER accessible format

The survey is biased toward users who download data, even though maps and documents are also available. Most users whose needs are satisfied through a visual analysis of the data through the RREX mapping and graphing interface, including those who download point data for use in energy analysis systems are under-represented in the statistics. Furthermore the education and research communities are likely over-represented.

The strong representation of the corporate community and users who identify themselves as developers is very encouraging. Policy as a use was not added until November 2008. It is not surprising that investor, policy, consumer, secondary education use categories are low, since these are the users we would expect to be primary users of RREX. Users within these use categories who download products would likely self identify themselves as researchers.

Nonetheless, an inspection of use category within organizations shows strong usage by utilities, investors and developers, in addition to researchers, within the corporate community (Figure 9). Likewise within the private citizen organizational type investors and developers are well represented.

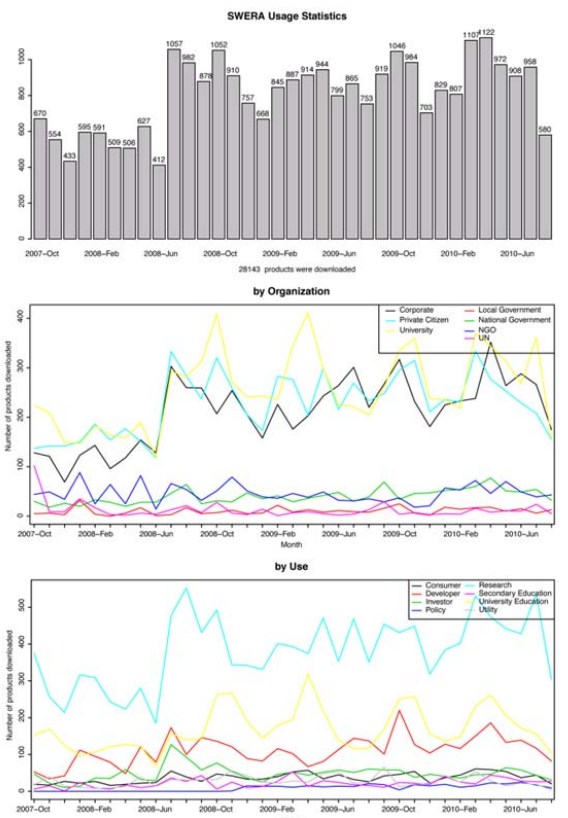

Figure 8. SWERA DSS User downloads

We recognize the need to better understand users of the SWERA DSS who do not download products. The user survey attempts to address this shortcoming, but can only provide oblique understanding of the broader user community. Ultimately we decided to error on the side of less invasive methods.

The goal of the SWERA project is to encourage the development of renewable energy resources. As such the strong showing of investors and developers is very encouraging. There is a need to improve outreach to secondary education and local governmental organizations to build for the future. The very strong use in research and university education demonstrates the SWERA is serving these communities well.

4. Lessons Learned/Project Experiences

In this section, we summarize our experiences from this project. During the development of the SWERA DSS, we have identified issues, both from technical and organizational standpoint, that need to be taken into consideration in such projects.

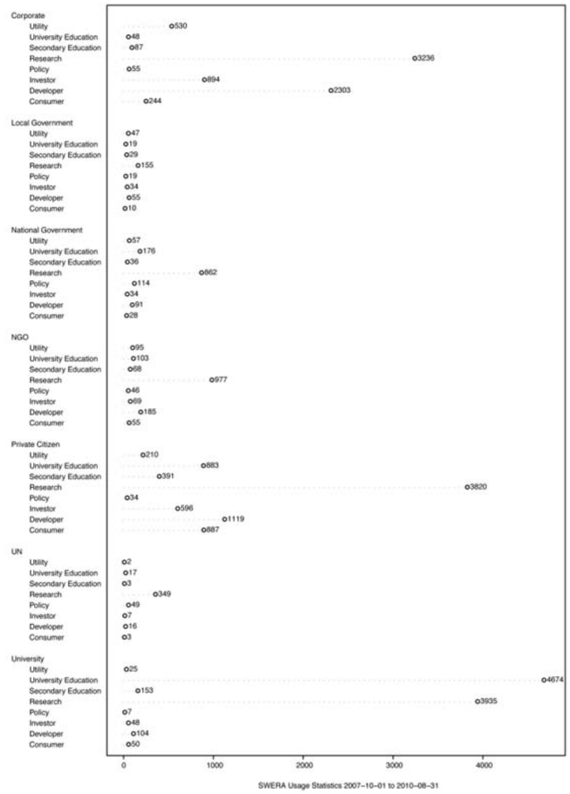

Figure 9. SWERA DSS Usage statistics

Several technical issues became apparent during the development of this project. First, rendering vast amounts of spatial data from online data sources turned out to a significant challenge. Ideally, it was desired for RREX to be able to access online global data from agencies such as NASA, upon execution of spatial queries implemented within the RREX. While access to spatial data from online sources is made possible in certain cases (such as the background image in the RREX), this was not practically feasible to implement in other cases, particularly in cases where global spatial data needed to be displayed (e.g., high resolution wind data at the global level). Caching such data on servers to optimize their delivery over the Internet was considered as a candidate strategy. The technical standards and specifications around this issue are in flux. For example, the WMS-C (as in Web Mapping Service – Cached), is a WMS Tile Caching proposal that is still evolving. It intends to allow map clients to fetch image tiles through either caching on the servers, or at an intermediate location or completely pre-generating the image data, while leveraging the existing OGC-compliant WMS servers. We are currently in the process of implementing this specification in the SWERA DSS to support online data source accessibility. In sum, vast amounts of spatial data and evolving standards were two main issues that needed to be addressed in terms of providing access to online data sources.

The next issue concerns with the nature of existing models. Decision models, such as HOMER and RetScreen, are available as standalone desktop applications with user inputs. The user has to download the specific models, fetch the correct data in the correct format, and then execute the models. Given that such decision models do not exist as web services, dealing with such models computationally in distributed settings over thin clients is not possible in its current form. Instead, the SWERA DSS supports querying the SWERA data archive through RESTful web service calls and fetches the relevant data in an XML format available for importing from within HOMER. This implies redundant user involvement for achieving interoperability between data sources and models. Developing web service wrappers on legacy code modules encapsulating decision models is a possible strategy in such a case, essentially web-enabling decision models for better user accessibility. However, there are organizational challenges in justifying the value added with associated development and maintenance costs.

A third issue that occurred happened with the natural evolution of the design. The original design was implemented using a GIS application called ka-Map. After about a year into the project, ka-Map announced that it would no longer be under development. At that point, there happened to be some errors with the ka-Map and further additions to the application. Because of these problems, a change in applications was instituted to implement a version of OpenLayers, which already had the means to process the tiling that was implemented with ka-Map and still provided for the OGC standard WMS services calls. The change provided for some nice additions to the system, but also required more time to provide the same functionality that was already previously provided through ka-Map.

Data interoperability also became an issue with the implementation of this DSS. The initial design of the system would provide for the different partners of SWERA to upload their data for the use within the system. This worked well when SWERA was just used as a database archive, but with the implementation of the DSS, the data needed to be in the same format for its use. While data interoperability was needed for the use of the data, this was not instituted through the application, but was instead decided to be checked and formatted by the SWERA team. The overall design for data uploading to the system had to change to one of a partner providing the data to the SWERA team followed by the SWERA team validating and reformatting if necessary the data before implementation within the system. Data specifications were published, but were never fully enforced before the data handoff between partner and SWERA team, which made this a necessary step.

With the new implementation of the DSS within SWERA, the overall design of the website, in terms of the scope of the SWERA users, also changed. The initial website and archive was designed with the partners in mind. Different pages were provided that detailed information that would be needed for their benefit. As the project was growing with the data coming at the global level, the scope of SWERA now exceeded that of just the partners and was turned more towards any user with renewable energy resource assessment interests. In this way, the content and presentation of the information being displayed to the user had to be changed to present a more general description of the information being seen. Static pages with the implementation of partner's countries were abolished in terms of more generalized pages that described all the data effectively for the different categories of renewable energy. Another example of this change was seen in the changes made to the RREX mapping application. The application started off with an ArcMap interface. This gradually changed to a more Google Maps type interface with more intuitive click reaction interfaces. Through a more Google Maps type interface, SWERA was changing the application to meet a more common way upon which the majority of users interacted with maps.

6. Research implications for distributed decision support

The project, while applied in nature allowed the research and development team to identify specific areas for research of particular importance in a distributed decision support environment. Following Sprague [21], we organize these areas around three main themes: dialog component, data management components, and model management component. An over-arching issue is development methodologies and design for DSS.

As noted earlier, the user interface requires efficient web-based rendering of large amounts of spatial data. Research is needed to stream line and standardize mechanisms for efficiently rendering large amount of spatial data over the Internet while leveraging existing OGC-compliant WMS servers.

Integrating and managing data from multiple heterogeneous sources becomes increasingly important. Computer science research themes in this area are particularly relevant. So is research concerning the development and leveraging of service oriented concepts to deliver data as a service. This can take the form of data management services that can be invoked on demand to search and retrieve data from relevant databases. Alternatively, entire data sets may be packaged as services with appropriate wrappers.

In a distributed setting, meta-data and semantics are of concern. Ideally, the objective is to streamline if not automate the processes for finding and retrieving relevant data. This is not possible without proper meta-data that would also capture relevant semantics.

Analogous to data, model management in a distributed setting can benefit from research at the intersection of service-oriented computing and the semantic web. In that regard, it is critical to conceptualize models as services that can be invoked on demand to address specific decision support needs. HOMER and RETScreen are examples of such models in the context of the SWERA DSS. In a dynamic (loosely-coupled) environment, research is needed to streamline the identification (searching), execution, and composition of these models as services. This is particularly important with the proliferation of models as knowledge nuggets and thus evolving as a national and organizational resource. In areas such as environmental management, such models are often available in a distributed setting and free of charge. The issue is often finding and being able to seamlessly and efficiently utilize these models for the decision problem on hand. Moreover, model representation and management approaches may need to be extended to accommodate the type of models used in such application domains.

With respect to DSS design and development, the above issue may be viewed from future development standpoint as well. At minimum, modular software development practices with well-defined application programming interfaces (APIs) can help achieving extensibility and interoperability. Service-oriented development can allow legacy applications such as standalone decision models to be seamlessly available for distributed decision support.

While technical issues seems to be the emphasis given the experiences and nature of this project, from an organizational perspective, issues relating to knowledge sharing comes to bear. Conceptualizing models as knowledge nuggets, research into the motivation for sharing models given the additional overhead that may be involved in packaging such models as services is warranted. This includes cost/benefit analysis for model providers, ownership and intellectual property issues, and confidentiality. Vendor support as evidenced by the DSS SWERA experience with ka-Map can also be an issue. Licensing of supporting model development and solution platforms is another issue that will need to be accounted in a business model.

7. Implications for DSS Research

Arnott and Pervan [22] discuss eight key issues to be considered by researchers in the DSS area. In light of our experiences with the SWERA DSS project, we comment on some of those relevant issues here without making any claims of generalizability. The first issue is that of importance of relevance of DSS research to practitioners. The SWERA DSS project was conceived as an applied research project. Its relevance and alignment with the funding agencies objectives were crucial to securing project funding. However, as the project evolved, it became a basis for understanding emerging research issues in the area of model management. This has led to a number of subprojects and resultant publications[1]. We would like to emphasize the potential that applied research projects can have in securing funding and also initiating further research projects that can have high relevance.

Another issue concerns the research methods and paradigms used in DSS. This project took a design-science approach [23] in building the SWERA DSS system. Usability study conducted for validation of the approach is reported elsewhere[1]. We agree with Arnott and Pervan's [22] view that DSS research, with its significant system-focus, has much to offer as a strong proponent of design science methodology. As regards to the issues of significance of theoretical foundations and presence of IT artifact, our experience with this and previous DSS projects suggest that DSS research related to model management, data warehousing, process management, and business intelligence areas tend to be focused primarily on the design and applications of technology and thus have a clear IT artifact focus. However, they typically lack the 'theoretical' (behavioral) grounding often seen in topic areas like group decision support systems, and negotiation systems, where behavioral models from psychology and decision sciences often form the theoretical basis

[1] References would be inserted after the blind review.

of research. However, areas such as model management and business intelligence build on computer science based disciplines (such as artificial intelligence, information retrieval) in terms of theoretical grounding, and their contributions are mostly design-focused. This supports the previous comment regarding the fit of system-focused DSS research with design science research methodology.

The issue of funding for DSS research is an important concern raised by several researchers including Arnott, Pervan, and Dodson [24]. Arnott et al.'s [24] study indicates that only about 14% of the DSS research receives any competitive grant funding, either from government agencies or industry. While among the DSS projects funded, majority of them are seen to be system-focused. Even in that category, DSS researchers face stiff competition from the computer science counterparts, which makes securing funding quite a challenging endeavor. Given this, a viable strategy for DSS researchers is to investigate interdisciplinary funding opportunities collaborating with researchers in sciences and other domains. The SWERA DSS project is an example of such a funded research project.

In terms of inertia and conservatism seen in DSS research, Arnott and Pervan [22] point out that personal DSS and group support systems research areas have dominated the field since the inception of the field. We suggest that there are significant opportunities for DSS research that can leverage current advancements in areas such as semantic web [25, 26], process analytics [27, 28], cloud computing, and so forth. For example, semantic web research can form the building block for integrating semantic information with decision models and data for intelligence reasoning and analytics [25, 26]. Similarly, decision-enabling process management can lead to better business intelligence [27, 28].

DSS has traditionally focused on 'managerial decision making' [22]. Yet, DSS research and contributions transcends academic boundaries. This is evidenced by the proliferation of intellectual contributions related to decision support in various application/problem domains. Most notably are healthcare and environmental management. Traditionally, researchers in these domains have carved out a niche in terms of publication and presentation venues. Nevertheless, it is these (and similar) application domains that can provide valuable insight for a DSS research agenda. DSS researchers need to be cognizant of the developments in these areas beyond the traditional IS-focused journal. The DSS community needs to recognize the importance of such inter- disciplinarily venues.

Rigor is also a concern at least as evidenced by the relatively low success rate in 'A' journals [22]. Granted, this may be explained the under representation of DSS research in 'A' journals is the increased reliance in design science. Such research has been traditionally less represented in mainstream IS 'A' journals. The strong application/practitioner focused coupled with the inter-disciplinary nature of DSS research adds further challenges for DSS researchers to be able to publish in 'A' journals and adds to the interia and conservatism issue raised in [22]. Hevner et al. [23] is instrumental for DSS researcher to demonstrate rigor of design science DSS research.

With publication outlets as a measure (proxy) for rigor, attention should also be given to outlets amenable to DSS research. Specifically, as a DSS community, further consideration should be given to developing and supporting 'A' journals dedicated to DSS research. Such journals should take account the unique characteristics of the field including relevance, research methods, multi-disciplinarily nature, and timeliness of publication. DSS research is particularly unique in IS research where research can proceed if not leading practice.

8. Conclusions

The DSS research agenda will inevitably be shaped by the intersection and self-reinforcing effects of design science and the focus on creating and evaluating "IT artifacts intended to solve identified organizational problems" [29], relevance to a particular domain and hence the inter-disciplinary nature of the research, and the existence of dissemination venues that accounts for the unique characteristics of the field.

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