Extended Abstract

Spatial Decision Support for Sustainability: Synthesizing Perspectives on Vulnerability, Risk, and Resilience

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This extended abstract describes preliminary findings by members of the Spatial Decision Support (SDS) Consortium about developing a SDS framework for sustainability (SDSFS). The SDSFS treats perspectives from geographic information science, decision science, and sustainability science, synthesizing among concepts about vulnerability, risk, resilience and sustainability to address complex decision problems. Researchers within those science domains have developed abundant interdisciplinary software applications, but in terms of information science, each has evolved with a distinct ontology (core concepts and their relations) and epistemology (methods that enable information processing). Whether sustainability is an all-encompassing concept or a seed concept or some combination in comparison to vulnerability, risk and resilience does not matter so much as sustainability acts as a bridging concept that is critical to a meaningful interpretation of the other three concepts. Broad and deep decision support software when applied to complex problems about sustainable systems, should appreciate how vulnerability, risk, resilience, and sustainability are inter-connected to provide stakeholders with a synthetic perspective of health and well-being.

Research involving SDSFS is building on efforts of the SDS Consortium regarding the SDS Knowledge Portal, developed as a SDS ontology including geodesign ontology (See links at www.sdsconsortium.org). The SDSFS is meant to address three goals: 1) act as a transdisciplinary bridge among diverse perspectives about sustainable systems problems often case in terms of coupled human-natural systems, human-environment relations, hazards-receptor systems, global environmental change and/or sustainable development; 2) foster integration of case study findings in support of transdisciplinary research and help synthesize information about best management practice; and 3) address a grand challenge with architecting a knowledge environment that can inform selection of SDS methods to address complex decision problems.

To address those goals, SDSFS research is guided by the following question. How can spatial-temporal dynamics of pressing social-economic-ecological problems that are viewed in terms of sustainable

systems influenced by vulnerability, risk, and resilience management perspectives be addressed by the decision support paradigm of data intelligence organization, design of feasible courses of action, and systematic evaluation of action choices using open systems architecture?

Complex decision problems such as food, energy and water sustainability often involve dynamic social, economic, and ecological conditions relevant to many organizations, and as such are often approached by organized collections such as task forces, partnerships and/or consortia. Federal, state and local agencies together with private sector and not-for-profit sector organizations often form task forces and partnerships to address single macro-scale projects. The SDS consortium has taken up development of SDSFS as a cross-cutting research to practice software effort that must be broad-based so that it can address a wide-array of problems. As such, SDSFS might be called a meta-framework, a framework of frameworks for knowledge infrastructure.

Development of SDSFS extends research about the measurement-informed ontology and epistemology for sustainability information representation (MOESIR) framework (Nyerges et al. 2014). The MOESIR framework is constituted of four tiers of information abstraction, two of ontology and two of epistemology. Tier 1 articulates the spatial-temporal dynamics of sustainable systems. Tier 2 embraces systems and articulates concepts and relationships among vulnerability, risk, resilience and sustainability of systems. Tier 3 embraces those concepts to form an epistemological foundation described in terms of assessment and intervention for decision support. Tier 4 is about applications, e.g. regarding health and well-being of land-water systems within urban-regional contexts. The tiers nest using an information gain approach; that is, they start simple and add information to enrich concepts. SDSFS extends MOESIR particularly at tiers 2 and 3, emphasizing conceptual and methodological connections among vulnerability, risk, resilience and sustainability assessment and intervention as the foundation of sustainability decision management software.

MOESIR was created principally to organize principles for characterizing spatial-temporal process modeling of systems. Spatial-temporal dynamics of systems as a combination of spatial-temporal process and change is argued to be important for understanding functional performance of a system. Knowledge about the dynamics of functional performance of complex systems is thought to be one of the main issues in understanding resilience and sustainability which is still considered a gap in our knowledge as related to decision support systems. SDSFS, implemented as a widely accessible computer-based ontology and epistemology, can guide development (i.e., conceptualizing, designing, implementing, and deploying) and assessment (i.e., monitoring and evaluating use of) of decision support software systems platforms.

In software that embraces vulnerability, risk, resilience, and sustainability concepts, information representations are not merely static data structures, but are influenced by dynamics operations. Depending on information need, operations can transform data structures into more meaningful information representations that parameterize process(es). Constraints on information representations which help narrow focus of information representation are also important, e.g. constraints taking the form of rules such as a range of X1 to X2 that can help contextualize functional performance levels of systems. Data structures, operations and constraints taken together are called ‘data models’ (Codd

1981). MOESIR is thus the framework for organizing use of data models to generate information representations and SDSFS is a meta-framework for organizing intelligence, design and choice about vulnerability, risk, resilience and sustainability assessment and intervention.

Other important frameworks linking to SDSFS include human-centric collaborative decision support, e.g. EAST as a theory of collaborative spatial decision support involves organizational and social aspects of the world in addition to substantive problems and methodological technologies (Nyerges and Jankowski 2010). Significant decision support problems are more often motivated by organizational missions and more broadly guided by social and cultural laws, and thus data models must embrace workflow technology that is situated within the broader context of sustainability knowledge production which is organizational, social and culturally relevant.

Next steps about SDSFS research involve organizing projects, workshops, and networks to cultivate the foundation and development of conceptual, logical, and physical cyberinfrastructure. New CyberGIS-enabled decision support infrastructure is needed to foster flexible solutions. Although a foundation for spatial-temporal decision science can be formed within five years, practice will take a bit longer. Nonetheless, through rapid prototyping, it is possible that community practice can be enhanced in various places, and it will be a matter of innovation diffusion to spread the development widely.

Project activity is underway consisting of three working groups identified by the SDS Consortium to further the SDSFS development: 1) working group1 focuses on extension of the SDS ontology platform, 2) working group 2 focuses on case study applications using the platform, and 3) working group 3 focuses on workflow engine evaluation to support application development for implementing case studies. Collaboration among the working groups is essential for effective development of the SDSFS. Workshops and networks will foster activities within and between SDS Consortium members, wherein membership is open to any scholars with background and continued interest in SDS research.

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