

Enabling Informed Participation In Governance for Mitigation and Adaptation Through Integration of Science into Society

Transformational pathways towards sustainable development require a broader involvement of all stakeholders in governance and decision making (Fig. 1). Public participation is important for environmental issues, including mitigation of climate change impacts and adaptation (Box 1). Crucial to effective public participation is the provision of relevant information. This is even more true in the context of evidence-based decision making on science-based issues, including decisions related to climate change mitigation and adaptation (e.g., Dietz and Stern, 2008). Co-design, co-creation, and co-usage of practice-relevant knowledge, while crucial for sustainable development, have not been comprehensively explored to date. The looming "data supernova" that results from rapidly increasing Earth observation data, data generated through digital media, the addition of human sensors in various forms, and the emerging Internet of Things (IoT) or Internet of Everything (IoE) provides opportunities for a new level of informed participation in societal decision-making, particularly if combined with increasingly available interoperable model webs, emerging tools for visualization and concepts for the linkage between data and models. We are developing concepts for the integration of the data supernova into a knowledge base, as well as techniques and processes to access this knowledge base in a meaningful way so that it can inform deliberations and decision making for sustainable development (Fig 2).

In a system-of-systems approach, we are designing a virtual stakeholder table (VST) coupled with a living knowledge base (LKB) to use current and future technology to manage knowledge and develop modeling tools that enable participatory, informed decisions. Among others, the VST facilitates participatory modeling, virtual deliberation, and democratic access to knowledge for a wide range of stakeholders (Fig. 3). A generalized concept for a human sensor addresses fundamental questions related to the use of crowd-sourcing, Big Data and citizen scientists as sources for socio-economic and environmental data and prepares data integration of current and future sensors, including the IoT and IoE. The integration of a model web with a living database provides novel avenues for decision support.

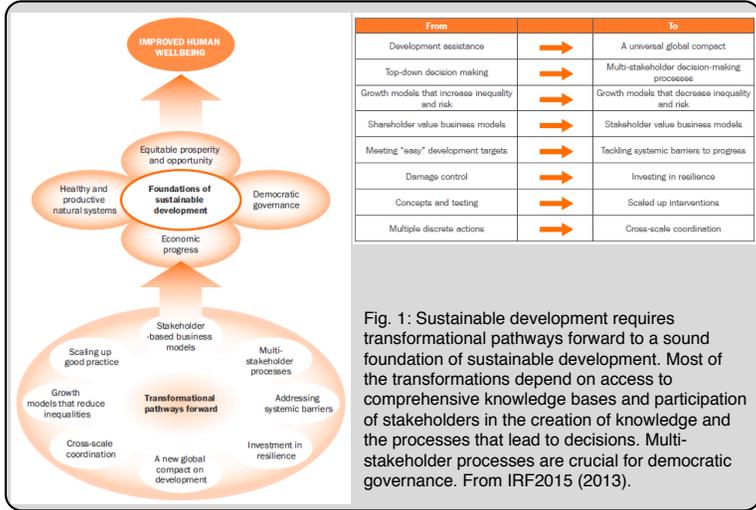


Fig. 1: Sustainable development requires transformational pathways forward to a sound foundation of sustainable development. Most of the transformations depend on access to comprehensive knowledge bases and participation of stakeholders in the creation of knowledge and the processes that lead to decisions. Multi-stakeholder processes are crucial for democratic governance. From IRF2015 (2013).

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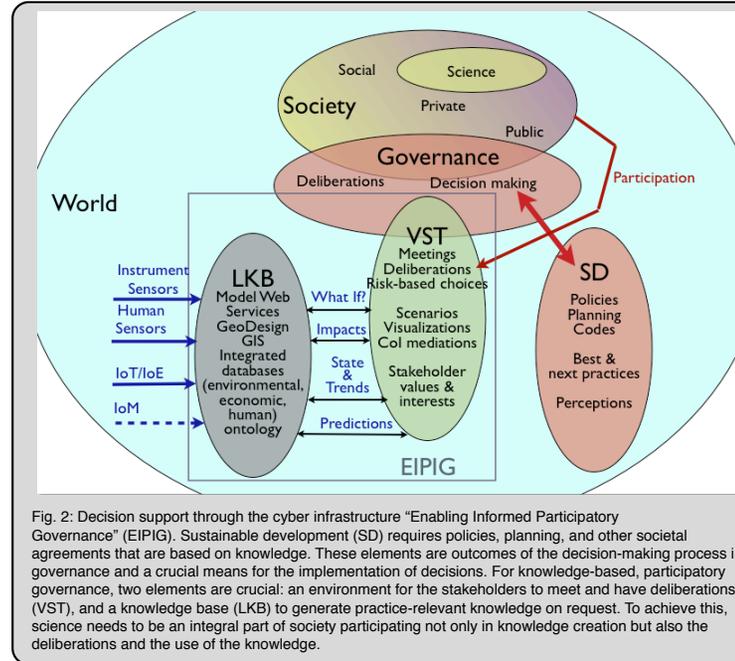


Fig. 2: Decision support through the cyber infrastructure "Enabling Informed Participatory Governance" (EIPIG). Sustainable development (SD) requires policies, planning, and other societal agreements that are based on knowledge. These elements are outcomes of the decision-making process in governance and a crucial means for the implementation of decisions. For knowledge-based, participatory governance, two elements are crucial: an environment for the stakeholders to meet and have deliberations (VST), and a knowledge base (LKB) to generate practice-relevant knowledge on request. To achieve this, science needs to be an integral part of society participating not only in knowledge creation but also the deliberations and the use of the knowledge.

The LKB is being populated based on information from a reference site, Hampton Roads, VA, an urban coastal region with a complex socio-economic structure threatened by climate change and sea-level rise. Coastal zones are at the front line of humanity's sustainability crisis. The complexity of the coastal zone presents convoluted governance challenges that require informed interaction of a wide range of stakeholders. The EIPIG is utilized for a number of case studies aiming at integration of science stakeholders into governance for thriving sustainable communities (Box 2). It also supports the development of new transdisciplinary educational pathways and outreach to a broad stakeholder network engaged in governance for sustainable development.

REFERENCES
 Dietz, T. and Stern, P. C. (eds.), 2009. Public Participation in Environmental Assessment and Decision Making. Panel on Public Participation in Environmental Assessment and Decision Making, National Research Council. IRF2015, 2013. Post-2015: Framing a new approach to sustainable development, Tech. rep., IRF2015 Secretariat, International Research Forum, www.irf2015.org.
 Mauser, M., Klepper, G., Rice, M., Schmalzbauer, B.-S., Hackmann, H., Leemans, R., Moore, H., 2013. Transdisciplinary global change research: the co-creation of knowledge for sustainability, *Current Opinion in Environmental Sustainability*, 5, 420-431.



Box 1: Dietz and Stern (2008): Recommendation 1: Public participation should be fully incorporated into environmental assessment and decision-making processes, and it should be recognized by government agencies and other organizers of the processes as a requisite of effective action, not merely a formal procedural requirement.

Box 2: Study cases used to validate the concept of EIPIG.
 • Study case 1: making integrated databases accessible;
 • Study case 2: combining models, instrumental sensors, and human sensors: flood warnings;
 • Study case 3: planning for an uncertain future: the case of sea level rise;
 • Study case 4: extreme events: developing options for disaster risk reduction.



Fig. 3: MARI works with a wide range of stakeholders in all societal sectors in co-design of research agendas, co-creation and co-usage of knowledge facilitated by EIPIG.

A particular focus of the Mitigation and Adaptation Research Institute (MARI) is on exploring the role of EIPIG in facilitating decision that account for uncertainties concerning climate change. Most of these uncertainties are epistemic, i.e., a range of knowledge gaps, including those resulting from the random nature of processes for which a statistical distribution may be known, those for which the causing processes are understood but the probabilities of specific outcomes are not quantifiable, and those for which even the processes are only partly known or not known at all. The communication of knowledge gaps is often impacted by the scientist's personnel and social context, including the value system, and self-reflection of all stakeholders involved in the co-creation of knowledge is crucial to separate knowledge from interpretation and opinions.