COMMON CONCEPTUAL AND OPERATIONAL FRAMEWORKS FOR RESEARCH AND SUSTAINABLE MANAGEMENT OF NESTED SOCIO-ECOLOGICAL SYSTEMS ACROSS LARGE WATERSHEDS

Angheluta VADINEANU¹ & Nusret KARAKAYA²

¹ Department of Systems Ecology & Sustainability – University of Bucharest, Romania
² IGEM Research & Consulting, Turkey

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In the last two decades, significant conceptual and operational constructs have been developed and applied, all of them being targeted for better identification and management of the complex relationships within and among environment and human populations.

That allowed to move relatively fast the policy and operational targets from the conventional management, based on sectoral and inappropriate spatial and temporal scales approach, and reductionistic interpretations towards integrated or ecosystem and landscape approach, and holistic interpretation across large scales (Smith and Maltby, 2003; CBD COP 5/Decision 6).
• The meta-analysis of a wide range of theories, concepts, and analytical and accounting tools from natural, social and technical sciences and their integration and synthesis allowed for:

i) identification key steps of the process;

ii) describing the emergence of the global science (s) which is or are focused on understanding and adaptive management of Socio-Ecological Systems → Sustainable Watershed Management;

iii) development the generic conceptual and operational frameworks for understanding and Sustainable management of Watersheds;

iv) clarification of meanings and ways of operationalization of two most used concepts in the policy and regulatory frameworks – Natural Capital and Ecosystem Services.
• Understanding feedbacks between socio-economic and natural components of the integrated “land system” is a key goal of sustainability science (Kates et al 2001).

The notion/concept of “land system” emphasizes that the Earth’s lands are coupled human-environmental systems in which both socio-economic and natural “factors” interact in shaping patterns and dynamics (GLP 2005, Turner et al 2007).
• Other scientists went a step further by launching and supporting the idea that physical, chemical and biological components, including humans and their created and controlled infrastructures of the Earth System as Environment are self organized across space and time scales into Socio-Ecological (Vadineanu 2001, 2007, Redman et al. 2004, Gunderson and Holling 2002) or Human and Nature Coupled (Lin et al. 2007) Systems.
Sagof (2011) after interesting critical analysis of these trends has stated that “as Ecology expands from site base science to subregional, regional, and global scales our conceptual scope must also expand to embrace not only climate, geology, hydrology, soils, but also the increasingly pervasive human dimensions of ecological change”.

He concludes that “the environment should be viewed as nested Socio-Ecological systems across scale of global Earth System”.

The objectives of SUWAMA Conference have been defined based on recognition that watersheds integrate human dimensions and in accordance with the Brisbane Declaration (2007) which states that environmental flow (quantity, quality and timing) should be managed to sustain freshwater and estuarine ecosystems, and human well-being dependent on these ecosystems. Such interpretation suggests that a watershed might be defined by a single or a set of nested Socio-Ecological Systems.
Figure 1. Integration and Development of Basic and Applied “Global Science”: Systems Ecology and Sustainability
“GLOBAL SCIENCE” of Nested Socio-Ecological Systems (SEcoIS)

- Develop Retrospective and Prospective Synthesis of data and knowledge concerning the dynamics of Climate, Biodiversity, Ecosystems and nested SEcoISs

- Understanding and modeling dynamic interactions, interdependencies and processes, within and among SEcoISs

- Develop theories, principles and conceptual models for the identification of the complex organization across scales of the Environment, Nature and Humans

- Develop and implement Strategies, Scenarios and adaptive management plans targeted to achieve 3-D-Sustainability in the nested SEcoISs

- Build intellectual and social capacity required for solving complex and large scale issues regarding sustainable development

- Build and use holistic analytical and operational framework, methods, tools and innovative technologies
Figure 2. Conceptual framework on the organization and relationships between nested Socio-Ecological Systems established in large watersheds. (The framework has been adapted and improved, based on previous versions applied to Lower Danube Catchment in late 1990s and US-LTER / ISSE Framework / Collins et al. 2007).
External drivers (social, economic and natural)

Module 1
Modelling the social capacity (eg. FCM, ABM)

Module 2
Modelling spatial (GIS) dynamics in the composition, structure, and functions of Natural Capital (eg. Modelling Land Use Change)

Module 3
Modelling services flow (eg. model of environmental flow; C & N stock flows)

Internal drivers

Composition, structure, and metabolism of Socio-Economic System

Regulation

Provisioning and information services

Figure 3. Integrated framework for modelling and simulation the interactions among socio-economic trajectories, Natural Capital change and services flows (materials, substances, energy and information) or socio-ecological flows. It shows the key role of social and cultural capital in analysing patterns and trajectories of social, economic and natural drivers (internal & external) as well as feedbacks between “Natural Capital ↔ Socio-Economic System”
Figure 4. Operational platform for adaptive management of nested socio-ecological systems at large watershed/sustainable watershed management

- **a** – shows the increase of relevance of knowledge and indicators for policy and decision making;
- **b** – shows the trend of integration, aggregation and synthesis;
- **c** – suggests the increase of stakeholders participation in the decision making and adaptive management;
- **d** – shows the increased relevance of data and information for understanding and modeling the complexity.

* Socio-Economic System
The integrated framework for modelling and simulating the interactions within and among socio-ecological systems from large watersheds shows how the need formulated by scientists, policy and decision makers, managers (Manson and Evans 2007, Valbuena et al. 2008, Gaube et al. 2009, Haberl et al. 2009) concerning operationalization the concepts of adaptive management or sustainable management could be met.
How are watersheds configuration influenced by internal and external social, economic and political drivers?

How do watershed patterns influence nutrient fluxes and environmental flows?

How can watersheds be better managed to achieve environmental objectives and promote sustainability?

Where are the opportunities for high impact policy interventions?
From anthropogenic point of view, ecosystem services have been defined as those resources and processes through which natural and seminatural – including human modified and controlled ecosystems and the species contained in them sustain and fulfil human life (Daily 1997, MA 2005) or as benefits that people obtain from ecosystems (Boyd and Banzhaf, 2007)