2. Knowledge and learning in environmental policy context

Knowledge is often held to be the main driver and framing power of environmental policy, which is also recognised and addressed by a growing body of literature on knowledge generation systems, and on the propagation and actual use of knowledge. The second part of the textbook explores the issues of learning and use of knowledge in the context of agenda setting, development and implementation of environmental policies. First, in order to frame the discussion, it introduces the concepts of *social-ecological systems* and *adaptive governance* (2.1). Next, it describes a broad range of issues related to *knowledge production and utilisation* and relates them to structure and participants of environmental policy process (2.2). After this, we explore such specific (albeit important) instances of knowledge production as *social learning* (2.3) and *local knowledge* (2.4), and discuss the problems of integrating them into environmental management and governance.

2.1. Governance of adaptation and adaptive governance

Viktar Kireyeu, Anton Shkaruba

Adaptation, adaptive management, adaptive governance, adaptive policies and other key words with "adaptive" in it, are increasingly populating international, EU, national and local policy documents, international treaties, agendas of strategy discussions and management plans. This is because global environmental change, in particular, climate change is a new reality for environmental management, and environmental managers are getting used to the idea that nothing is stable anymore, ecological, social and political contexts are highly dynamic, and that good management shall incorporate a significant *learning component,* evaluation of *uncertainties* and be ready for *experimentation*. This chapter will introduce the field of *vulnerability and adaptation* studies, in particular from a policy perspective.

Environmental policy is all about human-nature interactions. Concept of *social-ecological systems* (or SES) gave rise to a field of studies that looks at such interactions from an integrative perspective combining holistic approaches and issues of human well-being and social justice, i. e. provides a good fit to normative context of sustainable development. For this reason, and also because this concept is broadly employed in vulnerability and adaptation studies, the chapter opens with an introduction to social-ecological systems and their properties; then it continues with explaining the basic terminology of vulnerability and adaptation, introduces *adaptive management* and *co-management*, and to a broader concept of *adaptive governance*.

2.1.1. Social-Ecological Systems and their diagnostics

There is a number of concepts and approaches illustrating the coupled nature of human and biophysical systems, including socio-ecological systems (Gallopín, 1994), social-ecological systems (Berkes & Folke, 1998), human-environment systems (Turner et al., 2003), human-biophysical systems (Dietz et al., 2003) etc. These systems may exist at various levels, ranging from local to global.

Due to the strong theoretical base, the concept of *social-ecological systems* (SES) enjoys broad dissemination in the international literature, in particular on community-based management. It explains human-nature interactions in a relatively simple and coherent way, and works as a functional tool for visualisation of links and interdependencies within the system, including the spatial and historical patterns. It also can visualise how local institutions integrate into larger governance architectures, and the agency below the state develops taking advantage of polycentric nature of environmental governance.

The concept of SES was first proposed in order to explain and examine the complexity of interactions in a system that included humans interacting with a biophysical system and had an ability to sustain itself (Gallopín, 1989), and then it was further elaborated by many scholarly networks. The "social science cluster" of the global environmental research community usually sticks to definitions coming from the Elinor Ostrom's group (e. g. "…social systems in which some of the interdependent relationships among humans are mediated through interactions with biophysical and non-human biological units" (Anderies et al., 2004)). Scholars belonging to the Resilience Alliance (http://www.resalliance.org/) chose to emphasise the integrated character of the concept, and to stress that the delineation between social and ecological systems is artificial and arbitrary (Folke et al., 2005). They therefore offer definitions of SES, which are essentially very neutral and underlying the equal importance of social and biophysical components of social-ecological systems (e. g. "social-ecological systems are complex, integrated systems in which humans are part of nature" (Berkes et al., 1998)).

Depending on the position of institutional components, the literature describes SESs from the three perspectives: intersection (Fischer-Kowalski & Weisz, 1999), linked (Gallopín, 1994; Berkes & Folke, 1998), and those linked with a governance filter (Kotchen & Young, 2007).

SESs as intersections are discussed in the frame of *socio-metabolic approach* where society-nature interactions are conceptualised as interaction and co-evolution (Fischer-Kowalski & Weisz, 1999). The underlying idea is that human society is maintained by cultural (including interconnecting communication flows generated by political, economic, legal etc. subsystems of the society) and by biophysical modes of perpetuation. The biophysical mode is further decomposed as two interrelated processes — social metabolism (i. e. continuous flow of energy and materials from or to the natural environment) and colonization (deliberate interventions into the environment). The social-ecological systems here is the area where these two modes intersect and materialise in physical infrastructure, environmental impacts, management practices and policies, development agendas, educational and research programs, artistic reflections and so on, all interacting between each other, reinforcing, mitigating, destroying etc.

In the *linked SESs* discussed by Gallopín (1994), society and nature (or also ecological systems) interact through human actions coming from the society and ecological effects generated by the nature as a result of internal dynamics or external impacts (including the human actions). In this methodology an important part of the system analysis is related to the external environment (ecological and social) that interacts with actions coming from the societal system and modifies them (and this way influences the natural subsystem), but also may change feedback mechanisms of ecological systems or even cause their structural changes.

Kotchen and Young (2007) conceptualised the role of institutions as filters mediating between human actions and biophysical processes, rather than just providing a link between social and ecological systems (Folke et al., 1998). In this conceptualisation, governance system is seen as a combination of institutional filters working in both directions (see Fig. 2.1). The governance filter consists of the sets of rules, rights, and decision-making procedures that are created by humans to guide actions, including those that may have disruptive impacts on biophysical systems. It also provides mechanisms acting as a sort of "safety nets" against biophysical impacts on human welfare, such as insurance schemes and emergency assistance programs. The governance system should be capable of managing both of these relationships simultaneously (Kotchen & Young, 2007).

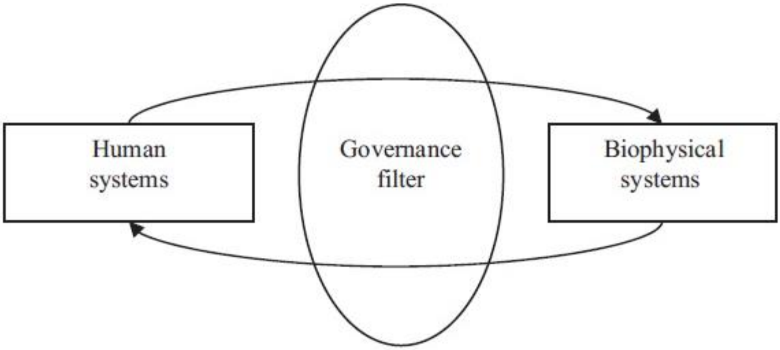

Fig. 2.1. Coupled human-biophysical systems.
Source: Kotchen & Young, 2007

The SES provides a conceptual base for a number of analytical and evaluation frameworks looking at the SES e.g. through glasses of stakeholder assessments, model explorations, historical profiling or case study comparison (Carpenter et al., 2005).

Elinor Ostrom (2009) developed a SES diagnostic framework, in which she recognised four dynamically interlinked subsystems: (1) resources systems, (2) resource units, (3) governance systems, and (4) users with their knowledge and understanding the resources. In order to fill this frame with details and link it to established methodological tools, Michael McGinnis (2010) offered a revision, which was very much based on the well standing Institutional Analysis and Development framework (IAD) (Kiser & Ostrom, 1982). He looked to address "*the criticism of the IAD framework as* *not taking concepts of relevance to ecologists as seriously as we were taking diverse levels of concepts related to institutions*" (McGinnis, 2010: 2). The integration of institutional and biophysical sides of SES's is mostly implemented through the analysis of *focal situations*, i.e. specific instances of managing the system or the sub-systems.

Some of the assessment approaches used within the Resilience Alliance are summarized e. g. in the series of workbooks available from http://www.resalliance.org offering tools and forms to fill in that can be used for more basic social-ecological inventories (SEI) as well as for the full resilience assessment. The workbooks provide guidance to a structural overview of SES, identification of vulnerabilities, driving forces and uncertainties, and call for an issue-based assessment and, where possible, for "collective" treatment of the issues. The workbooks also suggest to consider for the resilience assessment thresholds and their interactions and proximity (e. g. discussed by Kinzig et al. (2006), Briske et al. (2010) and assess both specified and general resilience (e. g. see Walker et al. (2009) for examples of a comprehensive analysis). Augerot and Smith (2010) offer a more straightforward SES assessment, which is structured according to the dimensions of the adaptive cycle: they ran a qualitative assessment of capital accumulation and connectedness at the regional scale. The methodology for valuation of ecosystem services proposed by Hein et al. (2006) does not specifically addresses SES, but it looks at biophysical properties of ecosystems as well as values and stakeholders' consent and therefore it is often used in the resilience assessment of SES.

2.1.2. Vulnerability and adaptation studies — introduction to the concept and terminology

To evaluate the governance of social-ecological systems, we need a conceptual framework, which would provide for integrative assessment of both human and biophysical components. The broadest and the most commonly used by climate change research community framework is *vulnerability* (Gallopín, 2006; IPCC, 2007).

Füssel and Klein (2006) distinguished risk-hazard, social constructivist, and integrated models to conceptualise and assess vulnerability. The *risk — hazard framework* is commonly used in technical research on disaster and risk management. Vulnerability in this model is a dose — response relationship between the hazard a system is exposed to and the range of adverse effects caused by the hazard. The *social constructivist framework* dominating in human geography and political economy defines vulnerability as an intrinsic characteristic of a community determined by socioeconomic and political settings. Vulnerability in this approach refers to socioeconomic causes of differential sensitivity and exposure. According to the *integrated framework*, vulnerability is a combination of possible impacts to a system triggered by external stressors. In this model, vulnerability has an *external dimension* — which refers to the 'exposure' of a system to an environmental change — and an *internal dimension* — which combines 'sensitivity' and 'adaptive capacity' to the environmental change.

The origin of the integrated framework is the hazards of place model (Cutter, 1996), which was developed to integrate biophysical and social determinants of vulnerability. This conceptual framework has an explicit focus on a locality. The overall hazard potential in this model is understood as a combination of risk and mitigation. It is filtered both through the social fabric and the geographic context, and results in a social or a biophysical vulnerability respectively. The vulnerability of places is defined as an intersection of these two vulnerabilities. There is a feedback loop from the place vulnerability to both the risk and mitigation. This relatively simple model is getting more complicated with all the parameters of the model constantly changing over time (see the bottom half of Fig. 2.2); furthermore, each of these parameters contains a number of nested elements.

The hazards of place model were further developed by IPCC. Their initial approach was to distinguish between *sensitivity* — how a sector is directly affected by global climate change (e. g., change in agronomic crop yield); *adaptability* — how a system could respond to global climate change (e. g., crop rotation); and *vulnerability* — the net effect after sensitivity and adaptability are evaluated (IPCC, 1996).

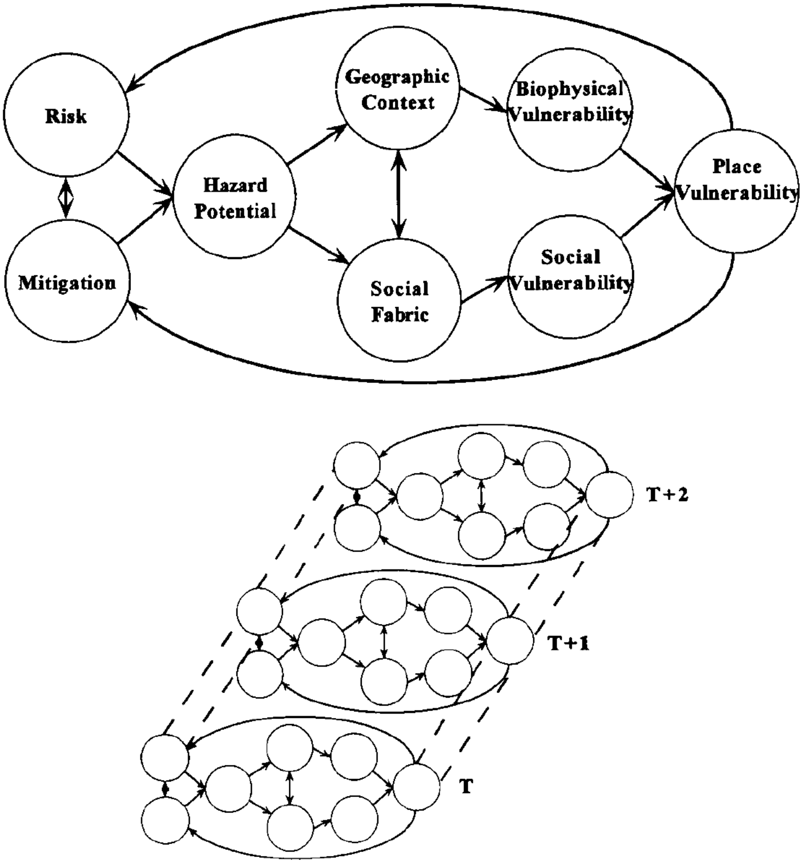

Fig. 2.2. The hazards of place model of Vulnerability.
Source: Cutter, 1996

However, in the synthesis chapter of the IPCC Third Assessment Report (TAR) Working Group II recognised the limitations of static impact assessments and challenged a shift towards dynamic assessments (based on functions of shifting climatic parameters, trends in economic and population growth, and the ability to innovate and adapt to changes), which finally led to the definition of vulnerability as "the extent to which a natural or social system is susceptible to sustaining damage from climate change" and the degree to which a system is unable to cope with "adverse effects of climate change". Vulnerability thus could be measured as "a function of the character, magnitude and rate of climate change and variation to which a system is exposed, its sensitivity, and its adaptive capacity" (IPCC, 2001b).

In the Advanced Terrestrial Ecosystem Assessment and Modelling (ATEAM) project, the term 'vulnerability' was defined in a way to include both the traditional elements of impact assessments (i. e. sensitivities of a system to exposures) and adaptive capacity to cope with potential impacts of global change). ATEAM adjusted the IPCC definition of vulnerability to make it directly related to social-ecological systems and human sectors relying on ecosystem services: "Vulnerability is the degree to which an ecosystem service is sensitive to global change plus the degree to which the sector that relies on this service is unable to adapt to the changes" (Metzger et al., 2005).

Exposure is a nature and degree to which ecosystems are exposed to significant climatic variations, as IPCC (2001b) defines, or to environmental change, as a broader definition used in the ATEAM project (Metzger & Schröter, 2006) suggests. In IPCC (2001b), *sensitivity* is the degree to which a system is affected, either adversely or beneficially, by climate-related stimuli. The effect may be direct (e. g., a drop of crop yield in response to a change in the mean, range, or variability of temperature) or indirect (e. g., damages caused by an increase in the frequency of coastal flooding due to sea level rise). *Sensitivity* used in ATEAM is the degree to which a social-ecological system is affected, either adversely or beneficially, by environmental change (Metzger & Schröter, 2006).

Knight and Staneva (2002) define *sensitivity* as the degree to which a system will respond to a change in climatic conditions (e. g., the extent of change in ecosystem composition, structure, and functioning, including primary productivity, resulting from a given change in temperature or precipitation).

The issue of *adaptation* to climate change and to its effects on human health and economic activities has received a considerable attention of researchers and policy makers (IPCC, 2001a, b). IPCC (2001b) defines *adaptation* as "any adjustment in natural or human systems in response to actual or expected climate change stimuli or their effects, which moderates harm or exploits beneficial opportunities". According to IPCC (2001b), adaptation can be autonomous or planned, anticipatory (proactive) or reactive (depending on whether the adaptation takes place before or after impacts of climate change have been observed), and also a private or a public. *Autonomous adaptation* is "triggered by ecological changes in natural systems and by market or welfare changes in human systems, but does not constitute a conscious response to environmental change". This type of adaptation changes the sensitivity of a system by changing its state. It is a part of the internal feedbacks in the social-ecological systems. *Planned adaptation* is "the result of a deliberate policy decision, based on an awareness that conditions have changed or are about to change and that action is required to return to, maintain, or achieve a desired state". Examples of such adaptations include an introduction of drought resistant crops, establishing protected areas and ecological networks to sustain landscape and biological diversity, widening river channels to cope with peak flows, and constructing dams to preserve water for drier summers.

Knight and Staneva (2002) defined *adaptation* as adjustments of practices, processes, or structures in response to projected or actual climate changes. Adjustments can be either spontaneous or planned, reactive or anticipatory. In some instances (e. g. in case of many ecosystems), options for planned or anticipatory adaptation may not exist. Adaptations can reduce negative impacts or take advantage of new opportunities emerging with changing climate conditions.

Potential impacts are all impacts that may occur under a projected environmental change without considering planned adaptation (Metzger et al., 2005). Residual impacts are the impacts of global change that would occur with planned adaptation measures taken (Metzger et al., 2005). According to Füssel and Klein (2006), the exposure, sensitivity, and potential impacts are only relevant at the level of *exposure unit* (a sector, activity or location assessed for climate change impacts (Carter et al., 1994)) as opposed to GHG emissions, concentrations, and climate change which are relevant at the global level.

IPCC (2001b) defines *adaptive capacity* as the "potential, capability, or ability of a system to adapt to climate change stimuli or their effects or impacts". In Millennium Ecosystem Assessment (2005), it is the "general ability of institutions, systems, and individuals to adjust to potential damage, to take advantage of opportunities, or to cope with the consequences". Both definitions imply that, in principle, adaptive capacity has the potential to reduce the damages of climate change, or to increase its benefits.

In the Third Assessment Report of IPCC, they propose 6 broad classes of factors that determine the adaptive capacity, namely (i) economic wealth, (ii) technology, (iii) information and skills, (iv) infrastructure, (v) institutions, and (vi) equity (IPCC, 2001b). Methodologies for empirical measurement of adaptive capacity and establishing the relative importance of its determinants are still not sufficiently robust. Brooks et al. (2005) and WRI (2009) have made attempts to develop a framework for determining adaptive capacity at the national level. Metzger et al. (2008) developed a generic index of macro-scale adaptive capacity, which was based on socio-economic indicators, determinants and components of adaptive capacity, such as female activity rate, equity, GDP, number of patents, and age dependency ratio. This index was calculated for subnational regions (i. e. lands, provinces).

Links between adaptive capacity and multilevel governance of social-ecological systems were revealed by Plummer and Armitage (2010). They recognise that the adaptive capacity has an important social dimension, and there is a need to understand the role of formal and informal institutions, as well as a relationship between the dynamics of governance and biophysical systems.

Adaptive capacity is directly related to the concept of *resilience*. This concept is widely used by ecologists and engineers. According to Holling (1973: 17) "resilience determines the persistence of relationships within a system and is a measure of the ability of these systems to absorb changes of state variables, driving variables, and parameters, and still persist." *Resilience* was the first concept to be used for the analysis of interactions between human and natural components. The concept is being continuously developed by the Resilience Alliance.

2.1.3. Adaptive governance

Addressing the issue of uncertainty associated with complex systems, Holling et al. (1978) found that the *resilience* (Holling, 1973) of a system is higher, when both management and natural components of the system are more variable. They proposed an *adaptive management* approach to increase the variability and, by extension, the resilience of management institutions. The essential parts of their approach were an explicit accounting for uncertainty, using an adaptive process for the design of management policies, and treating environmental assessment as an integral part of management. Depending on the way the policy design process takes place, Walters and Hilborn (1978) distinguished between *passive* and *active* adaptive managements. The former approach uses models based on prior knowledge and corrects them as mistakes occur, while the latter treats all management actions as experiments.

The adaptive management framework was further developed and applied for renewable resources by Walters (1986). He described traditional trial-and-error management as "unnecessary wasteful" and, in order to make adaptive management more intelligent, suggested to involve the structured synthesis and analysis of major processes and uncertainties, the development and implementation of improved monitoring programs, and formal optimization techniques to search for best possible policies accounting for both existing and future uncertainties.

The principles of adaptive management were applied to policy-making by Swanson et al. (2009). They proposed seven tools for devising adaptive policies, namely integrated and forward-looking analysis, built-in policy adjustments, formal policy review and continuous learning, multi-stakeholder deliberation, self-organization and social networking, decentralizing of decision-making, and promoting variation.

A broader concept of *adaptive governance* was introduced by Dietz et al. (2003). Adaptive governance, they argue, requires providing reliable information, dealing with conflicts, inducing rule compliance, providing infrastructure, and designing institutions prepared to a change. These requirements can be met by devising rules that are congruent with ecological conditions, clearly defining the boundaries of resources, devising accountability mechanisms for monitors, applying graduated sanctions for violations, establishing low-cost mechanisms for conflict resolution, encouraging analytical deliberation, nesting institutional arrangements, and promoting institutional variety.

To operationalise the concept of adaptive governance, Olsson et al. (2004) proposed *adaptive comanagement* approach that integrated the dynamic learning feature of adaptive management with the linkage attribute of collaborative management (Borrini-Feyerband, 1996). They argue that this approach, if combined with institutional support from higher levels, has a capacity to increase the robustness of social-ecological systems to the change. The essential requirements for the emergence of adaptive comanagement of ecosystems include legislation that creates social space for ecosystem management, funds for responding to environmental change, ability to monitor and address environmental feedbacks, information flow and social networks, integration of various sources of information, sensemaking of the integration results, and platforms for collaborative learning.

Adaptive governance of social-ecological systems in the periods of abrupt change was analysed by Folke et al (2005). In the systems of adaptive governance, according to them, actors and institutions are connected at multiple organizational levels; some actors provide leadership, vision, meaning, trust, and help to transform organizations into a learning environment. The authors highlight four interacting characteristics of adaptive governance of social-ecological systems: building knowledge on ecosystem dynamics; feeding ecological knowledge into adaptive management practices; supporting flexible institutions and multilevel governance systems; and dealing with uncertainties, surprises, and external perturbations. Further chapters specifically focus on knowledge generation, use and dissemination as core components of environmental policy process, in particular on such well discussed in vulnerability and adaptation literature issues as social learning and local knowledge.

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