Chapter 22
Public Participation and Environmental Education

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Learning together to manage together (Ridder et al. 2005)

Public participation can generally be defined as allowing people (stakeholders, interested parties, public) to influence the outcome of plans and working processes that constitute the operations of governance (CIS 2003). It can be practiced in different phases of integrated river basin management, but the public's environmental understanding forms one basis for participation. Environmental education is the process of recognizing values and clarifying concepts in order to develop skills and attitudes necessary to understand and appreciate the interrelation among people, their culture, and their biophysical surroundings (Palmer 2003). In this chapter, we discuss how environmental education and public participation interact with and are influenced by each other and need to be embedded in all areas and levels of societal processes.

Since participation is a principle of sustainable development (Costanza et al. 2000; Wagner et al. 2002), participatory decision-making is seen as key element for sustainable river basin management (Hedelin 2008). PP can be practiced in different phases of integrated river basin management (IRBM), from the involvement in decision-making process over the actual implementation of measures to the participation in environmental monitoring and research. An additional objective of PP is to increase public awareness of environmental issues and water management and to strengthen the commitment and support of decisions. Important for PP is the public's environmental understanding.

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Environmental education (EE) is the process of recognizing values and clarifying concepts in order to develop skills and attitudes necessary to understand and appreciate the interrelation among people, their culture, and their biophysical surroundings (Palmer 2003). EE also entails practice in decision-making and formulation at the individual and group levels of a code of behavior about issues concerning environmental quality (IUCN 1970; Howe 2009). The goal of EE is to develop a citizenry that is aware of, and concerned about, the environment and its associated problems and which has the knowledge, skills, attitudes, motivations, and commitment to work individually and collectively toward solutions of current problems and the prevention of new ones (UNESCO 1975).

For these reasons, EE forms one basis for PP, since participatory activities enhance environmental knowledge.

The structure of the chapter follows the discussion of the most addressed issues regarding PP and EE in IRBM. Based on the legal background for participatory processes, aims and potential benefits of PP documented by many authors are summarized. A theoretical paragraph deals with different levels of participation, their associated techniques and a basic scheme highlights the most important processes. Case studies show the potential of participatory processes in IRBM at different participation levels which reveal possible challenges and lead to potential solutions. Sustainable and participatory decision-making in IRBM results in the need for enhanced EE. Therefore, the integration of EE in different educational concepts is demonstrated in some examples. Finally, some promising and novel activities and methods to foster EE and PP, such as citizen science, are presented.

22.1 Legal Background for PP in Integrated River Basin Management

Much international legislation and policy has been developed to encourage PP (Bell et al. 2012). Indeed, the importance of community participation in sustainable development was enshrined within Principle 10 of the 1992 Rio Declaration of Environment and Development (UN 1992: Preamble of Chap. 23 “Strengthening the role of major groups”). Over 170 governments assembled at the Earth Summit in Rio de Janeiro and affirmed the importance of public access to information, participation, and justice in decision-making and produced the global action plan for sustainable development laid down in Agenda 21. The implementation of Agenda 21 was intended to involve action at international, national, regional, and local levels with regard to sustainable development (UN 1992). Some national and state, i.e., provincial, governments have legislated or advised that local authorities take steps to implement the plan locally, as recommended in Chap. 28 of the document. These programs are often known as “Local Agenda 21” or “LA21” aiming, among others, to protect freshwater resources (CIS 2003). Additionally, the International Conference on Water and the Environment in Dublin in 1992 set out the four Dublin

Principles that are still relevant today (Principle 2: “Water development and management should be based on a participatory approach, involving users, planners”).

In Europe, many agreements and EU directives have included provisions for participatory input to environmental decisions. The Water Framework Directive (WFD, Directive 2000/60/EC; EC 2000) is one of the first European regulations that explicitly demands a high degree of involvement of non-state actors in the implementation (Newig et al. 2005). PP is stated in the preambles 14 and 46 and in Article 14. In the EU Floods Directive (EFD, Directive 2007/60/EC; EC 2007), public information and consultation are stipulated in Article 9 and Article 10. Member States are required take appropriate steps to coordinate the application of both directives, focusing on opportunities for information exchange and for consulting the public at key stages. The active involvement of all interested parties under Article 14 of the WFD and Article 10 of the EFD shall be coordinated, and the Member States shall encourage all interested parties in the production, review, and updating of the river basin management plans (Annex VII) and the flood risk management plans. According to the philosophy of these two articles, decisions must be taken with maximum transparency. The text of the WFD is supplemented by guidance provided as part of the Common Implementation Strategy of the European Commission and the Member States (CIS 2003). This document describes the concept of PP and indicates also how to organize PP in IRBM, which actors to involve, when and how to organize PP.

In addition, the participation approach is also reflected in a range of further international agreements such as the European Landscape Convention (Council of Europe 2000), the UNECE Aarhus Convention (UNECE 1998) on Access to Information, Public Participation in Decision-making and Access to Justice in Environmental Matters, the SEA directive (2001/42/EC; EC 2001a) on the assessment of the effects of certain plans and programs on the environment, the Public Access to Information Directive (2003/04/EC; EC 2003a), and the Public Participation Directive (2003/35/EC; EC 2003b).

22.2 The Benefits of Public Participation

Many publications highlight the benefits of PP in IRBM (Mostert 2003; CIS 2003; Mostert et al. 2007; Reed 2008; Ker-Rault and Jeffrey 2008; Pahl-Wostl et al. 2008; de Stefano 2010; Demetropoulou et al. 2010; von Korff et al. 2010, 2012; Luyet et al. 2012; Hassenforder et al. 2015). These benefits are seen as:

1. Raising public awareness on environmental issues and specifically on each river basin’s environmental situation and local catchment by information and consultation processes
2. Making use of the different stakeholders’ knowledge, experience, and initiatives and thus improving the quality of plans, measures, and river basin management
3. Public acceptance, commitment, and support of decision-making processes
4. More transparent and creative decision-making

5. Fewer misunderstandings and delays and more effective implementation
6. Avoiding potential conflicts, problems of management, and costs in the long term
7. Increased social learning and experience are leading to enhanced democratic legitimacy of competent authorities and increased accountability
8. Capacity building among stakeholders and competent authorities
9. Strengthening of decision-making procedures
10. Improvement in the quality of river resources
11. Promotion of goals associated with sustainable development

Focusing on educational aspects, additional benefits are reported in terms of social learning, systems thinking, and systems understanding in participatory processes (Pahl-Wostl et al. 2008; Hassenforder et al. 2016).

1. Through the potentially intensive interaction in a participation process, participants can build new networks and work to resolve conflicts, thus having an opportunity to increase their social capital, which in turn may enable them to more easily solve problems in a wider range of contexts and new conflicts in the future.
2. Decision-makers, planners, or community members can directly experience a systems understanding that is understood through praxis and can therefore be readily translated into improved actions and decisions.
3. Participants are more likely to apply the new systems' understanding over the long term, beyond the temporal and planning targets of the initial participatory processes.
4. Participation can facilitate systems learning and thereby "implant" a foundational environmental understanding, tailored to solve similar long-term contested decision areas.

22.3 Participation Levels, Techniques, and Basic Framework of Public Participation

The "degree of participation" is one of the most addressed categories for process description in the literature (Hassenforder et al. 2015). Arnstein (1969), who wrote the first main contribution related to this topic, set out a ladder for citizen participation based on eight steps. Based on adaptations and revisions of Arnstein's typology (Vroom 2003; Ridder et al. 2005; IAP2 2015), we use the five following degrees of participation from lower to higher levels of participation and impact:

Information: provide the public with objective information.
Consultation: obtain public feedback on analyses and/or decisions and provide feedback to the public how the decision was influenced.
Involvement: cooperation with the public to ensure that public concerns are considered and reflected in the alternatives developed.

Collaboration: partner with the public in identification of the preferred solution and incorporate the public recommendations into the decisions.

Empowerment: place decision-making (and sometimes implementation) in the hands of the public.

The degree of involvement is a critical point in PP, because it influences all processes, in particular, the choice of participative technique. The lower levels of PP consist of one-way flows of information (either from the parties involved to decision-makers or vice versa), whereas the upper steps are characterized by the existence of two-way flows (Videira et al. 2006; Demetropoulou et al. 2010). At least 30 different participatory techniques have been applied in IRBM (Mostert 2003).

The first step of PP involves informing the public to create a foundation for participation. This can be achieved by leaflets, brochures, websites, and maps (CIS 2003; Ridder et al. 2005). Through consultation and collaboration processes, the government makes documents available for written comments, organizes a public hearing, or actively seeks the comments and opinions of the public through, for instance, surveys and interviews, (online) questionnaires, or public hearings or role playing games (CIS 2003; Ridder et al. 2005). Interactive Web GIS applications are promising tools to record public reactions that reflect local knowledge, thereby linking public comments with geographic positions or spatial coordinates that connect discussion with the specific reality of local culture and environment (CIS 2003).

The higher levels of PP imply that the public is invited to contribute actively to the planning process by discussing issues and contributing to the solution. Shared decision-making implies that interested parties not only participate actively in the planning process but also become (partly) responsible for the outcome. Appropriate tools for these levels of PP are, among others, workshops, review sessions, scenario building, and round table conferences (CIS 2003; Ridder et al. 2005; Maurel et al. 2007). Group sessions to define the problem can be mediated through model building to identify key relationships related to the problem. Modeling can be done at the conceptual level, or with mathematical simulation to look at problem dynamics, or with social simulation or role-playing of social relations (see Chap. 16). As an example of the latter approach, "citizen jury," is an interesting participatory technique where a group of randomly selected people, who represent a microcosm of their community, are paid to attend a series of meetings to learn about and discuss a specific issue and make public their conclusions. This method aims to strengthen the democratic process and to enhance social learning and environmental knowledge by including within it the considered views of a cross section of members of the public (CIS 2003).

The choice of PP level, or which sequence of levels to pursue, depends on balancing a range of factors that include goals (supporting decision process and/or education, the timing of PP, the stage of the planning process, the (political and historical) context for PP, available resources, objectives or benefits of PP, and the stakeholders identified to be involved (CIS 2003). A basic participation framework in IRBM is pictured in Fig. 22.1.

Fig. 22.1 Scheme of a basic participation process in IRBM (based after CIS 2003; Luyet et al. 2012; Ridder et al. 2005)

Following the problem identification, stakeholder analysis is an appropriate technique for getting to know the people, groups, and organizations that may influence the success of a project or may be affected by it. Defining the participation strategy involves determining the adequate methods and tools as well as the aim and the time of participation. To promote participation, the participation strategy should be discussed with the public, taking into account their concerns and interests (Ridder et al. 2005). During the implementation process, it is necessary to observe the participatory process and adapt tools and strategies if necessary. The monitoring and the evaluation of a participation process continue throughout the whole project and can be organized as a participation process in itself (Ridder et al. 2005). The evaluation is important in providing information to improve future, similar applications, enhancing the understanding of its impacts on stakeholders, and documenting experiences and outcomes (Luyet et al. 2012; Hassenforder et al. 2015).

Designing a participatory process and choosing the appropriate methods in IRBM depend on so many variables that it is difficult to undertake them in a standardized and linear manner. Rather, it requires an open and adaptive process (Dionnet et al. 2013). In the following section, we present current examples of PP on different levels of impact and spatial scales.

22.4 Applications of PP in Integrated River Basin Management

22.4.1 Public Information and Consultation

At the international scale, the ICPDR (International Commission for the Protection of the Danube River) is an example of an international RBM commission that values the importance of stakeholder involvement. The PP expert group deals with ICPDR activities concerning public information and consultation, outreach and awareness raising, and environmental education (ICPDR 2003). It plans the collection and consideration of comments related to WFD requirements. In 2004, based on a first hearing, the ICPDR developed formal consultation mechanisms, including a call for applications and selection of stakeholders. After a second hearing, the consultation of stakeholders in workshops and a dialogue on the RBM planning began. Online surveys and public calls for the submission of comments on draft documents on the river basin management plan (RBMP) and the flood risk management plan (FRMP) were conducted (ICPDR 2012; Frank 2015).

At the national scale, the "Round Table Water—*Runder Tisch Wasser*" was introduced in Austria in 2005, to interlink and consult national organizations of different sectors, e.g., economy, agriculture, municipalities, fisheries, NGOs, water supply, and water protection, focusing on ongoing developments in water management issues. Referring to the WFD, the Austrian public was consulted through online questionnaires for 6 months in 2015 to comment on the draft of the first FRMP and the second RBMP as part of a public hearing process (BMLFUW 2015a, b). All results are accessible online for the public at the "Water Information System Austria—*Wasserinformationssystem Austria*" (WISA—https://www.bmnt.gv.at/wasser/wisa).

At regional scale, online consultation projects such as "*Mitreden*-U," conducted by the German Federal Ministry of the Environment (BMU) in Germany in 2010 (Schulz and Newig 2015) and the Austrian *Flussdialog* introduced in 2008, proved that online participation is a useful participatory technique for including large numbers of residents at regional scale. Questions regarding local flood risk management or the potential development of tourism in the river landscape yielded a high respondent rate (Tragner 2009, 2010; Plansinn 2011). Selected results were integrated into the local planning process or in RBMPs (Plansinn 2011).

The concept of the *Flussraumbetreuung* was applied in pilot project on the Austrian river Traun in 2007 (Nikowitz and Ernst 2011). Partners of the government and several stakeholders established a 4-year river management position to foster integrative and sustainable decisions and plans for the river Traun at catchment scale. The aims were to develop concepts for RBMP and FRMP, the information and consultation of stakeholders within the catchment, accompanied by activities to promote environmental education. The *Flussraumbetreuung* could be stated as cost-effective and cost-efficient support of the WFD and EFD at regional scale (Nikowitz and Ernst 2011).

22.4.2 Involvement and Collaboration

At the international scale, the ICPDR supports the active involvement of stakeholders and the public in the governance of the Danube river basin through observer organizations on the levels of both expert group meetings and plenary meetings. Stakeholders were actively involved in defining environmental objectives and developing the "program of measures" (PoM) from 2005 onward (Frank 2015). Furthermore, the ICPDR develops the regional framework for water councils at the sub-basin and national levels, guarantees information dissemination, national and sub-basin consultation, and supports active involvement at the national scale.

Within the "River Basin Agenda Alpine Space," the "river basin dialogue" concept was developed to enhance the public's knowledge and collaboration and tested in 11 model river basins in the Alpine region (Revital & Freiland umweltcosulting 2007). The "river basin forums" and "river basin platforms" were tested in several model river basins as ways to join planners and responsible persons in public discussions and proved to be thoroughly suitable ways to develop RBMP through public participation (Revital & Freiland umweltcosulting 2007).

Within the regional project "Sustainable development of the Kamptal riverine landscape—*Nachhaltige Entwicklung der Kamptal Flusslandschaft*" (Preis et al. 2006; Stickler 2008), the residents of the river valley were actively involved in elaborating a citizens' guiding view to define the region's development goals (Muhar et al. 2006). The project team integrated this citizens' guiding view with other sectoral goals into a common guiding view of the Kamp river landscape (Renner et al. 2013).

At local scales, Local Agenda 21 activities are actively promoted by the national government in most European countries (FOSP 2005), among others, in Germany, Austria, Denmark, France, the UK, Italy, the Netherlands, Switzerland, and Spain. Within these countries, informal activities and local projects, such as on water protection, have been implemented and are considered as a multi-sectoral integration and networking tool (Prado Lorenzo and Garcia Sanchez 2007).

Several flood protection projects in Austria, such as at the river Golling or Großache, strike out in a new direction to actively involve the residents at early stages in the elaboration of the FRMP by co-planning activities (Stickler 2008). This collaboration is formally required as the landowners have to approve the flood risk plans.

22.4.3 Empowerment

The River Contract model was officially recognized by the French government in 1981 and was included in the 1992 Water Act (EEA 2014). It has increasingly been used as a tool to restore, improve, or conserve a river through a series of actions that are agreed in a broad participatory process involving all basin residents, and private and public entities involved in water management. In 2010 the process of creating a River Contract for the Matarraña in Spain began as a stakeholder dialogue that matured into their developing their own initiative. This horizontal engagement later informed stakeholder input to the RBMPs. This model of decentralized participative management was tested for more than a decade in the Walloon Region in Belgium (Rosillon et al. 2005). Some 16 ongoing projects have joined 43% of the Walloon Region and 48% of the region's 262 municipalities in the mutual responsibilities of a river contract (Rosillon et al. 2005). In Italy, Lombardy and Piedmont were pioneering regions, implementing a number of river contracts for the protection of spring systems, the environmental rehabilitation of flood detention basins, the enhancement of secondary hydrographic networks (e.g., channels, creeks), and the improvement of agricultural systems (WWAP 2015). Other Italian regions followed these examples and adopted their own river contract model. The projects vary from structural restoration measures such as construction of retention basins for flood control, while others include "social" measures such as environmental education and training (WWAP 2015).

22.5 Challenges of Public Participation and Possible Solutions

Below we present (Table 22.1) an overview of challenges and risks of implementing PP in IRBM as well as potential solutions (based on Luyet et al. 2012; Ridder et al. 2005; CIS 2003).

22.6 Environmental Education as Foundation for Sustainable Development

Sustainability for IRBM relies on environmental education (Pahl-Wostl 2002; Ison et al. 2007; Ilbury 2010) based on a dialogue between policy-makers, scientists, stakeholders, and the public at large. As early as September 1965, a meeting of the International Union for Conservation of Nature (IUCN) Education Commission's North West Europe Committee called for "environmental education in schools, in higher education, and in training for the land-linked professions" (Palmer 2003). In 1968, the United Nations Educational, Scientific and Cultural Organization (UNESCO) organized a Biosphere Conference in Paris, and in a later report on the event, the IUCN declared that "perhaps for the first time, world awareness of environmental education was fully evidenced" (IUCN 1970).

Environmental education (EE) is a transgenerational process with the long-term objective of imparting environmental awareness, ecological knowledge, attitudes, values, commitments for actions, and ethical responsibilities for the rational use of resources and for sound and sustainable development (UN 1992). Agenda 21 also looks beyond basic educational needs, outlining the necessity of using formal and informal education as tools for achieving environment and development awareness and building the skills necessary for sustainable lifestyles (UN 1992; Le Blanc et al. 2012). The United Nations Environmental Program states that young people will face major challenges in providing sufficient water and food, controlling diseases, generating sufficient energy, and adapting to climate change in near future. Therefore the UN-Decade "education for sustainable development (ESD)" was established between 2005 and 2014, and the teaching of skills related to global environmental

Table 22.1 Challenges and risks of PP in IRBM and their potential solutions

	Challenges	Potential solutions
Societal background	Centralized and hierarchical administrative structures may hamper the development of participatory processes (Demetropoulou et al. 2010; De Stefano 2010)	Support countries with centralized and hierarchical administrative structures in developing participatory mechanism (Demetropoulou et al. 2010)
Reservations about PP	Expensive process (Vroom 2000; Mostert 2003)	Plan PP and involve the public as early as possible; allow financial resources for participatory processes, particularly in early stages; balance the costs in terms of time and money and potential benefits
	Time-consuming process (Vroom 2000; Luyet et al. 2012)	Define a participatory plan and develop a realistic timetable; plan PP from the beginning of the project and involve the public as early as possible (CIS 2003) to minimize delays from repetition or misunderstandings
Stakeholder identification and degree of involvement	Involvement of stakeholders who are not representative (Junker et al. 2007; Reed 2008)	Implement a soundly based stakeholder analysis (CIS 2003)
	Potential stakeholder frustration (Germain 2001; Reed 2008; Pahl-Wostl et al. 2008)	Define the aim of PP and specify the extent that participation influences the final decisions (Videira et al. 2006; CIS 2003); give feedback to the stakeholders and specify clearly their role (Ridder et al. 2005)
	Empowerment of an already important stakeholder and the misuse of a stakeholder group to get advantage by using their influence (elite capture; Buttoud and Yunusova 2002; Platteau 2004)	Define an appropriate level of participation and balance out power pressures during the project (Ridder et al. 2005); involve experienced moderators at meetings (Reed 2008)
	In both the WFD and the EFD, the term "encourage active involvement" leaves substantial leeway for member states to implement a wide variety of forms of public involvement, including non-participatory forms of drafting plans (Newig et al. 2014)	Consult the public in draft FRMPs (EFD) and PoMs (WFD) as part of a strategic environmental assessment according to the SEA Directive (Carter and Howe 2006)
	Impacts of participation stand only for the minimum required level of public information. PP is perceived as a charade with no true involvement and collaboration of the interested parties (Videira et al. 2006)	Create of a new cadre of "river basin district managers" as key actors at the core of water management regimes. To succeed, this cadre will need particular skills and competences (Irvine et al. 2015), conducive organizational

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Table 22.1 (continued)

	Challenges	Potential solutions
		arrangements, and scope to build relationships and networks within and out with their organizations (Collins et al. 2007)
	There is no comprehensive, standardized scheme of PP project design available (Luyet et al. 2012). Every participatory process is essentially unique, so that there are no classes of solutions that can be readily and applied a priori to a specific case (Ker-Rault and Jeffrey 2008)	Adapt strategies based on open, flexible discussion during the implementation process. Explore the links between active public involvement in the preparation of RBMPs and FRP, and the subsequent role of these stakeholders in implementation, or more specifically, the influence of PP on certain categories of measures and elements in the management cycle (EEA 2014)
Adequate scale	Identifying the right scale for PP. Referring to the WFD, PP is required at many different scales: river basin district, river basin, sub-basin, water body, national level, national part of an international river basin district, regional and local government level, etc. (CIS 2003)	Adapt the participatory methods and techniques on the defined scale (s) and according to the number of people (CIS 2003)
Evaluation of PP	No standardized approach related to participation evaluation (Luyet et al. 2012)	Plan the participation evaluation at an early stage, well organized, and choose its criteria depending not only on the goals of the project but also on the focus, purpose, and timing of the evaluation (Luyet et el. 2012)

challenges and sustainability as well as lifelong learning are seen as increasingly relevant (Irvine et al. 2015).

22.7 Implementation of Environmental Education in Educational Concepts

At national scales various agencies are responsible for overseeing national strategies for integrating environmental education into formal and informal education (Le Blanc et al. 2012). For example, the incorporation of sustainable development into the curricula of primary and secondary education systems has generally been managed in one of three ways: (1) EE has been integrated directly into existing curricula (e.g., as in France, Germany, and the UK) and requires an interdisciplinary approach; (2) EE has been introduced as an additional educational activity, e.g., as part of an after school club (this approach has been taken in Israel, Bulgaria and Monaco); or (3) decision-making about the incorporation of EE has been devolved to school leadership. In Europe, most northern and mid-European countries have successfully incorporated EE in existing education systems (e.g., Austria, Denmark, France, Germany), whereas eastern and southern European countries have had little success in promoting EE (Leal-Filho 2010; Le Blanc et al. 2012).

22.7.1 Implementation of Environmental Education and Education for Sustainable Development in Higher Education

For more than 800 years, higher education institutions (HEIs) in Europe play an important role in educating professionals who lead, manage, and teach in society's institutions. Research and services to the public have become additional key missions in the early twentieth century (Scott 2006). Currently, HEIs are in the process of transformation, triggered by several global trends and challenges such as internationalization, global financial crises, commodification of education, and the "2030 Agenda for Sustainable Development."

The educational domain of HEIs started to put emphasis on the agenda of ESD from 2005 to 2014, wherein HEI's have been recognized as a key factor for sustainable societal and economic development. The sustainable development goals (SDGs) came into effect in January 2016, setting 17 goals and 169 targets to achieve a sustainable global development that meets the needs of the present generations, without compromising the ability of future generations to meet their own needs (UN 2015). Science is perceived to play an important role for the achievement of the SDGs, in terms of reflecting the interconnection of goals and targets, formulating evidence-based targets and indicators, assessing progress, testing solutions, and identifying emerging risks and opportunities (ICSU – ISSC 2015; Costanza et al. 2016; McKinnon et al. 2016; Lu et al. 2015). These global trends are paving the way to a new era for HEIs, suggesting fundamental changes of their structures, functions, societal roles, and collaborative activities with a wide array of stakeholders.

The integration of EE and ESD in higher education is presented via the example of the University of Natural Resources and Life Sciences Vienna (BOKU). BOKU is positioning itself as a teaching and research center for renewable resources, which are necessary for human life. BOKU's main objective is to make a considerable contribution to the conservation and protection of resources for future generations. As one of the first universities in Austria, BOKU finalized its sustainability strategy in 2014. Since then, sustainability objectives, measures, and timelines have been defined and are being implemented for the areas research, education, identity and society (organizational culture, strategy, and interactions with society), and operations (environmental management and social responsibility).

Building and preserving the integrity of riverine ecosystems requires sustainability-driven approaches, due to their ecological sensitivity and crucial value for human beings via the provision of resources and ecosystems services. Sustainable management mandates balancing ecological needs with the socioeconomic needs of growing human populations, based upon a sound understanding of the multifaceted functioning of riverine ecosystems. While several educational programs (both BSc and MSc levels) at the BOKU include riverine ecosystem management components, BOKU took a further step toward placing sustainable riverine ecosystem management as core learning outcome within the curricula of two master's programs, the "Applied Limnology (AL)" and the "international joint degree program Limnology and Wetland Management (LWM)". Both programs emphasize EE and ESD elements, such as:

- Core learning outcomes of the curricula and teaching/learning methods are emphasizing holistic, integrative, and critical approaches to tackle environmental sustainability issues.
- Interdisciplinary and transdisciplinary courses and teaching staff.
- Curriculum includes several courses wherein the ESD approach is integrated, plus specific courses on ESD.
- Integration of the global dimension and various temporal scales, different sociocultural environments and fostering intercultural communication.
- Participatory quality assurance mechanism (inclusion of stakeholders and students into quality assurance and curricula development).

Both, the AL and the LWM program are taught in the English language and are designed for scientists, technologists, engineers, conservationists, and environmental managers from all over the world. Both master's programs provide interdisciplinary expertise and professional skills for determining the ecological status of aquatic ecosystems, the assessment of human impacts, the conservation of endangered species and habitats, the development of appropriate restoration measures, and transdisciplinary expertise to interact with stakeholders, managers, and policymakers to achieve sustainable ecosystem management solutions. The LWM program is highlighting the global dimension in particular, by providing first-hand experience on the sustainable management of aquatic ecosystems in different climatic and sociocultural environments.

Info box
Master's programs "Applied Limnology (AL)" and "international joint degree program Limnology and Wetland Management (LWM)"

The 2-year AL program can be studied either at BOKU throughout or spliced-up with modules/courses offered by a large number of partner

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universities within and outside of Europe. The international 18-month Master's program LWM comprises one study semester at each of the LWM partner universities: BOKU (Vienna, Austria), Egerton University (Egerton, Kenya), and UNESCO-IHE (Delft, The Netherlands). The three taught program semesters are followed by a 6-month MSc research period at any of the partner universities, and the MSc degree is awarded as a joint degree (Weblink http://www.wau.boku.ac.at/ihg/master-program).

22.8 Activities and Methods to Promote Environmental Education and Public Participation

22.8.1 Lifelong Learning Initiative

The European Lifelong Learning Initiative defines lifelong learning as "a continuously supportive process which stimulates and empowers individuals to acquire all the knowledge, values, skills and understanding they will require throughout their lifetimes and to apply them with confidence, creativity and enjoyment, in all roles circumstances, and environments" (Watson 2003). The term recognizes that learning is not confined to childhood or the classroom but takes place throughout life and in a range of situations. The objectives of lifelong learning include active citizenship, personal fulfillment, and social inclusion, as well as employment-related aspects (EC 2001b). A key principle of lifelong learning is the improved access to learning activities including higher education institutions. This aspect opens educational opportunities to students and returning professionals, including short-term or part-time study programs, moreover supported by EU educational programs, such as Erasmus+.[1] The lifelong learning approach can well be applied to develop the capacity for sustainable water management (Irvine et al. 2015).

Governmental organizations and NGOs carry out a huge variety of individual activities to promote EE and participatory processes at different scales to raise the awareness on water issues. Focusing on IRBM the "World Water Day" and the "Danube Day" are examples for activities at international scale repeated at yearly intervals, where the public is informed about freshwater topics and invited to "water" events. As local authorities are closest to the citizens in their jurisdiction, they play an important role in the education and mobilization of the public in favor of sustainable development (Prado Lorenz and Garcia Sanchez 2007). Linked to Agenda 21, local and regional *Lernfeste* or "Learning Regions—*Lernende Regionen*" have been run in Germany and in Austria since the late 1990s (Adolf Grimme Institut 2001; BMLFUW 2012; Erler et al. 2014).

[1] http://ec.europa.eu/programmes/erasmus-plus/.

22.8.2 Educating Young Students in Systems Thinking and Systems Modeling

Equipping young people with the skills to participate successfully in increasingly complex environments and societies is a central issue for policy makers around the world. The OECD Program for International Student Assessment[2] thoroughly investigated the science competencies of 15-year-old students in 2006. The report documents that teenagers in OECD countries are mostly well aware of environmental issues but often know little about their causes and options to tackle those challenges in the future. Only the understanding of complex socioenvironmental systems establishes a basis for making decisions leading to sustainable development. Systems thinking paradigms provide useful tools for rethinking the relationship between humans and their environment and developing practical solutions to embody these new relationships (Tippett 2005; Oderquist and Verakker 2010; Zitek et al. 2013). Focusing on IRBM, there are several case studies where systems modeling enhanced systems understanding (Halbe et al. 2013; Hare 2011; Zitek et al. 2007). Additionally, it has shown that mental models underlying decision-making can be influenced by participatory modeling processes (Tippett 2005; Videira et al. 2005; see Chap. 16).

Within two Sparkling Science projects "FlussAuWOW and Traisen.w3," scientists worked together with 15- to 18-year-old students of Austrian Secondary Schools over 4 years on river basin management issues (Poppe et al. 2013, 2016). One of the aims of these projects was to apply multimodal school activities to foster systems understanding. To support the development of causal systems thinking, students developed qualitative causal models on processes in the catchment of the river Traisen within an interactive, hierarchically structured, learning environment that was developed within the EU-FP7 project "DynaLearn" (http://www.dynalearn.eu), which was based on qualitative reasoning (Bredeweg et al. 2013). Evaluations of students' pretests highlighted that the students did not know about the environmental problems on their doorsteps (Poppe et al. 2013). The comparison of students pre- and posttests proved that students' systems thinking and motivation for learning could be increased (Poppe et al. 2013, 2016). Ensuring that young people are proficient in system knowledge and understanding also in relation to their own surrounding environment makes it more likely that sustainable considerations are soundly addressed in the future.

[2] PISA – http://www.pisa.oecd.org.

22.8.3 Citizen Science

Citizen science provides a combination of environmental education and public participation in scientific research. It includes all activities that involve nonscientists (so-called citizen scientists (CS)) in authentic scientific research (Bonney et al. 2009; Dickinson et al. 2010; Wiggins and Crowston 2011). Currently, several hundred projects, mostly in the USA, Australia, India, Canada, and the Russian Federation, are conducted in different fields of science with over 1000 volunteers (Conrad and Hilchey 2011). The high number of CS projects can be attributed to an increasing public interest in nature conservation during the last century combined with decreasing financial support for ecological monitoring and the development of online resources and communication techniques, such as GIS-based information systems and graphical user interfaces, which facilitate the management of citizen science projects (Bonney et al. 2009; Dickinson et al. 2012). CS may provide a crucial part of IRBM through participatory processes, starting from detecting environmental problems via environmental monitoring data collection and assessment to the building a science basis for planning as well as supervising and evaluating projects. Citizen science projects can be classified according to public involvement in (1) *contributory* (projects led by scientists, CS only collect data), (2) *collaborative* (CS collect and analyze data, involvement in study design and dissemination possible), and (3) *co-created* projects (participant-driven projects; CS are involved in all phases of the research) (Wiggins and Crowston 2011; Dickinson et al. 2012; Miller-Rushing et al. 2012).

The strengths of citizen science lie in the provision of large data sets with long-time series (including also historic data) and better spatial and temporal resolution. The financial and personal restrictions of traditional research projects cannot support data collection of such quantity (Dickinson et al. 2012; Miller-Rushing et al. 2012). Citizen science projects can make distinctive contributions to ecological research in the fields of global climate change, landscape ecology, evolution, and macroecology, providing information about large-scale patterns and changes in, e.g., phenology, the distribution of rare and invasive species, or diseases (Dickinson et al. 2012). In addition, CS projects can function as early warning systems, e.g., extinction or invasion of species and failure in water quality. Through the inclusion of the public, citizen science also provides a framework for studying human biomes such as urban, agricultural, and residential areas (Dickinson et al. 2012).

Besides scientific research, citizen science projects usually aim to increase the public's environmental awareness by addressing nature conservation issues at multiple scales (local or regional), thereby providing key information for both managers and decision-makers (Dickinson et al. 2012). Both environmental education and scientific literacy are generated through the (mostly electronic) supply of educational background materials, easily understandable explanations of the underlying research questions, and clearly described working protocols. Some projects even aim at including formal science education with learning goals defined *a priori* by providing inquiry-based curricula for schools (Zoellick et al. 2012). Although the educational

Table 22.2 Challenges and possible solutions in citizen science projects (Conrad and Hilchey 2011; Dickinson et al. 2012)

Challenges	Solutions
Lack of volunteer interest/dropout of volunteers	Motivate participants via incentives such as contests, games, and certificates of recognition; ensure regular press release, newsletters, and blogs, which highlight the achievements of the participants; provide opportunities for social interaction and outdoor activities
Lack of funding	Emphasize need of large data sets; emphasize benefits, including environmental learning; guarantee data quality and usability
Inability of participants to access appropriate information	Use different electronic and analogous media (e.g., local newspapers) to advertise; enable easy access to information and data delivery also for participants not familiar or equipped with modern technologies (e.g., schools)
Data fragmentation, data incompleteness, sampling bias (e.g., different sampling time)	Aim at large sample size; use special statistical analyses; provide standardized sampling procedures
Insufficient expertise, lack of objectivity, observer variability (different skills, effort, etc.)	Train volunteers; provide professional assistance during data collection; provide well-designed protocols; simplify tasks; validate data via comparisons with professional data
Substandard experimental design	Include experimental design with better trained subgroups; use CS data as starting point for experimental studies
Utility of data for the management	Focus on outcomes that serve society; ensure monitoring data will be relevant to the policies; ensure data quality
Publication of data in peer-reviewed scientific journals	Ensure data quality; provide data validation; include scientific hypotheses

impact of citizen science projects has yet to be assessed, studies show that the collaboration with scientists is highly motivating for the participants, enhances their scientific literacy, and often results in robust learning outcomes that can influence career choices (Zoellick et al. 2012).

Despite the many advantages of involving the public in scientific projects, scientists are confronted with various challenges regarding participant recruitment, funding, data quality, and data usability (Table 22.2; Conrad and Hilchey 2011; Dickinson et al. 2012). Today, a huge number of websites (e.g., www.cits.ci.org, www.dataone.org, and www.citizen-science.at) provide cyberinfrastructure, tools, guidelines (e.g., Citizen Science Central Toolkit), and resources for the initiation and administration of citizen science projects (see, e.g., Silvertown 2009; Dickinson et al. 2012). Numerous free web services support scientists in the installation of project websites, the development of smartphone apps (e.g., Cyber tracker, EpiCollect), and the creation of online games and databases for GIS data (e.g., Open Street Map, Experimental Tribe; see, e.g., https://www.zentrumfuercitizenscience.at).

Nevertheless, long-term involvement of the public in scientific research may still be a challenge, especially in Europe. Incentives such as contests, games, certificates, and official partnerships can help to recruit and keep participants (Conrad and Hilchey 2011). Another major challenge in citizen science projects is the quality of the collected data. Data bias can occur due to variations in the skills and knowledge of the volunteers, different sampling efforts (e.g., oversampling of "interesting" species), and the unequal distribution of observations (e.g., increased data collections around centers of human activities) (Cohn 2008). However, studies have found that the quality of data collected by volunteers was comparable to those of professionals, if volunteers were properly trained and guided throughout the project, and research tasks were kept simple (Fore et al. 2001; Canfield et al. 2002). Data validation is a crucial step in scientific research and, thus, needs to be addressed thoroughly in citizen science projects to increase the acceptance of volunteer-collected data by both governmental authorities and editors of scientific journals (Cohn 2008; Dickinson et al. 2012).

22.9 Conclusions

In an era of rising environmental uncertainty, the need for scientific understanding of riverine systems and their processes represents an important rationale for including local residents in effective and sustainable river management. Despite all the international agreements to promote EE, the public is often not aware of the environmental problems on their doorstep. EE should serve as the basis for and be implemented specifically as part of the organization of any participatory science events. EE and PP interact with and are influenced by each other and need to be embedded in all areas and levels of societal processes. This will ultimately facilitate better overall understanding of environmental issues and should aid proper realization and implementation of policies supporting sustainable decision-making.

A key concept of social innovation is the involvement and empowerment of citizens. Both PP and EE are working to develop a number of such innovations, including social learning, system modeling, citizen science, as well as new approaches to communication. These innovations can be seen as experiments to build more democratic and adaptive processes for developing science and policy. As governance becomes more inclusive of citizens, these emerging processes that integrate science, policy, and practice are like developmental stages of a society in transition toward sustainable development. To sustain this transition, a great deal of attention is needed to study the role and importance of education and learning implications of participatory processes and environmental governance. These activities have the potential to transform behavior and may help change current patterns in water resource management toward a more sustainable social-ecological system.

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