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Ecosystem services and social perception

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Chapter 5. Ecosystem services and social perception

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5.1. Introduction

5.1.1 In a nutshell

- There is a variety of benefits that IRES provide to our societies, from the provision of materials such as water and timber, to iconic species, the regulation of biogeochemical cycles, and space for cultural manifestation and as a corridor for both wild and herded animals.
- Drying and rewetting processes, timing and duration of different aquatic phases, have an effect on the biodiversity and ecosystem functioning, as well as on the provision of ecosystem services and on the social perception of them.
- There are intrinsic and relational values associated to IRES that are not usually recognised, including sense of place, cultural identity, social cohesion or nature stewardship.
- There is a long list of indicators that can be used to assess the provision of ecosystem services, and different techniques of monetary and non-monetary methods can be applied to assess their value.
- Public participation is also necessary to understand the multiple values of IRES and to improve social perception. Participatory mapping, citizen science, and scenario planning are some of the methodologies can be employed.

5.1.2 The importance of accounting the value of ecosystem services of IRES

The most complete definition of ecosystem services is “the conditions and processes through which natural ecosystems, and the species that make them up, sustain and fulfil human life” (Daily *et al.*, 1997). But they can also be defined as simple as “the benefits people obtain from ecosystems” (M.A., 2003). Building on these definitions, ecosystem services research has spread and increased across different research fields and disciplines and incorporated multiple methodologies and approaches; in the case of river ecosystems they have been tentatively used in river conservation and restoration practices (Martin-Ortega *et al.*, 2015). In fact, environmental managers, when focusing on the provision of ecosystem services – in addition to biodiversity and ecosystem function –, highlight the importance of maintaining and improving human livelihoods and well-being. Ecosystem services-based approaches promote holistic management that allows the coexistence of multiple ways of using and enjoying a river with good ecological status. By using such approaches, managers not only improve the living conditions of people, but they also promote social acceptance of the environmental policy and management, and thus reduce social tensions and conflicts. At EU level, the importance of considering ecosystem services is highlighted by the Biodiversity Strategy which called on Member States to map and assess the state of ecosystems and their services in their national territory. They must also assess the economic value of such services and promote the integration of these values into accounting and reporting systems at EU and national level by 2020.

In this chapter, we focus on the ecosystem services provided by IRES, their biophysical conditions and people’s perceptions and values, as well as methods for assessing them from a supply and demand points of view.

5.2 Ecosystem services of IRES

Ecosystem services depend, not only on the ecosystem that provides them, but also on the society that values and benefits from them. Ecosystem services are by definition context-dependent. This means that the ecosystem services provided by Mediterranean, Alpine and Continental IRES will differ not only because of differences in their biophysical attributes, but also because of dissimilar and fluid socio-cultural contexts. This section provides an overview of ecosystem services that are common to all types of IRES. However, any assessment that aims at using an ecosystem services-based approach needs to first identify the main actors and stakeholders: “who benefits?”, “are there any losers?”, and “what services do they perceive and value?”. Of course, the local people may benefit or lose from IRES management, but some ecosystem services benefit all humans on Earth (e.g., carbon sequestration that reduces greenhouse gases). This can be done by doing a preliminary literature research, by observation, by asking a group of experts, key stakeholders, and/or by developing a survey that aims to reveal people’s perceptions and values.

In the following subsections, a description of the ecosystem services in IRES is presented according to their usual classification into **Provisioning**, **Regulating** and **Cultural** ecosystem services. The Common International Classification of Ecosystem Services (CICES) has developed a more exhaustive classification of services that we are not following here, but which is available at *https://cices.eu*. For an in-depth description of the services provided by IRES, you can also consult Stubbington *et al.* (resubmitted).

5.2.1 Provisioning ecosystem services

Provisioning services are the products directly obtained from ecosystems. They usually have a direct and consumptive use, which means that the enjoyment of those services usually requires the consumption of a good. They are also the easiest type of ecosystem services to assess in monetary terms, since those goods are sometimes already marketed. Consequently, these ecosystem services are relatively well understood and recognised and have usually been promoted at the expense of river health and other types of services.

The **provision of freshwater** by IRES is crucial for supplying drinking water and for maintaining agriculture, farming and industry, especially in arid and semi-arid zones, where permanent water courses are scarce or even absent. This service is consistent with the flow regime and the aquatic states, being the eurheic and hyperrheic the most recommendable for water abstraction (see Chapter 2 for more information). Moreover, some IRES are connected to aquifers, being able to provide freshwater if groundwater is present. To increase the provision of water when the needs are the highest, in summer, some management practices include the artificial recharge of aquifers, the storage in off-channel reservoirs (see Figure 5.1), and the use of efficient techniques of water use (e.g. drip irrigation).

IRES can also provide food in diverse ways. Fishing takes place during wet phases, although aestivating fish can also be captured by excavation during dry phases in arid regions. Hunting is a more common activity, since IRES are habitat for waterfowls. As providers of space for rearing animals, IRES are used as corridors for livestock shepherds, but it’s rare to have farming facilities installed in the river floodplain due to the unpredictability of flow regime. **Food provision** also includes the cultivation of crops (in the floodplains, but also in the river channel) and the collection of wild plants (e.g., blackberries, in Figure 5.2).

Figure 5.1. Freshwater provision. Water irrigation pond in Iruraitz-Guana, Spain, that is fed by an IRES (https://commons.wikimedia.org/wiki/File:Adana_y_Gauna_-_Balsa_de_riego_02.jpg)

Figure 5.2. Food provision. Blackberries growing close by a stream (https://www.pxfuel.com/en/free-photo-xjenh)

Figure 5.3. Provision of raw materials. In the picture we can see tones of gravel accumulated in the riverbanks of an IRES (©Iakovos Tziortzis)

Figure 5.4. Climate regulation. Organic matter is accumulated during the dry periods of this creek in the Burnham Beeches, United Kingdom, having an effect on carbon sequestration and climate regulation (https://www.flickr.com/photos/14730981@N08/15048881439/in/photostream/)

The **provision of raw materials** is based on the extraction of plants and inert materials i.e. gravel and sand for construction (see Figure 5.3), timber, fuelwood, decoration, and other multiple purposes. As well as perennial rivers, IRES provide habitat for species that are very often employed in different socio-cultural contexts (e.g., *Salix*, *Populus*), and also sediment for different purposes. In any case, intermittence does not seem to have a direct significant effect on the provision of those materials.

IRES play a critical role in the **provision of genetic resources**. It is generally believed that pools promote genetic diversity, resistance and resilience of, e.g., invertebrates and fish populations or even semi-aquatic vertebrates; and dry riverbeds promote communities that use the dry channels either as dispersal corridors or as seedbanks. Moreover, organisms inhabiting IRES experience extreme changes in flow conditions, from drying during summer to flooding during winters which lead to new adaptations, e.g. dispersal forms and resistance strategies that would promote recolonization. Those adaptations of, for instance, desiccation-tolerant invertebrates and plants that colonize during dry phases, are based on molecular strategies to protect against dehydration that may offer new opportunities of IRES for the **provision of biochemical products** that benefit human wellbeing (Stubbington *et al.*, resubmitted).

5.2.2 Regulating ecosystem services

Regulating services are those benefits provided by ecosystem processes that moderate natural phenomena. They usually have an indirect use value, and it is common that people do not perceive those intangible benefits they receive from regulating services because they are difficult to recognize.

Climate regulation explains the capacity of the ecosystem to buffer local climate conditions. In arid or semiarid zones, where trees are scarce, they are concentrated in IRES hence providing shed and causing a cooling effect. This benefits animals (e.g., livestock) and humans. Climate regulation also means buffering climate change effects, and it is especially linked to carbon sequestration. However, the carbon budget of IRES is not well understood. On the one hand, the capacity of streams to retain organic matter is enhanced during the dry phases when carbon accumulates and decomposition slows down (von Schiller et al. 2017; see Figure 5.4) , On the other hand, dry riverbeds can emit large quantities of carbon dioxide (Marcé et al. 2019). These processes may be altered by the presence of dams and woody debris in the river channel.

The **regulation of air quality** consists of the retention of pollutants by plants and microbes of the ecosystem; the improvement of the air quality brings pervasive effects on human health. In this sense, the presence of riparian forest will improve air quality by intercepting air pollution and absorbing gaseous pollutants through leaf stomata. This is however a general service provided by both perennial rivers and IRES.

The **regulation of nutrient cycling** – including water purification – by streams and rivers relies on transport (by the water flow) and residence time of water and solutes (defined by geomorphology), and biological and chemical retention of nutrients. Ecosystem services are linked to two different, interrelated aspects: on the one hand, to the continuity and balance of the global nutrient cycles; and, on the other hand, to water security (provisioning and quality) by reducing eutrophication. Different elements of IRES that favour nutrient cycling are the drying-wetting oscillations, the diversity of geomorphological elements, and the presence of aquatic plants, biofilms, and riparian forest.

Regulation of water flow and protection against extreme events is very important in IRES due to their variability and unpredictability inherent. The variability of the hydrological phases allows storing water within the floodplain. Dry river channels connected to the floodplain play an important role as sink for flood waters and may make the peak flow decrease (Boulton et al., 2017). In addition, it recharges alluvial aquifers. Higher water levels connect and recharge isolated pools and bring nutrients. In contrast, extreme flood events may damage riparian vegetation, lentic and lotic ecosystems.

In IRES, **erosion and deposition control** depend on the attenuation of runoff and discharge rates. Erosion is mainly controlled by the vegetation and soil erodibility. On the one hand, excessive erosion may cause incision plus the subsequent shrinking of the phreatic level and may damage infrastructure. On the other hand, excessive deposition may increase habitat homogeneity (e.g., filling river pools, so important in IRES), reduce storage capacity of reservoirs, and increase turbidity hence decreasing water quality.

There are no studies about the importance of IRES in terms of **pollination and seed dispersion**. However, we can say that in large agricultural areas, unmanaged vegetation is concentrated in IRES, so it can provide habitat for insects that will then pollinate the crops being grown on adjacent land (e.g., nesting sites for bumblebee queens, in Kells and Goulson, 2003). Moreover, IRES often act as corridors for migration of cattle and wild animals (Sánchez-Montoya et al. 2016), which certainly favours seed dispersion (Figure 5.5).

Disease and pest control basically depend on the riparian habitats' capacity of housing invasive species and pathogen vectors. For instance, pools of IRES druing drying phases may be key habitats for mosquitoes that transmit pathogens, whereas drying and flowing phases may avoid their reproduction (Dida et al. 2018). Time synchronization between flow regime and crop and vector's phenology is an important factor for the proliferation of disease and pests; and managers can avoid it by preserving native species, natural flow regimes and good ecological status (Duchet et al. 2017).

5.2.3 Cultural ecosystem services

Cultural services are defined as the non-material benefits people obtain from ecosystems. They usually can have both a direct or indirect use, non-consumptive, and a subjective value. However, an excessive flow of these services can also cause the degradation (e.g., by overcrowding) and commercialisation of nature.

Aesthetic values are the benefits associated with the visual, auditory and olfactory perception of IRES. Aesthetic values are of particular importance as sensory stimulation is one of the most intimate links that people have with ecological phenomena. IRES represent landscapes in which local public has interacted and related in very special ways becoming important landscapes by its visual characteristics. They may attract tourism as well (see the example of Figure 5.6)

The provision of **recreational activities** is presented in multiple ecosystems in very different ways. In IRES, such activities also differ between dry and wet phases. For instance, trekking and hiking are possible when the river runs low or dry, and canyoning, swimming or fishing when water is present (see Figure 5.7). Besides the flow level, recreational services are closely dependent on the weather too. Recreational activities may not only provide direct economic benefit from tourism, but also contribute to the physical and psychological health of people.

Environmental education and scientific knowledge is the capacity of IRES to generate and disseminate socio-ecological knowledge, such as the importance of temporal and spatial variability for IRES or the different uses of dry riverbeds for local societies. Educational and scientific activities promote pro-environment attitudes that can indirectly improve the perception towards IRES and, subsequently, the improvement of the ecosystem health and service provision. See Section 5.5.4 for methodologies to engage with stakeholders.

Figure 5.5. Seed dispersal. The use of IRES as passages by shepherds favours seed dispersal in Mozambique (https://upload.wikimedia.org/wikipedia/commons/f/f8/ILRI%2C_Stevie_Mann_-_Cattle_herd_walks_home_along_dry_river_bed_in_Tete_Province%2C_Mozambique.jpg)

Figure 5.6. Aesthetic values. Torrent de Paréis, Escorca, Mallorca, Spain, is a tourist place for its spectacular scenario (https://pixabay.com/photos/sa-calobra-torrent-pareis-mallorca-4753778/)

Figure 5.7. Recreational activities. Canyoning is an activity usually done in small rivers like IRES. This picture is taken in Fischen im Allgäu, Germany. (https://commons.wikimedia.org/wiki/File:Canyoning_in_Fischen_im_Allg%C3%A4u.jpg)

Figure 5.8. Local ecological knowledge. Pond water crowfoot (Ranunculus peltatus) contributes to the flowing-phase character of winterbourne chalk IRES in the south of England. © Andy House.

Figure 5.9. Local ecological knowledge. Traditional irrigation system (called 'acequias') based on the maximization of the profits from an extremely variable flow regime in Sierra Nevada Mountains, Granada, Spain. © Cristina Quintas-Soriano

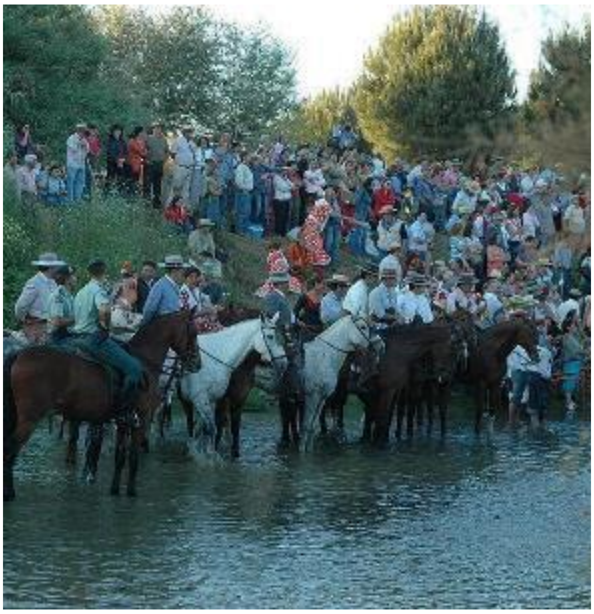

Figure 5.10. Spiritual and religious services. This is Quema River ford, and the Triana brotherhood on procession to the hamlet of El Rocío, Spain. (https://es.m.wikipedia.org/wiki/Archivo:Vado_rio_quema.jpg)

Local ecological knowledge is transmitted from one generation to the next when the IRES is well-preserved, and the ecosystem is degraded, and can provide sense of place (Figure 5.8). This service maintains for example the awareness of flash floods, which are very common in IRES, the ancient irrigation systems adapted to the IRES variability (see Figure 5.9), the visibility of those other services usually neglected by the environmental or water administration. With respect to ecotourism, a better local ecological knowledge improves the tourism supply, strengthen the tourism workers' skills, and offers a wider variety of sustainable leisure activities.

The deficit of knowledge on IRES-specific **spiritual and religious services** reflects the paucity of a wider consideration of cultural ecosystem services. Rivers and springs have attracted people since prehistoric times for perceived physical healing benefits. In many cases, these places were sacred for worship, sanctuary and pilgrimage, as well as spiritual fulfilment. Examples include the shrines to the Virgin Mary like in Fatima (Portugal) or Medjugorje (Bosnia Herzegovina), and the Chalice Well at Glastonbury (UK), with Celtic origins. Figure 5. 10 shows a ford crossing an IRES used in pilgrimages to El Rocío (Spain).

Today, **therapeutic services** are more linked to nature-based health care provision, so-called 'nature on prescription' or ecotherapy. In order to assess spiritual, religious and therapeutic services, an interdisciplinary approach is essential: ecologists and social scientists working with stakeholders, such as spiritual and indigenous groups, health care providers, and agencies that facilitate and promote practical interactions with the conservation of rivers.

Finally, the fact that cultural ecosystem services are the most context-dependent of all the services, makes particular uses emerge in different contexts and times. Thus, IRES are also used as car parks in populated areas, or even as dumping sites that wait for a flash flood to sweep away the rubbish where the stream is ephemeral.

5.3 Drivers of change of ecosystem service provision

5.3.1 Morphology

The morphological features of watercourses may greatly influence the ability of rivers to provide services. The basic morphometric parameters of the riverbed that directly affect the quality and quantity of service provision include the level of confinement, the channel sinuosity and the riverbed roughness. On the one hand, the level of confinement may explain the quantity of service provision. For instance, the less confinement, the wider the floodplains and the more timber biomass. On the other hand, the quality is more influenced by the channel pattern (i.e. single or multiple thread), and by the type of substrate (e.g., bedrock, alluvial gravel or silts). The more diversity of morphological features and habitats, the better the provision of gene pool protection and a diversity of recreational activities. Channel morphology is also one of the main variables that determine drying conditions of the riverbed, which is very related to hydrology and also determines the provision of services.

5.3.2 Hydrology

Hydrological variability characterizes IRES, being one of the most important variables that control not just freshwater provision but most ecosystem services. Ecosystem services provision depends on the aquatic states, as well as on their duration, frequency, timing and intensity. For instance, since greenhouse gases are released during rewetting events, the number of such events highly influences IRES 'role on climate regulation. An increase in the number of zero-flow days can compromise recreational swimming in pools, because isolated pools may not be attractive for swimming after weeks of flow disconnection due to contraction (size reduction), algae development, and decrease in water quality. On the other end, perennialization of IRES would reduce the provision of regulating ecosystem services such as flood and erosion control that are maximized during the dry phase when dry channels act as sinks for floodwaters and sediments.

5.3.3 Biogeochemistry of drying out and rewetting

Intermittence and the dry, wet, and transitional phases strongly influence nutrient inputs, in-stream processing, and downstream transport (see von Schiller et al. 2017 and Chapter 3 of this Handbook for more information). Thus, biogeochemistry drives ecosystem services provision in relation to the regulation of the carbon, nitrogen and phosphorus cycles. Carbon sequestration as well is related to climate regulation, while the release of phosphorus and nitrogen nutrients is important for fishery production downstream, and their retention improves water quality. In some cases, increases in organic matter and nutrient concentrations after rewetting from dry conditions in IRES can cause eutrophication and potentially lead to the occurrence of hypoxic blackwater events (Hladyz et al. 2011). This has not only an effect on the provision of fish and drinking water, but also on the aesthetics, since is not perceived as either visually or olfactory pleasant.

5.3.4 Biological communities in the interphase between the aquatic and the terrestrial

IRES species interact with each other and their environment to deliver cultural, provisioning and regulating services. As IRES shift between flowing, ponded and dry states, lotic, lentic then terrestrial species dominate communities, and service delivery thus changes over time. In all phases, cultural services reflect species' enhancement of recreation. For example, pond water crowfoot contributes to the flowing-phase character of 'winterbourne' IRES in south England (Figure 5.8). Provisioning services are most clearly delivered by human consumption of fish during wet phases – and by excavation of aestivating fish during dry phases in arid regions. In addition, desiccation-tolerant organisms may be sources of biochemical products. For example, molecules from a specialist fly larva have informed development of techniques to preserve mammalian tissues prior to medical use. IRES also provide regulating services, for example microbial processing reduces concentrations of inorganic nutrients, including those of anthropogenic origin, and longer water residence times enhance processing of both nitrate and phosphate when flow ceases.

5.3.5 Landscape and human activities

Landscape and human activities interact to one another to provide all types of ecosystem services. Bearing in mind the agricultural landscape, the presence of an IRES may imply the improvement of the quality of the drainage waters, which are rich in nutrients, and may mean habitat for pollinators and for pest predators. IRES running through urban areas may be green spaces for recreation and inspiration, and purify the air and smooth extreme climate events (e.g., heat waves). But IRES can also be isolated and degraded places where people go to dump their rubbish.

5.4 IRES and society

The perception and values of any ecosystem is also very correlated to the efforts of the administration and the society to preserve it. Dialogue and knowledge sharing about IRES helps improve people's perceptions and strengthen the values uphe ld, which is very important for the preservation of IRES, as well as for the prevention of related conflicts.

5.4.1 Management issues, trade-offs and conflicts

In environmental management, trade-offs are more likely to occur than win-win solutions. By identifying trade-offs, we can acknowledge diverse interests in managing IRES, detect inequalities in the distribution of ecosystem services benefits and prevent conflicts. Different types of trade-offs can identify different relations to IRES and to which managers should pay attention:

- Social trade-offs (between social classes, ethnic groups, or gender). For instance, in many places of Southern Europe, women usually do not participate from water governance in irrigated landscapes although they may work as farmers and benefit and use IRES (Molina et al. 2006).
- Inter-stakeholder trade-offs. For example, canyoning may be incompatible with native crayfish habitat, hence with the conservationists' will. And irrigators, recreationists and environmentalists may differ in their optimal management of flow regimes (see Jorda-Capdevila et al, 2015, and also Chapter 6 of this handbook).
- Spatial trade-offs. For example, the use of fertilizers and pesticides in crops in the river floodplains influence fish health and consequently anglers in the river channel. Another example, a dam upstream has an impact on all other uses downstream.
- Temporal trade-offs. For example, the trade-off between one generation that over-exploits the river by extracting gravel, and the next generation, which receives a degraded river.

When trade-offs exacerbate an impact, and a social group perceives that it has been neglected, its rights denied or its interests reduced, a conflict may appear. Environmental conflicts usually face two different types of groups that are distinguishable because they show opposed management solutions. Watershed authorities should not only pay attention to their positions – usually difficult to merge –, but also on their interests and needs. Often it is easier to bring the stakeholders together into a third solution. Other important aspects in a conflict are the influence levels of different stakeholder groups and the type of interest they have, for instance, a broad interest in terms of the diversity of ecosystem services that they benefit from versus a narrow interest, or an individual versus a collective interest. Typical environmental conflicts that concern IRES are related to land uses (see Box 5.1) or water management (Jorda-Capdevila et al., submitted).

5.4.2 Social perceptions and values

There is a vague appreciation of IRES by the public, which affects not only biodiversity and their ecological interiority but also the variety of ecosystem services they provide to people (Koundouri et al. 2017). Factors that define the disconnection between people and IRES are diverse and depend on cultural roots and socioeconomic context. For instance, in many Mediterranean regions commonly known as 'ramblas', there exist an aversion to IRES because they are perceived by the public as dangerous areas or used for as convenient dumping grounds for rubbish (Castro et al. 2019), therefore ignoring the fundamental role they play in preserving key services such as flash-flooding control or groundwater regulation (Armstrong et al. 2012).

Box 5.1. Example of a land use-related conflict in Menorca, Spain.

For centuries, the agricultural fields of the island of Menorca (Spain) have been delimited by dry stone walls (delimiting *tanques* – fields) and by drainage ditches (delimiting *daus* – smaller areas within the fields). The function of these traditional ditches was to improve the drainage of the fields in case of heavy rain, preventing flooding of the crops. These lead to major ditches, small canals or streams, thus constituting the first level of the hydrological networks of the Menorcan drainage basins. Over the last decades these ditches have been removed in the fields closer to streams, where the terrain is flatter, and the yield of agricultural work (plowing, sowing, harvest) can be easily improved by using larger machines. Over the years this has led to farmers complaining to the administration claiming that streams full of natural vegetation prevented the proper drainage of water and thus flooded the fields. This has resulted in (i) an increase in the frequency of mechanical cleaning of the streams with heavy machinery, eliminating all the natural vegetation without distinction and (ii) an increase in erosion.

Comparison of the same agricultural fields on 1956 and 2010, where it is possible to see the removal of the drainage ditches. Images from IDE Menorca.

Moreover, there is a bias related to the management and policy domains across multiple scales, which, influenced by the rapid need to meet societies' needs (i.e., urbanization and agricultural expansion), have been unable to ensure sustainable management and conservation strategies of IRES. Moreover, the failure of capturing a plurality of values associated to IRES is largely responsible for the widespread environmental degradation of these ecosystems (Boulton, 2014):

- Traditional assessments of ecosystem services have been mainly focused in valuing the use values or **instrumental values** of ES, e.g., fishing and birdwatching.
- **Intrinsic values** are also important to be considered. They represent the value that IRES have in themselves and are usually associated to, for instance, aesthetic value or sense of place.
- Many conservation concerns and conflicts could be better understood adding a third group of values called **relational values**, which can be defined as the social preferences, human principles, and virtues that articulate individual and collective relationships between humans and IRES. Relational values of IRES are related to cultural identity, social cohesion or nature stewardship.

5.5 Methods for assessing the value of ecosystem services

A recent report on rivers and streams assessment coordinated by the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services highlights that the valuation of ES has focused almost solely on perennial rivers, streams and reservoirs (Castro et al. 2016a,b), however, the value of ES provided by intermittent rivers and ephemeral streams have been largely overlooked (Koundouri et al. 2017, Boulton, 2014).

5.5.1 Indicators for service supply and demand

The ecosystem service concept constitutes new approaches in which it is possible to understand the linkages between ecosystems and social systems. In this sense, an ecosystem's capacity to provide services (supply side) and their social demand (demand side) highlights that the status of an ecosystem service is influenced not only by the ecosystem's properties but also by societal needs (Castro *et al.* 2013). Burkhard *et al.* (2012) defined the supply side as the capacity of a particular area to provide a specific bundle of ecosystem services within a given time period, and the demand side as the sum of all ecosystem services currently consumed, used, or valued in a particular area over a given time period. Table 5.1. shows a variety of indicators which can be used to estimate supply and demand of specific ecosystem services. Most of them are very general, applicable to many other kinds of ecosystems. In order to adapt them to IRES, it is important to consider the temporal variability of their flow regime. A monthly calculation of the following indicators may be enough to integrate dry, pool and flowing phases – when necessary – in any assessment of ecosystem services provision.

5.5.2 Monetary valuation methods

Monetary valuation methods aim to express the total economic value of an ecosystem in monetary terms. Monetary valuation methods are sometimes criticized because of the risk of commodifying nature for its own conservation. However, their main advantage is that they make Nature's values visible. Since many ecosystems do not have a market price, their values are often overlooked in the decision-making processes. This can lead to environmentally damaging practices. By estimating the value of ecosystems, monetary valuation methods highlight their importance and ensure their benefits are incorporated in public decision-making. This is ultimately expected to lead to a sounder management of natural resources. Monetary valuation methods have also been found to be very useful for the internalisation of environmental externalities, which may be done through

Table 5.1. Supply and demand indicators for the ecosystem services of IRES.

Ecosystem services	**Indicators of supply**	**Indicators of demand**
General indicators		Social perception / importance perceived
Provisioning ecosystem services		
Freshwater provision	Water yield	Water consumption
Food provision	Population size of species of interest (fish and waterfowl) Richness, abundance and distribution of wild riparian species that provide fruits or grains Fertile area within the river	Number of fish/hunting licenses Game quotas Fish catch rates Crop production Consumption rates of fish/game stocks/wild fruit and grains/crops
Provision of raw materials	Richness, abundance and distribution of wild riparian species that provide fibre and fuel Rates of sediment accumulation	Weight of extracted fibre and fuel Weight of extracted sediment
Provision of genetic resources	Biodiversity indices	No specific methods known. General methods can be applied
Regulating ecosystem services		
Climate regulation	Fluxes of POC and CO2 Presence of woody debris	No specific methods known. General methods can be applied
Air quality regulation	Riparian forest cover	No specific methods known. General methods can be applied
Nutrient cycling regulation	Presence of geomorphological elements, aquatic plants and biofilms, and riparian forest Flow regime Drying-rewetting oscillations	Water consumption production of wastewater
Regulation of water flow and protection against extreme events	Groundwater recharge Area of unconstructed floodplain Capacity of dam storage	Population living there
Erosion and deposition control	Vegetation cover Number of sediment tracks	No specific methods known. General methods can be applied
Pollination and seed dispersion	Quality of river habitat (e.g., MiQu, GUADALMED and ECOBILL protocols) Rate of flower visitations by aquatic insects Pollination Suitability Index for Riverine Landscapes	Area of crops that need pollination surrounding the stream Number of mammals using the stream as corridor
Disease and pest control	Abundance of mosquitoes able to transmit vector	Population living in or visiting the surroundings
Cultural ecosystem services		
Aesthetic values	Number of “viewer days” per year or the monetary value of a change in scenic quality	Population living there Number of visitors/tourists Pictures posted in social networks
Space for recreational activities	Very variable depending on the activity Travel cost method (assessing variations in travel effort across visitors)	Population living there Number of visitors/tourists
Education and research	Spatial models	Research papers with the IRES as case study Visits by schools / student surveys
Local ecological knowledge	Richness of profitable or iconic species Knowledge on the dynamics of the ecosystem flora and fauna of symbolic, mythic or totemic significance	Population living there Social media analysis Residents surveys
Spiritual, religious and therapeutic services	Presence and extend of protected areas, sacred/religious sites, pilgrimages, festivals or rituals, folk songs, myths, legends or genealogies	Population living there Number of visitors/tourists Mental health and wellbeing-related metrics

environmental pricing (e.g., green taxes, subsidies for environmentally friendly practices) or inter-stakeholder negotiations (e.g., payment for ecosystem services). See some information on the implementation of an economic valuation for an efficient environmental management in Box 5.2.

Box. 5.2. Implementation of an economic valuation for an efficient environmental management.

Water is a social but also an economic good for which it is important to identify and define its services and uses as well as the costs related to water use, i.e. financial/supply costs, environmental and resource costs. As discussed in Koundouri (2015) and Koundouri *et al.* (2019), IRES and water resources remain a public good. Thus, provision to one individual does not prevent others from using it. This is a form of market failure and can result in misallocation of resources. With regard to water quality, excessive pollution is caused by the existence of environmental externalities (e.g. waste treatment plants, factories, urban and agricultural run-off). Government failures can also lead to misallocation of resources, as for example subsidies for agricultural production leading to the overexploitation of water resources for irrigation purposes. As a result of these market inefficiencies and externalities, the natural resource is not allocated efficiently among alternative resource users. Allocative efficiency requires the identification and monetisation of the resource costs (i.e. the foregone opportunities which other uses suffer due to the depletion of the resource beyond its natural rate of recharge or recovery) and environmental costs (damage that water uses impose on the environment and ecosystems and those who use the environment). The economic literature proposes several monetary approaches to estimating these costs. Nevertheless, the quantitative findings remain sporadic while the transferability of the results from one site to another may be subject to limitations.

There are many different methods for the monetary valuation of ecosystems. Those that might be most useful for environmental managers are described thereafter. For more detailed information on each method, we recommend Chapter 5 in “The Economics of Ecosystems and Biodiversity” (Pascual *et al.* 2010).

If a product of IRES that is valued has a market price (e.g., fish sold at the market), then the quantity (e.g. fish in kg) produced by IRES can be multiplied by its price. However, most aspects of IRES ecosystems do not have a market price. In those cases, one of the following methods can be applied.

The **hedonic pricing method** is appropriate when IRES is located relatively close to human settlements and might affect (i.e. increase) the housing prices. This method estimates to which extent the presence of IRES explains variations in housing prices.

The **travel cost method** is designed for the valuation of those ecosystems that are used for recreational activities. Travel expenses and travel time spent for visiting an IRES represent the “price” visitors are willing to pay for accessing IRES. The method is most suitable for touristic IRES, such as the Torrent de Pareis (Figure 5.6).

The **contingent valuation method** directly asks respondents in the survey how much they would be willing to pay for an ecosystem or a change in its quality or quantity. It is dependent on the hypothetical scenario describing the change in the ecosystem.

The **choice experiment method** estimates willingness to pay based on the choices and trade-offs that respondents make in the survey between two or more hypothetical future scenarios. Each scenario is described by a number of characteristics or attributes. The method allows to value different attributes of the same ecosystem, for example, the number of aquatic bird species, water quality and the aesthetic aspect of IRES.

Finally, the **benefit transfer method** takes the monetary value of an IRES from another case study, ideally with similar biophysical characteristics and socio-economic context. This method is advisable only when resources (time, money or personnel) for collecting own data are limited and monetary values for other case studies exist, which is not yet the case for IRES.

5.5.3 Non-monetary valuation methods

The benefits that people derive from ecosystem services provided by IRES can be assessed with non-monetary methods too, called also as socio-cultural methods. These include both individual and group-based methods, where dialogue with experts or resource users – either beneficiaries or losers – can reveal how they perceive IRES, what importance they attribute to it, and what benefits they realize in different localities and periods of the year. Socio-cultural methods are able to reveal a wide range of values, from intrinsic (ecological) to relational (social) and instrumental (economic) values, and especially well-suited to understand and characterize intangible benefits that cannot be measured quantitatively (e.g. values of cultural ecosystem services). Visiting some hot spots or favourite places with respondents or using pictures as proxies – as suggested by photo-elicitation studies, photo-series analysis, photo-based Q-method, or the photovoice method – can help better characterize the variability of benefits according to the different phases of the river, which is crucial for the valuation of IRES. While socio-cultural methods do not monetize the value of ecosystem services provided, quantification is possible e.g. via simple ranking or scoring exercises, or by the collection of numerically available data (e.g. quantities of harvestable fish or the number of issued fishing licences), which can be further visualized in multi-layered maps. See more information on non-monetary valuation methods in Santos-Martín *et al.* (2016).

5.5.4 Engaging the beneficiaries

It is increasingly recognized that public participation is instrumental in laying the groundwork for sustainable practices in physical planning and management as well as social community building. In fact, as argued by specialists from different domains, to achieve sustainable communities it is necessary to: 1) involve local citizens, 2) allow citizens to analyze their own problems and fashion their own solutions, and 3) support community initiatives which allow them to be the instruments of their own change. Attention to sustainable community development practices foster social goals which can strengthen the connections between participatory practices and government or authority decision making. Of course, there are several participatory levels, which go from passive participation to active participation (see Figure 5.11).

In this subsection we summarize three different methodologies of public engagement for the gathering of social data on social preferences about ecosystem services in IRES: participatory mapping, citizen science, and participatory scenario planning.

Participatory mapping is a non-monetary valuation method that seeks the spatial relation between landscape characteristics and human wellbeing. By engaging the general public and stakeholders to identify place-based local knowledge, the method contributes to quantify supply and demand of provided services. This can be a facilitator for decision-making and communication. In IRES, to our knowledge so far, no exercise has been done on participatory mapping of ecosystem services. One study performed in the Ter River basin (Spain) analysed the perception of the local people and water administration about a small dam, and the expected perception about its removal. In the study, different interviewees were asked to draw supply and demand sites of perceived ecosystem services and their level of importance from 1 to 5 (Brummer *et al.* 2017).

What role do you play now as a citizen?	**Active Participation**	What role would you like to or think you should play as a citizen?
	Citizen as Decision maker: Citizens of a community have the clearest and perhaps the most accurate perception of needs and priorities of their community and should make the decisions themselves	
	Citizen as Consultant: Citizens should occasionally be consulted to contribute their professional opinions during the decision-making process, and when given adequate information can make educated decisions about various proposals.	
	Citizen as Respondent: Citizens do not necessarily know what is needed or what is the best approach, but their opinions should be surveyed and analyzed by well-trained experts and used in the decision-making process.	
	Citizen as Constituent: Expends on trained elected representatives have the right to make decisions on behalf of citizens and to assume that they are representing their constituents'' interests unless hearing otherwise.	
	Citizen as Voter: Citizens should vote for their representatives, but public decision making is a scientific pursuit and should be left to skilled experts and policymakers, not the general public.	
	Passive Participation	

Figure. 5.11. The role of the citizen in the decision-making process. Source: Regional Environmental Centre for Central and Eastern Europe - REC (1996).

Citizen science (CS) nowadays is defined as any practice of public participation and collaboration in scientific research. Although, in a more classical definition of CS, the public participation focuses mostly in data collection, especially for CS projects born from disciplines like biology, ecology, environmental sciences or hydrology. Thereby, CS projects focused on rivers usually ask for data about water quality or quantity, and some of them apply simplified bioassessment methods. On the other hand, very few projects ask citizens about their perception of the fluvial ecosystem or, directly about ecosystem services. Moreover, they are almost nonexistent for IRES, even though the collected data about ecosystem services might be useful to enhance participation and empower people in future management. See an example in Figure 5.12.

Figure. 5.12. RiuNet (www.riunet.net) is a CS Project that allows citizens to assess the hydrological and ecological status of IRES, as well as to inform about their cultural and social values such as bathing, aquatic sports, fishing, hiking, research and educational, aesthetics or inspirational values (see chapter 2, section 2.3.3).

Participatory scenario planning can be applied in ecosystem services assessments to collect social perceptions and initiate public dialogue about the benefits and values attached to certain ecosystems. If applied in a group-based format, scenario planning can involve various stakeholders, experts or citizens. Scenario planning starts with 1) identifying the major drivers (either socio-political or ecological ones) that influence the future state of a given ecosystem and 2) assessing the current state of the ecosystem. Based on the drivers and the current status, 3) alternative scenarios can be developed for the future, and then 4) scenarios can be evaluated in terms of how the ecosystem and its services will change, and how human well-being will be impacted. The public dialogue around the scenarios does not only allow us to understand which ecosystem services are of priority and why, but also helps local communities to plan future actions to preserve crucial ecosystem services. Participatory scenario planning is widely used in mixed ecosystems, although not many examples are known directly for IRES. In the OpenNESS project participatory scenario planning was applied in an area in central Hungary with temporal alkali lakes mosaics with open grasslands and forest steppes.

5.6 Conclusions and recommendations for managers

- There is an urgent need to understand the different world views and public knowledge that articulate values towards IRES and incorporate them into transdisciplinary processes that allows decision makers to addressing conflicts over IRES and increasing public perception and values regarding IRES.
- IRES can be of natural (climatic or geological constraints) and/or anthropogenic origin (e.g. perennial rivers that become IRES as consequence of flow regulation and water abstraction). This should be considered when assessing the provision of ecosystem services since they would require different approaches, assessment criteria and reference values which would ultimately determine a positive or negative overall evaluation.
- The value of IRES changes over time, not only between aquatic states, but also between seasons and over the years. Their value is not intrinsic to the ecosystem either, but depends on the sociocultural context, which may also change. Thus, by improving the condition, knowledge and awareness about IRES, managers can modify the way in which society perceives and values IRES.
- The economic literature develops a set of methodologies and approaches that can be implemented with regards to monetizing the environmental and resource costs associated with IRES. Policy makers and managers need to consider these alternatives to develop an optimal approach to efficient water management. In doing so they also need to consider: i) the full spectrum of multiple pressures put on river bodies and water supply, ii) the full range of users and beneficiaries from water resources, iii) the “polluter pays” principle and the fair allocation of cost recovery among different users and, iv) affordability and competitiveness implications of applying full cost recovery of water services.
- Non-monetary techniques for the assessment of ecosystem services are necessary to integrate instrumental, intrinsic and relational values associated to IRES. Through the engagement of experts and/or resource users, these techniques reveal people’s perception towards IRES, hence making them more suitable for mutual learning projects and when inter-stakeholder conflicts are present.

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