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FRESHWATER: THE IMPORTANCE OF FRESHWATER FOR PROVIDING ECOSYSTEM SERVICES

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Freshwater: The importance of freshwater for providing ecosystem services

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Synopsis (non-print item)

This chapter extensively presents the functionality of freshwater ecosystems, surface, groundwater and ice caps, that is inseparably linked to the ecosystem services provided by freshwater bodies and their importance for human and nature well-being. The ecosystem services provided by freshwater are of vital importance for supporting all life cycles, social processes and economic prosperity.

Abstract

Freshwater ecosystems, whether surface, groundwater or in the form of ice caps are fundamental for human life and for supporting the vast biodiversity, natural processes and cycling. They provide ecosystem services, thus, benefits for humans and their societies obtained from nature, in all four categories: provisioning, regulating, cultural and supporting. The importance of sustaining ecosystem integrity via protecting the ecosystem services, is undeniable. However, it comprises a big challenge provided the human-induced degradation of the natural environment that, in turn, affects the earth's natural capital: natural resources, associated services with the supporting processes.

1. Introduction

Freshwater ecosystems, whether surface, that is rivers, lakes, streams and wetlands, groundwater or in the form of ice caps are fundamental for human life and for supporting the vast biodiversity, natural processes and cycling. They provide ecosystem services, thus, benefits for humans and their societies obtained from nature, in all four categories: provisioning, regulating, cultural and supporting. The importance of sustaining ecosystem integrity via protecting the ecosystem services, is undeniable. However, it comprises a big challenge provided the human-induced degradation of the natural environment that, in turn, affects the earth's natural capital: natural resources, associated services with the supporting processes.

This chapter extensively presents the functionality of freshwater ecosystems that is inseparably linked to the ecosystem services provided by freshwater bodies and their importance for human and nature well-being. The ecosystem services provided by freshwater are of vital importance for supporting all life cycles, social processes and economic prosperity.

2. Fresh Water Bodies: Rivers & Streams, Wetlands and Ponds, Groundwater, Ice-Caps

Freshwater ecosystems, comprise only 2.5% of water on the planet, with most of it (68.7%) and (30.1%) being captured in ice caps and as groundwater, respectively. Most of the remaining 1.2% freshwater has the form of ground ice and permafrost (69.0%), 3% of it has the form of atmospheric moisture, while readily available surface water bodies, which comprise precious and critically important water resources add up to only 0.29 %. A total of less than 0.01% of the Earth's freshwater is found in lakes, wetlands, swamps, and rivers (Shikomanov, 1996; Brown et al, 2014). The biggest freshwater abundance is found in the Americas (45% of total freshwater resources); Asia has significantly smaller freshwater system (28%), Europe has 16% and Africa just 9%. The small freshwater amounts and the unequal distribution of freshwater resources result in 45 countries to have been listed as 'water scarce countries', in which water availability is at the maximum level of $500m^3$/inhabitant, and 44 countries to depend on other countries for more than 50% of their water use (Brown et al, 2014).

Life and people heavily depend on all types of freshwater. The importance of freshwater as an element of life, providing this unique service to the planet, is proven by and attributed to the unique properties of water due to hydrogen bonds in the water molecule (Bassano, Alessio, and Felice de Carlo, 2010) which support cell and body structures and functions, such as water being liquid over large temperature range; slow changes in temperature; it has a high boiling point of 100˚C and a low freezing point 0 ˚C; it presents adhesion, cohesion and surface tension; it expands as it freezes; it is a good solvent and filters out harmful UV radiation. Freshwater bodies, therefore, directly support species, human survival and quality of life. They provide services linked to numerous life services through the support of biodiversity, the hydrological elements and processes, such as natural irrigation services through precipitation and climate regulation, as well as economic services such as water for industrial production, commercial uses and agriculture, with 86% of global water use being used in agriculture and processing of agricultural goods.

Surface water bodies: Rivers and Streams, Lakes, Ponds and Wetlands

Surface water bodies, although comprise a small portion of freshwater they form the most direct water resource due to its easiness in accessibility. Lakes host a volume of water of $0.125*10^6 km^3$ that is less than 0.01 % of the total water volume on Earth, while rivers account for the tiny amount of $0.0017*10^6 km^3$, that is $0.0001*10^6\ km^3$ of the total. The largest freshwater lakes such as Lake Superior (Canada and United States), Lake Victoria (Kenya, Tanzania and Uganda), Huron (Canada and United States), Michigan (United States), Tanganyika (Burundi, Democratic Republic of the Congo, Tanzania, Zambia), Baikal (Russia), comprise vital resources for natural, social and economic growth.

Lake, wetland and estuary ecosystems are particularly rich in biodiversity and they provide multiple services. They host about 10,000 fish species and about 90,000 species of invertebrates, the vast variety of which inhabit the littoral zone and the shores. The benthic zone, the bottom area of lakes and wetlands in transition between the actual water body, the sediment and substrate, are of high ecological significance in sustaining life cycles through invertebrates, amphibians, crustaceans and molluscs. Wetlands, in particular, are characterized by high primary productivity. Wetland vegetation follows particular patterns, such as emergent plants with roots, floating plants with roots, floating plants without roots, and submerged plants with roots. Macrophytes and angiosperms (flowering plants), algae (green, yellow-brown, red, and blue-green) and detritivores are found in high abundance; they support processes of unaccountable value such as, the photosynthetic process, community respiration, fast nutrient cycling and the food webs (Murphy, 1998).

Water flowing ecosystems, lotic, or else rivers and streams, whether permanent, intermittent or ephemeral, provide undeniable benefits. The water flowing ecosystems are the most common transboundary systems with obvious importance for national security. They may comprise fields of political dispute regarding water and territorial sharing or may act as connecting elements. The world’s longest river, Nile (approx. 6853 km) serves as the only freshwater resource in proximity for most of the 12 countries within its river basin. The Amazon River is the world’s biggest river in volume ($219{,}000 m^3/s$ discharge), drains 8 countries, supports the Amazon rainforest and hosts a huge variety of species, including unique species such as the pink dolphins (*Inia geoffrensis*) and the Amazon giant otter (*Pteronura brasiliensis*). The shores of the Amazon are home to reptiles, mammals, birds, reptile, amphibians, invertebrates. Rivers comprise important water and food resources for the countries they serve, they provide rich habitats characterized by great biodiversity, and often are transboundary regions of high strategic importance for the countries they serve, they offer amenity and recreational areas.

Surface water bodies, whether rivers and streams or ponds and wetlands, offer nutritional products for the ecosystem and humans, food, fresh water, genetic resources and medicines, as well as habitat and biodiversity services through the creation of natural green and blue corridors connecting the, otherwise, disconnected or fragmented ecosystems. They offer supporting services, such as photosynthesis, oxygen provision, nutrient cycling, community respiration and they provide benefits through the regulation of life and ecosystem processes and cycles, that is, improvements in air quality, protection from shore erosion, climate regulation, CO_2 sequestration, flow attenuation and flood reduction. Flood prevention and increase in resilience to flooding are regulating services of great importance; surface water bodies are natural floodplains that provide flow attenuation and storm water management that result in flood control and collection of rainwater, while they reduce the pollutant load downstream (Grizzetti et al, 2019). Stormwater runoff management and flood prevention, also through the use of green infrastructure that aims to increase the potential for surface water accumulation have become priority concerns in urban planning (Chang et al., 2018; Berland et al., 2017) and in the ecosystem protection efforts. In addition, they act as carbon sinks as they have a high CO_2 absorption and storage capacity and offer obvious benefits in the efforts to combat climate change.

Surface water bodies, due to their high visibility to humans, have a significant contribution to human well-being through amenity and recreation (Arlinghaus 2006; Pretty et al. 2007). Humans always tended to settle near water bodies, proof of that being the fact that 50% of the world population lives within less than 3 km from surface freshwater ecosystems (Kummu et al. 2011). The vicinity of surface open water bodies was always an attraction of increased amenity value, from early settlers to the proponents of urban design based on water features, such as the 'Garden City Movement' of Ebenezer Howard, and the restoration actions of Niagara Falls (Apostolaki and Jefferies, 2009; Apostolaki and Duffy, 2017) to the latest decade that has seen explicit assessments of the importance of the water-human interactions in urban environments through numerous decision support tools aiming to quantify this relationship (Farell et al, 2010; Braat and de Groot, 2012; Russi et al, 2013). Attractiveness of surface freshwater ecosystems and their biodiversity richness attract visitors, sport practitioners and nature lovers, bearing clear benefits to their physical, mental and psychological well-being. The presence of surface water bodies and the contact with biodiversity are considered to provide health benefits, thus improve mental, spiritual, cultural, and physical health (Völker and Kistemann, 2013; McFarlane et al, 2019) and even increase property prices (Apostolaki and Jefferies, 2009; Venohr et al, 2018), at occasionally high levels.

Groundwater

Groundwater, the 'unseen' part of the hydrological cycle, is in connection and constant exchange of water with surface water bodies; groundwater aquifers are formulated due to percolation from the bottom of rivers, lakes, wetlands, estuaries and in return surface water bodies are replenished by groundwater flows (West and Obling, 2014). Although 'unseen', groundwater comprises the most important source of usable freshwater at global scale. Groundwater aquifers are crucial for the provision of water to cover all needs and provision for agriculture. Most of the irrigation water comes from the groundwater aquifers. In addition, the underground water storage sustains rich soil ecosystems in support of soil formation, providing habitats for groundwater dwelling species and land surface formations.

Groundwater is a slowly replenished resource; in most instances replenishment rates are significantly lower than exploitation rates, often resulting in fast drop of the water table and drying up of the resource. Results are several: the surface water bodies in conjunction are affected and the condition of these surface resources degrade; the availability of groundwater aquifers reduces; there is subsidence of land resulting in land reformations and loss of services provided by land use; saltwater intrusion that pollutes the groundwater aquifer (salinization of the groundwater aquifer).

Ice caps

Ice caps comprise the highest share of freshwater of earth. The ice coverage ranges from 4 million km^2 in each of the polar regions in the summer, to 16 million km^2 in the Arctic and nearly 20 million km^2 in Antarctica. The food webs and species forming the land and under-water ecosystems of the arctic regions differ significantly between them; from single-celled prokaryotes to large marine mammals in the former case, to Prokaryotes (Bacteria and Archaea) and eukaryotic trophic plankton, crustaceans and fish in the latter. Spring–summer phytoplankton bloom is affected by seasonal changes in the ice cover and in ice thickness, which in turn are regulated by air temperature, ablation rates and heat fluxes from the water column and they control spring-summer transmission of solar radiation through ice. The level of sunlight allowed to reach below the ice surface affects photosynthesis and consequently, biodiversity richness and food webs (Obryk, 2016 et al).

The direct transformations of water through all its forms, from water into ice and vapor in the atmosphere, establish strong links between climate change and ecosystem stability; arctic ecosystems respond in uncontrolled and unpredicted ways in any loss of arctic ice.

Ice caps, although cannot be used as a direct source of drinking water, they affect the livelihood of all other ecosystems through the climate regulation service they provide. On the other hand, the melting of ice that has been recorded since 1978, and is constantly intensifying, affects the underlying aquatic ecosystems, global climate, and in extent the world ecosystems and the services provided by them.

3. Connecting Nature and Society: Ecosystem Services

The relationship between humans and the natural environment can be characterised via ecosystem services (Haines-Young and Potschin, 2010). Ecosystem services refer to the benefits (both in terms of goods and services) which people obtain from nature, and as such the production of ecosystem services is a result of the interplay between social and ecological systems (MEA, 2003; Bennett et al, 2015). The most widely accepted classification of these benefits is provided by the Millennium Ecosystems Assessment working group (2003), which divides ecosystem services into four main categories namely:

- Provisioning services
- Regulating services
- Cultural services

- Supporting services

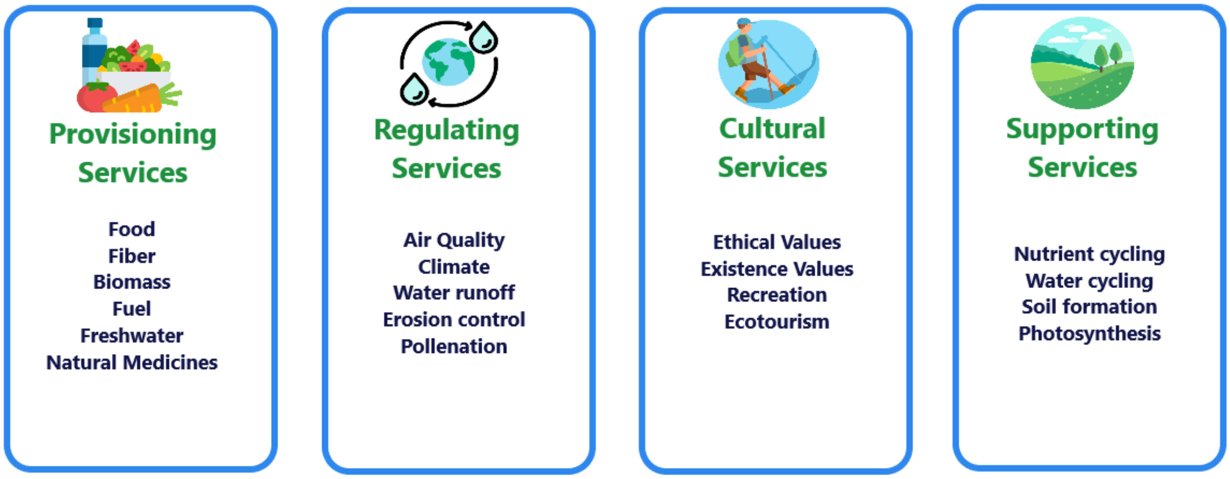

Figure 1: Categories of Ecosystem Services (Developed from: MEA, 2003; TEEB, 2010)

Provisioning Services: refer to products provided by ecosystems, including food (derived from both plants and animal products), fuel, fresh water, genetic resources, biochemicals and pharmaceuticals etc. Materials such as wood, and minerals for construction, or ornamental products such as animal skins and fibers for clothing or decoration are also considered provisioning services.

Regulating Services: relate to benefits resulting from the regulation of ecosystem processes such as water purification, waste management, air purification, pest control, erosion and storm protection, climate regulation, water regulation and pollination.

Cultural Services: refer to the intangible benefits offered by ecosystems, which relate to people's use of ecosystems for recreational activities, intellectual and spiritual development, social cohesion, cultural heritage, and aesthetic value.
Supporting Services: are otherwise referred to as '*Habitat Services*' (TEEB, 2010), and encompass the services which ecosystems offer in terms of creating the conditions necessary to provide a basis for all other ecosystem services and maintain the conditions for life on Earth (MEA, 2003). This includes provision of natural habitats, water and nutrient cycling, soil formation, and oxygen generation through photosynthesis. The key difference between supporting services and provisioning or regulating services, is that while humans do not directly benefit from supporting ecosystem services such as soil formation, they do in contrast benefit directly from the food provided from the soil.

Ecosystem Services Approach to Natural Resource Management and Development

In recent years, the Ecosystem Services approach has been widely adopted within natural resource management (Daily et al, 2009; Plant and Ryan,2013; Moore et al, 2018), as a useful framework which captures not just the monetary value of the natural environment, but also the intrinsic value locked within our rivers, seas, and landscapes. Here the concept of Total Economic Value (TEV) proves a useful tool, as it highlights the value that society derives from all natural capital (TEEB, 2010; Koundouri, 2015), thereby aiding decision-making in relation to resource allocation and management.

Furthermore, ecosystem services provide a critical link between the natural environment and human wellbeing (Akinsete et al, 2019) and offer a means to articulate the contribution of nature to human life, economic activity and societal development. Concepts such as the 'cascade model' (Haines-Young and Potschin, 2010) seek to illustrate these relationships, charting the connections between ecosystems, the services they provide, and the benefits these afford society. In recent years, the discourse has expanded to incorporate the link between the benefits to society in the context of human well-being, as well as socio-political processes such as policy development, decision-making, and planning and implementation of management strategies (Brock et al, 2018). Such models provide vital frameworks, through which ecosystem services, and the value of nature to society, and be further embedded into crucial decision-making processes.

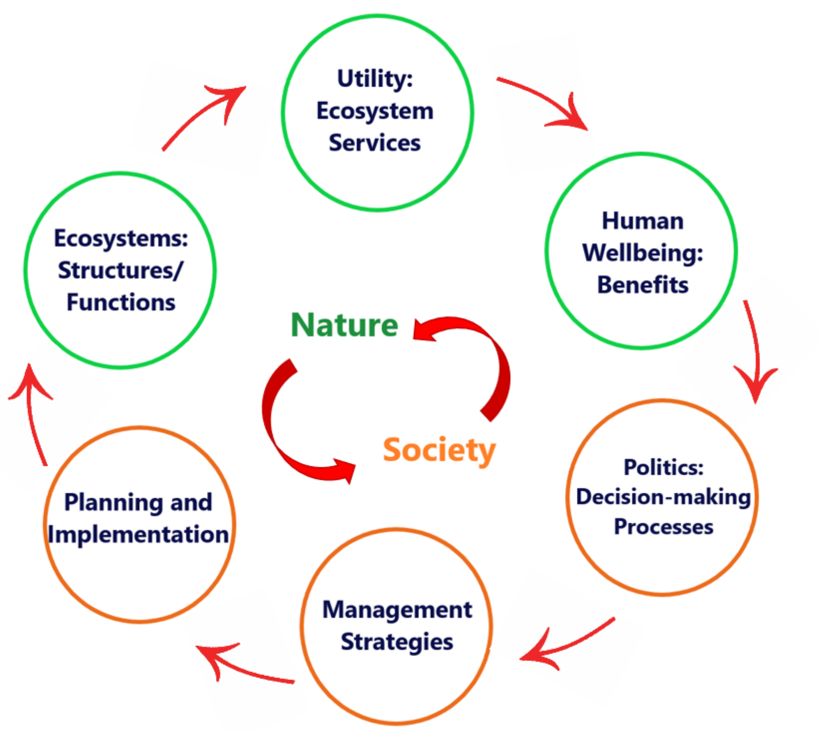

Figure 2: Interactions between the natural environment and society (Developed from: Haines-Young and Potschin; 2010 Brock et al, 2018)

Initiatives such as the Natural Capital Project (a partnership between Stanford University, the Chinese Academy of Sciences, the University of Minnesota, the Stockholm Resilience Centre, The Nature Conservancy, and the World Wildlife Fund), aim to integrate the value nature provides to society (ecosystem services) into all major decision-making processes in order to improve human and natural wellbeing. World Resources Institute, has taken this mandate a step further, actively targeting decision-makers in order to raise awareness within this sector (World Resources Institute, 2008). Despite ecosystem services being increasingly identified as a key tool to nurture societal development with consideration for the natural environment, there is still a fundamental gap in the recognition of the concept in terms of its role in supporting sustainable development, and implementation of global agendas such as the Sustainable Development Goals (SDGs) (United Nations, 2016). While tools such as MESH (Mapping Ecosystem Services to Human well-being), developed by the Natural Capital Project, are working towards supporting ecosystem services-based decision-making in the context of the SDGs and the SDG indicators (Natural Capital Project, 2016), there are still calls for ecosystem services to undertake a more prominent role in the implementation of the SDGs and the drive towards sustainable development (Wood et al, 2017).

4. The Ecosystem Services of Freshwater Bodies

Freshwater is a cross-cutting element which in fact integrates several ecosystem services, providing multiple benefits to various aspects of human life. The type and number of ecosystem services provided are unique to each individual ecosystem, and different types of freshwater bodies offer a host of different ecosystem services depending on the type of water body as well as its location, and condition. The core ecosystem services provided by different types of water bodies, are presented below.

Surface Water Bodies: Rivers & Streams, Lakes, Ponds and Wetlands

Majority of the global population relies on rivers, streams and lakes for fresh water supply, providing access to water for drinking, domestic use, sanitation, agricultural and industrial use. Not only do these water bodies provide water for alternative uses such as hydropower production, and transportation, but they also provide food, materials and pharmaceuticals in the form of products derived aquatic organisms which live in these ecosystem habitats. This group of water bodies also play a key role in maintaining water quantity via nutrient filtration, and over the long term, in nutrient cycling and soil formation (Feld, 2013). In addition, rivers, streams and lakes along with floodplains and wetlands, are critical for the control of floods and erosion. Wetlands and floodplains, are a nexus point of the terrestrial and aquatic ecosystems, which play a unique and vital part in the provision of ecosystem services and are generally considered to be the most valuable ecosystems (UNEP- Secretariat of the Convention on Biological Diversity, 2015). As well as providing both agricultural and aquacultural produce for food, biofuel, fibre and raw materials, wetlands also carry out integral processes such as water purification, flood and erosion control, and nutrient cycling. Additionally, the riparian zones of wetland ecosystems serve as nature-based carbon capture facilities and thereby mitigate climate change. Arguably one of the most vital ecosystem services offered by wetlands is the support of vast amounts of biodiversity, providing habitat for a number of rare and endangered species as well as most of the world's migratory bird populations. This assortment of biodiversity in turn make wetlands particularly attractive locations for tourism and recreational activities such as hiking, fishing, bird watching, photography and hunting (Ramsar Convention on Wetlands, 2005; Millennium Ecosystem Assessment, 2005).

Groundwater

With aquifers providing drinking water for up to two billion people, and irrigation for approximately 40% of the world's food, groundwater is essential for the storage and retention of clean water for domestic, industrial and agricultural uses (NRC, 1997; Morris et al., 2003; Bergkamp and Cross, 2006). Groundwater bodies and their systems are necessary for maintaining the hydrological cycle through discharge and recharge, thereby maintaining other freshwater bodies such as rivers and streams, while also mitigating against drought by straining freshwater flow during prolonged and extreme dry seasons (FAO, 2003). In cases where groundwater produces hot springs, they provide cultural ecosystem services such as therapeutic or recreational spars, and serve as heritage sites where such springs are considered sacred or of great aesthetic value (Griebler and Avramov, 2014).

Ice-Caps

While polar ice holds 68% of global fresh water, the least is known about the specific ecosystem services (Anisimov et al. 2001). It is known that polar ice, is plays a key role in regulating global temperatures, by reflecting a greater amount of solar radiation and heat (180 W m2 annually), than the annual solar input of 80 W m2 (Nakamura and Oort 1988). In addition, the polar ice provides a habitat for microbial organisms such as algae and bacteria, and serves as shelter and feeding ground for juvenile krill, along with larger animals like penguins and seals. Finally, polar ice is an invaluable source of knowledge and natural history, preserving a record of the Earth's climate in ice cores (Millennium Ecosystem Assessment, 2005; WWF Global Arctic Programme, 2015).

Table 1: Various Ecosystem Services Provided by Different Freshwater Bodies (Developed from: Aylward, 2005; Bergkamp and Cross, 2006; Ramsar Convention on Wetlands, 2005; Millennium Ecosystem Assessment, 2005; Palmer and Richardson, 2008; Feld, 2013; Schallenberg et al, 2013; Griebler and Avramov, 2014; CGIAR Research Program on Water, Land and Ecosystems, 2015; Mitsch et al, 2015; UNEP- Secretariat of the Convention on Biological Diversity, 2015; WWF Global Arctic Programme, 2015; Bock et al, 2018; Malinauskaite et al, 2019)

		ECOSYSTEM SERVICES			
		Provisioning	**Regulating**	**Cultural**	**Supporting**
FRESHWATER BODY	**Rivers and Streams**	– Water (quantity and quality) for consumptive use (for drinking, domestic use, and agriculture and industrial use) – Water for non-consumptive use (for generating power transport/ navigation) – Aquatic organisms for food and medicines	– Maintenance of water quality (natural filtration and water treatment) – Buffering of flood flows, erosion control through water/ land interactions and flood control infrastructure	– Recreation (river - rafting, kayaking, hiking, and fishing as a sport) – Tourism (river viewing) – Existence values (personal satisfaction from free-flowing rivers) – Cultural values (religious, historical or archeological value)	– Role in nutrient cycling (role in maintenance of floodplain fertility), – Soil formation – Predator/prey relationships and ecosystem resilience
	Wetlands	– Food (agriculture, aquaculture, fisheries) – Peat production for fuel and horticulture Furbearer and other animal harvesting Timber production	– Flood control Groundwater replenishment – Shoreline stabilisation & storm protection – Sediment & nutrient retention and export – Water purification – Climate change mitigation and adaptation (CO2 capture)	– Cultural values (religious, historical or archeological value) – Recreation – Tourism (hiking, fishing, bird watching, photography and hunting) – Existence values	– Reservoirs of biodiversity – Habitat for rare and endangered species – Wetland functions such as hydric soil development, primary productivity, serving as chemical sources,

				– Landscape aesthetics – Sites for human relaxation – Ecology education	sinks, and transformers, and water storage
	Groundwater	– Water (quantity and quality) for consumptive use (for drinking, domestic use, and agriculture and industrial use) – Water for non-consumptive us (geothermal and power production, hot springs for medical therapy) – Aquatic organisms	– Erosion and flood control – Climate change mitigation and adaptation (buffer against spatial variability in drought)	– Recreation (hot springs, mineral spas) – Historical/cultural value (sacred springs) – Spiritual knowledge and wisdom	– Maintenance of hydrological cycle (aquifer recharge and discharge)
	Ice-Caps	– Freshwater storage	– Climate change mitigation and adaptation (*albedo* – heat and solar reflection away from earth)	– Education and knowledge (record of the Earth's climate history preserved in ice cores)	– Habitat for microbial community (algae, bacteria, and small consumers) – Feeding ground for juvenile krill, penguins and seals

5. Current threats to Freshwater and Ecosystem Services

Although critical to natural and human communities, fresh water is threatened by a myriad of issues including overdevelopment, pollution, over abstraction and global warming. The threats to freshwater ecosystems strongly vary in space and time depending on both social and ecological contexts, with immediate impacts on ecosystem services. Needless to say, current concerns over freshwater, among others, focus on the fact that provisioning freshwater services are far from met on a global scale. Today, 748 million people worldwide remain without basic access to drinking water, 2.4 billion people lack access to basic sanitation services, 1 billion people practice open defecation and 1.7 billion people are currently living in river basins where water use exceeds recharge (UN Water, 2015; WWAP, 2017).

Provided the increasing population, which is expected to reach 8 billion in 2025, water withdrawals are expected to increase; the business as usual scenario predicts increase in water withdrawals of 22% by 2025 while the crisis scenario foresees 37% increase. Consequently, the stress to freshwater resources and the need to sustain ecosystem services, also as a means to achieve the targets set towards achieving the SDGs, are becoming increasingly pressing in the coming years (Aylward et al., 2005).

Freshwater bodies are experiencing declines in biodiversity at a far wider extent that the terrestrial ecosystems (Collen et al. 2014), affecting the vitality and survival of species, particularly of the most sensitive ones, like amphibians. The threats to freshwater biodiversity can be summed up to derive from: overexploitation, water pollution, flow modification that may degrade habitats, and human-induced invasion by non-native species. Protection of freshwater biodiversity, is therefore, prioritized but is still comprises a challenge as it is multi-dimensional. The trade-offs between conservation of freshwater biodiversity and human use of ecosystem goods and services, may impose additional threats for the ecosystems and may affect ecosystem functioning and resilience, human livelihoods and biodiversity.

Disturbances or even negative impacts to freshwater ecosystems derive even from recreational activities. The use of lakes and rivers have cumulative impacts on the ecology of the ecosystems and often contribute to high biodiversity losses that are notably higher at freshwater ecosystems in comparison to terrestrial and marine ecosystems. Rivers, in particular, seem to suffer the most by habitat alteration due to recreational activities, such as boating, swimming etc.; 56% of river water bodies were found to significantly suffer from habitat loss and habitat alterations in the E.U. (Fehér et al. 2012; EEA, 2015), with immediate impact on the social value of the ecosystem.

Wetlands, especially mangroves, are amongst the most threatened freshwater ecosystems. The shallow-water natural floodplains are facing degradation due to urbanisation, land use changes, water abstraction and pollution. Wetland loss is associated with losses in biodiversity and decline of critically important ecosystem services of socio-economic significance that include, among others, the stormwater management element, prevention of coastal erosion, nutrient cycling, water purification and reduction of waste load, habitat provision (Sannigrahi et al, 2019). Climate extremes affect wetland vitality and result in increased risk of flooding in the built wetland shores. The ecosystem service beneficiaries, i.e. farmers, consumers, locals, domestic water supply to cover demand, tourists and visitors, face higher levels of uncertainty in relation to the access and availability of the resource (Gómez-Baggethun et al, 2019).

The groundwater aquifers comprise the most widely used water deposits, therefore, suffer severe depletion dropping groundwater aquifers at levels that are considered non-usable. Over-abstraction of groundwater is affecting surface freshwater flows in rivers and lakes, is causing lowering of the water table and land subsidence, increases the cost of abstraction. In coastal areas it is resulting in upwelling and mixing of brines with fresh groundwater, resulting in salinization of groundwater aquifers, the most common type on groundwater pollution (West and Obling, 2014). Although the balance between freshwater and saltwater tends to remain relatively stable, over-abstraction has resulted in massive contamination of groundwater and the linked surface water resources with salt. An estimated 12.9 km^3 cubic kilometers of saline groundwater exists in comparison to about 10.5km^3 of fresh groundwater (Gleick,1996), with direct impacts for water supply and socio-economic services of the resource.

Despite the low attention to sea-ice biomes degradation in relation to the terrestrial and marine biomes, as previously observed (Malinauskaite et al, 2019), today there is increasing concern over the threats to ice caps. The ecosystem services related to climate regulation and biodiversity provided by ice caps are becoming of vital importance for the planet. The threats to ice caps derive from the actual loss of ice extent and reduction of thickness due the average increase in temperature. Even small changes in the ice properties may have long-lasting effects on sea ice, freshwater ice and the dependent ecosystems. The rapidly developing climate change accelerates the impact on ice caps. The climate regulation and hydrological support of ice caps is, therefore, significantly reducing. The interactions of the underline aquatic ecosystems with atmospheric air and solar radiation are also reducing with immediate impacts in primary productivity and biodiversity.

6. Recommendations on Sustaining Ecosystem Services

Management of freshwater resources should address the multifunctional nature of water, should cover the water and ecosystem needs without jeopardizing the integrity of ecosystem services and the benefits deriving from them for human societies, economies and the environment. Holistic approaches are aiming at human well-being, at ensuring good ecological status and increase benefits to the society. Integration of knowledge, ideas and services are tools to achieve protection of freshwater ecosystems and to engage into holistic management approaches that can be proven beneficial in protecting and sustaining ecosystem services. A holistic management framework of this kind, needs to draw attention to the links between environmental (natural), recreational, socio-economic aspects of freshwater systems while it actively engages into participatory processes that are beneficial for the end users and protective for the local natural environment. On top, ecological restoration of freshwater bodies and of their services can provide multiple social and economic benefits (Rey Benayas et al., 2009).

The Ecosystem-based Approach is an approach that links the direct and indirect contributions of ecosystems to human well-being and emphasizes on the protection and value of ecosystem attributes (Millenium Ecosystem Assessment, 2005). In extent, ecosystem-based water management is in support and sustenance of ecosystem services, thus, sustainable management in aquatic ecosystems that depend on policy integration, engagement and exchange of knowledge, targeting at the protection of natural ecosystems. This approach considers ecological integrity, biodiversity, resilience to change, it is carried out at the appropriate spatial scales, it develops and uses multi-disciplinary knowledge, it builds on social-ecological interactions, it involves stakeholder participation and transparency, it supports policy coordination and incorporates adaptive management concepts, thus, the ability to respond to a range of possible futures, weighting at the same time short-term actions against long-term benefits or alternative actions (Langhans et al, 2019). Holistic ecosystem-based management allows for trade-offs between the Ecosystem Services while taking societal goals into account. Ecosystem services are engaged, within this framework, to map the impacts of ecosystem changes to human well-being, ultimately aiming at identifying mitigation options or actions for the sustainable use of ecosystems, able to adverse the effects of drivers and pressures and improve quality of life via meeting the sustainable development goals (Apostolaki, Koundouri and Pittis, 2019). This framework works well provided it is initially well defined, it is based on extensive and consistent monitoring and on elaborate evaluation processes. Consistency on governance combined with innovative solutions are key to stakeholder engagement. The benefits deriving are related to open dissemination of processes, while conflicts of transboundary nature or of any other kind are resolved. The ecosystem-based approach comprises the basic tool towards ecological restoration, and action in response to environmental degradation caused by human activities. Restoration is seen as a tool towards regaining ecosystem services, re-establishing contact with nature and improving the well-being for humans and the natural environment.

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