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The Kabul River

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ECOSYSTEM SERVICES AND HUMAN WELL-BEING

4.1 INTRODUCTION

Addressing transboundary water governance entails a thorough understanding of the reasons of water challenges in the context of rationalized knowledge about the vital role of biodiversity and the ecosystem services of water. This chapter builds further on Hayat and Gupta's (2016) article on the ecosystem services of freshwater. It discusses the state-of-the-art knowledge of freshwater systems within the context of a basin. It addresses the question: How can the various drivers of freshwater problems affect the ecosystem services (ESS) of different kinds of freshwater and how does this, in turn, affect human well-being? To answer this question, I first define the natural and anthropogenic, and the direct and indirect drivers (see 4.2) of the problem of flow (quality, quantity and related ecosystem services of water) in river basins. This chapter then discusses freshwater and its different kinds (including rainbow-water, blue surface-water, blue groundwater, green water, grey water, black water and white frozen water or snow) (see 4.3); various types of the ecosystem services of nature (ESS) (see 4.4) with differing contributions to human well-being (i.e. good life, health, good social relations, and freedom of choice through security), and at different levels of governance (in section 4.5). The last section (section 4.6) draws inferences.

4.2 DRIVERS OF FRESHWATER PROBLEM AT MULTIPLE LEVELS

In the scholarly literature, the ‘_driver’ symbolises the cause of a problem which can occur in two ways: directly (e.g., affecting the behaviour of an actor to withdraw or pollute freshwater) or indirectly (e.g. to influence the direct drivers and thus affect freshwater problems indirectly). The literature on freshwater resources states that demand for freshwater is surpassing its supply in various parts of the world (Postel, Daily, and Ehrlich 1996). Scarcity of freshwater resources and inadequate access to water supply and sanitation services intimidate health, socio-economic growth, and sovereignty of countries (Palaniappan et al. 2010). Both natural (e.g., winds, storms, precipitation, tectonic movements, climate and weather variability) and anthropogenic (e.g. land cover changes, urbanisation, industrialisation, technological advances and climate change) activities can drive or cause problems. In some situations, these drivers can worsen the existing freshwater problems. Direct and indirect drivers are discussed in the following sub-sections in more detail (see also Table 4.1). For analytical purposes, I have clustered these drivers into direct and indirect, however clearly the drivers in one category are interlinked with drivers in another category.

4.2.1 Direct Drivers

The key direct drivers are agricultural development (e.g. commercial agricultural practices including animal husbandry, the extractive sector and water use in energy), industry (including services and infrastructure), municipal water supply and sanitation services e.g., household uses (drinking water, sanitation and hygiene) and demographic shifts (i.e., migration, population growth, increase in population density and urbanisation).

The core direct driver of freshwater problems is agricultural development (Gupta and Pahl-Wostl 2013b). This comprises commercial agriculture containing animal husbandry at large-scale large-scale (Dore et al. 2012). Agricultural uses including subsistence agriculture are responsible for about 70% of water use world-wide.

Industries, services and infrastructure also use water. Beyond agriculture, extraction of minerals such as petroleum products (Braune and Adams 2013); energy production (Van Weert and van der Gun 2012); production of mineral water (Rodwan 2014) and other industries also use water. The service industry also uses water, as does different infrastructures in society. Although industrial development is more relevant at the national level, it can strongly influence the local level (in terms of reducing or restricting access for marginalised people) and transboundary (increasing demand in transboundary river basins) water management relevant at the transboundary level.

Household uses (e.g., drinking water, sanitation and hygiene) make up a significantly smaller use of freshwater resources. While volumes of these uses are small in comparison, they still constitute important drivers that can contribute to poverty eradication (Moench 2002) while contributing to the cumulative problem of water contamination (Gupta and Conti 2017).

Various other factors that put direct stress on freshwater resources include changes in demography such as population growth, migration, and localised increase in the population density via urbanisation at all geographic levels (Gupta and Pahl-Wostl 2013a). Moreover, it can also enhance the competition for freshwater while too little or too much water can also affect human populations. Furthermore, the increase in population can also influence the quality of freshwater resources (MEA 2005; UN-Water 2012). Table 4.1 below offers the summary of direct drivers and their applicability at multiple geographic levels.

4.2.2 Indirect Drivers

The indirect drivers affecting the governance of transboundary water resources at multiple levels of governance include political dynamics between states occurring at all geographic levels, culture and ethnic elements (e.g., using resources inefficiently, attitudes concerning access and allocation, etc.), non-water-related policies (economic development, land tenure, agriculture and food security, and land use), the drive for economic growth, poverty, technological advances (agriculture intensification), international trade, climate variability and change and other natural causes.

The political dynamics between states can aggravate the direct driver of unequal access or demand, and further intensify the lack of agreement regarding resource management (Zeitoun et al. 2013; Zeitoun and Warner 2006). Both ethnic elements and culture can also serve as indirect drivers of freshwater problems. The attitude of actors towards inefficient use of resources, access and allocation, and public obligation in terms of environmental quality can result in behaviours that result in unnecessary use or pollution (Cullet and Gupta 2009). People's attitudes linked to culture are usually local through to national in character although there can also be a regional dimension.

Non-water related policies including those on growth and poverty eradication, agriculture, industry, infrastructure, land use, land tenure and trade are key drivers of water use and pollution (Braune and Adams 2013; Foster and Garduño 2013; Gupta and Pahl-Wostl 2013a; Moench 2002). Similarly, encouraging economic development for poverty alleviation may also result in land use changes that can contaminate freshwater or decrease its flow (Hoff 2009; Warner et al. 2013). This can also result in economic activities that cause unsustainable use of freshwater resources (Warner, Sebastian, and Empinotti 2013). The pursuit of profit in the economy often leads to the externalisation of the environment. Poor people also make choices that may lead to water problems. Technology is also an indirect driver as it can potentially lead to agricultural intensification and enhance the ability of water users to affect the quality and flow of freshwater resources (Söderbaum and Tortajada 2011).

In terms of economy and trade, market biases and demand for water-intensive products can take place by subsidies or ‘free-market’ trade rules. These actions can possibly drive freshwater challenges if they escalate demand and production in the agricultural and other related industries, primarily if these demands result from market alterations or marginalisation of environmental costs in pricing (Gupta and Pahl-Wostl 2013a; Söderbaum and Tortajada 2011). Table 4.1 offers an overview of indirect drivers and their applicability at multiple geographic levels. Climate variability and change is an indirect driver which is the most difficult to grasp as it is extremely complex in origin and operates across all geographic levels (Gupta and Pahl-Wostl 2013a). The special effects of climate variability and change on freshwater resources and how it can possibly distress the quality and quantity of freshwater are discussed in Chapter 1 (see 1.2.3). The increased frequency of droughts and floods due to climate variability (Villholth et al. 2013) may at one point reduce water flow in the rivers while at another point the river might overflow due to excessive rains or melting of glaciers. Moreover, it may put some regions at risk due to arsenic and fluoride mobilisation as well as salinisation of freshwater resources (Van Steenberg 2006). In addition, there are other natural factors such as tectonic movements, where earthquakes lead to changes in freshwater flow and level, and drinkable water resources become contaminated affecting micro-biota therein (Galassi et al. 2014), or hydraulic connections are formed between two diverse resources that were not earlier linked (Malakootian and Nouri 2010).

Table 4.1: Drivers of freshwater challenges at multiple geographic levels

Direct Drivers	Geographic Levels			Key References
	T	N	P/L	
Agriculture development (e.g., commercial agriculture practices including animal husbandry, the extractive sector & water use in energy)	X	X	X	Gupta and Pahl-Wostl 2013; Dore, Lebel, and Molle 2012; Van Weert and van der Gun 2012; Rodwan 2014
Industry (including services and infrastructure)	X	X	X	Van Weert and van der Gun 2012; Rodwan 2014
Municipal water supply and sanitation services e.g., household uses (drinking water, sanitation, and hygiene) and subsistence agriculture	NA	NA	X	Moench 2002; Braune and Adams 2013; Gupta and Conti 2017
Demographic shifts (i.e., migration, population growth, increase in population density, urbanisation, population growth)	X	X	X	Dore, Lebel, and Molle 2012; Gupta and Pahl-Wostl 2013; Assessment 2005; Water 2012a
Indirect Drivers				
Political dynamics between states	X	NA	NA	Zeitoun et al. 2013; Zeitoun and Warner 2006
Culture and ethnic elements (attitudes regarding access and allocation, wasteful use of resources, etc.)	X	X		Gupta and Pahl-Wostl 2013; Dore, Lebel, and Molle 2012
Non-water-related policies (agriculture & food security, land use, land tenure, economic development)	X	X	X	Foster and Garduño 2013; Hoff 2009; J. Warner, Sebastian, and Empinotti 2013; Gupta and Pahl-Wostl 2013
Economy (economic growth)	X	X	X	Hoff 2009; Gupta and Pahl-Wostl 2013
Poverty	X	X	X	Moench 2002; Braune and Adams 2013
Technological advances (agriculture intensification)	X	X	X	Söderbaum and Tortajada 2011; Gupta and Pahl-Wostl 2013
International trade (e.g. 'globalisation' or trade in virtual water)	X	X	X	Hoff 2009; Söderbaum and Tortajada 2011
Natural change and variability in weather, Droughts; Floods; Earthquakes; Landslides, tectonic movement.	X	X	X	Lashkaripour and Hussaini 2008; The World Bank 2009; IUCN 2012

4.3 FRESHWATER AND ITS TYPES

Having discussed the drivers of freshwater problems, I now turn to discuss the topic of freshwater itself. Freshwater is natural water in the ground and on the surface which has low absorptions of total dissolved solids and salts (Penuel et al. 2013). Freshwater does not mean that the water is directly potable; it is ‘sweet water’ in contrast to ‘salt water’ (Hendrickson III 2014). Freshwater habitats can be divided into still water systems including swamps, mires lakes, and ponds; running-water systems such as rivers; and groundwater structures which flow in aquifers and rocks. In addition, there is another type of water system known as green water which connects running-water systems with groundwater and which underlies many larger rivers containing more water than open water networks (Vihervaara et al. 2010).

The precipitation from the atmosphere in the form of mist, rain and snow is the primary source of almost all freshwater. Two-thirds of the global freshwater resources are locked up in permanent snow and glaciers while the remaining one-third is groundwater (Shiklomanov 1997). Out of the total water on earth, only 2.5 - 2.75% is freshwater; approximately 0.3% is surface-water (Ostfeld et al. 2012) containing 1.75 - 2% which is locked in glaciers, ice and snow; groundwater and soil moisture is roughly 0.5 - 0.75%; while surface water in rivers, swamps, and lakes is less than 0.01% (Alcamo et al. 2017; Pidwirny 2006). Approximately 87% of the surface freshwater is contained in lakes comprising the African Great Lakes which has 29% of the freshwater, the North American Great Lakes which has about 21%, the Lake Baikal in Russia which stores around 20%, while other lakes which have 14% of the surface freshwater resources. This means that only a tiny portion of freshwater is in rivers. Freshwater provides various ecosystem services to more than six billion people and supports approximately 126,000 freshwater species (Chapagain and Orr 2008).

Freshwater includes green and blue water including groundwater (Falkenmark 2003; Mekonnen and Hoekstra 2011). When these waters are in their vapourised stage (0.04% of total water) (Gleick 1996), they are referred to as rainbow water (Braun and Smirnov 1993); once it is used by humans, crops and industries, it emerges as grey (polluted water which needs water to dilute it) and black water (polluted with human feces and urine) (Andersson 2016). The water balance models of hydrologists have revealed that blue water (blue surface water and blue groundwater) is only one-third of the total global precipitation; this has led water resource scholars to investigate all steps between rainfall and blue water flows (Ukkola and Prentice 2013). With the current trend of agricultural intensification, there will not be enough blue water to sustain the irrigation needed for the agricultural sector (Barlow 2009; Barlow and Clarke 2017). The distinction between these water resources is essential because each kind of water has distinct biological, chemical and physical characteristics, and hence with specific ESS (see 4.4).

4.3.1 Rainbow Water / Atmospheric Moisture

Rainbow-water, also known as atmospheric moisture, is depleted by precipitation and replenished by evaporation (Sigurdsson et al. 2000); 90% of the evaporation is from oceans and water bodies and

10% from terrestrial evapotranspiration (Van Noordwijk et al. 2014). Its volume is about 12,900 km³ or 0.001% of the total water volume. If all atmospheric water rained down at once, it would only cover the Earth to a depth of about 2.5 centimetres (Sheil 2018). Water exists in three main forms in the atmosphere: (i) gas (as water vapour), (ii) liquid (as rain drops) and (iii) solid (as ice crystals). Atmospheric rivers refer to intense humidity in the atmosphere and include water vapour (Zhu and Newell 1998). Atmospheric rivers are long in length (i.e. several thousand kilometres) while they are only a few hundred kilometres wide, but have the capacity to take more water than the largest river on Earth – the Amazon River (ibid).

4.3.2 Blue water

The concept of blue water, first coined in 1995 (Zhao et al. 2015), has been used by managers and scholars globally (Falkenmark and Rockström 2006; Pittock 2011). In the early days, water consumption data only included the surface blue water extraction by the agricultural sector, industries and municipalities, while not taking into account its other possible uses (Vanham 2012). Blue water includes surface water and groundwater resources (Wang et al. 2013) and is roughly 42,700 km³ (Shiklomanov 1997; Vaux 2012) stored in underground aquifers, lakes, and rivers (Pittock 2011). Surface blue water requires to be sustainably used to avoid negative impacts on the environment (Hoekstra et al. 2012). In arid and semi-arid zones (e.g., Southern Europe, the Southwest of the United States, North Africa, the Arabian Peninsula, Central and South Asia and parts of Australia), the share of surface blue water is the biggest (Mekonnen and Hoekstra 2011).

4.3.3 Groundwater

Groundwater is a subset of blue water and refers to water in the Earth's crust in all physical states (Winter 1999). It is fed primarily by rainwater: water that does not flow in surface-water streams and is not utilised by plants and trees or evaporates, percolates into the underground aquifers (Sophocleous 2002). Some of the ESS that is associated with groundwater is of high economic value as these services support a range of production and consumption processes (Emerton and Bos 2004). In comparison to blue surface water, blue groundwater has a very long residence time – averaging about 300 years (Robinson and Ward 1990).

4.3.4 Green water

The volume of water that is deposited in the soil after rainfall is known as green water (Vaux 2012). In other words, green water is the rainwater that does not become run-off (Wang et al. 2013) or groundwater. The concept of green water - also coined in 1995 (Zhao et al. 2015) but has received less attention than blue water (Falkenmark and Rockström 2006). Approximately 60% of freshwater flow is green water (Dent 2005), and accounts for approximately 80% of global crop production (Liu et al., 2009). Green water is used by the roots of plants and evaporates through plant transpiration processes (Zang et al. 2015).

4.3.5 Grey water

The wastewater produced from household uses like washing clothes or bathing can be referred to as grey water or polluted water (Wang et al. 2013). Greywater has comparatively higher potential for reuse due to the small level of contamination (Allen, Christian-Smith, and Palaniappan 2010). The reuse of greywater can potentially compensate the demand for new water supply up to some extent (López-Zavala, Castillo-Vega, and López-Miranda 2016). Furthermore it can meet a wide ranges of economic and social needs (Allen, Christian-Smith, and Palaniappan 2010) and may also possibly reduces the energy and carbon footprint of water services (Griffiths-Sattenspiel and Wilson 2009). This polluted water includes leached nutrients and pesticides from agricultural practices (Tsuzuki et al. 2010) and drain water from hand basins, kitchen sinks and laundries, without any input from toilets (Bergdolt et al. 2012).

4.3.6 Black water

Black water, also called drain water, sewage, brown water and foul water, coined in the 1970s, is the water generated by toilets (Tsuzuki et al. 2010). It is different from industrial wastewater which has been used for making a commercial product. It is drain water containing urine, feces and discharge sewage from flush toilets including anal cleansing water (Bergdolt et al. 2012). It contains a higher amount of organic solids, nutrients and pathogens (ibid) and is distinct from grey water (Oteng-Peprah and Acheampong 2018) by having lesser amounts of detergents and greater concentrations of organic pollutants and nutrients (Santos et al. 2014). It is essential to decompose pathogens that exist in black water on a priority basis before releasing water safely into the environment. However, decomposition can be challenging if it contains large quantities of excess water or pathogens (ibid).

4.3.7 White Frozen water / Glaciers

The water cycle expresses how water travels above, on, and through the Earth (Vörösmarty and Sahagian 2000). However, more water is stored in ice-sheets and glaciers as compared to the water in the water cycle at any point in time on the Earth's surface (Radić and Hock 2014; Siegert 2006). Approximately 90% of the ice mass of Earth is in Antarctica (Rignot et al. 2011). Similarly the Greenland ice cap covers 10% of the total global ice quantity (Hanna and Braithwaite 2003; Nordhaus 2018). The ice cap averages about 5,000 feet (approximately 1524 meters) in thickness, but can be as thick as 14,000 feet (approximately 4,268 meters) (USGS 2018). The National Snow and Ice Data Centre of the United States of America (USA) reveals that seas would rise by about 230 feet (approximately 70 meters) if all glaciers melted today (ibid).

4.4 ECOSYSTEM SERVICES OF DIFFERENT KINDS OF FRESHWATER

4.4.1 Defining Ecosystem Services

The ecosystem services concept was developed in the framework of the Millennium Ecosystem Assessment (MEA), which provided technical information and evaluated the significance of

ecosystem change on human well-being (MEA 2005). The MEA framework discusses that a vibrant relation exists between ecosystems and humans and that it is crucial to study the connections among four key components i.e., direct drivers, indirect drivers, ecosystem services, and human well-being (Liu et al. 2007). The MEA framework observed that linkages between ecosystems and humans is perhaps less explored and least well-understood among the above four key components (Yang et al. 2013). However as stated by Abdallah et al. (2008), the linkages between human well-being and the social factors that influence this relationship have been given more attention. To better understand the relationship, Yang et al. (2013) states four reasons for evaluation of human reliance on ecosystem services: first, governance can be enhanced by thoroughly understanding the relationship between poverty and ecosystem services (Shackleton et al. 2008; Suich et al. 2015); second, the equity provisions in governance can be appropriately planned once the unequal distribution of benefits from ecosystem services across diverse population groups can be better assumed (Liu and Ming-Te 2011); third, a proper understanding of unmanaged threats and unexploited opportunities that arise with ecosystem change (e.g., droughts, floods, landslides, and storms) (Yang et al. 2013) facilitates a risk management approach; and fourth, for meaningful communication between policymakers and politicians, the quantitative measurement is essential to better understand the human-nature interactions (Alberti et al. 2011).

Since the publishing of the Millennium Ecosystem Assessment, some authors have felt that the concept of ecosystem services unduly focuses on the quantification of ecosystem services and overlooks the quality of the holistic and comprehensive nature of relations between humans and nature (cf. Larigauderie and Mooney 2010; Perrings et al. 2011). For this purpose Pascual et al. (2017) developed a new concept of Nature's Contributions to Humans. This concept argues that nature's contributions are more holistic and reflect complex relations between humans and nature. However, it continues to draw on the four elements of the ecosystem services.

4.4.2 Freshwater and ecosystem services

Freshwater is a vital resource for the survival of all ecosystems. For example, a key concern for hydrological ecosystems is acquiring minimum stream flow, particularly maintaining and restoring water allocations (Palaniappan et al. 2010). Human utilisation of freshwater for irrigation, domestic use and industrial applications can have adverse impacts on down-stream ecosystems (Gordon et al. 2010) see also Table 1.2 in Chapter 1). This section links different kinds of freshwater to the ESS concept, which shows the contribution of biophysical ecosystem processes to human well-being (MEA 2005; NEA 2011). The concept of ESS is essentially anthropocentric because all the processes and components of ecosystems are studied as services which humans require, demand or benefit either directly or indirectly (Boyd and Banzhaf 2007).

Nature supports the biodiversity of genes, species and ecosystems. In addition to protecting biodiversity, ecosystems provide *supporting* services (see 4.4.3; such as erosion control, climate regulation and oxygen production), *provisioning* services (see 4.4.4; including food, freshwater, fibres, genetic materials and ornamental materials etc. (MEA 2005; Nellemann 2009), *regulating*

services (see 4.4.5; comprising environmental benefits and climate regulation, disease regulation, flood management, water treatment and waste management etc.) (MEA 2005; Nellemann 2009) and *cultural* services (see 4.4.6; including material benefits to communities through a variety of spiritual and religious services) (MEA 2005). Table 4.2 summarises how different kinds of water are linked to specific ESS.

4.4.3 Supporting Services

Supporting services of ecosystems underlie the sustainability of all other ESS. The supporting services of freshwater are intrinsic for all water colours. These include (a) supporting the hydrological cycle, recharge, evaporation and transporting of water (including vapour, which is done by wind and rainbow-water), and precipitation; (b) storing water; (c) soil moisture, soil formation, erosion and erosion control; (d) nutrient cycling of e.g. oxygen, carbon, nitrogen, phosphorous, salt concentration and/or dilution (Laruelle 2009); (e) primary production and supporting photosynthesis (Alahuhta et al. 2013; Nellemann 2009); and (f) supporting biodiversity: rainbow water provides a habitat for birds, surface water for fish and other aquatic organisms, and green-water through promoting landscapes for various terrestrial life forms; and ecosystems associated with groundwater are dependent on water quality, discharge fluctuation and the pressure level of the aquifer (Merz et al. 2001).

Supporting services differ from other ESS by their indirect impacts on humans over long periods of time. In other words, changes in the provisioning, regulating and cultural context of ESS have direct impacts and last for short-to-medium periods. Some services, such as erosion control, climate regulation and oxygen production classified as supporting and regulating services, serve both functions (MEA 2005; NEA 2011) see Table 4.2) and have short-to-long-term effects on human well-being.

4.4.4 Provisioning Services

The literature does not discuss in detail the provisioning services of rainbow water, except through its role of providing fresh, clean water directly to the surface of earth. A range of provisioning services are provided by clean blue and green water. Even grey water is seen as a useful, predictable source of water that can be reused. Black water is polluted water and can spread disease, but can be reused after thorough treatment.

In terms of security, the availability of adequate freshwater resources ensures safe and equitable access to all people and communities; where resources are low or controlled through privatisation and/or hegemonic control, the safety of access and the quality of water can be negatively influenced. This has led to, *inter alia*, the tipping points hypotheses at the global level, water wars hypotheses at the transboundary level (Jarvis and Wolf 2010), and the human water security hypotheses at the national level (Vörösmarty et al. 2010).

In terms of health, the supply of good quality freshwater fosters good health; polluted water can be harmful for both aquatic organisms and the humans who consume it (Dallas and Rivers-Moore 2014) or bathe in it leading to symptoms like fever, skin irritation, eye infections, as well as stomach pain and disorder etc. Surface water contamination is mainly caused by pesticides use which may affect soil fertility and impact humans (Pendleton et al. 2012).

In terms of good social relations, the availability of good quality water is critical for social cohesion and mutual respect while the poor and/or reduced quality of freshwater can create social stress and mutual disregard. The provisioning ESS of freshwater can occur at multiple levels (local, provincial, national, regional, and global levels) and in many different ways; for example, the deterioration of freshwater quality or overflow in lakes and rivers may on the one hand, affect some kinds of employment (e.g. fishing or farming activities), while on the other hand, they may create new types of employment (e.g. flood protection) at multiple geographic levels (cf. Berkes 2004).

4.4.5 Regulating Services

All kinds of water contribute to regulating services, in particular rainbow water, blue surface water, blue groundwater, green water and white ice. Grey water takes water out of the system, alters its state from good to bad, or temporarily removes it locally through the piped water system (Al-Jayyousi 2003); it may have a lower contribution to regulating services (Brown 2007). On the other hand, if grey and black water are returned to the freshwater system untreated, they can lead to the transmission of diseases, disturb other ESS and may reduce benefits for humans (Naidoo and Olaniran 2014).

In terms of safety, regulating services support biodiversity and human life (Díaz et al. 2005; Wall and Nielsen 2012). However, when the regulating services are disturbed by climate change, this can lead to heatwaves, floods and droughts which probably affect human security (Dallas and Rivers-Moore 2014). In terms of achieving a good quality of life, regulating services are very important (McMichael et al. 2005). However, rise in temperature of water, reduction in the absorption of dissolved oxygen, mobilisation of chemical pollutants (including metals, pesticides and pathogens), or changes in water flows may affect water and food availability and the feeling of well-being (Nellemann 2009). These pollutants can affect human health and may reduce their productivity (Schwarzenbach et al. 2010; WHO 2013). There is a lower causal relationship between regulating services and good social relations, except where climate change is seen as affecting trust between countries and peoples (Hurlbert and Gupta 2015).

4.4.6 Cultural Services

Rainbow, surface and groundwater have positive influences on cultural services and enhancing human well-being. Grey and black water have limited influence on educational services; however, a thorough knowledge about their influence can contribute to human well-being. Cultural services can affect security where freshwater bodies marking state boundaries are affected by the uncertain

impacts of climate change, which may affect inter-state relations (López-Hoffman 2010; Sanchez and Roberts 2014; M. Young 2015). Cultural services may affect the quality of life by providing aesthetic and recreational options (Daniel et al. 2012). However, pollution, vector migration resulting from climate change and invasive species reduce water quality for recreation, biodiversity and tourism, and may reduce the value for disadvantaged/indigenous communities (Dallas and Rivers-Moore 2014). This may lead to weak social bonds due to the dispersion of communities, increase in climate refugees and enhanced inequality. The spiritual, recreational and cultural aspects of clean rainbow and blue water can enhance the feeling of well-being of people, facilitate social cohesion and mutual respect, and thereby contribute to the institutionalisation of cooperative mechanisms (Dellapenna and Gupta 2009: eds.).

Table 4.2: Ecosystem services of different kinds of freshwater

		Supporting Services	
Kinds of Freshwater	Provisioning	Regulating	Cultural
	Supporting hydrological cycle, transporting water (including vapor); climate regulation; water storage; enriching soil & erosion control; nutrient cycling of e.g. oxygen, carbon, nitrogen, phosphorous (Keys et al. 2012); habitat, primary production, photosynthesis (Alahuhta et al. 2013)		
Rainbow water	Huge storage of water on Earth; habitat for birds and insects	Climate regulation, hydrological regulation	Aesthetic (inspiration for art), spiritual (rain Gods/ Gods of thunder), inspiring knowledge)
Blue surface water	Fodder, clean water, food, hydropower, fish and aquatic life, navigation (Alahuhta et al. 2013)	Climate/hydrological regulation, sediments transport (Keys et al. 2012)	Recreational (fishing, boating), spiritual (water for religious activities) (Sarvilinna et al. 2012)
Blue groundwater	Clean water, food production, heated & cooling water for power plants, providing nutrients such as sulphate/nitrate (Carr and Neary 2008); supports land – extraction leads to land subsidence	Water purification, waste treatment, salinity regulation, climate regulation through CO2 leakage into groundwater (UNEP 2006)	Educational value, water for various religious ceremonies (UNEP 2006)
Green water	Fodder, food, pastureland, herbs and shrubs (Keys et al. 2012)	Evaporation (flowing downwind to later fall as precipitation); aquifer recharge (Keys et al. 2012)	Forests and landscapes for tourism, spiritual needs and education (Keys et al. 2012)
Grey water	vegetable & fodder production, energy production, mining (UNEP 2006), fire-engines, toilet flushing, preserving wetlands	Climate and water regulation, evaporation flowing downwind to later fall as precipitation (UNEP 2006)	Promotes tourism and education (UNEP 2006)
Black water	Fodder, insects & worms as birds' food	Spreads disease unless managed	Educational services regarding its negative effects
Frozen water / glaciers	Habitat for animals; storage of water	Albedo effect	Preserving data for humans, preserving life forms frozen in the past

Source: Hayat and Gupta 2016

4.5 ECOSYSTEM SERVICES AND HUMAN-WELLBEING

This section explains how human well-being can be potentially influenced by the ESS of different kinds of freshwater (MEA 2005; WHO 2013; WHO/UNICEF 2015). In the MEA framework, human well-being represents ‘_security’ (safety, security from disasters, safe access to resources); basic material for the ‘_good life’ (in terms of livelihoods, shelter, water, and food); ‘_health’ (in terms of physical power, feeling fit and having access to a safe and clean environment); and ‘_good social relations’ (e.g. respect for each other, strong social bonds, and the capability of helping others) (MEA 2005). All these enhance the freedom of choice and action (see Table 4.3).

Poverty is a multidimensional issue and can be defined as the distinct deficiency of well-being (McGregor and Pouw 2016). The definition, experience and expression of well-being, ill-being or poverty depends on the context, that reveals limited physical, social, and individual elements such as culture, gender, age, geography, and the environment. In all perspectives, ESS are crucial for human well-being for their provisioning, regulating, cultural and supporting services. Human interference in ESS can intensify the benefits to human society. In this vein, the idea of ‘_freedom of choice and action’ is relevant and is briefly explained in the following sub-sections according to its various components and how these components are affected by changes in ecosystem services due to a range of drivers.

4.5.1 Freedom of Choice and Action

Freedom and choices are fundamentally founded on the numerous other features of well-being and are shaped by changes in ecosystems in terms of biodiversity and supporting, provisioning, regulating or cultural services. Human well-being can be enhanced by promoting the sustainable interaction between human and ecosystems which are further sustained by essential institutions including technology, organisations, and instruments. Formation of such institutions through participatory approaches and transparency can add to freedom of choice and may also enhance social, ecological, and economic security.

4.5.2 Physical and Economic Security

Changes in provisioning services can put a stress on economic and human security that may directly disturb provisions of food, fish and other goods and may lead to conflict over resource degradation. Similarly, variations in regulating services can affect the scale and frequency of landslides, droughts, floods, or other calamities. Additionally, alterations in cultural services can also affect human and economic security, for example, the degradation of spiritual and ceremonial attributes of ecosystems can lead to fragile social relations within a community. Ultimately, these kinds of variations can influence freedom of choice, material wellbeing, health, security and good social relations. Ecological security can be defined as the minimum level of ecological stock necessary to ensure sustainable flows of different ESS. Nonetheless, the tangible benefits enabled by scientific developments and various institutions are neither automatic nor equitably shared. In addition, some advances in technologies and institutions can cover or intensify responsible governance and different environmental challenges. In this regard participative decision-making is a vital component of

governance accountability but it can be costly to sustain in terms of time and resources (Anggraeni et al. in press).

4.5.3 Good Life (Survival and Existence)

Provisioning services (production of fibre and food) and regulating services (natural purification of water) are crucial elements for a good life. Unequal access to these essential ESS can enhance the wellbeing of small segments of people at the cost of others who are denied access.

4.5.4 Health (Good Health and Enhanced Productivity)

Health has direct links with provisioning (production of fibre and food) and regulating ESS, including for example, those services that affect the dissemination of disease-transmitting pests as well as irritants and pathogens present in air and water. Recreational and spiritual benefits are another kind of cultural services.

4.5.5 Good Social Relations through Active Participation

Any changes in cultural services can affect social relations which are directly related to quality of life and human wellbeing. Table 4.3 links the impacts of the ESS of the different colours of water to human well-being. It is worth noting that although human well-being was stressed in the Millennium Ecosystem Assessment, the IPBES emphasises the concept of ‘more good life’ (Díaz et al. 2015).

Table 4.3: Impacts of ESS of different colours of water on human well-being

Well-being	Supporting Services																					
	Provisioning (PS)						Regulating (RS)						Cultural (CS)									
	R	Bs	Bg	Gn	Gr	BB	W	R	Bs	Bg	Gn	Gr	B	W	R	Bs	Bg	Gn	Gr	B	W	
Freedom of choice and action	+	+	+	+	+	±	+	+	+	+	+	?	?	+	+	+	+	+	-	-	+	Adequate resources ensure safe access; where resources are low, the possibility & safety of access is influenced.
	Security	PS are important for survival and livelihoods. However, pollution, salt water intrusion, salt concentration in soils, poor pollination and nutrient cycling affects food production; and oxygen depletion, acidic water bodies and river sediments suffocate aquatic life while sediments accumulate in the tissues of fish and shellfish. Affects related livelihood options.																				
Good Life	Good Life	PS are important for survival and livelihoods. However, increased water temperature, decreased dissolved oxygen (Dallas and Rivers-Moore 2014), increased pollutants and pathogens, and changes in water flows affect aquatic ecosystems and ESS (Nellemann 2009: p.2009).																				
	Health	Clean water essential for good health; but contaminated drinking water leads to diarrhoea and intestinal parasites (Dallas and Rivers-Moore 2014). Harmful for both aquatic organisms and humans.																				
Good Social Relations	Good Social Relations	Good quality water supports social cohesion and mutual respect; while poor and reduced quality of water can create social stress and mutual disregard.																				
	Health	Increased contaminants affect human health.																				
Well-being	Good Social Relations	To the extent that climate change is seen as affecting water quality, this can affect good social relations and trust between countries (Hurlbert and Gupta 2015).																				
	Health	The spiritual, recreational and cultural aspects of clean rainbow- and blue water can enhance the feeling of well-being of people.																				
Well-being	Good Social Relations	CS lead to social cohesion and mutual respect that have led to the institutionalisation of cooperative mechanisms through history (Dellapenna and Gupta 2009 (eds.)).																				
	Health	CS of water bodies provide aesthetic and recreation options. However, pollution, vector migration resulting from climate change and invasive species reduces water quality for recreation, biodiversity for tourism activities and the value for disadvantaged/indigenous communities (Dallas and Rivers-Moore 2014).																				

Source: Hayat and Gupta 2016

4.6 INFERENCES

This chapter (a) has shown that the direct drivers of poor water quality are agriculture, industry, households and demographic shifts. The indirect drivers include political drivers between and within states, culture and ethnic elements, non-water-related policies comprising poverty reduction policies and economic growth, the financial incentive of local industries, poverty of the local people, technological advances, international trade and climate variability and change and other natural factors. This implies that transboundary multilevel water governance needs to address the direct, if not, indirect drivers. This chapter (b) categorizes freshwater into atmospheric moisture, blue surface and groundwater, green water, white water, grey water, black water and. Further, (c) it demonstrates that each of these kinds of freshwater have different ecosystem services (see Table 4.2) with differential impacts on human well-being (see Table 4.3). These points imply that multilevel transboundary water governance requires to better understand the role of the different kinds of freshwater and their changing ecosystem services in order to achieve better management for human and natural purpose.