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Watershed Sustainability: An Integrated River Basin Perspective

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Definition

The current pressures exerted naturally and anthropogenically on water resources have repercussions on the sustainable development of ecosystem services provided by watersheds. The study of the theoretical framework of the Watershed Governance Prism (WGP), through the lens of the Duero River Basin (DRB) in Mexico, allows identifying which of the multiple perspectives of water governance present the greatest restriction among the rest of the perspectives related to adverse decision-making processes, critical sustainable development of water resources, and restraint environmental services. The association of the main problems of the DRB with the axes of the WGP demonstrates that the use of the WGP helps to identify the opportunities to promote the desired sustainable development. Consequently, these results offer a new assessment on how watershed issues can interact with the WGP thought the identification of perspectives to create and enable justice and equity in watershed sustainability.

Synonyms

Water governance; Water sustainability; Sustainable watershed management; Watershed management on water sustainability.

Introduction

Large-scale driving forces of change (e.g., urbanization, climate change, floods, and droughts) require effective public policies that reinforce the resistance of both human and environmental water systems to preserve the ecosystem services provided by watersheds (Alpuche Álvarez et al. 2021). Addressing these challenges will require

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coordinated efforts at macro and local levels, such as strengthening resilience and implementing environmental flows and policies to combat water pollution (World Bank 2018). The search for solutions to these challenges demands inter- and transdisciplinary approaches (Arrojo et al. 2005).

The need to develop a holistic approach for integrated water management was boarded in 1992 (Arrojo et al. 2005), and this approach incorporates social, environmental, cultural, institutional, and political aspects (Domínguez 2012). Additionally, achieving sustainable systems for resource management is not possible in the absence of effective governance (Arrojo et al. 2005). This integrated participation will allow better management of the resources of a watershed (Andrade-Pérez 2007; Nava 2013).

Watersheds are an accepted scale for water governance activities (Cohen and Davidson 2011), and currently, the evolution of water-environmental management approaches conducted by government agencies and scientific research groups nationally and internationally has been notable in literature. These theoretical frameworks include, from the highest to lowest order, Integrated Water Resources Management (IWRM; Savenije and Van der Zaag 2008), Ecosystem Approach to Health (Ecohealth; Lebel 2003), Water Framework Directive (WFD; Water Framework Directive 2000), Ecosystem Approach (EA; CBD 2014), Watershed Governance Prism (WGP; Parkes et al. 2010), and the Sustainability Wheel (SW; Schneider et al. 2015).

The objective of the present work was to analyze the theoretical framework of the Watershed Governance Prism (WGP) in the Duero River Basin (DRB) in order to identify which of the multiple perspectives of water governance present the greatest restriction (that is, is more problematic) among the rest of the perspectives, as a consequence of the deficiencies in the decision-making processes, reduced sustainable development of water resources, and environmental services of the watershed. The study also aims to identify which aspects of the prism (watersheds, ecosystems, social systems, and health and well-being) are neglected or overlooked.

WGP Framework and Study Area

The WGP is a contemporary conceptual framework that presents multiple facets of governance, characterizing water resources management linking social and environmental aspects with the social determinants of health in a watershed context. The WGP comprises four constitutive elements or vertices: watersheds, ecosystems, health/well-being, and social systems. The interaction between them forms six linear links: (1) ecosystems–health/well-being, (2) watersheds–ecosystems, (3) watersheds–health/well-being, (4) watersheds–social systems, (5) social systems–health/well-being, and (6) ecosystems–social systems. The interaction between the axes forms four surfaces that represent the different perspectives of water governance.

Perspective A comprises water governance for sustainable development (links: watersheds, ecosystems, and social systems).

Perspective B comprises water governance for ecosystems and well-being (links: watersheds, ecosystems, and health/well-being).

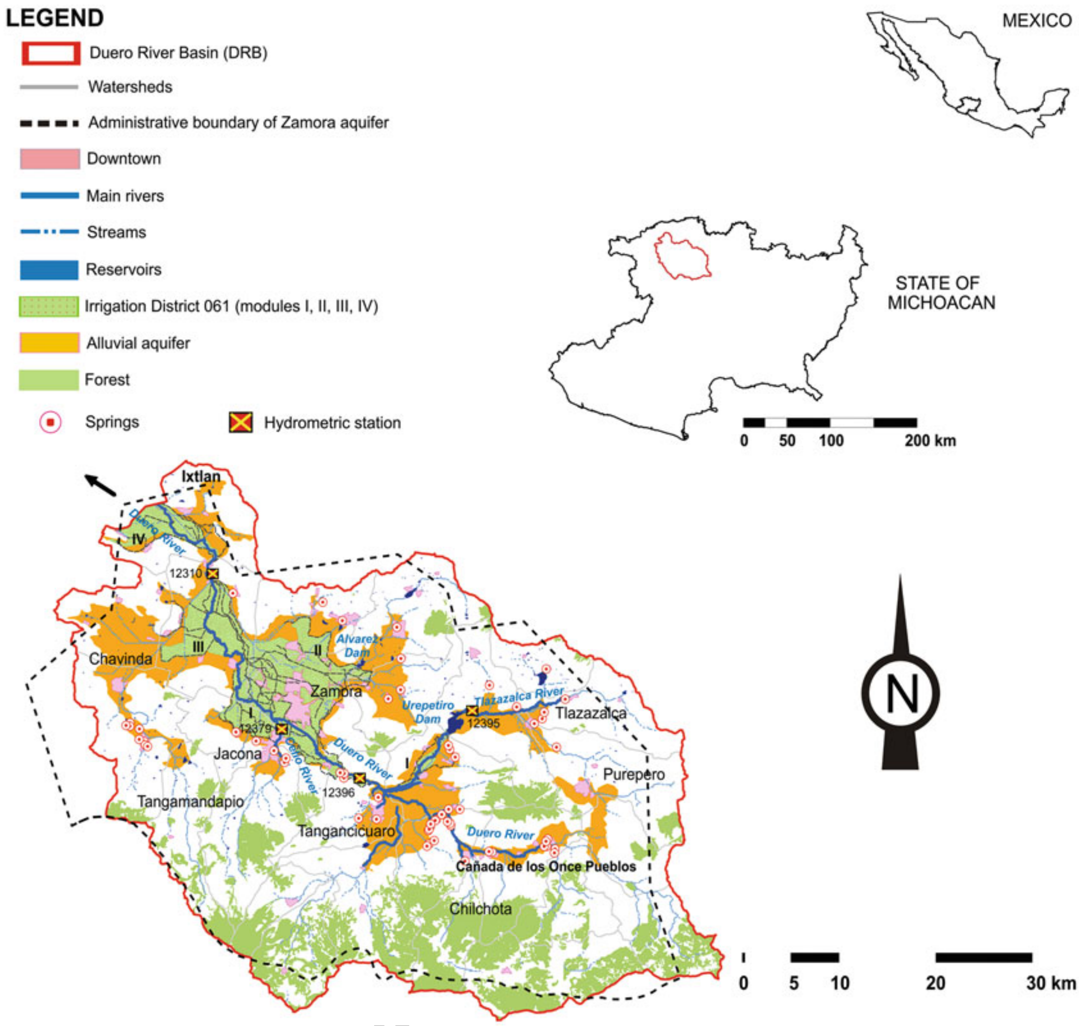
Perspective C comprises water governance for social determinants of health (links: watersheds, social systems, and health/well-being).

Perspective D comprises water governance for the promotion of socio-ecological health (links: ecosystems, social systems, and health/well-being).

Finally, integrating the four perspectives (A, B, C, D) makes up the WGP, facilitating integrated watershed governance and understanding between the four perspectives (Parkes et al. 2010).

The Case of the Duero River Basin

The DRB is located northwest of the state of Michoacan, Mexico (Fig. 1). It possesses a wealth of natural and water resources, such as rivers, lakes, springs, aquifers, pine and oak forests, and geysers. The aquatic biological diversity is represented by numerous fish and macroinvertebrate species. Additionally, there are places



Watershed Sustainability: An Integrated River Basin Perspective, Fig. 1 The Duero River Basin (DRB)

where people can enjoy recreational and cultural activities (ecosystem services), such as Lake Camecuaro National Park, La Beata hill, the Geiser de Ixtlan Recreation Center, and various spas, all of which are located in the Duero region, providing the opportunity to interact with the environment closely. There are also storage dams, a hydroelectric power plant (El Platanal), agricultural areas, canals, extraction wells, treatment plants, and drinking water systems, making up the hydraulic infrastructure. Moreover, this region provides water to a population of close to 400,000 inhabitants (Comisión Nacional del Agua-Instituto Politécnico Nacional (Conagua-IPN) 2009; Velázquez 2005; Velázquez et al. 2011).

Despite its natural wealth, the DRB faces adversities that affect the river flow regimes, river corridors, aquatic habitats, deforestation, erosion, land-use change for agricultural activities, introductions of exotic species, wastewater discharge into rivers, and the lack of wastewater treatment. Furthermore, the lack of technicalized irrigation, eutrophication in irrigation channels, loss of biodiversity, and degradation of water quality due to pollutants exacerbate water availability and accentuate the fragility of ecosystems. Additionally, there is increasing urbanization of river stretches, lack of specific sites for solid waste storage, and constant social pressure for improved water resources management (Conagua-IPN 2009, Velázquez 2005; Velázquez et al. 2011). In this order of ideas, the main topics that limit effective water governance in the DRB are mentioned below.

Discharge of Wastewater into the River Network

The Duero River receives direct discharges of residual waste from three main cities: Tangancicuaro, Zamora, and Jacona. The null register or appearance of collective enteric diseases suggests that the water dilutes pollutants, which is an important task, in addition to the retention or filter action that the soil exerts on pollutants. However, studies are needed on the degree of survival of enterobacteria in agricultural soils, the proportion of bacteria that pass into vegetables due to irrigation using wastewater, and the incidence of diseases in farmers who use this polluted water. Urban areas, such as Zamora and Jacona, add pollution derived from industrial, agro-industrial, and service activities. Moreover, the irregular settlements located on the banks of springs and rivers (Tangancicuaro and Chilchota) add to the pollution problem. The sewage discharge into rivers exists due to the lack of regulation on discharges and functional, operational infrastructure for its treatment (Velázquez 2005).

Lack of Wastewater Treatment

The sanitation system in the region is represented by sewage and drainage services, which generally discharge into agricultural irrigation infrastructure. Although they have low-efficiency levels, some populations have treatment plants (the municipality of Zamora being an exception, operating at 90% of the total volume of wastewater generated; Velázquez 2005). In Jamanducuaro (Tlazazalca) and Atacheo (Zamora), wastewater treatment is supposed to be done using an Imhoff tank and oxidation lagoon, respectively, both of which are not operating. However, two treatment plants – the Anaerobic Reactor of Carapan (BOD 30%) and Extended Aeration System (EAS) in the Zamora supply region (FC, 90%) – have variable efficiency in terms of removal of biological oxygen demand (BOD) and fecal coliforms (FC), respectively. The installed treatment capacity in the EAS is 6 l/s with a treated flow rate of approximately 4–6 l/s. Finally, Zamora has another treatment plant that operates through a stabilization lagoon system (FC, 99%; BOD, 72%) with a capacity of 330 l/s (Pimentel et al. 2011; Velázquez 2005).

Shortage of Water in the Watershed Localities

With regard to water supply and scarcity, Pimentel (2007) identified some localities that suffer from low water availability for primary consumption. While La Labor does not have a potable water service, in La Sauceda, Rinconada, and Romero de Torres (in the same municipality), there is well water supply every third day, lasting 3–10 h, while in Atacheo and Ojo de Agua, there is daily well water supply (managed by each community) lasting 1–3 h. All these localities are within the municipality of Zamora. In La Luz, El Valenciano, and El Limon localities (in the municipality of Ixtlan), there is a daily well water supply lasting 3–8 h, although the water presents boron problems. All these communities live under stress due to the short duration of the water supply and the high electricity cost. Some communities also have legal disputes over the distribution of water volumes: for example, the municipality of Zamora consumes 180 l/s of the Del Bosque spring (in the municipality of Jacona), but only 60 l/s arrive during the day (Velázquez, 2005).

Aquatic Ecosystems Affected by Environmental Degradation

Karr (1981) argued that fish quantity and biodiversity are good indicators of environmental quality. Moreover, anthropogenic activities (such as water extraction for irrigation, loss of river continuity due to barriers, and wastewater discharges) increase and endanger the existence of some fish species, subsequently affecting the environment. The most stressful time for the ichthyological community is the dry season (from January to May) due to the natural decrease of river flows. For example, from 2000 to 2012, some identified species such as *Menidia jordani* still preserve their "tolerant" status, while in the Cyprinidae family, the status of *Algansea tincella* changed from “tolerant” to “moderately tolerant,” and the status of *Aztecula sallaei* changed from “moderately tolerant” to “sensitive”; *Goodea atripinnis* maintains a “highly tolerant” status, but *Alloophorus robustus* changed from “moderately tolerant” to “sensitive” (Ramírez-Herrejón et al. 2012; Lyons et al. 2000; Mercado-Silva et al. 2006).

Influence of Human Activity on Water Bodies

López-Hernández (1997) identified the central to lower part of the DRB as having the lowest biological index values, qualifying the waters as contaminated and with less capacity for self-purification. Moncayo-Estrada et al. (2011) have highlighted the necessity of maintaining good water quality in the rivers of the DRB. Subsequently, Moncayo-Estrada et al. (2015) evaluated the biotic integrity index to compare it with previous years (1986, 1991). They found that the Etucuaro region has retained its “regular” condition, while Lake Camecuaro changed from a “good” to “regular” status; additionally, the El Platanal watershed status was “poor” and that of Zamora, La Estanzuela, and San Cristóbal “A” changed from “regular” to “poor.” Bacterial contamination was also found from the Cañada de Los Once Pueblos to the limits of the Zamora valley, except for the Carapan and Camecuaro springs (Velázquez 2005).

The Use of the Irrigation District

The irrigation district (ID-061) presents various issues, such as the loss of cultivation areas due to urbanization, water scarcity, irregular settlements in canal maintenance areas, urbanization in river stretches, flooding, changes in land use, disabling canals by the presence of subdivisions, differences between irrigation modules, and lack of civic culture. Furthermore, as the hydraulic gradient descends along the Duero River, water quality decreases. For example, sewage limits the cultivation of higher-value fruits and vegetables (such as strawberries), as Irrigation Modules II and III users receive water from the river already contaminated with drainage and other discharges based on their location. However, when the river crosses Module IV (located in the lower zone, toward the DRB boundary), it has already received all the upstream discharges, necessitating higher expenses in the production processes (Velázquez 2005).

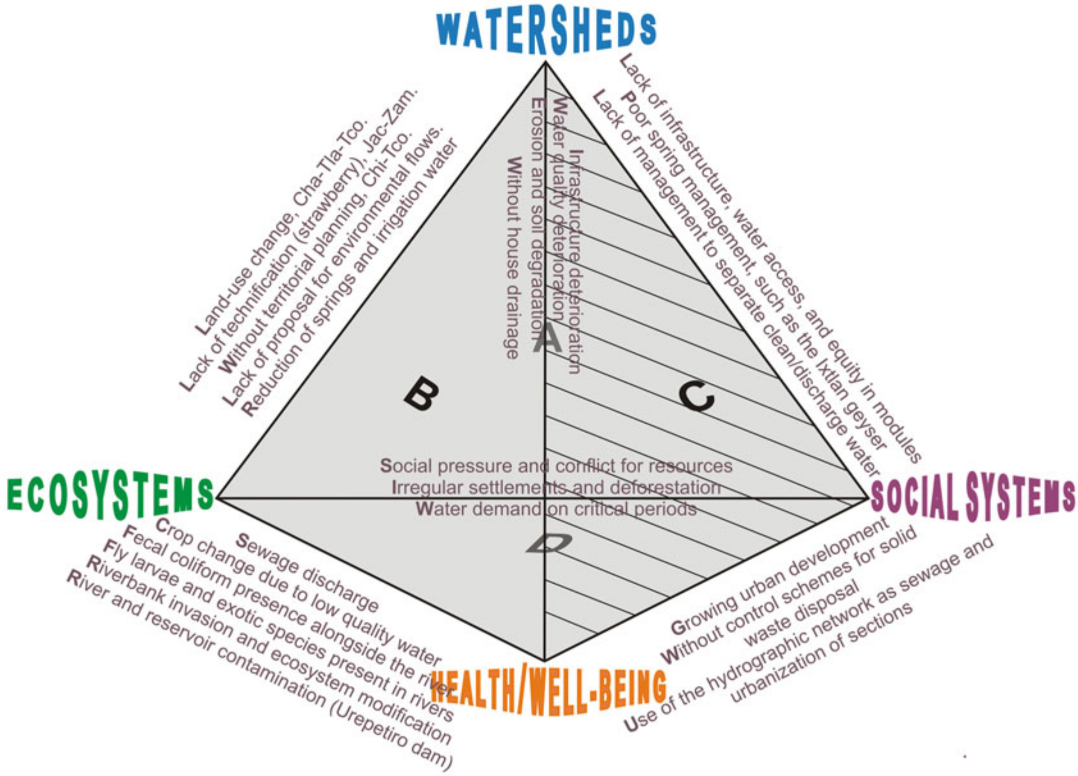
Limitation of Multilevel Governance

An analysis of a key actors’ map of the three levels of government (federal, state, and municipal), local organizations and associations, agricultural producers, and irrigation modules, among others, for the management of watershed resources, revealed no links between them despite being in the same region (DRB). However, some information flows are fed back to the rest of the actors in the watershed. Thus, it is necessary to identify and formulate mechanisms that promote social participation. Regarding the three government levels, it is also necessary to develop and strengthen the institutional image and revise cross-cutting public policies (Conagua-IPN 2009). These topics contribute to the loss of ecosystem capabilities and water quality degradation (Velázquez 2005), putting the socioeconomic development of the watershed at risk. Consequently, it is vitally necessary to halt these adverse conditions (Moncayo-Estrada et al. 2015).

Just as the prism axes can be interpreted as isolated links, the perspectives of the prism can be interpreted as a union or integration. Subsequently, we can take advantage of this quality of the prism to associate the perspectives with the proposals formulated for the improvement of the sustainable development of water resources and the watershed. These improvement actions were identified from technical studies made by Conagua-IPN (2009) and Velázquez (2005).

The DRB Under the WGP Framework (Axis Analysis: The Relationship Between the Vertices)

Figure 2 illustrates the connection between the representative problems of the DRB and the links between the six axes of the WGP. According to Bunch and Waltner-Toews (2015), not all the prism axes will be identified as important in each situation, but by identifying the line of problems



Watershed Sustainability: An Integrated River Basin Perspective, Fig. 2 Link between the axes of the WGP, and the issues of the DRB. Municipalities: Jacona (Jac), Zamora (Zam), Chilchota (Chi), Tangancicuaro (Tco), Tlazazalca (Tla), Tangamandapio (Tmp), Chavinda (Cha), and Ixtlan (Ixt). Prism adapted from Parkes et al. (2010) and modified with information from Conagua-IPN (2009) and Velázquez (2005)

and developing a description, the prism can provide information about the search for the problem.

The most common issues arising from failures in water governance, related through the WGP, are as follows:

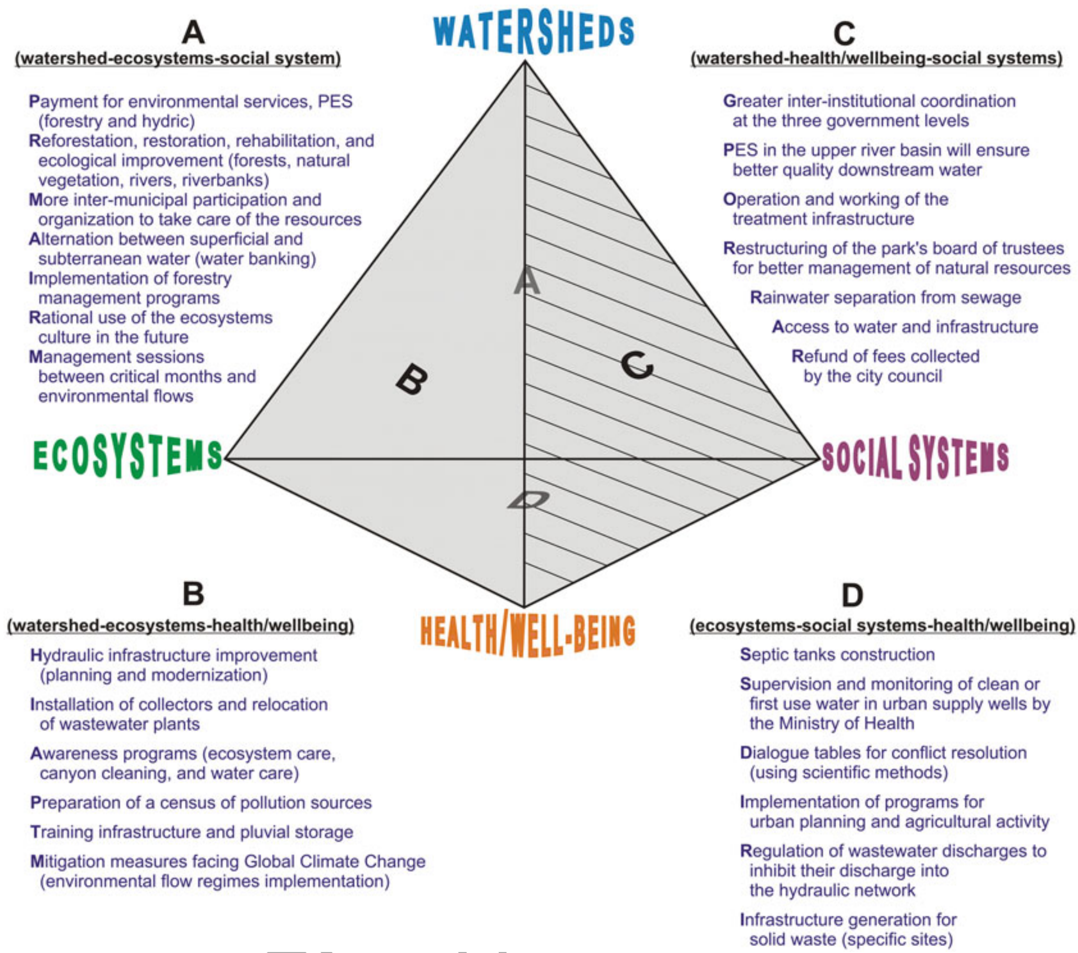
1. Ecosystems and health/well-being (Parkes et al. 2010). As there is no site in the hydrographic network that can escape wastewater pollution, the wastewater problem has serious consequences for public health (Velázquez 2005). The chemical composition of groundwater in the watershed demonstrates high concentrations of toxic elements such as boron (B) and lead (Pb) (Velázquez et al. 2011). Pb in groundwater is probably related to volcanic origin materials such as siliceous sands (Inocencio-Flores et al. 2013). As groundwater is meant for domestic and urban use, it is necessary to perform a detailed analysis of the chemical, physical, and microbiological composition in the sources detected to prevent potential health issues. For example, crop change, exotic species introduced in the river, and the loss of vegetation in banks are all issues caused by water quality degradation (Conagua-IPN 2009).
2. Watersheds and ecosystems (Parkes et al., 2010). Proposals are needed to implement environmental flow regimes. Because of poor infrastructure and lack of governmental financial support, the lack of irrigation technology causes great difficulties that prevent irrigation modules from achieving financial self-sufficiency (Velázquez, 2005). The lack of territorial planning caused by changes in land use (Conagua-IPN 2009) is evidenced in streambed regulation, degradation of slopes, flow

rate, channeling, and alterations in river morphology, all of which are mainly caused by agricultural activity.

3. Watersheds and health/well-being (Parkes et al. 2010). Some populations have wastewater treatment plants, although most operate with low levels of efficiency. The sanitation system is represented by sewage and drainage services that regularly discharge waste into the river, which end up in the irrigation infrastructure. For example, the Dren Chavinda drain and the Ixtlan municipality drainage system are connected to the Duero River. Dams and hydraulic infrastructure suffer from deterioration and flooding. In the wet season, Dren Chavinda risks overflowing, and there are mosquito outbreaks (Velázquez, 2005). Only 19 springs (that supply the population) benefit from conservation efforts, while 26 others do not have a similar program (Zavala-López 2011).
4. Watersheds and social systems (Parkes et al. 2010). Module I (ID-061) has a natural supply from the Orandino and Tamandaro springs, with adequate water quality and quantity. However, Module IV (downstream from the Duero River) receives wastewater and discharges from the Zamora-Jacona conurbation. The advantage in Module I is that many of its farmers can reach an insured market with agribusiness companies closing the production-marketing cycle. Regarding water access, 17% of the population (out of 402,698 inhabitants in 2000) did not have tap water access (Velázquez 2005); moreover, the financial situation of ID-061 has deteriorated, and there is no local investment in local projects to improve water management (Conagua-IPN 2009).
5. Social systems and health/well-being (Parkes et al. 2010). Landfills and leachate generation present an infiltration risk into the aquifer (Velázquez 2005). In the DRB, there are 13 final disposal sites without control schemes (unprotected landfills); one is found in the municipality of Zamora (Conagua-IPN 2009). In 2009, the DRB region had 447,324 inhabitants who generated solid waste of 0.72 kg/hab/day. Of the amount of urban solid waste generated, only 70% is collected for disposal in respective landfills, with the rest being dispersed in the environment. The accumulation of solid waste on riverbanks and tributaries is a common sighting (Conagua-IPN 2009), posing great risks to public health.
6. Ecosystems and social systems (Parkes et al. 2010). Pimentel et al. (2011) stated that conflicts between communities over water allocations have worsened due to the claim of some municipalities (mainly Zamora). They proposed that municipalities with resources (Tangancicuaro and Jacona) purchase water from their springs. However, agricultural users have prevented these requests from being fulfilled. The physical and chemical properties of the spring water in this area exceed the wells' water quality in Zamora; thus, it is more important (Conagua-IPN 2009); moreover, there is great demand for water in critical periods (dry season).

Figure 3 illustrates the improvement actions proposed for the desired sustainable development in the DRB.

Perspective A: Water governance for sustainable development (linking watersheds, ecosystems, and social systems; Parkes et al., 2010). Payment for ecological services (PES) in the upper watershed has been proposed to counter clandestine logging. Sites in forests, sections of rivers, and riverbanks that require reforestation and restoration and ecological improvement programs should be identified and evaluated to achieve beneficial impacts related to erosion and soil recovery, increase aquifer recharge, capture CO_2, and facilitate local biodiversity recovery. The modernization of agricultural activities will optimize water use (Conagua-IPN 2009; Velázquez 2005). Modernization in the hydro-agricultural infrastructure and technification of the agricultural surface can be realized in coordination with users and local authorities. This initiative comprises the exchange of 5 Mm3 of surface water for 5 Mm3 of groundwater. This



Watershed Sustainability: An Integrated River Basin Perspective, Fig. 3 Prospects of the WGP with proposals aimed at promoting sustainability in the DRB. (Prism adapted from Parkes et al. (2010) and modified with information from Conagua-IPN (2009) and Velázquez (2005))

being the highest quality water, it will increase produce exports to international markets (Jiménez 2011).

Perspective B: Water governance for ecosystems and well-being (linking watersheds, ecosystems, and health; Parkes et al. 2010). Proposing environmental flow regimes (EFR) in the DRB can serve as a mitigation measure against the pressure of climate change. These flows can continue to maintain and preserve the functionality and structure of ecosystems and the environment (habitats, banks, and aquifers), in addition to increasing resilience and reducing the loss of ecological integrity. Armas-Vargas et al. (2017) made an EFR proposal based on the physical habitat simulation method, using the Physical Habitat Simulation System (PHABSIM) model. However, more planning is required, especially concerning developing a pollution source roll due to wastewater discharges. A decrease in the concentration of fecal coliforms has been observed in the upper and middle part of the DRB (between Chilchota and Tangancicuaro) due to the contributions of springs (Conagua-IPN 2009; Velázquez 2005).

Perspective C: Water governance for social determinants of health (linking watersheds, social systems, and health; Parkes et al. 2010). It is necessary to continue promoting social participation in the decision-making process because water plays a fundamental role in all aspects of public and private life. The Duero River Basin Commission (DRBC) can organize a joint coordination effort for sanitation actions (Pimentel et al. 2011). There are projects underway to reopen and operate abandoned treatment infrastructure, access to drinking water, and sewer coverage. As there are communities governed by consuetudinary law, it is necessary to continue motivating and encouraging them to use the drainage infrastructure. Payment through economic compensation is recommended to avoid the use and pouring detergents into the river (Conagua-IPN 2009; Velázquez 2005).

Perspective D: Governance for socio-ecological health promotion (linking ecosystems, social systems, and health; Parkes et al., 2010). The use of septic tanks in small towns should be promoted (Velázquez 2005). Inocencio-Flores et al. (2013) and Velázquez et al. (2011) confirmed the presence of contaminants in water sources (wells and springs). Additionally, it is convenient for a third party (Ministry of Health) to supervise and monitor water quality at the sources identified. Pimentel et al. (2011) suggested analyzing bacteriological and other contaminants, such as heavy and organic metals. To protect the environment and public health, direct discharge into the river watershed network should be avoided and treatment systems reactivated. It is also important to establish solid waste deposit sites (Conagua-IPN 2009) and canyon cleaning programs by involving citizens and encouraging state participation (Velázquez 2005).

A Threefold Discussion

Good and Bad Water Governance

Much more is known about bad governance than good governance (Rogers 2002). From our interpretation, Fig. 2 illustrates that the DRB is undergoing a crisis, which is reflected (or diagnosed) by the various issues facing watershed resources. According to Nava (2013), this crisis will persist until governance is renewed, innovated, and adapted at the watershed level. For De Carvalho and Angulo (2014) and the Water Governance Facility (2016), if there are insufficient human and financial resources, lack of investment funds, inadequate or deficient management of resources, bureaucracy, corruption, and water organizations that do not contribute to the formulation of public policies, there will be poor water governance, making it impossible to solve or even identify the cause of water problems. According to Pahl-Wostl (2009), most resource management problems originate from governance failures. The presence of these symptoms in the DRB makes sense when, in the local press, the municipalities of the watershed are regularly exhibited and urged to participate and join efforts to achieve the sanitation of resources by calling on local and federal authorities to integrate and stop pollution from wastewater discharge into the rivers and canals of the DRB. After a decade of deliberations and negotiations, in 2017, the work of the DRBC was resumed to resolve some of the present issues (lack of financial resources to build treatment plants and conduct sanitation actions), in addition to the creation of a trust with contributions from governance actors. Figure 2 illustrates four perspectives representing different types of water governance, where we observe relatively more issues in the axis composed of ecosystems and health/well-being, followed by the watersheds and ecosystems axis, and the watersheds and health/well-being axis. The prism indicates a priori that water governance for ecosystems and well-being (referred to in Perspective B) is currently identified as the most problematic compared to the other perspectives (D, A, and C) and, together, impact the resilience of the water-environmental resources of the DRB.

The results demonstrated that the governance of water for ecosystems and well-being (Perspective B) is the governance with the most issues in the DRB. The study carried out by Bunch et al. (2014) concluded that out of a sample of 100 articles reviewed, the study of Perspective B was dominant over the rest of the perspectives of the prism. This implies that the scientific community prefers to focus on issues related to eco-hydraulic and hydrological aspects of the watershed, as well as environmental and watershed management. According to Parkes et al. (2010), when attention is focused on Perspective B, the vertex that can be overlooked is that of social/equity issues. As Pimentel (2007) pointed out, there are still DRB communities where the drinking water service is intermittent or every third day, and high-energy costs lead to inequality. Additionally, there is an increasing urban development; lack of infrastructure, access to water, and household drainage; shortages; irregular settlements; poor management of separating rainwater from discharges further; and conflicts and social pressures for water resources.

Pimentel et al. (2011) highlighted conflicts between communities over water allocations. However, reducing wastewater discharges to the river network is more of a priority than reducing water shortages in the localities of the basin (not to mention the stress and low availability to which they are subjected). The problem of the discharge of wastewater without treatment in the hydraulic network has existed for more than 20 years, with implications for human health, as well as economic effects for irrigation modules downstream of the Duero River, in addition to the degradation of river ecosystems. For example, if farmers located downstream of the Duero River want to grow strawberries and use the river's water (as an ecosystem service), they would not market their products in the same way due to the degradation of the quality of the river water. Consequently, there is unequal competition among farmers who grow strawberries with high-quality water from a well or spring, presenting a greater economic advantage when marketing their products. Conagua-IPN (2009) and Velázquez (2005) observed that the main problem of ID-061 is that it is located within urban areas receiving municipal discharge. An attempt to solve this problem was made with the construction of treatment plants, most of which do not operate. However, the organizations' performances have been insufficient in sanitizing the water in the watershed, and there have been high levels of bacteriological and chemical contamination (Pimentel et al. 2011).

For Hurlbert and Diaz (2013), the limitations are related to the existence of neoliberalism, which is characterized by the limited role of the state in the economy and an active and enthusiastic role of the private sector as the main engine of economic development, with superfluous attention to environmental issues, and considering water as a market product or a privately owned good. For Rogers (2002), if water resources are excessively managed through private markets, only those with higher incomes will have access to water. However, if it is administered by public authorities, it is also not certain whether there will be equal water access. For this reason, we understand that bad practices in water governance depend on decision-making. For Batchelor (2007), water governance encompasses how allocation and regulation policies are exercised in water management. For example, in the first months of 2015 in Mexico, the emblematic case of privatizing water emerged in the national public press, making modifications to the National Water Law. The considered measures that were planned, such as mega aqueducts, intensive use of surface and underground resources, and fracking, caused social discontent, in addition to the scandal experienced by the highest authority of the water agency (Conagua), due to questions against it about direct allocations (without tenders), conflict of interest, and lack of experience in management, among others. For these reasons, water users distrust the terms privatization and neoliberalism, as corruption and unethical practices are still present in decision-making, with the repercussion on water governance.

To achieve good governance, negotiation; agreements for water use, clear and transparent regulations; the recognition of rights, obligations, roles, and responsibilities (De Carvalho and Angulo 2014); access to information; cooperation between stakeholders; accountability; recognition of water uses and customs; and collective decision-making (Domínguez 2012) are all necessary. Good governance is fundamental for improving access to water and sanitation services, ensuring the sustainable and equitable use of water resources, and expanding the provision of sanitation and drinking water supply services (Stockholm International Water Institute [SIWI] 2015). In general, without good water governance, it will not be possible to achieve long-term water security (Tortajada 2010). For the Water Governance Facility (2016), effective governance of water resources will be key to achieving the fair allocation of water resources and conflict resolution. In 2019, a wastewater discharge dispute arose surrounding Lake Camecuaro, one of the main ecotourism attractions of the DRB (municipality of Tangancicuaro). After a year of negotiations and management efforts between the municipal and state governments, a wastewater treatment plant and a sanitary sewer were installed to guarantee the sustainability of the water bodies and their interaction with adjacent ecosystems. Government authorities must ensure the correct application of their normative base not solely by raising fines, as according to Lebel (2003), the health of the ecosystem is equal to human health.

Figure 3 illustrates some of the proposed actions derived from good governance in the DRB. These include various developments and dialogue between multiple stakeholders. For example, Perspective A highlights the PES, as well as the alternation between surface and groundwater. Perspective B highlights the modernization of hydraulic infrastructure, as well as a pollution source registry. Perspective C highlights greater transverse and horizontal coordination, as well as access to water and infrastructure. Finally, Perspective D highlights the construction of septic tanks and the integral management of solid waste (at specific sites). According to Parkes et al. (2010), the WGP has the property of unifying different perspectives of water governance to facilitate integrated watershed governance. At the end of 2007, the DRBC was created to improve water management, develop hydraulic infrastructure, increase the environmental recovery of the watershed, and contribute to the conflict resolution associated with competition between water uses and water users. The DRBC integrates various governance actors, allowing sanitation action and coordination. These interactions promote and facilitate water governance in the watershed, whose purpose lies in managing water resources and providing water services.

Participation in Water Governance

The water crisis has motivated governance actors to participate and organize strategies to achieve sustainability and balance in the watershed. This has led to a consensus among the actors to assess and organize the watershed, and related ecosystems before environmental threats and adverse risks appear, with consequences for socioeconomic well-being. For Pimentel and Velázquez (2015), the participation of landowners and communities is essential in making decisions about water management due to their extensive knowledge and operations in the territory. The creation of organizations such as the Duero River Basin Commission (DRBC), according to Nava (2013), allows actors to reaffirm their willingness to work together for the integrity of ecosystems, preserve the traditional way of life, and promote societal participation in decision-making. For Pimentel et al. (2011), although the formation of the DRBC is an important step, it does not guarantee the sustainable management of water resources due to extensive bureaucracy and little social participation.

Society can increase its participation in protecting the environment in many ways. According to the Ottawa Charter (WHO 1986), this is possible through the empowerment of people by increasing their control over their health, thereby improving it and creating favorable environments for health promotion. This can also be done by developing public policies to strengthen the community's socio-ecological environment and requiring the designated authorities to fulfil their obligations and responsibilities. Similarly, financing is essential for the implementation of programs. According to Pimentel and Velázquez (2015), the DRBC does not have an operational budget for buildings and infrastructure projects, as its budget covers management, studies, and conciliation.

To Warner (2005), as the population size in most cities, towns, and municipalities prevents the direct participation of all stakeholders in decision-making at the watershed level, participation is not a simple task. Furthermore, the question of who represents the large groups of stakeholders is highly politicized. For example, in the DRB for more than a decade, the local press has been following the meetings, which have presented disappointing results, urging the participants to join forces and work decisively to achieve common long-term benefits, such as the sanitation of the Duero River, a constant concern for water actors. Peters and Pierre (2002) argued that all negotiation implies discussion and divergent interests among the participants. For Warner (2005), a multi-stakeholder dialogue is not just a conversation but also an interactive approach to meet and interact in a forum for conflict resolution, negotiation, and collective decision-making, seeking consensual solutions through mutual understanding. Legal, political, or bureaucratic concerns also limit the negotiations of multiple stakeholders. In the case of the DRB, various actors have been participating due to their concern for the environment. For example, strawberry producers in the Zamora Valley, faced with the need for high-quality water for agriculture and to comply with international market regulations, carried out a study coordinated by Velázquez (2005) that addresses the problem of wastewater in the Duero River.

Van Buuren et al. (2019) classify this participation as "Project-oriented initiatives," in which stakeholders/citizens mobilize to develop their own project proposal, challenging government decision-making. However, due to the requests and demands established by users of the DRB's water resource, a collaboration agreement was established between the National Water Commission and the National Polytechnic Institute, Michoacán Unit, to carry out the Comprehensive Sanitation project of the Duero River Basin (Conagua-IPN 2009). Van Buuren et al. (2019) refer to this participation as "Capacity-driven participation," where interested parties are invited to participate and strengthen the capacity of governance and empower stakeholders through collective action. Pimentel and Velázquez (2015) propose integrating four watershed level into the DRBC, where peoples and communities can participate, thus allowing direct and accurate information on resource issues, generating rapid diagnoses for decision-making.

The Prism as a New Opportunity for Integration

The issues and initiatives of the DRB, presented through the WGP, interact in the vertices of the prism. The simple structure of the WGP justifies linking the issues with the axes and the solution actions with the prism perspectives. The DRB-WGP interaction allows us to visualize the issues interacting with other prism environments (ecological, health, and socioeconomic) and identify which perspectives are limiting or restrictive for integrated watershed governance. In the same way, in the four perspectives of the prism, the actions that will be implemented in the watershed are visualized through the different types of water governance, which, applied together, can produce improvements in the DRB in the short and long term. The concentration of the issues identified in the WGP allows us to suggest the following governance restricting order, starting with the governance of water for (1) ecosystems and well-being, (2) promotion of socio-ecological health, (3) sustainable development, and (4) the determinants of social health (Perspectives B, D, A, and C, respectively). Among the vicissitudes in the DRB, polycentric governance is practised due to the verticality between organizations (Conagua-Basin Council-DRBC); participatory horizontality between municipalities; and transfer of operations, conservation, and management of ID-061 to the users of the irrigation modules. For Parkes et al. (2010), the WGP proposes a shift toward the integrated governance of watersheds as a basis for fostering health, sustainability, and social-ecological resilience.

It would be interesting to incorporate the direct participation of the governance structure into this study to identify the degree of support or obstruction towards various adaptation actions, using the Water Governance Assessment Tool (WGAT) (Bressers et al. 2013). The analysis of organizations – such as the Conagua, the Lerma-Chapala Basin Council, the Duero River Basin Commission (DRBC) – and agency bodies – such as municipalities, water operating agencies, water users' committees, indigenous communities, and irrigation modules – could be of help to better understand why problems such as wastewater discharge are caused or accentuated by the lack of treatment, water services, or environmental protection.

Conclusions

Through this study, the WGP has allowed us to link various watershed issues with the prism axes and propose various solutions for watershed sustainable development from the prism perspectives, moving from an isolated (traditional) vision to an integrated perspective. This led to identifying the most relevant issues (symptoms) of the DRB, which are mainly concentrated in the ecosystem–health/well-being axis, followed by the watersheds–ecosystems and watersheds–health/well-being axes, and to a lesser extent on the remaining axes. This demonstrated that Perspective B, the governance of water for ecosystems and well-being, is the main limiting perspective generating failures in water governance. Likewise, Perspectives D, A, and C are gradually contributing to the water crisis in the DRB, consequently hindering integrated watershed governance. In other words, Perspective B requires the highest priority or attention when initiating improvement actions to achieve the desired sustainable development in the DRB, requiring decision-making for proposals or alternative solutions indicated in each perspective of the WGP-DRB. With this analysis applied to the DRB, it was also possible through the theoretical framework of the WGP to identify that the social systems vertex overlooks social and equality problems, such as houses without drainage services, direct access to water, or electrical power.

This entry offers a different perspective on how the issues in the watershed can interact with the WGP, contributing to the identification of perspectives that generate ineffective water governance practices and proposals or improvement initiatives that generate effective practices in water governance aimed at mitigation, improving resilience, and the sustainable development of the watershed. This is analogous to a medic consultation, where there is a symptom analysis, followed by a diagnosis and then a treatment plan for the symptoms, and more importantly, the disease.

Cross-References

- Sustainable Development Goals (An overview of the interconnected relationship of SDGs and urban and regional development).
- Water conservation and efficiency (Encouraging water-efficient agricultural and industrial processes).
- Water security (what is water security? And its role in achieving SDG 6).

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