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Evaluating Environmental Law Effectiveness in Water Protection and Pollution Reduction: Lessons from Brazil, Germany, and India (1995-2007)

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Master's in Development Studies

Supervisor: Maria Inês Gameiro, Associate Professor  
ISCTE - Lisbon University Institute

October, 2025



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E HUMANAS

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Department of Political Economy

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## **Acknowledgements:**

To my parents, Claudia and Ricardo, who religiously took me to the beach and taught me to appreciate and respect water. They always wanted me to see for myself how vast the planet is, and in trying, I discovered that despite our differences, there are things that unite us all - water is one of them.

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To my friends in Uruguay, who have always inspired me and given me strength to pursue my dreams. To my friends in Lisbon, for making this city a home for me.

Water and time are finite; let us make the best of them while we have them.



**Resumo:**

Este texto examina a eficácia dos marcos nacionais de proteção e gestão dos recursos hídricos no Brasil, Alemanha e Índia, implementados entre 1995 e 2007, período caracterizado pela intensificação da atenção global ao desenvolvimento sustentável e aos princípios da Gestão Integrada dos Recursos Hídricos. O foco é avaliar como os três sistemas jurídicos selecionados, que emergiram de trajetórias históricas, políticas e económicas divergentes, bem como de condições geográficas e de recursos hídricos distintas, converteram legislações ambiciosas em resultados concretos. Através de uma análise comparativa, são utilizadas fontes primárias (leis nacionais, relatórios governamentais e internacionais e conjuntos de dados sobre a qualidade da água) e literatura secundária para avaliar a eficácia da implementação e da aplicação da lei, na perspectiva do construtivismo institucional.

O estudo conclui que a eficácia da legislação ambiental depende não só de um desenho legislativo abrangente e progressivo, mas também da garantia de instituições coordenadas e responsáveis, de medidas focadas na prevenção, participação e apropriação social a longo prazo e de ciclos adaptativos integrados com recolha de dados adequada. Apesar das inúmeras diferenças entre estas três nações, as conclusões da avaliação mostram que a eficácia é sempre dinâmica e pode ser aumentada através da constante recalibração entre o direito, a ciência e a sociedade. Estas lições oferecem insights práticos para os decisores políticos e académicos que procuram reforçar a governação ambiental num elemento absolutamente essencial - em primeiro lugar, para a nossa existência e, em segundo lugar, para o nosso desenvolvimento.

**Palavras-chave:** Proteção da água; Estrutura nacional; Sistemas jurídicos; Instituições; Eficácia; Gestão integrada; Responsabilidade; Desenvolvimento sustentável; Governação da água; Ciclos adaptativos



**Abstract:**

This paper examines the effectiveness of national water protection and management frameworks across Brazil, Germany and India introduced between 1995 and 2007, a period characterized by intensified global attention to sustainable development and to the principles of Integrated Water Resource Management. The focus is on assessing how the three selected legal systems, which emerged from divergent historical, political, economic trajectories, as well as water resources and geographical conditions; converted ambitious legislation into outcomes. Through a comparative analysis, primary sources (national laws, government and international reports and water-quality datasets) and secondary literature come together to help assess the effectiveness of implementation and enforcement, through the lens of institutional constructivism.

The study concludes that environmental law effectiveness depends not solely on comprehensive and progressive legislative design, but also on ensuring coordinated and accountable institutions, prevention-focused measures, long-term societal participation and ownership, and embedded adaptive cycles with appropriate data collection. Despite the myriad of differences across these three nations, the findings of the assessment show that effectiveness is always dynamic, and it can be increased through constant recalibration between law, science, and society. This lessons offer practical insights for policymakers and scholars seeking to strengthen environmental governance on an element that is absolutely essential - firstly, to our existence, and secondly, to our development.

**Keywords:** Water Protection; National Frameworks; Legal Systems; Institutions; Effectiveness; Integrated Management; Sustainable Development; Environmental Governance; Adaptive Cycles

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## **Glossary of acronyms:**

**UN** - United Nations

**FAO** - Food and Agriculture Organization of the United Nations

**SDG** - Sustainable Development Goal

**MDG** - Millennium Development Goal

**EU** - European Union

**EIA** - Environmental Impact Assessment

**BOD** - Biochemical Oxygen Demand

**DO** - Dissolved Oxygen

**FC** - Fecal Coliform

**NWF** - National Water Framework

**TCA** - Amazon Cooperation Treaty

**IWRM** - Integrated Water Resources Management

**WWTP** - Waste Water Treatment Plant

**STP** - Sewage Treatment Plants

**PoM** - Program of Measures

**ANA** - National Water and Sanitation Agency / Agência Nacional de Águas e Saneamento Básico (Brazil)

**CNRH** - National Water Resources Council / Conselho Nacional de Recursos Hídricos (Brazil)

**WFD** - Water Framework Directive (Europe, Germany)

**BMUKN** - Federal Ministry for the Environment, Climate Action, Nature Conservation and Nuclear Safety / Bundesministerium für Umwelt, Naturschutz und nukleare Sicherheit (Germany).

**UBA** - Federal Environmental Agency / Umweltbundesamt (Germany)

**CPCB** - Central Pollution Control Board (India)

**MoEFCC** - Ministry of Environment, Forest and Climate Change (India)

Note: the name of the Ministries have changed under different governmental administrations. For the purpose of this text, the current names will be used.

# 1. Introduction

## 1.1. Sustainable development and environmental law

The intense connection between water and human beings is one of the most fascinating aspects of the interaction with our surroundings, how natural physical elements affect us and vice versa. One can argue that all disciplines find themselves continuously studying water and this connection, or better said, dependency - development studies is certainly no exception, considering most of human use of fresh water is being utilized for developmental activities. 94 percent of fresh water use is directed towards agriculture and industry, while only 6 percent is used to meet human physiological needs (Dantas & Schmitt, 2015). Within that smaller percentage, lie a myriad of challenges that are, at times, put lower in the priority list than they should be, considering this element is absolutely essential - firstly, to our existence, and secondly, to our development. The incorrectly perceived abundance of fresh water resources by a large number of its users, has created an indifference or even rejection towards its protection and more equitable distribution. While consumption patterns, distribution, availability, and environmental protection varies widely per country; water pollution is a global challenge: it has seen an increase in both developed and developing countries, affecting key development areas such as the health of billions of people, the preservation of fauna and flora, overall environmental sustainability as well as economic growth (Food and Agriculture Organization of the United Nations, 2018).

*“The application of traditional environmental remedies, such as the “polluter pays” and “user pays” principles, however, does not appear to have been sufficient to lessen human insensitivity to environmental issues (which does not seem limited only to water-related problems). Today, therefore, the legislative and executive branches seek to address this issue by instituting various public policies aimed at positively encouraging the maintenance of a healthy and balanced environment”* (Dantas & Schmitt, 2015).

Environmental law looks for an ideal, an aspiration, as the current state of affairs is nowhere close to being environmentally sustainable. Because of that, it usually includes varying levels of adherence, exceptions and exemptions, and at times, ambiguous rules for implementation or execution. Moreover, as pointed out by Brazilian jurist A.H. Benjamin:

*“No one would categorically state that this aspiration has been fully met anywhere in the world, not least because the expectations of content, of existential and functional conditions and standards of evaluation are not set in stone forever; they fluctuate over time and space”* (Benjamin, 2023).

One can closely study and pick apart a law, but the final shape it will take in the world and its effectiveness are a whole different analysis, and particularly for environmental legislation, it is a complex task. For planners and lawmakers to design effective measures that prevent pollution and reduce risks, they must first grasp the current state of aquatic systems, the drivers and pressures that cause water-quality degradation, the institutional, socio-cultural, economic, and environmental systems that surround it. Rigorous diagnosis, prediction, and monitoring are required to understand water systems and mitigate harmful impacts; it is not enough to look at statistics of a typical, standard set of indicators. Even if experts were to do that, many sources of pollution are nowadays diffuse and interlinked, particularly in the agriculture sector, making it even more challenging to select said set of indicators.

We now have data insights that can help us look back and find learnings and more effective solutions to protect water bodies. The aim of this paper is not to look at static pictures of indicators pre, during and post implementation of the selected laws to find answers; but to study in a dynamic way, mixing qualitative and quantitative analysis, whether it is possible for us humans to find, in the intricacies of the different countries, cultures, nations, geographies, lessons that can help address a problem that is relevant to, without exaggeration, *everything* - including the survival of life as we know it.

The legal frameworks that will be included in this analysis refer to a specific period in time, when the world was figuring out the new international order after suffering through two World Wars and the recently ended Cold War. The studied period saw several pivotal moments in the evolution of global environmental governance and water management: in the wake of the post-Cold War realignment, nations turned their attention from ideological rivalry to cooperative development, emphasizing market liberalization, democratic consolidation, and transnational problem-solving (Viñuales, 2023). World leaders had been gathering to come up with ideas on how to rebuild, cooperate and tackle the issues of most global relevance at the time such as hunger, child mortality, gender equality and environmental sustainability.

The 1992 Rio Earth Summit and the Dublin Statement on Water and Sustainable Development reframed water as a finite and vulnerable resource essential for life, the environment and development, and promoted the Integrated Water Resources Management (IWRM) cross-sectoral approach as a cornerstone for sustainability (Geethanjali & Rao, 2020). This approach vouched for the coordinated management of water, land and ecosystems to balance social equity, economic efficiency, and environmental sustainability. In 2000, country leaders gathered at the United Nations and agreed on a bold experiment for

the time: eight Millennium Development Goals (MDGs) to guide global action until 2015. The adoption of MDGs further embedded water access, sanitation and environmental protection within the global development agenda, driving countries to strengthen their national frameworks to meet targets for safe and equitable water use (Leite et al., 2022). This recognition reinforced the view that water security was central to sustainable development, and reflected a growing faith in multilateral cooperation to address transboundary challenges, which would lead to the Sustainable Development Goals (SDGs) that superseded the MDGs in 2015. In different ways, all the SDGs are arguably connected to the protection and provision of water, for instance, renewable energy sources, global food demand, climate change, and public health are all interconnected and all necessary for the provision of safe water and sanitation (Leite et al., 2022).

It was in this context that Brazil, Germany, and India each embarked on ambitious reforms between 1995 and 2007 to modernize their water laws and improve pollution control. Brazil, motivated by industrial pollution and deforestation pressures, strengthened its environmental framework (Benjamin, 2023) and created a national water resources management system. Germany translated EU water directives into national law, demonstrating how supranational frameworks could reinforce domestic compliance and accountability (Haumont, 2023). Meanwhile, India was (and still is) facing acute freshwater stress, and despite its decentralized water governance, introduced national programs like the National River Conservation Plan (NRCP) and updated policy frameworks emphasizing efficiency, participation, and sustainability (Cullet, 2007; Sinha & Sedai, 2025). Across diverse contexts, the global shift toward integrated governance reflected in these three cases a growing recognition that water was not merely a resource, but a public good at the heart of ecological integrity, economic development, and human survival.

Due to unforeseen events, mutating synergies, public priorities and opinions shifting, fast-evolving technologies (for better and for worse), there will never be a perfect law or outcome. In this context, and from the study conducted, it appears water protection frameworks need to be absolute and strict in granting water protection a priority status, but more flexible and adaptive when it comes to the ways of monitoring, predicting, reacting and resolving. Since water pollution comes from increasingly varied sources, it is also key to ensure that the regulatory approaches are not only enforceable, measurable, realistic and time-bound (FAO & IWMI, 2018), but also focused on the main polluters to be addressed in each body of water by quantifying their relative contribution. It is known that prevention is typically cheaper than restoration of ecosystems, which implies that the focus needs to be on data collection, accurate modeling or predictive models, as well as on changing behavior

and incentivizing the use of good practices to prevent pollution at the sources (FAO & IWMI, 2018).

This paper mainly places the focus on broad policy frameworks at the national scale, which should cover all polluters and pollutants under their umbrellas. These overarching instruments cannot possibly cover and regulate all the specifics required, but should provide private and public organisms and individuals with the principles and pillars of a country's water protection support and philosophy. Moreover, the (lack of) effectiveness of international environmental treaties, due to their inability to guarantee enforced compliance and sanction its members, has meant that compromises to environmental protection can vary widely from one country to another. This diversity lends itself for analysis and search for lessons learned and challenges addressed.

The overarching discipline that this work is framed within is Development Studies, and within it, the objectives from the UN's Sustainable Development Goals (and the 2030 agenda): Goal 6 of clean water and sanitation, Goal 11 of sustainable cities and communities, Goal 13 of climate action and Goal 14 of life below water.

## **1.2. Research hypothesis and objectives**

The main question to be addressed through this study is whether there are any common lessons to be learned from enforcement of environmental water protection laws in three significantly different countries that can be applied elsewhere to help increase overall effectiveness. Specifically, this work will analyze how the effectiveness of national water governance and protection frameworks in effect between 1995 and 2007 in achieving positive, significant outcomes (among others, increased safeguard, reductions in water pollution, coordinated governance) varies significantly across Brazil, India and Germany; under the hypothesis that through that, common lessons and learnings will be uncovered, which can be applied in and help other countries achieve increased effectiveness.

This is provided through an analytical, critical and comparative study that explores the challenges these laws faced after becoming in force, and the objective is completed by utilizing primary sources, such as national legal texts, national governments' reports on water quality, international organization reports and datasets; as well as secondary data obtained from a literary review including books, articles, academic pieces.

The objectives to be achieved include identifying challenges in the implementation and enforcement of effective national legislation, the lessons that have been extracted from

said experiences, retrieving common ones and concluding with a summary of findings and a set of best practices that can be used across different countries. Lastly, and through the abovementioned, this work aims to provide an understanding of some of the needs for further evolution of national legal frameworks in the environmental area.

### **1.3. Scope and rationale behind the study**

This study is motivated by a strong interest in the functioning of legal systems and how they interact with social, political, and environmental realities. While the researcher's undergraduate studies were focused on international law, this dissertation deliberately shifts the focus to national legal frameworks. Despite the significant role of international organizations such as the United Nations, international treaties do not contain supranational enforcement mechanisms, and compliance therefore depends on domestic law and institutions.

The importance of future water protection as essential for ecological and human survival cannot be more critical at this point in time and is expected to only increase in the future. The laws designated to regulate and safeguard water resources are an essential dimension of sustainable development.

Brazil, Germany and India were selected for comparative analysis. With differences in geography, economy, governance structures, and environmental pressures, all three introduced significant water protection-related legislation between 1995 and 2007. Brazil established a National Water Law and Policy in 1995, followed by the Clean Water Program in the early 2000s and a Federal Water and Sanitation law in 2007. Germany updated its Federal Wastewater Ordinance and Water Resources Act in 1996 and subsequently transposed the EU Water Framework Directive (2000). Lastly, India adopted its revised National Water Policy in 2002, building upon mechanisms developed during the prior decade. Examining these cases together allows for a journey across diverse legal traditions, institutional infrastructures, and socio-cultural-economic contexts; with the aim to take away lessons of regulatory success and failure in the area of water protection.

For the scope of this study, effectiveness is understood as the extent to which the law's spirit and objectives are realized in practice - that is, whether legal provisions are implemented and achieve their intended outcomes. However, this dissertation will not aim to cover all possible definitions of effectiveness, encompassing a myriad of dimensions, from socio-economic to biological effects. The analysis does not reduce or limit effectiveness to

either mere formal compliance by relevant public and private actors, or success in a selected number of water quality indicators across time. This will become evident from the selected theoretical lens...

#### **1.4. Analysis' theoretical framework**

The theoretical lens under which this study will be framed is institutional constructivism, through which environmental law can be analyzed as not just a set of formal norms and regulations, but also both a product of and an effect on socio-political norms, of cultural ideas. The way that water is defined within a society (and its norms, identities and concepts) will shape the content and design of the legal frameworks, as well as their outcomes (and effectiveness) once in force in it. To set the scene, constructivism is defined by E. Adler (1997) as:

*“The view that the manner in which the material world shapes and is shaped by human action and interaction depends on dynamic normative and epistemic interpretations of the material world” (Adler, 1997).*

Further to this point, N. Onuf (1994) explains that humans construct reality through their deeds, such as speech acts, which can be institutionalized into rules through repetition, and provide the context and basis for the meaning of human action:

*“Every time agents choose to follow a rule, they change it - they strengthen it by making it more likely that they and others will follow the rule in the future. Every time agents choose not to follow a rule, they change the rule by weakening it, and in so doing they may well contribute to the constitution of some new rule” (Onuf, 1994).*

As explained, humans have been utilizing freshwater globally mostly towards economic developmental activities such as agriculture and industry (94 percent together), which paints a picture of the way institutions and societies have constructed the meaning of water, its protection, allocation and distribution. The way freshwater is falsely framed through institutions (formal and informal) and actors as abundant and as an economic resource, is of higher priority than it being considered a human right that must be fairly distributed, or an essential component of ecosystems that must be protected. Legal frameworks can have the power to legitimize, scrutinize and change how actors use water, and vice versa. Through this lens, this paper aims to look at the laws implemented in Brazil, Germany, and India between 1995 and 2007, not only in terms of compliance and enforcement, but also in terms of how national institutions constituted water as an object of protection and development.

For Brazil, institutional definition of water was evolving towards recognition as a national patrimony; while in Germany the EU’s framework looked at water as a subject of ecological sustainability and a public health matter. India’s legal framework reflected a vision of water as a driver of development and a disputed commodity across states, in tension with a pivot towards it becoming a fundamental human right within judicial interpretations/applications of the law. This analysis therefore will not look at inputs and outputs in isolation, but explore the challenges, the roadblocks in practice, the lagoons and missing pieces; how social practices, cultures and historical experiences shape how water is conceptualized (as an economic resource, a commodity, a human right, a security issue), is protected; and whether that protection is effective.

*“Successful rule-following therefore depends on the overlap of norm setters and norm followers’ structures of references. It follows that studying social practices in context allows analytical access to the interpretation of meaning, which produces sustained compliance with norms” (Wiener, 2006).*

## 1.5. Key data points

To close this section, the table below summarizes essential, relevant pieces of information for context and to keep in mind throughout this study:

**Table 1.** Key data points for Brazil, Germany and India.

Data point	Brazil	Germany	India
<b>Population, total thousands (&amp; rural %)</b> <small>(World Bank, 2024b)</small>	211,998.57 (12% rural)	83,510.95 (22% rural)	1,450,935.79 (63% rural)
<b>GDP per capita, at purchasing power parities (Current international)</b> <small>(World Bank, 2024a)</small>	USD 22,333.4	USD 72,300.1	USD 11,158.9
<b>Income classification</b> <small>Gross National Income per capita - Atlas method (World Bank, 2024)</small>	Upper-middle income	High income	Lower-middle income
<b>Government system and administrative division</b>	Federal republic, with a presidential system of government. Composed of the Union, 26 states, the Federal District, and over 5,000 municipalities	Federal parliamentary republic, comprising 16 Länder (states)	Sovereign, socialist, secular, and democratic republic with a federal system that has strong unitary features. 28 states and 8 union territories, with over 800 districts and smaller administrative units in existence.

<b>Water protection governance</b>	Water and sanitation mostly fall under the competence of states and municipalities	Under the federal structure, the Länder (states) hold significant responsibilities for implementing and enforcing water laws, including the management of surface and groundwater resources.	Water management is overall a state subject, but the central government retains powers over inter-state rivers and national planning
<b>Main national governmental institutions for Water governance</b>	National Water and Sanitation Agency or Agência Nacional de Águas (ANA), under the Ministry of Environment and Climate Change	Federal Ministry for the Environment, Nature Conservation, and Nuclear Safety (BMUKN), supported by the Federal Environment Agency (UBA)	Ministry of Jal Shakti, Central Water Commission (CWC), Central Ground Water Board (CGWB), Central Pollution Control Board (CPCB), under the Ministry of Environment, Forest and Climate Change (MoEFCC)
<b>Renewable freshwater resources per capita</b> (Our World in Data, 2021a)	27,014.99 m <sup>3</sup>	1,286.12 m <sup>3</sup>	1,022.48 m <sup>3</sup>
<b>Agricultural / Industrial* / Municipal water withdrawals as a percentage of total water withdrawals</b> (Our World in Data, 2021b) *does not include hydropower.	61.3% / 14.53% / 24.2%	4.2% / 54.30% / 41.5%	90.4% / 2.23% / 7.4%
<b>Irrigated land (% of cultivated area)</b> (Our World in Data, 2021c)	2.91% (as of 2017)	3.05% (as of 2020)	42.27% (as of 2021)
<b>Hydropower share of power generation</b> (Our World in Data, 2024)	55.66%	4.91%	7.59%

## 2. Country Overviews and Environmental Law from 1997-2005

### 2.1. Brazil

#### 2.1.1. Country Overview

Brazil is a tremendously water-rich country, with an estimated 12 percent of the world's surface water resources located there (Water Action Hub, 2025); corresponding to more than 40 thousand m<sup>3</sup> of renewable freshwater resources per inhabitant (UN, 2023). Despite this, water resources are not spread equally nor properly distributed (Santin et al., 2023), with multiple areas experiencing water stress, especially in the north (UN, 2023). Groundwater resources are also vast, with aquifers as the massive Amazon and the transboundary Guarani Aquifer, both among the largest in the world.

The country can be divided into three river basins: the Amazon, Tocantins-Araguaia and San Francisco; plus two river basin complexes or groups: the Plata river basin (with Brazilian sub-river basins Paraná, Upper Paraguay and Uruguay); and the remaining rivers flowing into the Atlantic, which are divided into several basins (FAO, 2015). More than one-third of renewable freshwater is formed in neighboring countries, making transboundary cooperation a necessity in order to manage it (UN, 2023).

The Amazon river, with a length of about 6400 km, is not only the world's second longest river, but also the widest and deepest one. It has the largest flow of water and drainage area, and the basin accounts for 73.6 percent of the internal surface water resources (FAO, 2015). The long-term average internal renewable surface water resources are estimated at 5661.2 km<sup>3</sup> per year (ANA, 2009). Around three-quarters of resources come from the Amazon river basin, which has been seriously threatened by deforestation (UN, 2023). Its water and forest are essential for the hydrologic cycle and climate system, not only at a regional level, but a global one too (UN, 2023). Relatively recently, an "underground ocean" of freshwater in the Amazon has been discovered: the Amazon Aquifer, which has a volume 3.5 times greater than the Guarani Aquifer that had long been regarded as the world's main underground freshwater reserve (Dantas & Schmitt, 2015).

With these vast sources in mind, it is not surprising that in Brazilian decision-making, fresh water has been mistakenly labeled as "inexhaustible," and also mistakenly, not concerned itself as a society with proper use of water, failing to give due importance to the issue (Dantas & Schmitt, 2015). While the Amazon River experiences great floods in the northern part of Brazil, not far from there, the Northeast region is frequently stricken by droughts (Dantas & Schmitt, 2015).

Brazil's territory is divided into 26 states and one Federal District, each with their own government and constitution; and 5,570 municipalities. The competence of water provision and sanitation falls under the competence of said states and municipalities, and is organized by river basin. The National Water and Sanitation Agency (Agência Nacional de Águas e Saneamento Básico - ANA) is the main federal institution fully dedicated to water resources, implementing the country's National Water Resources Policy and defining reference standards for the regulation of basic sanitation services. It acts under the supervision of the Ministry of Environment and Climate Change. Other institutions involved in the management of water and sanitation include the Ministry of Health, the Ministry of National Integration, the Ministry of Cities, the Brazilian Institute of Geography and Statistics and the Geological Survey of Brazil (UN, 2023). A National Water Resources Council was established to promote coordination and participation. It is chaired by the Minister of Environment and Climate Change (UN, 2023).

As rivers flow across different federative units, the Brazilian hydrographic division is different from its political-administrative organization, with 12 hydrographic regions as defined in 2003 through a resolution (number 32) by the National Water Resources Council (Conselho Nacional de Recursos Hídricos). Moreover, the National Water Resources Plan divides the territory into 47 Water Resources Management Units (UGRHs) for interstate basins and 17 UGRHs for state basins (ANA, 2024). ANA has been producing annual reports on national water management since 2009, but there are a lot of regional and local nuances that exceed the scope of said reports (ANA, 2024).

The main water source is rainfall, with an annual average estimated at 1,760 mm. However, there are large variations geographically, even within basins, as well as interannually. Less than 500 mm can be observed in the semi-arid region, while more than 3,000 mm in the Amazon (of the 255,000 m<sup>3</sup>/s of water that, on average, flows across Brazil, almost 80 percent is found in the Amazon Basin) (ANA, 2024). Interannual variations tend to be greater in the semi-arid region, and to mitigate the impact and enhance availability, a hydraulic infrastructure is in place to store and release water, especially through artificial reservoirs (ANA, 2024).

Brazil is considered an upper-middle income country, despite its significant disparities across regions and society (UN, 2023). Since the early 2000s and due to a fast paced economic growth, it is part of the BRICS. Water as an economic resource is of tremendous importance in that development, and closely related to the energy sector, as hydropower generates three-quarters of the electricity in the country, its use for this purpose at times competing with withdrawals for municipal uses, especially in times of drought (UN, 2023). As

one of the largest producers globally of both agricultural and industrial products, the withdrawals of water accompany the magnitude of the local and international market Brazil has. Agriculture is responsible for 62 percent of water withdrawals (although only 8.7 percent of agricultural land is irrigated); 14 percent for industry, and navigation and recreation follow in largest internal uses (UN, 2023). Moreover, the exports of water from Brazil to the world (estimated 67.1 billion m<sup>3</sup>/year) are comparable to the renewable freshwater resources of entire countries like Kazakhstan and the Republic of Korea (UN, 2023).

One of the key elements of an efficient water protection infrastructure is data collection and monitoring quality, and in Brazil, the National Hydrometric Network (RHN) and the National Water Quality Monitoring Network (RNQA) are some of the main sources. While they have been able to collect a vast volume of data, there are still remaining areas that there is no information for. Some states have only recently started collecting information, and monitoring is not consistent across regions, with ANA highlighting deficiencies in both temporal and spatial representativeness (ANA, 2024). For surface-water quality status, ANA has been using the typical parameters: Dissolved Oxygen (DO), Biochemical Oxygen Demand (BOD) or Total Organic Carbon (TOC, in the state of São Paulo), Total Phosphorus, and Turbidity. Average parameter values are calculated only for sites with at least four observations during this two-year period (ANA, 2024).

In recent decades, ANA has seen water use grow substantially, with withdrawals for sectoral uses expanding by an average of 536 billion liters per year between 1940 and 1980, accelerating to 781 billion between 1980 and 2000, and to 1189 trillion between 2000 and 2021. Between 2022 and 2040, they are expected to increase by more than 30 percent, an expansion of 1.290 trillion liters of water per year on average (ANA, 2024). Irrigated agriculture plays a major role, along with human supply (urban and rural), livestock supply, industry, thermal power generation, and mining as the main consumers (ANA, 2024). Demands also vary by state: Rio Grande do Sul is one of the main demanding states due to flooded rice irrigation; Bahia and Minas Gerais are also top ones, with center-pivot irrigation as the main cause. São Paulo has also got high demand for urban water supply. Each use has its own dynamics, and the municipalities with the highest withdrawals are associated with different sociodemographic and economic activities across the country (ANA, 2024).

Urban human water supply is the second-largest use of water in the country, and around 85 percent of urban population is supplied by surface sources, especially in major cities as São Paulo, Rio de Janeiro, Brasília, Fortaleza, and Porto Alegre (ANA Atlas Águas, 2021). The remaining 15 percent of the urban population is supplied by groundwater sources. Rural human supply represents only 2 percent of total water captured in 2023,

largely due to population decline in rural areas, and with alternative sources (instead of the public distribution network) playing an essential role (ANA, 2024).

Since the 1950s, industrialization has been a primary focus in Brazil, requiring huge infrastructure investments. For this purpose, power generation was, at the time, the predominant use of water, industry and government disregarding the Water Code to aid this strong push (Kerr do Amaral, 1996). Accelerated urbanization quickly created tensions, as providing large cities with drinking water and sewage services was competing with energy generation, already evident since the early 1970s. The prioritization of economic growth did not justify the increase in child mortality due to diseases related to inadequate water quality protection and wastewater treatment (Kerr do Amaral, 1996). It was evident that the existing legal framework and its institutions were inadequate to manage those challenges.

However, during the past 20 years, Brazil has been increasingly invested in wastewater to significantly improve its water quality (UN, 2023). Part of this progress is explored in this text, as the legal framework that has been implemented in the period selected is certainly a component of it. The UN highlights the information campaigns conducted in the 1990s on the links between sanitation and the environment; as well as the large-scale federal investment during the 2000s and 2010s, resulting in 900 wastewater treatment plants built between 2013 and 2019, as well as septic tanks which are key in rural areas.

Access to safe drinking water and sanitation are above the average for Latin America: in 2012, 98 percent of the total population had access to improved water sources (100 and 85 percent in urban and rural areas respectively) and 81 percent of the total population had access to improved sanitation (87 and 49 percent in urban and rural areas respectively) (Santin et al., 2023). Nonetheless, two-thirds of municipalities still lack wastewater treatment and 100 million people lack sanitation (UN, 2023). Sanitation coverage remains a huge challenge, especially in rural areas. Some of the areas or populations that experience much lower coverage than the national average are, particularly: the north and north-east, parts of cities with informal housing, and indigenous and Quilombola people. This results in higher exposure to waterborne disease and other related problems (UN, 2023). Additionally, water supply is highly contrasting across geographic regions: although the Amazon basin is resource abundant, the North region is sparsely populated and at times lacks economic resources; while in the Northeast, severe droughts impact the 40 million people living in it; the West is dominated by the savanna and wetlands and dedicates mostly to agricultural and livestock related activities; all the way down to the South where industrial

and financial epicenters where excessive consumption and pollution rates have been recorded (Porto & Kelman, 2000).

### **2.1.2. National environmental laws: legal approach to protect water and reduce pollution**

As a precedent to the period in scope for this analysis, the Water Act established in 1934 had been the main instrument for Brazilian water legislation. It was considered by legal experts as advanced for the period it was enacted in (ANA, 2009), including the polluter pays principle, which was not an internationally recognized practice at the time, and proposing integrating the multiple uses of water (Kerr do Amaral, 1996). In 1979, an Irrigation Law was promulgated that set government policies for irrigation development.

The 1988 Constitution defines federally-controlled public waters as bodies of water or rivers which flow through, or border on, several states or a foreign country (Art. 20, III). State-controlled public waters are, on the other hand, bodies of water or rivers which rise and end within the territory of a single state (ANA, 2009).

In 1991, São Paulo was the first state to establish a specific policy for water resources under its control, which laid out a guide to the State Policy on Water Resources and the Integrated Water Resources Management. The states of Ceará (1992), Santa Catarina (1994), Rio Grande do Africa (1994), Bahia (1995), Rio Grande do Norte (1996) and Paraíba (1996) followed, establishing also policies on water resources (ANA, 2009). This is highlighted to show how relatively recently the states have developed their water management systems.

#### **2.1.2.1. The Federal Water Law (1997)**

The Federal Water Law 9433/1997 establishes the National Water Resources Policy (NWRP) and creates the National Water Resources Management System (SINGREH), regulating item XIX of art. 21 of the Federal Constitution. This law gave greater scope to the 1934 Water Code and defines water as a public good and a limited natural resource with an economic value (FAO, 2015). The National Water Resources Council (CNRH) is the highest body with the mandate to promote the coordination of water resources planning. It is the strict competence of the Federal Government to legislate on water (FAO, 2015).

As one of the most valuable creations of this law, the National Water Resources Management System, which contains core principles that help readers understand how water's definition and value is further constructed in this legislative framework. These include the following: a) water is a public domain, a limited natural resource with economic value, and its use must be proportionate in the management of water resources multiple; b) in situations of water scarcity, priority use will be given to human consumption and animal watering; c) the hydrographic basins are the territorial unit responsible for the implementation of the National Water Resources Policy and the performance of the National Water Resources Management System; d) the management of water resources must be decentralized and count on the participation of the Public Power, users and communities (Article 1).

While these represent significant progress in the public institutional construction of water, the materialization of them depends on a complex myriad of factors that will be later addressed. To ensure enforceability, the NWRP must provide for: (I) the establishment of Water Resources Plans; (II) the classification of water bodies into categories according to their predominant uses; (III) the granting of rights to use water resources; (IV) charging for the use of water resources; (V) compensation to municipalities; and (VI) the creation of a Water Resources Information System.

The system is composed of the following bodies, per Article 33 of the law: National Water Resources Council, National Water Agency (created later in 2000, see item 2.2.2.2); State and Federal District Water Resources Councils, Hydrographic Basin Committees and Federal, State, Federal District and Municipal Government Agencies. Through this, the law installed a more decentralized management, with the aim to promote a significant advance in more adequate and sustainable nation-wide distribution and use of water resources.

Another relevant addition from this law is assigning the competence of granting rights to water use for abstraction and effluent discharge to the National Water Agency, which means control is in the hands of a federal actor. In terms of privatization, concessions regarding water supply and sanitation were implemented during the time of this framework (more specifically, during President Fernando Henrique Cardoso's presidency). However, despite it being more prevalent (and considered unsuccessful in many cases) among neighbouring countries, in Brazil it was only selected cities that granted them (Da Silva, et al., 2008).

Aligned with the law's definition of water as a public good with economic value, it introduces charging for water use, with an aim to encourage more rational use and generate

funds for water management and infrastructure. The fees are approved by the River Basin Committees (another mandated incorporation from this legal instrument), with coordination with the other agents abovementioned, and under the supervision of the National Water Agency. Before, no system existed for this, as the focus was ensuring access and hydropower usage.

As general guidelines, the law provides some change in the existing direction. It guides organisms to coordinate across water body types and regions, but simultaneously take into consideration the nuances and differences between them while doing so. It also directs the National Water Resources Management System to act in coordination with other sectoral plans and industries.

Last but not least, the concept of sustainable development is incorporated as a guiding principle and an aim with this law, which is both another novelty in this space for Brazil, and aligned with the direction the international institutions were heading to as well. At this point, there was not much else other than that. Nonetheless, in 2000 and within the UN, Brazil committed to the Millennium Development Goals (MDGs), which solidified the commitment towards sustainable development and led the way to today's framework of Sustainable Development Goals and the 2030 agenda.

#### **2.1.2.2. Creation of National Water Agency Law (2000)**

An essential part of the new National Water Resources Management System, is the role of the National Water and Basic Sanitation Agency. It was created and regulated in 2000 by law 9984, as a federal entity (autarchy under special regulation), with autonomy, and linked to the Ministry of the Environment and Climate Change. It is responsible for inspecting and implementing the National Water Resources Policy, for establishing reference standards for the regulation of public sanitation services, as well as establishing rules for its performance, administrative structure and sources of funds (Santin et al., 2023).

#### **2.1.2.3. National Basic Sanitation Policy (2007)**

Lack of an effective sanitation system is highly harmful to both the environment and public health, universal access to basic sanitation services has been recognized and incorporated as part of the international community's agenda relatively recently, and solidified through the UN's SDGs via Goal 6 (ensure availability and sustainable management of water and sanitation for all), as well as in water safety planning resources on offer by the World Health Organisation (WHO) since 2006 (Leite et al., 2022).

Law No. 11445, of 5 January 2007, was Brazil's first national framework for basic sanitation, and was founded under the principle of universal access to sanitation services. It established high level objectives such as overall improved services, reuse of wastewater and rainwater, rationalization of water use and energy efficiency; as well as provided guidelines and responsibilities. According to the Policy, basic sanitation consists of four components: water supply, sewerage, urban cleaning and solid-waste management, and urban stormwater drainage and management. This law emphasizes the interrelation among them and the importance of treating them equitably and in an integrated manner to benefit society and the conservation of water resources.

Under this framework, municipalities and the Federal District are the holders of sanitation services. They may organize, regulate, oversee, and provide these services directly or delegate them to public entities, inter-municipal consortia, or private concessionaires, subject to legal and contractual conditions. Indeed, this is an area where Brazil has seen more privatization or concessions, as the proposal is to reduce or even remove the direct action of the public power, allowing delegation to the private sector (Santin et al., 2023).

Despite allowing private agents to play a larger role, the universalization target would require a scale of investments and a stable political environment that, as we will see, have not been materialized. Moreover, this law does not set up a specific binding target or deadline for this goal either (which is amended in the 2020 update).

#### **2.1.2.4. A note on regional cooperation**

The Amazon Cooperation Treaty (TCA) was signed in 1978 by Bolivia, Brazil, Colombia, Ecuador, Guyana, Peru, Suriname and Venezuela, entering into force for Brazil in 1980. There are two fundamental principles in the treaty: sovereignty and sustainable development. Among the objectives proposed are: harmonious development of the Amazon, an equitable distribution of the benefits, improving the quality of living of its peoples; and achieving the full incorporation of their Amazon territories to the respective domestic economies (FAO, 2015).

Although the focus appears to be more on economic development, one of the key reasons why cooperation and joint protection is environmentally crucial, is due to the fact that degradation of resources, biopiracy and disorder in one territory can compromise the balance of a system involving eight countries (Nunes, 2016), as although most of the river's course lies within Brazil, many of its tributaries originate in neighboring countries.

In 1995, the eight nations decided to create the Amazon Cooperation Treaty Organization (ACTO), to strengthen and implement the objectives of the TCA. The amendment to ACT was approved in 1998 and the Permanent Secretariat of ACTO was established in Brasilia in 2002, and installed permanently in 2003. Nevertheless, the creation of an intergovernmental entity and a permanent secretariat was not enough to provide Pan-Amazonian diplomacy with the necessary dynamism (Nunes, 2016).

P. H. Faria Nunes' research leads him to state that ACTO has not produced substantial concrete effects, and undergoes long periods of inertia and is briefly revived when there is a perceived threat of a return to the discourse on the internationalization of the Amazon, or to present a joint position in global environmental negotiations (Nunes, 2016). He partially attributes this to the excess of South American cooperation and integration projects with overlapping objectives (e.g., MERCOSUL, CAN, UNASUR, IIRSA), relegating ACTO to a secondary role. Another reason preceding ACTO are frictions among several member countries, such as undefined borders between Andean/Amazonian countries, disputes between Brazil and Argentina due to the Itaipu Dam.

On the topic of South American integration projects, and in the beginning of the 1990s, Mercosul was created, involving Argentina, Brazil, Paraguay, and Uruguay (Venezuela currently under suspension, and Bolivia incorporated recently). Its foundational treaties include environmental protection among the goals of this organization - while formal recognition of water protection as a common goal and promotion of joint water management in shared water bodies are definitely a step in the right direction, enforcement of these ambiguous principles in reality is dependent on the member states' legislative framework (for instance, regarding standards for water quality). For these developing economies, industrialization and trade, especially agriculture and deforestation-linked goods; has been higher on the priority list than water ecosystems protection, and despite the countries disagreeing, the mechanisms to ensure compliance are weak. V. S. Radovich analyzing the role of this organization in the protection of aquatic and marine resources, highlights:

*“Legal scholarship generally agrees that the main problem facing MERCOSUR is the absence of supranationality. That is, since there has been no delegation of competences, there is neither direct effect nor supremacy of the community legal order. (...) This becomes even more complex due to the federal structure of most of its Member States, where overlaps may arise between federal jurisdiction and that of provincial, state, or local authorities”* (Radovich, 2016).

Mercosul has taken some steps forward in regulating environmental protection in general during the studied period, but there is still a long way to go regarding the specific environmental protection of both aquatic and marine resources. In 1997, a specialized group on Environment proposed a specific Agreement on the Environment, which came into force in 2004. Said Agreement created a legal avenue for states to demand coordinated policies on water resources, as well as the normative basis for future agreements. Nonetheless, actual implementation remained weak and fragmented.

### **2.1.3. Main challenges and observations**

The abovementioned laws have all been considered key achievements, but the challenges remain enormous, as managing this abundantly rich natural heritage in a sustainable manner is not a simple task and needs to be constantly updated (Santin et al., 2023). Even with extensive regulation efforts that took place in the studied period, providing legislative instruments at a national level for the first time in several areas, some of the problems related to water protection and management remain unsolved.

One of the major concerns has been the uneven, poor distribution of water resources across Brazilian territory, which remained unresolved in reality (Dantas & Schmitt, 2015). The Northeast region, frequently affected by droughts, has almost 30 percent of Brazil's population but only 3 percent of the country's water availability, and existing legislation has been incapable of resolving a problem of this nature (Dantas & Schmitt, 2015). In the Federal Water Law, the ambiguous principle of fair distribution has seen large-scale initiatives from the government, but not a nationwide efficient distribution plan.

To exemplify, the Federal Government launched the São Francisco River Integration Project, with the aim to guarantee water supply of more than 390 municipalities in the semi-arid Northeastern region, impacting more than 12 million inhabitants. This meant a tremendous infrastructure investment of canals, aqueducts, tunnels, among others, and was thus listed among the 50 largest infrastructure constructions underway in the world (Dantas & Schmitt, 2015). While there were improvements in terms of households served (e.g., more reliable and secure services), the expected pace was not accomplished, and in many municipalities, having water connected did not translate to a consistent supply (da Silva Santos, 2020). Although universalization has not been achieved yet, a positive effect was the reduction in deaths caused by diarrhea, highlighting an improvement in the quality of water supply in the region (da Silva Santos, 2020). On the other hand, this project came with

unintended effects on ecosystems in receiving areas that have not necessarily been attended. It remains to be seen whether its ambitious long-term benefits will take place, as that is dependent on maintenance, governance and complementary policies.

Another project worth mentioning was the Water Producer Program (Programa Produtor de Água), ANA's initiative to reduce erosion and siltation of water sources in rural areas. On a voluntary adherence basis, the program provides technical and financial support for the implementation of water and soil conservation actions, such as the construction of terraces and infiltration basins, the improvement of rural roads, the recovery and protection of springs, the reforestation of permanent preservation and legal reserve areas, environmental sanitation, among others (Dantas & Schmitt, 2015). It also involves payment of incentives to rural producers who can prove their contribution to the protection and recovery of water sources, generating benefits for the basin and the population. It is undeniable, despite the disputes that are common in projects of this nature, that such initiatives undertaken by public management must be continued (Dantas & Schmitt, 2015). According to the State Forestry Institute (Instituto Estadual de Florestas), this has been particularly successful in the Minas Gerais state, with 45.3 percent of the national projects taking place there, across 95 municipalities (Instituto Estadual de Florestas, 2025). It has certainly shown qualitative improvements where implemented (springs recovery, erosion control, community awareness), but universality issues remain.

On a related note, the tremendous difference in human water supply between urban and rural areas continues as a painpoint for Brazil. According to ANA, urban human supply represents the second largest use of water in the country (estimated withdrawal for urban human supply in 2023 is about 23 percent of total). Concentrated in clusters and placing increasing pressure on water sources and production systems, and heightening the complexity and interdependence of supply solutions (ANA, 2024). Like others, if not managed, both through regulation and infrastructure, this issue continues expanding, as population and urban areas continue to grow, demand intensifies, often resulting in conflicts over water use.

An additional problem ANA has drawn attention to in its national annual reports is the amount of losses in the distribution network, mainly due to the increasing frequency of water scarcity events and the heightened risk of contamination of treated water. In 2022, according to the SNIS, losses in Brazil's water distribution network (IN049) were 37.8 percent. This is a high percentage, especially in a scenario where demand continues to grow and resources are increasingly limited (ANA, 2024).

Focusing on the country's chronic sanitation problem, there was a clear legislative intent to address it, the 2007 law being a key milestone in establishing guidelines and creating regulatory agencies. However, data suggests that the universalization targets will not be achieved by 2033 (as per the deadline stated in the 2020 updated law), given the scale of the required investments, the time, and the political environment necessary for their realization. Approximately 50 percent of Brazilian homes do not have access to basic sanitation, and the statistics in the years after the legal framework came into force demonstrated that an update was necessary (Santin et al., 2023).

A pattern can be identified, as the coverage of sanitation services across the country (between administrative entities such as states and municipalities) and between urban and rural areas is also unequal (Gugliano & Carbonai, 2013), *especially in certain administrative entities (i.e., states and municipalities)*. One of the arguments is that there has not been enough investments for universalization to happen, as well as a history of uncertainty regarding service ownership, fragmentation, and incipient track record (Leite et al., 2022). According to 2019 data from the Diagnosis of Water and Sewage Services of the National Sanitation Information System, water supply to the population increased by a mere 2.6 percent between 2007 and 2017.

Moreover, in reality, the issues highlighted may have an even stronger impact, but there are still data collection and monitoring gaps that prevent ANA to have the full picture, despite this improving in recent years: there are blind spots and inconsistent data quality (ANA, 2024, OECD, 2022).

OECD data from the survey on the Governance of Regulators of 2014 suggested that among the five economic sectors analyzed, the scope of action of water regulators is, concerningly, the second least restricted (OECD, 2022).

All of the issues that either remained or increased, beg the question of why were the regulations insufficient in their contents and enforcement, and what factors surrounding them play a part in obstructing the achievement of the objectives stated in the laws.

#### **2.1.4. Outcomes and findings**

The inequitable distribution that remained after implementation of these legal instruments, with areas like the Northeast suffering chronic scarcity despite national abundance, show their insufficiency in the topic of hydrological asymmetries. Some of the implemented projects did show partial success, which are related and aligned with the spirit

of the above-mentioned framework. Moreover, several academic works (Santin, et al, 2023) argue that Law 9.433 led to decentralization, participatory governance (river basin committees), classification of water bodies for use, and provided regulatory instruments. These are all necessary conditions for improving water quality, but not sufficient to guarantee it. It has been noted that implementation remains uneven; many rivers and lakes remain polluted, especially in more urban and industrialized settings. There are still practices of illegal deforestation, use of unregulated pesticides, dumping of domestic and industrial waste in surface waters and other factors that lead to a reduction of achievements on the ground (Santin et al., 2023). Distribution losses levels as high as ~38 percent, as well as the remaining data monitoring gaps due to blind spots and inconsistent data quality, add to the roadblocks of effective implementation of the principles of the analyzed laws (ANA, 2024).

There is a need for ANA to engage with sub-national authorities more effectively both in terms of more harmonized data collection and quality, as well as ensuring a common understanding and enforcement of the laws, and that sub-national regulators have the tools to adopt the principles and practices referenced in them (OECD, 2022). For the need of buy-in from these actors on shared objectives, including those who fear the loss autonomy or freedom, OECD (2022) suggested economic incentives and penalties, improving transparency across states and creating a benchmarking system with information accessible to wider public too.

Some experts have argued that in order to achieve better results, a more participatory approach is the way forward (OECD, 2022), aligned to the findings from the International Conference on Water and the Environment (ICWE) in 1992. This would entail citizens and customers being involved in discussions through roundtables, participatory budgets, public hearings, and independent ombudsman offices (Leite et al., 2022), as well as building strategic relationship with the unions, associations, local regulatory agencies, public companies as key stakeholders of the sub-national authorities (OECD, 2022).

As time passed, some of these frameworks have been updated or further regulated. Due to the lack of the universalization of water supply services, and with the aim of improving the economic sustainability of operations, among other reasons, law 14026 was enacted in 2020, altering the institutional framework for water supply and sanitation (Leite et al., 2022). With the amendment, ANA became responsible for the role of regulatory and supervisory agent of the public service, encouraging national and foreign investments in the sector (Santin et al., 2023). Nonetheless, authors are already finding that the social sustainability aspect was left unattended, and that the new law is not necessarily a means for achieving efficiency in resource allocation or service provision (Leite et al., 2022). It

appears unlikely that the targets of 99 percent of the population served with drinking water and 90 percent served with sewage collection and treatment by December 31, 2033, will be achieved.

All in all, the laws studied above introduced positive changes that partially addressed water protection. They addressed some of the main issues related to water protection on a national level in principle, but without requiring a structural solution with measurable targets.

The Federal Water Law introduced river basins as the basic management unit, and created instruments such as river basin plans to regulate and rationalize use. It formally established principles such as priority of human and animal consumption in times of scarcity (versus electricity and industrial production) and introduced the concept of sustainable water usage. Additionally, it was innovative in relation to previous laws on the matter, as it addressed the need for participatory instruments, creating River Basin Committees with participation from government, users, and civil society - the first time participatory water governance was institutionalized at a national level in Brazil.

However, the framework failed to create a nationwide redistribution mechanism or plan for solving the structural geographic imbalances with binding targets, nor did it directly target the difference in water supply between urban and rural areas through specific objectives on the matter. On sustainability, it promoted rational use and efficiency, but did not regulate distribution systems or put specific targets in place.

The National Basic Sanitation Policy addressed the problem of difference in water supply across urban and rural areas in a more direct manner, establishing universality and equity in sanitation principles, requiring municipalities to prepare sanitation plans with targets for expansion, as well as for reducing losses in water distribution networks, and increasing efficiency through reuse and rainwater capture. It also attributes legal responsibility of provision and oversight with the municipalities, but states that there is a need for social control in service provision from users participating in the decision-making and oversight processes. Nonetheless, uneven service provision is still a problem currently, and this law (unlike the 2020 version), did not include binding targets or deadlines either, making for a weaker implementation.

## **2.2. Germany**

### **2.2.1. Country Overview**

After World War II, densely-populated Germany's rapid economic development exceeded its water bodies' capacity, and became a synonym of high pollution levels, which even at the the early 1970s, was already causing grave concern. Moreover, after the German reunification in 1990, the country saw many challenges in building a consistent, modern water supply and wastewater disposal across the East and West (Bundesministerium für Umwelt, Naturschutz und (BMUKN), & Umweltbundesamt (UBA), 2001). Not long before that, in 1986, the Upper Rhine River turned blood-red, a large fire of the Basel chemical company Sandoz caused approximately 30 metric tons of pesticides and dyes entering the Rhine, causing the death of countless fish and small animals. One year later, poisonous killer algae proliferated in the North and Baltic Seas, killing thousands of seals. Both disasters generated immense media outrage, followed by political responses. Quick political action was essential, and legislation concerning water protection needed to be, and was, significantly heightened (BMUKN & UBA, 2001).

Water consumption and pollution levels have been significantly reduced in time, thanks to a reaction of strict environmental policies, strong investments, as well as cooperation of various actors: the federal government, states, municipalities, businesses, professional associations, and last but not least, involved local citizens (BMUKN & UBA, 2001). Some examples of investment include: construction of thousands of biological Wastewater Treatment Plants (WWTP) in the municipal sector, intensive wastewater treatment and supplementary internal measures in industrial enterprises, emission of contaminants and oxygen-consuming, organic wastewater components into bodies of water and hundreds of kilometers of sewer pipes laid (BMUKN & UBA, 2001). To further exemplify, the Ruhr River which had been associated with large industrial activities, formerly known as Europe's Sewer, has seen a substantial amount of work both in the legislative and infrastructure side, from Germany and international cooperation, causing pollution levels to have improved so much that salmon has returned to it.

These achievements have been considered as an example that high standards of living and being a modern industrialized nation does not necessarily have to be accompanied by water pollution and a high level of water consumption (BMUKN & UBA, 2001). Nonetheless, all water management problems in Germany are not yet resolved:

among others, one area that remains a challenge is reorientation of agriculture, especially of intensive livestock farming, toward ecological cultivation methods (BMUKN & UBA, 2001), especially nutrient runoff such as nitrates and phosphates contaminating groundwater and surface waters. The EU has even taken Germany to the European Court of Justice for insufficient nitrate reduction measures under the Nitrates Directive.

Despite the abundant freshwater resources with relation to the population and territory (around 182 billion m<sup>3</sup> of naturally available water), there are regional and seasonal shortages and varying suitability of supply (BMUKN & UBA, 2001). With a water infrastructure of very high technological standard of by international comparison, the average rate of leakage was 9 percent on average in 2001 (BMUKN & UBA, 2001). The conscientious use of water has been reflected in the continuous decline in volumes of water used in industry and in households. In domestic use, the average inhabitant uses about 128 litres per day, a number that has remained quite static in the past two decades (OECD, 2023, and BMUKN & UBA, 2001).

The challenges faced during the years in scope for this analysis and highlighted by the UBA (the environment agency of the German government) in 2001, remain relevant nowadays. Utilities are still under pressure to further reduce operational and maintenance costs while ensuring affordability and high service standards. The agricultural sector continued to be one of the main sources of nutrient pollution, with nitrate and phosphate runoff representing the most pressing obstacle to meeting EU Water Framework Directive (WFD) targets. Moreover, new categories of pollutants, including pharmaceuticals, pesticides, PFAS, and microplastics, demand research and the development of advanced protective measures. Germany has not yet achieved 'good ecological status' for many water bodies as required by the WFD, and future strategies must increasingly address climate change impacts such as droughts, falling groundwater levels, and water scarcity.

The country's administration is divided in 16 federal states (or Länder), and its hydrological design includes 10 river basin districts, with the five largest (Danube, Elbe, Ems, Rhine, and Weser) across multiple states and covering about 90% of the territory; plus the coastal regions of the North and Baltic seas. While the states are responsible for regulating and enacting water supply and wastewater disposal within the legal framework and oversight of federal laws and institutions, it is the municipalities that have a protagonic role. They organize service provision, charge tariffs and fees, and bear the legal responsibility for water supply and wastewater disposal (BMUKN & UBA, 2001). Within the framework of EU and federal standards, they decide on the organisational form and technological approaches that best meet local needs.

The municipalities are neither private firms (in the typical corporate sense), nor only subordinate arms of the state, they have constitutionally guaranteed local self-government (Kraemer et al., 2007). While they are able to delegate operational tasks (to municipal associations, third parties, private contractors), they retain oversight, strategic decision-making, and regulatory control (Kraemer et al., 2007).

Nonetheless, the legal framework for water services is set by the government authorities and agencies at the state and federal levels, usually transposing EU legislation. This way, they influence the general conditions of water services, water prices (including the principle of cost recovery), water quality, abstraction (permitting requirements and conformity with environmental objectives), and environmental measures such as the establishment of water protection zones around sources. Municipalities, on the other hand, have to decide on the institutional, organizational or contractual arrangements for the provision of water services (Kraemer et al., 2007).

Germany's water sector has been, and still is, characterized by a pluralistic organisational structure of public-law and private-law utilities, dominated by municipalities. While there are more than 6,000 suppliers, the largest 100 companies account for the majority of water delivered, with service areas usually aligned with municipal boundaries or contiguous urban regions (Kraemer et al., 2007). Unlike in other European countries, the sector is not dominated by international corporations, but by a large number of municipal and medium-sized enterprises (BMUKN & UBA, 2001). Water utilities often increase efficiency by combining management of water with other services (like wastewater or energy) or by forming associations with nearby municipalities, from an organizational focus (management, billing, planning) rather than technical. This decentralized model reflects the constitutional guarantee of municipal self-government that has been in place for over 200 years, reinforced by Germany's federal system, and underpins the strong position of municipalities in service provision, despite the influence of EU and federal regulatory frameworks (Kraemer et al., 2007).

The water supply sector occupies a special position in German competition law. Practices usually prohibited, such as exclusive service areas, long-term monopoly contracts, price fixing on a "most favored customer" principle, demarcation agreements between municipalities - are permitted for water supply. Despite these exceptions, the sector remains competitive in multiple ways. Different organizational models compete for legitimacy and efficiency; utilities are benchmarked against each other (not competing directly with another utility for the same customers, but through comparison across municipalities); and since results are published, public and political scrutiny of tariffs creates further pressure. In

addition, private firms compete in upstream markets for equipment, engineering, and concession contracts, while professionals in the sector compete for recognition in the community and influence (Kraemer et al., 2007).

The system of strong municipal control combined with diverse competitive pressures, serves as an equivalent to conventional utility regulation, and produces high service quality, effective cost recovery, and internationally competitive prices (Kraemer et al., 2007). However, the absence of large national champions limits Germany's visibility in global water markets, even as its technology providers export specialized expertise. The decentralized and municipal character of the system also makes cooperation with international development institutions more difficult, although German utilities could still contribute to global water and sanitation goals through partnerships with towns and cities in other parts of the world (Kraemer et al., 2007).

When it comes to the standards that all entities are held to, the definition is completed across multiple levels: the EU provides the overarching framework through directives such as the Water Framework Directive, Drinking Water Directive, and Nitrates Directive, while federal law transposes these into national regulations, including the Federal Water Act, Drinking Water Ordinance, Groundwater Ordinance, Wastewater Ordinance, and more. Municipalities remain the key actors in implementation. As an example:

*“The requirements and standards are formulated most concretely at the lowest level, where framework requirements of the respective superordinate level must be observed. For example, the final decision with regard to treatment standards for a WWTP is made by the municipality. Nevertheless, the municipality must still heed the conditions set by the district government; the district government, on the other hand, must observe the minimum requirements set by the state and federal governments, which must conform to the EU directive (for municipal wastewater)” (BMUKN & UBA, 2001).*

Furthermore, there are municipalities, especially where more sensitive river catchment areas are found, where stricter legal limits or higher performance treatment technologies than the required by the federal laws are often voluntarily installed (as is the case in the catchment area of Lake Constance, in Bavarian bathing lakes, or at the Baltic Sea coast) (BMUKN & UBA, 2001).

As for the political process for that decision making, discussions or hearings take place within a close network formed between the various decision-making bodies and the municipal council, the county parliament, scientific associations and interest groups. This

federal, multi-layered structure is able to successfully include all interested parties and experts. The other side of the coin, is that such a decentralized decision-making structure makes it difficult to implement all central specifications of the European legislation in time and form (BMUKN & UBA, 2001). Inter-municipal cooperation and associations play a particularly important role, especially in rural areas, often emerging voluntarily, and encouraged by some state governments. The strength of the German model lies less in centralized control and more in its consensus-oriented governance: experts, stakeholders, and affected groups are systematically consulted, and decisions are shaped by compromise and broad democratic legitimacy. This process has the disadvantage of being slower at times, but the advantage of producing more durable and widely accepted solutions (BMUKN & UBA, 2001).

Some key characteristics or principles when it comes to regulation of water management include: price controls, financial incentives for sustainable use of water, water abstraction and waste discharge charges, minimum quality standards for drinking water, as well as for technologies and plants, prohibition or limiting of substances hazardous to water bodies (for instance, in the Act on Washing and Cleaning Agents) (BMUKN & UBA, 2001). Overall, sustainability is a guiding principle for all policies implemented, and plays a decisive part even if not perfectly implemented at all times. Another highlight from the overall regulatory framework and standards, is its adaptability and result-oriented definitions. Considering the constantly evolving technologies and research on pollutant materials and their effects, frameworks can easily become obsolete if too detailed or it involves slow standardization processes (BMUKN & UBA, 2001).

By the late 1990s, Germany had essentially completed nationwide connection to public sewerage systems (BMUKN & UBA, 2001), and today, connection rates exceed 99 percent, Germany being the European country with the highest wastewater reprocessing and recycling rates (BMUKN, 2025a). The focus has shifted from building new networks to maintaining and modernising aging infrastructure, including the repair of extensive sewer networks and upgrading of treatment plants. Wastewater disposal is financed through user tariffs and fees, and connection to public systems remains mandatory in most municipalities (BMUKN & UBA, 2001). The current challenges lie in ensuring resilience against climate change impacts, reducing micropollutants, and improving the energy efficiency of treatment facilities.

Moreover, achievements on the level of water body remediation cannot only be accredited to federal and state authorities: there is a participation and strong commitment from citizens' action committees and environmental organizations that was essential to the

political implementation of water protection measures (Umweltbundesamt, 2001). The set monitoring standards for the dischargers of contaminants were recorded in water books of not accessible to the public, based on the protection of corporate secrets. After campaigns and court cases to abolish that, Germany has gone far on the path to transparency. The reassignment of permits for point sources today is negotiated at public debates. Other water body users as well as environmental organizations are able to view, comment on, and criticize the application documents (BMUKN & UBA, 2001).

To complement the legal framework and participatory instances, especially in water bodies such as the Rhine where disasters have occurred, there is a very comprehensive and constant analytical monitoring of the quality of water and pollutants. Industrial companies located there have had to develop a strong sense of responsibility for water protection due to the high level of surveillance (BMUKN & UBA, 2001).

This country rarely experiences water stress, but when it occurs, it can be seasonal and regional (Kraemer et al., 2007). There are areas with historically high water consumption linked to industry, such as the industrialized mining region between the rivers Ruhr and Lippe in the Rhenish coal-mining district, and the regions around Stuttgart, Bremen, Frankfurt, Halle and Leipzig, which are supplied by long-distance or inter-basin transfers (Kraemer et al., 2007). Germany has had sufficient water resources for all uses, and the sources have been diversified, using naturally protected groundwater where possible, spring water and groundwater from infiltration, or surface water. The deficits to be addressed are more so found in controlling pollution by nutrients, pesticides and their metabolites from agriculture, and from small-scale sources of pollution in urban areas (Kraemer et al., 2007).

A practice that has proven efficient in Germany over time is for water suppliers to contract with land-owners and land-users, particularly in agriculture, to ensure that land use and agricultural methods do not compromise the protection of water sources (Kraemer et al., 2007). This involves management contracts or the purchasing of agricultural land by water suppliers and its lease back to farmers with management conditions, favoring organic farming and other low-impact methods. Regulators have allowed German water suppliers to pass on to water consumers the costs of compensating farmers for the required changes in management practices. Moreover, in a practice contrary to the polluter pays principle, German water users, through the water price, pay the polluter or potential polluter for practicing non-polluting or low-polluting methods (Kraemer et al., 2007). The reasoning behind that is that it is much more costly to treat and clean the drinking water than to pay to reduce pollution at its origin.

Water use per person in Germany is low, especially when compared to other industrialized countries, which means that the high fixed costs of maintaining the supply network and infrastructure have to be covered by fewer litres sold, driving up the unit price of water (Kraemer et al., 2007). Overall, even though there is sufficient national water resources and no pressing need for frugal use, users have been driven by a general striving towards an ever-improved efficiency, as well as by a deeply-ingrained attitude of conservative use. This has allowed new, innovative ideas and technologies to be developed and successfully implemented (BMUKN & UBA, 2001). Therefore, Germany's experiences cannot only be attributed to innovative technologies and finances, but to the strong commitment and idiosyncrasy of its inhabitants (BMUKN & UBA, 2001).

### **2.2.2. National environmental laws: legal approach to protect water and reduce pollution**

For a brief background, Germany's national federal law on Water Resources management (Water Resources Act - Wasserhaushaltsgesetz or WHG) was first passed in 1957. Initially, it had a strong focus on legal regulation of water use rights (such as abstraction, discharges, navigation), and on pollution control and allocation (permitting, effluent charges). Traditionally, water territorial units were structured around political-administrative boundaries, meaning states and municipalities, rather than ecological ones, such as river basins.

The framework had a diffuse distribution of competencies, fragmented institutions with limited coordination between federal, state and municipal levels, producing silos instead of an integrated strategy. Some consider the administrative implementation of water planning was not very successful, as previous plans often lacked binding effect and were taken more as advisory and implementation lagged (Albrecht, 2013). During the 1990s and 2000s, this act was extensively revised to align or transpose the European Union's framework.

In 1996, the European Commission embarked upon consultations on water policy in the European Union, forming the basis for a proposal for a Directive establishing a framework for Community action, which was submitted one year later. It was amended and presented to the European Parliament in 1999. After a lengthy period of negotiations, compromise was achieved by the Council and the Parliament in 2000, and the Water Framework Directive of the European Community entered into force in December 2000, establishing the coordinated and harmonized management and protection of waterbodies

within river basin districts that transcends national and regional boundaries (BMUKN, 2025a).

### **2.2.2.1. The Water Framework Directive of the European Community (2000) transposed as the Federal Water Act amendment of 2002**

Germany's water legal framework and planning underwent a revival in the new millennium, with the transposition of the European Water Framework Directive 2000/60/EC (WFD) into national law in the 7th amendment to the Federal Water Act in 2002 (Albrecht, 2013). It applies to inland, transitional and coastal surface waters as well as groundwaters. It establishes an integrated approach to water management, respecting the integrity of whole ecosystems, including by regulating individual pollutants and setting corresponding regulatory standards was established (European Commission, 2025). It is based on a river basin district approach, to make sure that neighbouring countries cooperate to manage the rivers and other bodies of water they share (Article 3 WFD). This constituted one of the main changes in the existing German framework and institutional administration.

The ambitious legal instrument for the water field at the time had a central objective and binding target to achieve a good ecological status for *all* water bodies (watercourses, lakes, coastal waters, groundwater) within the EU by 2015 (Article 4 WFD), and preventing further deterioration, which places aquatic ecology in the centre of water management. The directive provides a specific set of planning tools: for each river basin district, members have to establish a programme of measures (Article 11 WFD) and a river basin management plan (Article 13 WFD). By December 2009, the programmes and plans for the German river basin districts got into force (Albrecht, 2013).

As time passed, authors have highlighted that some of the most valuable areas from the WFD was its consistently extensive, river basin district-related approach, taking into consideration the different waterbody types, and approaching contaminants and substances in a combined and parameter-related way (Hering et al., 2010). The first two overall objectives the framework states is "*to protect and enhance the status of aquatic ecosystems and groundwater, including terrestrial ecosystems directly depending on the aquatic ecosystems*", and "*to promote the sustainable use of available water resources*" (Art. 1, WFD). This sets the scene for how the concept of water will be constructed throughout the document.

With regards to groundwater protection, the WFD required the European Commission to submit a suitable framework with special measures to reduce and limit pollution, which took place in 2003, and finally the Groundwater Directive of 2006 entered into force in 2007 (transposed by Germany in 2009 as part of the new Federal Water Act of 2010). Its principal element is that it distinguishes a good qualitative groundwater status on the basis of uniform, EU-wide quality standards and threshold values to be defined at national level. If classified as having a bad status, suitable measures had to be taken to improve the groundwater body to achieve good status by 2015.

The WFD permits the designation of “artificial” or “heavily modified” water bodies, but only under strict conditions. Such designation is allowed where achieving good ecological status would be impossible or disproportionately costly, and where essential uses such as hydropower, navigation, or flood protection would otherwise be significantly impaired. In these cases, the environmental target is lowered to achieving good ecological “potential” rather than “status.” Nonetheless, chemical quality standards remain fully binding, regardless of designation, and there needs to be consideration of future measures and possible environmentally friendly alternatives.

As alluded to, coordinated management within river basins is central in the Directive, and the German water industry has adapted to this principle (BMUKN, 2025a). Previously, there was little uniform management of river basins, apart from the work carried out by the water associations and river basin-related planning of certain sub-tasks, such as wastewater disposal (BMUKN, 2025a). Particularly, Member States were to ensure that the management plans and the programmes of measures were coordinated for the entire river basin. With international river basins such as the Rhine, responsibility for coordination should be shared between the participating States, and a management plan had to be prepared for each national and international river basin district.

Reporting obligations also mutated accordingly: Germany had to identify its ten river basin districts, including the international ones, and report back to the EU on how they were delineated. The status assessment of surface and groundwater bodies was also required to the states - this being the first time that Germany introduced binding obligations for the states on water status reporting. Monitoring networks and river basin management plans that were aligned to the WFD objectives and requirements was also included (BMUKN, 2025a). The Länderarbeitsgemeinschaft Wasser (LAWA), established in 1956, is a permanent working group that coordinates water management across the states. It plays a central role in harmonising state implementation of water law, developing technical standards, and coordinating EU reporting obligations under the Water Framework Directive. In practice,

LAWA ensures that Germany's federal structure can deliver consistent national water policy outcomes and reporting (BMUKN & UBA, 2022).

Overall, the WFD marked a shift away from the traditional "command-and-control" model of water management, which treated environmental problems in isolation (Voulvoulis et al., 2017). Under the old system, regulators monitored individual pollutants at discharge points and enforced strict limits, assuming that addressing each problem separately would improve overall ecosystem health. While this approach had helped industrial societies tackle the most health-threatening pollution in the past, it reduced ecosystems to isolated parts, neglected their complexity, and overlooked interactions and trade-offs across different scales. This proved inadequate for achieving long-term ecological sustainability (Voulvoulis et al., 2017). The WFD introduced an integrated, ecosystem-based approach to water management, centred on river basins as natural units. This model recognizes the interdependence of water systems with other physical and socio-economic systems, and seeks to manage water resources holistically, rather than through isolated parameters (Voulvoulis et al., 2017).

Another way the WFD acknowledges the complexity of water management is by requiring public participation in planning, ensuring that multiple perspectives are included in decision-making. It introduced an "experimentalist" approach at the time, through its Common Implementation Strategy: composed by provisional goals, regular review, and continuous learning (Voulvoulis et al., 2017). Unlike older directives that imposed fixed targets, the WFD gave Member States flexibility in how to achieve its objectives, while still imposing binding operational duties such as monitoring and reporting, which can be enforced through the EU Court of Justice (Voulvoulis et al., 2017).

Looking at the whole framework, there were few but important hard targets: the "non-deterioration" rule, and the binding objective for all surface and groundwater bodies to reach at least "good status" by 2015 (Art. 4. WFD). This last one softened by also allowing derogations (extensions to 2021 or 2027, or less stringent objectives) under the conditions previously mentioned. Germany is among the countries that has made extensive use of these extensions and exemptions.

The way the WFD defines good ecological status is very thought-provoking and another innovative inclusion for its time (Voulvoulis et al., 2017). In recognition of ecological variability and different water types, the EU understood that good ecological status could not be set by a single absolute standard. The Directive defines it as the condition of a water body with no or only very minor human impacts. To assess this, it uses the concept of

“reference conditions,” describing what biological communities (e.g. plankton, benthic species) would look like in undisturbed waters. Each water type therefore requires its own reference conditions, against which actual conditions can be measured to determine whether the status is ‘good’ (in summary, type-specific use of reference conditions) (Voulvoulis et al., 2017). Following systems principles, ecological status is used in this framework as an environmental indicator of system performance. This refers to the distance between the current state and the desired one, in this case, the deviation of the current state of a water body from its state under undisturbed, reference conditions. The aim is to indicate the deviation of the system state from its state under undisturbed, reference conditions, and not to provide an absolute value of ecosystem quality. Annex V outlines three groups of ‘quality elements’: biological, and two supporting ones, hydromorphological and physico-chemical, to be used in the classification of ecological status.

Finally, to guide the shift away from traditional “end-of-pipe” pollution controls, and instead promote sustainable, catchment-based management, the WFD adopted the DPSIR framework (Drivers, Pressures, State, Impacts, Responses). It links human activities to their environmental impacts and the measures needed to address them. Central to the WFD is integrated river basin management, which treats land and water as a single system. This requires a paradigm shift towards systems thinking: an interdisciplinary and holistic approach that considers ecological, social, and economic factors together (Voulvoulis et al., 2017).

#### **2.2.2.2. The Federal Wastewater Ordinance (AbwV) (1996, updated 2004)**

This framework established federal, legally binding technical standards, including pollutant limits for different types of wastewater. It came in place as part of the sixth amendment to the Water Management Act in 1996, to regulate and set minimum discharge standards in municipal wastewater treatment, and ensure compliance with EU rules. An example is the Urban Wastewater Directive 91/271/EEC, which obligates Member States to collect and purify wastewater from households and small businesses, and is designed to reduce organic pollution as well as nitrate and phosphorus emissions from these sources (BMUKN & UBA, 2018). The ordinance contains 54 annexes with detailed requirements for domestic wastewater and various industrial sectors. These set the minimum discharge standards under federal law, but states and their water authorities may impose stricter requirements, for example to protect sensitive ecosystems or the public interest. As a result, many municipal WWTP operate with stricter discharge limits than the federal minimum standards (BMUKN & UBA, 2001). Minimum wastewater requirements date back to the 1976

amendment of the Federal Water Act, but these were general obligations, therefore, the importance of this ordinance lies in that it was the first to codify detailed, nationwide, legally binding pollutant limits for municipal and industrial wastewater discharges, marking a decisive step in harmonising wastewater regulation (BMUKN & UBA, 2018).

An amended version of the Waste Water Ordinance of 2004 put new provisions into place and replaced the above mentioned one. It achieved consolidation of the legal framework on the matter and alignment with the EU Water Framework Directive. The update introduced the principle of Best Available Techniques (BAT), stricter pollutant limits, and linked emission control more explicitly to ecological protection goals. It also establishes that protective measures in the water sector shall not be to the detriment of the air, waste and soil sectors (BMUKN, 2025c).

In 1996, the EU Council had come up with the Integrated Pollution Prevention and Control (IPPC) Directive, which established the best available technology standard in all environmental laws as a uniform basis for integrated assessments. The German Waste Water Ordinance of 2004 therefore aligned its requirements for waste water discharges more strongly with this BAT principle across all areas. Specifically, it implies an assessment of the entire sewage chain (input material, preventive measures, sewage system, sewage treatment facility) and the interface to other sectors (BMUKN, 2025c). In the German framework, the permissible pollutant load depends on each industry's ability to minimize emissions into water by observing technically and economically viable, progressive processes (BMUKN & UBA, 2018).

While the ordinance installed minimum requirements, which reflect the BAT principle and vary per industry; it is still aligned with the decentralized nature of the rest of the German water legal framework. Permits for the direct discharge of treated wastewater into a waterbody are issued at the discretion of the responsible water authority, so long as they abide by those limits and BAT principle, and with the restriction of protection of waterbodies (BMUKN & UBA, 2018).

Last but not least, in terms of principles, the ordinance supports the concept of wastewater avoidance through its general requirement that it may only be discharged into a waterbody if the pollutant load is kept as low as possible, via the use of water-saving procedures or processes (for instance, washing and cleaning operations, indirect cooling and the use of low-pollutant feedstocks and auxiliary materials) (BMUKN & UBA, 2018). Moreover, there are details on industry-specific measures for avoidance in the annexes too. There are numerous manufacturing processes and examples which largely (and in some

cases completely) avoid the discharge of wastewater through a combination of measures, thereby preventing harmful effects in the waterbodies. An example can be converting to water-conserving in-house circulatory systems, or using dry cooling towers instead of wet cooling towers (BMUKN & UBA, 2018).

It is worth noting that this framework works in conjunction with the Wastewater Charges Act (in force since 1981), which mandates direct dischargers to pay a fee for the direct emission of wastewater into a waterbody. The fee is determined from the quantity and harmfulness of specific constituents discharged into the water, applying the polluter-pays principle (BMUKN & UBA, 2018). Collected charges are earmarked for water protection measures, such as upgrading WWTPs. In 2005, the act was amended to increase the charge per harm unit as of 2006.

### **2.2.2.3. The Sewage Sludge Ordinance (AbfKlärV) (1992, revised 2002)**

The purpose of this instrument, initially effective from 1992, has been to regulate the use and disposal of sewage sludge to reduce water contamination. It supplements provisions of the Fertilizer Ordinance (1996). It regulates pollutants in the use of sewage sludge for fertilising agricultural soils, and stipulates that application is to be limited and completely prohibited on land used to cultivate fruit and vegetables, permanent grassland and in certain water protection areas. The ordinance requires that sludge-treated soils be regularly analysed for pollutants and sets out pollutant limits that must not be exceeded in the application of sewage sludge, to ensure unimpaired use of the land (BMUKN, 2025b). There was a revision in 2002, where these provisions continued to be tightened, however it was not until 2017 that a major reform took place.

## **2.2.3. Main challenges and observations**

### **2.2.3.1. EU Water Framework Directive**

While the EU Water Framework Directive entered into force in December 2000 and was initially transposed into German law in 2002 through amendments to the Federal Water Act, a comprehensive implementation was not possible at the time. Only the general intent of the Directive was incorporated into the 2002 version of the WHG, while regulatory tasks in particular were still assigned to the states for implementation. This is due to constitutional limits (Art. 75, pre-2006 reform), under which the Federal Water Act could only provide

framework rules, leaving most regulatory details to each state (BMUKN, 2025a). The 2006 federalism constitutional reform gave the federal government full legislative competence in water law, and Germany adopted a new WHG in 2010, thereby achieving comprehensive transposition of the WFD into federal law. Therefore, the first challenge addressed here is the existing constitutional framework preventing full implementation.

Within the topic of institutional organization and hierarchy, since each of the German states set the legal framework and oversee the municipalities, who are responsible for services provisions related to water. However, there were no independent regulatory agencies for water and sanitation at the federal level (unlike in other sectors such as energy), to ensure integration and transparency across municipalities and states, as resisting came from the understanding that municipal self-government, regulating and benchmarking (through surrogate competition) is sufficient.

After the reunification, many East German municipalities were dramatically contaminated, needing to be quickly and effectively cleaned up, as well as to make great investments in WWTPs among other areas in a short period of time. This required the joint efforts of the nation, the municipalities, the states, and the private companies in a national solidarity action; resulting in more than 2,000 WWTP's built, sewer pipes were laid, and entire branches of industry were cleaned up (BMUKN & UBA, 2001).

Another highlighted challenge is that, while the integrative and ambitious ecological targets have strict deadlines and exigent timetables, there is a lot of margin for interpretation and flexibility in how to achieve them (Voulvoulis et al., 2017). Lack of clarity in some of the guidance materials meant that there were mixed results and reporting (Voulvoulis et al., 2017).

For several countries, the WFD transposition meant transitioning from established monitoring networks to those that support a more integrated approach to water management. Fortunately, Germany already had well-developed monitoring networks for chemical water quality, which made that part of the implementation less of a heavy lift. The challenging part was to transition to a monitoring network that recognizes the overall status of the ecosystems, which is what the WFD aims to improve, rather than the specific, more detailed elements listed in the Directive within its Annex V (Voulvoulis et al., 2017). Adapting from parameter-based to ecosystem-based monitoring systems required new typologies, such as the abovementioned reference conditions for rivers and lakes, which Germany did develop, but with delays. Moreover, Germany's existing network, while extensive, was

focused on chemical parameters, rather than biological quality elements as mentioned in said Annex.

Many Member States struggled with WFD effective implementation, as they continued traditional water management practices, focusing on controlling individual pollutants rather than addressing the complex interactions within catchments (Voulvoulis et al., 2017). This “command-and-control” mindset assumes linear causality and often results in measures that target symptoms instead of underlying pressures (Voulvoulis et al., 2017). Programmes of Measures (PoMs) were frequently designed around the quality elements defined by the Annex V, such as chemistry, hydromorphology, or fish fauna; instead of tackling systemic drivers of degradation. While improvements in the individual elements are important, they should be outcomes of pressure reduction and ecosystem recovery. In Germany, for example, research showed that PoMs were often implemented to address point-source pollution, even where it had not been identified as a key pressure, raising doubts about their effectiveness in achieving WFD objectives (Voulvoulis et al., 2017). This meant an investment of time and resources on treating a problem (point-source pollution) that was not the main reason why water bodies were failing WFD objectives of “good ecological status”, essentially treating the wrong symptom (European Commission, 2015).

A highlighted feature of the WFD was its participatory requirements in terms of decision-making. The interpretation of most Member States was to opt for more traditional administrative structures, such as assigning a competent authority through which associated catchment management activities could be made operational (Voulvoulis et al., 2017). This tendency led to significant barriers to effective multi-sectorial integration and governance, as championed by the WFD. The institutional mismatch between the water management structure in Germany and the WFD's catchment management requirements, indicated cross-sectorial cooperation and public involvement to be considered a low priority and misaligned with traditional water management practices (European Commission, 2015). This paradigm shift towards the systemic and participatory principles of the WFD was not an easy journey, given long standing traditional decision-making processes and structures, experts understand that the WFD certainly planted the seeds for a more integrated water management (Voulvoulis et al., 2017).

Authors have pointed out that there often appeared to be a direct conflict between the flexibility provided in implementing the WFD, and the effectiveness of water management with regards to the achievement of environmental goals (Voulvoulis et al., 2017). The Directive showed revolutionary ambition in how waters in Europe should be managed and

setting binding targets, but then national interpretation and weak enforcement mechanisms decelerated the introduction of a system-oriented, adaptive management:

*“Considering the misunderstandings with the definition and the role of ecological status in the WFD process; the ineffectiveness of measures developed to improve element classifications often without fully understanding the system as a whole; the limited contribution of basic measures for previous water policy legislations towards achieving the objectives of the WFD; tendencies to implement measures that do not readily address significant pressures; and continuing with centralised decision-making processes, identified here as obstacles to the shift towards participatory catchment management, the lack of real change enabling a fundamental shift towards systems thinking could be seen as the underlying cause of all of these”* (Voulvoulis et al., 2017).

That considered, the process of shifting to systems thinking when managing catchments is not easy, as it involves recognizing their differences and coming up with a tailored approach for each management. This means there is not one single recipe to be applied to all: each catchment is composed by its own complex web of interactions of highly interdependent human and natural systems (Voulvoulis et al., 2017). That complexity requires extensive interdisciplinary research and knowledge integration, focusing on participatory processes to enable all relevant actors and stakeholders co-create new knowledge and adapt their practices (Voulvoulis et al., 2017).

When EU member states submitted their WFD river basin management plans to the European Commission in March 2010, almost all member states accomplished the formal implementation, but Germany reported being far from achieving “good status”, and exemptions were claimed for 82 percent of all surface water bodies and for 36 percent of all groundwater bodies under Article 4 (Richter et al., 2013). The availability of derogations in the WFD are not illogical, as the binding target timeframes have been considered as tremendously ambitious, but it meant that countries like Germany were more lax and widely use them - by the second cycle (2015 plans, for 2021), the picture had only modestly improved. The UN reports that the main reasons are overbuilding, straightening and transverse structures interrupting the flow of watercourses. Moreover, the chemical status of around 25 percent of the bodies of groundwater in Germany is bad due to high nitrate values (UN, n.d.). Therefore, the picture for the third cycle (2021-2027) is not looking very optimistic, as many water bodies (particularly rivers affected by hydromorphological pressures as navigation and flood control) are expected not to reach good status even by 2027.

Despite the challenges mentioned, there is a strong federal commitment to invest significantly in the public water supply. Even back in 2001, the government had reported approx. 2.5 billion Euros invested annually during the previous decade, towards the expansion and renovation of the public water supply network, mainly the pipeline network, but also into purification plants and storage facilities for drinking water (BMUKN & UBA, 2001).

In addition, the continual increase in water demand seen in other countries (namely, Brazil and India) is not experienced in Germany. This is due to a mixture of water-saving or efficient technological developments, the increased use of rainwater and greywater, the construction of water circulation systems, promotion of substitution of water in production processes, and measures towards reduction of leakages (BMUKN & UBA, 2001).

#### **2.2.3.2. The Federal Wastewater Ordinance**

Enhancing the capacity wastewater treatment plants built with the best available technology (which Germany has invested significantly on) is insufficient. To take it to the next level integrating additional effective measures for the elimination of micropollutants and nano-materials into the wastewater treatment plant is required (BMU, UBA, 2018). Moreover, different pollutants emerge through time, so a related challenge will be eliminating the ones in waste water that had not been considered at the time of implementation of these legal instruments (and implementing technologies accordingly). Some examples highlighted by the Federal Ministry are pharmaceutical residues, antibiotics from animal husbandry or chemicals displaying hormone-like effects even in minute quantities (BMUKN, 2025c). Naturally, adopting BAT, upgrading treatment plants and implementing new technologies, involves frequent and costly technical upgrades, and capacity and funding will vary per state. Continuously striving for the balance of cost recovery via tariffs while enforcing strict regulation and BAT, is not easy.

Similar to what was mentioned for the WFD, meeting or staying below numerical discharge limits, does not necessarily translate into the expected ecological improvement, which challenges the practical effectiveness of the framework.

#### 2.2.4. Outcomes and findings

Regarding the implementation of the planning instruments under the WFD: by the end of 2009, all German river basin districts, river basin management plans and programmes of measures had been established and the implementation of the measures had been running (Albrecht, 2013). The supply of clean water and sanitation is guaranteed in Germany, which has meant that the focal points for national water protection efforts (and to achieve SDG 6) has been primarily the improvement of water quality (target 6.3) (Federal Government, 2021).

Despite considerable progress in water resources protection, almost all of the 9,800 bodies of surface water and more than a third of the 1,200 groundwater bodies in Germany have not yet achieved “good ecological status” or good ecological potential within the meaning of the WFD (UN, n.d.). Overbuilding, straightening and transverse structures interrupting the flow of watercourses are the main causes identified by the Federal Government (Federal Government, 2021).

High nitrate values are the cause of bad chemical status of around 25 percent of groundwater bodies in Germany. The groundwater monitoring points where the nitrate limit of 50 mg/l is not exceeded has remained virtually unchanged since 2008, and the goal of keeping it below that limit at all monitoring points has not been achieved (groundwater is supposed to be below it at every monitoring point by 2030) (Federal Government, 2021). As reported in 2001, 83 percent of nitrogen pollution of Germany’s environment came from agriculture, therefore, legislation is not enough to guarantee levels below the abovementioned ceiling, water suppliers and authorities need to cooperate closely with the sector with the aim of restricting their use of fertilizers and pesticides in the most efficient way possible (BMUKN & UBA, 2001).

If we were to assess the effectiveness of the WFD in Germany, solely based on the binding environmental targets it had, it was not successful. The European Commission is, naturally, not satisfied with implementation results thus far, in particular with the use of exemptions to the environmental objectives, considered as enablers of delays and of water quality improvement falling down the list of states’ priorities (Boeuf et al., 2016).

As a reflection of the paradigm of the Integrated Water Resources Management (IWRM), the WFD was successfully able to incorporate several of its principles into a binding legal framework, such as integration across different water uses and pressures, management on the basis of natural hydrological units such as river basins, more

participatory decision-making, consideration of ecological, social and economic dimensions of water use and protection together, implementing pricing and full-cost-recovery mechanisms to promote conservation and efficiency, and finally, recognizing it as both a public and economic good (UN, 1992; Richter et al., 2013).

Specifically, requiring the compliance of polluters with emission targets, the achievement of “good status” in surface and groundwaters with timeframes, the inclusion of polluter-pays and full cost recovery principles, as well as the requirement of river basin management plans with a deadline, turn the IWRM into enforceable law for all member states. Of the ten river basins defined in Germany, eight extend across at least one international border (Richter et al., 2013), which only accentuates the importance of having a regional legal framework and cross-border plans and management. For instance, through international river basin associations such as the International Commission for Protection of the Elbe, or federal states associations like the River Basin Community Elbe. Moreover, water authorities and other specialized bodies in Germany’s 16 states have already completed the necessary technical legwork and have exchanged information with each other (Richter et al., 2013).

In the past, environmental management had mostly relied on regulatory instruments, leaving water authorities inexperienced in participatory, cooperative forms of governance beyond formal consultation exercises (Moss, 2004). Despite challenging, integrating participatory initiatives in water governance, adapting to contribution of interested parties and the broader public has been a key instrument in the implementation of the WFD in Germany, with the federal states promoting intensive communication and discussion, and receiving back high levels of interest and feedback, mainly from municipalities and environmental organisations, as well as affected user groups. This feedback was used during the reworking of the river basin management plans, which was completed at the end of 2009 (Richter et al., 2013).

In the first implementation cycle of the WFD, the federal states widely applied deadline extensions and exemptions, highlighting the difficulties of achieving the 2015 target. Exemptions were granted for about 82 percent of surface water bodies, with only 18 percent expected to reach “good ecological status” by the initial deadline. The main justifications were technical infeasibility, natural conditions, and the long-term modifications required from the intense usage and pollution of a densely populated and industrialized country as Germany (Richter et al., 2013). For groundwater, exemptions applied to 36 percent of bodies, while 62 percent had already achieved good status and 2 percent were expected to do so by 2015. Slow responses to nutrient reduction measures and the delayed ecological

recovery of species were key limiting factors (Richter et al., 2013). Therefore, the effectiveness of WFD implementation is constrained by structural, ecological, and temporal challenges, requiring adaptive management and long-term restoration strategies rather than short-term compliance fixes.

Around 9,900 surface water bodies (of which 9,070 are rivers), plus 1,000 groundwater bodies, were grouped into 225 planning units (surface water bodies) and 41 working areas (groundwater bodies). As of 2010, 87 percent of surface water bodies were classified as 'moderate' (30 percent), 'poor' (34 percent) and 'bad' (23 percent). The failure to achieve "good ecological status", is usually due to radical changes to its hydromorphology via pressures such as navigation, hydropower or excessively high nutrient load, mostly caused by agricultural activities (Richter et al., 2013). For lakes, transitional and coastal waters, failing this objective is mainly due to high nutrient input. As mentioned, Nitrate is the main pollutant, pesticides and other pollutants play a smaller role in groundwater pollution (Richter et al., 2013). Therefore, the main issues in all ten German river basins are to reduce nutrient and pollutant input into surface waters and groundwater from diffuse and point sources, to improve surface-water hydromorphology and to restore free passage for fauna, particularly fish (Richter et al., 2013).

The cost of implementation of measures towards the WFD's environmental objectives was of a large magnitude (estimated EUR 9.4 billion by the end of the first management plan period in 2015) (Richter et al., 2013). For that purpose, the full cost recovery principle (Art. 9) is effectively applied to municipal water services, although environmental and resource costs are only partially internalized, agricultural and industrial users often do not pay the full environmental externalities associated with water use. Furthermore, the polluter-pays principle, legally established, has its weaknesses in diffuse pollution, again, particularly from the agriculture sector. Commensurability is another principle legally (Art. 4.5) and practically established, through which environmental measures must make economic sense, be justified, affordable, and reasonable in proportion to their ecological benefit. In Germany, this has been invoked when approving exemptions and extensions to the good status deadline, illustrating how economic pragmatism shapes the practical effectiveness of local implementation, as well as the relevance of the concept of water as an economic good. The majority of costs are covered by tax revenues, fees and charges. Overall, the key sources for financing the programmes of measures are various funds from the European Union, the Federal government, state governments and local authorities (Richter et al., 2013).

The accomplishments in management improvement had mostly come from state regulations and methods, rather than the national level (Richter et al., 2013). Differences in

the provision of information in river basin management plans, in the rules for the designation of heavily modified water bodies or the use of exemptions had been identified. Therefore, the Federal government, states and the LAWA agreed to kick off a harmonisation process to ensure a transparent, cohesive and coordinated approach for the next river basin management planning phase, and the European Commission noted significant improvements in the second river basin management plans cycle, with only few gaps and areas of improvement in the areas mentioned (2015-2021) (Richter et al., 2013, European Commission, 2019).

Additional areas identified as needing improvement are reducing emissions from incineration plants, adding more substances to the list of standards, and a strong need to integrate more effective water protection instruments into the agri-environment (as mentioned, this is one of the most pressing issues), since several measures aligned with the polluter-pays principle are voluntary for farmers, and often subsidized (Richter et al., 2013). The polluter-pays principle must ensure the integration of all users responsible for ecological deficits and the loss of ecological functions, extending to the construction of water bodies for hydropower generation and shipping too (Richter et al., 2013).

Germany's environmental tax system has been lagging behind the polluter-pays principle: environmentally related tax revenue has declined relative to GDP and remains below the OECD Europe average (OECD, 2023). This is not due to lower environmental pressures according to OECD, but rather a lack of annual inflation adjustments, a change that has been recommended (OECD, 2023). 13 of 16 federal states charge for water abstraction currently, but the federal government intends to restructure wastewater charges and to introduce extended producer responsibility measures, creating stronger incentives for reducing water pollution from municipal and industrial wastewater (OECD, 2023).

The North-West and South-East agricultural areas are still affected by high livestock concentration and intensive land use, with diffuse agricultural pollution (high levels of nutrients running off from fertilizers in fields, especially phosphorus and nitrate) deteriorating surface and groundwater bodies with eutrophication, as acutely seen in the Baltic and North Sea (OECD, 2023). OECD has pointed this as one of the main problem areas that Germany needs to strengthen efforts for, to adequately monitor and address this pollution. The country has revised the fertilizer legislation comprehensively in 2017 and 2020 - while a significant reduction of nitrogen surpluses as well as of ammonia and nitrous oxide emissions is expected, it will take years before the impact is visible (OECD, 2023). Another way forward recommended by OECD is promoting nature-based solutions and economic incentives to reduce the use of fertilizers (OECD, 2023). This also evidenced the importance of increasing

the coordination levels as well as the coherence of the policies with the fields of: agriculture, energy generation, transport (especially shipping) and production or use of chemicals (Richter et al., 2013).

The German water sector, as others, faces increasing challenges from climate change, with prolonged droughts, heatwaves, and declining river and groundwater levels already disrupting inland navigation and industrial supply chains, as seen during the 2019 Rhine drought. These have a tendency to expose the vulnerability of existing water infrastructure and governance mechanisms, and impact other sectors, such as the energy one (OECD, 2023). In response, the new National Water Strategy from 2023 outlines a long-term vision to 2050, aiming to strengthen resilience through integrated water management, improved infrastructure, and cross-sector coordination. It emphasizes preventing water scarcity, enhancing quality, investing in flood prevention and nature-based solutions, and broadening the financial base for adaptation. Developed through a two-year participatory national dialogue, the strategy reflects a shift toward more inclusive and adaptive water governance, aligning with the principles of the EU WFD and IWRM (OECD, 2023).

Although all the above issues are still relevant to this day, and therefore it was important to highlight them, the country has made several improvements to its legal framework since (UN, n.d.). Within the context of the UN Water Action Decade (2018-2028), the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety conducted a two-year National Dialogue on Water with stakeholders from 2018 to 2020 and has also been engaged in a National Citizens' Water Dialogue (UN, n.d.). These efforts culminated in a proposal for a new National Water Strategy that was established in 2023, including a long term vision for sustainable water management by 2050, combining measures for water availability, quality, infrastructure adaptation, and ecosystem restoration. It has been Germany's most comprehensive effort to date to integrate climate resilience and participatory governance into national water policy.

Additionally, legal provisions on fracking have been in force since 2017, restricting the use of fracking technology in Germany (UN, n.d.). Fertilizer application legislation was revised between 2017 and 2020, taking a major leap towards preventive action on water bodies from the damaging effects of nutrient inputs (Federal Government, 2021).

Furthermore, contributions have not only been at the national level, as the German Government is, according to the UN, the world's second-largest bilateral donor to development cooperation in the water sector, cooperating in more than 20 partner countries,

and assisting partner countries with funds of around EUR 3.3 billion from 2013 to 2017 (UN, n.d.). The country is also participating in the development of a global indicator-based monitoring system for water quality and water resource management, as well as of a global database for water quality data as part of the UNEP programme GEMS/Water (Federal Government, 2021).

There is no doubt that the WFD signified a major policy progression and has been delivering environmental improvements, as Germany has reduced several environmental pressures, despite an important industry base and dense population (OECD, 2023). Nonetheless, the Directive could have played a greater role in delivering coherent and sustainable water management in Germany. The role of ecological status as a performance indicator, better characterisation of river basins (including analysis of pressures, impacts and economic analysis), improving monitoring to capture the interactions between stressors, ensuring that PoMs aim to improve system state by managing pressures, improved participation and interdisciplinarity to address the complex issues associated with water management; are all affecting the effectiveness of this Directive and call for a transition towards systemic thinking (Voulvoulis et al., 2017). There has been little progress in reducing and preventing the level of municipal waste, water quality evidently remains a concern; sustainable farming, while progressing, needs to be further promoted; and water infrastructure needs to become more climate resilient (OECD, 2023).

Looking at the results from the Wastewater Ordinance, the framework implemented has been part of why Germany is the European country with the highest waste water reprocessing and recycling rate, with over 96 percent of the waste water from private households or public facilities discharged into nearby sewage treatment plants (STPs) for processing (BMUKN, 2025c). Discharge of untreated wastewater remains prohibited under the Federal Water Act, regardless of its origin; nearly all wastewater is undergoing biological treatment with targeted nutrient removal. However, emerging pollutants such as pharmaceuticals, per- and poly-fluoroalkyl substances, and hormones remain a growing challenge, as current treatment technologies cannot fully remove these trace substances yet (BMUKN, 2025c).

To target this issue, the Federal Government's "Trace Substance Strategy," has been adopted since, which promotes advanced treatment technologies and preventive measures. It was developed in a comprehensive dialogue process since 2016, and while considered a milestone, it lacks binding pollutant thresholds. The German Centre for Micropollutants, founded in 2021 and part of the Federal Environment Agency, supports these processes and provides technical advice (BMUKN, 2023). For the future, there are several innovative

approaches (for instance, new approaches in sewage sludge recycling, and nitrogen recycling in wastewater treatment plants) being considered and tested by Germany, as shared in the 2018 report on water resource management from the German Environment Agency (BMU, UBA, 2018). Upgrading treatment infrastructure and integrating fourth-stage purification (an additional processing stage to significantly reduce emissions of micropollutants into surface waters, as conventional plants are not designed for that) are considered key measures for compliance with EU standards and achieving the goals of the recent 2023 National Water Strategy (BMUKN, 2023).

## **2.3. India**

### **2.3.1. Country Overview**

Densely populated, dependent on the monsoon, and largely rural; India has 18 percent of the world's population, but only 4 percent of its water resources, making it one of the most water-stressed countries in the world (India Water Portal, n.d.). This increasing scarcity has been creating tensions between regions and sectors and threatens food security and livelihoods (Singh & Goyal, 2025, FAO, 2023). India receives roughly 4,000 km<sup>3</sup> of rainfall a year, but it is uneven in space and time (Kumar et al., 2005). Per-capita water availability is falling toward water-stressed and, in some places, water-scarce levels as population grows (NITI Aayog, 2019, FAO, 2023). Climate change is making the water cycle more erratic, with more extremes and greater year-to-year variability (NITI Aayog, 2019).

Groundwater is the backbone of the supply, especially in rural areas but increasingly in urban ones too, as about 85 percent of the population relies on it for drinking water, and over 60 percent of irrigated agriculture depends on it (World Bank, 2012). Satellite data show rapid depletion in parts of the Northwest, equivalent to about 4 cm of water height per year (Rodell et al., 2009). Groundwater was traditionally governed by old legal principles tied to land ownership, allowing landowners to extract water with little regulation. However, as depletion worsened, it became clear that these rules were unsuitable and the central government encouraged states to develop new groundwater laws to control over-extraction and promote sustainable use (Cullet, 2007).

About 80 percent of river flow arrives in just 4-5 monsoon months. Himalayan snow and ice do not create large net water, but they do help distribute it during the dry season (Kumar et al., 2005). Further imbalances are evident, for instance, the

Ganges-Brahmaputra-Meghna basin (~34 percent of area) provides ~62 percent of water (Kumar et al., 2005).

The majority of agricultural production is rainfed (53 percent), making India heavily dependent on the increasingly erratic monsoon. Droughts are becoming more frequent and rain-dependent farmers are already facing a crisis (India Water Portal, n.d.). Subsequently, water use is dominated by irrigation, and in 2010, withdrawals highly dominated by the use of irrigation, coming from both surface water and from groundwater (Water Action Hub, n.d.). Demand is expected to continue to rise, tightening the gap between utilizable and needed supply (NITI Aayog, 2019).

*“India is suffering from the worst water crisis in its history and millions of lives and livelihoods are under threat. Currently, 600 million Indians face high to extreme water stress and about two lakh people die every year due to inadequate access to safe water . The crisis is only going to get worse. By 2030, the country’s water demand is projected to be twice the available supply, implying severe water scarcity for hundreds of millions of people and an eventual ~6 percent loss in the country’s GDP. (...) Thus, there is an imminent need to deepen our understanding of our water resources and usage and put in place interventions that make our water use efficient and sustainable”* (NITI Aayog, 2018).

Untreated sewage and industrial effluents degrade many of the major rivers, as the Ganga, Yamuna; with big city outfalls contributing heavy loads (IGNOU, n.d.). Pesticide residues such as organochlorines, organophosphates, pyrethroids, are reported across several states, affecting water, ecosystems, and food safety (India Water Portal, n.d.). The Central Pollution Control Board (CPCB) has identified hundreds of polluted river stretches, some have improved across the years and been delisted, but many still remain (CPCB, 2022; CPCB, 2023).

In addition to being one of the world’s leading pesticide producers, intensive agricultural practices have caused widespread pesticide contamination across many states. Contaminated surface water, groundwater, and soils are often exceeding WHO and BIS safety limits (India Water Portal, n.d.). As many pesticides dissolve easily in water, they penetrate aquifers and create long-term pollution that is hard to reverse. The impacts vary regionally, but include groundwater contamination, food chain bioaccumulation, and severe health effects such as cancers, reproductive disorders, and neurological diseases. Major incidents, such as endosulfan poisoning in Kerala’s Kasaragod district, highlight the human cost of chronic exposure. States like Punjab, Haryana, Maharashtra, and Uttar Pradesh face acute contamination of drinking water from agricultural runoff, while regions such as West

Bengal, Assam, and Rajasthan experience ecosystem degradation, food safety issues, and declining fish populations. Overall, pesticide pollution in India represents a growing challenge for water quality, public health, and agricultural sustainability (India Water Portal, n.d.).

Health impacts are tremendous, with about 37.7 million people contracting waterborne diseases annually, and diarrheal disease is claiming many young children and causing large productivity losses (Chaudhuri & Roy, 2017, Kumar et al., 2022). Moreover, on a study conducted by the World Bank including India among other economies, found that when rivers become very heavily polluted, regions downstream experience lowered economic growth, losing between 0.8 and 2.0 percent of economic growth (World Bank, 2019). NITI Aayog's Composite Water Management Index 2019 report specifically mentions that 6 percent of India's GDP will be lost by 2050 due to the water crises, if the country continues under a business-as-usual approach (NITI Aayog, 2019)

Central Pollution Control Board (CPCB) surveys in metros and industrial clusters have shown diverse groundwater issues related to salinity, nitrates, fluoride, coliform bacteria, and metals. Drivers include over-abstraction, weak sewerage and solid-waste systems, and industrial discharges; and coastal areas face seawater intrusion (CPCB, n.d.). CPCB has urgently recommended regulating extraction, expanding sewerage, improving waste management, testing sources, and using artificial recharge (CPCB, n.d.). However, traditional, supply-driven and end-of-pipe approaches prevail and struggle with today's complex socio-ecological systems (Amarasinghe et al., 2007). Since the 1990s, water law and policy have been reworked with the aim to tackle the main issues of scarcity, pollution, and groundwater dependence (Cullet, 2007).

Overall, India's monsoon-driven hydrology, severe regional imbalances, and heavy groundwater reliance, meet with a multi-level governance system with uneven capacity. The country is divided into 28 states and 8 union territories for administrative purposes, with some districts further divided into sub-districts (over 800 districts and smaller administrative units are in existence). Some union territories such as Delhi and Puducherry have elected legislatures, while others are directly ruled by the central government. Overall, its government is federal in structure with unitary features. In terms of hydrology, India's water resources are divided into 20 major river basins, such as the Indus, Ganges, and Brahmaputra systems.

Monitoring and transparency have improved (CPCB, 2022; 2023), and flagship programs have expanded access (UN India, 2021). Nonetheless, persistent diffuse pollution,

urban treatment gaps, and groundwater over-extraction continue to limit ecological recovery and public health (Amarasinghe et al., 2007; Singh & Goyal, 2025).

### **2.3.2. National environmental laws: legal approach to protect water and reduce pollution**

Indian water governance lacks a single, comprehensive legal framework to regulate freshwater across all dimensions: it is a patchwork of colonial-era laws, states' acts, and relatively recent environmental and human rights jurisprudence (Cullet, 2007). The current legal system combines common law principles, such as landowners' traditional rights over groundwater, with state irrigation acts and national pollution control laws. These often overlap or conflict, creating inconsistencies between state and central policies and their results, as seen in reports from the National Institution for Transforming India or NITI Aayog, the policy think tank for the Government of India.

Historically, irrigation law was the most developed area, reflecting colonial priorities for large-scale irrigation works (Cullet, 2007). Acts such as the Northern India Canal and Drainage Act of 1873 and the Madhya Pradesh Irrigation Act of 1931 established strong government control over surface water for public purposes. This legacy continues today, with many states asserting ownership of surface and groundwater resources.

Under India's constitutional framework, water is primarily a state subject, which translates into states having the power to regulate water supply, irrigation, drainage, and hydropower. On the other hand, the central government retains authority over interstate rivers, navigation, and pollution control through instruments like the Inter-State Water Disputes Act (1956) and the Water (Prevention and Control of Pollution) Act (1974) (Cullet & Gupta, 2009).

The Indian Constitution does not directly recognize a fundamental right to water, however, court decisions deem that as implied in Article 21 (right to life), and expanded as the recognition of the right to a clean and healthy environment (Cullet, 2007). However, implementation remains weak, with limited integration of human rights principles into statutory and administrative practices (Cullet, 2007).

Local-level customary rules for water use are often based on caste, community, or traditional irrigation practices, and continue to operate informally. Despite that, they are frequently displaced or ignored by formal legislation, resulting in a fragmented, multi-layered legal landscape, characterized by overlapping jurisdictions, uneven enforcement, and limited coherence between central, state, and local governance levels (Cullet, 2007).

### 2.3.2.1. National Water Policy (2002)

The National Water Policy (NWP) of 2002 marked a significant shift in India's water governance paradigm, building upon the earlier 1987 version to reflect the country's changing socio-economic context. It kicks off defining water as a *“prime natural resource, a basic human need and a precious national asset”*. It recognized that India had used up most of its ability to expand irrigation by 1999-2000, and with the population still rapidly growing (projected to around 1.39 billion by 2025), the available water per person would become increasingly scarce - making water management and conservation urgent priorities (Geethanjali & Rao, 2020). Therefore, the 2002 policy emphasized efficient use, equity in allocation, and recognition of water as a finite resource. It introduced for the first time a stronger focus on demand management, rainwater harvesting and integration of groundwater with surface water (Geethanjali & Rao, 2020). In doing so, it attempted to move away from purely supply-driven expansion towards a more holistic perspective of water resources.

One of its distinctive reforms was the endorsement of the drainage basin or sub-basin as the planning unit, and its explicit push for the establishment of river basin organisations to oversee integrated water-resource planning (Geethanjali & Rao, 2020). It acknowledged that water management needed to transcend administrative divisions and integrate both surface and groundwater as part of a unified system. This meant a departure from earlier models that treated water mainly in terms of reservoirs and canals, a shift towards basin-level coordination which many observers have praised as necessary, but arguably under-implemented (Rathee & Mishra, 2021).

Although there is not a direct mention of the IWRM in the document, several of the texts encourage its principles, evidencing the international momentum this framework had gained:

*“Water is part of a larger ecological system. Realising the importance and scarcity attached to the fresh water, it has to be treated as an essential environment for sustaining all life forms”.*

*“Water is a scarce and precious national resource to be planned, developed, conserved and managed as such, and on an integrated and environmentally sound basis, keeping in view the socio-economic aspects and needs of the States. It is one of the most crucial elements in developmental planning”.*

*“Planning and implementation of water resources projects involve a number of socio-economic aspects and issues such as environmental sustainability, appropriate resettlement and rehabilitation of project-affected people and livestock, public health concerns of water impoundment, dam safety etc. Common approaches and guidelines are necessary on these matters”.* (Government of India, Ministry of Water Resources, 2002).

The policy laid out strong, ambitious principles: prioritizing drinking water first, followed by irrigation, industry and other uses; but it did not sufficiently address how states and local bodies lacking capacity would operationalize these reforms (Rathee & Mishra, 2021). The addition of ecology was a change compared to its previous version, as well as the order of industry before navigation. It also placed emphasis on the economic value of water, urging states to gradually introduce volumetric pricing and reduce subsidies for pumped groundwater, with the aim to encourage more sustainable use and discourage wasteful extraction, especially in over-exploited basins (Geethanjali & Rao, 2020).

An innovation in NWP 2002 was its explicit endorsement of private sector participation (PPP) in water planning, development, and management (Clause 13). The policy proposed that private entities could bring in financial resources, corporate efficiency, and improved accountability, through various ownership and operational models such as build-operate-transfer or leasing (Pandit & Biswas, 2019). This, similar to the IWRM principles, reflected global policy trends of the time, rather than coming from domestic assessments or consultations. It appeared to follow the international enthusiasm for privatization expressed during the with limited consideration of India’s social and political realities (Pandit & Biswas, 2019).

Some experts have pointed out that throughout this legal instrument (same as in its previous and next versions), there is a frequent use of “should” and “needs to be”, a language that is interpreted as vague, non-committal, and conveying a recommendation, rather than an obligation; for instance, *“utilisation of water should be optimized”* or *“erosion control should be promoted”* (Pandit & Biswas, 2019).

### **2.3.2.2. Environmental Impact Assessment (EIA) Notification (1994, updated in 2006), issued under the Environment (Protection) Act (1986)**

Although the definition is expansive and dynamic, UNEP considers Environmental Impact Assessment (EIA) as a tool used to identify the environmental, social and economic impacts of a project prior to decision-making (UNESCO, n.d.). Its aim is to predict said impacts at an early stage in project planning and design, to find ways and means to reduce

adverse impacts, shape projects to suit the local environment and present the predictions and options to decision-makers (Drishti IAS, 2020).

India's EIA framework was introduced under the Environment (Protection) Act of 1986, and represents a cornerstone of preventive environmental governance. The first EIA Notification of 1994 had mandated prior environmental clearance for a wide range of activities with potential water implications, such as river-valley projects, mining, thermal power plants, industrial complexes, and infrastructure developments. This shifted environmental assessments from an administrative decision to a statutory process, designed to evaluate impact on water resources, aquatic ecosystems, and pollution levels before project approval.

The 2006 EIA Notification, which superseded the 1994 version, aimed to address the limitations of its predecessor and marked a major institutional reform through the decentralisation of regulatory authority between the central government and the states (Drishti IAS, 2020). Projects were classified as Category A, assessed by the Ministry of Environment, Forest and Climate Change (MoEFCC), and Category B, appraised at the state level by the State Environmental Impact Assessment Authorities (SEIAA) and Committees (SEAC). This version also strengthened procedural thoroughness, through a four-stage process: screening, scoping, public consultation, and appraisal. Within that, a highlight is the formalization of public consultations as a mandated step and therefore an essential component of EIA, initiating the decentralization process to delegate power to the State governments. It also required half-yearly compliance reporting to improve monitoring of pollution, which provided regulators with a cadence to verify delivery on water-quality controls (such as effluent standards, zero-liquid-discharge claims), source protection, and catchment safeguards (Drishti IAS, 2020).

It is worth pointing out that as a notification, it remains subordinate to legislation, and does not constitute a full act or rule, and can be amendable by executive action.

### **2.3.2.3. Special Mention: Ganga Action Plan (Phase II) (1993-2000s)**

The Ganga Action Plan (GAP) was launched in 1986 marking India's first large-scale attempt to control river pollution through a centralized, state-supported intervention. The Ganga River, covering 26 percent of India's landmass and supporting 43 percent of its population, was prioritized as a national environmental and cultural asset. Phase II was approved between 1993 and 1996, and sought to build upon the first phase by extending pollution control efforts to tributaries (a freshwater stream or smaller river that flows into a

larger river), such as the Yamuna, Gomti, Damodar, and Mahanadi, and by incorporating sewage treatment, riverfront development, and public awareness measures.

In terms of sewage treatment, under this phase, the strategy from the central government was to intercept, divert and treat sewage before reaching the Ganga or its tributaries. Over 35 STPs were planned across five states, with focus on urban centers such as Kanpur (CSE, 2014). Another inclusion was riverfront development and beautification projects, aimed at reducing direct human waste disposal and improving sanitation along the riverbanks. For instance, steps leading to the river in pilgrimage cities such as Varanasi and Haridwar were renovated and provided with public sanitation facilities to reduce direct defecation and bathing-related contamination (CSE, 2014). Lastly, regarding measures towards public awareness and community involvement, phase II generated awareness campaigns through schools, local NGOs and citizen groups, and the government supported Ganga Action Plan Awareness Weeks and community-based river clean-up drives, aiming to create a sense of ownership among locals (CSE, 2014).

In 1995, GAP was merged into the broader National River Conservation Plan (NRCP), expanding its reach to seven states and introducing a cost-sharing formula of 70 percent central and 30 percent state funding. Despite partial completion of over 650 projects and construction of multiple STPs, the programme's core objective to restore the Ganga's water quality to acceptable "bathing standards" remained unmet. CSE also points out that community participation remained weak, as planning and decision-making were top-down, with little local consultation (CSE, 2014).

#### **2.3.2.4. Special Mention: National River Conservation Plan (NRCP) - 1995**

The NRCP, launched in 1995, evolved directly from the GAP Phase II and marked a significant broadening of India's river pollution control efforts (Jagran Josh, 2015; Press Information Bureau, 2006). Recognizing that river pollution extended far beyond the Ganga basin, the NRCP expanded the scope of intervention to include 34 rivers across 20 states by 2005. The programme's central objective was to reduce the pollution load in Indian rivers and improve water quality through coordinated central and state-level initiatives under the MoEFCC. In 1996, all GAP-related projects were officially merged under the NRCP umbrella, consolidating river conservation schemes into a single national framework (Press Information Bureau, 2006).

The NRCP focused on a combination of core and non-core activities to mitigate pollution and enhance river health. Core measures focused on the interception, diversion,

and treatment of sewage, while non-core ones included riverfront development, afforestation, construction of public toilets and electric crematoria, as well as community awareness programs (Jagran Josh, 2015; IGNOU, n.d.). By the mid-2000s, the NRCP had established a cumulative sewage treatment capacity of approximately 4,064 million litres per day, serving 178 towns along 38 rivers (IGNOU, n.d.). Afforestation efforts were incorporated to stabilize riverbanks and enhance water retention. Furthermore, the plan emphasized public participation and awareness-building through environmental education campaigns, although the degree of local engagement varied across states. Financially, the scheme was primarily centrally funded, with a 70:30 cost-sharing ratio between the central and state governments (IGNOU, n.d.).

Overall, the NRCP represented an important evolution in India's environmental policy-thinking: from river-specific, project-based interventions under the GAP, to laying the groundwork for integrated river basin management at a national level.

#### **2.3.2.5. Special Mention: Supreme Court Interventions**

From the 1980s through the early 2000s, India's Supreme Court emerged as one of the most powerful and activist judicial bodies in the world, playing a decisive role in shaping environmental protection and water governance (Niyati, 2015). Judicial activism arose in part due to regulatory weaknesses and administrative inertia, prompting the Court to intervene directly in environmental matters through Public Interest Litigation. The Court expanded the interpretation of Article 21 of the Constitution, understanding the "*the right to a clean and healthy environment*" as part of the right to life. This judicial reinterpretation marked a turning point in India's environmental jurisprudence, transforming environmental protection from a policy aspiration into an enforceable constitutional right (Niyati, 2015).

Following the Bhopal Gas Tragedy of 1984, environmental protection rose to the forefront of national policy debates. The tragedy exposed severe deficiencies in India's legal and institutional framework and catalyzed a wave of environmental legislation, including the Environment (Protection) Act of 1986, which became India's umbrella environmental law (Niyati, 2015). In the following years, the Supreme Court and High Courts progressively widened environmental law's scope, introducing doctrines such as the polluter pays principle and absolute liability, and strengthening accountability mechanisms for hazardous industries. The Court's interventions in cases like, among others, *M.C. Mehta v. Union of India* (1987, 1991) compelled both industrial and municipal actors to increase compliance with pollution control measures, particularly in river basins as the Ganga and Palar (Antharvedi, 2007).

In the Ganga Pollution (Tanneries) case, the Court ordered the closure of more than 150 tanneries (where chemical processes transform raw animal skins into leather) and 190 other industries discharging untreated effluents into the river, and mandated the installation of effluent treatment plants (ETPs) across industrial clusters in Uttar Pradesh, Bihar, and West Bengal (Niyati, 2015). Additionally, it directed municipal bodies to construct and operate STPs and held local authorities accountable for ongoing water pollution. The Court's reasoning drew from international environmental norms, such as those articulated in the 1972 United Nations Conference on Human Environment, recognizing that environmental protection is fundamental to human rights and development (Niyati, 2015). Through continuous monitoring, on-site inspections, and self-initiated orders, the judiciary sought to enforce its directives, although long-term compliance remained inconsistent due to weak administrative execution and lack of financial capacity at the municipal level (Niyati, 2015).

Judicial activism also expanded to protect groundwater resources and address corporate exploitation of water - the landmark Plachimada Coca-Cola case in Kerala of 2003-2004 illustrated this dynamic (Antharvedi, 2007). Local communities and the Perumatty panchayat challenged the company's over-extraction of groundwater (estimated 1.5 million litres per day) which led to water scarcity and contamination of wells and paddy fields. The Kerala High Court, invoking the public trust doctrine, ruled that natural resources such as water cannot be privatized for commercial purposes and must remain available for public use (Antharvedi, 2007). The state government subsequently ordered the closure of the Plachimada bottling plant, a rare instance of judicial support for community-led environmental justice.

While these interventions strengthened India's environmental jurisprudence, their effectiveness in achieving long-term pollution control remains mixed. The judiciary's proactive stance acted as a catalyst for new regulatory measures, such as the Municipal Solid Waste (Management and Handling) Rules of 2000, and fuel conversion policies in Delhi, but the implementation gap between judicial orders and administrative action persists. The Supreme Court's directives often suffered from limited enforcement capacity, bureaucratic resistance, and insufficient political will (Niyati, 2015). Critics argue that excessive judicial involvement sometimes blurred the lines between the judiciary and the executive, leading to what has been called executive judicial activism (Niyati, 2015). Nevertheless, judicial activism provided critical momentum for environmental governance reform, embedding sustainability principles into constitutional interpretation and public consciousness.

Overall, the Supreme Court's interventions, rooted in constitutional values and human rights, transformed environmental law from a fragmented administrative function into a cornerstone of India's governance architecture. With persisting implementation, it reflects both the strengths and the limitations of relying on courts to lead environmental governance in a complex federal system (Antharvedi, 2007; Niyati, 2015).

#### **2.3.2.6. Special Mention: Central Pollution Control Board (CPCB) Guidelines**

During the period studied in this text, the CPCB regularly revised and expanded the General Standards for Discharge of Environmental Pollutants under Schedule VI of the Environment (Protection) Rules, 1986. Several amendments, particularly those notified between 2000 and 2007, tightened effluent discharge limits for parameters such as biological oxygen demand (BOD), chemical oxygen demand (COD), total suspended solids (TSS), and heavy metals, and extended these standards to more industrial categories. These revisions created a stronger baseline for pollution control, requiring industries and State Pollution Control Boards (SPCBs) to upgrade treatment infrastructure and strengthen enforcement mechanisms.

Recognizing persistent non-compliance in highly polluting sectors, the MoEFCC and CPCB launched the Charter on Corporate Responsibility for Environmental Protection (CREP) in 2003. The Charter identified 17 highly polluting industrial categories, including distilleries, tanneries, pulp and paper, and textiles, and outlining specific time-bound environmental action points for each (CPCB, 2003). CREP introduced the concept of near zero liquid discharge (ZLD) for sectors such as distilleries and dyeing units, requiring industries to adopt technologies like biomethanation, composting, and incineration to achieve complete reuse or recycling of wastewater. Compliance was linked to bank guarantees and periodic monitoring, effectively integrating accountability and performance incentives into environmental regulation.

Parallel to these national efforts, the CPCB also evaluated the performance of Common Effluent Treatment Plants (CETPs) serving small and medium industries. A 2005 review identified systemic inefficiencies in design and operation, such as hydraulic overload and inadequate sludge management. This prompted the issuance of new operational guidelines to improve compliance and efficiency. These reviews underscored the uneven enforcement capacity of SPCBs and the need for centralized technical oversight to standardize pollution abatement performance (CPCB, 2003).

By the mid-2000s, the CPCB's evolving approach reflected a shift from broad standard-setting to a more integrated management, combining regulatory tightening, industry responsibility, and technological innovation. The period also laid the foundation for later initiatives such as the Zero Liquid Discharge (ZLD) mandates in the National Green Tribunal (NGT) era and the Namami Gange Programme post-2014. While enforcement remained inconsistent across states, this decade marked the institutionalization of stricter environmental governance and reflected India's shift towards closer alignment with international best practices in industrial wastewater management.

### **2.3.3. Main challenges and observations**

One of India's main roadblocks to an effective water protection framework is institutional fragmentation, characterized by a national water governance system splintered with central agencies such as the Central Water Commission (CWC), Central Ground Water Board (CGWB), and Central Pollution Control Board (CPCB), each focusing on separate aspects and operating in silos, creating overlap and lack of clear accountability - a picture of segregated, uncoordinated governance (NITI Aayog, 2018). Water policies were often drafted without a common framework across political and hydrogeological boundaries, making basin-level management nearly impossible (Pandit & Biswas, 2019). Despite the 2002 NWP advocating for IWRM principles and participatory approaches, these remained largely rhetorical due to limited coordination and the absence of enforceable legal mechanisms (Pandit & Biswas, 2019; Rathee & Mishra, 2021).

Another defining feature was, and continues to be, India's data collection and availability deficit in water management. The Composite Water Management Index and later assessments have identified severe shortcomings in hydrological data coverage, reliability, and transparency (NITI Aayog, 2018). Most water-use data is available only at the aggregate level, while groundwater estimates were derived from a small sample of approximately 55,000 wells out of 12 million nationally, leading to a poor understanding of regional dynamics (NITI Aayog, 2018). Fragmented information systems, isolated departmental operations, and limited inter-state coordination have exacerbated inefficiencies (NITI Aayog, 2018). The lack of a unified data framework impeded evidence-based policymaking, particularly for groundwater management, where over-extraction continued unchecked. By 2007, more than half of India's groundwater wells were declining, and major cities such as Delhi, Chennai, and Hyderabad were facing acute depletion risks. Considering this, assessing the effectiveness of a policy of national scope through quantitative indicators remains hypothetical.

At the same time, the center-state structure of Indian federalism adds another layer of barriers to coherent policy implementation. While water remained a “state subject” under the Constitution, most national programs, such as the NRCP for irrigation schemes, were centrally funded and administered. This mismatch often led to low ownership at the state level and poor maintenance of assets once central funding ceased (Cullet & Gupta, 2009). While the NRCP recorded localized improvements in biochemical oxygen demand (BOD) and chemical oxygen demand (COD) levels (Sinha & Sedai, 2025), long-term sustainability was undermined by weak monitoring, operational inefficiencies in sewage-treatment plants, and low river flow due to upstream diversions (MoEFCC, 2009). These gaps mirror broader governance trends in other sectors: fragmented authority, limited technical capacity, and insufficient decentralization (Cullet & Gupta, 2009).

India struggled to prevent the rapid industrial growth from further straining regulatory capacity: the MoEFCC, which had been empowered under the Environment Protection Act of 1986, struggled to balance economic development with environmental protection. While GDP per capita nearly tripled between 1984 and 2004, this growth was accompanied by rising pollution and public health risks (Broughton, 2005). Small-scale industries, particularly in semi-urban areas, often discharged untreated effluent directly into drainage channels. As one example, the Yamuna River in Delhi saw heavy-metal concentrations (including lead, cadmium, and chromium), reaching hazardous levels due to inadequate waste treatment and enforcement (Broughton, 2005).

The management of chemical pollution from the agricultural and industrial sectors was deficient, particularly in terms of pesticide regulation, which remained fragmented and weakly enforced. Limited laboratory infrastructure, widespread use of banned chemicals, and inadequate awareness among farmers have led to persistent contamination of soil and water systems (India Water Portal, n.d.-b). Subsidy structures also favored chemical pesticides over bio-based alternatives, discouraging adoption of integrated pest management (India Water Portal, n.d.-b). These governance failures highlight the disconnect between policy intent and operational capacity, particularly in rural and semi-urban contexts where regulatory oversight is weakest.

#### **2.3.4. Outcomes and findings**

Overall, during the period of 1995 to 2007, India made significant strides in formalizing its water governance architecture through a combination of legislative reforms, policy instruments, and institutional restructuring. Despite these advancements, significant challenges persisted in translating these frameworks into effective environmental outcomes.

The NWP 2002 was conceived as a major revision of the earlier 1987 framework, aiming to address new pressures of population growth, urbanization, and industrial expansion. Yet, despite its more progressive rhetoric, such as introducing ecology as a recognized priority and endorsing IWRM, the policy faced significant conceptual and implementation challenges that limited its effectiveness (Rathee & Mishra, 2021). One of the key criticisms was its vague and non-binding character: Pandit and Biswas (2019) note the language relied heavily on terms such as “should” and “needs to be,” which hardly exude enforceable commitment. It was deficient in clearly specifying institutional responsibility, funding mechanisms, timeframes, or legal consequences for non-compliance. This normative rather than mandatory approach led to what Pandit and Biswas (2019) referred to as a “feel-good” policy: well-intentioned, but operationally hollow. The absence of binding legal authority meant that NWP 2002 functioned more as a guiding vision than an enforceable strategy, relying on states to adopt its provisions voluntarily.

Moreover, while the policy introduced ecology as a new claimant in the hierarchy of water allocation (listed fourth), civil society organizations and environmental groups criticized the ranking for treating environmental needs as secondary (Pandit & Biswas, 2019). Critics argued that ecological water flows should have been prioritized immediately after drinking water to maintain river health and prevent further degradation of aquatic ecosystems. The focus remained anthropocentric, reflecting a utilitarian view of water as an economic good, over a shared ecological resource (Rathee & Mishra, 2021).

The policy encouraged private sector participation (PSP) and public-private partnerships (PPP) as instruments for improving efficiency and service delivery, even explicitly stating in Clause 13 that PSP “*should be encouraged in planning, development and management of water resources projects for diverse uses, wherever feasible*”. This reflected the global neoliberal influence of the time, but was adopted in India without adequate socio-political contextualization. In practice, very few PPP models materialized, even in urban water supply systems, due to public opposition, tariff disputes, and weak regulatory mechanisms (Pandit & Biswas, 2019). Scholars argue that the inclusion of PPPs in NWP 2002 was more aspirational than pragmatic, echoing international trends rather than reflecting India’s local (formal and informal) institutional realities.

In terms of institutional integration and data governance, NWP 2002 endorsed integrated water resources management, but fell short due to a lack of an actionable roadmap for inter-agency coordination. India's water governance continued to be fragmented among multiple bodies, each operating with distinct mandates and limited data-sharing mechanisms (Rathee & Mishra, 2021). Surface water is managed separately from groundwater, and quantity treated separately from quality. Despite acknowledging IWRM as a desirable principle, NWP 2002 neither defined institutional linkages nor provided mechanisms for basin-level management, monitoring, or accountability.

The policy's economic focus also generated controversy, emphasizing that water should be treated as an economic good to encourage conservation and efficient use. This approach disregards the marginalization of vulnerable populations, particularly smallholder farmers and low-income urban communities, who could not afford increased tariffs or metering charges (Rathee & Mishra, 2021). Civil society groups warned that such commodification could exacerbate existing inequalities, especially in states with weak regulatory capacity. The absence of a clear social protection framework further deepened concerns that water pricing could prioritize cost recovery over equity.

Implementation shortfalls compounded these conceptual flaws. As water remained a state subject under the Constitution, the central policy relied on voluntary adoption by individual states. Many states either failed to draft their own aligned water policies or did so without concrete implementation mechanisms (Pandit & Biswas, 2019). Moreover, funding constraints and bureaucratic fragmentation hindered the translation of policy into local programs (Rathee & Mishra, 2021). Consequently, the ambitious goals of NWP 2002, such as improving water-use efficiency, promoting participatory management, and ensuring sustainable groundwater use, remained largely unfulfilled by the late 2000s. Ultimately, it revealed structural and ideological contradictions, blending neoliberal efficiency aspirations with welfare and sustainability language, yet failed to reconcile these in a coherent implementation framework. The result, as Pandit and Biswas (2019) and Rathee & Mishra (2021) conclude, was a policy that expanded India's environmental discourse but fell short of producing measurable outcomes. India's aspirations remained as so, due to the persistent gap between policy rhetoric and on-ground reality.

The Central Pollution Control Board (CPCB) attempted to issue draft effluent standards during this period, but exceeded its statutory remit (due to limits established in the Environment (Protection) Act, 1986), creating a legal vacuum that states interpreted inconsistently (India Water Portal, n.d.-a). This acts as another evidence of one of India's

enduring governance issues: overlapping jurisdiction and weak statutory clarity across environmental institutions.

As for results coming from the EIA framework, refined in 2006, weak appraisal capacity, poor baseline data, and limited public participation often allowed high-impact projects (such as hydropower and industrial complexes) to proceed without robust water-impact assessments. The subordinate legal status of the EIA notification, which can be amended by executive order, further reduced its consistency and authority (Drishti IAS, 2020). Some of the highlighted shortcomings of the EIA process in practice have been: exemptions for projects not listed within the framework, lack of experts as environmentalists and social scientists participating in expert committees, public hearings carried out in an untimely manner or not at all at times, lack of credibility and quality of studies and reporting coming from the EIA processes. Addressing this issue and making sure that clearance is withdrawn when conditions are violated would lead to better water protection in the future.

In this period, there was a clear aim towards expansion to national, integrated water governance, for instance, from the GAP II to the NRCP, and participatory ideas such as Water User Associations. Once again, while decentralization advanced on paper, uneven capacity and unclear accountability limited scale and equity of outcomes, especially for small or non-landowning users (Cullet, 2007).

Pollution reduction scaled up under NRCP, but urban sewage remained a strong constraint. A national review shortly after shows municipalities had installed treatment capacity equivalent to only about one-fifth of sewage generated, with even less actually treated, signaling a long-standing operational, maintenance and financing gap (IDFC, 2011). In the Ganga basin specifically, later technical assessments corroborate the persistence of this structural problem: the main stem continued to receive billions of liters of sewage daily, most of it untreated; industrial volumes were smaller but disproportionately toxic. These results are consistent with the limitations of the studied period in the matter: investments focused on end-of-pipe hardware rather than network connectivity, flow restoration, and operations (Mateo-Sagasta & Tare, 2016; IDFC, 2011).

Groundwater became the engine for irrigation as canal performance stagnated, creating rising overdraft risks that were already evident by the 2000s. Policy responses (model bills, draft state laws) sought to regulate abstraction, but the underlying land-linked private access rule and subsidy-driven pump expansion undermined the legal framework (Cullet, 2007; IDFC, 2011). India had become the world's largest groundwater-based economy, supplying irrigation for more than 60 percent of agriculture, amid declining aquifers

(World Bank, 2012). This shift, driven by energy subsidies and poor canal maintenance, led to alarming groundwater depletion and overdraft conditions in several states. The framework's rhetoric on demand management and pricing, met in practice with weak metering and political economy constraints, which limited the reduction of extraction or improving efficiencies (IDFC, 2011).

Institutionally fragmented and with overlapping mandates (e.g., surface water, groundwater, and pollution control spread across different agencies), India faced many complications in the goal to implement basin-scale planning and enforcement. Although national policies called for planning by hydrological units, basin plans and empowered river-basin organizations did not materialize for interstate systems, limiting cumulative-impact control and coordinated allocation (Cullet, 2007; Pandit & Biswas, 2019). Data systems were also immature: only in 2008 did India's Water Resource Information System (India-WRIS) emerge as an attempt to create a centralized platform (Gupta, 2020), evidencing that the framework developments studied in this text had tremendous information gaps for both decision-making and implementation.

Evaluations undertaken in the following decade reinforce these findings: national coordination and detailed water data collection remained weak, while interstate disputes and fragmented policies continued. Many states also fell behind in improving groundwater recharge, rural water quality, and wastewater treatment. These ongoing problems reflect the unresolved structural constraints from earlier policy periods (NITI Aayog, 2018, 2019).

In sum, the period in scope delivered policy breadth, without depth in results: nationalization of river conservation efforts and modern policy language (IWRM, participation, economic valuation) did not translate into corresponding outcomes, as sewage networks and operation and maintenance lagged, groundwater governance remained structurally misaligned, and institutions and data were not sufficiently prepared for basin-scale management, which also lacked enforcement mechanisms (Cullet, 2007; IDFC, 2011; Pandit & Biswas, 2019; Mateo-Sagasta & Tare, 2016). It was a critical phase in India's water policy evolution, characterized by expanding legislative and institutional frameworks. However, the combination of legal ambiguity, weak intergovernmental cooperation, and inadequate regulatory infrastructure constrained the effectiveness of even well-intentioned policies. As India's population and industrial footprint grew, these systemic weaknesses entrenched a cycle of policy abundance and implementation scarcity, where laws proliferated but on-the-ground outcomes lagged.

### **3. Comparative analysis of country outcomes and findings**

#### **3.1. The value of comparative analysis in environmental law research**

Viñuales (2023) observes that while environmental law has expanded rapidly since the late twentieth century, systematic comparative analysis remains rare, often limited to incidental references across jurisdictions rather than structured methodological inquiry. He identifies four key purposes of comparative study: clarifying a system by contrast, interpreting foreign systems, refining institutional practice, and extracting analytical categories to map broader patterns. This thesis draws upon these functions to examine Brazil, Germany, and India as distinct yet interlinked systems responding to similar challenges of water governance, enforcement, and sustainability.

Cross-country comparison can be used as a diagnostic tool: how these three federal systems manage water pollution can further enlighten on ways the institutional, legal, and policy variables influence implementation effectiveness. It also reveals a tension between national and intra-national legal structures and global or transnational environmental challenges. Although environmental pollution, such as water contamination, transcends borders, governance authority remains territorially anchored, particularly within federal systems like India and Brazil, where constitutional divisions of power shape environmental regulation.

Moreover, it is not only within the water sector that this type of analysis can be useful. As expressed throughout this text, the connection across sectors is of tremendous importance; industrial, agricultural, and energetic sectors are some of the key ones here, but water, in one way or another, touches all areas: pollution control frameworks can only be as effective as they are integrated in the whole system - economic, social and cultural. If regulation is created by looking at water resources in an isolated manner, it does not matter how innovative, progressive, or advanced it is; on the ground, it will likely remain an ideal, and not a reality. The period from 1995 to 2007 witnessed significant legislative and institutional reforms in all three countries: Brazil's water basin reforms and enforcement decentralization, Germany's implementation of EU water directives, and India's river conservation and groundwater regulation policies. Evaluating their respective outcomes thus contributes to the broader comparative agenda of fine-tuning environmental law systems to enhance water protection and pollution control effectiveness.

### **3.2. Where does the strength or fragility of these environmental laws come from? The implementation gap**

The effectiveness of environmental law is not a static outcome, but a continuous, multidisciplinary process that depends on legal, administrative, sociological, and even statistical dimensions (Prieur, 2021). Assessing both whether laws exist (existential) and whether they are meaningfully applied and enforced (effectiveness), ultimately leading to measurable environmental results (efficiency), are all important aspects that need to be studied. Authors, such as Prieur (2021), have promoted the use of legal indicators to understand effectiveness, identifying six categories of legal indicators: existential, applicability, substantial, institutional, enforcement, and extralegal. In India, for instance, the persistence of groundwater depletion and river pollution despite numerous legal developments, points to weaknesses in institutional and enforcement legal indicators (limited monitoring capacity, poor inter-agency coordination, and inadequate judicial compliance). In Brazil, the strong constitutional and legal foundation for environmental protection contrasted with uneven state-level enforcement, revealing gaps in extra-legal indicators, including governance capacity and political will.

Germany's integration of EU water directives during this period exemplifies higher institutional and enforcement coherence, showing how effective law application can translate into measurable pollution reduction, despite its flaws. Furthermore, F. Haumont (2023) argues that the strength of European environmental law lies not merely in the richness of its legal framework but in its structured mechanisms for transposition, implementation, and enforcement. Within the EU, directives such as the WFD (2000/60/EC) had to be transposed into national law, with the European Commission monitoring compliance and the Court of Justice empowered to impose financial penalties for non-implementation. This institutional design ensures a level of accountability that directly links supranational oversight with domestic environmental performance. The EU's requirement for integrated river basin management, periodic reporting, and penalty mechanisms under Article 260 of the Treaty on the Functioning of the EU (TFEU) pushed Germany to align national policy with regional standards. In contrast, Brazil and India, with overlapping jurisdictions, limited data transparency, and weak enforcement capacity often prevented water laws from achieving their intended outcomes, even when legislation appeared robust on paper. The lesson there is that legal effectiveness requires not just comprehensive regulation, but also clear, institutionalized enforcement pathways through clearer accountability mechanisms, stronger monitoring, and more independent judicial oversight (Haumont, 2023).

Brazilian author A.H. Benjamin (2023) has argued that Brazil's environmental legislation, while among the most modern and comprehensive in the Global South, suffers from a persistent implementation deficit, as enforcement remains undermined by four core weaknesses: defective legislative drafting, contradictory policy content, weak enforcement institutions, and chronic underfunding of environmental agencies. Benjamin attributes much of the dysfunction that causes legislation, such as the National Water Resources Policy (1997), to fail in its objectives to cultural and institutional factors. He highlights the Brazilian "jeitinho" (the informal bending of rules), and a historical imbalance between the discourse of rights and the one of duties. Germany's integration within the EU's supranational legal framework, with binding directives and penalty-based enforcement, exemplifies institutionalized accountability; India, as well as Brazil, exhibit strong statutory frameworks but weak federal coordination and monitoring. Together, these cases underscore Benjamin's core insight: comprehensive environmental law is insufficient without institutional capacity, cultural legitimacy, and measurable indicators of implementation.

### **3.3 Complementing with quantitative insights: trends in key water quality indicators**

For the selection of the indicators of water quality below, inspiration has been taken from the paper "Determinants of Declining Water Quality" by E. Ayana (2019). However, it is important to note that this list is certainly not exhaustive, and there are further biological and chemical characteristics of water, as well as physical and aesthetic ones (in terms of appearance and smell) that define water quality. When assessing drivers, which can be natural and/or anthropogenic factors with strong relationship with a given water quality indicator, the author names five factors as especially key ones: agriculture activities (including deforestation), climatic factors, geographic factors, economic factors and urban expansion (Ayana, 2019).

#### **3.3.1. GEMStat Reporting**

Data from three periods was downloaded from GEMStat: from 1992 to 1994 (pre), from 1995 to 2007, and from 2008 to 2011 (post). The selected water quality indicators are Biochemical Oxygen Demand (BOD), Dissolved Oxygen (DO) and Fecal Coliform (FC), as they are the few ones where data is mostly available for the three countries across the three periods.

Said reports have shown for India, increasing levels of BOD, DO, and FC after 2007; severe increases for Brazil during 1995-2007 for all, with only partial recovery post. This might not be an accurate reflection of the indicators themselves, but a lack of data collection

or coverage. For Germany, BOD improved across the years, DO stayed high but stable, FC data was incomplete.

### 3.3.2. AQUASTAT (FAO) Reporting

(E): Estimate; (I): Imputed; (A): Official

**Table 2. SDG 6.4.1.: Water Use Efficiency (US\$/m<sup>3</sup>)**

Year	Brazil	Germany	India
1990	No data	No data	0.71 (I)
1995	No data	No data	0.87 (I)
2000	17.18 (I)	No data	1.07 (I)
2005	19.19 (I)	No data	1.36 (I)
2010	18.61 (I)	70.24 (E)	1.81 (I)
2022	22.67 (I)	126.28 (E)	3.42 (I)

**Table 3. SDG 6.4.2.: Water Stress (percent)**

Year	Brazil	Germany	India
1990	1.97 (E)	No data	51.35 (E)
1995	2.49 (E)	66.93 (E)	57.01 (E)
2000	2.65 (E)	61.52 (E)	62.68 (E)
2005	2.73 (E)	55.29 (E)	64.59 (E)
2010	3.54 (E)	45.22 (E)	66.49 (E)
2022	1.50 (E)	35.35 (E)	66.49 (E)

**Table 4. Wastewater: Treated municipal wastewater (10<sup>9</sup> m<sup>3</sup>/year)**

Year	Brazil	Germany	India
1990	No data	No data	0.92 (A)
1995	No data	No data	1.24 (A)
2000	1.28 (I)	No data	1.57 (A)

2005	1.78 (I)	No data	3.16 (A)
2010	3.32 (I)	0.02 (I)	4.38 (A)
2022	6.36 (I)	0.02 (I)	4.42 (A)

**Table 5. Total renewable water resources per capita (m<sup>3</sup>/inhab/year)**

Year	Brazil	Germany	India
1990	57,977.83 (E)	1,932.05 (E)	2,209.20 (E)
1995	53,463.98 (E)	1,877.59 (E)	1,989.90 (E)
2000	49,690.18 (E)	1,882.70 (E)	1,806.28 (E)
2005	46,819.48 (E)	:1,876.98 (E)	1,654.92 (E)
2010	44,640.75 (E)	1,905.21 (E)	1,536.73 (E)
2022	41,116.20 (E)	:1,831.45 (E)	1,340.58 (E)

### 3.3.3. World Bank Reporting

#### 3.3.3.1. People using safely managed sanitation services (percent of population) - Brazil, Germany, India as of 2022:

Brazil at 50 percent; Germany at 97 percent; India at 52 percent (World Bank, 2022).

#### 3.3.3.2. Water stress (Future) - Most recent values (2080):

Global rankings as follows: Brazil: 134, Germany: 99; India: 42 (World Bank, n.d.).

#### 3.3.3.3. Proportion of bodies of water with good ambient water quality - Most recent values (2017-2020)

Brazil: 71 percent (2020), Germany: 39 percent (2017); India: Not available (World Bank, n.d.).

#### 3.3.3.4. Clean ocean water, 0-100 (best) - Most recent values (2024)

Brazil: 64.7 percent, Germany: 69.2 percent; India: 32.9 percent (World Bank, 2024).

### **3.4. Common challenges in implementation**

Despite significant progress in modernizing their legal frameworks between 1995 and 2007, Brazil, Germany, and India all struggled with structural and operational barriers that limited the effectiveness of their water governance systems. Although the three differ in institutional design and income level, their experiences reveal a shared pattern: ambitious laws were introduced faster than the institutional, financial, and/or technical capacity needed to enforce them. The main common challenges can be divided in five areas: institutional fragmentation, data and monitoring weaknesses, financial and technical constraints, social and territorial inequalities, and the difficulty of translating policy ambition into enforceable outcomes.

#### **3.4.1. Institutional fragmentation and coordination gaps**

One of the most persistent difficulties across the board was the mismatch between legal ambition and institutional coherence. Brazil's water governance system became more participatory after the 1997 Federal Water Law, but remained deeply fragmented between federal, state, and municipal bodies. The coexistence of multiple agencies, such as ANA, state water institutes, and municipal sanitation companies, often led to overlapping mandates and accountability gaps (Santin et al., 2023; Leite et al., 2022). Moreover, while river-basin committees have the aim to foster collaboration, their decisions were often advisory rather than binding, limiting their impact on overall water management and pollution control.

India faced similar fragmentation, but in a context of even greater administrative complexity: the CWC, CGWB, and CPCB each managed specific aspects of water governance disconnected from one another, creating silos and duplication (NITI Aayog, 2018). The 2002 National Water Policy encouraged integration through basin planning and stakeholder participation, yet mechanisms to coordinate across jurisdictions or enforce collaboration were lacking (Pandit & Biswas, 2019; Rathee & Mishra, 2021). As a result, inter-state river disputes and sectoral conflicts continued to undermine coherent policy action.

Lastly, Germany faced a different kind of challenge, though it stemmed from a similar structural issue. The EU's WFD required rivers to be managed according to natural catchment areas rather than administrative borders, but Germany's federal system initially made it difficult to apply this approach consistently across its states. Prior to the 2006 constitutional reform, the federal government could only provide framework rules, leaving

most regulatory details to the states (European Commission, 2019; OECD, 2023). Even after centralization, coordination among state agencies and sectors, especially agriculture, energy, and navigation, was challenging. Therefore, across all three countries, fragmentation diluted or delayed enforcement and made integrated management difficult.

#### **3.4.2. Social and territorial inequalities**

Brazil's geographic asymmetry is evident: the semi-arid Northeast holds almost one-third of the country's population but only 3 percent of its renewable water resources (Dantas & Schmitt, 2015). Despite the implementation of national frameworks, millions still lacked reliable access, and rural areas lagged far behind cities (Santin et al., 2023; ANA, 2024).

India is also familiar with this urban-rural divide: large cities like Delhi or Chennai faced scarcity and contamination, as rural regions lacked basic sewage infrastructure. Economic liberalization initiatives and private-sector participation (PSP) experiments introduced tariff debates and raised concerns over affordability for vulnerable groups (Rathee & Mishra, 2021). Uneven access to safe water and sanitation is a reflection of more profound socio-economic inequalities, not just of territorial factors.

Germany's challenge was not related to access, but to regional legacies and agricultural intensity, as nitrate pollution concentrated in northwestern and southeastern Länder with dense livestock operations (OECD, 2023). These different structural asymmetries, demanded differentiated policy tools, but enforcement often remained uniform, producing uneven results.

#### **3.4.3. Weak data and monitoring systems**

Reliable and comprehensive water data is essential for diagnosis, enforcement, and adaptive policymaking, yet each of the analyzed countries faced gaps in monitoring infrastructure, consistency, and transparency. Despite Germany's extensive legacy monitoring networks, they initially measured mostly chemical parameters rather than ecological status indicators required by the WFD (Voulvoulis et al., 2017). Transitioning to ecosystem-based monitoring was resource-intensive and unevenly implemented across states.

In India, data scarcity was severe: groundwater estimates were based on a tremendously limited sample, which provided little insight into regional variations or over-extraction patterns (NITI Aayog, 2018). Data remained compartmentalized across

agencies, with deficient inter-state sharing or public access, an opacity that weakened both accountability and public trust.

Brazil made progress through ANA's monitoring networks and basin information systems, but coverage and quality have been inconsistent. National reports continued to identify blind spots and losses exceeding one-third of treated water in distribution systems (ANA, 2024). For all countries, limited data integration hindered effective and adaptive planning, as well as the evaluation of policy success.

#### **3.4.4. Financial and technical constraints**

Regardless of the different context, all the cases had in common that implementing the ambitious frameworks (for their time), required a significant financial and technical burden for implementation. Expanding wastewater treatment, rehabilitating river basins, and maintaining infrastructure require having the right expertise at hand, all of which necessitate sustained investment and skilled staff. Brazil's sanitation reforms and large-scale projects (such as the São Francisco River Integration) illustrated how infrastructure-heavy solutions can deliver local benefits, but still fall short at achieving universality due to high costs and complex maintenance requirements (Santin et al., 2023; Leite et al., 2022).

In Germany, although resource and funding availability were higher, cost-effectiveness dilemmas were still in the picture: implementing the WFD's demanding ecological targets required billions of euros in upgrades to wastewater and flood-management infrastructure (Richter et al., 2013). Even with high tariff recovery, financing the next generation of technologies under principles such as the Best Available Technology (for instance, on advanced micropollutant removal) posed new affordability questions (BMUKN & UBA, 2018; OECD, 2023).

India's centrally sponsored programs, as the NRCP or urban sewage treatment plants, often stalled once federal funding ceased or maintenance was delegated to under-resourced local authorities (Cullet & Gupta, 2009; Sinha & Sedai, 2025), often resulting in the problem of facilities built, but not sustained. All in all, financial sustainability remained elusive in most cases: tariff systems rarely covered full costs while ensuring social equity, and long-term capital planning was frequently subordinated to political cycles.

#### **3.4.5. Translating ambition into enforceable outcomes**

Last but not least, one of fundamental shared challenges, was the implementation gap between legal rhetoric and tangible improvements. Germany's WFD framework

contained the mission of good ecological status achieved for all waters by 2015, but by the first review cycle, 82 percent of surface waters still failed to meet that goal, pushing repeated deadline extensions (Richter et al., 2013).

While Brazil's reforms produced participatory governance and gradual improvements, 7-40 percent of treated water is still lost before reaching consumers, and over half of households lack adequate sanitation (Leite et al., 2022; ANA, 2024). India's 2002 NWP articulated IWRM and included ecological priorities; however, binding obligations, defined responsibilities, or monitoring mechanisms were not accompanying them (Pandit & Biswas, 2019). In the coming years, water quality in major rivers deteriorated, groundwater declined, and sectoral programs operated in isolation.

These outcomes illustrate the policy abundance combined with the implementation scarcity cycle, coming from a combination of weak enforcement culture, fragmented accountability, insufficient public participation, and underdeveloped adaptive management. Without mechanisms to update plans based on evidence or sanction non-compliance, even progressive frameworks struggle to deliver environmental outcomes.

#### **3.4.6. Summary**

In conclusion, Brazil, Germany, and India each demonstrated that the existence of comprehensive, robust environmental law is not synonymous with ecological effectiveness. Fragmented institutions, insufficient data, uneven financing, and social inequities constrained implementation across all three systems. Differences in income or administrative sophistication moderated, but did not erase, these barriers. Whether in Germany's industrial catchments, Brazil's semi-arid basins, or India's over-drawn aquifers, these structural weaknesses continued to emerge in different forms. Moreover, all the challenges mentioned accumulate, impact each other and typically further amplify their negative impacts. Recognizing these shared challenges provides a necessary foundation for identifying the cross-cutting lessons explored in the following section.

### **3.5. Common lessons and learnings retrieved for effective environmental law**

Across Brazil, Germany, and India, in the frameworks from the analyzed period, a clear pattern emerges: laws multiplied faster than outcomes. Legal innovation, including river-basin planning, cost-recovery signals, participatory bodies, and wastewater standards, expanded quickly; yet implementation capacity, monitoring systems, and cross-sector

alignment lagged. The most transferable lessons from these three trajectories can be assembled in nine themes.

### **3.5.1. Text does not equal outcome: build for enforcement, not only aspiration**

All three countries adopted ambitious national water frameworks, but where statutes lacked binding duties, clear timetables, or institutional owners, progress stalled. Germany's WFD regime showed that hard obligations with review and penalties (e.g., EU infringement procedures) create more substantial compliance incentives than programmatic exhortations (Voulvoulis et al., 2017; European Commission, 2019). India's NWP 2002, by contrast, read more like guidance than command: rich in intent, thin on enforceability, making results dependent on voluntary state uptake (Pandit & Biswas, 2019; Rathee & Mishra, 2021). In Brazil, celebrated principles (basins, participation, priorities) did not by themselves remedy long-standing territorial asymmetries or chronic sanitation gaps without funded mandates and measurable targets (Leite et al., 2022; Santin et al., 2023).

### **3.5.2. Institutions must match hydrology and competence**

Effective water law needs institutional fit with river basins and with the country's constitutional architecture. Germany eventually did centralize key elements in a revised Federal Water Act (2010) to finish WFD transposition and coordinate states' action (European Commission, 2019; OECD, 2023). India's institutional fragmentation with CWC for surface water, CGWB for groundwater, CPCB for pollution, made basin-scale management and accountability diffuse, even as NWP 2002 endorsed IWRM (Cullet, 2007; NITI Aayog, 2018; Pandit & Biswas, 2019). Brazil's basin committees institutionalized participation, but could not by themselves reallocate water or finance universal sanitation without state or municipal execution capacity (Leite et al., 2022; Santin et al., 2023). The comparative lesson is to align mandates, funding, and maps: give a lead body authority to plan at basin scale, fund measures, and require delivery from sectoral agencies.

### **3.5.3. Monitoring, data, and diagnostics are non-negotiables**

Germany entered the WFD with strong chemical monitoring but still needed to add ecosystem-status metrics (biology, hydromorphology) for accurate and compliant diagnostic power (Voulvoulis et al., 2017). India's data gaps, including very limited groundwater sampling, weak transparency and consistency, repeatedly blocked evidence-based regulation and course corrections (NITI Aayog, 2018; Gupta, 2020). Brazil expanded networks (ANA's systems), yet persistent non-revenue water and uneven quality tracking signaled operational and surveillance deficits (Leite et al., 2022). Sustainable improvement demands basin-wide, open data: pressure-state-response indicators, traceable baselines, and compliance dashboards that tie monitoring to enforcement and budget allocation (IDFC,

2011; Mateo-Sagasta & Tare, 2016). Moreover, monitoring, data collection and diagnosis cannot be static: climate change, increased urbanization, new technologies and industrial waste with changing components, new pesticides and diffused contamination are some of the pressures that defy effectiveness of non-adaptive models and processes.

#### **3.5.4. Address root causes, not just symptoms**

A common weakness across all three countries was the tendency to focus on visible pollution symptoms rather than the underlying pressures that cause them. Under the EU Water Framework Directive, many Programmes of Measures (PoMs) in member states, including Germany, initially concentrated on reducing point-source pollution, such as discharges from wastewater plants. However, this approach overlooked the fact that diffuse agricultural runoff and hydromorphological alterations were often the real barriers to achieving good ecological status (Voulvoulis et al., 2017).

India's and Brazil's cases show the same logic in different forms. India's large investments under national river-cleaning programs prioritized end-of-pipe solutions, such as constructing STPs; but neglected the supporting systems such as sewer networks, maintenance, and ensuring adequate environmental flows. As a result, many plants remained underused or ineffective (IDFC, 2011; Mateo-Sagasta & Tare, 2016). In Brazil, mega-projects such as the São Francisco River Integration Project expanded water access in some regions, but created ecological trade-offs in others, particularly for downstream ecosystems. This highlighted the importance of basin-wide assessments that evaluate cumulative pressures before implementing large-scale infrastructure (Santin et al., 2023).

The key lesson is clear: effective water policy must begin with diagnosing pressures, not merely treating symptoms. Strategies should target the root causes, such as nutrient runoff, disrupted flow regimes, or physical barriers, before relying on technological end-of-pipe measures. This systems-based approach ensures that interventions are cost-effective, sustainable, and ecologically meaningful.

#### **3.5.5. Economic instruments work, if they reach diffuse sources and fund O&M**

Across all three countries, experience shows that economic tools can drive effective water management when they are well designed, equitable, and reinvested wisely. In Germany, cost recovery is well integrated into municipal water and wastewater services, ensuring financial sustainability. However, extending the polluter-pays principle to diffuse agricultural pollution, such as nitrate and fertilizer runoff, remains a work in progress. The government has strengthened fertilizer regulations and revised environmental taxes, as a

way to introduce further producer responsibility mechanisms, but results take time as ecosystems respond slowly to reduced nutrient inputs (OECD, 2023).

India, meanwhile, adopted the principle of treating water as an economic good to promote efficiency and conservation, but water pricing and metering rarely changed consumption behavior or limited over-abstraction - largely because of political sensitivities and the need to protect low-income users (Cullet, 2007; NITI Aayog, 2019). Future reforms could balance these concerns by coupling tariffs or abstraction charges with social safeguards and targeted subsidies for vulnerable groups.

In Brazil, the push for cost recovery through sanitation reforms sought to attract investment and improve services. However, persistent water losses and uneven access across regions reduced financial efficiency and limited reinvestment potential (Leite et al., 2022). Successful models now emphasize linking tariff revenue directly to maintenance, leak reduction, and nature-based solutions that restore water sources and reduce long-term costs.

From the above, the shared lesson extracted is that economic instruments work best when they close the loop between users, ecosystems, and reinvestment. When instruments are transparent, inclusive, and reinvested locally, they not only improve financial sustainability but also build trust and accountability, turning water management into a shared social contract rather than a technical exercise.

### **3.5.6. Groundwater governance: the not-so-hidden foundation of water security**

Groundwater sits at the heart of national water management, and the experiences of these three countries show both its importance and its vulnerability. In India, groundwater became the backbone of the country's irrigation economy, driven by cheap energy, weak surface irrigation systems, and the widespread use of borewells. This rapid expansion made India the world's largest groundwater-irrigated economy, but it also pushed aquifer depletion beyond the control of existing laws and model bills (Cullet, 2007; IDFC, 2011; World Bank, 2012).

Brazil's experience offers a contrast, as its rural catchments show that land-use management and soil conservation programs, such as the Produtor de Água ("Water Producer") initiative, can help reduce erosion, improve groundwater recharge, and sustain baseflows. However, these programs face recurring challenges of scaling up, stable financing, and consistent monitoring to confirm results (Santin et al., 2023).

Germany highlights another side of the issue: despite strong regulations, nitrate pollution from agriculture continues to contaminate groundwater in several regions, evidencing that even with strict rules, aquifers recover slowly, and it can take years or even decades for improvements in farm practices to show up in water quality data (European Commission, 2019; OECD, 2023).

Effective groundwater governance depends on managing at the aquifer scale: through licensing and withdrawal caps, combined with energy-pricing reform, agricultural incentives for conservation, and farmer-led monitoring programs. Shared aquifer management plans that unite these tools offer the most realistic path to balancing productivity, equity, and sustainability.

### **3.5.7. Participation must be co-decision, not consultation**

The WFD mandated public involvement, yet many processes remained administratively centralized; genuine co-production of knowledge and measures was the exception (Voulvoulis et al., 2017). Brazil's basin committees and payment-for-services pilots showed the promise of participatory tools, but authority and budgets often sat elsewhere (Santin et al., 2023). In India, user associations were promoted on paper, but capacity and social inclusion constraints limited scale and equity (Cullet, 2007; NITI Aayog, 2019). Participation that creates a significant impact grants communities defined powers (e.g., plan approval rights), transparent data, and incentives tied to performance.

### **3.5.8. Build resilient systems through adaptation and long-term planning**

Water governance is not a one-time project, but a long-term, adaptive process that must evolve with both environmental change and institutional learning. In Germany, decades of canalization, river barriers, and intensive agriculture have left hydromorphological and nutrient legacies that take time to reverse. The lesson there is that recovery requires steady investment in ecological restoration, such as re-naturalizing riverbanks, reconnecting floodplains, and upgrading water infrastructure to withstand droughts and floods intensified by climate change (OECD, 2023).

Another dimension of resilience can be seen in Brazil's experience, as regional inequalities in water availability, combined with high distribution losses, make it essential to protect long-term investment cycles and ensure financing stability for maintenance and modernization. Periodic updates to basin and sanitation plans can help align funding with performance, and ensure that resources are directed to measures that show real improvements in both access and quality (Leite et al., 2022).

For India, policy continuity is a struggle, with chronic sewage treatment backlog and groundwater depletion calling for consistent, long-horizon programs that survive electoral cycles and administrative turnover (IDFC, 2011; NITI Aayog, 2019). Embedding adaptive management in national and state plans through regular data review, evaluation, and public accountability can transform short-term projects into sustained progress.

The thread that brings all three countries together, and truly interconnected with the third theme above, is the importance of adaptive management: learning from monitoring, updating basin and sanitation plans periodically, and re-targeting finance toward the interventions that demonstrate measurable impact. In an era of climate uncertainty, flexibility, continuity, and evidence-based adjustment are the foundations of lasting water security.

### **3.5.9. The reactive approach is expensive: preventing is less costly than fixing**

Environmental regulation often strengthens only after crises force action. The history of water governance across the three countries demonstrates that responding to disasters rather than preventing them, comes at immense ecological and financial costs.

Germany's Rhine River chemical spill in 1986, which released toxic substances from a Basel warehouse fire, acted as a catalyst of reforms both in national and European water law. The tragedy not only devastated ecosystems across multiple countries, but also prompted the development of the EU WFD and stricter standards for industrial wastewater and accident prevention (Voulvoulis et al., 2017; OECD, 2023). This underlines that the cost of prevention, through better safety planning, monitoring, and early warning systems, is far lower than the cost of ecological recovery and transboundary remediation.

In India, the 1984 Bhopal gas disaster remains a defining example of the price of weak environmental oversight. The event exposed gaps in industrial safety, liability frameworks, and emergency preparedness, leading to the eventual creation of the Environment (Protection) Act of 1986 and the EIA Notification process (Drishti IAS, 2020). Yet, as later reviews have shown, compliance and enforcement remain inconsistent, with some clearances granted without rigorous public participation or adequate impact assessment. The key lesson is that timely, transparent, and science-based environmental assessments can prevent both social and ecological harm, if they are properly enforced and independently reviewed (Cullet & Gupta, 2009).

The common insight is clear: preventing pollution and degradation is cheaper, fairer, and more sustainable than restoring damaged ecosystems. Preventive mechanisms include: rigorous and transparent EIAs with public participation; early-warning and monitoring

systems for industrial discharges and watershed health; regular infrastructure inspections and maintenance funding through designated tariffs; and independent oversight institutions capable of halting high-risk projects when safeguards are inadequate. As the OECD (2023) notes, long-term investments in prevention generate higher returns through avoided damages, lower remediation costs, and greater public trust.

## 4. Conclusion

This study set out to examine Brazil, Germany, and India, each with distinct socio-political, economic, and institutional realities, as they implemented and enforced environmental water protection frameworks that entered into force between 1995 and 2007. The main question was whether, despite these differences, shared structural and institutional challenges, as well as transferable lessons, could be identified to help other nations strengthen the real-world impact of their water governance systems and overall enhance the global effectiveness of environmental law. The findings retrieved as a result of this journey affirm this.

Each country passed ambitious and often innovative legal frameworks: Brazil's National Water Law (1997) introduced participatory river basin management; Germany's transposition of the EU WFD embedded IWRM principles into binding law; and India's National Water Policy (2002) recognized water as both a social and economic good. Despite that, the degree to which these frameworks translated into measurable environmental improvements and safeguards depended not on the sophistication of the legal text itself, but on institutional coherence, implementation capacity, and the political economy surrounding enforcement (Santin et al., 2023; Voulvoulis et al., 2017; NITI Aayog, 2019). Therefore, to conclude this study, the main, broad lessons are articulated below to summarize the learnings extracted.

Starting with the dependency of effective environmental law on implementation systems that match legal ambition, as in all three countries, fragmented institutions and weak coordination reduced coherence between implementation and/or enforcement agencies, leading to duplicated mandates or enforcement gaps. An effective framework will require the provision of streamlined governance structures, accompanied by transparent data systems and empowered regulatory agencies.

Secondly, through Germany's iterative river basin planning under the WFD and Brazil's creation of basin committees, it was seen that inclusive governance improves

legitimacy and information flow, providing us with the lesson that participation and adaptive management are an indispensable part of sustained law effectiveness. Participation must be paired with learning mechanisms, such as periodic reviews, monitoring, and reallocation of resources, so as to adapt the frameworks to ever-changing conditions (OECD, 2023; Leite et al., 2022).

Experience across all cases showed that prevention through monitoring, early warning, and environmental assessment is far less costly than remediation after contamination events like the Rhine spill or Bhopal disaster. Additionally, financial mechanisms such as pollution charges, abstraction fees, and cost-recovery tariffs can fund maintenance and incentivize efficiency, if designed with equity safeguards (Cullet, 2007; OECD, 2023). The third learning is evident: economic and preventive instruments are essential complements to command-and-control regulation.

Through the theoretical lens of institutional constructivism, the updated frameworks were analyzed beyond the formal, institutional dimension, but also how they interacted and were influenced by socio- and geo-political, economic and cultural realities of the countries and regions. Enduring cultural and historical legacies were found as shapers of the results of environmental law implementation and enforcement. In both Brazil and India, the colonial legacy of resource extraction and centralized control left institutional patterns in which water was treated as an instrument of economic production above a shared ecological and cultural good. These historical trajectories continue to influence modern policy, where struggles over access, distribution, and accountability reflect deeper inequalities embedded in postcolonial governance structures (NITI Aayog, 2019; Santin et al., 2023). On the other hand, Germany's water governance evolved in the context of a longer tradition of local stewardship and social-ecological balance, corroborating how cultural norms of collective responsibility can reinforce the legitimacy of environmental law and impact the achievement of its goals and spirit.

From the above, the crucial lesson is clear: building societal (from individual users to corporations to local authorities) ownership of water protection is of paramount importance. Where environmental awareness and civic participation were cultivated through basin committees in Brazil, public dialogues in Germany, or grassroots campaigns in India; laws began to transcend the text and became part of social practice, a shared cultural value. When water protection shifts from a tedious regulatory requirement to a shared cultural value, stewardship and accountability mindset becomes gradually embedded in everyday behavior. Legal frameworks that have carried out the participatory processes required to

achieve this, when effective, go beyond managing and protecting water: they redefine the relationship between people, nature, and the state.

When bringing all these insights together, it is hard not to come to the conclusion that the effectiveness of environmental water law lies not only in drafting robust legislation, but also in the inclusion of content that demands and guarantees sustained, well-resourced, and accountable implementation. The three countries studied showed different paths toward this goal: Brazil, trying to find a balance between decentralization and regulation; India, between economic development (industrialization and urbanization) and sustainability; and Germany, with the integration of ecological targets within federalism. Nonetheless, they all reveal in different ways that adaptive and coordinated institutions, preventive action, and public participation are at the core of a sustainably effective water protection framework.

The objectives from the global environmental governance agenda, including the UN Sustainable Development Goals and the ongoing Water Action Decade, require that national legal systems evolve from reactive and fragmented responses towards coherent, long-term, and learning-oriented frameworks. The lessons extracted from Brazil, Germany, and India are aligned with that plea and show that effectiveness is dynamic and can be increased through constant recalibration between law, science, and society. Strengthening implementation, fostering participation, and embedding adaptive governance appear to be the most promising paths towards ensuring that water protection laws do not remain aspirational, but become instruments of tangible, measurable, just, and sustainable outcomes.

## 5. References

Adler, E. (1997). Seizing the middle ground: Constructivism in world politics. *European Journal of International Relations*, 3(3), 319-363.

<https://doi.org/10.1177/1354066197003003003>

Agência Nacional de Águas e Saneamento Básico. (2024). *Conjuntura recursos hídricos Brasil 2024: Informe anual*. Ministério da Integração e do Desenvolvimento Regional.

[https://www.snirh.gov.br/portal/centrais-de-conteudos/conjuntura-dos-recursos-hidricos/conjuntura2024\\_04122024.pdf](https://www.snirh.gov.br/portal/centrais-de-conteudos/conjuntura-dos-recursos-hidricos/conjuntura2024_04122024.pdf)

Albrecht, J. (2013). The Europeanization of water law by the Water Framework Directive: A second chance for water planning in Germany. *Land Use Policy*, 30(1), 381-391.

<https://doi.org/10.1016/j.landusepol.2012.04.009>

Amarasinghe, U. A., Sharma, B. R., Aloysius, N., Scott, C., Smakhtin, V., & de Fraiture, C. (2007). *Spatial variation in water supply and demand across river basins of India*.

International Water Management Institute (IWMI).

<https://cgspace.cgiar.org/server/api/core/bitstreams/e59a4015-37de-44d8-a1c4-7e24aaeb4a1a/content>

Antharvedi, U. (2007). Water Pollution and Judicial Response.

<http://dx.doi.org/10.2139/ssrn.955227>

Ayana, E. (2019). *Determinants of declining water quality*. World Bank.

<https://openknowledge.worldbank.org/server/api/core/bitstreams/40396ad5-ea02-52da-bbb3-b4c19b1c330b/content>

Benjamin, A. H. (2023). Forests and the environmental rule of law: Reflections on the effectiveness of Brazilian legislation. In *Measuring the effectiveness of environmental law through legal indicators and quality analyses*, IUCN Environmental Policy and Law Paper, 91, 77-88.

<https://portals.iucn.org/library/sites/library/files/documents/EPLP-091-En.pdf>

Boeuf, B., Fritsch, O., & Martin-Ortega, J. (2016). Undermining European environmental policy goals? The EU Water Framework Directive and the politics of exemptions. *Water*, 8(9), 388. <https://doi.org/10.3390/w8090388>

Broughton, E. (2005). The Bhopal disaster and its aftermath: a review. *Environmental Health*, 4 (Article 6). <https://doi.org/10.1186/1476-069X-4-6>

Bundesministerium für Umwelt, Naturschutz und nukleare Sicherheit (BMUKN), & Umweltbundesamt (UBA). (2001). *The German water sector - Policies and experiences*. Umweltbundesamt.

<https://www.umweltbundesamt.de/sites/default/files/medien/publikation/long/2752.pdf>

BMUKN, UBA. (2018). *Water resource management in Germany: Fundamentals, pressures, measures*. Umweltbundesamt.

[https://www.umweltbundesamt.de/sites/default/files/medien/1410/publikationen/waterresource\\_management\\_germany\\_digital\\_aktualisiert.pdf](https://www.umweltbundesamt.de/sites/default/files/medien/1410/publikationen/waterresource_management_germany_digital_aktualisiert.pdf)

BMUKN. (2023). *National water strategy*.

[https://www.bundesumweltministerium.de/fileadmin/Daten\\_BMU/Pool/Broschueren/nationale\\_wasserstrategie\\_2023\\_en\\_bf.pdf](https://www.bundesumweltministerium.de/fileadmin/Daten_BMU/Pool/Broschueren/nationale_wasserstrategie_2023_en_bf.pdf)

BMUKN. (2025a). *Implementation of European Water Framework Directive in Germany*.

<https://www.bundesumweltministerium.de/en/topics/water-management/overview-water-management/policy-goals-and-instruments/water-protection-policy-in-germany/implementation-of-european-water-framework-directive-in-germany>

BMUKN. (2025b). *Sewage Sludge Ordinance*.

<https://www.bundesumweltministerium.de/en/law/sewage-sludge-ordinance>

BMUKN. (2025c). *Wastewater*. <https://www.bundesumweltministerium.de/WS648-1>

BMUKN, UBA. (2022). *Water Framework Directive - The status of German waters 2021: Progress and challenges*. Umweltbundesamt.

[https://www.umweltbundesamt.de/sites/default/files/medien/1410/publikationen/water-framework-directive-2021\\_bf.pdf](https://www.umweltbundesamt.de/sites/default/files/medien/1410/publikationen/water-framework-directive-2021_bf.pdf)

Central Pollution Control Board (CPCB). (2003). *Charter on corporate responsibility for environmental protection: Action points for 17 categories of industries*. Ministry of Environment & Forests. <https://www.indiansugar.com/PDFS/CREP-2003-FullText.pdf>

CPCB. (2007). *Groundwater quality studies in metropolitan cities and problem areas (Groundwater quality series)*.

<https://cpcb.nic.in/openpdffile.php?id=UHVibGJjYXRpb25GaWxlLzc3NF8xNTQ0NDI3NjQ3X0dXUVMtMS5wZGY=>

CPCB. (2022). *Annual report 2021-22*. Ministry of Environment, Forest and Climate Change, Government of India.

<https://cpcb.nic.in/openpdffile.php?id=UmVwb3J0RmlsZXMvMTczM18xNzQ0MDg4NjgzX21lZGlhcGhvdG8yMDM0Ny5wZGY=>

CPCB. (2023). *Annual report 2022-23*. Ministry of Environment, Forest and Climate Change, Government of India.

<https://cpcb.nic.in/openpdffile.php?id=UmVwb3J0RmlsZXMvMTY2OV8xNzI3NDE0NTc1X21lZGlhcGhvdG8yOTAyNy5wZGY=>

Chaudhuri, S., & Roy, M. (2017). Rural-urban spatial inequality in water and sanitation facilities in India: A cross-sectional study from household to national level, *Applied Geography*, 85, 27-38. <https://doi.org/10.1016/j.apgeog.2017.05.003>.

Cullet, P. (2007). *Water law in India: Overview of existing frameworks and proposed reforms*. International Environmental Law Research Centre (IELRC) Working Paper 2007-01.

[https://prod-qt-images.s3.amazonaws.com/indiawaterportal/import/sites/default/files/iwp2/Water law in India Overview of existing framework and proposed reforms Philippe Cullet \\_IELRC 2007.pdf](https://prod-qt-images.s3.amazonaws.com/indiawaterportal/import/sites/default/files/iwp2/Water%20law%20in%20India%20Overview%20of%20existing%20framework%20and%20proposed%20reforms%20Philippe%20Cullet%20_IELRC%202007.pdf)

Cullet, P., & Gupta, J. (2009). Evolution of water law and policy in India. *The Evolution of the Law and Politics of Water*. International Environmental Law Research Centre.

[https://www.uvm.edu/~pbierman/classes/gradsem/2014/India\\_Water\\_Compiled.pdf](https://www.uvm.edu/~pbierman/classes/gradsem/2014/India_Water_Compiled.pdf)

Dantas, M. B., & Schmitt, G. B. (2015). Os desafios da sustentabilidade ambiental na gestão dos recursos hídricos: O papel do direito e do poder público no Brasil e na Espanha. In *Água, sustentabilidade e direito (Brasil - Espanha)*, 11-29. Universidade do Vale do Itajaí (UNIVALI).

<https://rua.ua.es/server/api/core/bitstreams/f3c620b5-e5e2-45cc-b1cb-c6a207b7e43d/content>

Drishti IAS. (2020). *Environmental impact assessment (EIA)*.

<https://www.drishtiias.com/to-the-points/paper3/environmental-impact-assessment-1>

European Commission. (2019). *Commission staff working document: Second river basin management plans—Member State: Germany*.

<https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=SWD:2019:41:FIN&qid=1551205988853&from=EN>

European Commission. (2012). *Report from the Commission to the European Parliament and the Council on the implementation of the Water Framework Directive (2000/60/EC) River Basin Management Plans*. COM(2012) 670 final.

<https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52012DC0670>

European Commission. (2015). *Communication from the Commission to the European Parliament and the Council: The Water Framework Directive and the Floods Directive—Actions towards the 'good status' of EU water and to reduce flood risks*.

<https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52015DC0120>

European Commission. (2025). *Water Framework Directive*.

[https://environment.ec.europa.eu/topics/water/water-framework-directive\\_en](https://environment.ec.europa.eu/topics/water/water-framework-directive_en)

Federal Government. (2021). *Report on the implementation of the 2030 Agenda for sustainable development: German voluntary national review to the HLPF 2021*.

[https://sustainabledevelopment.un.org/content/documents/279522021\\_VNR\\_Report\\_Germany.pdf](https://sustainabledevelopment.un.org/content/documents/279522021_VNR_Report_Germany.pdf)

Food and Agriculture Organization of the United Nations (FAO). (2015). *AQUASTAT Country profile - Brazil*. Rome, Italy.

<https://openknowledge.fao.org/server/api/core/bitstreams/d1001017-94e1-4f32-aff-89180000a9b5/content>

FAO, International Water Management Institute (IWMI). (2018). *More people, more food, worse water? A global review of water pollution from agriculture*. International Water Management Institute on behalf of the Water Land and Ecosystems research program of the CGIAR. Rome, Italy; Colombo, Sri Lanka.

<https://openknowledge.fao.org/server/api/core/bitstreams/686ea465-7847-428e-b599-b236f2240e47/content>

FAO. (2023). *Transition to sustainable agriculture vital for water and food security, say FAO, IFAD, AND WFP*.

<https://www.fao.org/india/news/detail-events/en/c/1653958/#:~:text=Partners-.Transition%20to%20sustainable%20agriculture%20vital%20for%20water%20and%20food%20security.and%20uses%20water%20more%20efficiently.>

FAO. (n.d.). *AQUASTAT Dissemination System*. [Data sets].

<https://data.apps.fao.org/aquastat/?lang=en>

Geethanjali, K. V., & Rao, T. (2020). *Tracing the history of India's national water policies: Perspectives for National Water Policy 2020*. NLS Enlaw.  
<https://enlaw.nls.ac.in/tracing-the-history-of-indias-national-water-policies-perspectives-for-national-water-policy-2020/>

Gugliano, A. A., & Carbonai, D. (2013). Participatory water governance in Mercosur countries. In *World social science report 2013: Changing global environments* (pp. 460-463). OECD Publishing, Paris/Unesco Publishing, Paris.  
<https://doi.org/10.1787/9789264203419-en>.  
[https://www.oecd.org/content/dam/oecd/en/publications/reports/2013/11/world-social-science-report-2013\\_g1g32ae1/9789264203419-en.pdf](https://www.oecd.org/content/dam/oecd/en/publications/reports/2013/11/world-social-science-report-2013_g1g32ae1/9789264203419-en.pdf)

Gupta, I. (2020). *Creating a repository for India's water resources data*. India Water Portal.  
<https://www.indiawaterportal.org/groundwater/management/creating-repository-indias-water-resources-data>

Guzzini, S. (2003). *Constructivism and the role of institutions in international relations*. Copenhagen Peace Research Institute.  
<https://ciaotest.cc.columbia.edu/wps/gus06/gus06.pdf>

Haumont, F. (2023). The effectiveness of European environmental law. In M. Prieur (Ed.), *Measuring the effectivity of environmental law: Legal indicators for sustainable development*. Peter Lang / CIDCE - Normandy Chair for Peace.

Helbing, D., Brockmann, D., Chadeaux, T., Donnay, K., Blanke, U., Woolley-Meza, O., Moussaid, M., Johansson, A., Krause, J., & Perc, M. (2015). Saving human lives: What complexity science and information systems can contribute. *Journal of Statistical Physics*, 158(3), 735-781. <https://doi.org/10.1007/s10955-014-1024-9>

Hering, D., Borja, A., Carstensen, J., Carvalho, L., Elliott, M., Feld, C. K., Heiskanen, A.-S., Johnson, R. K., Moe, J., Pont, D., Solheim, A. L., & van de Bund, W. (2010). The European Water Framework Directive at the age of 10: A critical review of the achievements with recommendations for the future. *Science of The Total Environment*, 408(19), 4007-4019.  
<https://doi.org/10.1016/j.scitotenv.2010.05.031>

India Water Portal. (n.d.). *The toxic trail: Pesticide pollution and its impact on India*.  
<https://www.indiawaterportal.org/water-quality-and-pollution/pollution/the-toxic-trail-pesticide-pollution-and-its-impact-on-india>

Indira Gandhi National Open University (IGNOU). (n.d.). *Unit 12: Water pollution - India's major rivers*. eGyanKosh. <https://egyankosh.ac.in/handle/123456789/90458>

Infrastructure Development Finance Company (IDFC). (2011). *Water: Policy and performance for sustainable development*. India Infrastructure report 2011. [https://prod-qt-images.s3.amazonaws.com/indiawaterportal/import/sites/default/files/iwp2/India\\_Infrast\\_ructure\\_Report\\_IDFC\\_2011.pdf](https://prod-qt-images.s3.amazonaws.com/indiawaterportal/import/sites/default/files/iwp2/India_Infrast_ructure_Report_IDFC_2011.pdf)

Instituto Estadual de Florestas (IEF). (2025). *Minas Gerais consolida protagonismo nacional com novo Programa Produtor de Água*. <https://ief.mg.gov.br/w/minas-gerais-consolida-protagonismo-nacional-com-novo-programa-produtor-de-agua>

Jagran Josh. (2015). *National River Conservation Plan (NRCP)*. <https://www.jagranjosh.com/general-knowledge/national-river-conservation-plan-1441621095-1>

Jolly, S., & Singh, S. (2021). Environmental Impact Assessment Draft Notification 2020, India: A Critique. *Chinese Journal of Environmental Law*, 5(1), 11-36. <https://doi.org/10.1163/24686042-12340062>

Kerr do Amaral, H. (1996). *Brazilian water resource policy in the nineties*. Minerva Program. <https://www2.gwu.edu/~ibi/minerva/Fall1996/helena.kerr.amaral.pdf>

Kraemer, R. A., Pielen, B., & de Roo, C. (2007). Regulation of water supply in Germany. *CESifo DICE Report*, 2, 33-39. <https://www.ifo.de/DocDL/dicereport207-forum4.pdf>

Kumar, R., Singh, R. D., & Sharma, K. D. (2005). Water resources of India. *Current Science*, 89(5), 794-811. <https://www.currentscience.ac.in/Volumes/89/05/0794.pdf>

Kumar, P., Srivastava, S., Banerjee, A., & Singh, A. (2022). Prevalence and predictors of water-borne diseases among elderly people in India: Evidence from Longitudinal Ageing Study in India, 2017–18. *BMC Public Health*, 22, 993. <https://doi.org/10.1186/s12889-022-13376-6>

Leite, M. C. de O., Felipe, E. S., Fogaça, M., & Maher, R. (2022). A comparison of Brazilian, North American, and English water supply regulation models. *Groundwater for Sustainable Development*, 18. <https://doi.org/10.1016/j.gsd.2022.100748>

Mateo-Sagasta, J., & Tare, V. (2016). *Ganga water quality: Dirty past, promising future (overview of knowledge gaps)*.

[https://www.researchgate.net/publication/341398605\\_Ganga\\_water\\_quality\\_Dirty\\_past\\_promising\\_future](https://www.researchgate.net/publication/341398605_Ganga_water_quality_Dirty_past_promising_future)

Ministry of Environment, Forest and Climate Change. (2009). *Status paper on river conservation in India*. Government of India.

[https://moef.gov.in/uploads/2018/04/Status-Paper-Ganga\\_2.pdf](https://moef.gov.in/uploads/2018/04/Status-Paper-Ganga_2.pdf)

Moss, T. (2004). The governance of land use in river basins: Prospects for overcoming problems of institutional interplay with the EU Water Framework Directive. *Land Use Policy*, 21(1), 85-94. <https://doi.org/10.1016/j.landusepol.2003.10.001>

NITI Aayog. (2018). *Composite water management index - First edition*. Government of India.

<https://www.niti.gov.in/sites/default/files/2023-03/CompositeWaterManagementIndex-CWMI.pdf>

NITI Aayog. (2019). *Composite water management index 2.0*. Government of India.

<https://www.niti.gov.in/sites/default/files/2019-08/CWMI-2.0-latest.pdf>

Niyati, M. (2015). Judicial activism and environmental protection in India. Indian Science Congress Association (ISCA). *International Research Journal of Social Sciences*, 4(4), 7-14.

<https://www.isca.in/IJSS/Archive/v4/i4/2.ISCA-IRJSS-2014-327.pdf>

Nunes, P. H. F. (2016). A organização do tratado de cooperação amazônica: uma análise crítica das razões por trás da sua criação e evolução. Centro Universitário de Brasília (UniCEUB). *Revista de Direito Internacional*, 13(2), 219-243.

<https://bdjur.stj.jus.br/entities/publication/07b66090-4233-4128-af7f-cd665c9f2195>

Onuf, N. (1994). The constitution of international society. *European Journal of International Law*, 5(1), 1-19. <https://doi.org/10.1093/oxfordjournals.ejil.a035857>

Organisation for Economic Co-operation and Development (OECD). (2015). *Water resources governance in Brazil*. OECD Studies on Water. OECD Publishing.

<https://doi.org/10.1787/9789264238121-en>

OECD. (2022), *Fostering Water Resilience in Brazil: Turning Strategy into Action*, OECD Studies on Water, OECD Publishing. <https://doi.org/10.1787/85a99a7c-en>

OECD. (2023). *OECD environmental performance reviews: Germany 2023*. OECD Publishing. <https://doi.org/10.1787/f26da7da-en>

Our World In Data. (2021a). *Renewable freshwater resources per capita*. <https://ourworldindata.org/grapher/renewable-water-resources-per-capita>

Our World In Data. (2021b). *Agricultural water as a share of total water withdrawals, 2021*. <https://ourworldindata.org/grapher/agricultural-water-as-a-share-of-total-water-withdrawals>

Our World In Data. (2021c). *Share of agricultural land which is irrigated, 2021*. <https://ourworldindata.org/grapher/agricultural-land-irrigation>

Our World In Data. (2024). *Share of electricity generated by hydropower, 2024*. <https://ourworldindata.org/grapher/share-electricity-hydro>

Pandit, C., & Biswas, A.K. (2019). India's National Water Policy: 'feel good' document, nothing more. *International Journal of Water Resources Development*. 35(6), 1-14. [https://www.tandfonline.com/doi/full/10.1080/07900627.2019.1576509?utm\\_source=researchgate](https://www.tandfonline.com/doi/full/10.1080/07900627.2019.1576509?utm_source=researchgate)

Porto, M., & Kelman, J. (2000). Water resources policy in Brazil. *Rivers*, 7(3), 250-257. <https://arquivos.ana.gov.br/institucional/sge/CEDOC/Catalogo/1999e2000/WaterResourcesPolicyInBrazil.pdf>

Prabhu, S., & Chitale, V. (2024). *Decoding India's changing monsoon patterns – A tehsil-level assessment*. Council on Energy, Environment and Water. <https://www.ceew.in/sites/default/files/decoding-how-climate-change-is-changing-monsoon-rainfall-patterns-in-india.pdf>

Press Information Bureau (PIB). (2006). *National River Conservation Plan (NRCP)*. Government of India. <https://www.pib.gov.in/newsite/erelcontent.aspx?relid=18777>

Prieur, M. (2021). *Measuring the effectivity of environmental law: Legal indicators for sustainable development*. Peter Lang / CIDCE - Normandy Chair for Peace.

Radovich, V. S. (2016). Thoughts on the role of Mercosur in the environmental protection of aquatic and marine resources. *Revista Facultad de Derecho*, 41, 1-21. <https://doi.org/10.22187/rfd2016210>

Rathee, R. K., & Mishra, S. K. (2021). Water policies in India: A critical review. *Indian Journal of Science and Technology*, 14(47), 3456-3466. <https://doi.org/10.17485/IJST/v14i47.1828>

Richter, S., Völker, J., Borchardt, D., & Mohaupt, V. (2013). The Water Framework Directive as an approach for integrated water resources management: Results from the experiences in Germany on implementation, and future perspectives. *Environmental Earth Sciences*, 69(2), 719-728. <https://doi.org/10.1007/s12665-013-2399-7>

Ritchie, H., & Roser, M. (2017). *Water use and stress*. Our World in Data. <https://ourworldindata.org/water-use-stress>

Rodell, M., Velicogna, I., & Famiglietti, J. S. (2009). Satellite-based estimates of groundwater depletion in India. *Nature*, 460(7258), 999-1002. <https://doi.org/10.1038/nature08238>

Santin, J. R., Rigo Berndsen, G., & Manoel, V. (2023). A efetividade da lei de água: Interface Brasil, Angola e Estados Unidos da América. *Seqüência: Estudos Jurídicos e Políticos*, 43(92), 1-28. <https://doi.org/10.5007/2177-7055.2022.e91639>

Sinha, A., & Sedai, A. K. (2025). National river conservation plan and water pollutants in India. *Economic Analysis and Policy*, 85, 2192-2206. <https://doi.org/10.1016/j.eap.2025.02.031>

da Silva Santos, A. H. (2020). Avaliação ex-post das consequências socioeconômicas do Projeto de Integração do Rio São Francisco com Bacias Hidrográficas do Nordeste Setentrional. *Revista Cadernos de Finanças Públicas - Edição Especial*, 2(1), 1-47. <https://doi.org/10.55532/1806-8944.2021.128>

da Silva e Souza, G., Coelho de Faria, R., & Moreira, T. B. S. (2008). Efficiency of Brazilian public and private water utilities. *Estudos Econômicos*, 38(4). <https://doi.org/10.1590/S0101-41612008000400008>

Singh, S., & Goyal, M. K. (2025). A review of India's water policy and implementation toward a sustainable future. *Journal of Water and Climate Change*, 16(2), 493–510. <https://doi.org/10.2166/wcc.2025.560>

Sinha, A., & Sedai, A. K. (2025). National river conservation plan and water pollutants in India. *Economic Analysis and Policy*, Elsevier, 85(C), 2192-2206. <https://doi.org/10.1016/j.eap.2025.02.031>

UNESCO. (n.d.). *Glossary - Environmental impact assessment*.

<https://whc.unesco.org/en/glossary/239>

United Nations. (1992). *The Dublin Statement on Water and Sustainable Development*.

Dublin, Ireland. <https://unesdoc.unesco.org/ark:/48223/pf0000137373>

[https://www.cawater-info.net/bk/water\\_law/pdf/dublin\\_statement.pdf](https://www.cawater-info.net/bk/water_law/pdf/dublin_statement.pdf)

United Nations. (2023). *SDG 6 Country Acceleration Case Studies 2023: Brazil*. UN Water.

[https://transparency-partnership.net/system/files/migrated\\_document\\_files/countrycasestudies\\_23967\\_brazil\\_.pdf](https://transparency-partnership.net/system/files/migrated_document_files/countrycasestudies_23967_brazil_.pdf)

United Nations. (n.d.). *Germany: Progress on achieving SDG 6*. UN Department of Economic and Social Affairs.

<https://sdgs.un.org/basic-page/germany-34125#:~:text=Despite%20considerable%20progress%20in%20the,a%20National%20Citizens'%20Water%20Dialogue.>

United Nations. (n.d.). *India - Health, Water and Sanitation*.

<https://india.un.org/en/171844-health-water-and-sanitation>

Viñuales, J. E. (2023). *Comparing environmental law systems*. Cambridge University Press.

<https://doi.org/10.1017/S0020589323000453>

Voulvoulis, N., Arpon, K. D., & Giakoumis, T. (2017). The EU Water Framework Directive:

From great expectations to problems with implementation. *Science of The Total*

*Environment*, 575, 358-366. <https://doi.org/10.1016/j.scitotenv.2016.09.228>

Water Action Hub. (n.d.). *Country overview: India*.

<https://wateractionhub.org/geos/country/101/d/india/>

World Bank. (2012). *India Groundwater: a Valuable but Diminishing Resource*.

<https://www.worldbank.org/en/news/feature/2012/03/06/india-groundwater-critical-diminishing>

World Bank. (2019). *The Impact of Water Quality on GDP Growth: Evidence from around the World*.

World Bank. (2024). *Population, total*. <https://data.worldbank.org/indicator/SP.POP.TOTL>

World Bank. (2024a). *GDP per capita, PPP (current international \$) [Data set]*. World Development Indicators. <https://data.worldbank.org/indicator/NY.GDP.PCAP.PP.CD>

World Bank. (2024b). *Rural population (% of total population)* [Data set]. World Development Indicators. <https://data.worldbank.org/indicator/SP.RUR.TOTL.ZS>

World Bank. (n.d.). *Indicator: Proportion of bodies of water with good ambient water quality.* [https://data360.worldbank.org/en/indicator/WB\\_ESG\\_EN\\_H2O\\_BDYS\\_ZS](https://data360.worldbank.org/en/indicator/WB_ESG_EN_H2O_BDYS_ZS)

World Bank. (n.d.). *Indicator: Water stress (Future).* [https://data360.worldbank.org/en/indicator/WRI\\_AQDT\\_FUTURE\\_BWS?compBreak1=WRI\\_AQDT\\_WEIGHT\\_TOT&compBreak2=WRI\\_AQDT\\_SCENARIO\\_BAU](https://data360.worldbank.org/en/indicator/WRI_AQDT_FUTURE_BWS?compBreak1=WRI_AQDT_WEIGHT_TOT&compBreak2=WRI_AQDT_SCENARIO_BAU)

World Bank. (n.d.). *People using safely managed sanitation services - Brazil, Germany, India.* <https://data.worldbank.org/indicator/SH.STA.SMSS.ZS?locations=BR-DE-IN>

World Bank. (n.d.). *Clean ocean water.* [https://data360.worldbank.org/en/indicator/WEF\\_TTDI\\_OHICLEANWATER](https://data360.worldbank.org/en/indicator/WEF_TTDI_OHICLEANWATER)

World Bank Blogs. (2024). *World Bank country classifications by income level for 2024-2025.* <https://blogs.worldbank.org/en/opendata/world-bank-country-classifications-by-income-level-for-2024-2025>

Water Action Hub. (n.d.). *Country: Brazil.* <https://wateractionhub.org/geos/country/31/d/brazil/>

Wiener, A. (2006). Constructivism and sociological institutionalism. In Cini, M., Bourne, A.K. (eds) *Palgrave Advances in European Union Studies*. Palgrave Advances. Palgrave Macmillan, London. [https://doi.org/10.1057/9780230522671\\_3](https://doi.org/10.1057/9780230522671_3)  
<https://www.wiso.uni-hamburg.de/fachbereich-sowi/professuren/wiener/dokumente/publikationenaw/beitraegeinsammelbaendenaw/wiener-2006-constructivism-and-sociological-institutionalism.pdf>