Journal of Intercultural Management
Vol. **15** | No. **3** | **2023**
pp. **125–147**
DOI **10.2478/joim-2023-0014**

Agata Krząstek
Cracow University of Economics, Poland
agata.krzastek@gmail.com
ORCID ID: 0000-0001-5251-188X

Magdalena Wawoczny
Cracow University of Economics, Poland
mawawoczny@gmail.com
ORCID ID: 0000-0002-8504-8358

Polina Kempinsky
Harvard University, USA
polina_kempinsky@hks.harvard.edu
ORCID ID: 0000-0001-6462-4224

Water Resource Management in Poland and Israel – Similarities and Differences

Received: 03-11-2023; Accepted: 14-12-2023; Published: 27-12-2023

ABSTRACT

Objective: The study explores water resource management, including identification of similarities and differences, in Poland and Israel, countries with divergent geographical histories — Poland, historically rich in wetlands, and Israel, originating from a desert landscape. The article presents the current state of research on the level of water resources in both mentioned countries, as well as water resources management systems and who is responsible for this area.

Methodology: The analysis is firmly grounded in data sourced from reputable secondary publications. This work draws extensively from scientific literature, including books, papers, and reports. In addition to data-driven insights, it incorporates comparative data analysis, which allows for a nuanced examination of trends and patterns. Furthermore, the inclusion of literature analysis and deductive reasoning provides a comprehensive framework for understanding the multifaceted aspects of the subject matter. This approach not only bolsters the credibility of the analysis but also enables a more robust and informed perspective on the topic at hand. The comparison between Poland and Israel was chosen due to our specific interests and the ongoing scientific collaboration of the authors. Additionally, both countries serve as intriguing case studies given their distinct approaches to water resource management. Poland and Israel hold a special significance as our homelands, affording us a deeper understanding of the local context and water-related challenges. On the other hand, Israel stands out for its reputation for efficient and innovative management of water resources, which piqued our research interests. The comparative analysis aimed to extract best practices and potential areas for further scholarly investigation in the realm of water resource management. Through this comparative examination, we hoped to derive insights that could be valuable, contributing to sustainable water resource management practices.

Findings: Poland is currently struggling with periodic and local water deficits, which will deepen due to ongoing climate change (Rączka et al., 2021, p. 8). This requires an immediate and coordinated action. Drawing on the experience of a nation like Israel, which has historically struggled with water scarcity, can provide invaluable insights needed to address this pressing crisis.

Value Added: A comparison of the practices of both countries, in this case Poland and Israel, as well as a comparative analysis of water resource management systems, will allow us to list practices that can be initiated to manage water resources more effectively.

Recommendations: The subject of water resource management is wide, especially as it belongs to many scientific fields. A broader research context is recommended; the authors made a comparative analysis considering selected reports on the management of water resources. It is a limiting perspective of the research; therefore, to approach the topic holistically, it is necessary to consider other research fields, as well as to deepen the analysis with other countries.

Key words: water management, water resources, water resources management, Poland, Israel

JEL codes: Q01, Q15, Q25

Introduction

Effective water management is crucial for fostering sustainable development on a global scale. Recognizing its significance, the United Nations General Assembly has endorsed the Agenda for Sustainable Development, outlining 17 pivotal Sustainable Development Goals. Among these, the sixth goal places a paramount emphasis on the imperative of granting all individuals access to clean water and sanitation through the sustainable stewardship of water resources.

This underlines the fundamental role that ensuring an ample supply of clean water performs in laying the foundation for sustainable progress and advancing prosperity worldwide. Beyond meeting basic human needs, responsible water management also serves as a linchpin for economic growth, environmental conservation, and the overall well-being of communities across the globe (United Nations, 2015).

The United Nations reports indicate that approximately 70% of the total water demand is allocated to agricultural activities. It is important to recognize that implementing a closed-loop economy model transcends mere government actions; it necessitates systemic shifts across various sectors. This holistic approach requires collaboration between governments, industries, and communities to optimize water usage, reduce waste, and foster sustainable practices. By prioritizing water conservation and efficiency in agriculture, we not only ensure food security but also contribute significantly to the broader goals of environmental sustainability and resilient economic systems. Freshwater accounts for only about 3% of the Earth's total water resources, and its volume is estimated at 35 million cubic meters, more than two-thirds of which are retained in glaciers and snow cover. The second largest source is groundwater, which accumulates approx. 29.6% of the resource, while rivers, fresh lakes, and shallow groundwater account for only 0.4% of the volume of all freshwaters (Bajkiewicz-Grabowska & Mikulski, 2013). Freshwater, stored in surface resources and underground, accounts for only 2.5% of the Earth's water resources. Both Poland and Israel are in the group of countries facing a water deficit.

Rising temperatures and fluctuations in the temporal and spatial distribution of precipitation will cause changes in the availability of water for the needs of residents, the environment, and economic activities. In recent years, the problem of water scarcity and the associated drought phenomenon has intensified. This is due to both increasing atheroprogression and climate change. The widespread, chaotic process of urbanization and the accompanying sealing of catchment areas are contributing to changes in the balance of water resources (Zarządzanie Zasobami Wodnymi, 2022). Water management is a complex process with a systemic nature. It has a huge impact on the functioning of many branches of the economy and directly affects society, as well as water and water-dependent ecosystems.

This article seeks to delve into the similarities and disparities in water resource management between Poland and Israel. By examining the current state of research on water resource levels, as well as the systems and stakeholders responsible for their management in both countries, this study aims to shed light on effective strategies and practices. The methodology employed in this analysis relies on a robust foundation of data derived from reputable secondary sources, encompassing scientific books, papers, and reports. Through an extensive review of the existing literature, this work integrates comparative data analysis, offering a nuanced exploration of trends and patterns in water resources management. Additionally, the inclusion of literature analysis and deductive reasoning provides a comprehensive framework for understanding the multifaceted dimensions of this critical subject matter. The choice to focus on Poland and Israel in this comparative study is rooted in the specific interests and collaborative efforts of the authors. These countries serve as compelling case studies, each exhibiting distinctive approaches to water resource management. Through this comparative analysis, the aim is to extract best practices and identify potential areas for further scholarly exploration in the realm of water resource management. By drawing insights from Israel's historical experience with water scarcity, we aspire to provide valuable contributions to address the pressing water deficits faced by Poland. This study endeavors to not only inform policy and practice but also to stimulate broader discussions on sustainable water resource management.

Water Resources in Poland – Literature Review

The topic of water resources in Poland has been discussed in the literature, but in the context of climate change, environmental pollution, and the use of water for industrial purposes on a massive scale, this topic is gaining in importance.

Water management, and the issues connected to it, dates to the times of the Roman Empire. The work Flumina Omnia Sunt Publica (EN. all rivers are

public) mentioned that time in the Corpus Juris Civilis has permanently shaped the way of understanding water as a public asset (Rolinski, 2012). In the Middle Ages, there was a development in the water management laws; it introduced water use licenses, allocation of consumption quotas, taxing irrigation canals and waterways, and positioning water as one of the sources of power. The present-day European water laws are deeply rooted in documents from the nineteenth century collating very fragmented water regulations and decrees dealing separately with every water use (drinking water supply, land improvement, transport, etc.) (Szalinska, 2018, p. 26). In the 20th century, there was increased human interference in the natural environment, especially regarding water. Water was one of the main factors of dynamic development, on which the economy was strongly dependent. It is worth mentioning that in the past, actions were taken to promote deforestation and drain lakes and wetlands. The goal was to increase agricultural areas or create new settlement areas. All these activities resulted in a significant deterioration of water quality and a reduction in water resources. Lakes perform an important role in water management and, unlike rivers, provide stability. Despite this, most decisions to drain Polish lakes were considered inappropriate, and the presence of water in the drained areas was more justified than in agricultural areas (Ptak, 2018). Areas of Poland were rich in peat bogs. Wetlands covered approximately 18 percent of the area of the country, but almost all of them, because of degradation, no longer fulfil their former ecosystem functions. As a result of land improvement, approximately 85 percent of peat bogs have lost the characteristics of swamp ecosystems, thus turning from carbon sinks into sources of carbon dioxide emissions into the atmosphere (Nauka w Polsce, 2023).

Poland's water resources are small (54,3 km^3) (Pawełek, 2015, p. 368). Low water resources and incorrect water conditions result from decisions made in the past regarding drainage, regulation, or interference with the natural activity of water reservoirs. The problems currently faced by entities responsible for water management include drying of river valleys, flood risk management, or the lack of ecological continuity of the stream (Bartnik & Książek, 2007, p. 16). River regulation, the aim of which is, among others, reducing the risk of flooding by "accelerating the outflow of water from the valley floor in a riverbed of

shortened length, taking into account the environmental effects of this procedure, has recently been perceived as a controversial action. The results in terms of regulatory work are even contrary as expected. Shortening the course of rivers which beds are cut in easily erodible material causes their rapid deepening, which increases the volume of full-bed flow and a reduction in the frequency of above-bed water levels" (Łajczak, 2006, p. 18).

Precipitation is low, and annual river flows per capita in Poland typically reach a value three times lower than the average in European countries. A significant area of Poland lies in a zone of low precipitation and high variability in time and space (Łabędzki & Kanecka-Geszke, 2016). Several indicators are worth mentioning: annual resources of surface water flowing away from the territory of Poland in 1980–2010 were on average 63.1 km^3, including own resources and inflows from abroad. The minimum resources were 37.9 km^3 (1990) and the maximum exceeded 90 km^3 (1981). The average annual precipitation in Poland over the 1951–2000 multi-year period was 617.4 mm, which yields almost 193.1 km^3 of water. The surface water collection of the country's own resources is 18.2% (Hungary 333.2%, Sweden – 1.2%). In Poland, per capita, it is about 1800 m^3/year, during the drought this indicator falls below 1000 m^3/year/person (Gutry-Korycka, 2018). Water collection per an inhabitant is 302 m^3/year/person (Pawełek, 2015, p. 368); it is only about 35% of the European average (e.g., Estonia – 1036 m^3/year/person, Denmark – 120 m^3/year/person). Water deficits periodically occur in 75% of the country (Poland Voluntary National Review, 2018). Climate change is also important, as it significantly affects rainfall. As the climate warms, winter seasons in Poland are becoming warmer. However, the increase in warming is not constant – winter temperatures in the country depend significantly on the type of circulation that takes place in each season. If the so-called North Atlantic Oscillation index (NAO – approximately expressed as the standardized difference in pressure values between the Icelandic Low and the Azores High) is negative, the winter is rather cold (Nauka o klimacie, 2018). Snowfall has been important for the landscape of this part of Europe over the years, and it is decreasing every year. The melting of snow is crucial for the water level in rivers. Poland has fewer freshwater resources than most OECD countries (OECD, 2017). Therefore, more than two-thirds of surface water bodies failed to meet

the 2015 good-status objectives of the EU Water Framework Directive. Seasonal floods occur in Poland, causing long-lasting and heavy rainfall. In Poland, rainfall and snowmelt floods occur most frequently. Ice jams also form often. Polish rivers are characterized by a snow-rain regime, which means that they reach high water levels twice a year. This happens mainly in spring and summer, due to snowmelt and high rainfall. Similarly, there are also low water levels twice a year. This takes place at the turn of summer and autumn and in winter. Frequent floods are typical of Polish rivers. Their causes are varied. The most common of them include heavy rains, sudden spring thaws, traffic jams, and storm winds (ZPE). Snow performs a crucial role in the entire system, serving a distinct purpose compared to rainfall. The characteristic of snow is its slow melting process, allowing water to gradually seep into the soil. Snow serves as the foundation for replenishing groundwater resources, which nourish aquatic ecosystems (rivers, reservoirs, lakes) and water-dependent ecosystems (wetlands, marshes, peatlands). The absence of snow can consequently lead to the emergence and exacerbation of water deficits (PAN, 2020).

Water resources management in Poland is implemented through a range of instruments designed for this purpose, from water management planning through water consents water rights, water management control to information system of water management. The issue of water management was also tackled in the Polish Voluntary National Review in 2018. The Polish Voluntary National Review (2018) claims the increase in available water resources, and improvement of their ecological status and chemical quality is crucial for the government. Therefore, there is an urgent need to create legal and financial mechanisms conducive to the sustainable use of water resources and the implementation of water-saving technologies, as well as the construction and modernization of sewage treatment plants. Polish review implements the provisions of the EU Water Framework Directive – Directive 2000/60/EC of the European Parliament and establishes a framework for Community action in the field of water policy (Official Journal of the European Union 327, 2000) through the implementation of measures aimed at the improvement of the status or potential of water bodies specified in the developed planning documents (river basin management plans, national water, and environmental program,

national municipal wastewater treatment program) (Poland Voluntary National Review, 2018). For the implementation of the comprehensive water policy of the European Union countries, the Water Framework Directive was established to improve the quality of surface water and groundwater, while maintaining a sustainable balance between natural phenomena and human activities, through the principle of sustainable development. As part of the implementation of the Directive, significant progress has been made in Poland in the field of water quality improvement. However, the main goal, which is the *good* status for every water resource in the country has not been achieved.

Polish main goals for further improvement are to increase available water resources and improve their ecological status and chemical quality. Therefore, it is crucial to implement accurate laws like those mentioned above. Also, financial mechanisms for the sustainable use of water resources are needed. In upcoming years, droughts will be progressing, therefore, countries such as Poland should prepare their systems and adjust them to the changing climate reality. One of the means to achieve these goals was also to be the implementation of the Water Law which introduced regulations in the field of water management, taking into account the consideration of the principle of sustainable development, as well as the formation and protection, use, and management of water resources. In Poland, activities related to water resources management were outlined by the Strategy for Responsible Development. The percentage of the population using sewage treatment plants and water supply systems is largely correlated with the rate of technical infrastructure development. In turn, the infrastructure (both technical and social) is co-financed, in most cases, from public funds, including European Union funds (Raszkowski & Bartniczak, 2021). Unfortunately, despite the recommendations, in the recent past, there was, among others, an ecological disaster on the Oder. However, it should be noted that the condition of the Vistula River is also not good. The condition of Polish rivers is influenced by long-term and very low water levels, which enable the inflow of pollutants due to the river's sensitivity, discharges of sewage and waste that contain biogenic compounds, including phosphorus and nitrogen, discharges of saline mines, and industrial waters, and an increase in water temperature or changes in hydrological conditions (PAN, 2022).

Water management is carried out by several organs on many levels. Based on the European Committee of the Regions, the structure is as follows. On the central level, it is the State Water Holding – Polish Waters (Państwowe Gospodarstwo Wodne Wody Polskie) and the Ministry of Climate and Environment, which supervises the management. It holds ownership rights over state-owned waters and establishes and collects water use fees and taxes. The Ministry of Climate and Environment oversees adopting the National Environmental Policy as well as oversees several institutions. Another organ are the Regional Water Management Boards (RWMBs), which are responsible for water management in the water regions. Among their activities, the Boards identify significant pressures and assess their impact on the status of surface and groundwater in the region, develop terms of water use in the water region, prepare flood studies in the water region, develop draft plans for flood protection, and coordinate activities related to the protection against floods and drought. Voivodeships-level institutions are responsible for regional implementation and enforcement of national water policy, permits for investment, including pollution discharges, and regular water monitoring. They are responsible for the protection of drinking water sources, in cooperation with the regional water authorities, and implementation of specific measures set out in the RBMP and FRMP as well as in the National Program for Urban Wastewater Treatment is carried out at the local level. Worth mentioning is the State Water Holding (Państwowe Gospodarstwo Wodne), which is responsible for the protection of water quality and the natural values of the water environment, with the leading role of the special administration for environmental protection under the authority of the minister responsible for environmental protection. This activity is set up by the Polish Constitution against administrative decisions issued by PGW Wody Polskie, Państwowe Gospodarstwo Wodne Wody Polskie (PGW WP) – a state legal entity comprising the structure of Polish water administration bodies, established in 2018. Three basic substantive divisions are the flood and drought protection division, the water services division, and the water environment management division. Part of their activity is education and raising awareness among citizens.

Water Resources in Israel – Literature Query

Israel has been struggling with a shortage of freshwater since its inception. Moreover, all kinds of economic, political, or natural crises, which the state must deal with in the short period of its existence, necessitate the need for good management of water resources, thus creating a demand for high managerial qualifications among employees.

About 75% of Israel's area is made up of the Judean and Negev deserts. Israel's main water sources are the Jordan River, Lake Tiberias, and several smaller remaining river systems. Groundwater reservoirs are natural sources and must be used very carefully to prevent them from drying out or becoming saline. It should be noted that Israel does not have exclusive control over the tributaries of the rivers within its territory; Israel must share the resources of the Jordan River with Jordan, Syria, and Lebanon (Sodolski, 2020).

Israel's annual water supply is 2 billion cubic meters for its 9 million inhabitants, with a population density of 400 people per square kilometer. There are 300 m^3 of water per inhabitant per year. Renewable water resources in the country amount to 1.7 billion m^3 per year (Embassy of Israel in Poland). The main consumer of freshwater is the agricultural sector, which uses more than half of all domestic water, the rest is intended for municipal and industrial needs. In Israel, the area of arable land is systematically growing through the development of desert areas, which, however, involves huge financial outlays for irrigation, soil desalination, and fertilization. The specificity of Israeli agriculture is also the fact that collective forms of farming (kibbutzim) perform a significant role in it, covering more than half of the orchards and arable land (Bożyk & Grzybowski, 2012, p. 246). Residents and municipal management consume one-third of these resources (Israel National Review, 2019, p. 115). In Israel, saline desalination water currently performs a dominant role in the supply of drinking water (85%), and only 15% is natural groundwater and surface water (Witkowski, 2018, p. 34). To manage water resources in Israel, under the Water Law of 1959, the state and the Water Commission decided to take control of private water resources and all types of water (including sewage and rainwater) (Teschner et al., 2012, p. 460). Despite limitations related to

the terrain or political situation, Israel does not suffer from a lack of water, but it must ensure its proper management.

In the 19th century, when modern sewage and water supply systems were being implemented in Europe, Israel still used simple pipes placed on the surface. Under the rule of the Ottoman Empire at that time, there were no plans to modernize waterworks, and there was no desire to modernize agriculture. Most of the land suitable for agriculture belonged to Arab families in Damascus and Beirut, who rented it to Arab farmers within the territory of modern Israel. They, in turn, lacked both the plan and the financial resources needed to improve irrigation. The creation of a new country and the influx of new settlers whose goal was to fertilize the desert initiated the development and implementation of new technologies. Tel Aviv, founded in 1909, was the first to install modern waterworks. Plans for the distribution and management of the limited amounts of water were prepared even before the uprising, as they were the basis for survival in difficult weather conditions. In Israel, the activities of the progenitors are still visible today, because the entire country is covered with a network of waterworks that are responsible for distributing fresh water from natural sources and from installations that desalinate salt water (coming from the sea). The desalination process has become beneficial for Israel; currently, approximately 50% of freshwater comes from this process (Sodolski, 2020).

Water law legislation regulates water matters in Israel in terms of establishing a comprehensive spatial policy and is the most comprehensive legal regulation regarding water management in the country. The water supply process involves several factors. The production segment includes the state-owned water utility Mekorot, seawater desalination plants, and local water utilities that collect water. Local water companies are responsible for water distribution. In 2007, the Israel Water Authority was established to transfer the authority over water management and regulation to a single government body to ensure professional and effective management and supervision. Broadly speaking, the Israel Water Authority is responsible for regulating, operating, and developing the water sector, developing new water sources, and setting prices for related sectors, protecting and restoring natural water sources, and

establishing rules for calculating the costs of water-related services (Fanack Water, 2023).

In Israel, measures are taken to care for the quality of water and the protection of related ecosystems. Pollution prevention measures as well as monitoring of contaminated reservoirs are systematically implemented. An example is a directive on industrial wastewater standards, which imposes heavy penalties on industrial plants which activities exceed the permissible standards of components contained in the directive (Israel National Review, 2016, p. 117).

Climate change also poses a serious challenge to the management of water resources in the country. It is assumed that in the coming decades, due to its influence, the structure of precipitation and average temperatures will constantly change. Higher temperatures in the winter are expected, as well as a decrease in the amount of precipitation and its distribution, which significantly contribute to the increase in water demand in agriculture, for which the most resources are used (Fleischer et al., 2008, p. 508).

The issues of water management were included in the Israeli Voluntary National Review of 2019 (Israel National Review, 2019). The country's water resources are limited as well as difficult to account for in annual national balances due to their volatility. Tailored operational plans, as well as the diversity of water resources, are designed to help achieve water management excellence. The primary goal of the water sector in Israel, which has been approved in the zoning plan, is to guarantee water supply, ensure the quality of water resources, provide sewerage services, and designate the use of treated wastewater, as well as manage runoff and drainage – all for the sustained welfare of all consumers. In addition, it is also important to guarantee the sustainable use of natural resources, to monitor and respond to pollution, to remove point sources of pollution, and to allocate fresh water for the maintenance of biodiversity (Israel National Review, 2019, pp. 116–118).

According to the data of the European Committee of the Region, the areas of the CoR's compulsory consultation policy distinguish between activities related to the environment and the fight against climate change at the central and local levels. The Israeli Ministry of Environment is responsible for activities at the central level Responsibilities include water treatment activities as

well as wastewater cost management and standardization. At the local level, for water-related matters, compulsory powers of local authorities include desalination of water and issues related to sewage services (European Committee of the Region, Israel).

Water Management in Poland and Israel – Similarities and Differences

Although Poland and Israel differ, inter alia, in the influence of conditions, landforms, size, the number of inhabitants, and the economic and political situation, both countries struggle with the problem of freshwater operations.

Both countries are characterized by relatively low water resources, and in the face of the deepening climate crisis, it is expected that both in Poland and Israel, temperatures will increase, and the amount of rainfall will decrease. That is why it is highly important to care for the existing water resources. For both countries, care for water quality, its ecological condition, and ecosystems, is crucial. In Poland, the need to develop legal and technological solutions has been expressed. In the case of Israel, a directive has been introduced setting standards for industrial wastewater. This directive regulates the list of components that, after exceeding a certain level, are prohibited, and there are financial penalties for exceeding them, because of which it is not profitable for industrial plants to pollute water (Israel National Review, 2019, p. 117).

Concerning water, the Voluntary National Review distinguishes 12 criteria: drinking water, sanitation, hygiene, wastewater, water quality, efficiency, water stress, water management, transboundary, ecosystems, cooperation, and participation. Based on the above criteria, it is possible to compare the two countries in terms of water resources.

Regarding drinking water, in both countries, residents benefit from safely managed drinking water services. In Poland, this percentage is 98 and in Israel 99. Moreover, this indicator shows progress over time, which means that the quality of drinking water has improved year after year (United Nation,

Poland, Israel). In Poland, the concentration of phosphorus and nitrogen very rarely exceeds the acceptable levels for drinking water. However, it should be kept in mind that the presence of water enables the massive development of phytoplankton, which can cause allergic reactions in human bodies (Rączka et al., 2021, p. 12). In Israel, tap water also poses no risk to the health and well-being of consumers and is safe to drink. However, it is worth paying attention to water desalination, which deprives the water of minerals, including ions of magnesium necessary for the human body and agricultural production. Studies show that in many Israeli cities, deficiencies of magnesium ions were observed in the tested samples of desalinated water, which may expose the consumer to harm in the future (Rosen et al., 2018).

In the case of sanitation, 91% of Poles and 95% of Israelis use safely managed sanitation services, which constantly progresses over time (United Nations, Poland, Israel). Both countries are also undertaking educational activities on water and sanitary hygiene. The degree of progress is very far-reaching, and it can be assumed that it will reach 100% in the coming years. Civilization changes cause fluctuations in the quality of wastewater, which is associated with new forms of pollution that are discharged into water. That is why it is highly important for both countries that new technologies constantly follow the pollutants that arise and that they develop new strategies for the protection of water resources. New forms of pollution, including refractive pollution and those related to pharmacological substances, including antibiotics, hormones, estrogens, and chemotherapeutic agents, require innovative technical and technological solutions that should be created and supported by legal regulations. It is essential to conduct intensive research in this area. Therefore, a research and development program should be established for highly efficient and energy-saving methods of wastewater treatment and the treatment and management of sewage sludge, as well as the renewal of wastewater for various applications (Gromiec, 2020, p. 8).

For wastewater flow, Israel ranks higher, with a 93% (safely) treated wastewater flow. Poland scored 83% (United Nations, Poland, Israel). Pollution of freshwater resources in Poland is a result of negligence in wastewater management in the past. Major sources of pollution are effluents from municipal wastewater

treatment plants and surface runoffs (Mikosz, 2013). Subsequent regulations and increasingly far-reaching modernization have made this condition significantly improved in recent years, but there is still a lot to be done in this area in Poland, especially in rural areas. A good example to follow is Israel where wastewater effluent's reuse and desalination have become the main source of water to compensate for the future water shortage (Icekson-Tal et al., 2003). In sewage recycling, Israel constitutes a unique test case in policy, science, technology, and infrastructure for other countries facing water scarcity that may be exacerbated by growing populations and global climate change (Futran, 2013).

In terms of water bodies with good quality surrounding water in Poland, the result was 96%. As far as Israel is concerned, the result has not been presented. Presented is the performance index that shows changes in water use efficiency over time, showing progress compared to other countries. Israel got 135$/$m^3$ and Poland 49$/$m^3$ (United Nations, Poland, Israel). Despite this, according to research, Poles are still not able to fully trust drinking water directly from the tap without prior preparation. According to user ratings, the water flowing out of the tap is contaminated, does not have the appropriate consumer values (color, taste, smell), and contains too much fluoride. These opinions are expressed despite the widespread availability of drinking water in taps and assurances about its quality. This is due to the public's lack of trust in the safety of water provided by water companies. Research has shown that these fears have no justification in practice and are deeply rooted in the consciousness of Poles. Tap water meets all the necessary standards, mainly because it is well managed, constantly monitored by water utilities, and appropriate sanitary services, as well as thanks to investments in the modernization of treatment processes. The utility parameters of water (color, taste, smell) differ in individual urban centers, which may raise concerns among users, but their quality is unchanged (Kłos, 2015).

Freshwater shortages directly affect food safety, access to safe drinking water, public health and hygiene, and environmental well-being (Ercin et al., 2019). The water stress level index concerns freshwater abstraction as a percentage of the available freshwater resources in the country. 31% of renewable water resources are being phased out after considering environmental flow requirements.

In recent years, however, researchers have shown possibilities of sustainable management of water resources during periods of drought and the possibility of adapting to future climate changes (Kubiak-Wójcicka & Machula, 2020). In the case of Israel, the figure is 100% (United Nations, Poland, Israel). This creates opportunities to acquire good practices and implement Israeli solutions in Poland.

Considering the Water Management Index, Israel scored 85% for the implementation of Integrated Water Resource Management. Poland achieved the result of 75% (United Nations, Poland, Israel). Real measures in the field of water protection in Poland were not undertaken until the pre-accession period and after Poland joined the European Union. Within a dozen or so years after joining the EU, many investments with the support of structural funds have been implemented. They were mainly concerned with the provision of good quality drinking water, the disposal and treatment plants and sewage treatment plants were built, as well as water supply and sewage networks, especially in previously neglected areas. However, the planned good water status was not achieved by the previously indicated 2015. It is hard to compensate for an age-old neglect (Hakuć-Błażowska et al., 2020, pp. 24–25). Whereas Israel is known for its effective demand management to increase water productivity, reduce per capita potable water consumption, and shift water to higher-value irrigated crops. The allocation of water for various purposes (agriculture, nature, and public gardening) is strictly regulated by annual directives that constantly relate to the hydrological situation, such as continuous drought and the severity of drought in previous years. The necessity to limit water use and to ensure procedures for water reservoir rehabilitation is considered. The need to conserve water sources and the needs of the various sectors are balanced constantly based on hydrological considerations. To promote water conservation, the Water Authority launched media campaigns to encourage people to use water more sparingly. During recent years of drought, a comprehensive and successful nationwide media campaign was launched calling on citizens to save water. Combining regulations with educational and media campaigns, Israel has succeeded in stabilizing domestic consumption below the annual quantity of 90 cubic meters per capita. It saved Israel an investment in another large desalination plant (Israel National Review, 2019, p. 127).

The ecosystem indicator is also worth paying attention to. According to data, 4% of the catchments in Poland experience rapid changes in surface water, and in the case of Israel, the result is 8% (United Nations, Poland, Israel). A significant part of Poland's territory faces threats that are increasingly important for ecosystems, caused by the reduction of surface water resources. The areas at risk of a quantitative deficit of these waters in the early 1990s were very large, also due to inadequate water management in the regions. An increasingly limited availability of resources is a barrier to economic development (Gutry-Korycka et al., 2014, p. 89).

As for hygiene, cooperation, and participation indicators, data were not published for both countries (United Nations, Poland, Israel).

In comparison, in both Poland and Israel, the historical development of water management practices has shaped their present-day approaches. Poland's laws and regulations regarding water management evolved over centuries. Activities such as deforestation and the draining of wetlands for agriculture and settlement led to a significant decline in water quality and resources over time.

Contrastingly, Israel's challenges with water scarcity since its inception spurred immediate initiatives to manage limited resources. The country's early endeavors focused on modernizing water systems and utilizing technologies for survival in arid climates, especially within desert regions like the Judean and Negev deserts.

Poland faces periodic water deficits due to historical decisions on drainage and regulation, resulting in reduced water resources. The country experiences low precipitation, leading to fluctuations in river flows and reduced water availability per capita, often falling below European averages. The management challenges include drying river valleys, flood risk, and lack of ecological continuity.

In Israel, the struggle with water scarcity is constant, given the limited natural resources and the need for careful groundwater management. Despite facing the challenges of sharing water resources with neighboring countries, Israel has adopted innovative measures, including desalination, which currently accounts for a significant portion of its freshwater supply. The agricultural sector consumes a substantial portion of Israel's water resources, with investments in irrigation technologies and the development of arid lands.

Both nations have put in place legislative systems to manage their water resources. Poland's policies are in line with EU directives, with a focus on

modernizing sewage treatment plants, improving ecological conditions, and using water sustainably. Even with improvements in water quality, it is still difficult to get all water bodies to a good state.

Israel's 1959 Water Law concentrated on regulating all forms of water, including rainwater and sewage, and consolidating control over private water resources. The nation uses strict policies to combat pollution, including harsh fines for industries that do not follow the rules.

Below comparative table summarizes the key aspects of water resource management in Poland and Israel:

Table 1. Key aspects of water resource management in Poland and Israel

Aspect	Poland	Israel
Contextual Differences	Influenced by diverse geography and demographics	Challenges influenced by arid conditions
Focus on Water Quality/ Ecosystems	Emphasis on legal/ technological advancements	Stringent directives for industrial wastewater
Drinking Water & Sanitation	98% coverage; concerns about tap water perception	99% coverage; desalination's mineral impact
Wastewater Treatment/ Pollution Control	83% treated wastewater flow; past pollution	93% treated wastewater; successful recycling
Efficiency/Water Stress	\$49/m^3 efficiency; 31% renewable resources use	\$135/m^3 efficiency; 100% water stress level
Integrated Water Resource Management	75% implementation; recent improvements	85% implementation; efficient demand control
Ecosystem Impact/ Development	Threats from reduced surface water resources	Changes affecting ecosystems

Source: own study based on the analysis of secondary sources.

Conclusion

Having an advanced public and private research and development (R&D) sector helps Israel to arrive at technological and economical solutions in the fields of water production and water treatment (i.e., desalination and recycling) (Netanyahu, 2007). Israel, because of its location, had to reach for the above-mentioned solutions from the beginning. Now, after years of implementing innovative technologies, it has a national water surplus and exports water to its neighbors. Poland was much more privileged; however, it is at the threshold of a serious water supply crisis when it will also have to reach for such solutions. Water and sewage management in Poland has systematically been transformed in terms of quality and quantity since the 1990s (Piasecki, 2019). However, still much must be done especially in rural regions to improve wastewater management and access to sanitation systems. In the coming years, there will be more challenges that Poland will have to face regarding water deficits. Implementing good practices from countries like Israel can significantly ease the situation. It is essential to acknowledge the limitations of this research. The study focused on a specific set of reports and secondary sources, providing a partial view of the broader landscape of water resource management. A more extensive data collection and analysis from primary sources, coupled with on-the-ground field studies, would offer a more robust and nuanced perspective. Furthermore, considering the dynamic nature of water resource management, ongoing research is crucial to stay abreast of evolving practices and technologies in this critical field.

Considering these considerations, further research endeavors should aim to address the identified limitations and build upon the foundation laid by this comparative analysis. By doing so, we can continue to contribute to the development of sustainable and effective water resource management strategies that can be applied on a broader level.

References

Bajkiewicz-Grabowska, E., & Mikulski, Z. (2006). Hydrologia ogólna. Warszawa: PWN.

Bartnik, W., & Książek, L. (2007). Regulacja rzek i potoków górskich w warunkach równowagi hydrodynamicznej. *Infrastruktura i Ekologia Terenów Wiejskich, 4*(2), 15–26.

Bożyk, S., & Grzybowski, M. (Eds.) (2012). *Systemy ustrojowe państw współczesnych*. Białystok: Wydawnictwo Temida.

Embassy of Israel in Poland. https://embassies.gov.il/WARSAW/ABOUTISRAEL/Pages/srodowisko.aspx. Access: 11.11.2023.

Ercin, E., Chico, D., & Chapagain, A. K. (2019). Vulnerabilities of the European Union's Economy to Hydrological Extremes Outside its Borders. *Atmosphere, 10*(593), 1–19.

Fanack Water (2023). https://water.fanack.com/israel/water-management-in-israel/. Access: 13.10.2022.

Fleischer, A., Lichtman, I., & Mendelsohn, R. (2008). Climate change, irrigation, and Israeli agriculture: Will warming be harmful? *Ecological Economics*, *65*, 508–515.

Futran, V. (2013). *Tackling water scarcity: Israel's wastewater recycling as a model for the world's arid lands?* GWF Discussion Paper 1311, Global Water Forum. Canberra, Australia.

Gospodarowanie zasobami wodnymi, OEES nr 5 Gospodarowanie wodami w Polsce – OEES. https://oees.pl/magazyny/gospodarowanie-wodami-w-polsce/?doing_wp_cron=1665074904.3577098846435546875000. Access: 13.10.2022.

Gromiec, M. (2020). *Nowe koncepcje gospodarki wodno-ściekowej-osadowej*. Monografie 166. Lublin: Wydawnictwo Polskiej Akademii Nauk.

Gutry-Korycka, M., Sadurski, A., Kundzewicz, Z. W., Pociask-Karteczka, J., & Skrzypczyk, L. (2014). Zasoby wodne a ich wykorzystanie. *Nauka, 1*, 77–98.

Hakuć-Błażowska, A., Napiórkowska-Baryła, A., & Turowski, K. (2020). *Wybrane aspekty zarządzania wodą I powierzchnią ziemi ze szczególnym uwzględnieniem planowania przestrzennego*. Olsztyn: Instytut Badań Gospodarczych.

Icekson-Tal, N., Avraham, O., Sack, J., & Cikurel, H. (2003). Water reuse in Israel – The Dan Region Project: Evaluation of water quality and reliability of plant's operation. *Water Science and Technology: Water Supply, 3*(4). DOI: 10.2166/ws.2003.0067.

Implementation of the Sustainable Development Goals, Israel National Review (2019). https://digitallibrary.un.org/record/3866775. Access: 10.10.2022.

Implementation of the Sustainable Development Goals, Polish Voluntary National Review (2018). https://digitallibrary.un.org/record/3866726?ln=en.

Komunikat 01/2020 interdyscyplinarnego Zespołu doradczego do spraw kryzysu klimatycznego przy Prezesie PAN na temat zmiany klimatu i gospodarki wodnej w Polsce. https://journals.pan.pl/Content/117654/PDF/100-105_Stanowisko_Woda_pol.pdf. Access: 09.10.2023.

Kłos, L. (2015). Jakość wody pitnej w Polsce. *Folia Oeconomica*, *2*(313), 195–205.

Kubiak-Wójcicka, K., & Machula, S. (2020). Influence of Climate Changes on the State of Water Resources in Poland and Their Usage. *Geosciences*, *10*(312).

Łabędzki, L., & Kanecka-Geszkel, E. (2016). *Deficyty wody i potrzeby nawodnień roślin uprawnych w Polsce.* In W. Dembka, J. Kusia, M. Wiatkowski, & G. Żurek, *Innowacyjne metody gospodarowania zasobami wody w rolnictwie* (pp. 241–260). Centrum Doradztwa Rolniczego w Brwinowie.

Łajczak A. (2006). Regulacja rzeki a zagrożenie powodziowe, na przykładzie Nidy. *Infrastruktura i Ekologia Terenów Wiejskich*, *4*(1), 217–233.

Mikosz, J. (2013). Wastewater management in small communities in Poland. *Desalination and Water Treatment*, *51*(10–12), 2461–2466.

Nauka o klimacie (2018). https://naukaoklimacie.pl/aktualnosci/polskie-zimy-w-xx-i-xxi-wieku-cz-2-273. Access: 02.11.2023.

Nauka w Polsce (2023). https://naukawpolsce.pl/aktualnosci/news%2C95301%2Cnaukowcy-praktycy-ochrony-i-inni-eksperci-o-potrzebie-ochrony-bagien-i?fbclid=IwAR21mlt3b-ZWHr3XSaV12iuWeBvDLKpyySCm5ul8IC2ZumxCiylAAflG5f74. Access: 13.11.2023.

Netanyahu, S. (2007). Water Development for Israel: Challenges and Opportunities. In C. Lipchin, E. Pallant, D. Saranga, & A. Amster (Eds), *Integrated Water Resources Management and Security in the Middle East* (pp. 62–72). Springer.

OECD. (2017). *Diffuse Pollution, Degraded Waters: Emerging Policy Solutions*. *OECD Studies on Water, OECD Publishing*. Paris. https://doi.org/10.1787/9789264269064-en.

Official Journal of the European Union (2000). *32*, 1.

Pawełek, J. (2015). Water management in Poland in view of water supply and sewage disposal infrastructure development. *Infrastructure and Ecology of Rural Areas*, 2.

Piasecki, A. (2019). Water and Sewage Management Issues in Rural Poland. *Water*, *11*, 625. DOI: 10.3390/w11030625.

Polska Akademia Nauk PAN (2022). K*atastrofa na Odrze – geneza, teraźniejszość, zalecenia na przyszłość*. Retrieved from https://klimat.pan.pl/katastrofa-na-odrze-geneza-terazniejszosc-zalecenia-na-przyszlosc/. Access: 13.10.2023.

Ptak, M. (2018). Odtworzenie warunków wodnych osuszonych jezior w Polsce – wybrane przykłady. *Badania fizjograficzne Seria A – Geografia Fizyczna*, *9*(A 69). DOI: 10.14746/bfg.2018.9.14.

Sodolski, M. (2020). *Jak użyźniono pustynię. Gospodarka wodna w Izraelu*. Retrieved from https://klubjagiellonski.pl/2020/06/26/jak-uzyzniono-pustynie-gospodarka-wodna-w-izraelu/. Access: 13.10.2023.

Szalinska, E. (2018). Water Quality Management Changes Over the History of Poland. *Bulletin of Environmental Contamination and Toxicology*, *100*, 26–31.

Raszkowski, A., & Bartniczak, B. (2019). *On the Road to Sustainability*: Implementation of the 2030 Agenda Sustainable Development Goals (SDG) in Poland. *Sustainability*, *11*(2), 366.

Rączka, J., Skąpski, K., & Tyc, T. (2021). *Zasoby wodne w Polsce – ochrona i wykorzystanie*. Warszawa: Fundacja Przyjazny Kraj.

Rolinski, M. (2012). Elementy prawa wodnego w rozwoju historycznym ze szczególnym uwzględnieniem polskich ustaw wodnych (część I). *Studia Iuridica Lublinensia*, *18*, 83–91.

Rosen, V. V., Garber, O. G., & Chen, Y. (2018). Magnesium deficiency in tap water in Israel: The desalination era. *Desalination*, *426*, 88–96.

Teschner, N., McDonald, A., Foxon, T. J., & Paavola, J. (2012). Integrated transitions toward sustainability: The case of water and Energy policies in Israel. *Technological Forecasting & Social Change, 97*, 457–468.

United Nations, Unwater, Israel. (2022). https://www.sdg6data.org/country-or-area/Israel?fbclid=IwAR0mWNTFEpYuvgj2jmYSdSzpKyF3UJhcwTLhoffvipL2wGiVR8TJ-ujm7lE. Access: 10.10.2022.

Witkowski, A. J. (2018). P*aradoksy* światowej *gospodarki wodnej*. Katowice: Monografie Śląskiego Centrum Wody. Tom 1.

UN General Assembly, Transforming our world: the 2030 Agenda for Sustainable Development (21 October 2015). A/RES/70/1. Retrieved from: https://www.refworld.org/docid/57b6e3e44.html. Access: 20.10.2022.

Zarządzanie Zasobami wodnymi w Polsce, United Nations Global Compact Report. (2018). https://ungc.org.pl/wp-content/uploads/2021/04/raport-zarzadzanie-zasobami-wodnymi-www-1.pdf. Access: 9.10.2022.