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Water Security in an Integrated Water, Hydrogen, and Carbon Development Strategy

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Abstract:

Purpose: The paper examines water security as a strategic component of sustainable development in the context of integrated water, hydrogen, and carbon-based development. It aims to highlight the role of water as a critical resource shaping economic transformation, environmental protection, and social resilience, with particular emphasis on Poland's conditions and challenges.

Design/methodology/approach: The study is based on a qualitative and conceptual analysis of academic literature, strategic reports, legal acts, and policy documents related to water security, sustainable development, ESG principles, and resource management. Descriptive, analytical, and comparative methods are applied, supported by secondary data from national and international sources.

Findings: The analysis indicates that water security is a multidimensional concept encompassing environmental, economic, social, and institutional dimensions. Effective water security requires integrated governance, long-term strategic planning, technological innovation, and alignment with sustainable development and ESG frameworks. The study highlights key challenges related to water scarcity, infrastructure deficits, climate change, and regulatory barriers, as well as opportunities arising from innovation and cross-sector cooperation.

Research limitations/implications: The paper is conceptual in nature and relies on secondary data, which limits empirical generalization. Nevertheless, it provides a comprehensive framework for future empirical research on water security, resource governance, and sustainable transformation.

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Practical recommendations: Policymakers and stakeholders should prioritize integrated water resource management, investment in modern water infrastructure, innovation in water technologies, and public awareness initiatives. Strengthening institutional coordination and aligning water policies with sustainable development goals are essential to enhancing water security.

Originality/value: The paper contributes to the literature by offering an integrative perspective on water security within a broader resource-based development strategy. It emphasizes water as a foundational element of sustainable transformation and highlights its strategic importance for economic resilience, environmental protection, and social well-being.

Keywords: Water security, transformation, sustainable development.

JEL Code: Q01, Q25, Q56.

Paper type: Research article.

1. Introduction

The foundation of these considerations will be one of the most basic and primordial chemical compounds - water, which constitutes the basis of the world and all living organisms. The development of innovation and modern technologies requires the shaping of social consumer attitudes that support the growth of a sustainable economy and the creation of a socio-economic ecosystem.

The beneficiaries of such an ecosystem would include governments, scientific and research centers and institutes, entities, organizations and institutions, national and international programs, local governments, and decision-makers active in the 3W economic sector. This responsibility is ensured by transparent and ethical conduct that contributes to sustainable development, takes into account stakeholder expectations, complies with applicable law, is integrated with organizational activities, and is practiced within its operational realities (Anam, Zygier, and Saszuk, 2020). Such an approach supports Goal 6: “Clean Water and Sanitation” of the 2030 Sustainable Development Agenda.

The social capital of the 3W sector combines real ambitions with innovative scientific, economic, and legislative solutions. The 3W idea may represent an opportunity to build real socio-economic potential that strengthens Poland’s economic development.

The transformation of the economy and implementation of sustainable development mechanisms is drawing widespread attention from the media, public opinion, and the business environment, focusing on the synergy of resources and the potential of

technologies, innovative ideas, organizations, institutions, and human resources that create a conducive space for implementation. Poland, with its market potential to play a significant role in the development of the 3W sector, requires a strategy that takes into account scientific, research, and business potential one that facilitates the commercialization of discoveries on the one hand, and reduces barriers on the other. The functioning area of the 3W sector is closely connected to water, climate, and energy security.

Due to the editorial volume limitations of the article, the focus will be on the essence and significance of water the leading chemical compound essential for life, existence, and the sustainability of the Planet. Water plays a key role in the global socio-economic system and is of immense importance to humanity and ecosystems around the world.

Therefore, it is essential to continuously take on new challenges aimed at sustainable water resource management, protection of aquatic environments, and ensuring universal access to clean water for all. Hence, water security is a comprehensive concept that includes health aspects, economic (ecological security), social (sanitation and food safety), and environmental dimensions (access to drinking water, its use, and management).

Theoretical considerations on these issues should not exclude but rather provoke debates and contrast different observations and viewpoints by raising questions about the purpose, essence, and future directions of the development of the 3W sector, including water security. The purpose of the article is to promote the 3W idea and, beyond that, attempt to answer the following questions:

- (1) Is Poland prepared for threats related to access to water?*
- (2) To what extent can the development of the 3W sector contribute to strengthening water security?*
- (3) What barriers influence the state of water security, particularly in Poland?*

The article uses critical analysis of literature, data contained in 3W Idea reports from 2021 to 2023, information from Supreme Audit Office (NIK) reports, national and international sources, legal acts, reports, specialist periodicals, and online sources, supported by the descriptive method.

2. Transformation of Water Security as a Process in Achieving Sustainable Development Goals (ESG)

The word transformation originates from the Latin *transformatio* and means "conversion" or "change." It is commonly regarded as a concept that is both "more complex" and "narrower" than the term change. This distinction allows us to conclude that all transformations are changes, but not every change is a transformation.

A change refers to any noticeable modification of an element of reality. Transformation, on the other hand, should be understood as a non-trivial and intentional process of altering a specific part of the environment within a defined time frame, aimed at creating a new and, above all, lasting state of that environment (Directive (EU) 2022/2464).

A transformation occurs as a result of a sequence of events or internal factors and aims to bring about a complete or partial, radical change in the operating conditions of subsystems or systems, communities, or organizations. It is a process that includes many interrelated elements and stages and encompasses a variety of actions, decisions, and interactions among the actors involved in the change.

It requires an understanding of and attention to multiple factors such as organizational culture, strategy, policy, innovation, technological development, the economy, society, and the natural environment. Interactions between these elements can have consequences in other areas, potentially leading to unexpected outcomes or conflicts. As a dynamic process, transformation may be iterative involving the cyclic repetition of stages such as analysis, planning, implementation, and evaluation.

To achieve the intended goals, a transformation must take into account the assumptions, interests, and objectives of stakeholders. The effectiveness of transformation processes requires strong leadership in change management, the mobilization of human and material resources, and the ability to motivate, collaborate, and engage.

Treating the process of transforming water security as a systemic change, it represents a comprehensive area of actions, changes, and innovations aimed at transforming the water system in an ecologically and socially sustainable way in order to effectively address challenges related to water security, sanitation, and climate change.

Making sustainable choices based on the available scientific and research potential, artificial intelligence, innovative solutions and new technologies, as well as national and international programs in the implementation of policies and legal frameworks, contributes to the principles of sustainable development in water resource management and in the provision of services, programs, and infrastructure investments that support sustainable development in the water sector.

Water security is defined as a concept within which threats to the sustainable development and safe use of water sourced from natural and human-acquired origins are recognized. It also refers to pressures on water resources (flooding or inundation) or their absence (drought or pollution) (Grey and Sadoff, 2007).

Sustainable development is a form of socio-economic development that equally encompasses the achievement of economic, social, and environmental goals. It is an

idea and a philosophy of thinking about development in terms of social justice and equality, seen as values that ensure intergenerational continuity (Gliwa, 2012). It is also a concept that has evolved over the years, assuming that economic growth should be balanced with the protection of the natural environment, society, and the efficient use of resources in order to ensure the well-being of both current and future generations (Goleński, 2020).

A key value is the harmonious coexistence of economic, social, and environmental aspects in the development process. In the context of these considerations, it is essential to note that development can be regarded as sustainable only if it is accompanied by social progress.

According to the report of the World Commission on Environment and Development, “sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs.”

Therefore, sustainable development should be understood as a “multidimensional, humanitarian concept of development aimed at improving the quality of life and the well-being of humanity under the constraints of Earth’s limited resources, taking into account the long-term effects of pre-industrial activity, also known as 'environmental ethics', which includes respect for nature and environmental protection (Hnatyszyn-Dzikowska and Łyszczarz, 2008).”

The principle of sustainable development is reflected in the Constitution of the Republic of Poland (Constitution of the Republic of Poland 1997) and the Environmental Protection Law (Environmental Protection Law 2023). For the purposes of this article, sustainable development including in the water sector should be understood as an integral and holistic mechanism encompassing ethical, spiritual, and intellectual dimensions in the pursuit of relatively lasting synergistic interactions between the areas of environment, society, and governance (ESG: Environmental, Social, and Governance) at global, national, local, and organizational levels, in relation to the assessment of the impact of organizational activities on the implementation of the 17 United Nations Sustainable Development Goals (SDGs).

A key contribution to the implementation of ESG is the document entitled “Transforming Our World: The 2030 Agenda for Sustainable Development,” signed by the leaders of 193 UN member states, including Poland. These principles are described in the form of six fundamental ESG goals (SDGs) (NIK, 2024a): (1) accountability of the organization for its activities; (2) transparency in decision-making and organizational actions; (3) ethical conduct (including in promotional activities); (4) respect for the law; (5) respect for international norms of behavior (particularly where national legislation is lacking or flawed); (6) respect for human rights.

The contribution to the sustainable use and protection of water and marine resources is defined in EU Regulation 2020/852 (3SI, 2024).

The synergy arising from the exploitation of water the global and central resource of the 3W concept will undoubtedly find application in innovative projects and technologies of the future. The implementation of this postulate will be possible through the reduction of water consumption and the improvement of water use in the industrial sector, agriculture, and households.

The objective related to water purification can be achieved through the development of innovative solutions for water treatment and desalination. In the area of good ESG practices, there are currently 8,564 organizations operating in Poland across 28 sectors, of which 846 are actively engaged in ESG initiatives.

Detailed data is available in 21 reports on good practices in responsible business in Poland. Public disclosure of an organization's impact on the environment, social issues, and corporate governance requires a proactive attitude from companies, including a willingness to implement changes in their operations. According to the EU directive on corporate sustainability reporting (Directive (EU) 2022/2464.), the obligation for companies to report on ESG has been modified.

The non-financial reporting process has been divided into four stages (CORDIS, n.d.): (1) in 2025, for the fiscal year 2024, it will apply to companies already subject to the current Non-Financial Reporting Directive; (2) in 2026, for the fiscal year 2025, it will include all large companies meeting at least two of the following criteria: total assets exceeding €20 million, net revenue above €40 million, or more than 250 employees; (3) in 2027, for the fiscal year 2026, it will include SMEs that exceed two of the following three thresholds: total assets over €4 million, net revenue over €8 million, or more than 50 employees; (4) in 2029, for the fiscal year 2028, it will apply to non-EU companies generating more than €150 million in net sales revenue within the EU.

It is estimated that the number of companies submitting annual ESG reports will increase from approximately 300 in 2021 to around 3,500 by 2027, including those in the 3W water sector.

3. Water in Civilizational Development

Water and access to it are inseparable elements of life and civilizational development, while its management and protection constitute a key factor in ensuring lasting social, economic, and ecological development (NIK, 2024b). Poland is one of the most water-scarce countries in Europe.

On average, the annual water availability per capita in Europe is 5,100 m³, whereas in Poland it is only 1,700 m³ per capita. This highlights the importance of rational

management of available water resources and the need for water conservation. Water demand is defined as the amount of water necessary for users to meet their needs. It is often considered equivalent to water withdrawal, although technically these terms are not synonymous.

In 2021, total water consumption in Poland amounted to 8,845 hm³, with industrial use (mainly energy production) accounting for 72%, water supply network operations for 18.5%, and filling and replenishing fish ponds for 9.5%. Groundwater withdrawal in Poland in 2021 made up 19% of the total and ranged between 0.3 and 1.6 km³ per year. The quality of the aquatic environment is affected by pollution resulting from human activity. The most common sources of pollution include: (1) industrial pollution; (2) agricultural pollution; and (3) municipal pollution with over 80% of global wastewater being discharged into water bodies without adequate treatment.

With the development of agriculture, industry, environmental pollution, and climate warming, the need to ensure global water security is becoming a priority for national governments. The Earth's water resources are estimated at approximately 1,386 billion km³ (covering 70.8% of the planet's surface), which amounts to around 0.13% of the Earth's total volume (estimated at 1,083.207 billion km³).

The vast majority of this water is contained in the oceans: the Pacific (660 million km³), the Atlantic (310.4 million km³), the Indian (264 million km³), the Southern (71.8 million km³), and the Arctic Ocean (18.7 million km³). Saltwater accounts for as much as 97.5% of global water resources, while freshwater represents only 2.5%, of which 68.7% is trapped in glaciers and 30.1% is stored in groundwater. Surface waters make up just 1.2% of all freshwater resources.

Water consumption in Europe by sector is distributed as follows (UNSD, 2022): (1) services - 2.5%; (2) households - 11.6%; (3) mining, extractive industries, and construction - 17.7%; (4) energy - 27.8%; (5) agriculture - 40.4%. In Poland, the largest share of water use comes from industry (about 72%), including 11% from the chemical sector; the municipal sector accounts for about 12%; energy production approximately 25%; agriculture about 10%, with projections showing an increase in agricultural water use to 11% by 2027.

Water is also a shared economic sector for the Three Seas Initiative (3SI) countries. The Three Seas Initiative was launched in 2015 as a joint project of the Presidents of Poland and Croatia, bringing together 13 EU member states from Central and Southeastern Europe. Its strategic objective is to preserve and strengthen the unity of the EU and the Euro-Atlantic space by addressing development disparities.

Key cooperation areas for 3SI include trade, transport, energy, digital communications, and infrastructure development for rail and road networks. Although trade within the 3SI accounted for only 15.1% of Poland's total

international trade in 2021, Poland has initiated a number of projects aimed at accelerating economic development including the construction of North-South infrastructure, the Via Carpatia and Via Baltica road corridors, the Rail Baltica rail connection, and the Danube-Oder-Elbe waterway.

Despite the failure of this last project, it is worth noting that official speeches and strategic documents related to the Three Seas Initiative do not address water resource management for example, water use in industry or wastewater treatment. However, water-related issues, risks, challenges, and opportunities are gaining importance, and the geopolitical initiative of the Three Seas region should respond to these challenges by expanding its list of priorities to include joint water investments.

97.5% of global water resources are saltwater. Humanity currently uses only 1% of freshwater, with 2.5% of that portion stored in glaciers. The cost of desalinating seawater largely depends on its salinity level. Pollution of regional sea surfaces is high. In the case of the Baltic Sea, this issue affects 96% of its surface; for the Black Sea, 91%; the Mediterranean Sea, 87%; and 75% of the surface of the northeastern Atlantic.

In Poland, approximately 60% of rivers are classified as having moderate ecological status, 30% as poor or bad, and only 10% as good or very good. The core responsibility for ensuring access to water for the population including water abstraction, treatment, and distribution has been assigned by Polish legislation to water and sewage utility companies.

The percentage of the global population with access to safely managed drinking water services reached 74.3% in 2021, marking an increase from 63.4% in 2005 (+10.9%). The civilizational development of emerging economies, which drives higher demand for water due to growing societal needs and new economic requirements, can become a source of potential water-related conflicts, including water stress. A country's socio-economic system experiences water stress when the availability of freshwater in relation to its withdrawal becomes a barrier to development.

4. Water - A Resource Without Which the World Could Not Develop

Water resource management is beginning to play a dominant role as a regulator in the context of climate change, migration processes, armed conflicts, refugee crises, social and humanitarian challenges, economic recessions, and urban development, and it requires the implementation of innovative and new technological solutions.

Effective water resource management is a challenge essential to ensuring water security through sustainable socio-economic development, along with systems and components of critical infrastructure, including buildings, facilities, installations, and

services vital to national security and the safety of citizens, as well as for the efficient operation of public administration bodies, institutions, and businesses. Components that ensure access to water are of fundamental importance (BGK, 2022a).

Strengthening the institutional and social resilience of local governments and the state in the context of water security should also be reflected in strategic documents, such as Poland's National Security Strategy (BGK, 2021). In Poland, 80% of water sourced for socio-economic needs comes from surface water, and the remaining 20% from groundwater (GUS, 2023).

Problems with water management in Poland stem from government decisions made in recent decades, manifested in, among others: excessive interference in river regulation; neglected land drainage systems; delayed retention processes (Lusawa, 2009); over-drainage of swamps and wetlands; a misunderstood approach to revitalization that involves removing greenery from urban spaces and replacing it with concrete surfaces; the way water and sewage services are managed; and outdated and failure-prone infrastructure.

Water security management requires effective monitoring, both in quantitative and qualitative terms. It is estimated that the global water quality monitoring market will grow at a rate of 7.3% annually (CAGR) and reach a value of USD 3.8 billion (PLN 15 billion) by 2025 (Lipiński, 2017).

Among the actions that can significantly improve water security in Poland are: (1) preventing the emergence of water deficits; (2) eliminating the risks of droughts, floods, and protecting groundwater; (3) developing the wastewater treatment market; (4) advancing research and innovation in water treatment and desalination (the Polish company Grupa Azoty Zakłady Chemiczne Police is working on desalination technology); (5) ensuring stable living conditions for the population and supporting business development; (6) implementing technologies that enhance the competitiveness of enterprises; (7) effective water retention (in Spain, over 40% of rainwater is retained, while in Australia, the installation of rainwater tanks is legally required). Retention reservoirs play a key role during this period of highly dynamic climate change.

Worldwide, including in Poland, technologies are being developed that enable effective retention and recovery of treated water. Globally, the rainwater harvesting market is projected to grow by approximately 6% annually (Compound Annual Growth Rate, CAGR) through 2027 (OPI PIB, 2022).

On one hand, such technologies allow the storage of water that can be used during droughts; on the other hand, they help prevent flooding during periods of increased rainfall (Petersen-Perlman, Veilleux, and Wolf, 2017).

The advantages of natural retention measures include: (1) the ability to store water in soil, landscapes, or aquifers; (2) restoring ecosystems to their natural functions; (3) maintaining ecological flow in rivers and mitigating climate change; (4) improving the microclimate, water quality, and protecting biodiversity; (5) social aspects – such as tourism; (6) cultural aspects – preserving the environment for future generations.

Today, artificial retention also plays an important role, focusing on the expansion of hydrotechnical and drainage infrastructure (flood protection, energy generation, municipal water supply, drought mitigation, flow regulation, irrigation, etc.) (PN-ISO 26000, 2012).

The value of the global water market is steadily increasing. In 2020, it was valued at over 800 billion USD and by 2028 its estimated value will reach 1,470 billion USD (Płaczek, 2023). Key factors driving the global increase in water prices include, among others: water shortages, rising living standards, inefficient infrastructure, and economic growth. Economic and social factors stimulate investment and the implementation of new technologies in the water sector in areas such as water sourcing, optimization of its distribution and transport, treatment, purification, and usage optimization.

Contemporary trends in this field include: (1) the use of artificial intelligence in the water supply sector; (2) obtaining drinking water from the atmosphere (AWG, Atmospheric Water Generation Technology) (Regulation (EU) 2020/741); (3) aquaponics - a food production system combining conventional aquaculture (breeding aquatic fauna in tanks) with hydroponics (growing plants in water) (Polityka Insight, 2023); (4) passive systems related to wastewater treatment in rural areas with dispersed housing (GUS, 2023).

Future technologies in water purification currently include a range of innovations aimed at effective, economical, and ecological removal of water pollutants. Among the promising technologies are (Regulation (EU) 2020/852): (1) the use of nanomaterials capable of removing chemical pollutants from water and for desalination and purification; (2) membrane filtration (nanomembranes) that captures contaminants at the molecular level; (3) oxidation processes using UV radiation to break down chemical pollutants into harmful substances; (4) the use of microorganisms and biotechnology for natural water purification; (5) the use of detailing technology (obtaining freshwater from seawater); (6) the use of intelligent water quality monitoring systems and early detection and response to threats (IoT - Internet of Things technology), including artificial intelligence algorithms for precise management of water purification processes; (7) the development of energy-efficient water purification technologies.

In the case of the Baltic states, the use of desalination technology would solve the problem of drinking water for decades. This is due to the inflow of fresh river water from the land and the penetration of salty ocean water through the Baltic Straits.

Because of the relatively large influx of freshwater, the salinity of the Baltic Sea increases with depth (Szubrycht, Rokiciński, Mickiewicz, 2022). The spread of desalination technology along the Baltic coast, due to its accessibility, may prove to be a beneficial alternative on the one hand, while on the other, the development of desalination technology is associated with high investment costs.

However, the desalination process requires about 10 times more energy than sourcing water from other sources. Industrial-scale desalination often requires its own power plants, which in turn results in rising water prices, as was the case in the agricultural sector in Spain. Therefore, innovations in desalination investments represent the future of water technologies, but are treated as one of the alternatives (BGK, 2023).

The architecture of the digital world has not bypassed the water resource management sector. Modern technologies for the water sector make it possible to respond precisely to the needs of end users, ensuring the reliability of services delivered. A key technology enabling the digitization of the water sector is artificial intelligence. It allows real-time monitoring of water consumption and quality, constant process control, and improved forecasting performance (IWA, 2020).

To implement the postulate of rationally ensuring water security, it will be necessary to introduce innovative technologies that enable the acquisition of drinking water of appropriate quality. A radical change in habits related to excessive water use is also essential, especially in highly developed countries. In this context, two fundamental pillars of water stewardship should be distinguished, not only at the national level.

The first pillar is the proper management of water resources (Tomaszewska, 2018); the second is the proper treatment of water resources. Proper water resource management involves increasing global public awareness regarding the reduction of consumption and the improvement of water use efficiency in households, industry, and agriculture. It is important to focus on the creation of new technologies that would successfully fulfill existing production functions, but with no or significantly reduced water usage.

Defining water indicators in terms of physical and chemical properties is crucial for selecting the appropriate water treatment process according to consumer needs. Water circulation processes can be efficiently monitored and managed using modern technological solutions, such as the smart water grid. The “Smart Water Grid” concept refers to the implementation of IT technologies, automation, and remote monitoring in the management of water resources and systems of water distribution and quality, aiming on the one hand to improve efficiency and on the other to enable sustainable water resource management.

The implementation of smart water networks is a prerequisite for improving the efficiency of water systems, minimizing losses, enhancing water security

management, and promoting sustainable development and conscious use of water resources. Although political initiatives in the area of water security are important, they remain insufficient.

Europe must turn to innovation and the development of new technologies, including through the promotion of the 3W sector in developing pioneering methods that will ensure water security and proper water supply for all citizens (Environmental Protection Law, 2023). The EU is currently proposing a number of projects that promote and support initiatives aimed at reducing water scarcity and pollution, increasing efficiency in its use, and lowering greenhouse gas emissions in the water economy sector.

5. Opportunities, Challenges, and Threats in the Development of the Water Sector within the 3W Concept

Poland, in comparison to other European countries, finds itself in an unfavorable hydrological situation, primarily due to limited water resources and questionable management of water and sewage services, including outdated and failure-prone infrastructure.

According to the latest report by the Supreme Audit Office (NIK), in order to ensure water security especially in crisis situations it is necessary to (Act on collective water supply and collective wastewater disposal – consolidated text ((Act on collective water supply and collective wastewater disposal, 2023): (1) clearly define, by the Council of Ministers, the branch of government administration responsible for matters related to the public water supply system, and (2) undertake effective actions by top-level and central public administration bodies to establish principles that guarantee the security of water supply during crises, including the preparation of the necessary documentation in this area.

It appears essential to implement centralized and coordinated cross-sectoral and inter-institutional mechanisms aimed at the comprehensive protection of the population. Every organization, especially water and sewage utilities, should understand their place and role in ensuring local water security not only in the event of crisis situations.

Emphasis should be placed on developing the capacity for individual self-sufficiency for as long as possible in terms of resources necessary for survival during emergencies. Water security, in the context of the 3W concept, is associated not only with opportunities but also with challenges and potential threats.

When attempting to articulate each of these aspects, it is important to consider the varying geopolitical situations at the regional, international, and global levels. Opportunities supporting water security include, among others, innovation and the

development of new technologies, which can contribute to access to clean water and the sustainable use of water resources.

Education and public awareness regarding the importance of water protection can lead to more rational water resource management. Disseminating inventions developed in Polish research institutions and enterprises through educational and informational campaigns, developing additional cooperation and knowledge transfer mechanisms, utilizing existing and creating new interactive platforms for collaboration and exchange of knowledge and experience, and supporting new ideas and expert recommendations for ESG-related initiatives proposed by companies such as encouraging participation in the Łukasiewicz Research Network's "Łukasiewicz Challenges" are all essential actions.

These issues should be closely integrated with the natural environment. International cooperation, along with joint initiatives, projects, and agreements involving the international scientific community and corporations operating within the ESG framework, can support more effective water resource management, particularly in the case of transboundary rivers.

A true test of the effectiveness and realization of development opportunities not only in terms of water transformation will be presidential, parliamentary, local, and regional (EU) elections held across various continents, supported by relevant national and international programs and accompanied by campaign promises that will generate political emotions.

The year 2024 is set to be a global election year, with around 2 billion eligible voters participating in elections across approximately 64 countries (Ustawa o zarządzaniu kryzysowym, 2007). As such, global elections, including those to the European Parliament, will have the potential to significantly influence climate and energy transformation, as elected politicians in these institutions make key decisions regarding energy policy, environmental protection, and climate-related actions.

Local elections are crucial for decisions at the community level, where planning, public transportation, waste management, and other issues impacting the natural environment are determined. Governments and parliaments are responsible for setting national climate and energy strategies. Elections are pivotal moments when political parties present their programs in these areas, and the resulting decisions directly affect budget allocations across sectors, including projects related to renewable energy, energy efficiency, and research into eco-friendly technologies.

Legal frameworks shaped by parliaments can either promote or hinder climate and energy transformation. Governments decide on investments in new infrastructure, such as renewable power plants including nuclear energy, power grids, public transport, and environmentally friendly technologies. Meanwhile, elections to the European Parliament influence a country's position on EU-level climate policy.

International cooperation is essential in mitigating the negative effects of climate change, and elections to international bodies may impact a country's involvement in global initiatives.

For this reason alone, it is worth monitoring political programs and the actions of politicians in these areas to understand what concrete measures they plan to take to reduce the negative impacts of climate change and promote renewable energy sources. An important factor supporting systemic water transformation in the long term is the regular conduction of public opinion research on ecological, energy, and climate awareness, as well as sustainable development.

Also noteworthy is the expanding body of literary studies within the field of environmental humanities. Environmental humanists call for a radical transformation in thinking, expressed in developing a sense of connection between humans and other beings at the molecular level.

Challenges in the area of water security include, among others, climate change associated with rising temperatures and extreme weather events, which can lead to water shortages, droughts, and floods.

Excessive consumption and pollution resulting from industrial, agricultural, and residential activities may lead to a deficit of clean water. Additionally, the social impoverishment of certain segments of the population may result in unequal access to clean water, potentially generating social conflicts and migration trends.

Threats related to water crises include: (1) international crises resulting from a large number of users; (2) internal crises caused by the unequal distribution of water resources; (3) resource-based crises, such as significant differences in the daily amount of water available per capita; (4) crises related to water quality. Crises more often stem from the lack of water than from actual water wars.

Climate change also contributes to the reduction of freshwater resources and, alongside armed conflicts, represents one of the greatest threats to human health and life worldwide. Extreme weather events, wars, and conflicts can lead to humanitarian crises related to access to clean water and sanitation.

Barriers to the development of innovation, including in Poland, by thematic areas, include:

(1) financing of innovative activities, such as the high costs of innovation, especially among SMEs; limited own funds for innovation; lack of systemic solutions for financing projects in the pre-investment phase; and the costly process of valuing intellectual property;

(2) bureaucracy and law, including excessive bureaucracy and legal frameworks not adapted to the challenges of innovation, such as administrative burdens, long timelines for obtaining funding, complicated procedures for valuing intellectual property, lack of clear legal interpretation, and lengthy contract negotiation processes;

(3) institutional cooperation, including difficulties in business–science collaboration, such as inefficient information exchange, lack of responsiveness from scientific partners, difficulties in estimating the costs of purchasing technological solutions from third parties, lack of incentives for researchers to lead innovation projects, insufficient specialization in scientific research in Poland, absence of a complete and regularly updated database of R&D potential of Polish universities, excessive focus of the business sector on short-term needs, and overly hierarchical structures in academia that prolong the process of identifying experts;

(4) data and IT tools, including limited access to intellectual property management tools, monitoring project sustainability, high costs of IT tools, insufficient cybersecurity in business–science relations, and fear of competition taking over developed solutions;

(5) education, knowledge, and experience, including knowledge gaps in legal regulations, the latest technological solutions and global trends, awareness of services offered by infrastructure-equipped institutions, knowledge of innovation support instruments, and lack of qualifications, competencies, and specialist knowledge due to insufficient lifelong learning;

(6) fragmentation of knowledge and information about available forms of support, and a lack of education focused on fostering innovative attitudes;

(7) socio-cultural attitudes reflected in distrust and risk aversion.

These considerations highlight the importance of institutions and organizations in researching, monitoring, and promoting sustainable development and environmental and climate protection at the international and regional levels.

Professionalism, substance, and effectiveness depend not only on the ability of institutions to cooperate with each other but also on their relationships with national governments in addressing global threats, challenges, and opportunities in shaping the actors responsible for ecological, climate, and environmental security.

Nation-states also apply various innovation strategies. The initiative known as the National Innovation System is a response to the need to develop legal, financial, and IT tools that comprehensively support innovation in Poland. Tools that support the national innovation system include:

- (1) tools that enable the management of innovation activities, monitoring of activity continuity, and identification of relationships between projects, stakeholders, and innovation outcomes;
- (2) tools for presenting the scientific and R&D potential of higher education and research institutions;
- (3) tools for analyzing the potential of inventions;
- (4) tools for presenting the ecosystem of institutions supporting innovation and facilitating the building of partnership relations;
- (5) tools that support compliance with legal regulations;
- (6) tools for collecting and measuring data on knowledge and technology transfer;
- (7) tools that help develop pro-innovation attitudes;
- (8) tools that provide advisory services and funding at every stage of an innovation project's implementation.

Credibility and ethics in conducting business within the ESG framework may be associated with the risk of dishonest practices, such as so-called "greenwashing" by companies. An additional problem may arise from potential claims related to the effects of climate change or environmental pollution, which can legally be linked to the insurance sector and the filing of complaints by affected parties.

6. Conclusions

A sustainable world of the future is one in which the water resources of the 3W concept and beyond available to the global society will be used as efficiently as possible, by minimizing consumption and accounting for the full ecological costs.

The process of development and technological progress, along with inventions and innovations, serves as a driving force supporting the implementation of water-related projects within the 3W framework, currently initiated and developed by Bank Gospodarstwa Krajowego.

The realization of this mission results from the fundamental assumption that further civilizational progress, economic growth, and R&D development should not come at the expense of future generations or lead to the depletion of valuable (and scarce) resources.

Future scenarios envision sustainable development in which the transformation of the economy toward zero emissions will be supported by new 3W technologies, with water as a key driver of civilizational advancement.

To achieve this ambitious challenge, it is essential to mobilize social capital composed of talented scientists capable of forming task-oriented teams, bold entrepreneurs, visionary non-governmental organizations, and responsible representatives of the public sector all committed to improving the quality of life for the global population through special development programs based on public-private partnerships.

The integration of all national and international stakeholders into a unified organizational and communication ecosystem unleashes enormous potential and creates opportunities for preparing Poland for the upcoming era of sustainable development challenges and the shaping of consumer behavior.

While Poland has relatively favorable conditions for managing water access risks, continued efforts are needed to revitalize and build new technologically advanced water infrastructure that increases access to clean water, protects water resources, and raises educational awareness in this vital social area.

Overcoming barriers that impact water security requires coordinated actions at the local, regional, national, and international levels, as well as the active engagement of society, public institutions, and private sector entities in efforts to protect and sustainably manage water resources.

Water security is a matter of fundamental importance for the health, life, and stability of communities around the world. Addressing the challenges and threats related to water resources requires sustainable management, innovation, the development and implementation of new water technologies, public education, and international cooperation.

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