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QUANTITY AND AVAILABILITY OF FRESHWATER RESOURCES: THE WORLD – EUROPE – POLAND

Renewable water resources account for a mere fraction (0.1 to 0.15%) of world's total freshwater resources. The average long-term annual renewable water resources per capita are presently assessed at approximately 6,500 m^3 globally, at 4,500 m^3 in Europe, at 4,000 m^3 in the European Union, and at 1,600 m^3 in Poland. Despite the comparatively high values of the average available water resources (the indispensable minimum being estimated at 1,000 m^3 per person yearly), many countries and regions all over the world are affected by considerable water shortage. The causes and effects of the uneven distribution, availability and consumption of freshwater resources in the world, in Europe, and Poland are made subject to detailed analysis.

1. INTRODUCTION

Water is an ubiquitous substance. Not surprisingly, its existence, availability, and potential of immediate use are generally taken for granted. Water is indispensable to human life as well as to the proper functioning of aquatic ecosystems and water-related systems. Water is used for industrial and non-industrial purposes, and thus stimulates economic growth and civilizational progress. It is essential to note, however, that the widespread belief about the instant access to and an unlimited availability of freshwater resources has been made subject to revision in the past fifty years.

2. WORLD'S WATER RESOURCES

Total water resources in the earth's hydrosphere are assessed at approximately 1.4 billion km^3, where freshwater resources (about 35 million km^3) account for 2.5%

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only, while salt water (oceans, seas, salt groundwater and salt lakes) constitutes as much as 97.5% (figure 1) [1], [2].

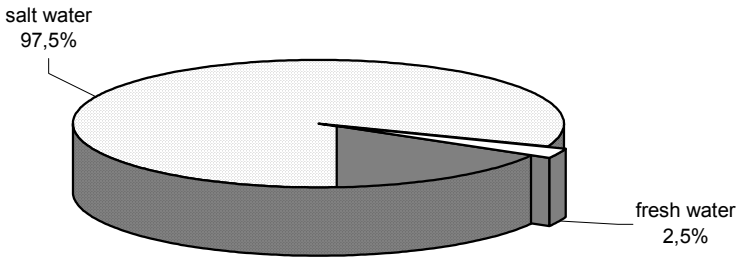

Fig. 1. Water resources in earth's hydrosphere

Most of the world's freshwater is frozen in ice caps and glaciers (69.55%). A large part is found in the lithosphere (30.11%) (groundwater, freshwater present as soil moisture). Freshwater resources coming from rivers and lakes constitute only 0.27%, freshwater present in the atmosphere and in wetlands as well as biological water accounting for 0.07% (figure 2).

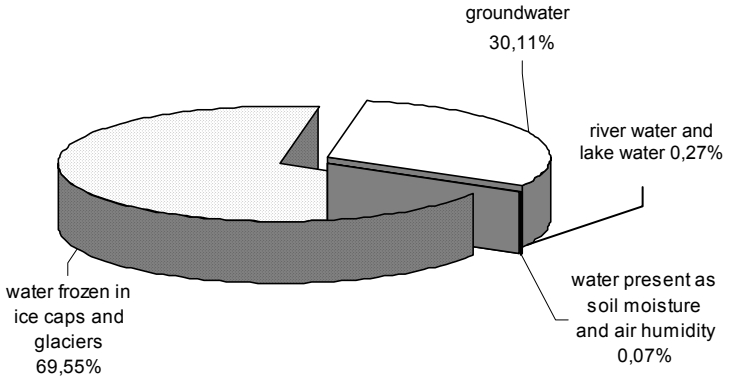

Fig. 2. Freshwater resources

The available freshwater resources (river water, lake water, and some part of the groundwater) are assessed at about 0.4 to 1.0% of the total freshwater quantity, which comprises 0.01 to 0.025% of the world's total water resources. Interestingly, the renewable water resources that are accessible for human use account for only 0.1 to 0.15% of the freshwater resources and for as little as 0.0025–0.0036% of the world's total water resources.

Although the world's long-term average annual quantity of renewable freshwater resources per capita is now estimated at several thousand cubic meters (the indispensable minimum being 1,000 m^3), freshwater is very unevenly distributed, and that is

why some areas, e.g. North Africa or West and South Asia, are affected by chronic water scarcity.

In the time span of 1970–1990, the average annual freshwater quantity per capita has decreased by one-third: from approx. 12,000 to 8,000 m^3 (at a population growth reaching 40%), and is predicted to fall to the level of about 4,800 m^3 by 2025 (figure 3) [3].

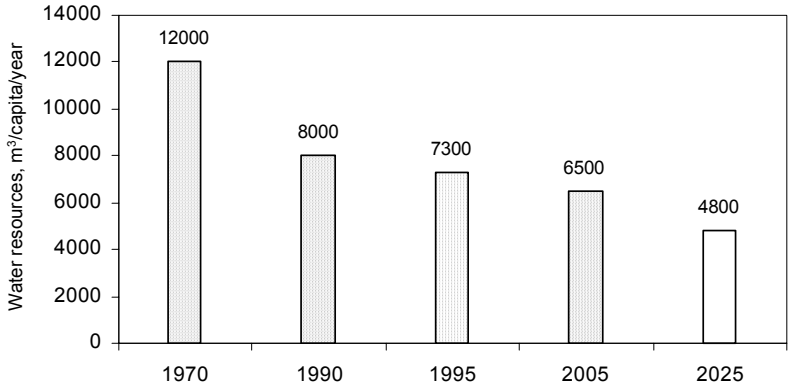

Fig. 3. Annual renewable freshwater resources in the world

According to the United Nations' Report [3], the lowest availability of freshwater resources (m^3/capita/year) is faced by the populations of Kuwait (10), Gaza Strip (52), United Arab Emirates (58), Bahamas (66), Qatar (94), Maldives (103), Libya (113), Saudi Arabia (118), Malta (129), and Singapore (149). According to the classification established by the European Environment Agency (EEA), the availability of water resources in those countries is *extremely low* (below 1,000 m^3/capita/year).

Countries where the availability of freshwater per capita is the highest (apart from Greenland and Alaska) include, among others, French Guyana (812,120), Iceland (609,320), Guyana (316,700), Suriname (292,600), Congo (275,680), Papua New Guinea (166,560), Gabon (133,330), Solomon Islands (100,000), and Canada (94,350). In all of them water availability is defined as *very high* (over 50,000 m^3/capita/year).

Optimistic forecasts assume that by the year 2050 a two-billion population living in 48 countries will face the problem of freshwater shortage; according to pessimistic forecasts, a six-billion population from 60 countries will be afflicted by water scarcity.

The main reasons underlying the world's shortage in freshwater resources can be itemized as follows [3]:

- Uneven distribution of freshwater resources: areas affected by and those threatened with water shortage are in the majority; arid and semi-arid zones account for 40% of the earth's surface but receive only 2% of the global runoff.
- Substantial, time-related variations in the annual precipitation patterns as well as the observed climate changes (it is predicted that in the future they may contribute in 20% to the rise in water scarcity in the world).

• Considerable rise (by 75%) in the number of world's population (from 3.691 billion in 1970 to 6.454 billion in 2005) and the concomitant increase in water consumption.

• Pollution and degradation of the natural environment due to the lack or inefficient operation of water supply and sewerage systems. In developing countries approximately 70% of industrial wastes and 90% of wastewaters are discharged into natural watercourses without any treatment [4], which imposes severe limitations on their reuse.

• Irrigation of cultivated land, which accounts for 70% of freshwater abstractions globally (figure 4). It is assessed that by the year 2030, water abstraction for irrigation will have further increased by 14%. Many countries (Iran, Iraq, Syria, Israel, Jordan, Egypt) use over 40%, some other (Yemen, Qatar, Saudi Arabia, Libya, Kuwait, United Arab Emirate) need even more than 100% of their renewable water resources for food production, which compels them to use their non-renewable resources (mine drainage water, demineralized water) [3].

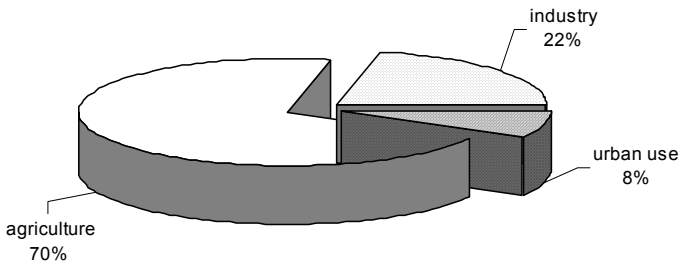

Fig. 4. Use of water abstractions in the world

Globally, the total water abstraction averages 3,760 km^3/year, which constitutes approximately 9% of the renewable water resources [5]. The UNO Report [3] estimates the abstraction of groundwater at 600 to 700 km^3/year, which accounts for 16 to 18.6% of total water abstraction.

The effects of the uneven distribution and the inefficient use of the world's freshwater resources can be summarized as follows [3]:

• At the beginning of the 21st century, a population of approximately 1.1 billion (18% of the world's population) had no access to unpolluted potable water.

• 2.4 billion people (40%) had no access to sanitary facilities.

• In developing countries approximately 50% of the population used contaminated water.

• Every year 2.2 million people die of diseases caused either by the consumption of polluted water or by the deplorable sanitary conditions.

• The destruction of aquatic ecosystems, which entails the threat of extinction for many species of mammals and birds due to the continuing exhaustion and pollution of both inland waters and wetlands.

• The number of water-related cataclysms (droughts and floods) has doubled since 1996 (35% of these occurred in Asia, 29% in Africa).

• Bordering drainage basins (there are 261 transboundary watersheds shared by 145 countries) have sometimes become the source of international conflicts. The past 50 years have witnessed 507 of them. In 37 instances, acts of violence occurred, and 18 of them transformed into armed combats between Israel and its neighbours (with the Jordan River water as the underlying cause).

3. FRESHWATER RESOURCES IN EUROPE

Assessed at around 3,500 km^3/year (on average) [6], European renewable freshwater resources account for 8% of the world's renewable freshwater resources (in 2005, the population of Europe constituted 11.2% of the world's population). On average, annual renewable water resources amount to 4,800 m^3 per capita in Europe and 4,000 m^3 per capita in the European Union [5].

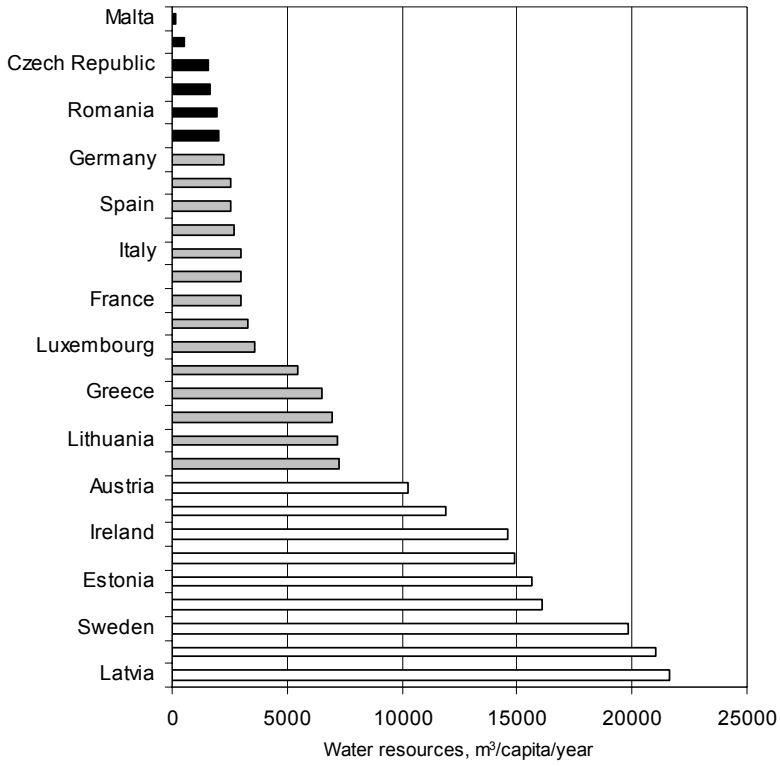

Fig. 5. Annual renewable freshwater resources in European countries

Owing to the uneven distribution of precipitations (particularly pronounced in the western part and in the mountainous regions) as well as to the changing climate, the annual availability of freshwater per capita varies from one European country to another (figure 5). The poorest water resources, classified as being of *extremely low* availability (below 1,000 m^3/capita/year), are found on Malta (166) and Cyprus (494). They are followed by the freshwater resources of the Czech Republic (1,563) and Poland (1,653), where their availability is described as *very low* (1,000–2,000). Freshwater resources classified as being of a *very high* availability (over 50,000) occur in Norway (83,066) and Iceland (580,205).

In 14 out of the 27 EU member states, the availability of freshwater is described as *low* (below 5,000 m^3/capita/year) and in the other states as *moderate* (5,000–10,000) and *higher than moderate* (10,000–20,000) (figure 5).

The growing disproportion in the available quantity of freshwater resources is, among others**,** attributable to the climatic changes, which are affecting the precipitation patterns in Europe. Thus, in some regions in the north of the continent, the annual precipitation rates have increased by more than 9% in recent years, as compared to the time span of 1946–1999. An opposite trend is being observed in southern and central Europe, where the yearly rates of precipitation decrease. The majority of climate-related forecasts assume that this tendency will continue. This indicates that water scarcity in southern Europe will be greater, particularly in the summer season [6].

The total water abstraction in Europe averages 353 km^3/year. This is an indication that 10% of the renewable freshwater resources are abstracted [6]. It is believed that water shortage and certain difficulties related with water supply (*low water stress*) occur when the necessity of using 10% to 20% of the renewable resources appears. But when the Water Exploitation Index (WEI) exceeds 20%, water-related problems (*water stress*) will become severe.

At the turn of the 21st century, the WEI approached 13% in all of the twenty-seven EU member states. However, only eleven of them (accounting for 13% of the total population of the European Union), mainly those in northern and some in central Europe, with a WEI lower than 10%, are not affected by water shortage (*non-stressed* countries). Ten member states (47% of the total EU population), including Poland, experience low water stress (with a WEI varying from 10% to 20%), while in six member states: Germany, Malta, Cyprus, Italy, Spain, and Belgium (40% of the EU population), fresh water scarcity is considerable (water-stressed countries with a WEI exceeding 20%). More details can be found in figure 6 (drawn up by the author on the basis of Ref. [5]).

The structure of water consumption in Europe is as follows [6]:

- On average, 51% of the total water abstraction is used for industrial purposes (40% of this quantity being used for power generation), 33% for agriculture (predominantly for irrigation), and 16% for urban use (figure 7).

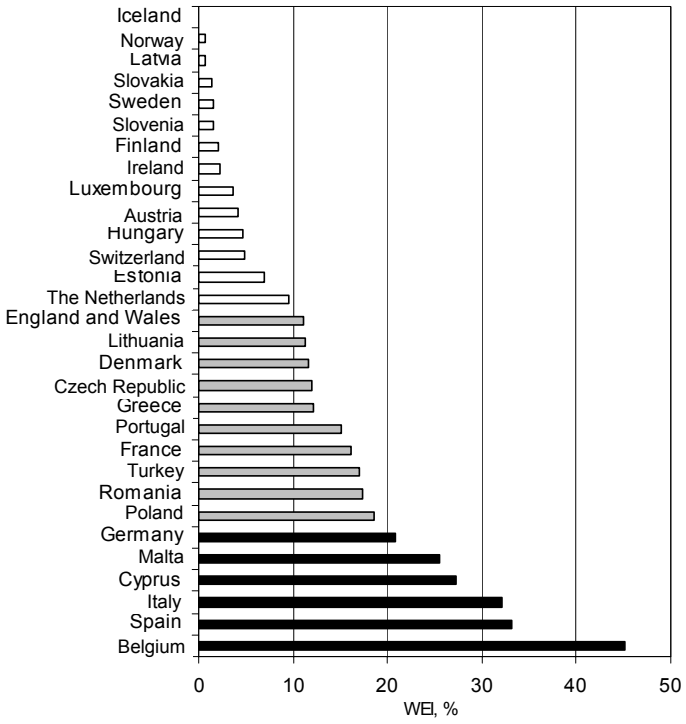

Fig. 6. Water Exploitation Index (WEI) in European countries

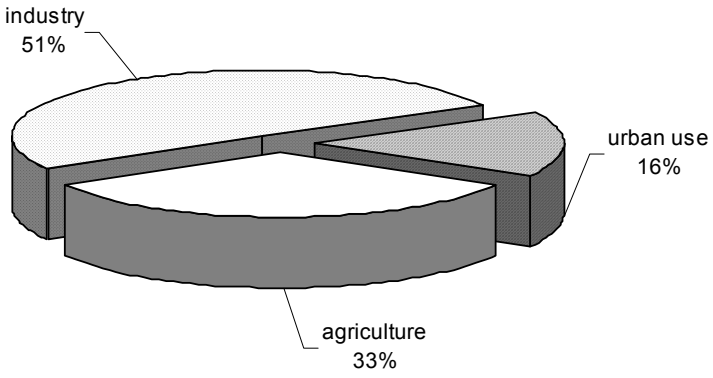

Fig. 7. Use of water abstractions in Europe

• Agriculture (especially irrigation practices) is the dominant water user in the southern EU countries. Water abstraction for this purpose (which is in some instances really extensive) accounts for the depletion of the groundwater resources, environmental degradation, and the deterioration of water quality, as well as for salt

water intrusion, e.g. into the large area of the Mediterranean coastline (Italy, Spain, Turkey).

- Most of the water abstracted in western and central European countries is used for industry, particularly for power generation.
- The process of economic transformation in the central European countries has notably reduced water abstraction for industrial purposes, agriculture, and urban use.
- The past decade witnessed a reduction in the use of water for power generation and a rise in water abstraction for the needs of agriculture, particularly in south-western European countries.

4. WATER RESOURCES IN POLAND

Poland is numbered among European countries with very poor water resources. Thus, long-term average annual freshwater resources approach 63 km^3, which accounts for less than 2% of the European total resources (the population of Poland constitutes 5% of the total population of Europe) [5].

With a quantity of freshwater resources per capita being about 1,600 m^3/year (where 13% of the water is the inflow from the neighbouring countries), Poland has been classified as a country of a *very low* water availability. In the EU member states, in Europe as a whole, and in the entire world, the water availability per capita is 2.5, 3, and 4 times as high as in Poland, respectively. In the European Union, only the Czech Republic, Cyprus and Malta have a lower availability of renewable water resources per capita than Poland does (figure 5).

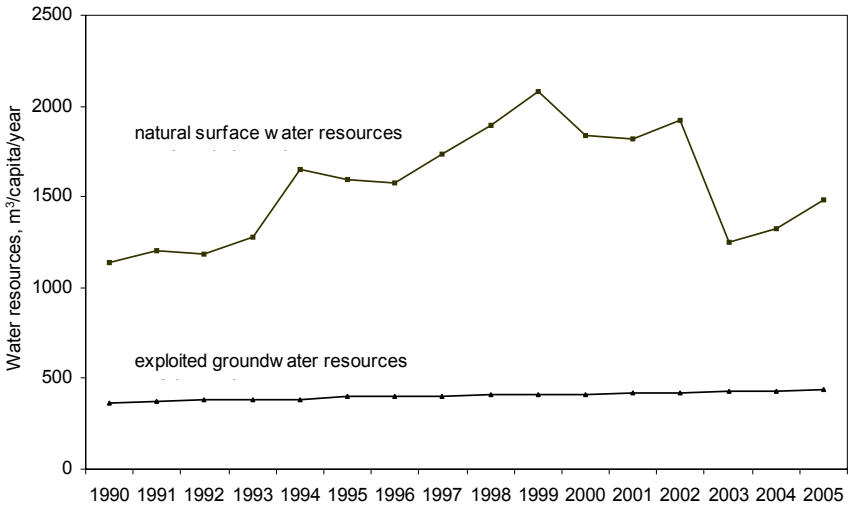

Fig. 8. Water resources in Poland in the time span of 1990–2005

The time-variability of the renewable surface water resources in Poland is depicted in figure 8 for the time span of 1990–2005. Thus, the lowest annual values (1,134 m^3) per capita were recorded in 1990, and the highest (2,077 m^3) in 1999 [5], [7]. The quantity of the available surface water resources also varies from one area to another. In 2005, for example, the lowest values were determined within the water region of Poznań and the highest in the water regions of Gliwice and Cracow.

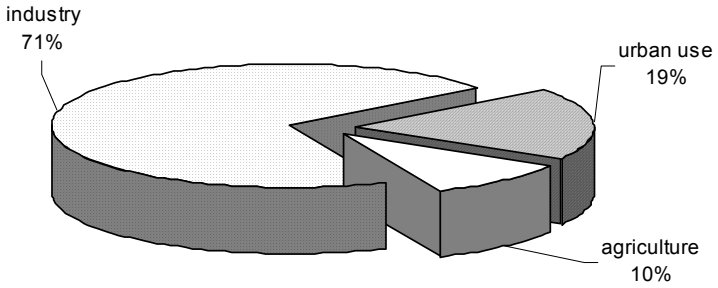

Fig. 9. Use of water abstractions in Poland

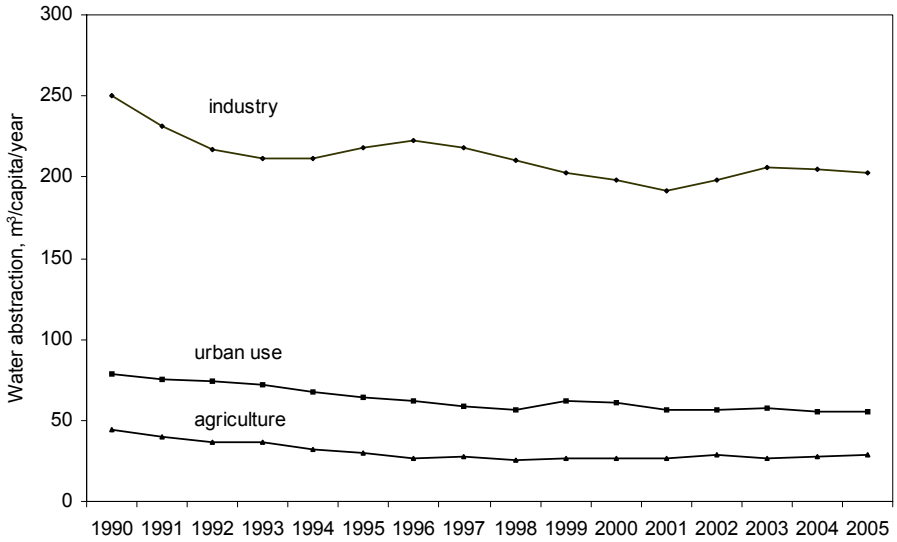

Fig. 10. Water abstractions in Poland in the time span of 1990–2005

In the past decades, industry has been the dominant user of Poland's water resources. In 2005, 71% of the total water abstraction were used for industrial purposes (where power generation constituted nearly 90%), 19% for urban use, and 10% for irrigation in agriculture and forestry (figure 9). Of the crucial significance to the water

supply for both the national economy and the population are the surface water resources, which cover approximately 84% of the overall water demand, the remaining sources being groundwater (15%) and mine drainage water (1%).

Since 1990, the year that followed the introduction of a free market economy in Poland, there has been a downward trend in water abstraction (figure 10). In the time span of 1990–2005, the total annual water abstraction per capita decreased by 23% (from 373 m^3 to 287 m^3) [5], [7], which was mainly due to the remarkable reduction (by nearly 19%) in water abstraction for industrial purposes. The decrease was primarily attributable to the restructuring of the Polish industry, to the closedown of many industrial plants and to the rationalization of water management in order to make it compatible with the rules of competitiveness and the increasingly strict environmental requirements. Annual water abstraction per capita for irrigation in agriculture and forestry decreased by 34% as compared to 1990, and that for urban use, i.e. for the operation of the municipal water supply system, by more than 30%. This is attributable primarily to the economical use of water in particular households.

Water Exploitation Index (WEI):

- Compared to the majority of European countries, the relation between the average annual total abstraction of freshwater and the long-term average freshwater resources (WEI) in Poland is disadvantageous.
- The time span of 1990–1996 was characterized by water stress, with a WEI varying from 20% to over 30% [7].
- After 1997, the WEI approached 18% (the decrease is due to the continuing reduction in the quantity of the water abstracted since the beginning of the 1990s and to the concomitant rise in the quantity of water resources in the second half of the 1990s), which is an indication that water stress is low [5].

5. SUMMARY

The limited quantity of freshwater resources as well as their time variability and uneven distribution in particular regions necessitate the following actions:

- an efficient and sustainable use of the available water resources,
- the development of such mechanisms that will balance the preservation or restoration of ecological integrity with the human needs that are to be satisfied by agriculture and industry.

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WIELKOŚĆ I DOSTĘPNOŚĆ ZASOBÓW WODY SŁODKIEJ: ŚWIAT – EUROPA – POLSKA

Odnawialne zasoby wody stanowią tylko niewielki ułamek (0,1–0,15%) ogólnych zasobów wody słodkiej na świecie. W przeliczeniu na jednego mieszkańca średnie roczne z wielolecia odnawialne zasoby wody są obecnie szacowane na około 6 500 m^3 na świecie, 4500 m^3 w Europie, 4000 m^3 w Unii Europejskiej i 1600 m^3 w Polsce. Pomimo stosunkowo dużych wartości średnich jednostkowych zasobów wody (niezbędne minimum szacuje się na 1000 m^3 na mieszkańca w roku), w wielu krajach i rejonach świata występują znaczne niedobory wody. Omówiono przyczyny oraz skutki nierównomierności czasowej i terytorialnej występowania zasobów wody słodkiej, a także ich dostępność i stopień wykorzystania na świecie, w Europie i Polsce.