Climate Change Impacts on Water Resources

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Abstract Water plays a vital role in both the environment and human life. Assessment of the impact of climate variability on water resources is an essential activity because we consider water as a strategic raw material. The quantitative characteristics of renewable water resources of a region or river basin can be determined by two approaches: by using meteorological data or by using river run-off observations. We have evaluated climatic and hydrological variables in selected river basins in Eastern Slovakia. We have compared the time series of observed variables over a period of about 60 years. The results of the work are the plots of observed variables,

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which we have evaluated. We have also been working on the using of water in selected Slovak river basins, namely by water abstraction and water discharge. The impact of climate variability on water resources in eastern Slovakia is minimal.

Keywords Climatic variables, Hydrological variables, Water using

1 Introduction

Research in hydrometeorology, water resources management, water use and water availability, and their temporal and spatial distribution, have all been based on the concept of climate stationarity. The implication has always been that climatic conditions and concomitant variations in water resources in the future would be analogous to those which have taken place during the past observational periods. In hydrology, this concept has also been used all over the world not only to assess water resources and water use but also to calculate extreme river run-off characteristics necessary for construction design. Long-term experience in design and exploitation of different water management structures in the world has shown the correctness and reliability – in any case, up to the present time – of using the premise of climate stationarity. However, the situation has changed dramatically in recent years with the question now raised of anthropogenic climate change due to atmospheric CO_2 increase arising from carbon fuel burning, industrial development and deforestation [1].

2 Assessment of Water Resources and the Impact of Climate Changes on Water Resources

The work focuses on the assessment of the use of water resources and climatological variables, especially in eastern Slovakia. The data were provided by the Slovak Hydrological Institute, regional centre in Košice.

The assessment of water resources is determining the amount, quality and availability of water resources, on which an evaluation of the possibilities of sustaining their development, management and control is established. The assessment of water resources offers the basis for a broad scale of activities related to water. Without such an assessment, it is impossible to plan, design, administer, operate and sustain projects for irrigation and drainage, ameliorating floods, industrial and household supplying of water, urban drainage, the production of energy (including hydropower), health, agriculture, fishing, moderating drought and preserving water-based ecosystems and littoral waters.

The nature of decisions based on information on the assessment of water resources may include large capital investments with a potentially massive impact on the environment. This demonstrates the value of the assessment of water resources and its tangible and intangible benefits. For ensuring the sustainable development in the future, appropriate government policies and programs are needed. Therefore, greater knowledge regarding the amount and quality of surface and groundwater is needed, and extensive monitoring, which would direct the management of these resources, is required.

Among the most critical impacts of climate changes are their effects on the system of hydrology and water management and thus also on socio-economic systems. Therefore, it is necessary to obtain an adequate understanding of the potential impact of anticipated climate changes: (1) on the availability and reliability of freshwater resources, (2) on the demand for water, on the occurrence of floods and drought and (3) on the consequences for efficient managing and security of existing animal and plant species and projects and structures associated with water. This enables the planning and implementation of effective countermeasures in the case of harmful consequences and revised policies in the case of favourable outcomes. Efforts should be focused on national and international programs which would include complex monitoring of research and control. Data relating to water are therefore essential for studies relating to climate changes and variability [1].

3 The Use of Water

Relying only on volume data and natural changes in run-off from catchment areas is not sufficient to reliably assess the future usefulness of water resources and the current availability of water. In addition to this, it is necessary to take changes caused by human activities into consideration. In recent decades, natural changes in the run-off of water and quantitative and qualitative characteristics of renewable water resources have been significantly influenced by the overall complexity of anthropogenic influences. These include those associated directly with the taking of water from river systems for irrigation, industry and household use. They also include control over the catchment, the change of use of basin lands as well as reforestation and deforestation, terrain management, urbanization and drainage. All these factors affect the total volume of water sources, the run-off regimen of a river and water quality differently.

Estimating the real role of all anthropogenic factors is not easy. We should not examine those factors which reshape the morphology of a basin. Such factors can have a large impact on small and moderate flows, as well as on water quality. Under certain physiographic conditions, these types of human activities may even support the increase of renewable resources of water simply by lowering the overall loss of evaporation from reservoirs. The estimate of global impacts of anthropogenic influences on water resources is based mainly on consideration of the role of factors associated with the direct taking of water from watercourses and the control of run-off from reservoirs. Those factors which cause unilateral reduction of run-off of surface water and groundwater are widely scattered, most intensively evolved and capable of producing a major impact on water resources in large regions.

The activities of man, his impact on water resources, are unambiguous: the problem of global warming in consequence of increased concentrations of carbon dioxide in the atmosphere and the strengthening of “greenhouse” effects. The unexpected increase of the air temperature and change of run-off influences renewable water resources and the character of their economic use. The not insignificant anthropogenic worldwide climate change recorded over the past decades, however, is reflected more in an estimate based on the observation of water resources and water consumption.

In terms of calculations for the future, we must note that the prognosis of global warming for the majority of thus far accessible regions is very inconsistent, especially in the expected changes of run-off. Therefore, these are not useful for assessing the estimates of water resources and water consumption. Furthermore, according to recent assessments for the future, the most important anthropogenic changes in the global climate are expected only after the years 2030–2040.

A quantitative estimate of global water resources for the past years and for the future decades was based on the use of water for public and household needs, industrial production and agriculture (irrigation). In association with the construction of reservoirs, water surfaces were also included. All prospects into the future point to potential anthropogenic global climate change, i.e. to a fixed climatic situation.

3.1 The Consumption of Water in Towns

The consumption of water in towns is directly connected with the amount of water used by the population, towns, housing estates and public services. Public supply also includes water for industry, which directly provides the needs of the urban populace, and this demand also consumes high-quality water from town water mains. In recent years, a significant amount of water has been used for gardening and for irrigating vegetable gardens and household yards.

The volume of public water resources used depends on the size of the urban population and the provided services, such as, for example, the range of the pipeline networks for supplying water and sewerage or the centralized supply of hot water where it is available. This likewise depends on climatic conditions. The majority of large towns at present draw water in the amount of 300–600 L daily per person. By the end of this century, it is anticipated that specific drawing of urban water per resident will increase to 500–1,000 L daily in the industrially developed countries of Europe and North America. On the other hand, developing agricultural countries located in Asia, Africa and Latin America use only 50–100 L/person/day. In some regions with insufficient water supplies, consumption is not more than 40 L/day/person.

The larger part of the water which was taken from water mains is returned to the hydrological system after use (purified or not) as wastewater if the sewerage canals are functioning. The primary sources of real consumption are waters which are lost to evaporation, from sewerage pipes, drainage of recreational areas, washing of streets and irrigating of gardens. Therefore, to a large measure, the range of water loss also depends on climate conditions. In hot, dry regions, forests are more important than in cool and damp conditions. The consumption of water for personal needs is not significant in comparison with the losses of water as a consequence of evaporation.

The relative values for consumption are usually expressed as a percent of received water and to a significant measure depend on the volume of the water drawn from public resources. Therefore, in modern towns equipped with centralized supply and efficient sewerage systems, the specific amount of water may be 400–600 L/person/day and consumption is usually not higher than 5–10% of the total intake of water. Small towns with a larger number of individual buildings which are not fully equipped with a centralized system may have a specific need for water of 150 L/person/day. Consumption in this context significantly oscillates and may reach 40–60%, with lower values in more northern areas and higher values in dry, southern regions.

A modern trend in the development of public water supplies around the world is the construction of large and small towns with an efficient centralized system for storing water and taking off wastewater, which links a larger number of buildings and residential areas. In the future, however, an increase is expected in the specific needs for water per person, while water consumption itself, expressed as a percentage of drawn-off water, is significantly reduced.

3.2 Water in Industry

Water is used for cooling, shipping and washing as a solvent and also sometimes is found in the ingredients of finished products. Thermal production of electric energy heads the list of uses. A large amount of water is needed for refrigeration equipment. Volumes of industrial water are completely different in individual industrial sectors and also in different types of production, depending on the technology of the production process. This depends on the climatic conditions, because the use of industrial water usually seems to be significantly smaller in northern areas than in southern regions, where the air temperature is higher.

In addition to thermal energy, other primary uses of industrial water are chemical and crude oil equipment, iron and non-iron metallurgy, wood-processing and the paper industry and machine manufacturing. The most important characteristics of water use – the volume of use of freshwater, the consumption of water and the offtaking of water – depend to a great measure on the water supply system.

The range of industrial consumption of water is usually a less important share of actual consumption. In the process of producing thermal energy, this may be some 0.5 up to 3%, but up to 30–40% for specific industrial processes. Development of the use of industrial water is one of the main reasons for water pollution in the world. This is explained by the fact that in various countries industrial growth has increased and is worsened by the fact that a large proportion of waste is released as wastewater into watercourses, predominately untreated or only partially purified. In the battle with such pollution problems, many countries have approved energy measures for reducing the use and release of industrial waters. Since the 1970s and 1980s, a tendency towards stabilization and even a drop in the demand for industrial waters can be seen. It is expected that in the future in many countries the trend will be a downward one regarding the larger use of systems for supplying circulating water and many industrial branches will aim at dry technologies without water usage.

3.3 Water for Agriculture

The irrigation of land has been practiced over millennia through the need to maximize the supply of water, but dramatic expansion of land irrigation took place primarily in the twentieth century, and irrigation was the main use of water in many countries. Agriculture at present is considered to be the largest consumer of water, representing approximately 80% of the total water consumption. Before crops began being cultivated, intensive development of irrigation occurred on all continents, which led to the growth of irrigated areas and ensure the growth of crops. In 1981, however, the measure of the global growth of irrigated areas fell significantly even in developing countries. The reason is mainly the very high costs for irrigation networks, which then leads to contamination of soil as a consequence of a lack of a proper drainage system, the exhaustion of irrigation sources and problems of environmental protection. In many developed countries, the range of irrigated land has now stabilized or even gone down and done so as a consequence of a reduction in crop production.

At present, approximately 15% of all ploughed land is irrigated. Food production from crops is, however, nearly half of all crop production. In the modern world, population growth has reached a great magnitude, and at the same time, an acute food deficit is recorded by nearly two-thirds of the world's population. Therefore, irrigation represents a greater share in the increased production of arable land and the efficiency of livestock breeding, and it is anticipated that irrigation in agriculture will continue to develop intensively in the future, especially in these countries, and will do so with very rapid population growth and insufficient land and water resources.

Values for specific water needs usually differ. In the future, they will change significantly depending on advanced irrigation systems, improved requirements for irrigation, regimes and techniques, and all factors should be taken into account with projects. Information on water consumption and irrigated areas in individual countries allows the calculation of the specific use of water for irrigation under various physiographical conditions. Apparently, in the north, the smallest values for the specific drawing of water are observed. In northern Europe, the values are in the range of 300–5,000 m^3/ha, while in the southern and eastern countries of Europe values reach 7,000–11,000 m^3/ha. Returned water equals approximately 20–30% of water intake. In the future, demand for irrigation water management could be significantly affected by the use of the best and newest engineering methods and irrigation techniques, such as, e.g. sprinklers, drip irrigation, etc., which help increase crop yields and reduce the volume of irrigation water required.

In addition to irrigation, there may also be the problem of supplying high-quality freshwater to the rural population in many developed countries located in dry areas. However, costs for potable water are insignificant in comparison with costs for irrigation.

4 Use of Water Worldwide and in Slovakia

From the practice of everyday life and our own experience, we are able to say when water is sufficient, when there is too much of it, and when we suffer a lack of it. It is possible to objectify this experience with numbers, which we arrive at from more than a half-century of nationwide continual monitoring of our surface and ground-water resources [1].

Before we get to specific date, we familiarize ourselves with perhaps the most cited estimates of I. A. Shiklomanov resources [1], one of the most essential hydrologists of recent years, who dealt with the assessment of long hydrological orders on a common measure. He came into the awareness of the hydrological community with these estimates, which he presented in 1992 at the International Conference on Water and the Environment in Dublin. He processed data on water used per resident for every continent (Table 1), and he used the year 2000 as a prediction [2].

A similar calculation is also made for Slovakia and is in good agreement with his data for Central Europe. I introduce them, especially so that we can compare them with the world and so that we are aware that only the regions of southern Europe and northern Africa are comparable or worse in this regard. We introduce (Table 2)

Table 1 The use of water per person (adopted from [2])

Region	The use of water (m^3 10^3/year/person)				
	1950	1960	1970	1980	2000
Europe	5.90	5.40	4.90	4.60	4.10
North Europe	39.2	36.5	33.9	32.7	30.9
Middle Europe	3.00	2.80	2.60	2.40	2.30
South Europe	3.80	3.50	3.10	2.80	2.50
North America	37.2	30.2	25.2	21.3	17.5
Canada + Alaska	384	294	246	219	189
USA	10.6	8.80	7.60	6.80	5.60
Caribbean	22.7	17.2	12.5	9.40	7.10
Africa	20.6	16.5	12.7	9.40	5.10
North Africa	2.30	1.60	1.10	0.69	0.21
Asia	9.60	7.90	6.10	5.10	3.30
South America	105	80.2	61.7	48.8	28.3
Australia	112	91.3	74.6	64.0	50.0

Table 2 The use of water per person in the Slovak Republic (adopted from [3])

	1931–1980	1990	1993	1996	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Usable water (m^3 10^3/year/person)	2.84	2.40	1.37	2.84	2.36	2.37	1.96	1.30	1.88	2.30	2.76	1.72	1.88	2.00	4.22	1.73	1.41	2.62
Abstracted water (m^3/year/person)		397.7	297.6	256.1	220.8	214.9	203.5	193.3	190.9	168.3	141.5	127.7	122.8	115.8	111.0	109.7	123.1	118.0
% of abstracted water from usable		16.6	21.7	9.0	9.40	9.1	10.2	14.8	10.2	7.3	5.1	7.5	6.6	5.8	2.6	6.3	8.8	4.5

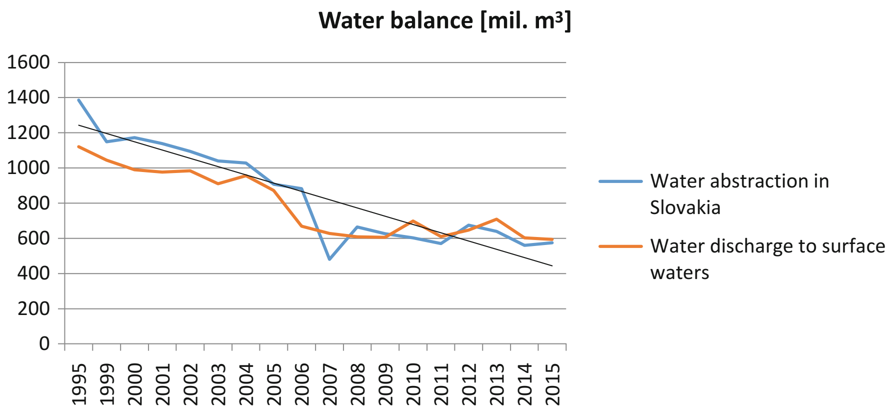

Fig. 1 Water balance in Slovakia (based on [4])

the state of use of water in Slovakia, namely on average up to 1980, then for selected years up to 2000 and for each year from 2000 to 2013 prediction [3]. The data are summarized for all basins in Slovakia.

The use of water in Slovakia from the point of view of water abstraction and water discharge during the period 1995 and 1999–2015 is depicted in Fig. 1.

5 Short Overview of Climate Change Studies in Slovakia with Respect to Water Resources

Possible changes in water resources due to the climate change impacts were studied since the beginning of the 1990s of the last century when the Czecho-Slovak National Climate Program (NCP) was established at the Ministry of Environment on 1 January 1991 [5]. The former Czecho-Slovak NCP was split into two separate state programs – the Czech and the Slovak ones after 1 January 1993. More than 23 subjects have participated directly in the Slovak NCP activities after 1993, coordinated by the Slovak Hydrometeorological Institute. The results were published in 12 monographs issued by the NCP in the 1994–2008 period and in four Slovak National Communications on Climate Change issued by the Ministry of Environment of the Slovak Republic in 1995, 1997, 2001 and 2005.

The first scenarios of expected climate change in Slovakia have been issued as early as in 1991, based on the incremental method. Later on, totally ten General Circulation Models (GCMs) from four world climate centres have been utilized in Slovakia [6]. At present, the regional models KNMI (The Netherlands) and MPI (Germany) are used to model possible climate change on the territory of Slovakia.

The impacts of climate change on water resources were studied by many authors. The main issues studied were oriented on changes in climate parameters and (1) long-term variability of discharges in Slovakia with respect to teleconnections [7], (2) long-term development in the water balance elements [8], (3) long-term run-off changes modelled by hydrological scenarios [9], (4) long-term drought occurrence in elements of the hydrological balance modelled by hydrological models [10], (5) reservoir water supply reliability [11] or (6) changes in spring yields and groundwater levels [12].

The results of hydrological studies published in Slovakia at the end of 1990s brought the following results. A significant run-off decrease over the whole territory of Slovakia during the spring and summer period was predicted [13]. The decrease around 20–25% was expected in the northern part of Slovakia; however, in the southern regions the expected decrease should reach from 30 to 40%, exceptionally, even more, up to 60%. On the contrary, a statistically significant run-off increase was predicted for the winter period, amounting about 20% in the northern regions and about 40% in the southern regions. The predicted changes in the spring yields, based on trend analysis, should reach the decrease in 10–60% depending on geographical location.

The results published after 2010 have confirmed that the increase in the long-term mean monthly run-off can be assumed in the winter and early spring. On the other hand, a decrease in the long-term mean monthly run-off can occur in the summer period [9]. As already indicated, the southern part of Slovakia and the lowlands will be more sensitive to run-off decrease. The decrease could reach in Southern Slovakia up to 67% and the southern part of the Eastern Slovakia up to 55% in 2075 [9]. At the same time, estimation of changes in the capacity of selected water reservoirs indicates that the expected change in climate would influence certainty of the water supply from reservoirs [9]. Evaluation of changes in groundwater resources between the period before 1980 and the period 1981–2009 was done in [12]. The results showed that decrease in groundwater resources already influenced at least 70% of the territory of Slovakia in 2009. The most significant adverse impact is predicted for the southern and central part of Slovakia, reaching 25–35% decrease in comparison to the period before 1980. The documented change in specific groundwater storage for the territory of Slovakia made $-250{,}000\ m^3\ km^{-2}$ in the period 1981–2009.

6 Assessment of Water Using Hydroclimatic Variables

6.1 Hornád River Basin

The Hornád River Basin (Fig. 2) is demarcated on the west by the Váh River Basin, on the south-west by the Hron River Basin, on the north by the Poprad River Basin, on the east by the Bodrog River Basin and to the south by the Bodva River Basin. Part of the southern boundary of the basin is formed by the state border with Hungary.

The partial basin of the Hornád River is defined by the ridge groundwater divide coming from the Kráľová hoľa group, which continues in a south-easterly direction through the Slovenský raj National Park along the ridges of the Volovské Mountains and at the hilltop Kojšová hoľa 1,246 m a s l turns to the Košice Basin, from where

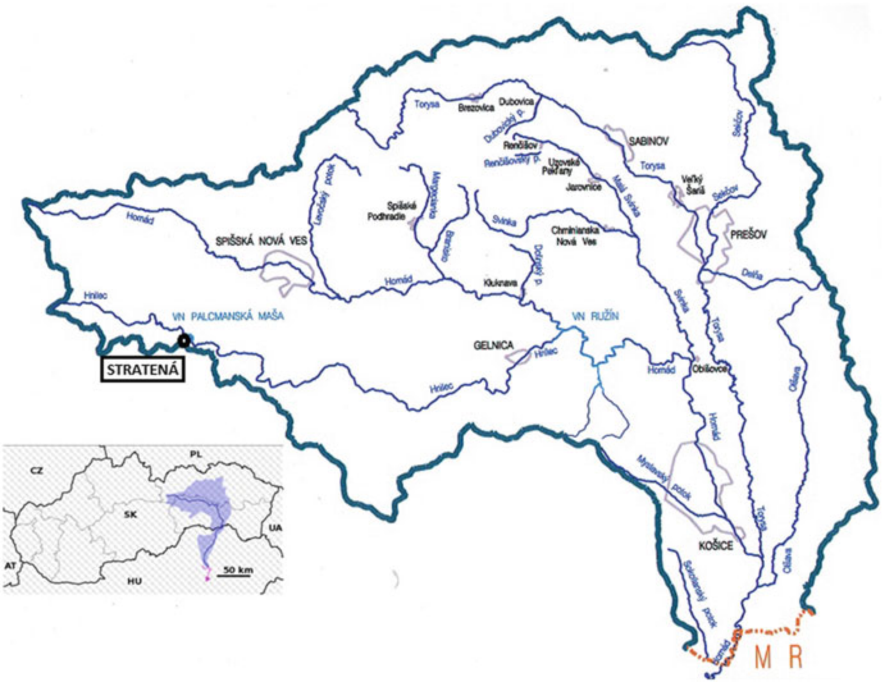

Fig. 2 Hornád River Basin

it leads as a valley groundwater divide along the highest places of the upland part of the basin at the state border with Hungary. Along the western side, the groundwater divide leads from the Kráľová hoľa group through Kozie chrbty. Then heads to the north-east and passes to the interface between the Poprad and the Hornád Basins, continuing by the ridges of the Levoča Hills in an easterly direction to the hill Minčol 1,157 m a s l in the Čergov Hills. From there, it drops further to the east to the hill Šipotská hora 557 m a s l in the Ondavská Uplands. Here, it takes a southerly direction and across the ridge of the Slanské Hills with the highest group Šimonka at 1,092 m a s l it again comes to the state border with Hungary [14].

The area of the partial basin of the Hornád is 4,414 km^2 [14]. Watercourses on the territory of the partial basin with an area greater than 1,000 km^2: Torysa. Watercourses on the territory of the partial basin with an area greater than 500 km^2: Hnilec. The long-term average discharge of the Hornád River at the closing-state border profile is 28.9 m^3/s.

The partial basin of the Hornád thanks to its complex orographic relations comprises of three climatic regions [14]:

- Warm: the south and south-eastern parts of the area fall into the climate zone of warm, moderately dry to damp with a cold winter. It is characterized by average annual precipitation of 600–700 mm. In the east, it extends up to the Sabinov area. Average annual air temperatures in the warmest areas are 9–10°C gradually falling in a northerly direction to 8°C.

Table 3 Hydrological balance in a partial basin of the Hornád River Basin (period: 1961–2000) (adopted from [14])

Partial basin	Area (km^2)	Precipitation (P) (mm)	Run-off (O) (mm)	P-O (mm)
Hornád	4,414	701	210	491
Slovakia	49,014	743	236	506

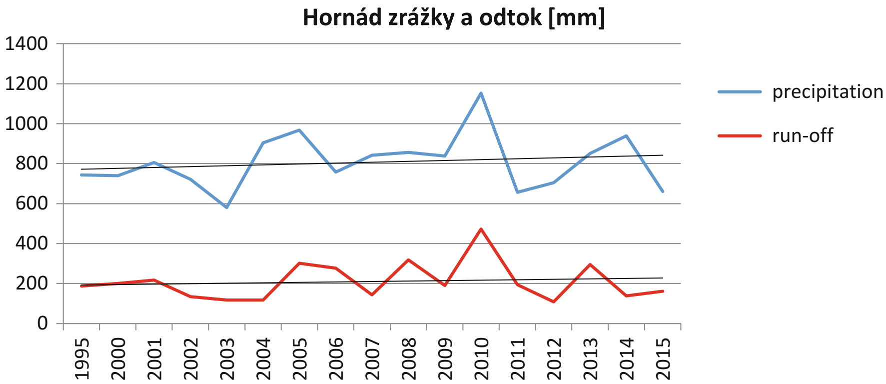

Fig. 3 Hornád River Basin precipitation and run-off (based on [14])

- Moderately warm: in the central part, is an area of moderately warm, moderately damp to damp, valley, foothill to uplands with average annual precipitation of 700–900 mm. This occurs on the territory of the Slanské Hills. Average annual temperatures reach 6–8°C.
- Cool: the northern and western part of the territory is a moderately cool area, which extends into the central part of the territory in the area of the Volovské Mountains with average annual precipitation of 700–900 mm. Average annual temperatures reach 4–5°C.

The Hornád River is the largest tributary of the Slaná River. The Hornád and Slaná rivers create, after the Bodrog River, the second largest river system in Eastern Slovakia. This river system forms a huge fan with its centre on Hungarian territory. The 81% (4,414 km^2) of the Hornád River Basin at the inflow into the Slaná River, out of the total area (5,436 km^2), is located on Slovak territory. This part is formed by the upper part of the Hornád River and its tributaries. Table 3 documents the basic elements of the hydrological balance in the Hornád River Basin.

Precipitation and run-off in the Hornád River Basin during the observed period 1995–2015 slightly increased, as it is depicted in Fig. 3.

6.2 *The Use of Water in Hornád River Basin*

The use of water in the Hornád River Basin from the point of view of water abstraction and water discharging during the period 1999–2015 is depicted in Fig. 4.

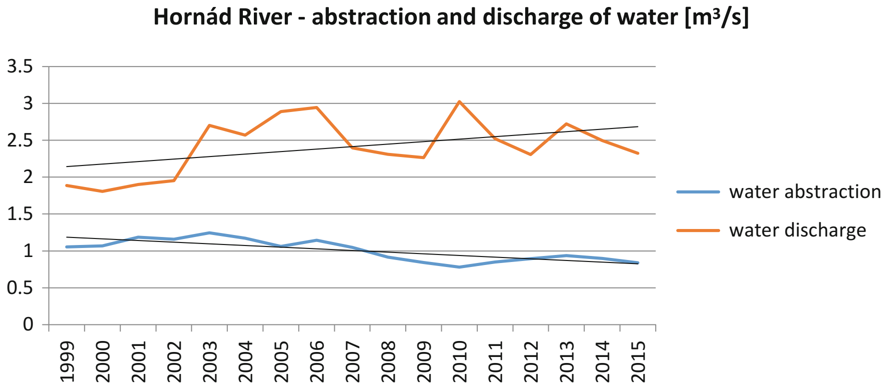

Fig. 4 Hornád River Basin: water abstraction and water discharging (based on data from [15])

Water abstraction has a decreasing tendency during the evaluated period 1999–2015, but at the same time, the water discharge is slightly increasing.

In the next section, the course of climatic and hydrologic variables in the river basin is analysed.

6.3 Course of Hydroclimatic Variables in the Hornád River Basin

Climatic and hydrologic variables are evaluated at the Stratená gauging station, ID 8530 (the Hnilec tributary). The following data were analysed:

- Stream flow [m^3/s]
- Surface water temperature [°C]
- Water stage [cm]
- Precipitation [mm]

The gauging station Stratená (see Fig. 2) is situated above the water structure (dam) Palcmanská Maša, in the territory of the Stratená village. It is located at the Hnilec River – the right-side tributary of the Hornád River.

The data between the years 1990–2000 are missing, so they are not included into the evaluation. Discharge values during the observed period 1954–1989 and 2001–2010 are slightly decreasing (Fig. 5). The water stage is also slightly decreasing as we can see from Fig. 6.

The station was moved approximately 1.5 km upstream in 1978. This is the reason of the abrupt change of water stage.

The surface water temperature was also observed at the monitored gauging station Stratená. The course of surface water temperature in Hnilec River is documented in Fig. 7.

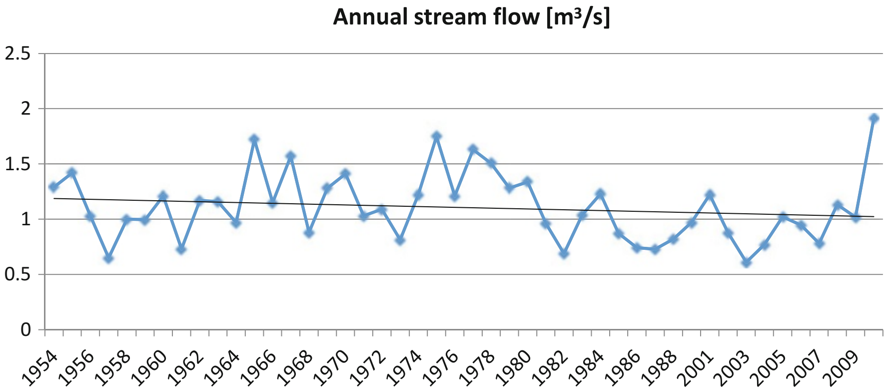

Fig. 5 Annual stream flow at Stratená gauging station in 1954–1989 and 2001–2010

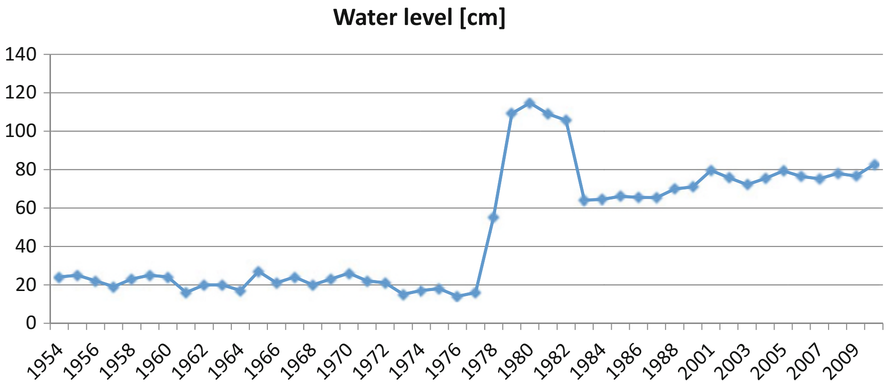

Fig. 6 The water stage at the Stratená gauging station in 1954–1989 and 2001–2010

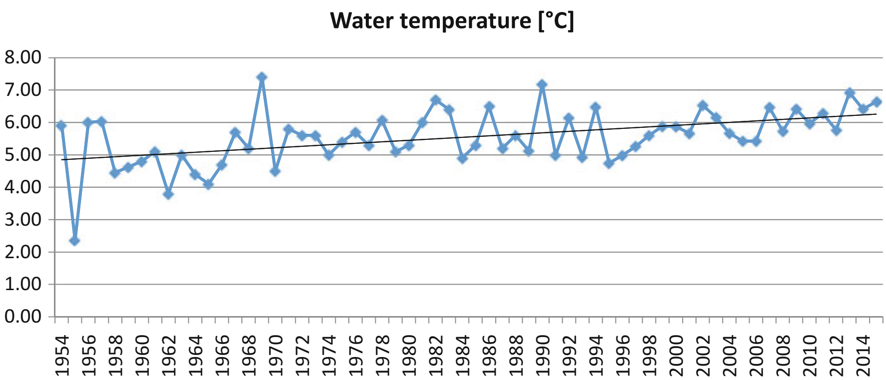

Fig. 7 Surface water temperature in Hnilec River at Stratená gauging station in 1954–2015

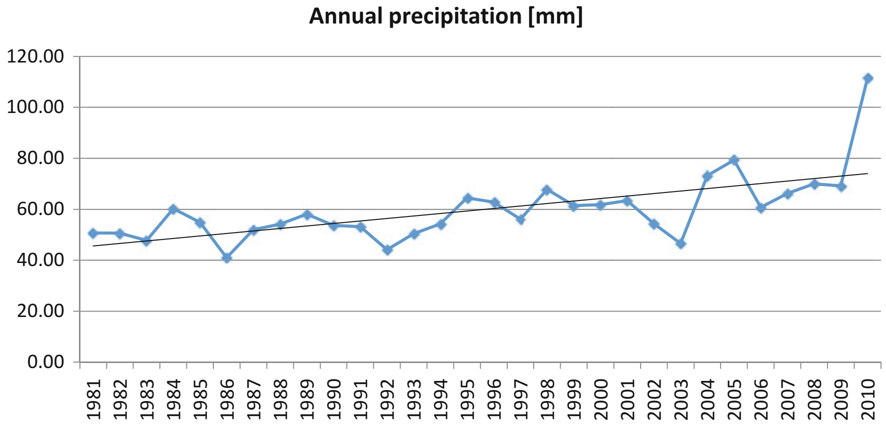

Fig. 8 Precipitation at Stratená station in 1981–2010

The annual surface water temperature in Hnilec River during the observed period increased in more than 1°C as it is depicted in Fig. 7. It is connected also with the increasing air temperature in the area during the last 50 years.

The course of precipitation was evaluated during the period 1981–2010. Precipitation increased in approximately 20 mm, as it is depicted in Fig. 8.

Water use – abstraction and discharging – was analysed in Sect. 6.2 together with other climatic and hydrological parameters for the Stratená gauging profile (Hnilec sub-basin) of the Hornád River Basin. The analysis proved that climate variability in Slovakia influences water resources only in slightly way, what is obvious from graphical evaluation.

7 Conclusion and Recommendations

Water management, like the power industry, is not a sector per se, but it does secure access to water for all other sectors and for society as a whole according to need. However, unlike energy, there are no alternative sources of water. And that is why for several years now we have considered water to be a strategic raw material. In addition to water provision, water management has another no less important task – protection from the undesired effects of hydrological extremes, such as drought and floods. Meteorology, climatology and hydrology, in particular, provide not only the marginal conditions but also direct input values into water management. For a long time, here in Slovakia and abroad, water management was determined based on the sources of water, the renewability of which was considered as a stationary process, whose central values and variance did not change over time. In considering of climate change, a phenomenon we are already confronting and which is primarily expressed in meteorological, climatologic and hydrological processes, it is shown that these processes are non-stationary. This means that we identify trends in time-related climatic as well as in hydrological orders. Water resources may decrease or increase depending on the development of climate elements. In the past, we were able to resolve annual or perennial fluctuations of available water sources either by using economic instruments or by creating water reserves in our conditions, with annual regulation.

Recommended activities include:

1. Increasing of cooperation between the climatological and hydrological communities with the elaboration of predictions on climate changes in individual annual periods and specific regions;
2. Strengthening the capabilities to collect, preserve and process data related to water, including data relating to climate changes;
3. The development of research programs on the national level and contributing to regional and international research projects related to the question of climate change, its early detection and its impact on the hydrological regimen. These should deal with the situation in developing and developed countries and could include cases focused on the elaborating and testing of speculative methods for impact assessment;
4. Assessment of the probable socio-economic and environmental impacts of such changes, the elaborating of strategies for reaction and financing and performing these strategies.

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