ADAPTATION MEASURES FOR WATER RESOURCES MANAGEMENT IN CASE OF DROUGHT PERIODS

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Abstract: The global climate changes are followed with the increasing of the average temperatures and decreasing of precipitation especially in the warmer part of the year. The change of these two parameters is one of the reasons for more frequent drought periods. The paper presents some adaptation measures for water resources management in the Republic of Macedonia in case of drought periods.

General data about climate in Republic of Macedonia have been presented. Different climate types characterize the territory from continental, changed continental, sub Mediterranean (changed maritime) to mountainous climate with various subtypes. Present status of available water resources has been presented, too. The total water resources of the Republic of Macedonia are estimated on: 18,8 $x10^9$ m^3 from rainfall (with 733 mm average rainfall), 6,22 $x10^9$ m^3discharged from the catchment areas, 0,52 $x10^9$ m^3 ground water and 0,42 $x10^9$ m^3 from the largest springs. Also current water demands for different users have been presented. Estimation of availability of the water resources to satisfy current and forthcoming demands of water has been done. It has been concluded that current water demands for irrigation, water supply of municipalities and industry, fisheries and biological demands can be met in an average year and in a typical dry year, for exp. with probability of appearance of 25%. In the years with less rainfall than the typical dry year, total water demands for the present moment cannot be satisfied.

Maximal values of the irrigation water requirements and maximal water supply demands usually occur at the same period of the year. This period happens to be in the warmer part of the year when there is not enough water to satisfy all demands. So, there is a possibility for occurrence of conflict situation between agricultural and non-agricultural users especially in drought periods. In the forthcoming period all users will need more water. So, it is important to mention the necessity for proper water resources management especially in the forthcoming period when the climate changes are expected to have an influence on water resources in the country. Several adaptation measures considering engineering and no engineering measures for water resources management in cases of drought periods have been presented.

Key words: water resources, drought, mitigation measures,

Introduction

Drought is a normal, recurring feature of climate that occurs in virtually all climatic regimes. It is the consequence of a natural reduction in the amount of precipitation received over an extended period, usually a season or more in length (Sivakumar. M.V.K., Wilhite D.A.,2002). Drought can also occur as a result of special interaction between natural and social environment. The natural and social environment are changing continuously through the past, but these changes have become very rapid during the last decades. The world's climate has always varied naturally. Scientists believe that a new kind of climate change is under way now. Some examples of climate variability and extreme climate events are the following: higher maximum temperatures, more hot days and heat waves over all land areas, higher minimum temperatures, fewer cold and frost days and cold waves over all land areas, more intense precipitation events, increased summer drying in mid continental latitude areas and associated risk of drought etc. It is expected that these events will have an impact on human health and welfare, on ecosystems and national economies. Vulnerability to drought is dynamic and influenced by many factors such as increasing number of population, land

use and other natural management practices, desertification processes, water management practices, technology, governmental policies and the environmental awareness. The purpose of vulnerability assessment is to identify the negative impacts on natural and social environment and to estimate their adaptability. Also, a global need for effective drought management is evident. An effective drought management should be consisted of three components: monitoring and early warning, risk and impact assessment and mitigation and response (Sivakumar M.V.K., Wilhite D.A.,2002). Mitigating drought is defined as long or short term actions, programs or policies taken during or in advance of drought in order to reduce the risk on natural and social environment. Mitigation measures involve a wide range of tools such as: policies, activities, plans, and programs. The paper presents vulnerability assessment and proposed adaptation measures for water resources management in cases of drought periods in the Republic of Macedonia.

Climate

The climate in Macedonia is diverse. Besides the total area of the Republic of Macedonia is relatively small a variety of climate types are present. The territory of the country is covered with different types of climate: continental, changed continental, sub-Mediterranean, mountainous climate, as well as their various subtypes. At the territory of Macedonia the influences of the Mediterranean and the continent overlap. In the southern part of the country it is sub Mediterranean, in the central and northern areas it is changed continental and on high mountains - mountainous.

According to the Macedonia's First National Communication under the United Nation Framework Convention on Climate Changes (2003), several more homogeneous climate regions and sub-regions are defined: region with sub-Mediterranean climate (from 50 to 500 m above mean sea level), region with moderate-continental-sub-Mediterranean climate (to 600 m a.m.s.l.), region with hot continental climate (600 - 900 m a.m.s.l.), region with cold continental climate (900 - 1100 m a.m.s.l.), region with sub-forest-continental-mountainous climate (1100-1300 m a.m.s.l.), region with forest-continental mountainous climate (1300 - 1650 m a.m.s.l.), region with sub-alpine mountainous climate (1650 - 2250 m a.m.s.l.), region with alpine mountainous climate (higher than 2250 m a.m.s.l.).

The average annual temperature is 11.50 C°. The warmest month is July with an average air temperature of 22.0 C°, while the coldest is January, with an average temperature of -3.0 C°. The temperatures are higher in the southern, than in the northern parts of the country. Moving towards north, the average annual temperature gradually declines. The calendar of precipitation in Macedonia, as well as their type shows significant irregularities. The average annual sum of precipitation in the Republic of Macedonia is 733 mm, while for the basin of river Vardar 700 mm. The central part of the country has lowest average annual sum of precipitation of only 400 mm. According to the National Self Capacity Assessment -Thematic Report on Combating Desertification and Land Degradation (2004), the territory of the Republic of Macedonia is characterized with following basic climate characteristics:

- The summer period of the year is characterized with very high air temperatures with longer period without precipitation and drought periods and aridness on climate.
- According to drought index by de Martone the territory of the Republic of Macedonia is characterized with drought index between 24.2 and 28.7 in the region with continental-sub-Mediterranean climate, in the region with hot continental climate this index is between 25.0 and 40.6, in the region with cold continental climate is 33.6 and 82.4 in the region with alpine mountainous climate.

Estimates on climate changes indicate that air temperature will increase by 1^0C to 3.5^0C in 2010 with increased rainfall in Northern Europe and decreased in Southern Europe. This may lead to reduction of renewable water resources in Southern Europe. The variation of drought risk and intensity is the most serious impact of climate change on water resources. Climate changes might have a considerable impact on the flood regime, too. According to the Macedonia's First National Communication under the United Nation

Framework Convention on Climate Changes (2003) an analysis of variations and fluctuations of the main climate elements (air temperatures and precipitations) have been performed for two meteorological stations, which have the longest series of data period. According to the document certain trend of increasing of annual air temperature has appeared after 1991. On the basis of annual sums of precipitation a trend of decreasing of precipitation has been noticed especially from 1984. The decrease of precipitation has been more significant in the eastern parts of Macedonia. The most characteristic dry period was between 1984 and 1994.

Further in the same document analysis of available water resources and estimation of their change for the forthcoming period have been done. It has been concluded that the time series data are insufficient for more reliable forecasts of the hydrological parameters trends for the forthcoming period and that for the observed period of forty years the average discharges have decreased from 10% to 20%.

Water Resources

According to the draft version of the Spatial Plan of Republic of Macedonia (1998) the total water resources of the country are estimated on: 18.8 x 10^9 m^3 from rainfall (with 733 mm average rainfall), 6.22 x 10^9 m^3 discharged from the basins, 0.52 x10^9 m^3 from the groundwater and 0.42 x10^9 m^3 from the largest springs. The annual resources per capita are estimated on about 2 600 m^3/annum.

There are four basins in Macedonia: Vardar, Strumica, Crn Drim and Juzna Morava. The major one is the river Vardar basin that covers 80.4% of the total territory of the country. The Strumica basin covers 6.5 % of the total territory. This area is poorest in water resources. The Crn Drim basin covers the basin of the Prespa and Ohrid Lake and the basin of the Crn Drim. This basin covers 12.9 % of the total territory. The basin of Juzna Morava is 44 km2 and it is the smallest one. The river Morava spring is in Macedonia and it belongs to the Danube basin.

Available water quantities from surface inflow waters in the Republic of Macedonia are estimated on 1 014 x10^6 m^3/annum. Available water quantities from outflow surface waters are estimated on 6 360 x10^6 m^3/annum. It has been estimated that 84% of the available water quantities in the country are domicile waters and only 16% are outside waters.

The total registered number of springs in the country accounts for 4 414. It should be noted that only 58 springs have a capacity of over 100 l/s.

There are three natural lakes in Macedonia: Ohrid, Prespa and Doyran Lake. All of them are shared with the neighboring countries. The largest one is Ohrid Lake. During the last fifteen years there has been a significant decline in the water level of both the Prespa Lake and the Doyran Lake.

Groundwater resources exist in the country, but it can be stated that there is insufficient data about its availability and quality. Observation and examination of groundwater have not been performed continuously.

The water resources from rainfall are significant, but in areas where the irrigation schemes have not been constructed yet, they do not enable stabile agricultural production. This is the case in central and eastern part of Macedonia. The problem with rainfall is the uneven spatial and temporal distribution over the country, showing more favorable conditions in the western part. The rainfall is minimal in the central part of the country where the potential for agricultural production is more favorable. It can be noticed that there is a lack of rainfall in the warmer part of the year. The temporal distribution presents long drought periods and high intensity rainfalls.

According to the Capacity Self Assessment within the Thematic Area of Land Degradation and Desertification, (2004), the water quality condition indicates that the natural balance of the rivers is already disturbed due to the pollution with organic matters, heavy metals, pesticides, toxic and organic compounds. The pollution is high downstream from towns where the industries are located, because of discharging wastewaters (industrial and communal) into rivers without treatment. The pollution is lesser in those sections that are passing through less densely populated areas, but even there pollution level sometimes

exceeds limits set by categorization of the watercourse and the determined Maximum Allowed Concentration by the existing water quality regulations. The condition of groundwater quality is not systematically observed. It can be stated that the quality of groundwater is similar to the surface water quality of a certain region. Disturbance of groundwater quality is possible near the existing landfills, mines, wild dumps and near some industries. The water of the springs is of good quality. Water pollution is evident only in surface and ground water especially in the area of Skopsko pole.

Water Resources Management

The major use sector of the water in the Republic of Macedonia is irrigation. Project designed area accounts for 163 693 ha of fertile arable land for the built irrigation schemes. The irrigation schemes are mainly constructed in the period between 1958 and 1980. According to the Spatial Plan of Republic of Macedonia (1998) the total irrigation requirements (in an average dry year) for the project designed area of 163 693 ha accounts for approximately 899.335 $x10^6$ m^3/annum. This represents 25% of the total water quantity discharged from the river network in Macedonia during an average dry year.

Almost all big irrigation schemes are supplied with water from reservoirs. Usually the reservoir dominates over the irrigated area and enables irrigation by gravity. The main distribution lines are open concrete canals or pressurized pipelines. The primary and secondary pipeline network usually consists of pipelines or earth built canals where surface irrigation methods are practiced.

The long period of exploitation of irrigation schemes has an impact on the irrigation schemes condition. So, really irrigated area is less then actual possible area for irrigation. For example in 1987 total irrigated area was 82 582 ha or 67.5% of the possible area for irrigation and it is the maximal value of the irrigated area. The ratio between irrigated area and area possible for irrigation continually decreases reaching the minimum of irrigated area of 34 696 ha in 1999. Such a low ratio in 1999 can also be explained by the rather high precipitation during the growing period (Donevska, 2000).

For the present moment water demands for water supply of population are assessed on 207.99 $x10^6$ m^3/annum, for tourists on 6.258 $x10^6$ m^3/annum and for industry on 274.147 $x10^6$ m^3/annum. The total water demand for water supply of municipalities and industry is 488.399$x10^6$ m^3/annum. The already built water supply systems are mostly of local water supply system type. Only four regional water supply systems have been built (regional water supply systems). These systems enable interconnection of several locations and their water supply with one water source. The main sources for water supply are springs, then ground water, reservoirs and river streams. The quality of the water is generally good, some problems are identified in rural areas. In some regions there is shortage of water during summer period due to many reasons. Water is also used for energy production. On the three basins there are 1 624 MW installed power. Water demand for fisheries is assumed on 16.68 $x10^6$ m^3/annum.

According to the draft version of the Space Plan of the Republic of Macedonia (1998) current water demands for irrigation, water supply of municipalities and industry, fisheries and biological demands can be met in an average year and in a typical dry year, for exp. with probability of appearance of 25%. In the years with less rainfall than the typical dry year, total water demands for the present moment cannot be satisfied.

Maximal values of the irrigation water requirements and maximal water supply demands usually occur at the same period of the year. This period happens to be in the warmer part of the year when there is not enough water to satisfy all demands. There is a possibility for occurrence of conflict situation between agricultural and non-agricultural users especially in drought periods (Donevska K., Dodeva S., Taseva J.). Due to the urbanization and industrialization competition of water between irrigation and other water users has become and will become focal point because they have to share limited water resources.

The technical condition of the water supply and irrigation network has a direct impact on the abstracted water quantity. The efficiency of the network influences the quantity of the demanded water. High water losses of the network in the Republic of Macedonia have an impact on efficiency of the water supply mains and distribution networks. There are rather

high water losses in water supply systems. They are accounted for 10% to 60 % of the water at the intake structures. Also, all irrigation schemes (except the irrigation scheme Strezevo) show high water losses (Donevska, 2000). They are assumed on 20% to 40 % of the water at the intake structures.

Drought as a hydrological events has a direct impact on water resources. Long-term water shortages directly influence water resources of basins and disturbs water balance conditions.

The drought periods are characterized with discharges under the annual averages at almost every river in Macedonia. Also, drought causes lowering of water level into natural lakes and artificial reservoirs and lot of secondary effects. Drought periods have an influence on ground water resources, too. Water scarcity situation results in difficulties in water supply of all users. Besides the impact on quantity on water resources, drought has an impact on quality on water resources. Low discharges influence on decreasing of river capability for wastewater receiving and transport. It causes river contamination.

Adaptation Measures in Drought Periods

In the last two decades a significant progress in drought management has been made on a global level. Wilhite (www.drought.unl.edu/mitigate/mitigate.htm) has proposed an assessment of drought mitigation technologies implemented by U.S. states about actions taken in response to drought conditions. These actions were classified in nine categories: monitoring and assessment programs, legislation and public policy, water supply augmentation, public awareness and education programs, technical assistance, demand reduction and water conservation programs, emergency response programs, water use conflict resolution, and drought contingency plans.

Republic of Macedonia has ratified a number of international environmental agreements. The UN Convention to Combat Desertification was ratified in March 2002. The responsible Ministry is executing a project titled National Self Capacity Self Assessment with the main objective to undertake an assessment of Republic of Macedonia's capacity to meet its obligations under the UNCCD convention. According to the Self Assessment of Country Capacity Needs for Global Environment Management-Capacity Self Assessment within the Thematic Area of Land Degradation and Desertification (2004), major issues related to UNCCD, that are partially obligation from the convention, partially steps that should be passed in order to create proper environment for fulfilling the obligation from the convention, and experts view of what should be done for preventing problems of drought, land degradation and desertification are elaborated. Some of the issues connected with the system level are:

- Development of national strategy for integrated approach to land degradation, desertification and drought;
- Development of national action plan for land degradation, desertification and drought and
- Development of local action plans for land degradation, desertification and drought.

Beside the actions that should be taken on a system level, the authors of the paper recommend some adaptation measures for water resources management in drought conditions:

- Demand Reduction. Regarding the fact that the irrigation is the major water consumer, the most effective measure should be reduce of the water losses along the distribution networks, as well application of methods of irrigation with higher efficiency. Most of the water supply systems in the Republic of Macedonia are suffering of high water losses in the convey structures and network. The first task should be rehabilitation of the structures and network and installation of measuring devices for the consumed water. The main objective is to reduce the quantity of the consumed water. Implementing water metering and leak detection programs is of high priority.
- Water conservation programs. In situations where demand reduction is already existing, the next step should be water conservation, urban as well as

agricultural. Also, sewage effluents and other wastewaters should be effectively reused.

- Providing new sources of water. As a long-term measure, the construction of more facilities for storing water in wet years for use in dry years, transporting water long distances from areas of surplus water to areas of water shortages and watershed management.

Other Measures

Currently, Republic of Macedonia is preparing new Water Law in order to harmonize its national legislation with EU legislation. In this new version of the law, six water related EU Directives have been transposed: Water Framework Directive WFD (2000/60/EC), Directive on the quality of water intended for human consumption (98/83/EC), Directive concerning urban waste water treatment 91/271/EEC), Directive concerning the quality of bathing water (76/160/EEC), Directive concerning the protection of waters against pollution caused by nitrates from agricultural sources (91/676/EEC) and Directive on the protection of the environment, when sewage sludge is used in agriculture (86/278/EEC). All the provisions from these Directives have been transposed in the national Water Law, including those related to drought conditions and recommended measures, which should be undertaken in order to reduce the inverse effect of the drought.

Also, River Basin Management Body (RBMB) should be established for each of the four major river basins: Vardar, Crn Drim, Strumica and Juzna Morava. The main role of that body should be integral water management of the river basin. These bodies shall be responsible for: carrying out the basic analysis of river basin characteristics, preparation and implementation of the River Basin Management Plans (RBMP), preparation the Programme of measures, collecting the monitoring data, controlling the operators (drinking water supply utilities, irrigation operators, industry water supplier, etc), protection from the adverse effects of the water (floods, drought, erosion process), protection of the water from pollution, preparation and updating of polluters cadastre, establishing and updating of register of protected areas, international cooperation regarding the preparation of international river basins management plans, performing scientific research in water field, etc. The measures like demand reduction, water conservation programs and provision of new water sources should be involved in the RBMP as measures for mitigation of the drought effects. These plans together with the national strategy and plans for land degradation, desertification and drought should provide successful reponse of our country in the case of drought periods.

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