

THE PARTICULARITIES OF WATER USE IN THE CENTRAL REGION OF THE REPUBLIC OF MOLDOVA

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Abstract. The purpose of this study is assessment of water use in the Central Region of the Republic of Moldova. The main topics presented in this paper are: 1) assessment of water resources in the Central Region of the Republic of Moldova; 2) tendencies of water consumption on the abstracted sources and on the main usage categories; 3) spatial and branch analysis of water use; 5) the main problems of water use and protection in the region of study. In the region of study are concentrated about 2/3 of groundwater reserves of Republic of Moldova. From surface sources is abstracted $\approx 3/4$ of total volume of water used and over 60% of water is used by households. Outside of Chisinau, over 70% of the water is abstracted from underground sources and is used for various agricultural needs. In the 2007-2017 years, the volume of water use registers a significant decrease which is conditioned, mainly, by decreasing of water abstracted from surface sources and used for agricultural activities, especially for irrigation.

Introduction

Water is one of the fundamental elements of life and a factor that determines economic development. Society and the economy will be able to develop only to the extent that water management will develop and this conditioning marks the role and importance of activity in the context of sustainable development (Management integrat, 2014).

The availability of Moldovan water resources depends in particular on the geographical position of the country within the Central and Eastern European climate contact zone. Currently, the national water-supply balance of the Republic of Moldova is adequate in relation to the available resources (Cazac et al, 2010).

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This balance is largely due to the sudden economic decline of Moldova in the recent past. Currently, Moldova suffers from a shortage of water, which is conditioned by low annual amount of rainfall, frequent dry periods and drought and wasteful consumption and massive pollution of drinking water resources and technology. To a person belongs 1500 to 2500 m³ of water or 2-3 times less than the European average, and there is often a frequent shortage of drinking water.

The Central Region comprises 13 districts from the central part of the Republic of Moldova, which form the Center Development Region (CDR), as well as the Chişinău municipality, which form the homonym development region. In addition, the Dubăsari district, which is located on the left bank of the Dniester, is assigned to the CDR and is subordinated to the official authorities of Chişinău, including Cocieri, Coşniţa, Pîrîta, Dorotcaia and Corjova. The total area of the Center Development Region is 10.6 thousand km² (31%) and the number of inhabitants is 1.1 million (33%). The districts in the central and eastern part of the region lie within the boundaries of the Nistru River and its tributaries, including the Raut River basin – Teleneşti and Orhei districts, the Bâc River – the Călăraşi, Străşeni, the Botna River – Ialoveni district. Most of the Ungheni, Nisporeni and Hincesti districts in the western part of the region are located in the Prut river basin (Bacal, Burduja, 2018). In addition, the eastern part of the Hincesti district is situated predominantly within the boundaries of the Cogâlnic river basin, which flows into the Black Sea Basin on the current territory of Ukraine.

1. Methodology

The recent intensification of natural and anthropogenic risks seriously affects the water supply capability of the population and of the economic activities in most of the world's countries (Vörösmarty et al, 2000). Complex evaluation of water resources and their consumption in relation to the manifestation of these risks becomes a priority research direction for geographic, social and economic sciences (OECD, 2003). In addition, geographic research has the advantage of achieving the complementarity of ecological, social and economic studies, having as the main objective: sustainable use and efficient management of water resources. Geographic surveys also play a leading role in creating methodological and scientific support for the application of OECD principles on good water governance (OECD, 2015), including the principles of regionalization and decentralization of water management, actively promoted by the OECD, both in the developed states and in the developing countries (OECD, 2003; 2012).

This study is elaborated in accordance with the WATECO Guidelines on the methodology of economic assessment of water use (Guidance document, 2003) for the implementation of the Water Framework Directive 2000/60 /EC on integrated

water management. For the study, the authors have focused on the River Basin Management Plans (RBMP) implemented in neighboring states, including the Danube River Basin Management Plan (Danube River Basin Management Plan) and Management Plan of Prut-Bârlad River Space (Administrația Națională „Apele Române”, 2016). Within the RBMP, a great attention is paid to the economic analysis of the of water use. Very valuable, in particular for determining the status and economic analysis of water use are research methodology and study transboundary rivers in the Black Sea Region and Belarus (EPIRB Program), (EPIRB). In the Republic of Moldova are being implemented Management Plans of Danube-Prut and Black Sea Hydrographical District (Bejan et al, 2017) and of Dniester Hydrographical District (HG nr. 814, 2017). Those plans must include detailed diagnosis of the status of river basins and of water bodies, recent trends of water consumption and economic analysis of water use. Also, for the elucidation of spatial, economic and social aspects of water use in region of study, have been consulted various publications in the field (Sîrodoev, Knight, 2008), as well as analytical studies of authors of this article (Bejan et al 2005; Bacal, Burduja, 2017, 2018).

The main research methods, which are used in this study, are: analytical,, comparative, statistical - mathematical, graphic and cartographic. *The analytical method* was used for: a) to identify quantitative and qualitative aspects of water use; b) diagnosis of situation of water use and elaboration of recommendations to prevent problematic situations in this field; c) definition of priority directions of activity optimization of water resources management in region of study. Also, the analytical method allowed the assessment of water use on the administrative districts from region of study as well as the branch analysis of water use and of recent tendency of water consumption on the main usage categories.

Statistical method was widely used in processing of statistical information on the water use in the in all administrative-territorial units. The *comparative method* was applied for establishing the trends in the branch and spatial aspects of the water use in each territorial-administrative unit in this region.

The main informational support of this study included: 1) Generalized Annual Reports on Water Management Indicators elaborated by the Agency „Apele Moldovei” (Agenția Apele Moldovei, 2007-2017); 2) Annual Reports of Inspection for Environmental Protection (Inspectoratul Ecologic de Stat (2007-2017); 5) analytical studies in this field, including of authors of this article (Bejan et al 2005; Bacal, Burduja, 2017, 2018). The study period covers the years 2007-2017.

2. Results and discussions

2.1. Water abstraction

The water supply of the localities of the Center Development Region takes place from the following main outlets of the Prut River: 4 main outlets in Ungheni, Nisporeni (Grozești - under construction) and Hâncești (Cotul Morii - under construction), designed to supply water for the localities in those districts. The Dniester River serves as the main source of water for the population of Rezina district as well as of the factories and industrial plants around. At the same time, the Vadul lui Voda outlet, designed to provide water for Chisinau municipality, has possibilities to extend to neighbouring districts, for example, Strășeni and Călărași.

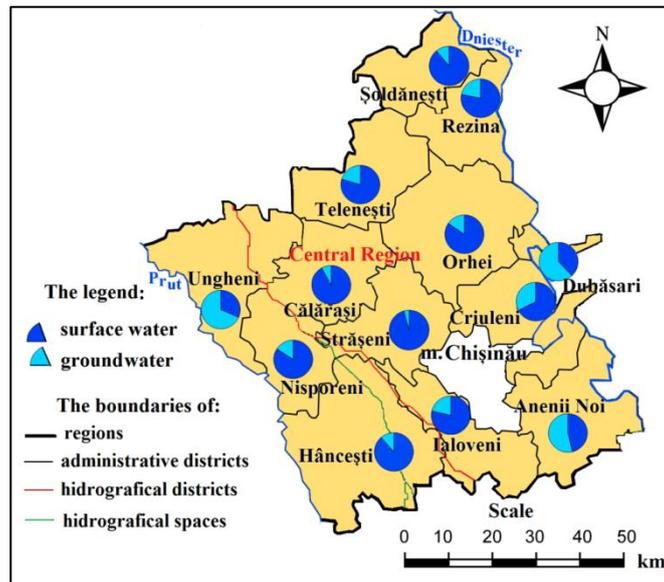


Figure 1. The share of surface and underground sources from total volume of water use
Data sources: Annual Reports on Water Management in the Republic of Moldova [1].

The main groundwater reserves explored and approved for the Central Region are about 1,047,200 (m³/day), which represents about 66% of the groundwater sources of the country [10]. The production capacity is sufficient to cover the current need of 23,000 m³/day and the forecast for the future need of 63,000 m³/day (2020) of the Central Region and can be considered in the planning of water resources (Cazac et al, 2010).

The main criteria on which the solution is set for the choice of the water source are: the required water flow; water quality; safety in exploitation; maximum

economic efficiency [2]. As far as the water consumption in the Central Region of the Republic of Moldova is concerned, all these factors are eligible.

In the Central Region of the Republic of Moldova are used, on average, 75.5 million m^3 of water, 73% (55 mil. m^3) of which are abstracted from surface sources. If we exclude Chişinău, the situation is completely different, the volume of used water from surface sources constituted 1/3 and of underground sources – 2/3 of total volume of used water.

The undergrounds sources prevail in the 10 from 13 districts of this region (Fig. 1). Only in the districts of Ungheni, Dubăsari and Anenii Noi, the largest amount of water used is abstracted from surface sources, which is conditioned by the fact that these districts are in the immediate vicinity of main surface water sources – Dniester and Prut rivers. In addition, the majority of rural population uses water from springs and wells, although they largely do not meet quantitative and qualitative standards, the main problem being the wear of water supply systems or their partial lack (Administrația Națională „Apele Române”, 2016).

The dynamics of water consumption during the study period (Fig. 2) recorded a significant decrease, by over 18 million m^3 . The volume of water used from surface sources, shows a more pronounced negative trend, with about 25%, including with 17% in the Chisinau municipality and by over 2 times in the districts of the region. At the same time, the volume of water used from underground sources registers a slow growth (+2%). In the central districts the volume of water use from underground sources increase $\approx 20\%$, but in the Chisinau municipality, the water use from this sources are decreased with over 40% (Agenția Apele Moldovei, 2007-2017).

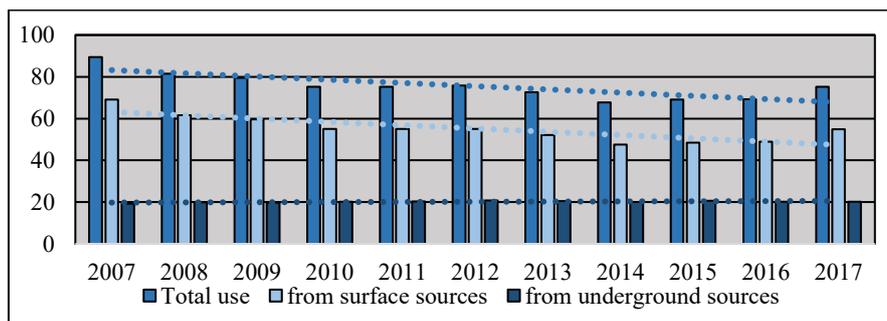


Figure 2. Dynamics of the volume of water used in the Central Region of the Republic of Moldova, by origin of abstracted sources, in million m^3 .

Analyzing the evolution of water consumption in this region during 2007-2017 (Tab. 1), we can see that the largest volume of water was used in 2007 (about

90 million m³), conditioned not only by the decreasing economy but also by the fact that this year Moldova was hit by a disastrous drought that affected 80% of the country's land. In 2012 there is again a drought that affected almost the whole of Republic of Moldova, which caused the increase in water consumption. This demonstrates the direct influence of weather conditions on water consumption, which is a primary factor determining the amount of water used each year.

Table 1. The main peculiarities of water use in the Central Region of the Republic of Moldova (average 2007-2017)

Districts/ municipalities	Surface (thousand km ²)	Population (thousand)	The total volume of water used (thousand m ³)	From surface sources (thousand m ³)	From underground sources (thousand m ³)
Șoldănești	0.6	36.7	886	97	787
Rezina	0.6	42.5	1161	240	920
Telenești	0.9	61.1	1224	259	968
Orhei	1.2	102	3335	494	2752
Criuleni	0.7	70.7	1994	635	1357
Dubăsari	0.3	29.3	1868	1171	700
Anenii Noi	0.9	79	3768	1998	1770
Ialoveni	0.8	93.2	2046	701	1342
Strășeni	0.7	82.7	1377	60	1327
Călărași	0.8	64.4	1136	86	1054
Ungheni	1.1	101	1868	1865	872
Nisporeni	0.6	53.2	2738	167	723
Hâncești	1.5	104	887	200	1688
Chișinău municipality	0.6	861	51177	47294	3862
Total	11.2	1780	75487	55262	20122

Data sources: [1;4]

Also, in most of the localities from the study region, it is preferable to use underground water, because hydro-technical infrastructure for abstraction and transport of water from surface sources is missing or destroyed. In many villages of these districts is used water from wells and springs that are often of the lowest quality, which causing the illness of the population (Bejan et al, 2017; Bacal et al, 2018).

As we can see in several districts (Anenii Noi, Criuleni), the volume of water used is not directly proportional to either the district or the population. This discrepancy justifies the role of large-scale businesses that make their major contribution not only to the economies of some localities/districts but also to water

consumption within them. In the Ungheni district, on average, a volume of water of about 1.9 million cubic meters of surface water is captured for consumption, being about 68% of the total volume, this being conditioned by the fact that this district is located in the immediate vicinity of the Prut River, the same situation being in the Dubasari district, which is near the Dniester river, where about 62% of the water used is captured from surface sources.

2.2. Branch structure of water use

The analysis of the branch structure of water consumption allows highlighting the economic directions that have the greatest attribution to this consumption, which facilitates the proper monitoring and management of the water resources. Concerning water conquest, we highlight three major branches: water used for domestic sector, agriculture, including irrigation and industry.

In the Central Region, over 63% (47.5 million m³) of the total volume of water are used for *domestic purposes* (Fig. 3, Tab. 2). The water consumption of the households by districts is conditioned by the size and number of its urban centers. Thus, over 90% (43.1 million m³) is used in the Chisinau municipality. Thus, if we exclude Chisinau municipality, the situation changes radically, and only 18% of the total water volume is used for domestic purposes (Fig. 3).

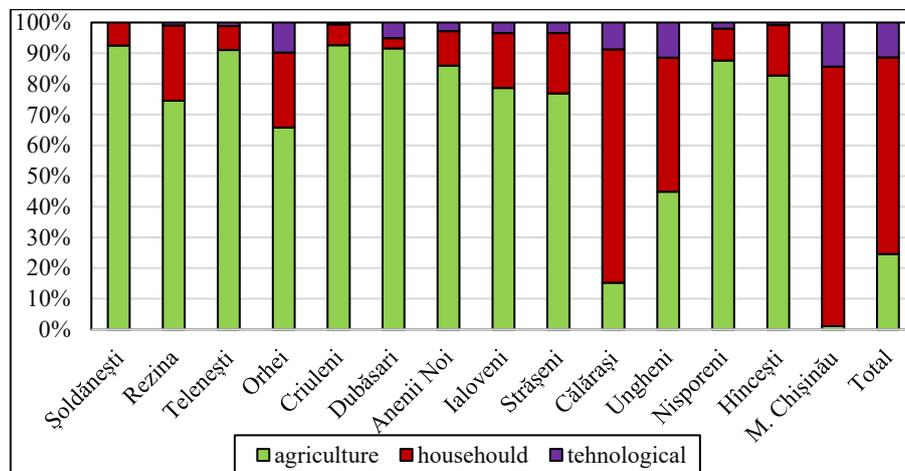


Figure 3. The main categories of water consumption in the Central Region of the Republic of Moldova by (average of 2007 – 2017 years)

In the Central Region *for agricultural purposes* are used only $\frac{1}{4}$ of the total volume of water use. The minimum share is due exclusively to Chisinau municipality, in which it is consumed more than $\frac{2}{3}$ of the total volume of water

used in this region. Moreover, in the Chisinau municipality for agriculture are used only about 1% of total volume of water use, and the rest used for domestic (85%) and industrial purposes (14%). At the same time, in the central districts, over 3/4 of the captured waters are used for agriculture, which is explained by both the agrarian character and the higher assuring with water resources. The maximum water use in agriculture is found in the districts with direct access to the Dniester riverbed and located in the proximity of Chisinau, including Anenii Noi (3.0 million m³), Orhei (2.2 million m³), Criuleni (1.9 million m³) and Dubasari (1.7 million m³). The minimum share for the districts of Ungheni (45%) and is due to higher dimensions and industrial specialization of this district center (Agenția Apele Moldovei, 2007-2017).

Therefore, Chisinau city has a decisive contribution not only to the economy of this region, but also to the economy of Republic of Moldova, in general. Besides Chisinau, the largest volume of water use for households is used in the districts of Ungheni (1.2 mil. m³) and Orhei (814 ths. m³), which have the largest urban centers of the region.

For irrigation are used, on average, 5.7 million m³ or 7.4% of total volume. In the central districts were used about 5.3 million m³ or 22% of total volume of water use. The volume of water used for irrigation is conditioned by the surface of basins and administrative territorial units in the perimeter of the hydrographical area, by the water reserves used for these purposes and by the presence of big agricultural farms in the region. Therefore, the maximum volume of water used for irrigation is found in districts of Anenii Noi (1.5 million m³) and Dubăsari (1.2 million m³), where so far there are large irrigation stations.

For *technological purposes* are used about 8.5 million m³ of water or 11% of total volume of water use, including 7.3 million m³ in the Chisinau municipality. In the Chisinau municipality, the biggest consumers of technological waters are [12]: *the water supply companies*, including SA Apă Canal (7.0 million m³); *food industry*, including beer factory SA Vitanta Intravest (447 ths. m³), the famous candy factory Bucuria (187 ths. m³), Bread Factory SA Franzeluta (98 ths. m³), sausage factory Carmez SA (75 ths. m³), the Yeast Factory (58.5 ths. m³), the Tobacco Factory (57.8 ths. m³), the dairy factory SA JLK (24.4 ths. m³) and the winery from Cricova (27.3 ths. m³); *thermo-energetic complex*, including thermoelectric power plants CET-2 (787 ths. m³) and CET-1 (340 ths. m³), as well as the company for production and distribution of thermal energy SA Termocom (115 ths. m³); *production of building materials*, including glass factories (114 ths. m³), SA Macon (15.7 m³); *light industry*, including factory for production of artificial leather SA Piele (46.3 ths. m³), Carpet Factory SA Floare Carpet (18.4 ths. m³), clothing factory SA Ionel (8.6 ths. m³); production of furniture and paper,

including the Factory for Cardboard Manufacturing (42.8 ths. m³); *the chemical industry*, including cosmetics factory SA Viorica Cosmetic (6.7 ths. m³); *hospitals*.

Table 2. Water use in the Central Region of the Republic of Moldova by main usage categories (average of 2007-2017 years)

Districts/ municipalities	The total volume of water used (thousand m ³)	Household (thousand m ³)	Agriculture, including irrigation (thousand m ³)	Tehnological (thousand m ³)
Șoldănești	886	66	815	8.1
Rezina	1161	266	790	101
Telenești	1224	95	1092	14
Orhei	3335	814	2149	323
Criuleni	1994	137	1850	14
Dubăsari	1868	61	1734	94
Anenii Noi	3768	377	2928	98
Ialoveni	2046	363	1597	70
Strășeni	1377	266	1063	323
Călărași	1136	347	706	43
Ungheni	1868	1191	1224	314
Nisporeni	2738	92	757	19
Hâncești	887	314	1567	15
Chișinău	51177	43138	577	7329
Total	75487	47528	18850	8451

In the central districts, the biggest and widespread water consumers for industry needs are [12]: *wine factories* from Ialoveni district (68.6 ths. m³), including Bardar Winery (18.1 ths. m³), Cascad Vin from Ialoveni town (13.8 ths. m³), Asconi from Puhoi (12.6 ths. m³) and the famous winery from Milestii Mici (9 ths. m³), Strășeni district (34 ths. m³), including the Romanești SA (26 ths. m³), Orhei district (31 ths. m³), including Chateau Vartely from Orhei (10.2 ths. m³), Aneni Noi district (31 ths. m³), including SA Agrovin Bulboaca (23 ths. m³) and from Calarasi district (16.5 ths. m³), including Calarasi Divin SA (13 ths. m³); *the poultry factories* from the proximity of Bălți city, including from Băneștii Vechi (14 ths. m³) and Sarateni Vechi, Telenești district, as well as in the proximity of Chisinau city, including from Floreni (60 ths. m³), Hirbovăț (25 ths. m³) and Bulboaca, from Bucovăț, Strășeni district (17.6 ths. m³), and Văduleni from Criuleni district (10.4 ths. m³); *pig farms*, including Pukoven SRL from Roșcani (156 ths. m³) and Funny Pig from Chirca (24.3 ths. m³), both from Anenii Noi district, SRL Porco Bello from Cimișeni, Criuleni district (49 ths. m³), Moldsuinhibrid (16.1 ths. m³) from Pohorniceni, Orhei district; *meat processing*

centers from the districts of Ialoveni (26 ths. m³) and Criuleni; *canning factories* from Cosnita, Dubasari (73 ths. m³), Anenii Noi (30 ths. m³) and Calarasi (5.7 ths. m³); large agricultural companies from Criuleni, Anenii Noi and Dubasari districts; *cement factory SA Lafarge* from Rezina (130 ths. m³), *quarries* from Cobușca, Anenii Noi district (26 ths. m³) and from Micăuți, Strășeni district (4.0 ths. m³).

The volume of water used for domestic purposes are decrease with over ¼ towards with 2007 year (Fig. 4), but this negative dynamics is due exclusively to Chisinau town. At the same time, in the central district is found an increase (+15%) of water use for domestic purpose and positive dynamics is recorded in the absolute majority of these districts. The maximum increase is observed in the districts of Strășeni (by 3.7 times), Nisporeni (by 2.3 times) Telenești (+71%) and Șoldănești (+60%). The positive dynamics is due to the recently rapid expansion of water supply networks exclusively based on the underground water sources, especially in rural area.

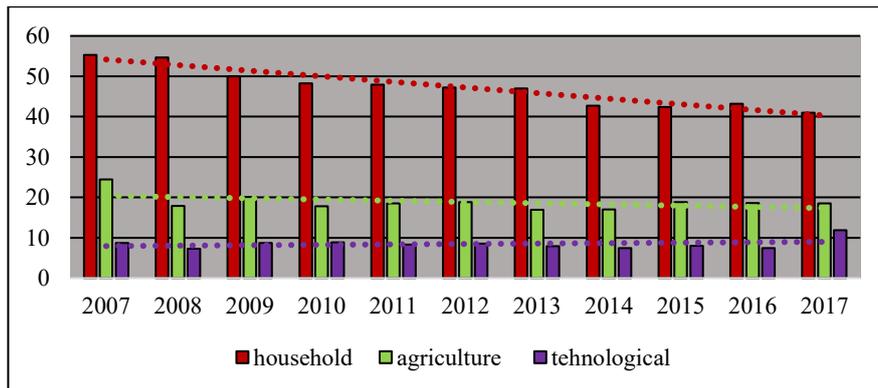


Figure 4. Dynamics of the volume of water use in the Central Region of the Republic of Moldova by the main usage categories, in million m³.

The volume of water used in agriculture also decreased, on average, with ¼ or from 24.4 million m³ to 18.5 million m³. The negative trend is found in the absolute majority of administrative districts (11 of 13), as well as in the Chisinau (-25%) municipality. The maximum decrease of water used for agriculture is registered in the districts of Dubasari and Hancesti (2 times). The increase of water use in agriculture is observed in the Telenești and Ialoveni districts.

The total volume of water used in irrigation has decreased by about 2.6 times. The highest decreasing rates (over 5 times) of the volume of water used for irrigation is attested in the districts of Hâncești, Rezina, Șoldănești and Orhei. The increase of water use for is observed only in the Telenești (+44%) district.

Conclusions

The volume of abstracted and used water is determined by size of districts and municipalities, by the access to the Dniester and Prut riverbed and the existing technical capacities of water transport, as well as by the volume of water used for agriculture and household purposes. From surface sources is captured $\approx 3/4$ from total volume of water used in the region of study. However, in the majority of districts (11 from 13) and localities, excluding Chisinau municipalities, Dubasari and Ungheni districts, predominates water supply from underground sources.

In the branch structure of water consumption, predominates the domestic sector (63%). At the same time, if we excluded Chisinau municipality, over $3/4$ of the captured waters are used for agriculture, and water use for domestic needs is only 17% of the total volume. The maximum water use in agriculture is found in the districts with direct access to the Dniester riverbed.

For technological purposes is used – about 8.5 million m^3 or only 11% of the total volume of water use in Central Region, of which over 90% is used in the Chisinau municipality. In the Chisinau city, the largest water consumers are municipal water supply company, food industry, power plants, industry of building materials. In the central districts, the biggest water users for technological needs are: winery, poultry factories, pig farms and enterprises for meat processing from the proximity of Chisinau and Bălți cities, canning factories and mining companies.

In the period under review, the volume of water registers a significant decrease which is conditioned, mainly, by similar decreasing of water abstracted from surface sources and used for agricultural activities, especially for irrigation. This tendency is conditioned both by massive depopulation of rural area and decrease of agriculture and food industry and by intensification of climate change and reduced regional capacity to adapt to these sensitive current challenges.

In the central districts is found an increase (+15%) of water use for domestic purpose, which is due to the recently rapid expansion of water supply networks in the rural area, but despite of this achievement the most of rural population continues to use polluted water from wells, springs and reservoirs.

In the next decade we expect an increase in the volume of water used, which will be conditioned by the expansion of public aqueducts and by increased of metered water consumption for domestic needs. Gradually, however, we can expect a slowdown of the increase rhythms of water consumption and a negative growth in the disadvantaged localities, especially of small and medium size.

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