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**D** – data interpretation
**E** – manuscript preparation
**F** – literature search

# Sustainable management of water resources in terms of the water needs for agricultural purposes in small rural communes based on the example of the Grybów commune, Poland

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**Abstract**

The article presents the results of the analysis of water needs in agricultural production of the Grybów commune (the district of Nowy Sącz, the Małopolska province). The aim of this study was to determine both the current water needs for agricultural purposes as well as changes in this regard based on structural and production data. The guidelines specified in the Ordinance of the Minister of Infrastructure of 14 January 2002 concerning average norms of water consumption were applied to determine water needs. The average annual water demand of crops together with permanent grassland (meadows, pastures) amounts to 23.7 mln $m^3$, of which about 2.15 mln $m^3$ is for winter wheat, 1.92 mln $m^3$ for potatoes and 17.6 mln $m^3$ for permanent grassland. Significant amounts of water (over 130,000 $m^3$) are used also for watering home gardens and cultivating vegetables in plastic tunnels and greenhouses. Water needs for animals farming reach about 235,000 $m^3$ in a year. Most water is needed for farming the cattle. It is predicted that the demand for water in the agricultural sector of the commune will increase by about 5.5% by 2030. Therefore, the activities monitoring the awareness of water saving and proper water management among the population of the villages are important.

**Key words:** *farm animal population, land use structure, types of sowing, water needs for agricultural purposes, water saving*

## INTRODUCTION

Growth and development of crops as well as farming animals require a lot of water. Also, the agri-food processing of crops and livestock requires significant volumes of clean and good quality water for its technological processes. Under average meteorological and climatic conditions, the water needs of plants are covered by precipitation and the water retained in the soil profile [DZIEŻYC *et al*. 2012]. If the sum of rainfall is not less than the sum of plant transpiration and soil evaporation it is an optimal precipitation. However, the amount of precipitation does not provide fully objective information on the coverage of water needs of plants. In relatively wet years, there may be after-drought periods due to not always favourable distribution of rainfall leading to crops reduction [KLIMA, KASPERCZYK, 2009; LISTOWSKI (ed.) 1983; NOWAK 1992; 2006].

Therefore, the assessment of water demand at all stages of agricultural production is very important in terms of balancing of water resources at the level of regions and

individual catchments [KOPACZ 2011; KUŹNIAR 2010; ŁABĘDZKI 2004, 2006; OSTROWSKI *et al*. 2008; TRYBAŁA 1996; ŚWIERK *et al.* 2015; TWARDY, KOPACZ 2014; 2015].

## OBJECTIVES, THE AREA AND METHODS OF RESEARCH

The aim of this paper is to estimate current water needs of agriculture together with determining direction of changes in this area and to check the state of awareness of young residents of southern Poland on selected activities related to the protection of water resources and their threats.

The analysis was carried out on the agricultural areas of the Grybów commune in the Małopolska province, the district of Nowy Sącz. Administratively, it is an urban-rural commune, but in practice it is a typically agricultural area, where agricultural land constitutes more than 60% of its total area.

Data on the structure of land use as well the structure of sowings and livestock population were collected in order to determine the water needs of agriculture in the commune and to estimate direction of their changes. For this purpose, the Central Statistical Office data contained in the Local Data Bank for 2014 as well as data collected under General Agricultural Censuses from 1996, 2002 and 2010 were used. The results of research on average water needs of the most important crops grown in our country were presented in Table 1 [CHMURA 2001; CHMURA *et al*. 2009; DMOWSKI, DZIEŻYC 2009; DZIEŻYC *et al.* 1990; 2012; OSTROWSKI *et al*. 2008] and the water needs of crops were determined accordingly.

The guidelines included in the Order of the Minister of Infrastructure of 14 January 2002 concerning average norms of water consumption [Rozporządzenie … 2002] were used to determine remaining "agricultural" water needs. The provisions stipulate, among others, the average water consumption norms for both the animal production in farms and livestock facilities as well as for agri-food processing units such as: creameries, breweries, bakeries, slaughterhouses and butchers, distilleries, sugar companies and tanneries. The Ordinance also contains the information about average water consumption norms during chemical plant protection treatments carried out on fruit trees, berry bushes and vegetables. Separately, the law refers to spraying rape, lucerne, hops and cereals including maize, strawberries, flax and tobacco. It defines average values of water consumption for soil neutralization and washing or rinsing the equipment used in plant protection process [Rozporządzenie… 2002]. On the basis of the above mentioned water consumption indicators and knowing the detailed structure of water use, types of sowing and livestock population, the quantities of water demand were determined according to the formula [KOPACZ, TWARDY 2015]:

$$Zw = 10\,(Wz_1Pz_1 + Wz_2Pz_2 + \ldots + Wz_nPz_n) \qquad (1)$$

Where: $Zw$ = demand for water ($m^3$); $Wz_n$ = average water needs for $n$-th kind of crop or animal (mm); $Pz_n$ = the sowing area of the $n$-th crop or the number of livestock population of $n$-th kind of animal (ha).

**Table 1**. Water needs of plants in the vegetation period

| Crop | Water needs (mm) | | |
|---|---|---|---|
| | according to DZIEŻYC *et al.* [1987; 1990] and DMOWSKI, DZIEŻYC [2009] | according to OSTROWSKI *et al*. [2008] | the absolute difference between average water needs \|1 – 2\| |
| | 1 | 2 | |
| Rye | 240–300 | 250–280 | 5 |
| Winter wheat | 230–250 | 270–300 | 45 |
| Spring wheat | 230–300 | – | – |
| Spring barley | 240–300 | 360–370 | 95 |
| Oat | 250–300 | 290–340 | 40 |
| Early potato | 230–280 | 280–330 | 50 |
| Late grown potato | 350–400 | 430–480 | 80 |
| Maize | – | 450–480 | – |
| Mangold | 430–490 | 450–540 | 35 |
| Sugar beet | – | 500–550 | – |
| Pea | 260–300 | – | – |
| Red clover | 350–460 | – | – |
| Lucerne | – | 450–500 | – |

Source: own elaboration based on cited references.

The Grybów commune (Fig. 1) is located in the Małopolska province and by territory it belongs to the district of Nowy Sącz (the district of the city of Nowy Sącz) constituting one of the eleven urban-rural communes that are located within the district boundaries. Despite division between urban and rural areas, the commune, as a whole, is typically agricultural.

The area of agricultural land covers 10 579 ha, which constitutes 62.2% of the total area of the commune, of which arable land covers 6 799 ha (40.0% of the total area of the commune) and grassland covers 3 079 ha (18.1%) acc. to data of Local Data Bank – Central Statistical Office LDB – CSO. Detailed information about the land use structure in the Grybów (Photo 1) commune is presented in Table 2.

In the structure of sowing in the Grybów commune, cereals are grown on more than half of the area, in particular winter wheat which represents 38.9% of the total sown area in the commune; spring cereal blends constitute 16.9% and oat 7.1% of the total sown area. The most popular crops among root plants are potatoes which are grown on over 500 ha and represent 16.5% of the total sown area. The remaining crops are grown on small areas of less than several percent of the total sown area (Tab. 3).

In the structure of livestock breeding in the commune, cattle is the largest number represented by 5 510 stock. Poultry is nearly 30 000 and pig farming with 995 stock constitutes a relatively small number (Tab. 4).

According to HESS [1965], the area of the Grybów commune is located within two climatic zones, i.e. a temperate/mild warm climate with an average annual temperature of 6–8°C and annual precipitation of 800–1000 mm as well as a temperate/mild cold climate with an average annual temperature of 4–6°C and annual precipitation of 1000–1400 mm. These types of weather are most likely the result of the polar-marine origin air masses frequently lingering over the area.

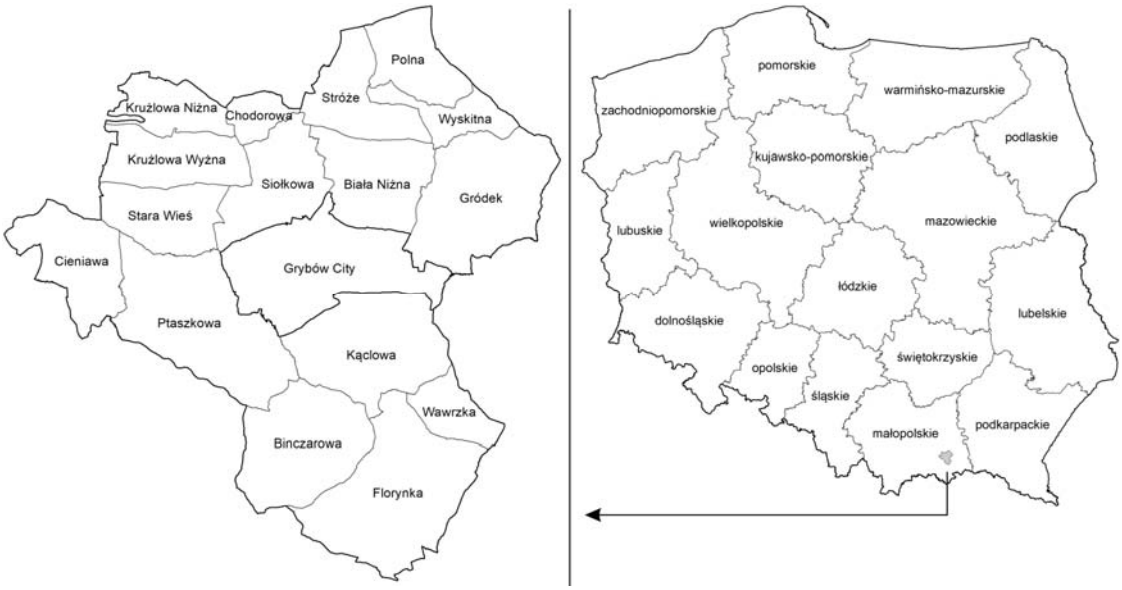


Fig 1. The Grybów commune and its localization on the map of Poland; source: own elaboration

**Table 2**. Land use structure in the Grybów commune and percentage of individual land category – as in 2014

| Category of the area | Grybów – town | Grybów – rural area | Total | % of total area |
|---|---|---|---|---|
| | ha | | | |
| **Total area** | **1 695** | **15 315** | **17 010** | **100** |
| **Land area** | **1 677** | **15 192** | **16 869** | **99.17** |
| Total agricultural land | 1 148 | 9 431 | 10 579 | 62.19 |
| – arable land | 763 | 6 036 | 6 799 | 39.97 |
| – orchards | 0 | 222 | 222 | 1.31 |
| – permanent meadows | 227 | 1 584 | 1 811 | 10.65 |
| – permanent pastures | 153 | 1 115 | 1 268 | 7.45 |
| – built-up agricultural land | 0 | 463 | 463 | 2.72 |
| – land under ditches | 5 | 11 | 16 | 0.09 |
| Total forest, wooded and bushy land | 364 | 5 193 | 5 557 | 32.67 |
| – forests | 321 | 4 827 | 5 148 | 30.26 |
| – wooded and bushy land | 43 | 366 | 409 | 2.4 |
| Total land under water | 18 | 123 | 141 | 0.83 |
| including: | | | | |
| – land under rivers | 18 | 122 | 140 | 0.82 |
| – land under ponds and lakes | 0 | 1 | 1 | 0.01 |
| Built-up and urban areas in total | 161 | 531 | 692 | 4.06 |
| – residential areas | 50 | 10 | 60 | 0.35 |
| – industrial areas | 2 | 29 | 31 | 0.18 |
| – other built-up areas | 9 | 29 | 38 | 0.22 |
| – not built-up urban areas | 0 | 1 | 1 | 0.01 |
| – recreation and resting areas | 3 | 9 | 12 | 0.07 |
| – roads | 67 | 391 | 458 | 2.69 |
| – railway routes | 30 | 62 | 92 | 0.54 |
| Wasteland | 3 | 37 | 40 | 0.24 |
| Other areas | 1 | 0 | 1 | 0.01 |

Source: own elaboration based on data of Local Data Bank – Central Statistical Office [BDL 2010].

Photo. 1. Agricultural landscape of the Grybów commune; source: https://www.gminagrybow.pl/pl/857/0/Wyskitna.html#prettyPhoto[photo]/3/

**Table 3**. The sown area of main crops in the Grybów commune – as for 2010

| Crop | Grybów – town | Grybów – rural area | Total | % of total sown area |
|---|---|---|---|---|
| | ha | | | |
| Winter wheat | 71.6 | 737.9 | 809.5 | 38.9 |
| Spring wheat | 4.0 | 46.2 | 50.2 | 2.4 |
| Rye | 4.9 | 32.9 | 37.8 | 1.8 |
| Winter barley | 1.1 | 10.5 | 11.6 | 0.6 |
| Spring barley | 4.6 | 48.4 | 53 | 2.5 |
| Oat | 16.8 | 131.4 | 148.2 | 7.1 |
| Winter triticale | 2.3 | 39.6 | 41.9 | 2.0 |
| Spring triticale | 1.4 | 10.7 | 12.1 | 0.6 |
| Winter cereal blends | 2.2 | 23.4 | 25.6 | 1.2 |
| Spring cereal blends | 36.6 | 316.2 | 352.8 | 16.9 |
| Maize for grains | 0 | 8.9 | 8.9 | 0.4 |
| Potatoes | 45 | 460.2 | 505.2 | 24.3 |
| Industrial crops | 1.1 | 4.4 | 5.5 | 0.3 |
| Sugar beets | 1.1 | 4.4 | 5.5 | 0.3 |
| Dried pulses for grains | 0 | 0.3 | 0.3 | 0.0 |
| Ground vegetables | 0.9 | 13.2 | 14.1 | 0.7 |

Source: own elaboration based on data of the General Agricultural Census [GUS 2011] and the Local Data Bank – Central Statistical Office [BDL 2010].

**Table 4**. Livestock population in the Grybów commune – as for 2010

| Name of the commune | Cattle | | Pigs | | Horses | Poultry | | Livestock unit |
|---|---|---|---|---|---|---|---|---|
| | total | of which cows | total | of which sows | | total | of which chickens | |
| | (unit) | | | | | | | (LU) |
| Grybów – town | 588 | 311 | 22 | 0 | 63 | 1 444 | 1 394 | 528 |
| Grybów – rural area | 4 922 | 2 913 | 973 | 71 | 370 | 26 846 | 24 306 | 5 024 |
| Total | 5 510 | 3 224 | 995 | 71 | 433 | 28 290 | 25 700 | 5 552 |

Source: own elaboration based on data of the General Agricultural Census [GUS 2011] and the Local Data Bank – Central Statistical Office [BDL 2010].

Grybów commune experiences relatively weak winds reaching 1–2 m·s$^{-1}$, as frequent as 40–50% in total. Also, there is a type of wind called 'halny' (of mountains origin), which occurs mainly in the cold season – from November to March inclusive and it features high wind speed from about 8 m·s$^{-1}$ [HESS 1965].

Grybów lies on the Biała (Tarnowska) River, also known as Biała Dunajcowa or Biała Grybowska River. Biała River constitutes the right-bank tributary of the Dunajec River and is about 101.8 km in length. The river originates in the Beskid Niski (about 900 m above sea level ) that is mainly made of flysch – sandstones and shales. At the beginning, the increase of Biała River's catchment area is insignificant. The catchment area is 209.7 km$^2$ at the height of the "Grybów" water gauge. The surface of Biała River's catchment increases in the area of Ciężkowice Plateau. The valley of the river is quite narrow in this section. It is located in the sandstones of the Ciężkowice Plateau. Along the river's flow there are a lot of left-bank and right-bank tributaries, including the following streams: Kąśnianka, Zborowianka and Szwedka. Differences in the land shaping range between 100 and 200 m in catchments of tributaries. After running through Tuchów, the Biała River expands to 2–3 m in the valley and then the River creates a gorge through hills made of inoceramic sandstone shales. The Biała River runs from the Carpathians to the Sandomierska Syncline below the estuary of the river running from Ostra Góra. Right-bank tributary of Wątok joins the Biała River at the 7.6 km. The Biała River's catchment has an agricultural as well as recreational function in the upper and middle course of the river. In the lower part of the Biała River, the catchment has an industrial function.

## DETERMINING WATER NEEDS FOR AGRICULTURAL PURPOSES IN THE GRYBÓW COMMUNE

Water demand in the plant production in the Grybów commune is mainly covered by precipitation. No other type of irrigation is used in the commune.

Table 5 presents the levels of water demand calculated for individual kinds of field crops. The average annual water demand for all crops, including permanent grassland (meadows, pastures) amounts to 23.9 mln m$^3$. Amongst the field crops the largest demand for water of 2.15 and 1.92 mln m$^3$ have winter wheat and potato respectively. Water demand regarding all basic cereals cultivated in the commune constitutes 65% of the general field crop needs and potato – 31%. On a larger scale of all agricultural land in the commune, permanent grassland is of highest water demand which amounts to 17.6 mln m$^3$.

**Table 5**. Water demand in plant production in the Grybów commune

| Crop | The minimum level of water needs | The upper level of water needs | Average annual water needs | The sown area (ha) | Water needs (m$^3$) |
|---|---|---|---|---|---|
| | mm | | | | |
| Winter wheat | 230 | 300 | 265 | 809.5 | 2 145 175 |
| Spring wheat | 230 | 300 | 265 | 50.2 | 133 030 |
| Rye | 240 | 300 | 270 | 37.8 | 102 060 |
| Winter barley | 220 | 280 | 250 | 11.6 | 29 000 |
| Spring barley | 240 | 300 | 270 | 53.0 | 143 100 |
| Oat | 250 | 340 | 295 | 148.2 | 437 190 |
| Winter triticale | 230 | 280 | 255 | 41.9 | 106 845 |
| Spring triticale | 210 | 260 | 235 | 12.1 | 28 435 |
| Winter cereal blends | 230 | 300 | 265 | 25.6 | 67 840 |
| Spring cereal blends | 200 | 280 | 240 | 352.8 | 846 720 |
| Maize for grains | 450 | 480 | 465 | 8.9 | 41 385 |
| Potatoes | 280 | 480 | 380 | 505.2 | 1 919 760 |
| Industrial crops | 420 | 500 | 460 | 5.5 | 25 300 |
| Sugar beets | 500 | 550 | 525 | 5.5 | 28 875 |
| Dried pulses for grains | 260 | 300 | 280 | 0.3 | 840 |
| Ground vegetables | 450 | 540 | 495 | 14.1 | 69 795 |
| Orchards | – | – | 426* | 37.6 | 160 301 |
| Grassland | 330 | 450 | 390 | 4 507.0 | 17 577 300 |
| **Total** | – | – | – | **6 626.8** | **23 862 951** |

Source: own elaboration based on DZIEŻYC *et al*. [1990]; DMOWSKI, DZIEŻYC [2009]; OSTROWSKI *et al.* [2008]; RZEKANOWSKI [2009].

A factual water usage covering, for example water from water supply networks or household wells, may also include the incidents of land owners watering home gardens and lawns as well as using irrigation systems in greenhouses and plastic tunnels.

According to the Order of the Minister of Infrastructure of 14 January 2002, about 2.5 dm$^3$ of water per 1 m$^2$ of land per day is used for watering home gardens and recreational parcels. It is assumed that on average, during the period from 15 April to 15 September i.e. 5 months, this type of crop is watered 15 days a month. Whereas, the plants grown in greenhouses and plastic tunnels consume about 4 dm$^3$ of water per 1 m$^2$ per day and on average the watering takes place 20 days per month during the whole year.

Within the Grybów commune boundaries there are 2904 farms, of which 482 grow ground vegetables on a total area of 14.1 ha; and there are 5143 houses with a garden (according to the Grybów Commune Office data). Considering the average area of the gardens (150 m$^2$), the crop areas in plastic tunnels and greenhouses (70,000 m$^2$) as well as using the norms contained in the above mentioned Order, it can be estimated that the water needs for described activities in the commune are as follow:

a) watering home gardens:
   - per day: 2.5 dm$^3$·5143·150 m$^2$ = 1 928 625 dm$^3$ = 1 928 m$^3$,
   - per year: 1 928 m$^3$·15 days·5 months = **144 600 m$^3$**;

b) growing vegetables in plastic tunnels and greenhouses:
   – per day: 4.0 $dm^3 \cdot 70\ 000\ m^2 = 280\ 000\ dm^3 = 280\ m^3$,
   – per year: $280\ m^3 \cdot 20$ days$\cdot 12$ months = **67 200 $m^3$**.

Using pesticides in plant production significantly increases water consumption. Within the current sowing structure in the Grybów commune, the total annual water usage for spraying procedures is 4362 $m^3$ of which winter wheat and potatoes are the highest takers. Spraying procedures involve the after-treatment washing of sprayers, which also generates the demand for water. The calculations, intentionally, do not cover permanent grasslands as in reality the commune does not use weed killers (Tab. 6).

**Table 6**. Average water consumption for plant protection procedures in the Grybów commune (except permanent grassland)

| Crop | Grybów – town | Grybów – rural area | Total | Indicative water consumption for plant protection procedures | Water consumption for plant protection procedures |
|---|---|---|---|---|---|
| | ha | | | $m^3 \cdot ha^{-1} \cdot year^{-1}$ | |
| Winter wheat | 71.6 | 737.9 | 809.5 | 1.25 | 1 011.9 |
| Spring wheat | 4.0 | 46.2 | 50.2 | 1.25 | 62.8 |
| Rye | 4.9 | 32.9 | 37.8 | 1.25 | 47.3 |
| Winter barley | 1.1 | 10.5 | 11.6 | 1.25 | 14.5 |
| Spring barley | 4.6 | 48.4 | 53 | 1.25 | 66.3 |
| Oat | 16.8 | 131.4 | 148.2 | 1.25 | 185.3 |
| Winter triticale | 2.3 | 39.6 | 41.9 | 1.25 | 52.4 |
| Spring triticale | 1.4 | 10.7 | 12.1 | 1.25 | 15.1 |
| Winter cereal blends | 2.2 | 23.4 | 25.6 | 1.25 | 32.0 |
| Spring cereal blends | 36.6 | 316.2 | 352.8 | 1.25 | 441.0 |
| Maize for grains | 0 | 8.9 | 8.9 | 0.40 | 3.6 |
| Potatoes | 45.0 | 460.2 | 505.2 | 2.40 | 1 212.5 |
| Industrial crops | 1.1 | 4.4 | 5.5 | 16.00 | 88.0 |
| Sugar beets | 1.1 | 4.4 | 5.5 | 1.80 | 9.9 |
| Dried pulses grains | 0 | 0.3 | 0.3 | 1.95 | 0.6 |
| Ground vegetables | 0.9 | 13.2 | 14.1 | 1.68 | 23.7 |
| Orchards | 2.26 | 35.3 | 37.6 | 23.50 | 883.6 |
| **Total** | **195.9** | **1 923.9** | **2 119.8** | **–** | **4 150.2** |
| Washing of sprayers | – | – | 2 119.8 | 0.10 | 212.0 |

Source: own study.

Due to the lack of detailed data on how many farmers treat the crops with plant protection procedures, it has been assumed in calculations that on all field and orchard crops the procedures are applied at least twice a year.

In summary, the estimated water demand in crop production for the Grybów commune amounts to approximately 24.08 mln $m^3$ of water. However, the main factors in direct water consumption from water supply network, wells, one's own reservoirs, trapped rainwater, etc., are the watering of plants in home gardens and the use of water for plant protection procedures. These amount to about 216,000 $m^3$ and constitute less than 1% of the total demand.

## WATER NEEDS IN ANIMAL FARMING

The values specifying water demand in animal breeding were adopted for the so-called small-scale livestock facilities (according to the previously mentioned Order of the Minister of Infrastructure) assuming that they constitute a practically prevailing majority in the area in question.

The total volume of water needed in animal farming amounts to 234,617 $m^3$ per year. Cattle farming requires over 112,000 $m^3$ of water annually; poultry farming is equally demanding with about 103,000 $m^3$ of water used per year (Tab. 7).

Table 7 shows that the specification does not provide the water consumption for farming of sheep and goats because of two reasons. There is a lack of reliable data related to the population of both species within the commune of Grybów. Moreover, traditionally every spring shepherds take large herds of sheep to different grasslands and meadows. Therefore sheep during grazing season venture far beyond the territorial boundaries of the commune. This means that water consumption by these animals is insignificant as they use water mainly from natural sources such as wells, springs and rivers.

**Table 7**. Water needs in animal farming in the Grybów commune

| Animal | Animal units | Water needs | | Water needs in $m^3$ per year |
|---|---|---|---|---|
| | | $dm^3$ per unit per day | $dm^3$ per day | |
| Cattle | 5 510 | 56 | 308560 | 112 624 |
| Pigs | 995 | 32 | 31840 | 11 622 |
| Horses | 433 | 45 | 19485 | 7 112 |
| Poultry | 28 290 | 10 | 282900 | 103 259 |
| **Total** | **35 228** | **143** | **642 785** | **234 617** |

Source: own elaboration based on average values of water consumption norms in farms and livestock facilities (according to Table 4 of Order of the Minister of Infrastructure of 14 January 2002).

## DIRECTION OF CHANGES IN WATER NEEDS FOR AGRICULTURE

Over the past decade or so, significant structural changes have taken place in Poland. Their most representative reflections are transformations in the structure and the intensity of the land use. The Grybów commune has not escaped the changes. As a result of socio-economic changes agricultural production has been reduced thus affecting the ratio of arable land to grassland and woodland areas [KOPACZ 2003; 2011]. Non-agricultural activities have intensified rapidly. In the region of southern Poland there has been a significant increase in the tourism industry resulting in a large demand for housing facilities that have been built on land previously used for agricultural purposes [MULARZ *et al.* 2007]. That is exactly what is happening within the district of Nowy Sącz and the Grybów commune. Figures 2, 3 and 4 present changes regarding the agricultural land use, population of farm animals and the sown area.

Most regression curves indicate downward trends in the most important agricultural parameters. The only growing numbers are observed in the meadow area and the population of chickens.

When analysing data from the Grybów commune and beyond, it is evident that the process of reducing agricultural land areas and farm animals population has been significantly slowed down. Hence, following a continuous transformation our country is subject to and confronting it with the specificity of agricultural production in the region

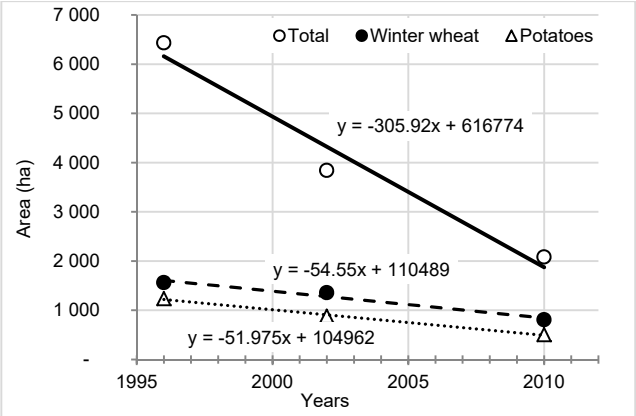


Fig. 2. Changes in the structure of agricultural land use in the Grybów commune; source: own study

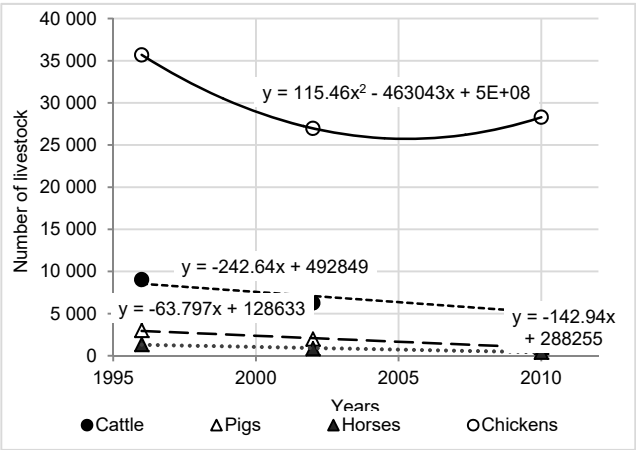


Fig. 3. Changes in the livestock population in the Grybów commune; source: own study

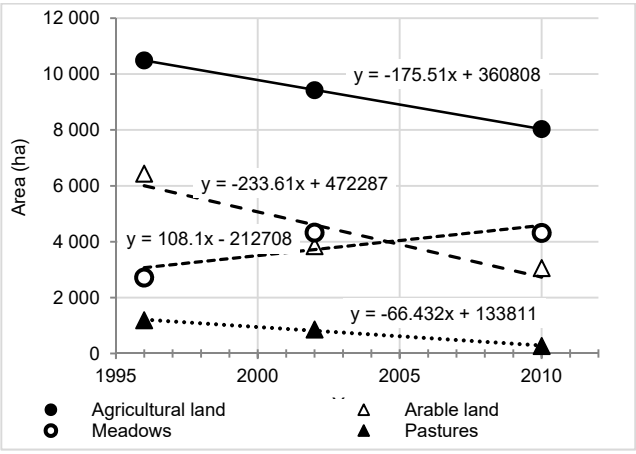


Fig. 4. Changes in the crop areas in the Grybów commune; source: own study

of Nowy Sącz and the Grybów commune, it can be assumed that quite soon we will see stabilisation in agricultural land acreage, including arable land, an increase in meadow acreage and insignificant variation in orchard areas.

The following is assumed regarding farm animal population:

– cattle – down by about 5%,
– pigs – down by 20%,
– horses for agricultural purposes – significant reduction,
– chickens – up by about 10–20%.

The value of the sown land area closely correlates with the area of arable land. It is estimated that the cereal crop areas will be of low variability.

In conclusion, it is evident that in the period from 1990 to 2010 a process of permanent limitation of agricultural production had been significantly restricted and there has been a slow restitution of cattle and sheep herds at present.

## AWARENESS OF WATER RESOURCES PROTECTION

Raising ecological awareness in a society is one of the most important tasks and must be undertaken at all levels of educational activity [OSTRACH 2011]. The role of social organizations, mass media and government authorities is of paramount importance as pro-ecological education can be done through their agendas. However, ecological education has its dilemmas and it is hard to decide which dilemma should be solved first as they are all interconnected in one way or another. Having said that, the issue of water management appears to be the most important while planning the safe development of every individual area of human life. Educating people how to use water resources effectively involves the knowledge of motives and methods of water protection, an awareness and foreseeing in advance the consequences of human actions and activities. These are also relevant when trying to promote correct attitudes and stereotypes contributing to a personal approach to the whole range of hydrology related issues.

The Earth's total water resources are estimated at 1.4 bln km$^3$. A mere 2.5% of the volume is fresh water accumulated mainly in glaciers, ice sheets and in difficult-to-access underground water deposits. Only 0.3% of fresh water resources is of a renewable nature, whereas the resources that are readily available and suitable for human consumption are of the capacity of 9,000 km$^3$ [KOZŁOWSKI 2007].

Poland as a country experiences a deficit in water resources. Those resources, to a great extent, should be managed effectively by farms cultivating arable land [KOPACZ 2011; KOPACZ, TWARDY 2015]. Considering the necessity of protecting the surface and underground water together with defining the methods of effective use of the resources, the European Union shapes environmental policy through legal acts aimed at restoring water resources to their proper standard and protecting water resources against pollution [OSTRACH 2013].

The norms regarding the protection of water resources and water management refer to the observance of procedures concerning the issuing of permissions for irrigation and the maintenance of buffer zones along watercourses. According to the norms, a farmer should have legal permission regarding water, when irrigating agricultural land with underground water in an irrigation system or using surface and underground water for irrigation purposes in quantities exceeding 5 m$^3$ per day. The maintenance of the buffer zone along water courses bans the use of fertilizers on arable land at a distance of at least 5 m from the shore

of lakes and water reservoirs of an area up to 50 ha and from other watercourses. For slurry the distance is at least 10 m.

The buffer zone covers also ditches but only those of more than 5 m in width along the upper edge of the ditch. Fertilizers can be applied on agricultural land at a distance of at least 20 m from the shore of the lakes with an area exceeding 50 ha. The same distance apply when fertilisers are used in areas located near the protection zones of water intakes and next to the coastal zone.

In Poland, the law prohibits a direct or indirect discharge into underground water a number of hazardous substances such as mercury, solid mineral oils, petroleum, fluorine organic compounds and substances that can form such compounds in the aquatic environment. The discharge of dangerous substances into the soil, especially unstable mineral oils, petroleum hydrocarbons, ammonia, nitrites and cyanides is also prohibited. However, this prohibition does not apply to farmers having a permission issued on the basis of Art. 270 of the Water Law [Ustawa… 2017] and following the conditions contained therein.

To know and to apply the above-mentioned norms should be a key purpose in all activities that farmers (producers) undertake to preserve the purity of surface water. With no good quality water it will be more and more difficult to increase good quality agricultural production and, of course, the produce will become more expensive. Initiating saving measures one can follow the water price increase route. That will force farmers to develop water saving methods such as underground irrigation, called the drop irrigation, which is much more economical than overground irrigation.

Technological progress in distribution, recycling and purification of water results in the improvement of water quality and, in the long term, lowering the demand for water. However, the current policy of cheap water makes it unprofitable to invest in water infrastructure and to study the effectiveness of its use [MAYOR 2001]. It does not seem likely that in the foreseeable future there will be a significant investment in an ecological use of water infrastructure. What can be done nonetheless is to raise the awareness of water saving techniques by those who benefit from water on an every-day basis [OSTRACH 2012].

Here are some of many water saving tips:

– turning off the tap while taking a shower, shaving, brushing your teeth and washing your hands; that is how to begin saving water;
– it is also worth repairing dripping and leaking pipes and taps;
– having a bath will consume between 150 to 200 l of water whereas an 8 to 10 min shower will only use half that amount;
– when buying household appliances, it is worth paying a little more to purchase a washing machine or a dishwasher of class "a" or higher;
– it is worth installing a pressure reducing device, if we think it is too high, and a water meter to monitor the water usage;
– the network monitoring, it can localise leaks in a short time;
– bath water can be used for flushing the toilet;
– rainwater trapped in retention reservoirs can be used for watering plants in gardens;
– it is advisable to install modern bathroom fittings such as perelators, thermostats that help more economical consumption of water.

A group of young people living in the area in question and its immediate surroundings was researched in terms of the extent to which the place of residence determines the awareness of water resources protection. The study was carried out in the State University of Applied Sciences in Nowy Sącz in the Institute of Pedagogy in the years 2015 to 2018 on a sample group of 80 students from the district of Nowy Sącz, where the Grybów commune is located. One group consisted of students living in the city and small-town areas. The second group was made up exclusively of students from rural areas. In the research using the diagnostic survey, a deliberate-random selection was applied to ensure that both environments were represented by 40 students. In the future, the respondents, students of the Pedagogy Institute, intend to work with children and teenagers, hence they will have an influence on shaping ecological attitudes of the generation of young people.

One of the survey questions asked the respondents's opinion on the extent their region can run a risk of water deficiency. The questions do not clearly define when there is a risk of water shortage and how it is related to the degree of water pollution. Therefore, respondents' answers only reflect their subjective assessment in this matter. The majority of students (88%) assessed the situation as unfavourable, however 72% of them expressed their opinions in a somewhat unclear manner (Fig. 5). That means the respondents were not able to clearly assess the risks associated with water deficiency in their area. In terms of quantity and quality, the water resources in the Nowy Sącz region do not present an issue for a significant discussion. According to the respondents a small number of industrial factories using water for their production are not regarded as posing any threat to water resources and its deficiency for public consumption. The same can be said for agricultural production.

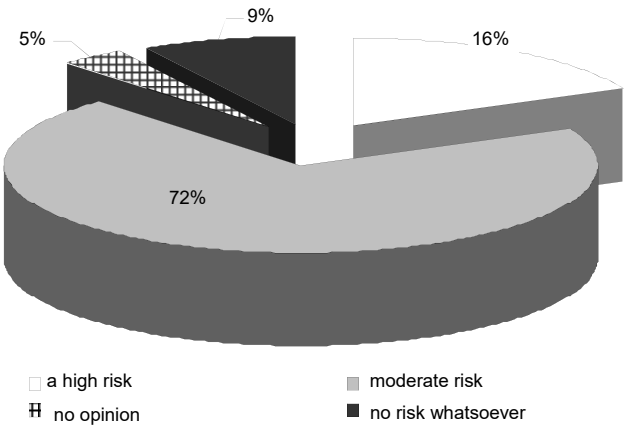


Fig. 5. Respondents' opinions on the region's risk of water deficiency; source: own study

**Table 8.** Activities undertaken by the sample group to save water in the household

| Type of action | Systematic actions | | | | Occasional actions | | | | No action | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | city | | village | | city | | village | | city | | village | |
| | *N* | **%** | *N* | **%** | *N* | **%** | *N* | **%** | *N* | **%** | *N* | **%** |
| Turning off a tap while washing hands | 33 | **82.5** | 12 | **30** | 6 | **15** | 24 | **60** | 1 | **2.5** | 4 | **10** |
| Quick repair of dripping water systems | 31 | **77.5** | 12 | **30** | 8 | **20** | 22 | **55** | 1 | **2.5** | 6 | **15** |
| Taking a shower | 36 | **90** | 30 | **75** | 4 | **10** | 10 | **25** | 0 | **0** | 0 | **0** |
| Having a bath | 10 | **25** | 5 | **12.5** | 14 | **35** | 8 | **20** | 16 | **40** | 27 | **67.5** |
| Purchasing household items of class A, A+ and A++ | 32 | **80** | 9 | **22.5** | 4 | **10** | 10 | **25** | 4 | **10** | 21 | **52.5** |
| Installing a water pressure reducer | 2 | **5** | 5 | **12.5** | 0 | **0** | 0 | **0** | 38 | **95** | 35 | **87.5** |
| Installing a water meter | 31 | **77.5** | 25 | **62.5** | 0 | **0** | 0 | **0** | 9 | **22.5** | 15 | **37.5** |
| Monitoring water and sewage networks | 1 | **2.5** | 0 | **0** | 0 | **0** | 0 | **0** | 39 | **97.5** | 40 | **100** |
| Water reuse network | 0 | **0** | 0 | **0** | 0 | **0** | 0 | **0** | 40 | **100** | 40 | **100** |
| Using rainwater | 0 | **0** | 0 | **0** | 4 | **0** | 8 | **20** | 36 | **90** | 32 | **80** |
| Using tap aerators | 36 | **90** | 2 | **5** | 4 | **10** | 26 | **65** | 0 | **0** | 12 | **30** |

Source: own study.

Hence, the next question, which was addressed to those who in the future will carry opinion-forming powers i.e. teachers-to-be and to people in charge of various educational centres, referred to the awareness of water contamination as a result of industrial production, agricultural activity, terrorism and ecological disasters in neighbouring regions.

The results of the survey on the risk of water contamination are very similar to those on the risk of water deficiency. A relatively small number of respondents (16%) sees the problem of water contamination in their region (Fig. 6). This group of respondents is most aware of dangers posed by modern civilisation. An excessive use of chemical substances that do not occur in nature but are applied due to business activity related requirements has, among others, an indirect adverse impact on the state of water resources. The largest group of respondents is aware that the process of managing of water protection raises concerns. Nearly 10% of respondents are unaware of the risks and the likelihood of their occurrence in the area of their residence. The results of the research indicate that the awareness about the risk of water contamination and its likelihood is very low. Hence concluding it must be said that the issue of water resources protection together with the entire natural environment should be covered by a special curriculum at every level of education, because only systematic educational activities can contribute to the improvement of citizens' awareness on the matter.

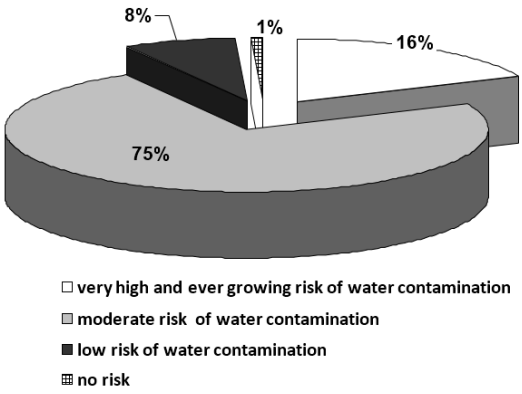


Fig. 6. Risk of water contamination; source: own study

The results of research on water-saving measures in households indicate that those activities are being undertaken more frequently in urban than in rural environment (Tab. 8). Residents of cities and small towns have more time to plan and analyse how to spend their money. This can be due to the fact that, as a rule, while not working from home but somewhere else (offices, factories, companies, etc.) it gives those people a lot of pleasure to improve the functioning and the quality of their households. Village residents attach less importance to the issues related to water saving as, more often than not, they work on their own farms which are located in the vicinity of their residence. While purchasing household items, the village residents are less concerned about white goods being ecologically friendly but they are more interested in the price. There is practically no interest or investment in the recycling of water or in the use of rainwater. Few have made an effort to catch and use rainwater in their households, therefore, they constitute a sample group insignificant in terms of research data. Their use of rainwater is mainly for watering garden plants and small-scale agricultural production.

## CONCLUSIONS

The analysis of water demands and anticipation of changes in this regard indicates that water deficits can be expected in the area of crop production. Fortunately, this relatively small increase in demand for "agricultural" water will have to be covered by rainwater anyway.

Considering, however, frequent incidents of drought in various regions of our country in recent years, some crop production improving measures should be undertaken in terms of adjusting the structure of production to the water resources potential of the area. It can be done by increasing the area on which low-water-consuming plants are cultivated at the expense of high-water-consuming crops. Also, certain agro-technical activities can be undertaken in order to improve soil structure and to increase water retention. However, these activities should be closely correlated with current market demand for specific agricultural products and the profitability of their production in a given area.

A significant factor that can eliminate periodic water deficits may be the popularisation of irrigation techniques

that have not been in practical use in the area in question, except for watering plants in home gardens and irrigating small-scale agricultural production in greenhouses and plastic tunnels. As these are quite costly investments, they should rather be treated as solutions-to-be in the future. Efforts should also be made to increase public awareness of water protection and its effective use, which must be done through systematic promotion of pro-ecological content during education process in a variety of educational units.

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## Zrównoważone zarządzanie zasobami wodnymi w kontekście potrzeb wodnych rolnictwa w małych gminach wiejskich na przykładzie gminy Grybów, Polska

W pracy przedstawiono wyniki analizy w zakresie potrzeb wodnych w produkcji rolniczej na przykładzie gminy Grybów (powiat nowosądecki, województwo małopolskie). Celem pracy było określenie aktualnych potrzeb wodnych rolnictwa, a także określenie na podstawie danych strukturalnych i produkcyjnych trendów zmian w tym zakresie. Do określenia potrzeb wodnych zastosowano wytyczne zawarte w Rozporządzeniu Ministra Infrastruktury z dnia 14 stycznia 2002 r. w sprawie określenia przeciętnych norm zużycia wody. Średnie roczne zapotrzebowanie na wodę roślin uprawnych wraz z trwałymi użytkami zielonymi (łąki, pastwiska) wynosi 23,7 mln $m^3$, w tym pszenicy ozimej oraz ziemniaka około 2,15 i 1,92 mln $m^3$, a trwałych użytków zielonych – 17,6 mln $m^3$. Znaczne ilości wody (ponad 130 tys. $m^3$) zużywane są także na podlewanie ogródków przydomowych oraz uprawę warzyw w tunelach foliowych i szklarniach. Potrzeby wodne w zakresie chowu i hodowli zwierząt gospodarskich sięgają w ciągu roku ok. 235 tys. $m^3$. Najwięcej wody potrzebne jest na hodowlę i chów bydła. Prognozuje się, że do 2030 r. nastąpi wzrost zapotrzebowania na wodę w sektorze rolniczym gminy o około 5,5%. W tej sytuacji ważne wydają się działania monitorujące świadomość oszczędzania wody i właściwe nią gospodarowanie wśród ludności zamieszkującej wsie.

**Słowa kluczowe:** *oszczędzanie wody, pogłowie zwierząt gospodarskich, potrzeby wodne w rolnictwie, rodzaje zasiewów, struktura użytkowania ziemi*