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JOURNAL OF WATER AND LAND DEVELOPMENT

e-ISSN 2083-4535

ITP-PIB

Polish Academy of Sciences (PAN) Institute of Technology and Life Sciences – National Research Institute (ITP – PIB)

JOURNAL OF WATER AND LAND DEVELOPMENT
DOI: 10.24425/jwld.2021.139035
2021, No. 51 (X–XII): 243–249

Characteristics of grasslands and their use in Poland

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RECEIVED 26.10.2021 REVIEWED 10.11.2021 ACCEPTED 14.12.2021

Abstract: Permanent grasslands are the most environment-friendly way of using agricultural lands. Apart from producing fodder, grasslands play many other important non-productive functions. Biodiversity is the key factor decisive for their high natural and productive values. Grasslands play an important role in water retention. Not all types of grasslands may be used agriculturally. Out of 16 types of habitats, 10 may be used for production, the others are biologically valuable. The surface area of permanent grasslands in Poland has markedly decreased during the last decade. Now, they constitute slightly more than 20% of agricultural lands occupying 3127.8 thous. ha (in 2019) including 2764 thous. ha of meadows and 363.8 thous. ha of pastures.

Keyword: meadows, pastures, permanent grasslands, Poland, small water retention

GENERAL CHARACTERISTICS AND CLASSIFICATION OF PERMANENT GRASSLANDS

Permanent grasslands (PG) constitute most environment-friendly way of using agricultural lands because of high natural and productive values thanks to their biodiversity. Great biodiversity of botanical composition makes the sward stable, resistant to variable habitat conditions, natural disasters, rapid climate changes etc. Fodder obtained from such diverse grasslands is cheap, valuable and highly efficient in animal feeding [Okularczyk 2002; Wasilewski 1998]. Four hundred plant species grow on grasslands in our climatic zone.

Permanent grasslands are very important components of agricultural lands. Apart from fodder production (productive function), grassland play many important non-productive functions:

- climatic (by creating specific microclimate, which involves also adjacent areas, by mitigating differences in temperature between day and night and between summer and winter),
- hydrological (by increasing water retention and by flattening flood waves),
- protective (by decreasing water and wind erosion, which is 25 times smaller on grasslands than on arable lands, by counteracting excessive decomposition and mineralisation of organic matter, by protecting surface waters from eutrophication and by decreasing nutrient migration to ground waters),
- phyto-sanitary (by intercepting dust from the air, neutralising noxious odours and secreting aromatic oils and scents),
- healthful (meadows and pastures are overgrown by about 60 plant species having therapeutic properties, which favourably affect fodder quality and health of humans and animals),
- landscape and aesthetic (grasslands are an important component of landscape due to habitat specific features, biodiversity and aesthetic values resulting from diversified palette of colours of flowering plants) [Wasilewski 2009].

PG are mostly situated in the valleys of rivers and lakes and in midfield depressions. Remarkable habitat diversity of our grasslands called for the need of their division and classification according to some established criteria. The division is known as typological division of meadows [Grzyb, Prończuk 1995]. With reference to habitat conditions, grasslands in Poland are divided into four main groups:

- wet grasslands (20%) – situated in river valleys periodically flooded by river water are usually fertile habitats well or excessively wetted, hence generally free from water deficits.
- dry-ground grasslands (40%) situated on local elevations in river valleys, on flat, non-flooded depressions, on mid- and near peatland elevations and at the edge of arable lands. With the exception of humid habitats, dry-ground grasslands are sites of low or moderate moisture. They are mainly fed by rainfall and to some degree by runoff waters. Dry-ground grasslands occupy various habitats both fertile and poor such

as impoverished dry grounds which are more suitable for afforestation than for grassland management with high inputs of nutrients and substantial irrigation.
- bog grasslands (8%) – situated on peatlands and wetlands are characterised by usually excessive moisture. They are overgrown mainly by sedges and often by mosses. Bog grasslands are not used agriculturally but have high natural values.
- post-bog grasslands (32%) – situated on reclaimed peatlands of fairly uniform soils mostly consisting of peat or partly decomposed peat and of stable moisture. They are usually drained. Without irrigation and proper grassland management and use, such grasslands experience rapid and unfavourable changes. Botanical composition is subject to changes and nitrogen is released due to decomposition of peat there. Released nitrogen not used by plants penetrates to ground and surface waters and partly to the atmosphere. Peat becomes pulverised resulting in the loss of proper physical and water properties of peat soils [Jankowska-Huflejt 2007; Kostuch, Nazaruk 2000].

Each group is divided into four types of habitats. Affiliation of a given grassland to definite group and habitat type is determined by its most important features: location in the terrain, soil type, fertility and water relations, and present biological process. These properties are reflected by specific plant cover (plant community), which is not a diagnostic feature but makes identification of particular units easier.

Not all kinds of grasslands may be used in agriculture. The main obstacles include: soil type and quality, moisture conditions, location of grasslands in terrain and fodder quality of overgrowing vegetation. Out of 16 kinds of grassland habitats, 10 can be used as pastures or meadows.

Dry grounds (impoverished, proper, rain-fed and wet), post-bog grasslands (drying, degraded, proper and wetting) and drying and/or proper wet grasslands are mainly used as meadows. Impoverished, proper and rain-fed dry grounds, post-bog grasslands (drying, degraded and proper) and drying wet grasslands are used as pastures. The six remaining kinds of grasslands i.e. all bogs and two wet grasslands are classified as natural habitats, which are not used in agriculture mainly due to their water conditions [Barszczewski, Wesołowski 2015].

Hay yields from meadows or from pasture sward may vary from 1 to 11 Mg·ha^{-1}. According to Kostuch and Nazaruk [2000], productive potential of our grasslands after exclusion of protected areas, proper regulation of water conditions and application of necessary management measures, was estimated in the year 1978 at about 30 mln Mg of hay, which is equivalent of 18 mln Mg of grain. Present utilisation of this potential is estimated at about 55%. It means loosing the opportunity of obtaining large amounts of fodder, which is one of the cheapest fodders calculated both per unit mass or per protein or per energy yield. Noteworthy, high and valuable yields are determined by appropriate management, air and water relations and the composition of grassland sward dominated preferably by most valuable species of grasses and legumes. Growing demand for high quality fodder in dairy farms stimulates changes in the present ways of grassland utilisation, fertilisation, preservation of fodder and organisation of feeding [Barszczewski 2008; Jankowska-Huflejt *et al.* 2009]. Present status of grasslands and the ways of their agricultural use are closely associated with animal stock and directions of animal breeding.

DISTRIBUTION OF PERMANENT GRASSLANDS AND SOIL CONDITIONS

The area of permanent grasslands has markedly shrunk in the last decade in Poland. At present, they now constitute slightly more than 20% of agricultural lands and occupy 3127.8 thous. ha including 2764 thous. ha of meadows and 363.8 thous. ha of pastures (data for 2019).

Since 2003 till 2020, grasslands occupied on average 3.24 mln ha of agricultural lands while in 2020 they covered 3.01 mln ha (Tab. 1). In this time period, the area of meadows slightly increased from 2.3 mln ha to 2.6 mln ha in 2020. So, the decline of grassland area proceeded at a cost of pastures, constituting on average 18.8% of agricultural lands. The area of pastures decreased from 0.9 mln ha in 2003 to 0.4 mln ha in 2019 and 2020. There are several reasons of such situation. The first is that the Main Statistical Office takes into account only pastures in good agriculture (utilised and fertilised). The second reason is the decreasing area of agricultural lands which are supplemented by ploughed pastures of stable water relations. The third reason consists in the abandonment of ruminant breeding in small farms that kept only few heads and resulting concentration of breeding and bigger milking of cows [Wasilewski 2011]. High milking efficiency of dairy cattle requires far reaching changes in the ways of feeding. Now, cattle are fed with preserved bulk fodder and concentrated fodder the year round according to the Total Mixed Ration (TMR) feeding system. Part of pastures remained and the other part was used as meadows.

To analyse PG in Poland further, provinces were divided into two categories. Fourteen provinces with prevalence of productive grasslands were attributed to the first category. The second was composed of two provinces with a high percent of grasslands situated in mountain and submountain regions where environmental functions are particularly important. Provinces of the first category were divided in four groups differing in the share of grasslands in the structure of agricultural lands:
group I – less than 10% share – Kujawsko-Pomorskie and Opolskie Provinces;
group II – 10–20% share – Lubelskie, Łódzkie, Wielkopolskie, Pomorskie, Zachodniopomorskie and Dolnośląskie Provinces;

Table 1. Changes in the area of permanent grasslands in Poland (mln ha) in the years 2003–2020

Grasslands	2003	2005	2007	2009	2011	2013	2015	2017	2019	2020
Total	3.3	3.4	3.3	3.2	3.3	3.2	3.1	3.2	3.2	3.0
Meadows	2.3	2.4	2.5	2.5	2.6	2.6	2.7	2.8	2.8	2.6
Pastures	0.9	1.0	0.8	0.7	0.7	0.6	0.4	0.4	0.4	0.4

Source: own study based on GUS [2020].

group III – 20–30% share – Mazowieckie, Świętokrzyskie, Śląskie and Lubuskie Provinces;
group IV – more than 30% share – Podlaskie and Warmińsko-Mazurskie Provinces.

Małopolskie and Podkarpackie Provinces, both with prevailing environmental functions of PG, were also attributed to group IV (Fig. 1).

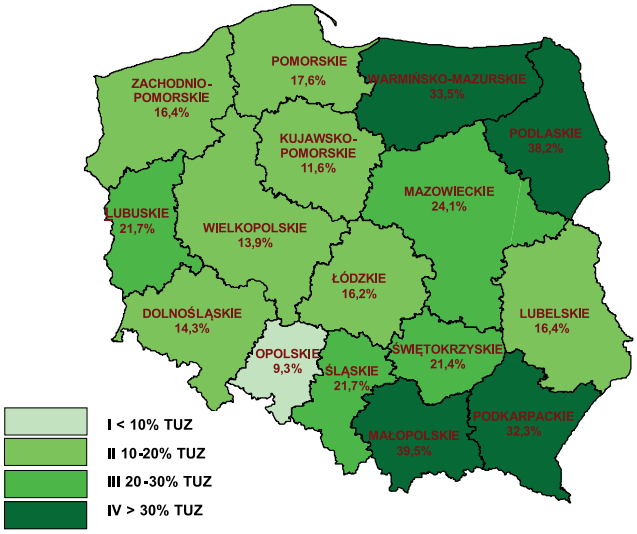

Fig. 1. The share of permanent grasslands (TUZ) in the structure of agricultural land in 2020 with the distinction of group IV with grassland of special importance for the environment; source: own study based on GUS [2020]

The share of permanent grasslands in agricultural lands differs among particular regions of the country (Fig. 1); in Małopolskie Province and in Podlaskie Province it markedly exceeds (>40% and about 40%, respectively) the country mean. In Warmińsko-Mazurskie and Podkarpackie Provinces, the share exceeds 30%. On the contrary, the share of grasslands in agricultural lands in Kujawsko-Pomorskie and Opolskie Provinces is about 10%.

Permanent grasslands usually occupy sites inappropriate for field crops because of moisture conditions, types of soil (peat) or elevation in mountain areas. Grasslands overgrow only 1.5% of good and very good soils but more than 40% of poorest soils. Soils ranked to the soil-agricultural complex 1z (good and very good) constitute only 2% of grasslands, those ranked to the complex 2z (medium) – about 60%. Such soils are a potential reserve of bulk fodder. Soils of the complex 3z (poor and very poor) are occupied by grasslands in 38%, usually in areas too dry or too wet for arable management [Barszczewski 2015; Jankowska-Huflejt, Domański 2008].

MEADOWS

Analysis of meadow productivity in the last decade has shown (Tab. 2) that unfavourable thermal and water conditions i.e. high air temperatures and too small precipitation (in the years 2015, 2018 and 2019) determined yielding and resulted in adverse changes in the structure of sward of grasslands, particularly those located in dry ground locations fed mainly by rainfall. As a rule, autumn rainfalls partly supplement water deficits and lead to the regeneration of some plant species. Unusual winters, however, with practically absent snow cover in lowlands accompanied by positive temperatures and low precipitation increase water deficits in soil. Seven years out of the decade (2011–2014, 2016–2017 and 2020) were typical with respect to thermal and water conditions and gave similar yields both total and in particular cuts. Mean hay yield from the first cut in the year 2020 amounted 0.248 Mg·ha^{-1} and the total harvest from meadows that occupy 2613.2 thous. ha was estimated at 6480.7 thous. Mg. Thermal and water conditions during the regrowth of the second cut were optimum across the country and mean yield from this cut was 1.85 Mg·ha^{-1} and total harvest was 2221.3 thous. Mg. Meadow yields from the third cut were estimated at 2221.3 thous. Mg. Mean hay yield from three cuts in Poland in the year 2020 was 5.18 Mg·ha^{-1}, and the total harvest was 13536.3 thous. Mg, which does not differ from respective figures in the previous years. The yield of grassland irrigated, regardless of a floristic type, was 2- to 3-fold higher than the yield of non-irrigated grassland. Hay harvested in irrigated meadows met the crude fibre, ash and fat requirements of animals [Grabowski *et al.* 2020].

Hay drying is still the dominating technology of preservation of meadow sward in Poland. According to the Main Statistical Office [GUS 2020], 55.4% of harvest from permanent meadows were processed for hay in 2019. Statistical data indicate, however, that more and more popular is conservation of meadow sward by ensilage. At present, more than 21.1% of harvest from permanent meadows is ensiled in Poland while in the year 2000 it was only 4.9% of total harvest (Fig. 2). Most (34%) of harvest from meadows is ensiled in north-eastern Poland (Podlaskie and Warmińsko-Mazurskie Provinces – Tab. 3). This is an effect of intensive dairy cattle breeding there, which demands the highest quality of bulk fodder [Wróbel 2015].

PASTURES

Permanent pastures occupy only 2.5% of agricultural lands but are their important component. Grazing is the most natural form of summer feeding of animals. Pastures play many important functions in farms, in productive space and in rural areas.

Table 2. Meadow yield in Poland in the years 2011–2020

Meadows	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Area (thous. ha)	2588.7	2521.3	2564.6	2634.4	2658.1	2691.6	2795.8	2754.5	2764	2613.2
Yield (Mg·ha^{-1})	5.05	5.19	5.08	5.21	4.19	5.24	5.42	4.71	4.46	5.18
Harvest (thous. Mg)	13084.9	13082.5	13028.0	13718.1	11126.4	14097.8	15146.0	12503.4	12334.7	13536.3

Source: own study based on GUS [2020].

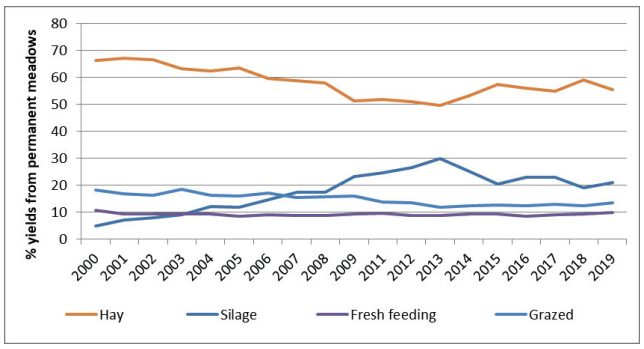

Fig. 2. Structure of harvests from permanent meadows in Poland (no data for the year 2010); source: own elaboration based on GUS [2020]

Table 3. Percentage structure of harvest from permanent meadows in the year 2019 (sum of three cuts)

Province	Meadow grass intended for			Used as pastures
	hay	green fodder		
		ensiled	currently fed	
Poland	**55.4**	**21.1**	**9.8**	**13.6**
Dolnośląskie	54.9	13.3	11.8	20.0
Kujawsko-Pomorskie	55.5	15.1	15.7	13.8
Lubelskie	83.6	2.0	10.3	4.0
Lubuskie	53.4	11.7	12.5	22.4
Łódzkie	62.0	9.5	13.9	14.5
Małopolskie	58.4	12.0	11.9	17.7
Mazowieckie	52.3	32.0	7.5	8.3
Opolskie	53.1	28.5	9.5	8.9
Podkarpackie	65.2	6.4	8.7	19.8
Podlaskie	44.4	34.7	7.6	13.3
Pomorskie	57.7	17.1	9.9	15.3
Śląskie	49.0	20.9	13.3	16.8
Świętokrzyskie	59.9	11.7	12.5	15.9
Warmińsko-Mazurskie	39.1	29.7	11.2	20.1
Wielkopolskie	62.5	26.6	6.0	4.9
Zachodniopomorskie	43.0	16.1	13.8	27.2

Source: own study based on GUS [2020].

Livestock grazing conducted from 2010 influenced the stabilisation of the species composition [Kulik *et al.* 2020]. They are able to provide big amounts of most valuable and cheapest fodder of high nutritive values. Pasture sward is the cheapest and most valuable fodder rich in proteins, energy, macro- and microelements and other substances favourably affecting animal health and the quality of obtained products (milk and meat). High quality of fodder is a guarantee of obtaining high efficiency of milking (18–20 l of milk per day) and daily body mass increments (0.8–1 kg per head). Pasture sward should be dominated by grasses (60–70%) and legumes (10–30%) with admixture of herbs (up to 10%) as dietetic and taste components. Most favourable content of fodder components and their appropriate proportions are obtained when the sward is 15–18 cm high [Barszczewski *et al.* 2015].

On a good pasture, sward should cover no less than 90% of its area. Dense sward guarantees yields of about 0.54 Mg·ha^{-1} of green biomass per 1 cm of height increment above 5 cm. Such density enables an uptake of 12–14 kg dry weight during 8–10 h of grazing by cow. Appropriate density of sward increases the resistance of sward against trampling by animals when grazing, which is especially important on organic soils [Wasilewski 2015].

Distribution of pastures varies across different regions of the country. Their share is highest in Warmińsko-Mazurskie Province, where they occupy more than 90 thous. ha. The smallest areas of pastures can be found in Opolskie Province (slightly more than 3 thous. ha) and in Podkarpackie Province (slightly less than 4.5 thous. ha). Total annual yield from pastures was 16.0 Mg·ha^{-1} in the year 2019 being slightly higher than in the previous season. Harvests from pastures in the same year were, however, lower than in the preceding year and amounted 5 832 040.5 Mg (Tab. 4).

Table 4. Yields and harvest from permanent pastures in the year 2019

Province	Area (ha)	Yields (Mg·ha^{-1})	Harvest (Mg)
Poland	**363842**	**16.0**	**5832040.5**
Dolnośląskie	18697	13.8	257727.5
Kujawsko-Pomorskie	13682	17.3	236336.8
Lubelskie	10264	16.6	170658.0
Lubuskie	13370	15.4	205850.5
Łódzkie	10658	16.2	173068.3
Małopolskie	19510	14.3	278502.2
Mazowieckie	49340	12.5	616137.6
Opolskie	3075	16.0	49284.1
Podkarpackie	24728	13.8	341097.1
Podlaskie	37541	19.6	734637.8
Pomorskie	22124	16.5	363935.4
Śląskie	7428	19.4	143809.5
Świętokrzyskie	4429	13.7	60776.3
Warmińsko-Mazurskie	94124	17.8	1678731.7

Source: own study based on GUS [2020].

CONTRIBUTION OF PERMANENT GRASSLANDS TO SMALL WATER RETENTION

Compared with other European countries, water resources in Poland are small and their status is an effect of improper reclamation measures applied in agriculture and forestry in the post-war years and of clearly visible climate changes like snowless winters and extreme droughts due to long-term deficits of rainfall. It is estimated that the amount of resources in this

Central and Eastern Europe is reduced by about 70% compared to the average for Europe. In drought periods it comes to limitation of economic activity, including agriculture [Patro, Zubala 2020]. Improving water productivity (WP) through deficit irrigation is crucial in water-scarce areas. To practice deficit irrigation, the optimum level of water deficit that maximizes WP must be investigated [Tadesse *et al.* 2020].

Increasing water deficits are also an outcome of long-lasting interference of humans in landscape, which has not enlarged water retention (deforestation, drying bogs, peat exploitation, field and grassland drainage) but rather accelerated water outflow from the area (straightening of water courses, elimination of postglacial water holes, enforcement and technical built-up of river banks etc.) [Kędziora 2007]. That is why the role of grasslands is so important for controlling water relations by turning surface runoff into infiltration. Economic and ecological role of water is determined not only by its absolute amount in a given area but also by water retention time in landscape. The latter depends on plant cover and on the time of water runoff to rivers [Kędziora 2007; Jankowska-Huflejt 2007]. Wet meadows situated usually in river valleys on alluvial soils play important role in water retention. They are able to accumulate about 10 mln m^3 of water. Wet meadows constitute 20% of grasslands in Poland.

Large amounts of water are retained during the snow melt and after heavy rainfalls. Spring maintenance of water on soil surface (up to 30 days) does not make harm to plants; on the contrary, it stimulates their growth and supports species diversity. However, water remaining on soil surface in summer for more than three days may cause losses of plants less resistant to air deficit. Apart from forests, permanent grasslands play an important role in increasing air humidity. Grasslands use a lot of water – coefficient of transpiration equals 400–700 dm^3 of water per 1 kg dry mass. Only small part of this water is used, however, for biomass production. Therefore, grasslands enrich the atmosphere with about 5 mln dm^3 of water from 1 ha of meadows and with 4.2 mln dm^3 of water from 1 ha of pastures. After nightly cooling, water in a form of vapour, mist or fog, and even as rain, partly returns on grasslands or on adjacent areas (including arable lands) thus improving moisture conditions of the latter.

The efficiency of water retention by any grassland largely depends on the content of humic substances in soil. The largest reserve of humus can be found in grasslands long covered by grasses. It is estimated that increasing organic matter content in soil by 1% increases water retention by 10 mm in top 30 cm soil layer.

HAZARDS AND PROTECTION OF PERMANENT GRASSLANDS

The existence of meadow communities is a result of human activity. Therefore, maintenance and functioning of grasslands requires human interference through mowing or pastoral use. Now, a serious problem in the protection of meadows is the abandonment of their mowing and a switch to animal grazing [Jankowska-Huflejt, Domański 2008]. Abandoned management of meadows may cause secondary succession, which ends up in their phytosociological impoverishment. Finally, meadows may disappear from agricultural environment of our country. Meadows are also eliminated by their reclassification to arable lands or by afforestation [Burczyk *et al.* 2018]. Disappearing meadows need protection, restoration or maintenance by traditional methods of management. Specific role in nature protection is attributed to the maintenance or recovery of grassland diversity through partial keeping extensive (the so-called semi-natural) grasslands devoid of fertilisation. Extensive management of grasslands means single or double mowing, moderate organic fertilisation and the first cut delayed until the stage of flowering [Jankowska-Huflejt, Domański 2008]. Such actions will help maintaining biodiversity in agricultural landscape and provide ecological stability of species-rich meadow communities, which harbour many animal species including rare and protected ones [Burczyk *et al.* 2018].

Key factors of the proper use of grasslands are rational technologies, which largely determine the amount and quality of produced fodder and environmental quality. Technological innovations focussed on renovation and improvement of botanical composition are particularly important for dairy farms which require fodder of the best quality parameters. Among methods of sowing and undersowing, technology is important but selection of appropriate plant species and varieties able to easily spread within old sward are crucial as well. Mixtures of seeds should be composed of grasses and legumes to maintain biodiversity and to restrict nitrogen fertilisation [Jankowska-Huflejt, Domański 2008]. One percent of legumes introduces annually 3–4 kg $N \cdot ha^{-1}$, which allows for reducing nitrogen fertilisation of grasslands by 3 $kg \cdot ha^{-1}$.

European Strategy for Biodiversity till 2030 under the title „Restoring nature to our life" published by European Commission on 20th May 2020 [EC 2020] formulates the goals pertaining to restoration of degraded ecosystems and their sustainable management through:

- increasing production in the system of ecological agriculture,
- increasing the number of nature-friendly elements of agricultural landscape,
- halting and turning the trend of declining populations of pollinators,
- decreasing the use and risk associated with pesticides by 50% till 2030,
- preventing and limiting results of natural disasters,
- protecting soils from the effects of unfavourable factors.

Farms in Poland are obliged to maintain naturally valuable grasslands situated in areas of Natura 2000. There is also obligation in the country to keep the area of grasslands unchanged compared with area established in the reference year 2015. Both these goals are accompanied by:

- prohibition on ploughing or transforming naturally valuable permanent grasslands (in case of ploughing or transformation, farmer is obliged to recover the area into permanent grassland),
- prohibition on transformation of permanent grasslands when the index of grasslands share in agricultural lands decreases by more than 5% in relation to the index established in the reference year. Percentage change of the index relative to the index in reference year is established every year till 30th November by the Minister of Agriculture and Rural Development. Grassland protection is a criterion, based on which non-productive grounds are qualified to direct subsidies [ARiMR undated].

CONCLUSIONS

Farms in Poland are obliged to keep the area of grasslands unchanged compared with area established in the reference year 2015.

Permanent grasslands (PG) constitute most environment-friendly way of using agricultural lands because of high natural and productive values thanks to their biodiversity.

Biodiversity is the key factor decisive for their high natural and productive values.

Apart from fodder production (productive function), grassland play many important non-productive functions: climatic, hydrological, protective, phyto-sanitary, healthful, landscape and aesthetic.

Grasslands play an important role in water retention. Not all types of grasslands may be used agriculturally. Out of 16 types of habitats, 10 may be used for production, the others are biologically valuable. The surface area of permanent grasslands in Poland has markedly decreased during the last decade. Now, they constitute slightly more than 20% of agricultural lands occupying 3127.8 thous. ha (in 2019) including 2764 thous. ha of meadows and 363.8 thous. ha of pastures.

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