




Problem of water scarcity in agriculture – case study of land improvement in Kujawsko-Pomorskie Voivodship

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Abstract: Today's agriculture is facing a range of challenges, the most important of which is the adjustment to the changing climate. In this context, water management is particularly vital. Droughts in Poland are becoming more and more frequent. That fact adds to the significance of irrigation and drainage systems.

This paper is an attempt at diagnosing the condition of (in 2016) and changes in (over the period of 2006–2016) irrigation and drainage systems in the Kujawsko-Pomorskie Voivodship (analysed by communes, until 2016 – according to Local Administrative Units – LAU level 2). The multidirectional analysis involves a comprehensive description of ameliorated lands, including the allocation of the EU funds dedicated for the support of flood protection and land improvement ventures.

It has been demonstrated that the present condition of land improvement does not reflect the needs of the agriculture in the studied area and that the changes implemented on the ongoing basis fail to make the situation better. In 2016, slightly over 40% of agricultural acreage was ameliorated, while the level at which land improvement needs would be satisfied approximated 70%. In over 1/5 of the ameliorated area, facilities needed reconstruction or modernisation. Drainage systems were in the majority, which indicates that the current needs, i.e. water scarcity, are not addressed.

Keywords: agriculture, climate, drought, Kujawsko-Pomorskie Voivodship, land improvement, water scarcity

INTRODUCTION

One of the biggest challenges to be tackled by the 21st-century agriculture is the adjustment to climate changes [FAO 2017; MRiRW 2019; ZEGAR 2012]. The ever-more frequent occurrences of extreme weather may, to a large degree, aggravate farming conditions, both in Poland [JÓZWIĄK *et al.* 2016; KACZAŁA 2014; STANKIEWICZ 2007] and in other regions of the world [PEÑA-GALLARDO *et al.* 2019; RAY *et al.* 2018; WANG *et al.* 2020]. In Poland, the problem of water scarcity in agriculture is becoming particularly conspicuous, since droughts are increasingly common. In the period of 2013–2018, droughts happened annually¹ [ZIELIŃSKI, SOBIERAJEWSKA 2019], with 38% of the Polish land

occupied by agricultural and forest areas being extremely and very exposed to drought [PGW Wody Polskie 2019]. The Kujawsko-Pomorskie and Wielkopolskie voivodships have the most progress in agricultural development in Poland [RUDNICKI *et al.* 2015], but these are also the regions most affected by droughts. Even the best developed agriculture cannot cope without regulation of the water regime in soil [VALIPOUR *et al.* 2020]. Drought here is defined as a phenomenon of a continuous nature and of a regional scope, where the availability of water is below the average established for particular natural conditions [IMGW undated].

In the light of the above, particularly essential are ventures related to land improvement, namely: ventures focused on regulation of the water regime in soil to adjust it to the optimal conditions for crops, consequently contributing to higher yields [KAPUSTA 1987; KIDA-KOWALCZYK 1978]. In Poland, for many years, such activities were basically single-channelled, i.e. they

¹ In the period of 1951–1981 droughts were recorded every five years on average, between 1982 and 2012 they were observed in three years of every five-year period [ZIELIŃSKI, SOBIERAJEWSKA 2019].

involved land de-watering (predominantly by draining). Generally, what constituted the problem was the excess of water in soil, while higher land productivity was a result of the drainage performed over a given area [LIPiŃSKI 2006]. Nowadays, it is the retention of water in the natural environment that is of the essence. However, land improvement in Poland, as a system, is not prepared to handle that task [ŁABĘDZKI 2009]. Moreover, the prevalent part of present irrigation and drainage systems is not working properly, which is dangerous, for one thing, and damages crop yields, for another thing to make matters worse [KIRYLUK 2019; SZPIKOWSKI *et al.* 2015], the 21st century has seen negligible enhancement of this system. Such a situation is caused mainly by insufficient funds from the state budget (on average, they cover about 20% of the demand) [KŁOS 2013].

Land improvement is a subject relatively rarely brought up in the spatial studies of agriculture. One of the reasons for such a lack of interest in the problem is the negligible coverage of the related issues in the available official statistics². Studies broken down into administrative units at the level of poviát or commune may, moreover, be based on geodesical data (land registers kept by County Offices)³ or data from the former Regional Boards of Land Amelioration and Water Facilities (Pol. Zarząd Melioracji i Urządzeń Wodnych – ZMiUW)⁴. The latter allow for multi-directional description of ameliorated lands, including their division into: basic and minor amelioration, irrigated and de-watered lands, arable land and permanent grassland, along with the documentation of a number of linear and surface elements of the land improvement system⁵. The studies hereby presented have been based on that very source.

Based on the above-mentioned information, the following research hypothesis has been proposed: the current condition of the land improvement system does not satisfy the needs of the agriculture in the studied area (Kujawsko-Pomorskie Voivodship) and the changes implemented on the ongoing basis make the situation no better. What is more, the paper undertakes the problem of using funds from the Common Agricultural Policy of the European Union (CAP UE) (flood prevention and land improvement ventures within the Rural Development Programme – RDP 2007–2013) and presents the analytical merits of the data gathered by the former Boards of Land Amelioration

and Water Facilities provided for low-level administrative units (poviats and communes).

The Kujawsko-Pomorskie region is at a particular risk of droughts. It is the resultant of many natural factors. It is reflected in the value of the climatic water balance⁶ in the period of 1970–2015 (Fig. 1). The susceptibility to droughts is escalated by vast areas of soils with low water capacity. In the northern part of the voivodship there are light and very light soils (catchment basins of the Brda, Wda, Maława Rivers). The most fertile soils are in the regions of Kujawy (Cuyavia) (black soils based on clay and silt), Pałuki, Krajna, as well as Chełmno and Dobrzyń Lake Districts [ŁABĘDZKI 2017].

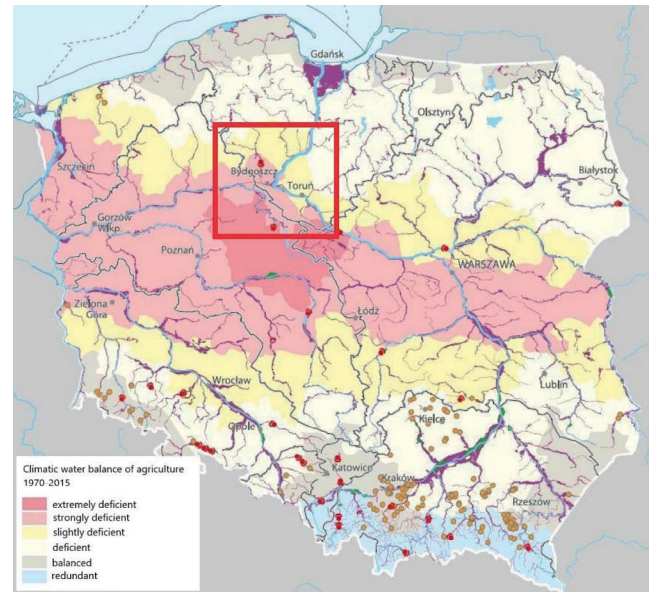


Fig. 1. Climatic water balance in Poland in the period of 1970–2015; source: MR [2017]

Among the 303 communes in Poland which were affected by droughts in at least three years in the period of 2014–2017, 84 were located in the Kujawsko-Pomorskie Voivodship (the second most affected region, with 62 communes suffering, was the Wielkopolskie Voivodship) [ZIELIŃSKI, SOBIEGAJEWSKA 2019]. Taking into account the role and significance of agriculture in the studied area [KACA (ed.) 2015; RUDNICKI 2016; Województwo Kujawsko-Pomorskie 2013], the development of the land improvement system is an important task, with the priority being given to activities related to improvement of the irrigation system [KACA *et al.* 2014a]. Water resources, which are insufficient for the needs of agriculture, and the process of steppe formation over large areas of the voivodship (particularly Kujawy) are the main vulnerabilities of and threats to the agriculture in the Kujawsko-Pomorskie region [KPODR 2017].

In 2015 a team led by E. Kaca formulated a programme for development of the irrigation and drainage systems in the Kujawsko-Pomorskie Voivodship. At present, it is the most comprehensive compendium of knowledge on this matter. The programme diagnoses the level of de-watering and irrigation, analyses development needs, and estimates the costs and the range of reconstruction and modernisation of land improvement

⁶ Difference in precipitation and evaporation.

² The results of the last national agricultural census (2010) provided information only on the surface area of crops covered with the irrigation system and on the number of farms using such systems [RUDNICKI 2016].

³ The registers include the category of 'grounds under water', which consists of grounds under the bodies of surface water that is standing, flowing or internal seawater, as well as grounds under ditches and ponds that are qualified in the Land and Property Register as arable lands.

⁴ Formerly: Voivodship Boards of Land Amelioration and Water Facilities, the old units of voivodship authorities. Nowadays: Państwowe Gospodarstwo Wodne – Wody Polskie (PGW-WP or National Water Holding – Polish Waters).

⁵ The list of linear facilities includes: ditches and natural watercourses, regulated watercourses, canals, pipelines, flood embankments; whereas surface facilities involve: lakes, water reservoirs, fish ponds. Moreover, those data render it possible to define, among other things, the area covered with flood embankment protection and the surface area of the range of impact of particular pump stations.

systems. It also points out that it is highly justified to develop land improvement systems and highlights the problem of the scarcity of water needed for irrigation. This paper, characterised by the presentation of selected issues at the level of particular communes, is an example of how studies on spatial management within the scope of agricultural amelioration can be presented.

MATERIALS AND METHODS

The primary source of data used for the purposes of this study consisted of the data on the surface area and structure of land improvement systems made available by the former Board of Land Amelioration and Water Facilities in Kujawsko-Pomorskie. Taking advantage of the statistical analysis of the data, a number of indicators were prepared (e.g. scope of land improvement, coverage of amelioration needs), the interpretation of which rendered it possible to achieve the research objectives and to verify the main research hypothesis. Also, data by the Agency for Restructuring and Modernisation of Agriculture (ARMA, Pol. Agencja Restrukturyzacji i Modernizacji Rolnictwa – ARiMR) were used in connection with the number and value of successful applications for the support of flood prevention and land improvement ventures within measure “Improvement and development of infrastructure related to the development and adjustment of agriculture and forestry”⁷. Upon comparison of the amount of these funds with the diagnosed needs with respect to reconstruction and renovation of amelioration facilities, the authors arrived at the basis for the assessment of the spatial allocation of pro-amelioration measures. The obtained results have been presented in a tabular form (poviats) and on maps (division into 144 communes of the Kujawsko-Pomorskie Voivodship).

RESULTS

SURFACE AREA OF LAND IMPROVEMENT SYSTEMS IN THE PERIOD OF 2006–2016

The data for 2016 demonstrate that in the Kujawsko-Pomorskie Voivodship there were 474.9 thous. ha of ameliorated lands. This area includes the impact area of both basic amelioration (e.g. barrages, water bodies, pipelines of over 0.6 m in diameter, regulatory and flood-prevention constructions) and minor amelioration (e.g. ditches, drainages, pipelines of less than 0.6 m in diameter, ponds). That area was highly diversified in terms of spatial features: at the level of poviats – from 0.8 thous. ha in 4 townships to over 45 thous. ha in the poviats of Inowrocław and Włocławek (Tab. 1); and – even more so – at the level of communes – from no ameliorated lands in 12 municipalities to over 10 thous. ha in Żnin (10.8 thous. ha), Kcynia (11.8 thous. ha) and Kruszwica (12.9 thous. ha).

⁷ The measure was part of axis I of the Rural Development Programme (RDP 2007–2013) – “Improving the competitiveness of the agricultural and forestry sector”. The funds were at the disposal of the Kujawsko-Pomorskie Marshal’s Office in Toruń, while their delivery fell within the scope of responsibilities of the Board of Land Amelioration and Water Facilities in Kujawsko-Pomorskie located in Włocławek.

A comparative analysis of the area of ameliorated lands in the studied region in the period of 2006–2016 showed that there was a slight increase by merely 1,082 ha. That negligible progress in land improvement is demonstrated by the fact that the studied period saw no change in the area of ameliorated lands in 115 communes (82% of all communes). Other communes, except 3 units characterised by a decrease in the studied area (Pruszcz, JezioraWielkie – decrease by up to 10 ha, and mostly Mogilno – decrease by 332 ha – the change due to the withdrawal of a large farm from the water company in Mogilno)⁸, featured an insignificant increase in the area of ameliorated lands (in total 28 communes), with only 3 communes exceeding the threshold of 200 ha: Włocławek in the poviat of Włocławek (204 ha), Dobrzyń on the Vistula (212 ha) and Tuchów (203 ha) in the poviat of Lipno. The above results confirm the marginal nature of investment in land improvement [KŁOS 2013]. The insufficient increase in the area of newly ameliorated lands is deemed even more negative due to the fact that the annual average depreciation of land improvement facilities approaches 2% [MICHNA 1987]. Therefore, no simple reproduction has been observed in land improvement, as a result of which growing impairments of facilities exceed the area of newly ameliorated lands.

Due to the above-mentioned low dynamics, further analysis of ameliorated lands in the Kujawsko-Pomorskie Voivodship was conducted on the data for 2016.

SELECTED ELEMENTS OF ANALYSIS OF LAND IMPROVEMENT SCOPE AND STRUCTURE (2016)

The spatial analysis of irrigation and drainage systems takes into account the percentage of ameliorated agricultural acreage in the total agricultural acreage. The scope of land improvement expressed in this manner yielded the average value of 41.7% for the Kujawsko-Pomorskie Voivodship and was a little higher than the national average (approx. 35%) [KACA *et al.* 2014a]. This indicator was characterised by substantial spatial diversification, both at the level of communes (from 26 communes with the value below 25% to 5 communes with the value above 75% – Fig. 2a) and at the level of poviats (Tab. 1).

High percentages of ameliorated lands were usually connected with the regulated water regime in the fluvial basins of the Vistula (reservoirs in Unisław and Grudziądz), the Noteć (Bydgoszcz and Noteć canals) and in the watershed area of Kujawy Lake District (Bachorze and Parchanie canals). On the other hand, low percentages of ameliorated agricultural acreage occurred in the areas where sandy, well-infiltrating soils dominate (especially Tuchola Forest). A low production potential of these soils makes it irrational, for economic reasons, to improve them through amelioration procedures [KACA (ed.) 2015].

Description of the structure of ameliorated lands involves also consideration of how water regime was regulated in the soil, i.e. drainage, on the one hand, and irrigation, on the other hand (Fig. 2b). Soils which prevail in the region are soils with a high and moderate production potential and with the proper moisturisation (natural or caused by land improvement procedures). Unfavourable agri-meteorological conditions (based on

⁸ Information obtained from a worker of Państwowe Gospodarstwo Wodne – Wody Polskie (PGW-WP or National Water Holding – Polish Waters).

Table 1. Selected indicators in the assessment of amelioration in the Kujawsko-Pomorskie Voivodship

Description	Ameliorated agricultural acreage			Coverage of amelioration needs	Facilities in need of reconstruction or modernisation – % in the ameliorated area	Value of pro-amelioration investments (RDP 2007–2013) in PLN·ha ⁻¹ of land requiring renovation or modernisation
	total area of ameliorated lands (in thous. ha)	scope of land improvement (% in the total area of agricultural acreage)	% of irrigated lands			
Voivodship – total	474.9	41.7	3.3	67.4	22.9	999.8
Including poviats of						
Aleksandrowski	24.6	64.0	0.4	82.0	3.6	1 281.5
Brodnicki	22.0	32.4	1.3	63.3	15.5	866.2
Bydgoski	17.4	27.3	9.1	62.3	11.4	266.0
Chełmiński	15.9	37.6	6.4	60.5	49.2	2 221.4
Golubsko-dobrzyński	18.7	43.5	0.0	80.0	20.7	11.2
Grudziądzki	26.0	48.3	0.2	61.1	24.5	497.7
Inowrocławski	45.7	49.0	4.4	73.5	32.9	73.4
Lipnowski	27.2	40.7	0.8	55.9	19.6	414.6
Mogileński	15.9	32.8	2.9	49.6	25.0	34.0
Nakielski	30.8	42.3	15.1	69.8	30.8	518.9
Radziejowski	33.4	64.8	0.0	85.5	25.3	26.6
Rypiński	15.4	37.9	7.5	61.7	22.9	487.7
Sępoleński	17.6	35.1	4.8	71.6	31.7	49.1
Świecki	22.5	29.9	5.5	61.1	17.2	9 741.7
Toruński	33.6	50.1	1.4	69.2	29.3	2 034.5
Tucholski	11.5	26.4	9.4	77.5	6.5	7 740.6
Wąbrzeski	19.3	48.0	0.7	61.8	19.4	361.2
Włocławski	46.1	44.8	0.5	65.8	11.8	1 323.8
Żniński	30.5	44.3	5.1	72.4	29.1	43.7
Townships ¹⁾	0.8	9.9	7.6	83.5	68.6	992.1

¹⁾ Bydgoszcz, Toruń, Włocławek, Grudziądz.

Source: own study.

the climatic water balance – a difference between precipitation and evaporation) prove large and very large needs for irrigation in most of the region [KACA (ed.) 2014b].

According to studies, the Kujawsko-Pomorskie Voivodship is typified by very small area of irrigated lands – 12.2 thous. ha. That percentage was at the average regional level of 3.3% of the total ameliorated lands. The highest percentage of irrigated lands – above 75% – was recorded in Białe Błota (77.9%, powiat of Bydgoszcz), Bobrowniki (82.8%; powiat of Lipno), Cekcyn (76.4%; powiat of Tuchola) and Dragacz (96.2%; powiat of Świecie) – Figure 2b.

Obviously, the sheer presence of the properly focused system does not guarantee any positive effect, because – following ŁABĘDZKI [2009] – in Kujawy it is impossible to perform irrigation in some years (on account of too low water levels in watercourses, lakes and small artificial reservoirs), which points to the need for comprehensive investments improving water retention.

From the perspective of agricultural development and the analysis of the scale of actual investment needs within the scope

of land improvement, the index showing the coverage of amelioration needs is particularly important; it has been defined as the percentage of ameliorated lands in the total area of lands which require amelioration works (696.3 thous. ha). On average, in the Kujawsko-Pomorskie Voivodship it is 67.4%, with the lowest value noted in Chrostkowo (powiat of Lipno) – 19.6%, in 45 units the value exceeds 75%, including 100% in Cekcyn (powiat of Tuchola), Obrowo (powiat of Toruń) and Solec Kujawski (powiat of Bydgoszcz) – Figure 3a.

The scope of amelioration of agricultural acreage is highly and significantly correlated ($r = 0.75$) with the commercialisation of agricultural production in particular regions of Poland [LIPINSKI 2006]. In the Kujawsko-Pomorskie Voivodship there are much bigger possibilities of achieving a growth in agricultural production through regulation of water regime in areas characterised by a high (above 50%) percentage of lands which are not ameliorated but which need amelioration, i.e. lake districts of: Brodnica, Chełmno, Dobrzyń, as well as Świecie Upland and Inowrocław Plain. Depending on the condition of soil (infiltra-

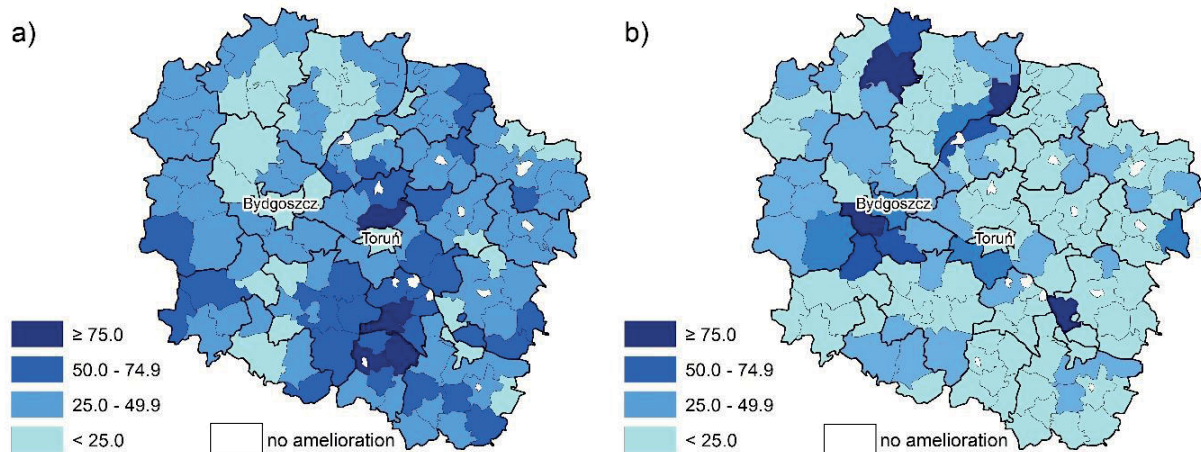


Fig. 2. Scope of land improvement: a) percentage share of ameliorated lands in the total agricultural acreage, b) percentage share of irrigated lands in the all ameliorated lands; source: own study

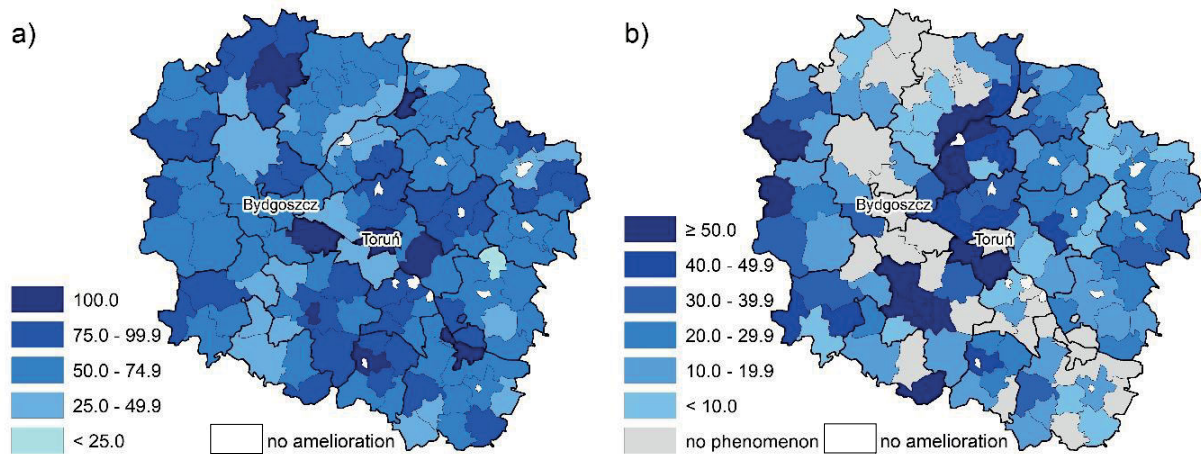


Fig. 3. Coverage of amelioration needs: a) percentage share of ameliorated lands in the total ameliorated agricultural acreage, b) percentage share of facilities requiring reconstruction or modernisation in the total area of lands under land improvement activities; source: own study

tion ratio) and climate (total precipitation), what is becoming conspicuous in those areas is the need to employ irrigation techniques. Such a growth in agricultural production is highly possible in the central area, where the lowest precipitation in Poland is recorded.

Land improvement ventures are characterised by huge capital intensity, and then also by expenditures which enable proper technical maintenance of land improvement systems [STACHOWSKI *et al.* 2017; WARD 2010]. Another issue related to the irrigation and drainage system in Poland is the technical condition of the facilities. These, in their majority, are not well maintained, which negatively affects the environment, including the soil [KACA *et al.* 2014a]. Therefore, it is particularly important to define the area of lands where land improvement systems require reconstruction or modernisation. It was established that the said area in the Kujawsko-Pomorskie Voivodship equalled 108.8 thous. ha.

That assessment was based on the percentage of the area covered by amelioration facilities in need of reconstruction or modernisation in the total area of lands under land improvement (474.9 thous. ha). In the Kujawsko-Pomorskie Voivodship it was 22.9%. When it comes to communes, there were 40 units with absence of the phenomenon (including 12 communes with no

ameliorated lands), 12 communes with the parameter exceeding 50%, with values of over 90% noted in Chełmno (powiat of Chełmno) and the town of Inowrocław and Złotniki Kujawskie (powiat of Inowrocław) – Figure 3b.

ANALYSIS OF DIVERSIFICATION IN LAND IMPROVEMENT INVESTMENTS WITHIN RDP 2007–2013

The reduction of the area of amelioration facilities in need of reconstruction or modernisation entails large financial expenditures. That issue has been presented on the basis of the analysis of the delivery of funds within axis 1 of the Rural Development Programme (RDP 2007–2013) – “Improving the competitiveness of the agricultural and forestry sector”, including the funds dedicated for the support of flood prevention and land improvement investments within measure “Improvement and development of infrastructure related to the development and adjustment of agriculture and forestry”, which were at the disposal of the Kujawsko-Pomorskie Voivodship Marshal’s Office and delivered by the former Board of Land Amelioration and Water Facilities in Kujawsko-Pomorskie located in Włocławek.

Those funds enabled completion of 51 ventures totalling 140.4 mln PLN (average investment value being about 2.75 mln

PLN). The analysis of the structure of those funds by material effects demonstrated predominance of payments to flood embankments (55.6%) and river regulation (27.0%). Substantially less money was dedicated for field drainage systems (13.8%), reclamation pipelines (2.5%) and other land improvement activities (1.2%).

What was taken as an indicator of the delivery of pro-amelioration funds from RDP 2007–2013 was the cost of such payments (PLN) per 1 ha of lands where amelioration facilities required reconstruction or modernisation – on average PLN1,000 in the Kujawsko-Pomorskie Voivodship (Tab. 1). The analysis of the above indicator at the level of communes demonstrated the following:

- 34 communes had no amelioration facilities which would need reconstruction or modernisation nor any RDP payments dedicated for such investments;
- 65 communes, despite the presence of amelioration facilities requiring reconstruction or renovation, did not have the above-mentioned payments from RDP 2007–2013;
- 6 communes received the above-mentioned payments from RDP 2007–2013 although they did not register any area of amelioration facilities to be reconstructed or modernised;
- 39 communes which had different proportions of the area of amelioration facilities to be reconstructed or modernised and the amount of RDP payments dedicated for those ventures, which was expressed in the varying values of the index showing the amount of payment delivery (PLN) per 1 ha of the area of amelioration facilities requiring reconstruction or (Fig. 4).

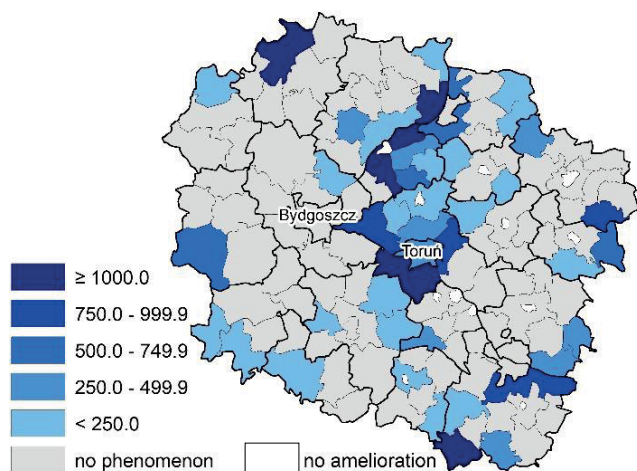


Fig. 4. Overall cost of flood protection and land improvement investments within RDP 2007–2013 per 1 ha of lands (in PLN) where facilities require reconstruction or modernisation; source: own study

CONCLUSIONS

The research hypothesis has been verified positively. In the Kujawsko-Pomorskie Voivodship, in 2016, slightly over 40% of agricultural acreage was ameliorated. Taking into consideration the needs within the scope of land improvement resulting from diverse natural environment (structure of soils, water regime, landform, climatic conditions) and anthropogenic characteristics (land cover, type of use), the coverage of amelioration needs

approximated 70%. The changes observed within the ten-year period (2006–2016) were marginal and did not have any considerable impact on the improvement of amelioration systems in the region. Unfortunately, the structure of land improvement systems, expressed by the relation of drainage systems to irrigation systems, is deemed negative. The level of the latter was abnormally low (only 3.3% of all ameliorated lands in the voivodship). According to the data by the former Board of Land Amelioration and Water Facilities in Kujawsko-Pomorskie, in more than half of the communes – including those particularly affected by droughts – the entire land improvement system was focused on drainage. It should be emphasised that in over two-thirds of the communes there were no irrigation systems. It points to a gross maladjustment to the current and real needs of agriculture (and not only) in this scope. Upon the analysis of the quality of the existing infrastructure, it transpired that the studied facilities require reconstruction or modernisation in over 1/5 of ameliorated areas; while in over a dozen communes the needs were noted in over 50% of ameliorated areas. These results, in combination with the problems presented in the initial sections of the paper dealing with water scarcity and drought in the Kujawsko-Pomorskie region, enable positive verification of the hypothesis which states that the current condition of the land improvement system does not satisfy the needs of agriculture in the studied area and that the changes which are being implemented do not improve the situation.

Another issue undertaken in the paper was allocation of the European funds for enhancing flood prevention and for developing land improvement systems. From the amount of resources used, only 17.5% were dedicated for the broadly-understood pro-amelioration measures⁹. The analysis of the overall amount of aid funds (140.4 mln PLN) in relation to the area of lands where modernisation works are required pointed to the concentration of payments in communes located in the close vicinity to the Vistula (the effect of capital intensive flood protection ventures). However, without a shadow of doubt, the scale of support in the perspective of 2007–2013 was insufficient and did not contribute to any substantial improvement of the situation. It is to be hoped that the current activities, such as: the counter-drought plan, campaigns aimed at raising the importance of low retention, or dedicated measures within the European Union's common agricultural policy (EU CAP), will give decidedly better effects.

The authors deem it positive that it is possible to perform spatial studies by administrative units on the basis of data obtained from the former Board of Land Amelioration and Water Facilities. Naturally, the paper – due to the formal publication page limit – does not present full analytical capabilities of this statistical approach (e.g. the problems of amelioration of permanent grasslands, linear elements of the system and ground facilities were skipped). Despite the undoubted weakness of the necessity to operate on averaged values for communes and poviats, such analyses may be useful for planning further activities by local authorities and other stakeholders.

The undertaken problems, due to their significance, should be studied further. Obviously, studies and strategies are merely the first steps to solve the mounting problem of water scarcity in

⁹ Obviously, from the perspective of human security, flood prevention measures should be given the priority.

agriculture. Next steps – more focused on drafting relevant legal regulations and increasing financial expenditures on water management in agriculture – must be taken by decision-makers and farmers.

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