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THE SCOPE OF SURVEY NECESSARY TO IDENTIFY WATER-RELATED HAZARDS IN RURAL AREAS

Barbara Posiak

Summary

Broadly understood agricultural-arrangement works are a tool for the implementation of multifunctional rural areas development. These works are defined as a set of integrated technical, organizational and legal procedures, taking into account the natural, economic, legal and social conditions, aimed at adapting the spatial structure of the area to the needs of its sustainable development, including new organization of agricultural production space. These may be activities in the field of water resources management, the purpose of which is to minimize the occurrence of extreme water-related phenomena – droughts and floods. However, it should be emphasized that these works are multidimensional. In addition to their positive impact on water resources, they create favourable conditions for the development of biological diversity, maintaining cultural landscape or limiting pollution to water. However, such activities may be properly planned and carried out in the course of the agricultural-arrangement works only when it is possible to identify and determine the elements that affect the circulation of water in rural space.

Keywords

agricultural-arrangement works • water resources management • small retention

1. Introduction

Water resources consist of surface waters and underground waters. They arise as a result of precipitation that determines their supply and natural renewability. These resources accumulate on agricultural and forestry land where they should be partially retained and used [Mioduszewski and Okruszko 2016]. Over the past years, an increase in the frequency of extreme phenomena associated with excess or deficiency of water has been observed. More and more areas in Poland experience the effects of climate change such as floods or droughts. As many as 40% of municipalities have been designated as flood risk areas, but only 1/3 of them are adequately protected [Jóźwiakowski and Siuda 2017]. Research shows strong links between natural disasters and climate changes as well as anthropogenic processes, including demographic changes, violent and unplanned urbanization, or human intervention in the natural environment [IPCC 2012, Kundzewicz et al. 2010]. It is necessary to implement procedures that

would reduce the negative impact of droughts and floods on the natural environment, and above all on the agriculture [Pijanowski and Litwin 2015, Radecki-Pawlik et al. 2014]. Remaining underestimated in Poland, as a tool for a comprehensive improvement of water management in rural areas, is the arrangement of rural areas, based on the process of land consolidation. Activities carried out in the framework of agricultural-arrangement works may include, inter alia, technical and non-technical procedures leading to the increase of the natural water retention [Pijanowski et al. 2012]. Unfortunately, tasks in this field are currently being implemented in insufficiently large areas of the country.

The purpose of this article is to discuss the extent of the physical inventory of the natural and technical elements of rural space that influence the formation of water circulation. Determining the type and location of these components is the basis for the proper planning of investment projects under agricultural-arrangement works. These elements are discussed in the following subsections. Considerations and discussions are based on review and analysis of existing elaborations [Bartnik et al. 2009, Bik et al. 2006, Bykowski et al. 2011, Dzikowska 2006, Hewelke et al. 2013, Majda et al. 2012, Mtamba et al. 2015, Mioduszewski [2004, 2005, 2008, 2014], Mioduszewski and Okruszko 2016, Phillips and Tadayon 2016, Radecki-Pawlik et al. 2014, Sobolewska-Mikulska and Wójcik 2012, Stańczuk-Gałwiaczek 2016, Ustawa 2001].

2. Selected aspects of water management in the rural space

Water resources are characterized by considerable seasonal and spatial diversity. The ability to store water in a catchment area is determined by retention. The latter allows the given area to retain water during the periods of "excess" and to use it in "deficit" periods. The term "small retention" is now defined more broadly as technical and non-technical measures, which by increasing natural retention capacity aim to improve water balance in the catchment area [Mioduszewski and Okruszko 2016]. Access to water in the right quantity and quality determines all human activity and meets the needs of the economy and the ecosystems [Heeb 2012, Mioduszewski 2005]. Occurrence of extreme phenomena such as floods and water shortages can cause significant losses, both in the economy (especially in agriculture) and in the environment [Mioduszewski 2014].

The influence of climate changes on the increase of water-related risks is observed, and forecasts suggest a significant increase of these risks. According to the projection, it is expected that prolonged dry periods and increased precipitation will occur [Kundzewicz et al. 2010]. The impact of the predicted fluctuations in precipitation regime and temperatures rise is particularly acute for agricultural production [Mioduszewski and Okruszko 2016]. Bearing in mind the negative impact of temporary water surpluses or shortages on the state of the environment and on human economic activity, measures should be taken to reduce the risks arising from the occurrence of these phenomena. It is necessary to implement procedures that would reduce the influence of droughts and floods on the natural environment, and especially on agriculture [IPCC 2012]. In Poland, the third category of water-related hazards is under-quality of

water, although it has undergone a significant improvement over the past two decades [Kundzewicz et al. 2010]. The complex arrangement of rural areas has a significant influence on the development of water management in space.

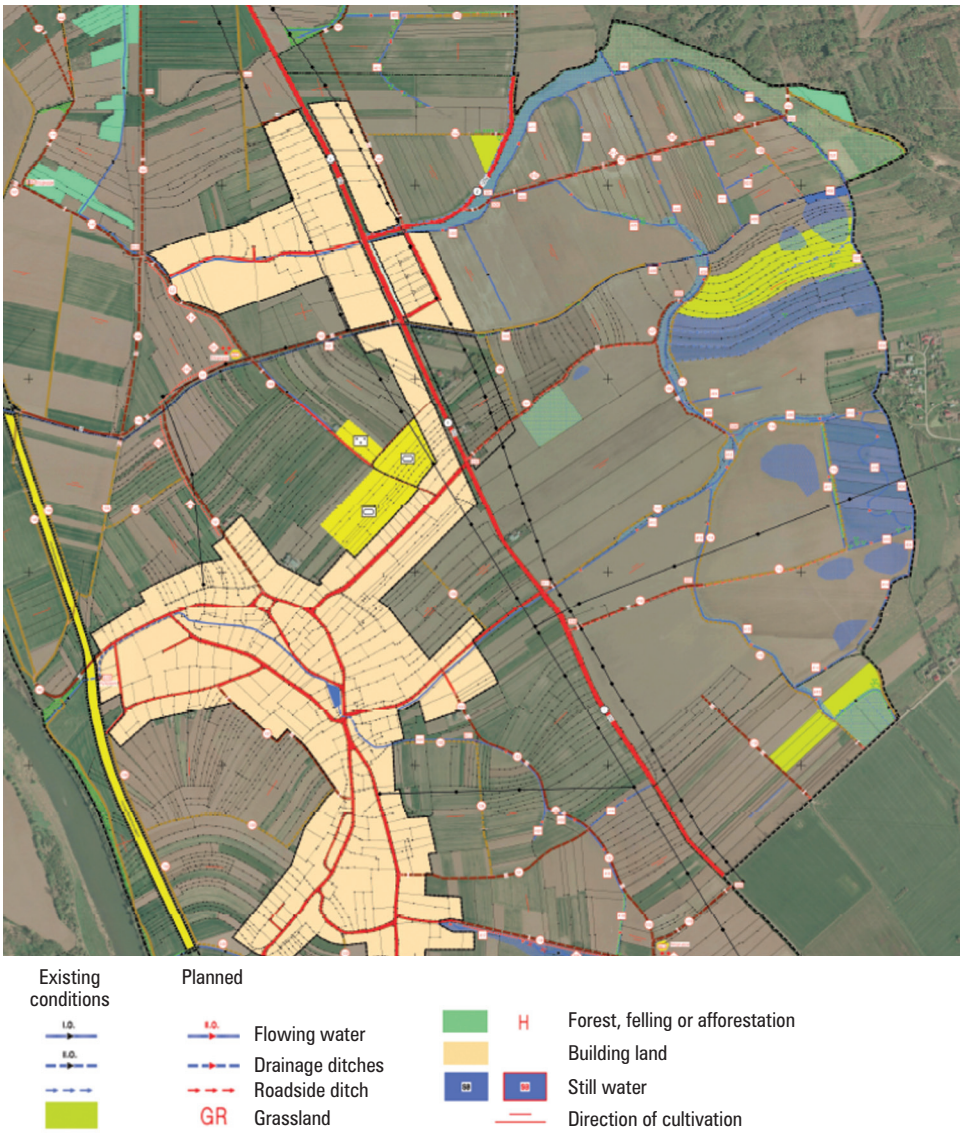
Agricultural-arrangement work (rural areas development) is defined as a set of integrated technical and organizational procedures, taking into account the natural, economic, legal and social conditions, aimed at adapting the spatial structure of the area to the needs of the sustainable development of the latter, including a new organization of agricultural production space. Land consolidation is very important here, since it allows designing many large water management-related investment projects and linking them to a range of other investment activities, such as agricultural roads or anti-erosion treatments.

The pilot document that is the base for the decision to initiate agricultural-arrangement proceedings is the "Integrated Rural Development Plan (ZPROW) for the preparation of agricultural-arrangement procedures for the Nieciecza and Czyżów villages" [Pijanowski et al. 2012]. This is an expert report prepared by experts from the Office for Rural Development and Agricultural Equipment in Meiningen, Thuringia – the German partner region of Małopolska – with the participation of Polish experts from the Marshal's Office of the Malopolska Region and the University of Agriculture in Krakow, drawn up in accordance with the legislation of the Federal Republic of Germany and Thuringia regional guidelines. Assumptions for the project of proceedings (ZPROW) include, among others the initial projects concept of water management investment (Figure 1) including planned: roadside ditches, drainage ditches, still water, plantings, directions of cultivation.

Investment projects designed in connection with the agricultural-arrangement works should include a broad range of activities from the scope of small water retention, devices for the water damming on the watercourses and reservoirs, restoration of small streams and floodplains, construction of retention reservoirs, construction and reconstruction of ditches, channels and drainage systems, as well as discharging precipitation water from paved surfaces to nearby unconsolidated areas. Natural activities in the field of small water retention can be classified into two categories [Mioduszewski and Okruszko 2016]:

- The first involves planning methods, i.e. creation of appropriate structure of fields and forests, reconstruction of semi-natural and natural wetland habitats, creation of plant protection zones, or transformation of land uses.
- The second category involves activities related to the agricultural land use (including cultivation methods). These include actions aimed at improving soil structure in fields and forests, erosion prevention, preservation of infiltrating areas in urbanized zones, and also preservation of the forest habitats and restrictions to the creation of runoff waterways in the forests.

The law in force in Poland allows for the implementation of agricultural-arrangement works, however, not all elements of comprehensive and sustainable rural development are sufficiently dealt with [Sobolewska-Mikulska and Wójcik 2012].



Source: [Pijanowski et al. 2012]

Fig. 1. Fragment of general assumptions for the project of land consolidation of Nieciecza and Czyżów villages in Żabno commune, containing the concept of a comprehensive settlement of the problems in the water management area (Malopolskie Voivodship)

Ways of preventing hazards arising from the water management area can be divided into two groups. The first contains actions aimed at adaptation or elimination of extreme natural phenomena in view of human needs. It assumes the decoupling

of human activity from changes in natural conditions through the use of technical solutions (e.g. water reservoirs, flood embankments). The second group of activities involves the adaptation of human activity to extreme natural phenomena through appropriate land use and management, so that the occurrence of phenomena has the least negative impact on human life and economic activity. It seems more pragmatic to apply the second approach, because the full adaptation of man to extreme hydrological phenomena is difficult to achieve with the current high population density and the development of river valleys. As far as possible, efforts should be made to limit the rapid outflow of melting and precipitation waters and to create the natural retention [Mioduszewski 2005].

It should be emphasized that the tasks of small retention are multidimensional. It is believed that, in addition to the positive impact on water resources (including flood protection and irrigation) they create favourable conditions for the development of biological diversity, maintaining natural landscape or limiting the spread of pollution [Mioduszewski and Okruszko 2016, Heeb 2012].

3. Scope of rural space inventory for the purpose of improving water management

3.1. Configuration of land

Configuration of land is an inherent part of the natural environment, and together with the geological structure, it makes up a kind of background for all natural and anthropogenic processes. Therefore, the knowledge of the land configuration should be the basis for the arrangement of rural areas. Configuration of land plays an important role in water retention. Small depressions of land are conducive to the formation of permanent or periodic ponds supporting water retention. The slope map created on the basis of the land configuration allows determining the direction of the potential surface water runoff. It is also important to analyze the shape of the catchment area, in the area where we plan agricultural-arrangement works, because the size and the course of the flood depends on it to a large extent, as well as the time of concentration and nature of flood wave. In an elongated catchment, the wave is usually flat, the rise lasts longer, and its culmination is lower than in the case of a compact catchment. In addition, the slope of the catchment area influences the dynamics and size of the outflow – as the inclination increases, the velocity of the surface runoff also increases; as a result, less water soaks into the soil. Configuration of the terrain also determines the presence of areas without outflow, where water reservoirs or marshes tend to be formed. These places, however, are subject to disappearance as a consequence of transformations – either natural or caused by human activity [Radecki-Pawlik et al. 2014].

All wetlands affect natural water retention. They include marshy areas, bogs, alder, and wet meadows. Natural wetlands covered with dense vegetation are characterized by high hydraulic roughness. In addition, the wetlands are characterized by small differences in altitude. As a result, floods or melting waters are flowing out from such areas slowly, affecting the relief of the floodwaters wave below the wetland. It is there-

fore necessary to identify these elements in the field. Protection of wetlands, as a non-technical method, will contribute to the development of small retention, and it will also create conditions for the protection of areas with rich natural values on the one hand, and for maintaining the biological diversity of the agricultural landscape on the other [Mioduszewski and Okruszko 2016, Mioduszewski 2004].

3.2. Watercourses

Watercourses, apart from rivers, include streams, flows and creeks. These may be permanent, periodic, or episodic. Watercourses are receivers of waters in the catchment area. Thus, all aspects of the watercourse's structure are significant, both its natural state (including vegetation cover of the bottom) and the elements emerged as a result of human activity, such as water barrages, damming structures, or other forms of river regulation. Strongly built-up riverbeds can pose a serious threat to the surrounding areas, especially at the time of extreme precipitation [Majda et al. 2012]. From the point of view of water-related hazards in rural space, all planned activities require an investigation of existing watercourses as potential receivers of water from drainage systems [Mioduszewski and Okruszko 2016]. It is important to spatially define floodplains. It is important that flood protection walls are also subjected to inventory, particularly as regards their range and condition [Majda et al. 2012].

3.3. Natural water reservoirs

As a part of the agricultural-arrangement works, the surroundings of lakes and small water reservoirs can be shaped. They perform, among others, hydrological functions associated with water retention; they affect the retention of runoff and provide potential for the use of stored water during the growing season. They are therefore an important element of the water circulation system in the catchment area, affecting the water balance and soil-water relationships [Mioduszewski 2014].

Old river beds existing in the catchment basin may also be used to increase water retention [Mioduszewski and Okruszko (Eds) 2016]. Determination of their location, size and character is important for planning optimal actions aimed at the increase of soil retention [Majda et al. 2012].

Natural reservoirs – as well as waterways – can be the receivers of water from the land drainage systems.

3.4. Artificial water reservoirs

The construction of water reservoirs is considered to be a technical method aimed at the development of small retention. This leads to balancing the retention capacity deficit by artificially increasing it [Bartnik et al. 2009]. Artificial water reservoirs include ponds (fish ponds, micro-reservoirs, household reservoirs) and small barrier reservoirs (formed by damming of the river bed and its valley). These reservoirs do not have to

be constantly filled with water; some of them are dry, and they are only filled when the water flow rate in the river increases [Mioduszewski and Okruszko 2016].

3.5. Water drainage facilities

Water reclamation consists in regulating water relations in order to improve the soil's production capacity, facilitate its cultivation and protect the agricultural land against floods. Water melioration facilities are divided into basic and detailed, depending on their function and parameters [Ustawa 2001]. Basic drainage facilities include: dams, sluice structures and water retaining constructions, barrages, reservoirs, canals, regulatory and flood protection structures and others. Detailed drainage facilities are: ditches, drainage, pump stations for pressure vessels, fish ponds and others [Ustawa 2001]

According to Mioduszewski [Mioduszewski 2004], more than 30% of the area of agricultural land in Poland is equipped with various elements of technical drainage infrastructure. These are the main drainage systems on arable land, while on grassland, they constitute networks of drainage ditches (mainly in river valleys). However, the drainage equipment gets gradually degraded as a consequence of the negligence of its operation and maintenance.

According to Bykowski and others [Bykowski et al. 2011], drainage ditches, in addition to fulfilling the function of the receiver of water from the drainage, or the supply of water for irrigation, allow the capturing and discharging of surface runoff waters during periods of thawing and prolonged precipitation. Their role is important because they reduce the risk of the formation of areas with too much moisture, and (by limiting surface runoff) they reduce the occurrence of water erosion. According to the same authors, the basic parameters of the technical condition of ditches are the following: depth, silting, and height of the plants (on the bottom and on the slopes).

3.6. Groundwater level

A very important issue in the development of small retention is the level of groundwater. As Mioduszewski states [Mioduszewski 2008], rainwater can be retained in soil pores between the surface of the terrain and the groundwater table. So the higher the level of groundwater, the lower the soil retention capacity defined as the volume that can be filled by inflowing water.

3.7. Terrain roughness

The roughness of the terrain depends directly on the type of its coverage and is a seasonal variable due to the vegetation stage of plants covering the area. Resistance of vegetation affects the flow of water through the floodplain. Vegetation characteristics in hydraulic modeling include description of spatial variability of location, type, height and density of vegetation. The areas covered with trees, shrubs and meadow vegetation

are characterized by high roughness [Bik et al. 2006, Mtamba et al. 2015, Phillips and Tadayon 2016]. Therefore the survey of high roughness terrain areas, as a factor that has a significant influence on the shape of the flood wave, is necessary.

3.8. Land use

Forest, wooded and bush areas

Wooded areas have the ability to retain significant amounts of water. Bartnik and others [Bartnik et al. 2009] compare the forest area to the shallow water reservoir (occupying the same area), capable of retaining more than a dozen millimetres of rainwater. Thus the rainwater is stopped by soil and vegetation, and only an excess of water can cause surface runoff. Undoubtedly, there is a positive impact of forests on limiting floods caused by heavy rains or melting snow [Mioduszewski and Okruszko 2016].

According to Dzikowska [Dzikowska 2006], a rational way of developing land of low usefulness for agriculture is their afforestation, which simultaneously improves the conditions of the natural environment (including increasing the water retention capacity). It is most appropriate to plan such areas as a part of comprehensive agricultural-arrangement works, which enable a holistic view on the issues of agriculture and the management of agricultural water resources. When designing land for afforestation, the soil's value is taken into account, as well as natural and physiographic borders and inclination of land, and susceptibility of soils to erosion [Stańczuk-Gałwiaczek 2016].

An important element of the agricultural space is the vegetation belt, which forms a protective buffer zone that reduces water pollution (isolation between agricultural roads, agricultural fields and ditches), eradicates erosion and increases biological diversity in agricultural areas.

Arable lands, their use, direction of cultivation

In the course of the agricultural-arrangement works, the conversion of arable land to grassland is also planned. Soils that are excessively concise, difficult to cultivate, located on slopes, with high level of groundwater, and near the water bodies are subject to such conversion [Stańczuk-Gałwiaczek 2016].

Agricultural land use is not usually seen as an activity improving the retention in the catchment area. However, water management can be improved considerably by using appropriate agrotechnical methods, which can be classified as actions for small retention. Also influencing water retention is the amount of organic matter in the soil, or the presence of the so-called plough sole (impermeable layer resulting from plowing). Non-technical measures for the improvement of small retention include the reduction of plowing or guiding it along the contours. These are anti-erosion measures that reduce the velocity of the surface runoff. Positive effects are also achieved through phyto-reclamation (cultivation of properly selected species of plants). These actions, apart from improving water retention capacity, can bring many other benefits to the environment, e.g. they influence the shaping of the rural

landscape [Mioduszewski and Okruszko 2016]. Detailed investigation of land use patterns is an important element in the planning of the process of comprehensive agricultural-arrangement works.

3.9. Type and structure of soil

The nature and structure of soils play an important role in shaping the water balance. As evidenced by the studies conducted by Hewelke and others [Hewelke et al. 2013], at low suction pressures, significant influence on water retention in soil may have basic physical features of soil formations (soil bulk density, solid phase density, organic matter content), as well as the mechanical composition represented by the fraction of sand, and clay and silt fractions. During floods, water fills the pores in the soil, while poorly permeable layers restrict retention. It is therefore important at the collection stage to obtain data on the type and structure of soils present in the studied area.

3.10. Sealing of catchment area

Build-up and development of adjacent areas with various types of pavements, squares and asphalt access roads, significantly affect both the surface and the underground outflow structure. Such investment projects and resulting infrastructure have a negative impact on water retention in the soil, and they change the physicochemical quality of water, which in turn has a negative impact on the condition of surface waters [Bartnik et al. 2009, Mioduszewski and Okruszko 2016]. Additionally, locating buildings in river valleys (thereby narrowing the river bed) may increase the frequency and extent of floods [Majda et al. 2012].

4. Conclusion

All human activities, including the construction of drainage systems, river regulation, changes in land use, or actions leading to catchment sealing, influence the circulation of water in nature, which affects the frequency of droughts and floods. The comprehensive agricultural-arrangement works, integrating various investment activities in the field of agricultural water management, should strive to increase the natural retention capacity of the area, to stop precipitation and melting waters, and to limit surface runoff.

Correct spatial identification of all elements that affect the water management in the rural environment is the starting point for comprehensive agricultural-arrangement works. Recognition of factors that affect water retention (and indirectly the occurrence of extreme phenomena associated with the excess or deficiency of water) will enable a proper planning of the various investment projects with the goal to comprehensively develop and protect rural areas. Elements that affect the quality aspect of water should also be taken into account. Since the actions for small water retention vary, plan-

ning these projects should be flexible. It is important for surveyors to cooperate with specialists in other industries during the design of agricultural-arrangement works. It is extremely important to have an individual approach to each object, and to adapt the planned tasks to the local conditions.

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Mgr inż. Barbara Posiak
Uniwersytet Rolniczy w Krakowie
Katedra Geodezji Rolnej, Katastru i Fotogrametrii
30-198 Kraków, ul. Balicka 253a
e-mail: barbara.posiak@urk.edu.pl