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MELIORATION SYSTEMS OF THE VISTULA DELTA

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1. Hydrographic Characteristics of the Study Area

Presently, the coastal alluvial plains represent the type of areas where the hydrodynamic balance is maintained artificially. This is due to their excessive moistening, which is caused by the lack of natural outflow. This, in turn, is an effect of the minimal land gradient, isolation from receivers by dykes and causeways, flooding of larger unregulated rivers, inflow and sub-flow of foreign surface and ground waters from the surroundings. Hence, in order to maintain the hydrodynamic balance and simultaneously provide conditions for man's activities, it is necessary to employ a water and melioration system.

For the purpose of the research, there was selected the easternmost part of the Vistula delta of 460 km^2 of area (Augustowski, 1976), known as Żuławy Elbląskie (Fig. 1). This area, according to J. Kondracki (1978), is a physical-geographical unit that constitutes part of Gdańsk Coast, a macroregion of South Baltic Coastlands.

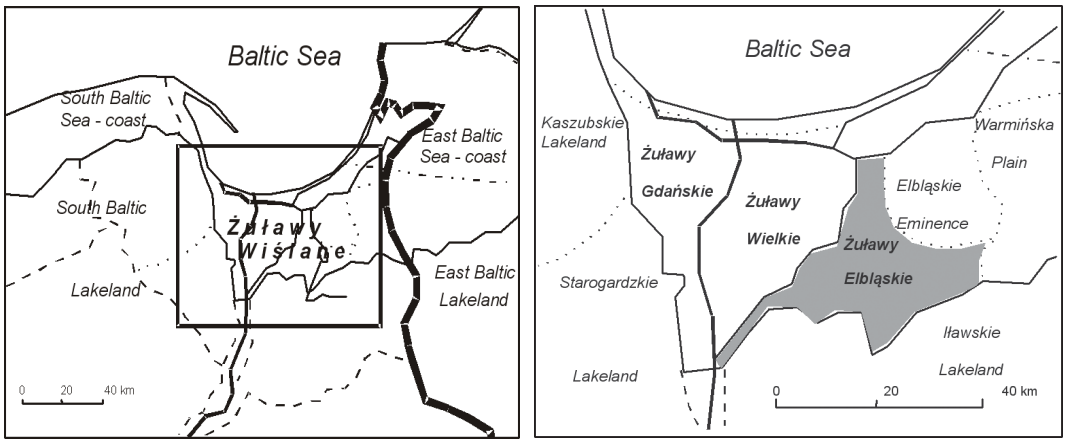

Fig. 1. Area of study.

2. Methods

The hydrographic interpretation is the key issue in the research procedure of this study. This method lies at the basis of the analysis from the perspective of the mutual spatial relationships of individual hydrographic elements.

The cartographic material was assumed to be the basic source of information. This covered hydrographic maps at a scale 1:50 000 (Mapa..., 1986–1987) and water and melioration maps at a scale 1:10 000 (Mapa…, 1987). The data from the District Department of the Water Facilities and Melioration Authority in Elbląg (Rejonowy Oddział Zarządu Urządzeń Wodnych i Melioracji) were also used.

3. Melioration Systems in the Eastern Part of the Vistula Delta

The water and melioration system protects the land from water-logging and flooding, and performs the functions of drainage and irrigation. From the very beginning of the

functioning of the system, the basic goal was the drainage of the primeval swamps and lagoons spreading between the outlet arms of Vistula. These actions were conditioned by the natural hydrographic system of the delta. The remaining actions that enabled the maintenance of drained areas in a condition appropriate for habitation and use were related to land melioration. The manner of melioration depended on the moment when it was performed, as the goals of these actions and melioration techniques changed throughout centuries together with the hydrotechnological advances. Thus, the changes caused by melioration depended more on local conditions than on the mesoscale hydrographic situation.

Both draining and melioration actions led to the formation of one compact water and melioration system in the Vistula Delta, rated among the so-called great water and melioration systems (GWMS) (Cebulak, 1991). The present functioning of the system is the resultant of natural conditions and the actions of many generations in the scope of forming, modernizing and exploiting the hydrotechnical facilities. Polders are the basic hydrological units in this great system. The unit that has a sufficiently individualized system of melioration ditches and canals – sometimes called the small water and melioration system (SWMS) – is also the basic hydrographic unit.

Water circulation is conditioned by the geographical environment of alluvial plains what is proved in the slightly permeable grounds, small land gradients and frequent location in depressions. Such areas require a dense network of ditches. On the other hand, the density of the network of ditches is limited by agrotechnical demands, as too big a number of ditches leads to high losses in arable land area and hinders mechanized farming. From the agrotechnical perspective, the length, distance between and direction of the course of ditches are important too. A decisive role of the existing hydrographic network of the delta may be demonstrated in the layout of the network of detailed land melioration. In this case, the manner in which it is performed is influenced by the distance from the receiver, the degree of anthropogenic transformation of the receiver and the orientation with regard to the receiver of the general direction of flow.

When the types of layouts of the small water and melioration systems (Fac, 1997) were determined it became possible to analyse the hydromorphic similarities and differences in the water network of polders (Table). Twenty three types were recorded in the eastern part of the Vistula Delta (Żuławy Elbląskie) (Fig. 2).

Table. Participation of the basic areas and tied types of melioration systems in Żuławy Elbląskie.

Types of basic systems	**Area (km^2)**	**Participation of area (%)**
perpendicular /P/	151.08	37
parallel /R/	41.08	10
diagonal /D/	81.3	20
unordered /U/	134.02	33
total	407.48	100
Types of tied systems		
perpendicular /p/	140.22	34
parallel /r/	0	0
diagonal /d/	61.47	15
mixed /m/	178.17	44
none	27.62	7
total	407.48	100

Fig. 2 shows that the greatest area among the main types is covered by regular ordered perpendicular (Prp, Prd, Pr) and irregular ordered perpendicular systems (Pip, Pid, Pim, Pi). A comparison of the distribution of these types with the data on the time of settling individual parts of the delta (Drwal, 1991) indicates that this type of SWMS systems could have been used to drain polders from the 16th till the 17th century. It was then that inhabitants of the present Dutch territory intensively settled in this area (Fac (Fac–Beneda J.), 1997).

One more regularity was also observed. The analysed type of systems occurs in the areas of the densest water network, exceeding 20 km/km^2 (Błaszkowski, 1992). The extent of these areas coincides almost completely with the extent of depression. In such areas, the circulation of water is forced mechanically rather than gravitationally. There is no need to construct ditches using natural land gradients. The canals collecting and discharging water to the main canals can join them at right angles.

The irregular unordered systems (Uip, Uid, Ui) that cover the second largest area (about 134 km^2, i.e. 33%) and occur near the main watercourses in the present Nogat delta and on the edge of Elbl^{1}g Plateau represent another main type of systems. These systems correspond in their layout to the natural hydrographic network. They were meliorated earlier than the areas with the ordered systems, i.e. before the 16th century. They lie beyond the depression and belong to the areas of the sparsest water network in Żuławy Elbląskie, less than 8 km/km^2 (Błaszkowski, 1992). Before the 16th century these areas were often affected by floods. In order to use them, it was necessary to drain them as fast as possible after each flood. Thus, systems discharging waters the shortest way to the receiver, i.e. the natural watercourse, often using the natural land gradient (the area built of alluvia accumulated by these receivers was slightly elevated above them) were constructed.

Two types of systems: regular and irregular ordered diagonal (Drp, Drd, Dr, Dip, Did, Dim, Di) and regular and irregular ordered parallel (Rrp, Rr, Rip, Rid, Rim, Ri) take up a much smaller area. There is also no clear pattern of their distribution. A rational interpretation is that these are systems somehow "joining" the above mentioned perpendicular and mixed systems.

Fig. 2 is also helpful in analysing the distribution of the tied types of melioration systems, determined on the basis of the layout of ditches of the third and lower orders with respect to ditches of the second order. The analysis reveals that mixed systems cover by far the larger area (Pim, Rim, Dim, Uim). These systems occur in the immediate surroundings of natural watercourses emphasizing the course of these flows. The layout of the ditches is, thus, to some extent conditioned by the system of the general hydrographic network. The necessity of fast draining of the frequently flooded areas adjacent to the natural watercourses, made people dig straight sections of ditches and canals according to the local land gradients.

The distribution of the tied types of perpendicular systems (Prp, Rrp, Drp, Pip, Rip, Dip, Uip) and diagonal systems (Prd, Drd, Pid, Rid, Did, Uid) is different. They occur at large distances from the main natural watercourses. One can risk the statement that such a situation was conditioned by the requirements of the melioration technology and agrotechnical needs, rather than by the system of the natural hydrographic network.

The tied systems do not form parallel systems. Drainage ditches, due to the role they play, must join the collecting ditches at right or acute angles. Drainage by parallel ditches would not perform the required task.

A small percentage of Żuławy Elbląskie (~7%) is taken up by systems lacking ditches of the third and lower orders (Pr, Rr, Dr, Pi, Ri, Di). Their greatest cluster occurs in polder Fiszewka S and is probably conditioned by strong secondary anthropogenic transformations in this area. Small patches of such systems are also found in peripheral areas, which is due to greater land gradients.

Fig. 2. Melioration systems. A – types of basic systems, B – types of tied systems, 1, 5 – perpendicular, 2, 6 – mixed, 3, 7 – diagonal, 4 – parallel.

Conclusions

The layout of the melioration network is conditioned by the occurrence of places with a considerable excess of moisture, by the manner and intensity of water supply, topographic features, ownership rights and settlement policy. Both at the level of main types as well as the tied ones, the occurrence of melioration systems classified as unordered and mixed was conditioned by the natural hydrographic network of the delta. On the other hand, the occurrence of perpendicular and diagonal types of systems at this level was determined by local conditions and hydrotechnical advances. The types of melioration systems do not reveal a relationship with the settlement network, including the road system. This is justifiable as it were the roads that corresponded to the network of ditches and canals, and thus to the already existing MSWM systems.

Summarising, it is worth mentioning that the distribution of individual types of melioration systems was determined mainly by natural conditions, especially water relationships and requirements of agriculture, and to a smaller degree, though clearly noticeable, the chronology of settlement and economic events.

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Vyslos deltos melioracijos sistema

Santrauka

Vyslos delta yra vienas įdomiausių ir svarbiausių Lenkijos regionų. Regionų, kur būtų taip artimai susiję gamtinis ir antropogeninis kraštovaizdžiai, yra nedaug. Tai ypač pasakytina apie hidrografinį tinklą, kuris jau nuo XII a. buvo stipriai pertvarkomas ir pritaikomas žmogaus reikmėms.

Melioracijos sistemos apsaugo teritorijas nuo užmirkimo bei užliejimo, taigi atlieka sausinimo funkciją, taip pat drėkinimo. Pagrindinė Vyslos deltos vandens ir melioracijos sistemos paskirtis nuo pat jos veikimo pradžios buvo tarp deltos protakų esančių pelkių bei lagūnų sausinimas. Vėlesni melioravimo būdai priklausė nuo nusausintų plotų naudojimo tikslų bei melioracijos techninių galimybių, kurie nuolatos keitėsi.

Melioracijos sistemos išplanavimą lemia perteklingai drėkinamų plotų išsidėstymas, vandens prietakos būdai bei intensyvumas, topografinės vietovės ypatybės, žemėvaldos formos bei gyvenviečių išsidėstymas. Planinės struktūros atžvilgiu melioracijos sistemos skirstomos į statmenąsias, lygiagrečiąsias, įstrižąsias, netaisiklingąsias bei mišriąsias. Netaisiklingųjų bei mišrių melioracijos sistemų paplitimą lėmė natūralus deltos hidrografinis tinklas. Taisyklingų formų (statmenųjų, įstrižųjų) melioracijos sistemų kūrimąsis priklausė nuo lokalių ypatumų, taip pat hidrotechnikos pažangos. Melioracijos sistemų tipų analizė neatskleidė glaudaus ryšio tarp šių tipų bei gyvenviečių ir kelių tinklo.

Taigi melioracijos sistemų tipų pasiskirstymą lėmė natūralios sąlygos, ypač vandentėkmės, bei žemės ūkio poreikiai, o nuo gyvenviečių bei ekonomikos plėtros jis priklausė mažiau.