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STRUCTURAL LAND PLANNING IN THE IRRIGATION AND DRAINAGE AREAS

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Abstract

The small size of landed properties and the fragmentation of land ownership hinder the use and functioning of the already built-up irrigation and drainage systems in Bulgaria. One of the ways to ensure their efficient work and to guarantee reconciliation of all users' interests, especially towards soil moisture management in their land, is by mutual adjustment of land planning and the technological requirements of those systems. The objective of the paper is to reveal rules for land planning of the irrigated and drained lands, in which the land use requirements meet the water use ones. The background is the concept that agricultural land-use structuring should consider the technological units such as water-supply tracts, IMs and drainage technological parcels. The systematic approach was used since the agricultural land represents an agroecosystem - a natural ecosystem formed and operated by human activity, and tenure interests are concerned. Suggestions for different irrigation technologies are made: furrow irrigation, sprinkling machines, sprinkling installations; drip irrigation; and open drainage systems.

Key words*: irrigation and drainage technologies; irrigation and drainage technological parceling, structural land planning.*

INTRODUCTION

A lot of problems in the nowadays agricultural land use stem from the ceaseless process of division of the landed properties, sales, and inheritance. The small-sized property puts obstacles not only to land cultivation but also to the functioning of the agricultural structures, especially of the irrigation and drainage systems. The built up in the past large-scale irrigation systems require large areas for applying their irrigation technologies: either ownership on large areas or large areas leased, which is a precondition of consolidated land use.

Some of the land market transactions cause fragmentation of land use hence for the worsening of the terrain conditions for amelioration activities. In case of irrigation, some of the problems consist of the following: the arable land diminishes because its primary purpose of the use is changed for canals and for a road network servicing the canals, the canal network becomes denser, water management gets complicated; the land is exposed to surface and slope water erosion hazards, irrigation requires additional investments etc.

One of the proper ways for eliminating the negative effects of the small-sized land property and land-use fragmentation on the functioning of the irrigation systems and for solving the resulting issues is by structural changes in land ownership and use, performed by land consolidation.

Referring to the available sources (Vassilev, 1933; Krekmanov, 1941; 1943; Georgiev, 1947; Davidov, 1978), the idea of land consolidation in Bulgaria dates from the beginning of the 20th century when some farmers acted towards setting spatial conditions for rationalizing of their fieldworks and production. Land consolidation issues were initially regulated by some texts in legal acts from 1921, 1933, while the Cadasters and Land Consolidation Act that was promulgated by SG 127 of 1 Jun 1941 comprised and regulated all the stages of the land consolidation process and the conditions of its implementation. This Act was denominated in 1950 when the socialistic compulsory collectivization started.

The Agrarian Reform of the 90-s of the past century focused on the restoration of land ownership resulted in parceled out property and land-use fragmentariness. The new socio-economic situation and the current technological conditions didn't imply the re-implementation of the old 1941 land

consolidation act. There was a horizon for elaboration on a new one with adequate context.

The practices of the Netherlands and Germany, which are countries with highly developed agriculture, show that water management systems and their functioning are within the national economy priority and should be regulated by a detailed Land Consolidation Act or related legislation or by an analogous section in the Land Development Act (Knoblauch, 1987; Van den Noort, 1987).

Bulgaria has no contemporary Land Consolidation Act yet. At the end of 20th century, several drafts of a Land Consolidation Act have been developed. One of them, dating from 1994 (unpublished and not promulgated) has focused on the areas under irrigation and drainage, especially on the necessity of flow corrections, on the construction of irrigation and drainage canals, on the estimation and the compensation of the losses from destroyed waterway facilities, etc. Today, the Agricultural Land Ownership and Use Act Land (prom SG No. 17 of 1 Mar 1991, last suppl SG No. 61 of 2 Aug 2019 - ALOUA, 1991) guarantees by Art. 4, para 4 the preservation of the already built up irrigation and drainage technique and the function of the equipped lands.

The restoration of the land ownership in irrigation and drainage areas, i.e. land division in these territories, was guided by instructions in Newscast No. 7, 1994 of that-time Land Reform Department of the Ministry of Agricultural Development, Land Use and Land Restoration. The instructions were based on detailed knowledge from preliminary research work (Davidov, 1978). Land division projects of irrigation and drainage lands had to consider the technological units in the irrigation and drainage technologies.

Now, when the Agrarian Reform is over, a lot of shortcomings and omissions in the land division plans are ascertained. The situation of many landed properties is in conformity with the WST, but not with the IM. The existing irrigation or drainage facilities are not taken into account in many projects at all. No assessment of the hydraulic network status was done, thus many canals were destroyed in vain. Soil categorization was considered for rain-fed conditions but not for irrigation ones. This non-compliance causes today serious malfunctioning of the irrigation and drainage systems.

There are three cases, in which specific technological parceling is to be done:

- when there are fields with already built up hydraulic structures,
- when new hydraulic systems are being built or when there are approved draft projects for implementing,
- when a procedure for building hydraulic systems has already started for lands that are included in a consolidation program.

The objective of the paper is to present the main ideas of scientifically based Guidelines for land consolidation design in irrigation and drainage areas and to outline the specificity of this design.

MATERIALS AND METHODS

The specific aspect of a draft land consolidation project in irrigated and drained territories is the mutual adjustment of the requirements for land development (land parceling, land division, land consolidation) (IRALOUA, 1991; Newscast No. 6, 1994) and the requirements for irrigation and drainage technological parceling (Newscast No. 7, 1994). The definitions for the technological parcels in the irrigation and drainage technologies are taken from the Newscast No. 7, 1994, which contains guidelines on the agricultural land division in the areas of the irrigation and drainage systems. The essential technological plots are defined there as follows:

- **Water Supply Tract (WST)** is the area, which is irrigated consecutively in series from a concrete-lined fully discharged canal or pressurized pipeline. At least one of the WST borders is contiguous with that canal or with the projection of the pipeline on earth surface. The water providing line element is equipped with one or more water offtake devices.
- **Irrigation Module (IM)** is a part of a WST that is operated by one offtake device. At least one of the IM borders coincides with a canal or the projection of the pressurized pipeline on earth's surface. Both are equipped with water offtakes.

Designing methods and professional knowledge in the field of Land Development and Irrigation and Drainage Engineering were used for drafting Guidelines for land consolidation design in such areas.

RESULTS AND DISCUSSIONS

Generally, land consolidation of irrigation and drainage areas has to be a specific part of a land consolidation plan. There are particular technological rules to be followed because of the specific function of these territories. The specific aspect of land consolidation in territories under irrigation and drainage is the technological parceling, connected with these activities and the applied technologies. Land consolidation aims at the proper situation of the consolidated parcels so that to enable land use and to facilitate the work of the existing structures. Any of the following particular terms should be fulfilled when consolidating lands:

- a consolidated plot must consist of a whole number of IMs, which are peculiar for the applied irrigation technology;
- an IM must consist of a whole number of landed properties, respectively consolidated plots.

The main activities of land consolidation in areas under irrigation or drainage should consist of the following ones:

1. Gathering the initial information:

Graphic information:

- a 1: 25,000 scale plan of the whole irrigation and drainage system, including the situation of the main elements and devices plotted – water resources, head delivery, and transport canals and pipes, pump stations with their characteristics, etc.;
- a topographic plan (1: 5,000) with detailed information about the waterway infrastructure - canals, pipes, pumping stations, dikes, flow corrections, etc., also with the WSTs and IMs borders plotted and numerical information about them;
- a cadastral plan (1: 5,000) of the landed properties.

Text notes:

- about the technological parceling and its peculiarities in the specific conditions of the given territory;
- a list of the WSTs with initial numerical data; design load factor for them, irrigation application efficiency;
- inventory lists of the hydraulic devices.

2. Fixing the borders and the size of the consolidated territory and the technological plots (WSTs, IMs, rice planted cells and irrigation tracts, drainage areas).
3. Making an inspection of the facilities status and amortization on the spot.
4. Developing a draft project for additional irrigation and/or drainage network if needed.
5. Outlining the irrigation fields by taking into account:

- the available water resources and their probability;
- the water conveyance efficiency of the water distribution net, i.e. its hydromodulus.

In order to evaluate the water supply of the field and tracts, a large-scale water resources - water consumption balances should be used. The water supply probability factor for the irrigation system is calculated by the eq. (1):

$$K_o = \frac{P\%}{75} \quad (1)$$

where $P\%$ is the actual water supply probability of the system.

Further the hydromodulus of every separate WST is estimated as (eq. 2):

$$q = \frac{Q}{F} \quad (2)$$

where: q - the hydromodulus, l/s/ha; Q - the WST canal or pipe discharge, l/s; F - WST surface, ha.

The hydromodulus probability factor of each WST should also be estimated (eq. 3):

$$K_x = \frac{q}{q_0} \quad (3)$$

where: K_x - hydromodulus probability factor, q_o is the standard hydromodulus, l/s/ha (0.70 for gravitational systems and 0.80 for pump systems).

For the water supply probability factor of the WST must be accepted the lower value of the calculated by eq. (2) and (3) value.

The IMs within a WST are consecutively irrigated, following a landowners' schedule.

6. Productivity estimation of the landed properties, participating in the land consolidation project.

7. Developing a draft project for the equivalent exchange of the landed properties.
8. Technological parcelling of the areas under irrigation and/or drainage.
9. Adjustment of the consolidated land plots to the technological plots.
10. Preparing the final documentation that consists of:

Graphic information:

- plans of 1:25,000 and 1:5,000 scale, in which the existing linear and surface elements of the hydraulic network and their easements are drawn;
- the borders of the WTSs;
- the borders of the consolidated plots with their cadastral numbering;
- the newly projected roads;
- information, sketches of the recommended irrigation and/or drainage activities in the consolidated lands.

Text notes, explaining the draft project.

The water distribution net within an IM is owned by the landowners.

Several main cases of water distribution technology are concerned in the Guidelines:

1) Subterranean pipe network with mounted hydrants (Figure 1).

WST has a rectangular form. The number of distribution pipelines determines the number of WST. The length of a WST is equal to that of the pipeline wing and the width is equal to the space between the wings. IM also has a rectangular form but its length is equal to the space between the water distribution pipelines and its width - to the space between the hydrants.

2) Subterranean pipe network with stationary sprinkler stands and drip irrigation systems (Figures 2 and 3).

WST consists of the area of all irrigation batteries that are consecutively watered for completion of an irrigation application. One of the borders coincides with the head pipeline. A sprinkler or a drip irrigation battery area represents the area of an IM. If a consolidated plot is greater than one irrigation battery, then it should consist of integer irrigation batteries. If not - a battery should be given to a group of

Figure 1. A scheme of structural land design in an area equipped with a subterranean pipe network with mounted hydrants

owners so that the total area of their properties should be equal to the area of an irrigation battery.

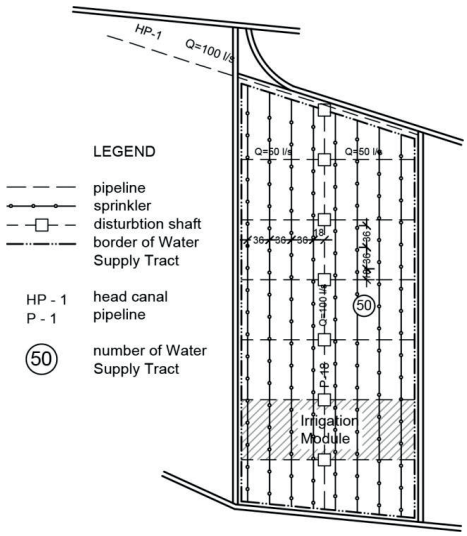

Figure 2. Technological parceling of an area equipped with a subterranean pipe network and stationary sprinkler stands

The borders of their plots should be in conformity with the situation of the sprinklers or of the drip pipelines. The area of one owner should be multiple of the area within four opposite situated sprinklers or should have a rectangular shape when irrigated by a drip pipeline.

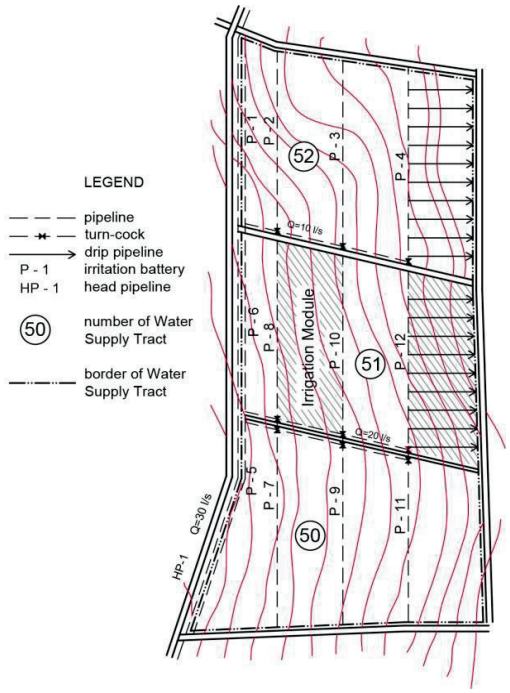

Figure 3. Technological parceling of an area equipped with a drip irrigation system

3) Subterranean pipe network for pivot center machines (Figure 4).

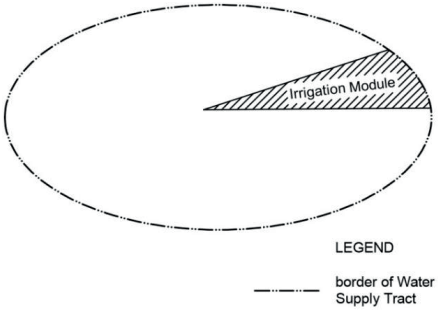

Figure 4. Technological parceling of an area equipped with a pivot center machine

The area of the machine is considered to be a WST. The IMs are parts of the WST with sectoral shape.

4) Open canal water distribution network for furrow irrigation (Figure 5).

WST spreads over the area that is irrigated by the lowest class canal. Its length is equal to the length of that canal and its width shouldn't exceed 200 m, taking into account that the latter follows the slope of the furrows. IM has a rectangular form. Its long side follows the furrow direction. Its short sides lie on two adjacent lowest class concrete-lined canals. IM width is fixed by the space between two adjacent offtake devices, and it shouldn't exceed 100 m.

The landed properties can consist of one or more IMs or be a part of an IM. In both cases, the irrigation efficiency should be taken into account.

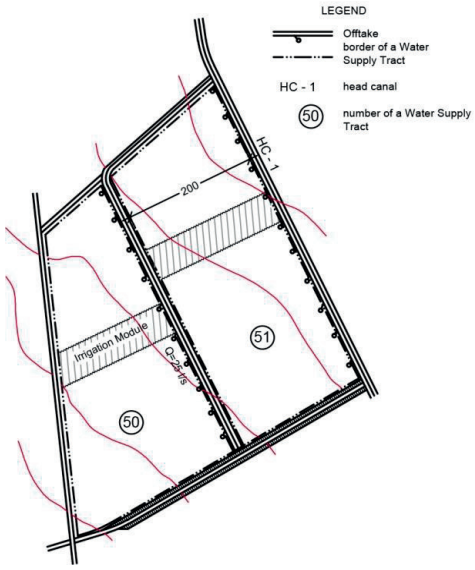

Figure 5. Technological parceling of an area equipped with a subterranean pipe network with mounted hydrants

5) Open canal water distribution network for sprinkling (Figure 6).

WST is the area which is irrigated from one motor-pump aggregate position. It is considered that a pump aggregate of 40 l/s debit serves 30 ha. The one border lies on the open canal; the others follow the general land planning and consolidation requirements. An IM consists of the irrigated area of one portable

sprinkler wing. Both long sides of an IM's are parallel and perpendicular to the open canal.

6) Rice irrigation system (Figure 7).

The technological parcelling of the rice fields is entirely conformed to their specific structure and service. One of the most important things there is that the consolidated landed properties should be equal to the rice field area. If it is smaller, the spare part will be destroyed. The size of the rice field should fulfil the requirement of a full probability water supply of the irrigation system.

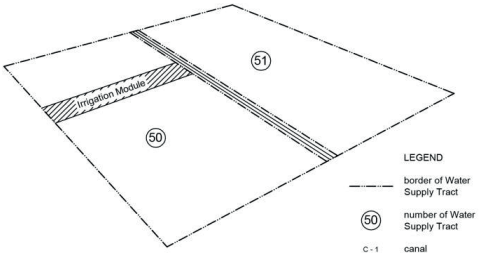

Figure 6. Technological parceling of an area equipped with a rice irrigation system

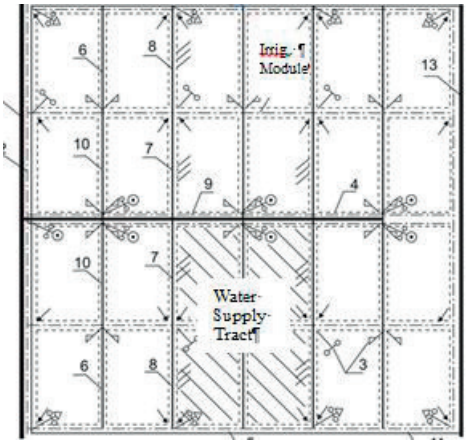

Figure 7. Technological parceling of an area equipped with a rice irrigation system (Source: Volkov, 1997)

7) Open drainage system (Figure 8).

The technological parceling of drainage systems equipped lands should be adapted mostly to the natural conditions of the land. A Drainage Technological Parcel should lie within the area drained by one collector and its draining facilities or within the drained by a single water surplus controlling device (drain ditch, sucker, and additional drains) area. Its configuration and size are conformed to the situation, configuration and size of the drained tract. It is important to have access to the natural and artificial water inlets of the drainage system and to follow the direction of the permanent and temporary water control line elements and of the land reclamation and other field works. The borders coincide with the natural water inlets - rivers, gullies, ravines, etc. They have to tally with the drainage basin borders - the drainage divides and the water diversion lines, head drainage canals and other open delivery or control network canals, main subterranean collectors and other ones of a smaller class that have shafts and other devices on the earth surface. The consolidated land should be equal to the whole drained tract area if possible or be adjusted to the situation of the drains, the shafts, inlets, and other devices.

Figure 8. Technological parceling of an area equipped with a drainage system

The detached drainage tracts should be given to single owners if possible or to a group of owners who would join a cooperative for proper operation of the drainage system.

CONCLUSIONS

The recent agrarian policy of Bulgaria has approved a small-sized property and fragmented ownership. This seems to be a narrow and inadequate frame for the agricultural production processes, a harmful one for land preservation and functioning of all land reclamation infrastructures. Land consolidation is the only way to restore the interests of both - the Nature and the land owners, a tool of approaching sustainable development. Land consolidation project is a

key to a future long-term functioning of the irrigation and drainage systems and to high productivity of reclaimed land. The main activities for creating a land consolidation project and the technical norms should be regulated in a Land Consolidation Act and in the Rules for its Implementation.

When drafting a land consolidation project, the technological parceling of the popular irrigation and drainage technologies have to be considered. Guidelines for harmonization of requirements of land consolidation and technological parceling have been developed. The main concept is that the consolidated plots and the technological plots should be mutually multiples in order to keep the functionality of the irrigation and drainage systems and to guarantee unhindered water use.

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