University of Szeged

The evaluation of the excess surface waters on the Hungarian lowland's south-east part, in the expectation of the water management in Europe

PhD dissertation

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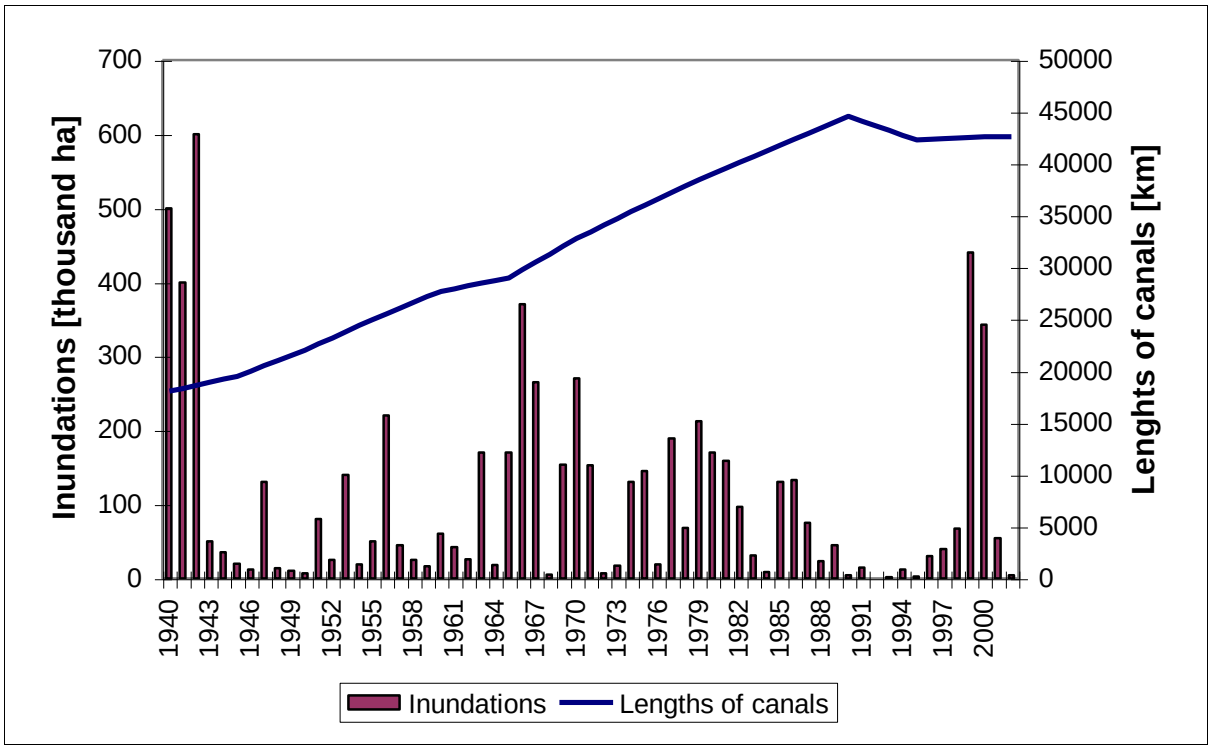
1. The justification of the research

The effort of the water damages decrease is realized in the frame of lowland drainage. It is very important, because the 60 percent of the cultivated lands, more than 4 million hectares are dangered by the excess surface waters in Hungary. The main task of the lowland drainage is the defence activity against the surplus surface water damages. There aren't natural deep valleys between natural conditions in the Lowland. For this reason those waters which aren't able to infiltrate into the deeper layers, inundate their origin place, or accumulate in the local depressions.

The inundations usually have large areas. There was a need of significant financial sources during the last decades. The efforts which were executed for decrease of the excess water damages, were determined by subjective methods. There wasn't emphasized the natural characteristics of the excess water. There weren't those possibilities in the foreground, which were in connection with the natural conditions. The methods in force adapted to the aims very well, but didn't emphasize the importance of the prevention at the case of critical situation. For this reason it wasn't able to give sufficient results in connection with the decrease of excess waters.



1. figure: Time series of the inundations and the lengths of canals (1940-2002)

The maximum of the inundated areas by undrained runoff reached the 600000 hectares (1942) during the documented time of the defence activity in Hungary. The development of the lowland drainage systems began with this excess water disaster which were accompany with this peak of the inundated. This development contained the increase of the lengths of canals and the increase of their capacity. By Figure 1. we can determine that the lengths and the capacity of the drainage systems were doubled during 50 years. In spite of this efforts we could record the 70 percent of the peak value in 1999 (440000 hectares). We can establish the new approach need in connection with the development of excess water and we can take suggestions for the efficient methods to decrease of the inundations by undrained runoff.

The main goal was decrease of the damages during the last 50 years. In spite of this aim after the development of systems there were large inundations by undrained runoff.

Hungary as a member of the European Union has engagement for the implementation of the Water Framework Directive. The goal of the Water Framework Directive is that all bodies of water should have achieved ‘good ecological status’ by 2015. For the sake of the cause we have to declare the conditions ahead in the River Basin Management Plans from 2006. We can declare that, the approach of the excess water is not possible only from the point of view of defence activity or from the point of view of agricultural sector, but the complex approach has to come to front. The aim is not only to apply the priority between the different condition systems, but has to analyse the requirements of different condition system, because the main goal is to prove the sustainable development for the water conditions, and we can fulfil this task only with the complex approach of the excess water.

Our studies shown that, the most efficient defence activity against the excess water and the requirements of the Water Framework Directive can coordinate with a practice of excess water management, which evaluate, analyse and use that but not only from the point of view of defence activity, not only from the point of view of water sources, not only from the point of view of natural conservation.

After a short introduction we can put into some questions in connection with the excess water.

Whether the methods are in connection with the excess water?

Whether the excess water runoff and the applied methods – for example the boundary conditions of the sizing methods – are coordinated with the natural character of the procedure?

How much is the influence of the anthropogenic factor at the lowland drainage systems?

How can coordinate the practice of excess water management to the requirements of the EU Water Framework Directive – as the most import document of the future in the Hungarian water management - ?

Whether can coordinate only with large problems each others the requirements of defence activity, and requirements of defence activity, requirements of river basin management, requirements of natural conservation in connection with the excess waters?

2. Applied methods

The following questions were determined during on further investigation:

- the analysis of quantity parameters of the excess water, the analyse of the characteristic curve,
- the analysis of the spatial occurrence of excess waters,
- the analysis of the water management practices which were used during the runoff procedures of excess water,
- the common analysis of the inundated areas by undrained runoff and the precipitation of the accumulation periods.

I ~~have~~ evaluated the relationship between the inundated areas and their possible runoff during the analysis of the quantity parameters of the excess water. My main goal was the determination of the characteristic line and it's parameters at the case of the study field.

In connection with the distribution of the inundations, there were large inundations since the last examined period which modified the distribution of inundations. The change of the requirements of defence activities by social and ecological conditions caused that the centre questions of the defence have moved. The sensitivity of smaller well cultivated areas increased in connection with the inundations and at some former well cultivated areas sensitivity deceased because the former big agricultural associations weren't prosper yet.
The analysis of the spatial occurrence of the excess water – on GIS platform – supports the plan of the land and region management, furthermore provide possibility for the objective evaluation of the defence activities results. In the mirror of the results analysis can began in connection with lowland drainage systems, and the strategy of the defence activities can modernize and it's practice.

We make efforts for the prevention of critical status and the exemption those areas which would be in dangerous situation with water management arrangements during the excess water periods. The applied technologies have been adopted to the parameters of the drainage systems, their natural circumstances and the preparedness of the staff, to the financial possibilities. The applied technologies based on former experiences, and adopted to the current environmentally conditions.

We can make an overview on the results of the applied technologies with analysis of the inundations map. We studied, which was the influence of the applied technologies on the spatial distribution of the excess waters.

We changed the technologies with the results of the analysis. The EU Framework's requirements make current the change. To joining the changes the applied technologies have to prove the fulfil of the different requirements. Have to provide solutions for the defence, for agricultural, ecological requirements too. The different requirements have to based on those requirements which were determined by the river basin's society.

The main goal with the common analysis of the inundated areas by undrained runoff and the precipitation of the accumulation periods was developed that method which can apply for the forecast of excess waters. The determinative element of the excess water's develop is the precipitation. The common results of the former authors papers is the development of excess waters at late winter – early spring is determinated by the precipitation of the accumulation period. The spatial distribution of the accumulation period's precipitation's sum and the spatial distribution of inundated areas take important information in connection with current catchment area. There wasn't analysis which demonstrated the relationship between the regional precipitation and the spatial distribution of the excess water. We can forecast with those figures in connection with conditions of the excess waters at late winter – early spring from the precipitation sum of the accumulation period.

3. Theses

1. When someone would like to define the phenomenon of inundations by undrained runoff, it will be realised that no suitable definition exists which includes its natural characteristic and its consequences. Several definitions contain only the damages of inundations. Especially definitions in foreign languages are not existing: in English usually inland water or surface excess water are used and in German "polderwasser". My recommendation for the definition of the inundation by undrained runoff is the following: *the excess water occurs as inundations on the surface, or from the saturated upper layers these waters do not flow away on natural (by gravity) way.*

2. Inundation can develop in two ways, i.e. horizontally or vertically. In the horizontal way the inundation is produced by natural way (gravity), or by anthropogenic effects (for example by using pumping stations). We can appoint if the development of inundation appears to horizontal flow direction, then between the effect of the natural circumstances and the location of the inundation is no direct connection.

   The vertical development way contains two vertical directions. The development of the concentration type inundation begins on the surface. At this case the concentrated water can't flow in to the deepest layers because of meteorological or morphological reasons. On the other hand, during special hydro-geological circumstances the water flow from the deepest layers to the surface determined by the conditions of ground waters.

3. From the study of characteristic curves and the quantity parameters of the inundations we can define, that the data accuracy is not significant in the range of the small inundation caused by undrained runoff and in the range of small flows. In the study area the greatest inundations and flows appears between January and March. This is important for the present and future practice, as the drainage system has to be able to accomplish its task. The characteristic curve's equation is the following:

$$\mathbf{Y= B_2}X^{\mathbf{2}}\mathbf{+ B_1}X+ \mathbf{A}$$

Y= maximum of the runoff [mm/hour]

X= specific inundation [ha/km^2]

$\mathbf{B_2}$=-0,002 [ha/km^2]

$\mathbf{B_1}$=1,044 [ha/km^2]

A=4,734 [ha/km^2]

4. From the field of the probability surface of quantity parameters I have defined that, the biggest inundations were between December and March (>2,5 ha/km^2). Based on the studied data I have to remark that smaller inundations (<1 ha/km^2) have similar probability. This wasn't proving by the experienced data. Probably, this fact is can be explained by the inadequate accuracy of the measuring method.

5. From the study of those peak flows which produced by the inundations we can define that, the more remarkable flow values (between 2 and 4 mm/hour) can be measured between February and May.

   Higher values can be rarely measured in summer. The observers measured higher flow values during the autumn in October and in November (between 1 and 3 mm/hour).

6. Based on the results on differences of the field of the probability surface of monthly flow peaks and the maximum of specific inundations I have assumed that, if at the studied month the monthly flow peak produced by a specific inundation, the difference of its probability surface converges to zero. Consequently, the connection can be proved at the minimum values of the two surfaces. We can conclude from the difference value, whether there is a delay period between the inundations and the flows, or the decreasing difference caused by other reasons. If the difference is positive, than there wasn't inundation in parallel with the flow, if the difference is negative there wasn't any flow from the inundation. We can define from the values of difference, that the maximum of the inundation and the maximum of the flows coincide with each other between January and March, consequently the flows produced by the inundations at this period. On the basis on the difference surface the extreme values of flow also can be defined, which does not pair from the extreme values of inundations between March and May. Probably, the rain is in balance with the capacity of the drainage system, the flow's dynamic is in harmony with the dynamism of the rain concentration, therefore, there are no inundations.

   The network assures the operation of reservoirs for long periods, considering the accumulation period. These reservoirs can help to eliminate the extreme effects of the water scarcity.

   A future development aim could be to use accurate measuring methods on the inundations and flows in the future.

7. The inundation probability map of the area shows, that inundations can be experienced on the 20 % of the area. There were inundations only on 1 % of the area, but such areas also exist where inundations were eight times. On the base of this fact we can define that the conditions of the inundations on the study area are indispensable from the point of view of the rural development. Form the point of view of inundation the most frequently areas are near to Szentes and Hódmezővásárhely.

8. On the study area the area where inundations appear can have two different shapes: large, extended patches or long elongated lines. At the oval shaped, patched inundations mild surface slope was identified. On these areas during the concentration period the inundations do not flow towards the direction of lower areas, and the location of the inundation remains the same.

9. In the case of elongated shaped inundations the probability of inundation increases along the canals where the slope of surface is greater. Therefore, during the study of the concentration procedure of inundations the temporary capacity of the recipient canal must be considered as a modifying function. If the recipient channel has a high level it cannot drain more water causing inundations along the canal. The flow of concentrated waters into a recipient channel does not determine the quantity of the concentrated water, but the capacity of the recipient. The recipient channel is able to drain the access waters if the quantity of the concentrated water is not greater than the storage capacity of the recipient drainage system. If the quantity of the departing water is greater than the capacity of the recipient, the difference between the two volumes will cause inundations in the vicinity of the outlet and will result inundations upstream. This procedure can be observed at the pumping stations, where sometimes that amount of water causes inundations which is exceeds the capacity of the station. The high probability of the inundations along the canals makes further corrections necessary in the recently applied sizing procedure, because the probability of inundation increased along the canals.

10. The canals of drainage systems would be built with bigger slope than the catchment original slope. The spatial distribution of the excess waters would be modify by the canals. We can declare that the distribution increased along canals, on this way the drainage system modified the center of weight of inundations on the traces.

11. During the last 40 years in the inundation defence activity the most important aim was to increase the natural flow velocity. Based on the probability map of inundations one can define, that the modernization of the sizing method is indispensable because the modified concentration theory is not suitable for the use. The defence activities should be modernized in the case of inundations along the canals which are signed to eliminate inundation damages. Instead of the applied priority of the draining categories of sensitivity should be determined in connection with the inundations. The determined sensitivity categories should be considered in the financial analysis.

12. In connection with the implementation of the EU Water Framework Directive, a sustainable development of river basins has to be provided. We have to aspire to favourable water management conditions in connection with small catchments, to reserve water resources. To reach this aim the reservoirs can provide reservation and can eliminate the charging of canal network.

13. The literature research shows that the effect of anthropogenic factors has not been examined in the required depth in the different articles. These factors can decrease the efficiency of the forecasts. It would be important to determine the value of inundation hazard as a function of the caused damages.

14. During the study of the development of excess water is very important the local and regional parameters to take consider in the proper level. Not proper to take consider on the regional level the local parameters.

15. The network of canals plays a determinative role the spatial varying of inundations. Because of the increased probability the lowland drainage system's capacity should be re-sized. During the procedure an effort should be taken to reconstruct the "original" probability of the inundation and the role of gravity should be emphasised in the delaying of flows. If we drain away only the excess waters, than we will foresee the development of the water resources balance of the catchment.

16. We have to make effort to build reservoirs considering the location of inundations. We have to extent the water resources management activities on those waters which appeal in the excess water periods. At those activities of which the aim is the delaying of the surface water flow, parallel connection between the parts of the drainage should be design instead of serial connections. (The reservoirs along the canals can be an appreciate approach of this question.) Expectedly the range of water will be more balanced because of the continuous draining and the effect of the anthropogenic impacts can decrease.

    In connection with the effect of rain, I have defined the distribution of measured precipitation values. These figures can be used in the activity at time of excess waters to plan the prevention activities.