pp. 11-20

2. Development of risk and hazard maps for floods in localities on Chilia Branch

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Abstract: The paper meets the requirements of Directive 2007/60 / EC of the European Parliament and Council from 23 October 2007 on the assessment and management of flood risks, namely making hazard maps and flood risk maps at individual river basin scale detailed for localities on Chilia branch: Patlageanca, Sălceni, Ceatalchioi, Plauru, Pardina, Chilia Veche and Periprava. The designed hydraulic scenarios simulate real situations with breaches in the protective embankment of a width of 20m for 1 day. In total, were made 33 scenarios starting from the minimum to the maximum flooding levels with a step of increasing the water level at 25cm. Based on flood hazard maps, there were also made flood risk maps using the vulnerability curves for the analyzed categories: buildings, agriculture, road, forest, grassland.

Keywords: flood risk, hazard map, flood risk map, hydraulic modeling

INTRODUCTION

Developing and implementing a modern and efficient monitoring system and a predictive model for the dynamics of sedimentation in the Danube Delta is an essential element, and in his absence will still maintain an unappropriated management regarding desilting actions for the canals, dredging and management of sediment deposits. Also, there will still be obstacles in natural water circulation, leading to blocking access channels and eutrophication in areas with low water flow. In the absence of investments to support local action to reduce nitrate pollution of waterways will continue to maintain a high tendency of pollution from agricultural and animal husbandry. Without development of studies and technical assistance for biodiversity conservation and restoration of ecosystems and natural habitats in Natura 2000, will be kept the inadequate conservation status of species and habitats of community interest affected by anthropogenic impacts. (EPC, 2016)

In March 2015, the European Environment Agency (EEA) published its five-year pilot report, 'European environment - state and outlook 2015' (SOER 2015). The report provides a comprehensive assessment of the environment in Europe, trends and prospects and places it in a global context. It informs on the implementation of the European environmental policy between 2015 and 2020 and analyzes the opportunities to modify existing policies and knowledge used to inform these policies in order to achieve the 2050 vision of the European Union to live well within the planet limits.

In this direction, the European Environmental Policy includes in the world general scenario the growing pressures on the ecosystems, the consequences to more severe climate change impacts and increased pollution effects. From this perspective, the hydraulic hazard and risk scenarios for small scale floods fit into the strategy of the European Environmental Agency. (EEA, 2016)

METHOD

Planning for development of hazard and risk maps for localities on the Chilia Branch is presented in Figure 1.

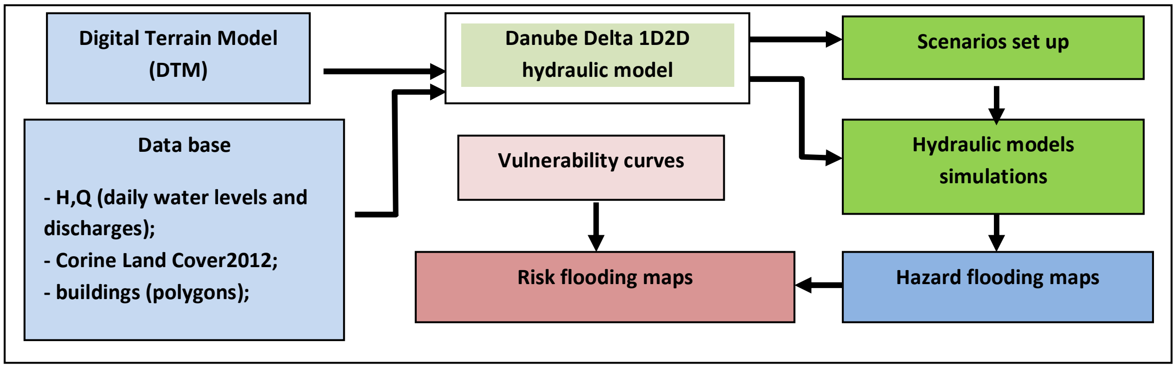


Figure 1 Methodology for development of hazard and flood risk maps

The input data used for localities on the Chilia Branch (figure 2) used the following spatial data:
-Digital model of the terrain – DTM (project "CARTODD", 2009-2012);
-Digital model of elevation –DEM (project "CARTODD", 2009);
-Buildings/houses belonging to the localities by digitizing the polygons on orthophoto images;
-HRLs (High Resolution Layers) and land cover (project CLC 2012, 2012-2014);
-Hydrographic data bases (daily series of levels and flows in hydrographic stations).

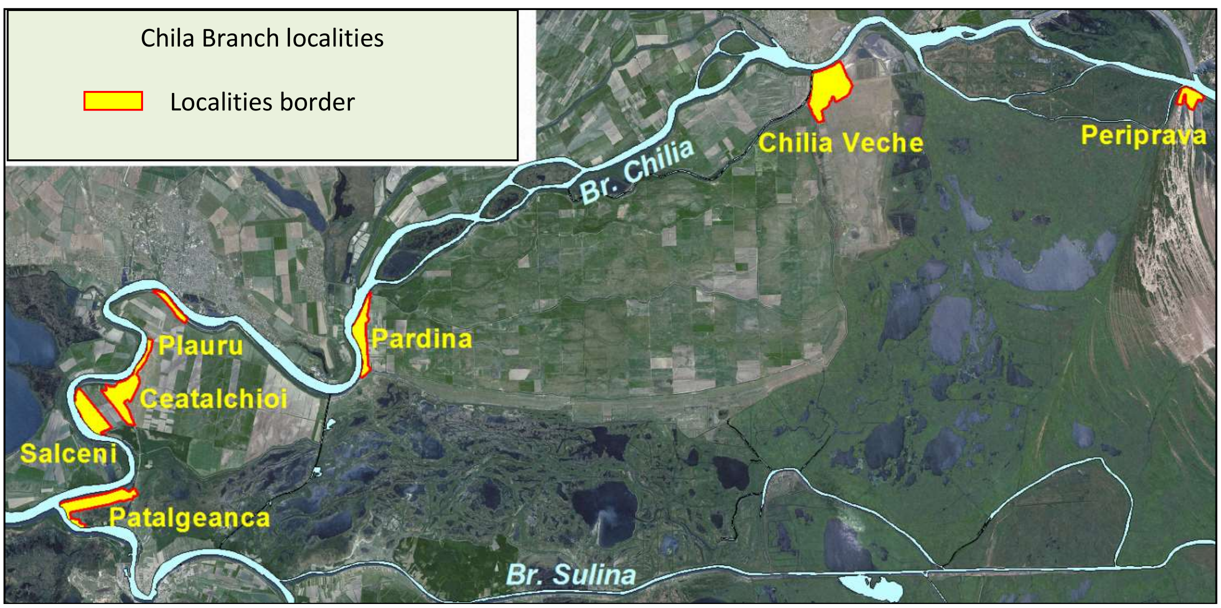


Figure 2 Localities on Chilia Branch

Due to the fact that Corine Land Cover uses big polygons of 25 ha, we digitized the buildings/houses in the localities on a small scale (figure 3), in accordance with the digital resolution model of the terrain ("cell size" of 5m)

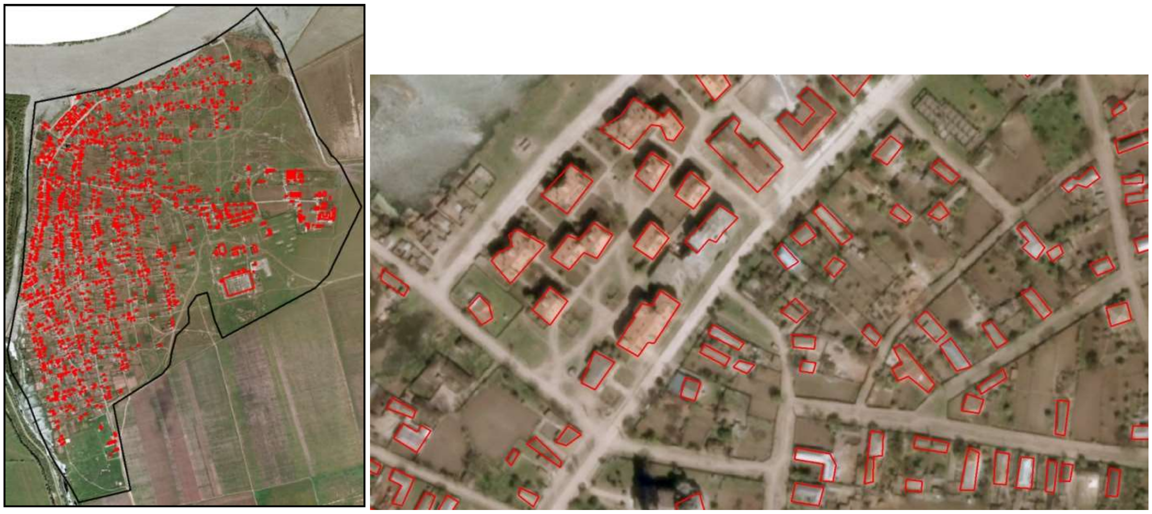


Figure 3 Vectorization of the buildings perimeter for Chilia Veche Locality.

For the establishment of hazard scenarios for floods, there were taken in consideration two aspects:

a) Establishing the localization of levees from breach defenses ;
b) Set levels of the Danube from the minimum level of flooding determined by the digital terrain model to the maximum Danube level on the Chilia Branch.
The levees in the breach defenses were positioned to have the most negative impact for each locality based on the digital terrain model. Breaches width was set at 20 m (Figure 4) and 1 day breach opening (time required for taking urgent actions).

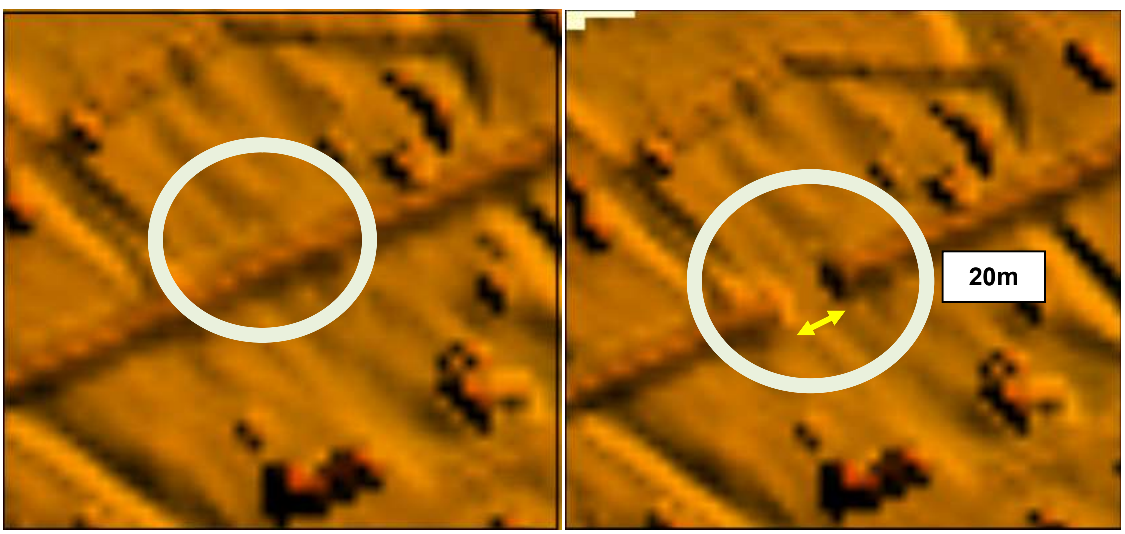


Figure 4 Levee of 20m on the breach defense

The set of hydraulic scenario was performed using the hydraulic model of the Danube Delta 1D2D to determine the minimum flooding of each locality. Based on these minimum values and using a minimum of 25cm step to increase the maximum water level recorded at hydrometric stations resulted in 33 scenarios flood hazard and risk : 6 for Patlageanca, 5 for Salceni, 4 for Ceatalchioi, 6 for Plauru, 5 for Pardina, 3 for Chilia Veche and 5 for Periprava (Table 1).

Table 1. Level sets used for 1D2D hydraulic modeling

Locality	Chilia Branch water level (m) ("0" reference MN 75)																	
Patlageanca												3.75	4.00		4.25	4.50		4.75	5.08
Salceni												3.75	4.00		4.25	4.50		4.75	
Ceatalchioi												3.75	4.00		4.25		4.54		
Plauru								3.00	3.25	3.50		3.75	4.00	4.18					
Pardina								3.00	3.25	3.50	3.63								
Chilia Veche					2.00	2025.00	2.41												
Periprava	0.25	0.50	1.00	1.19															

For each locality on the Chilia Branch, it was used the digital terrain model, not only for locality limits, but also for a more extended surface which can permit the real model of floods. This situation is specific for Salceni, Ceatalchioi and Plauru localities which have considerable shared surfaces (Figure 5).

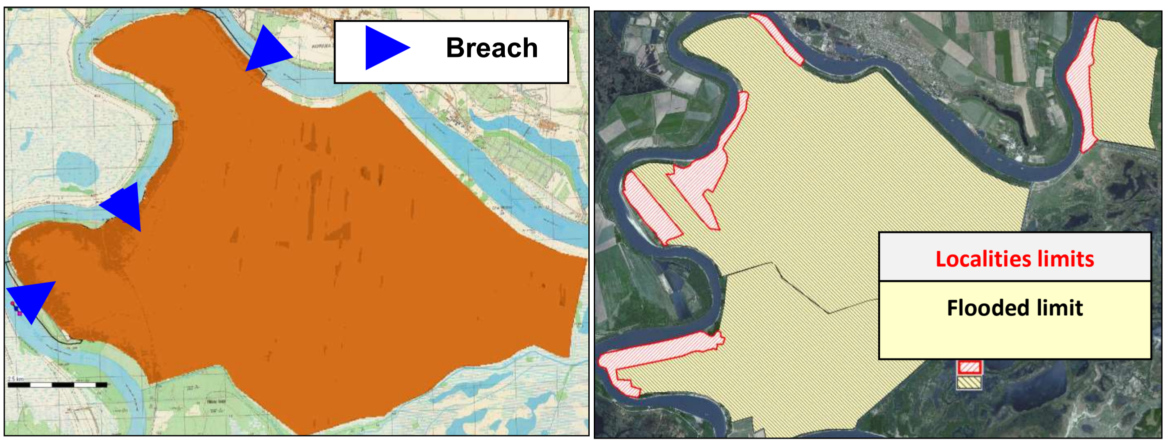


Figure 5 Digital model limits of used terrains for 1D2D hydraulic models of localities on the Chilia Branch on maximum levels.

The categories for terrain land cover is used both for determining the hydraulic roughness factor (Manning) and to quantify the flood risk index for each different category. Flood risk analysis quantifies the impact of flooding (risk ratio depending on water depth) on population (risk priority) and material assets (buildings, farmland, roads, forest, pasture, etc.). All these correlations are characterized by vulnerability curves (project "Danube Floodrisk", 2009-2012) for each social or economic category analyzed (**Figure 6**).

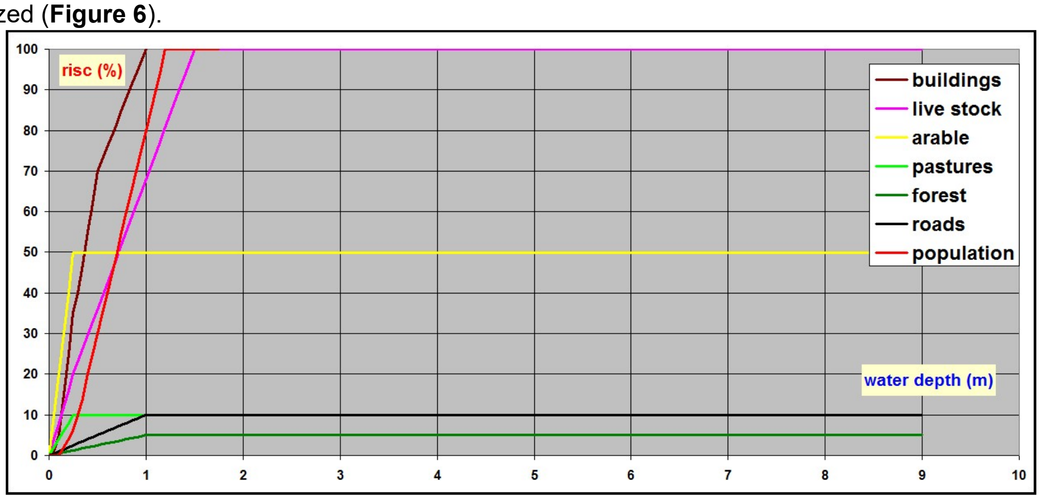


Figure 6 Vulnerability curve for different categories.

Since the system of construction of houses in Danube Delta is adobe, the vulnerability curve for buildings has been modified for this type of construction (**Figure 7**).

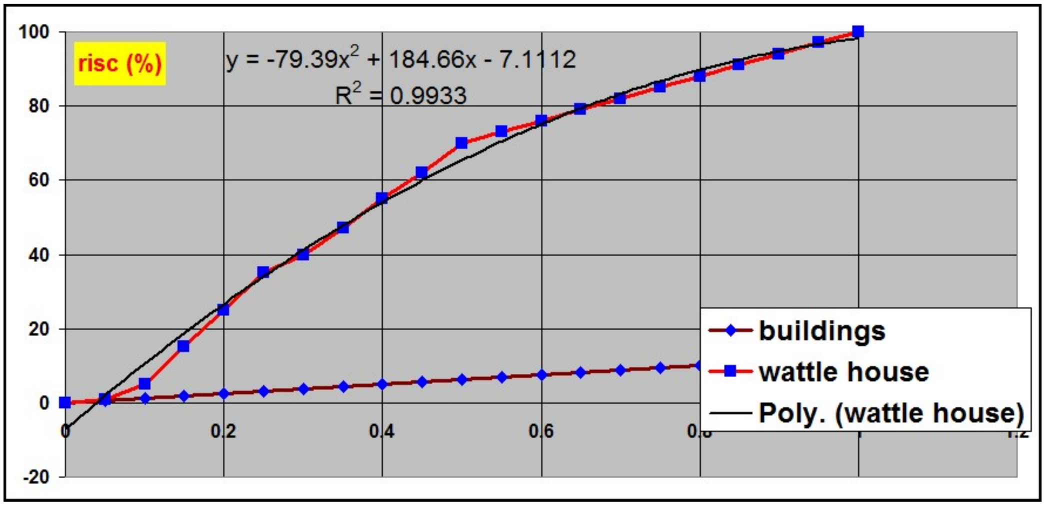


Figure 7 Vulnerability curve for adobe type buildings.

The hydraulic model 1D2D, created and updated for more than 20 years by DDNI, was used to run scenarios in the Danube Delta (**Figure 8**)

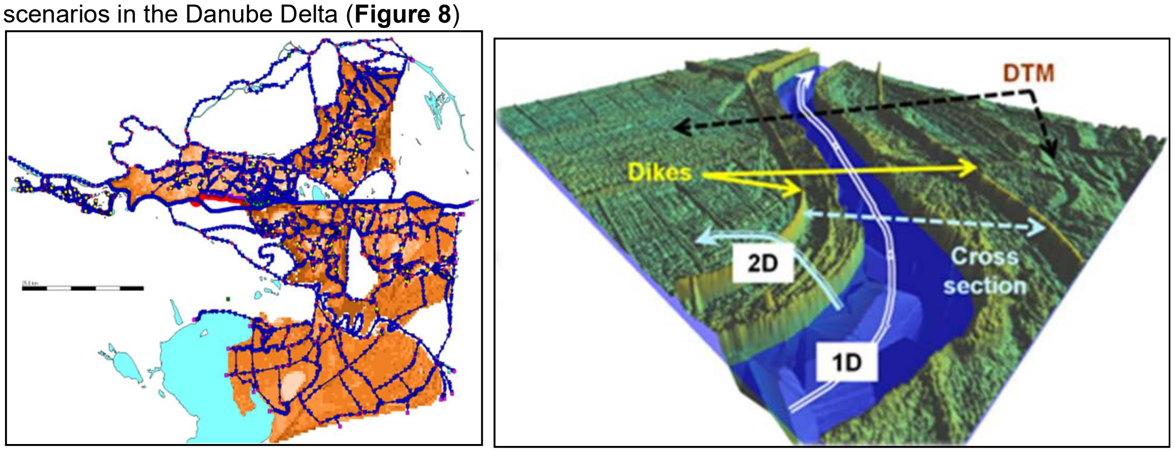
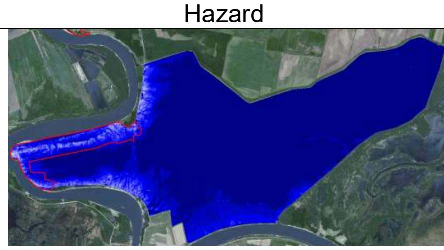
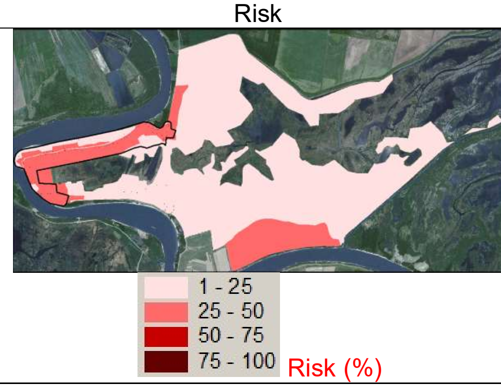


Figure 8 Hydraulic model 1D2D for Danube Delta

RESULTS

After running 1D2D hydraulic models for the 33 scenarios (breaches width was set at 20 m and 1 day breach opening) there were carried out flood hazard maps for localities on the Chilia Branch. For the worst case of maximum levels, in Table 2 hazard and flood risk maps are presented for each locality from Chilia Branch.

Table 2 Hazard and risk maps for floods for localities on the Chilia Branch.

	Hazard	Risk
Patlageanca Cota 5.08 m MN75 S_inundata 4488 ha		

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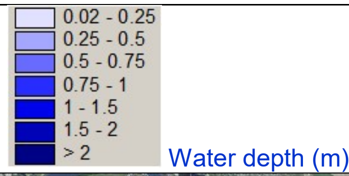
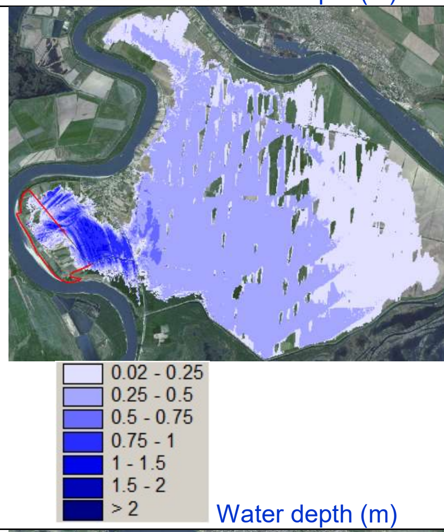
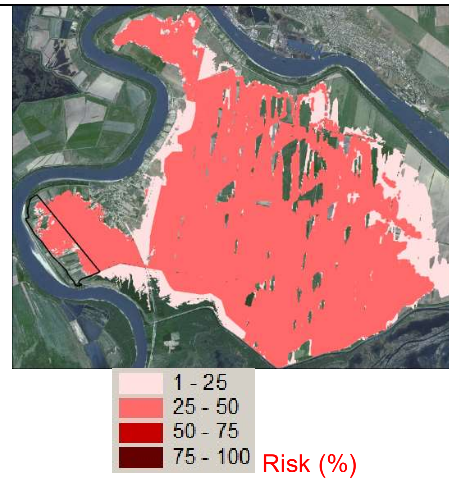
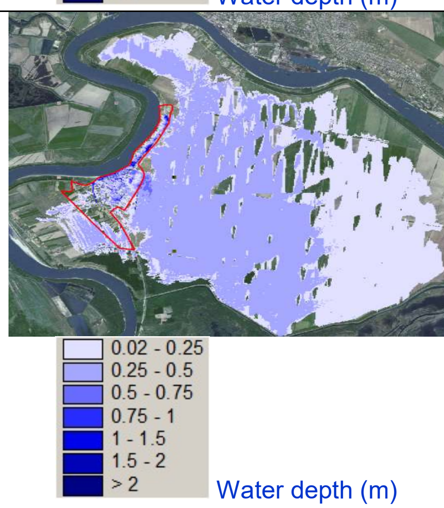
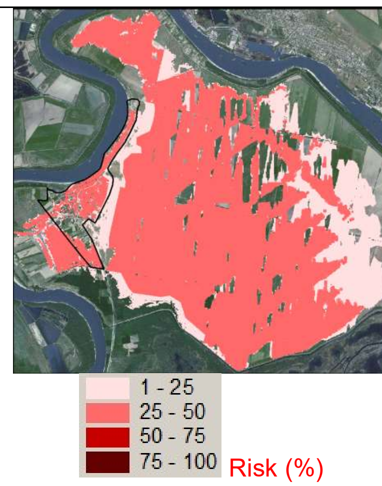
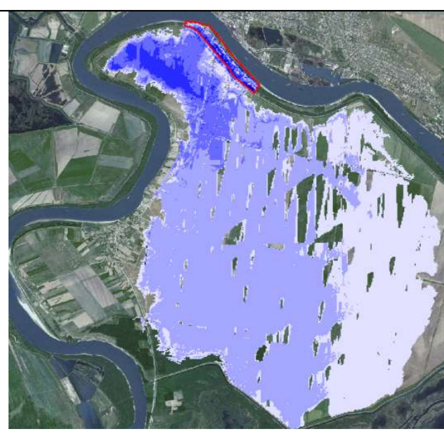
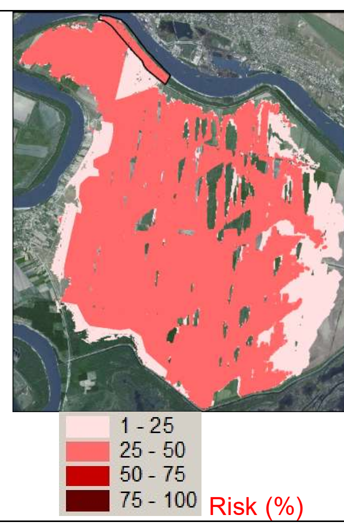
<tr><td></td><td></td><td></td></tr>
<tr><td>Salceni
Cota 4.75 m MN75
S_inundata 5173 ha</td><td></td><td></td></tr>
<tr><td>Ceatalchioi
Cota 4.54 m MN75
Flooded area 4735 ha</td><td></td><td></td></tr>
<tr><td>Plauru
Cota 4.18 m MN75
Flooded area 4541 ha</td><td></td><td></td></tr>
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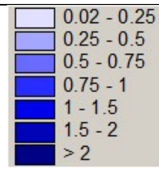
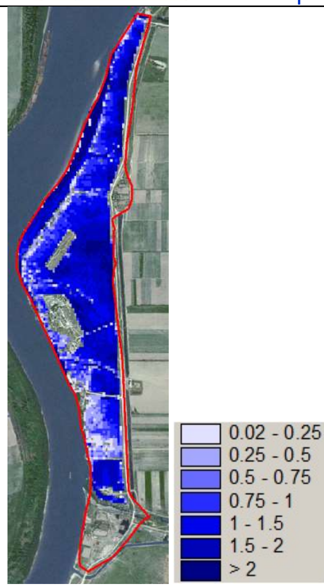
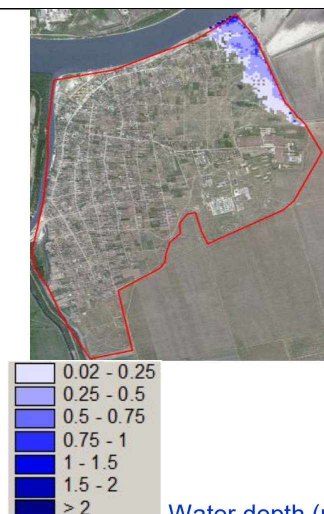
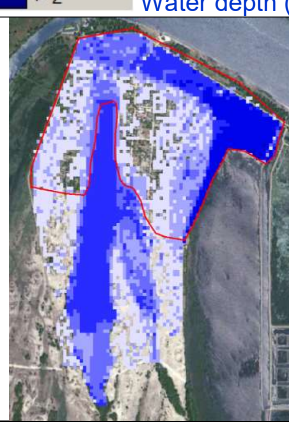
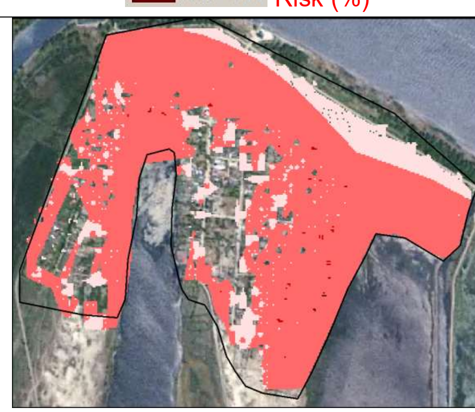
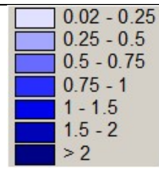
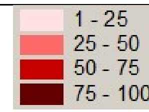
	 Water depth (m)	
Pardina Cota 3.63 m MN75 Flooded area 154 ha	 Water depth (m)	 Risk (%)
Chilia Veche Cota 2.41 m MN75 Flooded area 22 ha	 Water depth (m)	 Risk (%)
Periprava Cota 1.19 m MN75 Flooded area 160 ha		

	 Water depth (m)	 Risk (%)

CONCLUSIONS

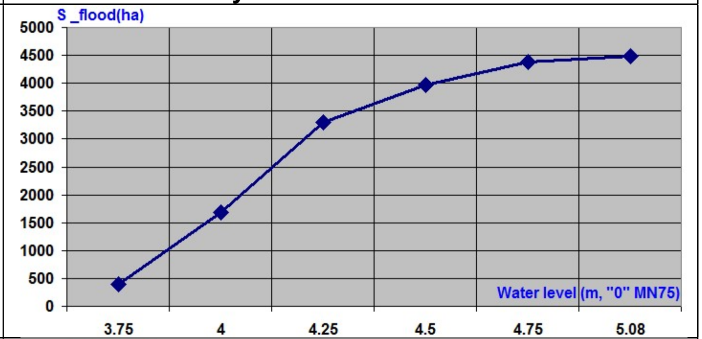
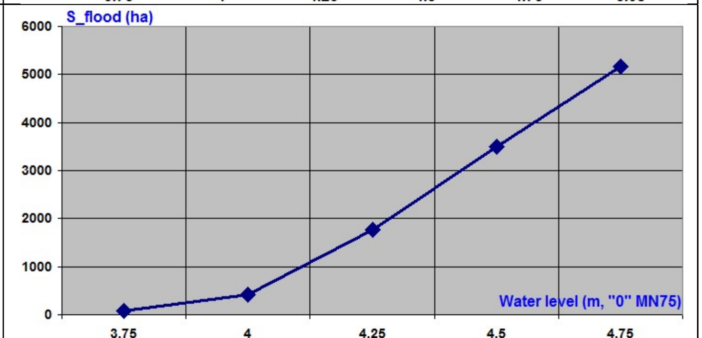
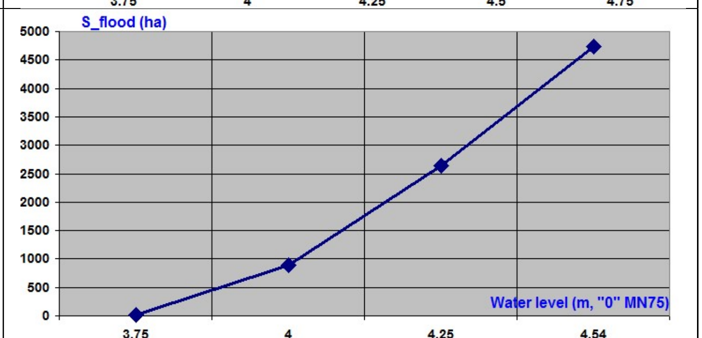
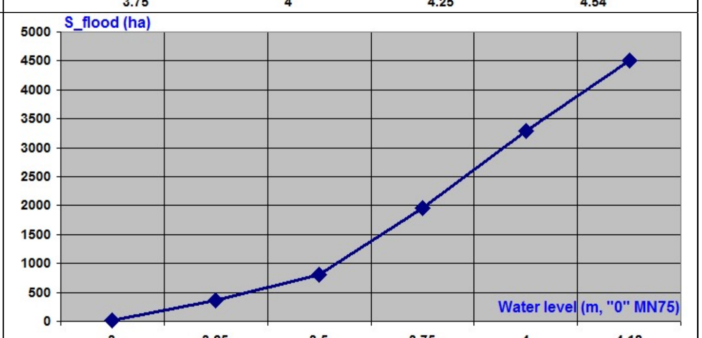
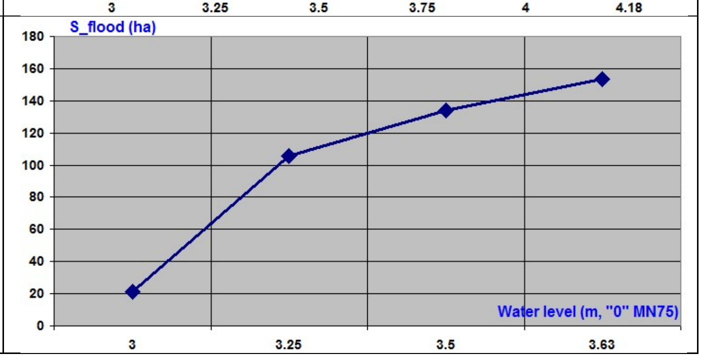
The paper summarized the results carried out during 2016 of the project “Flooding hazard and risk maps for the Danube Delta localities “ performed by the Danube Delta National Institute for Research and Development Tulcea (proiect PN 16 28 03 02 04, 2016) in the frame of the national research plan.
The paper shows the methodology used to develop the hazard and flood risk maps on a small scale in detail with applications for localities on the Chilia Branch as a mandatory step of switching from standard maps of flood hazard (range comeback 30, 100 years) to simulate real situations that may arise in a short time (1 day) by breaking the protective breaches.
To define the set of scenarios for hazard floods for localities on the Chilia Branch, 2 steps have been undertaken: the localization of levees in breach defenses for the worst case floods and establishing the set of values of Danube levels, necessary for 1D2D hydraulic modeling from minimum levels of flooding to the maximum, corresponding to the year 2010.
Finally, there were obtained 33 hydraulic scenarios as follows: 6 for Patlageanca, 5 for Salceni, 4 for Ceatalchioi, 6 for Plauru, 5 for Pardina, 3 for Chilia Veche and 5 for Periprava.
For the worst case scenario, namely high historic quotas for the Danube, flooded areas for each locality and flood risk classes are the following:

Locality	Water level (“0” reference MN 75)	Flooded area (ha)
Patlageanca	5.08 m	4488
Salceni	4.75 m	5139
Ceatalchioi	4.54 m	4676
Plauru	4.18 m	4391
Pardina	3.63 m	136
Chilia Veche	2.41 m	21
Periprava	1.19 m	160

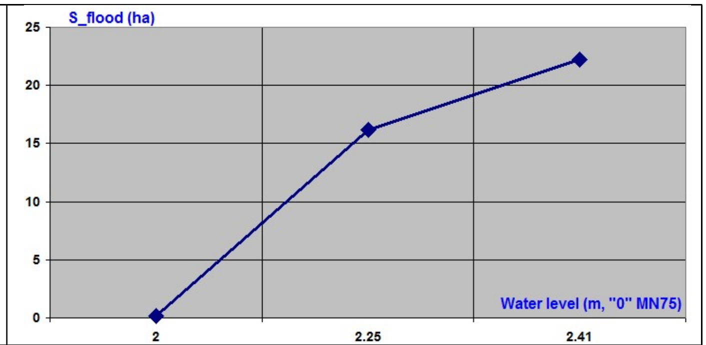
Locality	Water level (“0” reference MN 75)	*Risk classes (%)*			
		1-25	*25-50*	*50-75*	*75-100*
Patlageanca	5.08 m	81.14	18.81	0.02	0.03
Salceni	4.75 m	17.76	82.24		
Ceatalchioi	4.54 m	22.98	77	0.01	0.01
Plauru	4.18 m	20.18	79.8	0.01	0.01
Pardina	3.63 m	1.03	97.84	0.25	0.88
Chilia Veche	2.41 m	18.56	81.44		
Periprava	1.19 m	15.42	84.37	0.18	0.03

The flooded area dynamics of the analyzed scenarios are presented in the table 3.

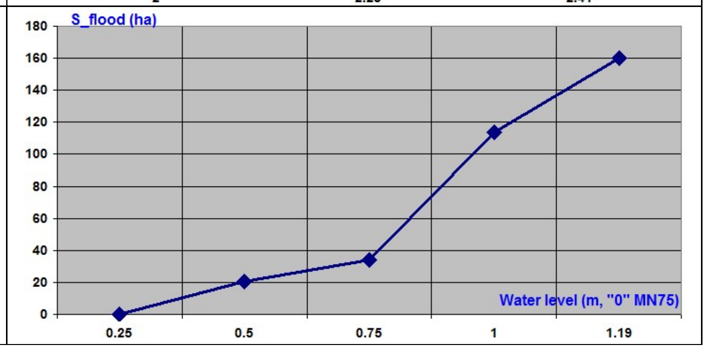
Table 3. Flooded surface for each localities and scenario

Locality	Flooded surface dynamics
Patlageanca	
Salceni	
Ceatalchioi	
Plauru	
Pardina	

Chilia Veche



Periprava



The scenarios simulation results show that all the localities from Chilia Branch (Patlageanca, Salceni, Ceatlachioi ,Plauru, Pardina, Periprava) aside from Chilia Veche are vulnerable to unexpected breaches in the defense dikes.

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Received 7 March 2017
Revised 31 March 2017