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25. Flooding Hazard and Risk Maps for Localities along Sulina and Sf. Gheorghe Branches

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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 along Sulina and Sf. Gheorghe Branches. 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 42 scenarios for Sulina Branch and 33 for Sf. Gheorghe Branch 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 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). The work updates the flood hazard and risk maps elaborated for the localities along Sulina and Sf. Gheorghe Branches (Constantinescu, 2017).

MATHERIAL AND METHODS

Planning for development of hazard and risk maps for localities along Sulina and Sf. Gheorghe Branches is presented in Figure 1.

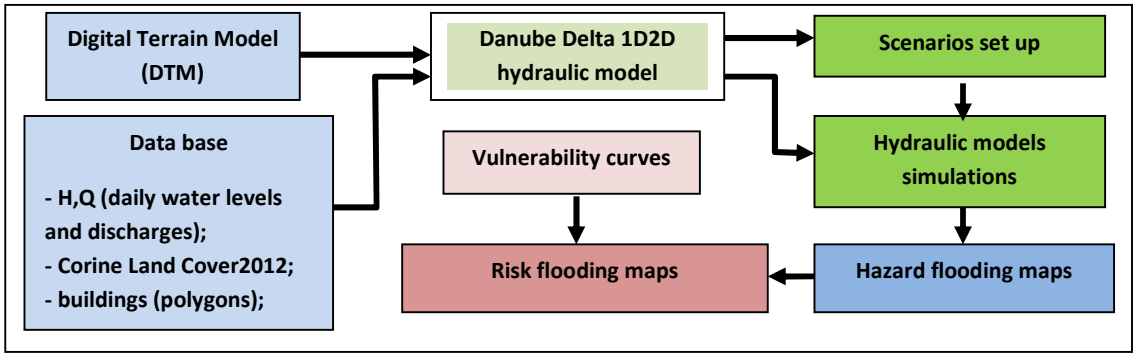

Figure 1. Methodology for development of hazard and flood risk maps

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The input data used for localities along the Sulina and Sf. Gheorghe Branches (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 (digitizing the polygons on orthophoto images);
-HRLs (High-Resolution Layers) and land cover (project CLC 2012, 2012-2014);
-Hydrographic databases (daily series of levels and flows in hydrographic stations).

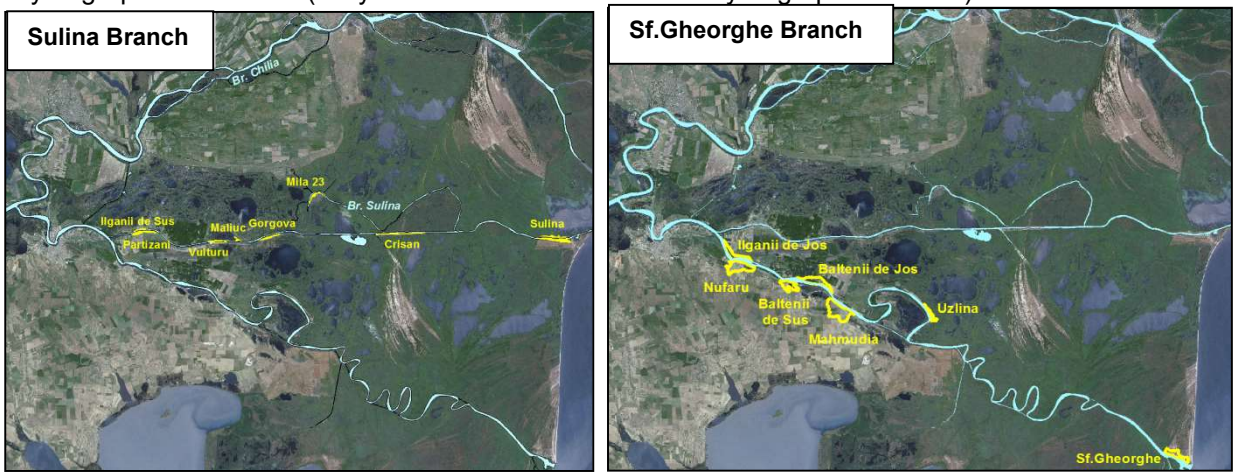

Figure. 2. Localities along Sulina and Sf. Gheorghe Branches

For the establishment of hazard scenarios for floods, there were taken into 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 along Sulina and Sf. Gheorghe Branches.
The levees in the breach defenses were positioned to have the most negative impact (figure 3, 4) for each locality based on the digital terrain model. Breaches width was set at 20 m and 1-day breach opening (time required for taking urgent actions).

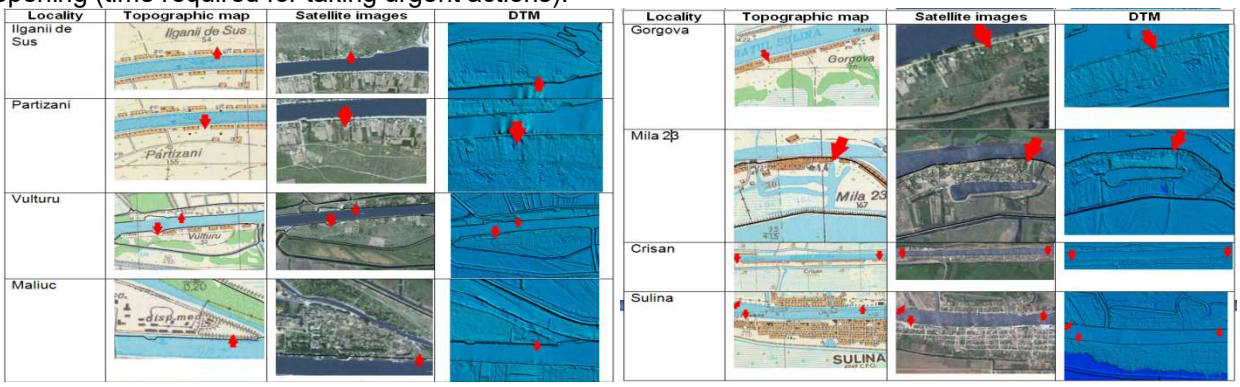

Figure. 3. Breaches scenarios along Sulina Branch

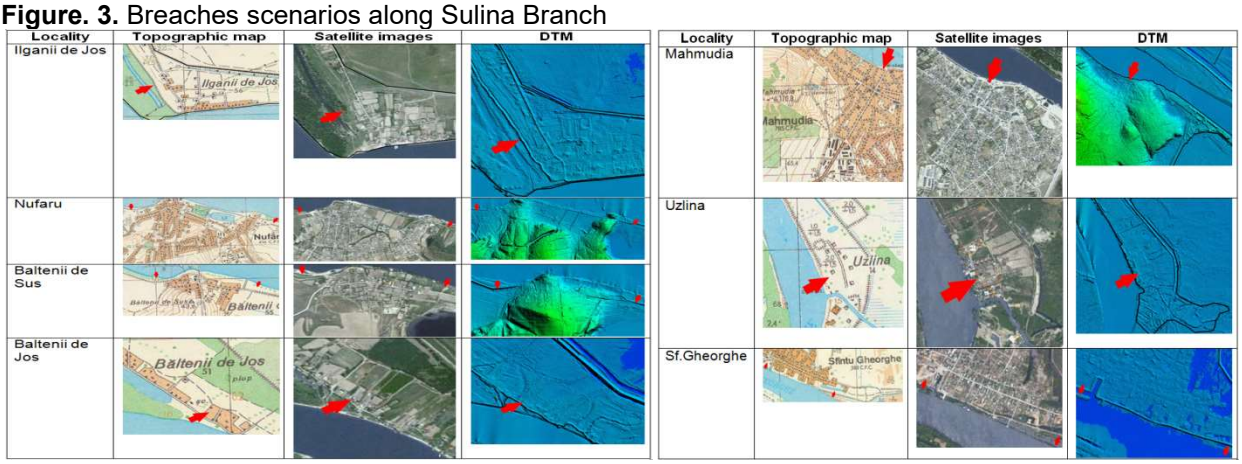

Figure. 4. Breaches scenarios along Sf. Gheorghe Branch

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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 were analyzed 42 scenarios for Sulina Branch and 33 for Sf. Gheorghe Branch (Table 1).

Table 1. Level sets used for 1D2D hydraulic modelling

Localities	Iganii de Sus	Partizani	Vulturu	Maliuc	Gorgova	Mila 23	Crisan	Sulina
Water level Sulina Branch (m MN75)								
		2.50	2.25	2.25	2.50	1.75	1.60	0.75
	2.95	2.75	2.50	2.50	2.75	2.00	1.85	1.00
	3.20	3.00	2.75	2.75	3.00	2.25	2.10	1.24
	3.45	3.25	3.00	3.00	3.11	2.50		
	3.70	3.50	3.25	3.25				
	3.95	3.75	3.50	3.43				
	4.32	4.00	3.61					
		4.32						
Scenarios	6	8	7	6	4	5	3	3
42 Scenarios								

Localities	Iganii de Jos	Nufaru	Baltenii de Sus	Baltenii de Jos	Mahmudia	Uzlina	Sf.Gheorghe
Water level Sf.Gheorghe Branch (m MN75)	3.00	3.00	2.25	2.25	2.75	1.75	0.35
	3.25	3.25	2.50	2.50	3.00	2.00	0.60
	3.50	3.50	2.75	2.75	3.19	2.25	0.87
	3.75	3.75	3.00	3.00		2.50	
	3.87	3.87	3.25	3.25		2.62	
Scenarios	5	5	6	6	3	5	3
33 Scenarios							

For each locality, 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.

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 (Constantinescu, 2017).
The hydraulic model 1D2D, created and updated for more than 20 years by DDNI, was used to run scenarios in the Danube Delta.

RESULTS AND DISCUSSIONS

After running 1D2D hydraulic models there were carried out flood hazard maps for localities along Sulina and Sf. Gheorghe Branches. The results for the worst scenarios (high water levels) are presented in figure 5a,b for Sulina Branch and table 6a,b for Sf. Gheorghe Branch

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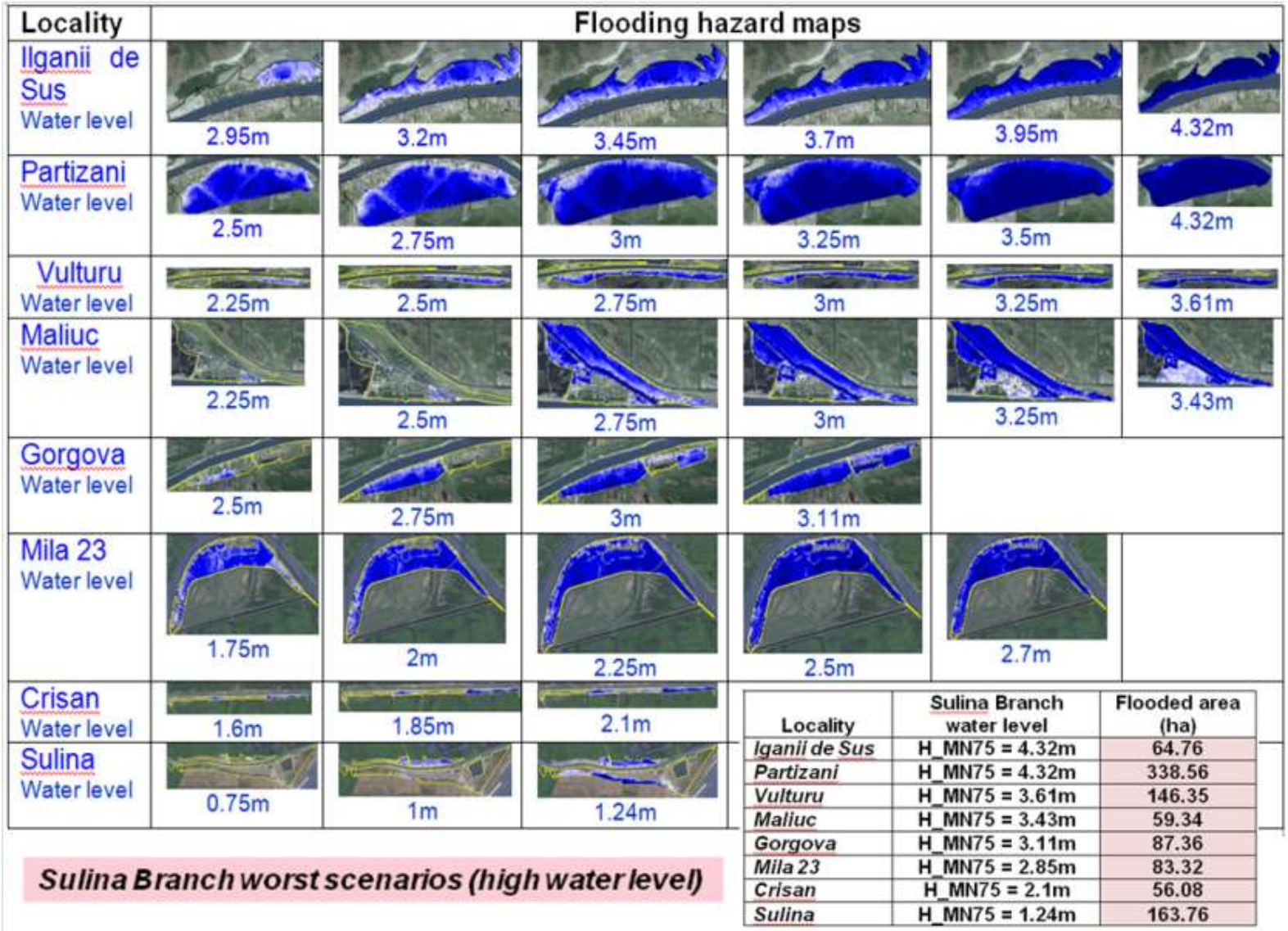

Locality	Sulina Branch water level	Flooded area (ha)
Iganii de Sus	H_MN75 = 4.32m	64.76
Partizani	H_MN75 = 4.32m	338.56
Vulturu	H_MN75 = 3.61m	146.35
Maliuc	H_MN75 = 3.43m	59.34
Gorgova	H_MN75 = 3.11m	87.36
Mila 23	H_MN75 = 2.85m	83.32
Crisan	H_MN75 = 2.1m	56.08
Sulina	H_MN75 = 1.24m	163.76

Figure. 5a. Flooding hazard maps for localities along Sulina Branch

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Fig. 5b. Flooding risk maps for localities along Sulina Branch

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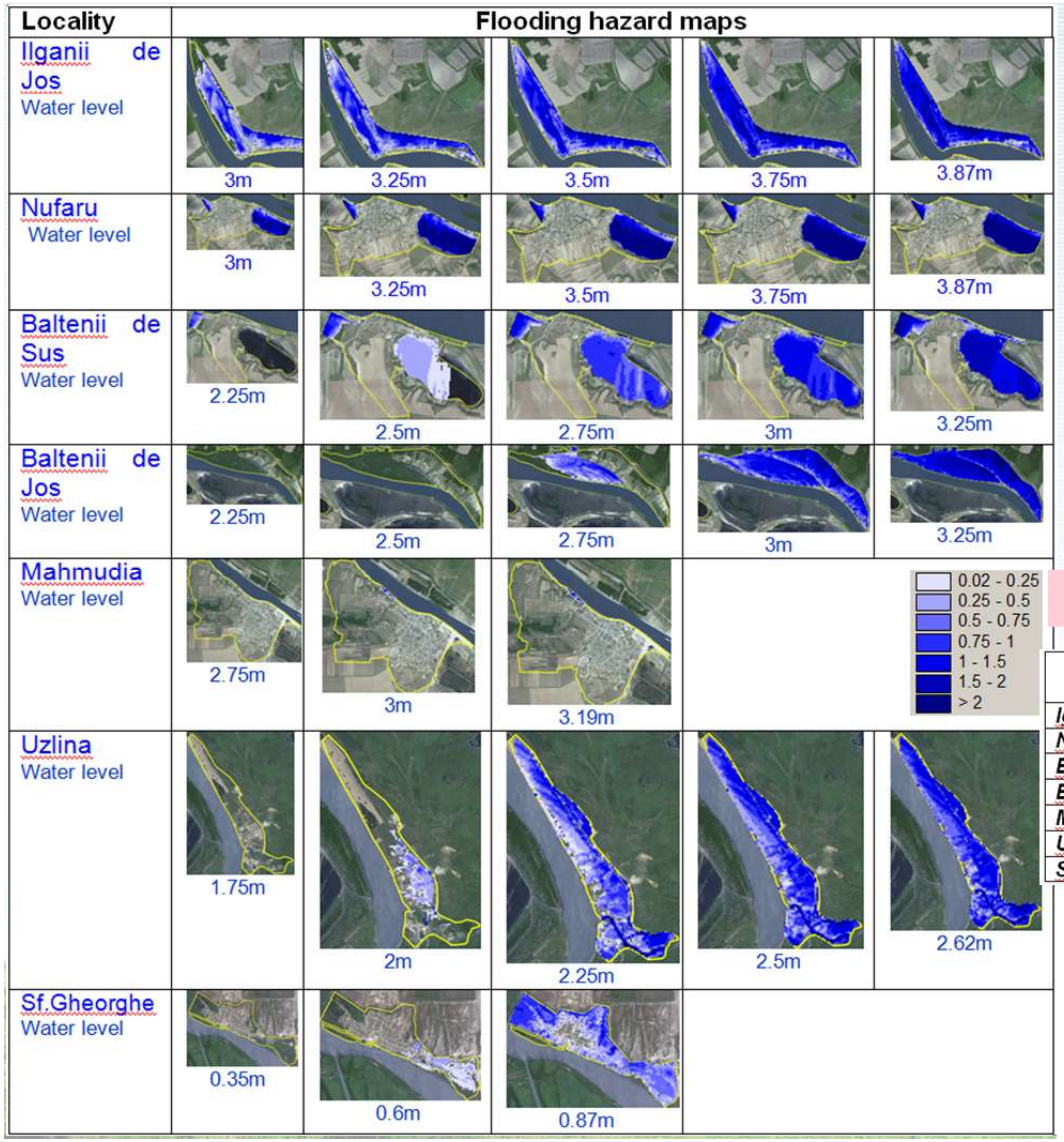

worst scenarios (high water level)

Locality	Sf.Gheorghe Branch water level	Flooded area (ha)
Iganii de Jos	H_MN75 = 3.87m	189.5
Nufaru	H_MN75 = 3.87m	98.8
Baltenii de Sus	H_MN75 = 3.25m	62.6
Baltenii de Jos	H_MN75 = 3.25m	273.1
Mahmudia	H_MN75 = 3.19m	3.56
Uzlina	H_MN75 = 2.62m	71.5
Sf.Gheorghe	H_MN75 = 0.87m	146.9

Fig. 6a. Flooding hazard maps for localities along Sf.Gheorghe Branch

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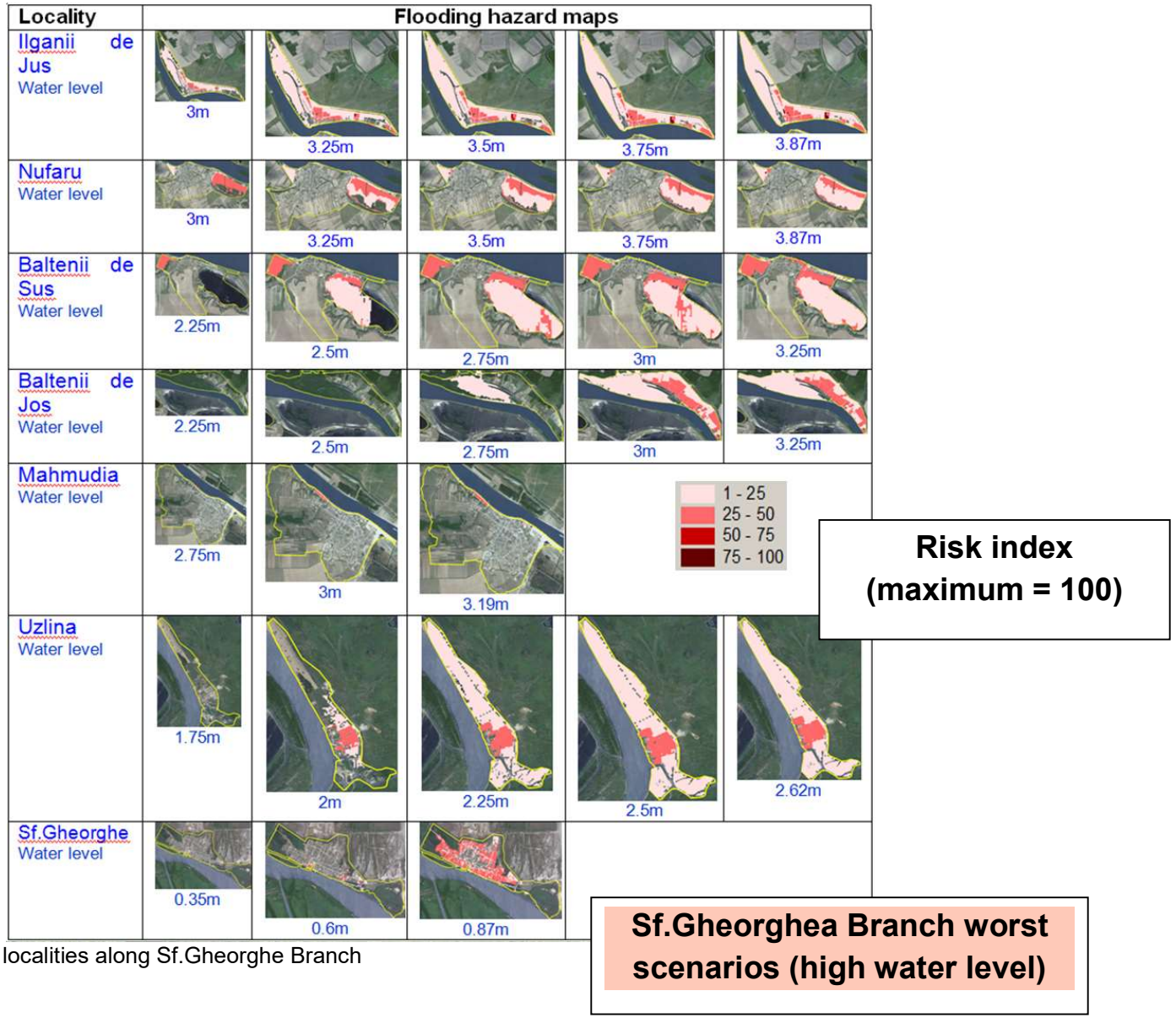

Figure. 6b. Flooding risk maps for localities along Sf.Gheorghe Branch

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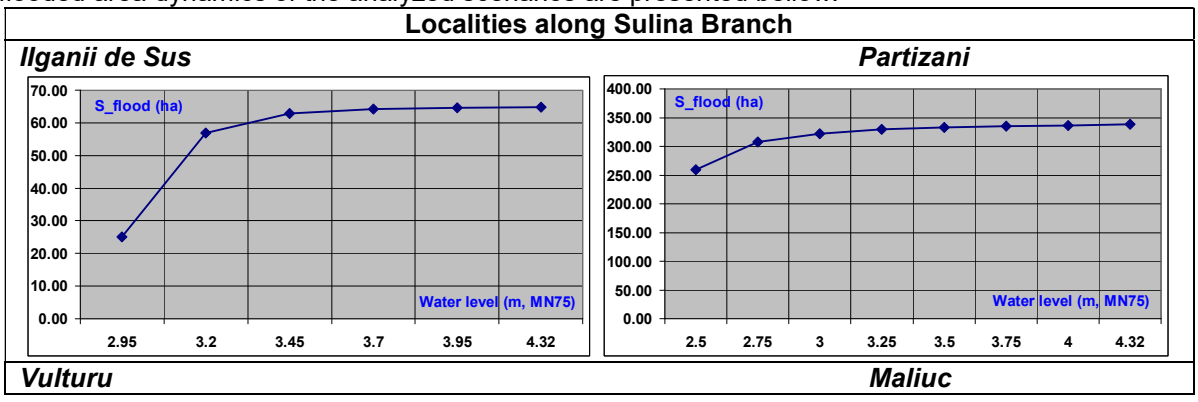
CONCLUSIONS

The paper summarized the results carried out during 2016 - 2017 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 (project 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 along Sulina and Sf. Gheorghe Branches 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 along Sulina and Sf. Gheorghe Branches, 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 42 scenarios for Sulina Branch and 33 for Sf. Gheorghe Branch.
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 along Sulina Branch	Water level ("0" reference MN 75)	Flooded area (ha)
Ilganii de Sus	**4.32m**	**64.76**
Partizani	**4.32m**	**338.56**
Vulturu	**3.61m**	**146.35**
Maliuc	**3.43m**	**59.34**
Gorgova	**3.11m**	**87.36**
Mila 23	**2.85m**	**83.32**
Crisan	**2.1m**	**56.08**
Sulina	**1.24m**	**163.76**
Locality along Sf. Gheorghe Branch	**Water level ("0" reference MN 75)**	**Flooded area (ha)**
Iganii de Jos	**3.87m**	**189.5**
Nufaru	**3.87m**	**98.8**
Baltenii de Sus	**3.25m**	**62.6**
Baltenii de Jos	**3.25m**	**273.1**
Mahmudia	**3.19m**	**3.56**
Uzlina	**2.62m**	**71.5**
Sf.Gheorghe	**0.87m**	**146.9**

The flooded area dynamics of the analyzed scenarios are presented bellow.



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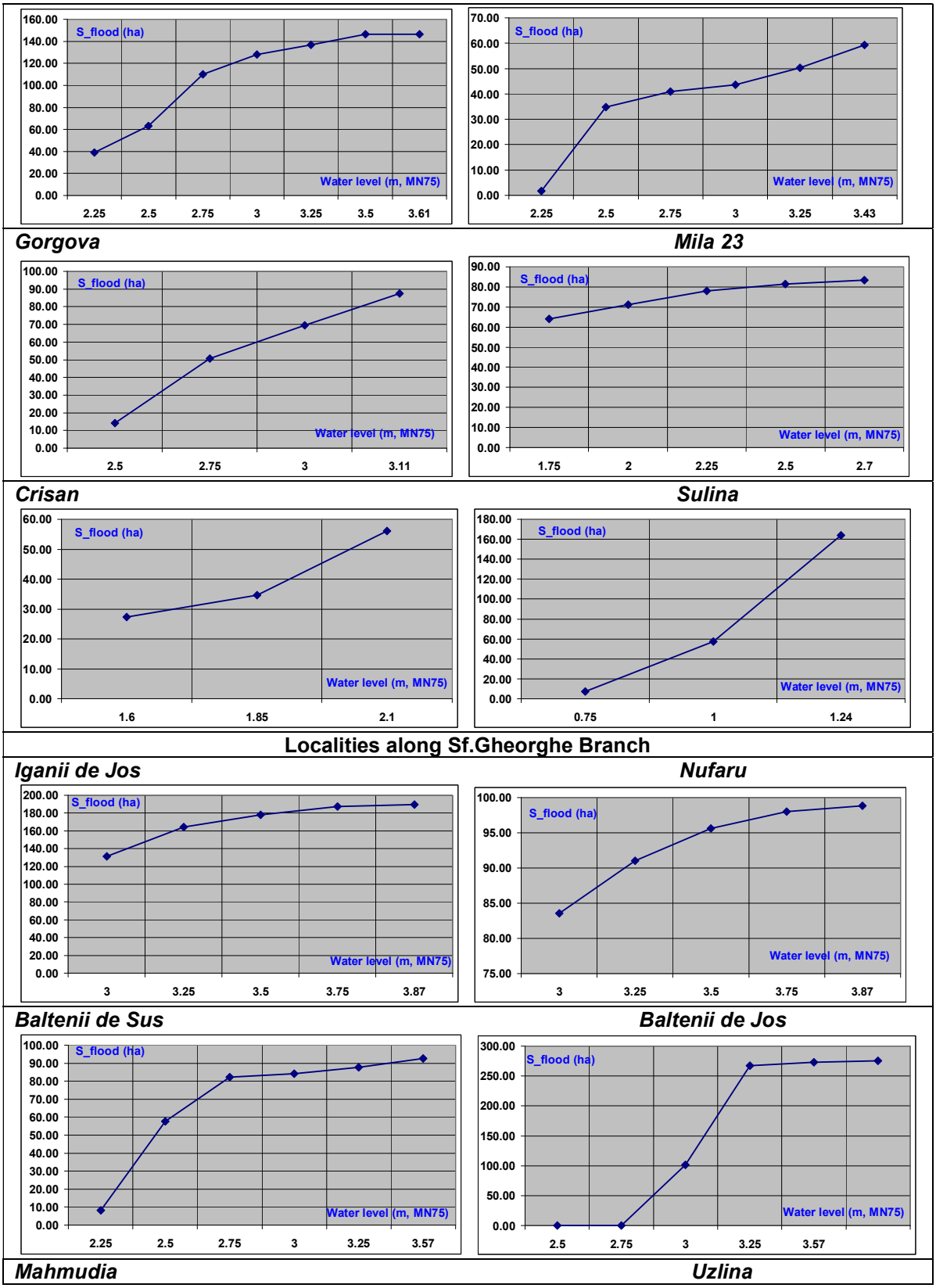

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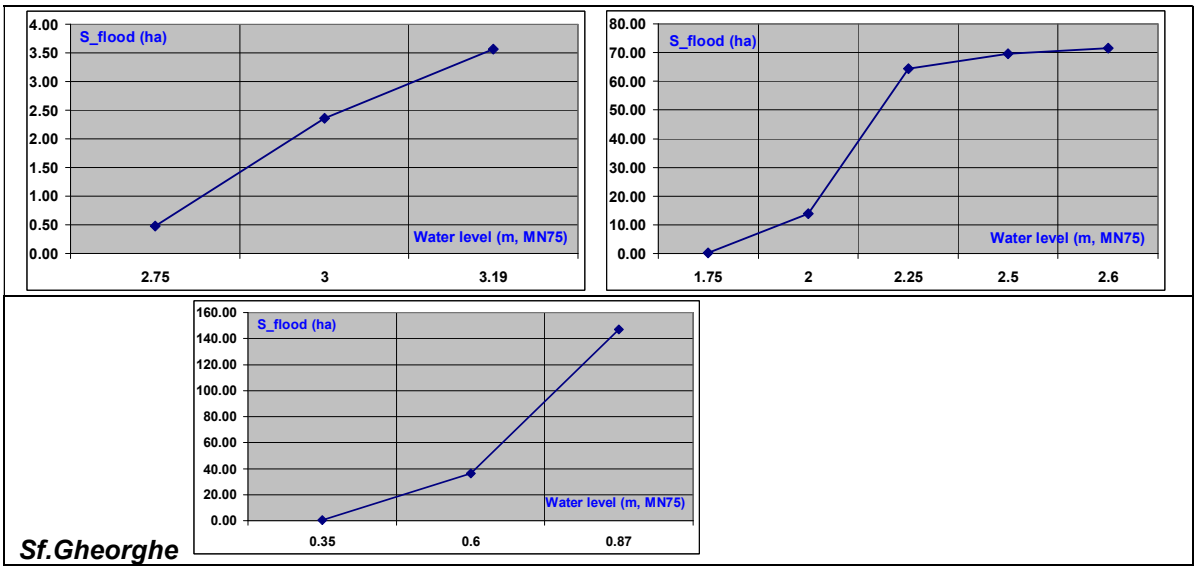

The scenarios simulation results show that all the localities, except Mahmudia, from Sulina Branch and Sf.Gheorghe Branch are vulnerable to unexpected breaches in the defense dikes.

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