METHOD TO ASSESS THE EXTREME HYDROLOGICAL EVENTS IN DANUBE FLUVIAL DELTA

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ABSTRACT. Method to assess the extreme hydrological events in Danube fluvial Delta. In this paper the subject is about of testing a method for Romania to assess the extreme hydrological events. In this paper through hydrological extreme events it should be understood as the extreme droughts and the extreme flooding. The place to be tested this method for Romania is the Danube Delta, fluvial delta to be more precisely. The importance of the area consists in the fact that is the third Delta of the Europe (after the Volga's and Kuban's). The method that is supposed to be tested on a specific part of the delta is aiming to rise the knowledge about the extreme hydrological events (drought and flooding) and to be able to respond in an appropriate way to these. For this paper it will be taken into account the hydrological events occurred in 2003 (the exceptional drought) and in 2006 (the exceptional flood). To do the analysis there were used satellite images (LANDSAT) from the period that was taken into account and additional there were used the hypsometrical model of the Danube Delta for the specific area. The first two datasets (2003 and 2006 satellite images) give information about were the border of the water (in drought period and respective in flooding one) reached. The second dataset (the delta's hypsometry) give information about the altitude of the terrain in order to establish which areas, at a certain water level, are flooded. The result of these datasets combination is the calibration of the hypsometrical model of the Danube Delta, in that region, regarding the hydrological events in the sense of building-up the hydrograds as isolines. The new approach of this matter can be more concrete and makes easier to see on the cartographic support the hydrologic events. The information obtained from these datasets makes the awareness regarding the extreme hydrological events to be higher and respective the measures taken to mitigate these will be more efficient.

Keywords: GIS, Danube Delta, hydrological extreme events, remote sensing, satellite images.

1. INTRODUCTION

In the last past years the natural phenomena act more and more with extreme characteristics. The hydrological component from the nature does not do any exception from the new trend in nature. Thus, there is need of finding new means to analyze and to research these phenomena in order to be able to predict

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them and to be able to develop techniques in order to mitigate these more often extremes. The modern way of the present to study these extremes is using the Geographical Information System (GIS) and the complementary datasets (LiDAR data, satellite images, ortophotos etc.).

From the recent examples of studies that regard the hydrological events there can be mentioned some. Shaker et al. (2008) said that “highly heterogeneous land cover class, inclusion of texture may not enhance the classification performance and classification of PAN imagery was sufficient to delineate the flooding areas”. Ho et al. (2010) “proposed an effective method for flood hazard assessment based on geomorphologic approach by applying Modified NDWI, SRTM DEM and land cover classification of satellite data through their correlation. Solely application of SRTM DEM restricts the analyses due to low spatial resolution”. Barneveld el al. (2008) concluded “the flood forecasting systems for the Rhine and Kemijoki Rivers prove to be robust and accurate tools for predictions up to 10 days ahead. Algorithms have been added to include information from satellites (SAR images) in the data-assimilation process of these flood-forecasting tools”. In his article, Jeyaseelan, A.T. (2008) précised that “the remote sensing and GIS technology significantly contributes in the activities of all the three major phases of drought and flood management namely: Preparedness, Prevention and Response/Mittigation”.

The area that is studied and where the method is applied is the fluvial part of Danube Delta. The exact area is the so called Sontea-Fortuna and it is situated in the Central-West part of the entire Danube Delta (fig.1). Danube Delta, representing in a concrete sense the most important terminal field of an European river (exception being the Volga River), is situated in the North-West part of the Black Sea basin, in a mobile region of the Earth’s crust (preDobrogean basin) (Romanescu, 1995). The entire delta is a hydrologic subsystem of a superior level of hydrological subsystem. Al the hydrological systems, no matters the state of their presence in the entire territorial ensemble (underground waters, rivers, lakes, Black Sea) they are under the control of the main “inputs” as precipitations (X) and under the control of the main “outputs” as evaporation (Z) (Bojoi, 2000). The ratio between these two parameters (X/Z) represents the flowing potential of a territory (Bojoi, 2000). In the Romanian Geography, volume I, in 1983 it was specified that the field regions from the South-East of the country have the value of the flowing potential of the territory about 0.5. This value shows the fact that the studied area has humidity deficit.

The importance of studying this area resides from the fact that this area is part of the Danube Delta Biosphere Reserve (DDBR) and the concept of biosphere reserve is to protect biodiversity including human beings. The droughts and the flooding affect in a direct and indirect way the humans as part of biosphere. These two extreme phenomena could be assimilated to the natural hazards.

The natural hazards, suppose the presence of a potential disequilibrium for an event which can cause a future disequilibrium. The natural hazard is a result of the human-environment relationship and represents a potential malfunction of the territory and of the territoriality (Romanescu, 2009).

Between these two extreme phenomena there are a lot of different intermediate variants of the hydrological status.

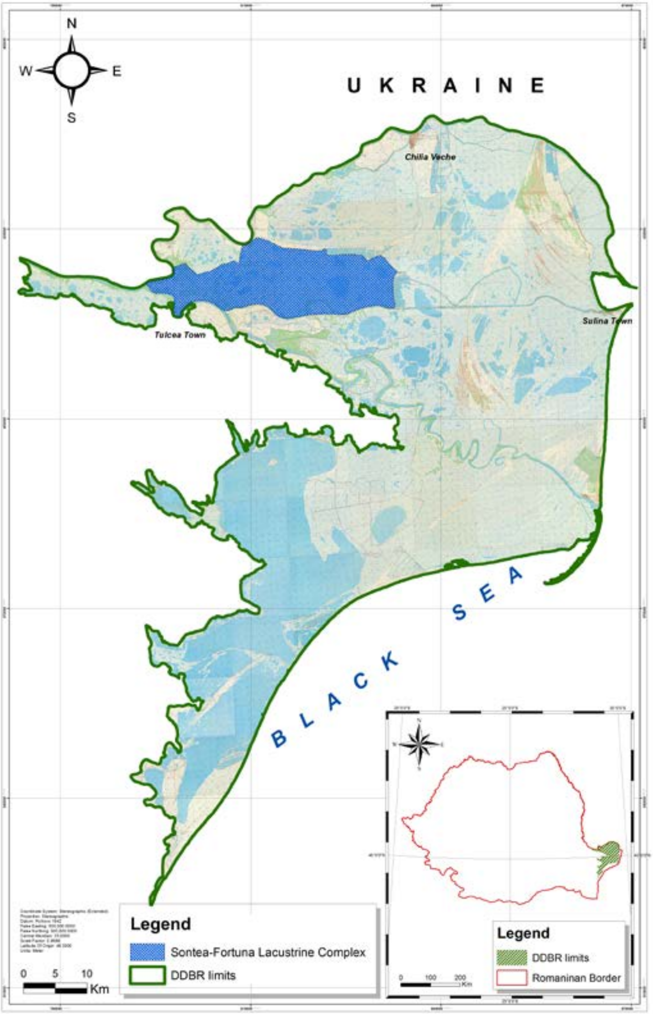


Figure 1. ***Localization of the Sontea-Fortuna lacustrine complex***

2. MATERIALS AND METHOD

Materials that were used for this paper are formed by two categories: the first one consists in materials that were processed and the second one consists in materials that were used to process the first category. From the first category there can be mentioned the LANDSAT satellite images (30 m resolution) taken from the specific periods. LANDSAT Satellite (http://glovis.usgs.gov/) consists in a set of artificial satellites of the Terra with the purpose of terrestrial resources research. The program was accomplished by the collaboration between NASA, NOAA, USGS and EOSAT (Donisa and Donisa, 1998). Those periods include the situation of the extreme phenomena that were taken into account: the 20th of September 2003 for low levels of the Danube River waters and the 13th of July 2010 for high levels of the Danube River waters. For the same area was used the elevation model of the Danube Delta as shape file (GIS file format). This layer was created at the Danube Delta National Institute for Research and Development-Tulcea having as a support the Map of Danube Delta created in 1983 having as author Gastescu P. et al. (1983) (1:700.000). The second category is mainly formed by the ArcGis (3.x and 9.0) software that helped in digitizing the shapes of the water bodies in both extremes.

The method used is very simple and it consists in digitizing the contours of the consistent water bodies from the studied area using the mentioned software and as a support the two set of LANDSAT time series datasets. In the digitizing process were taken into account the main water bodies from the studied area.

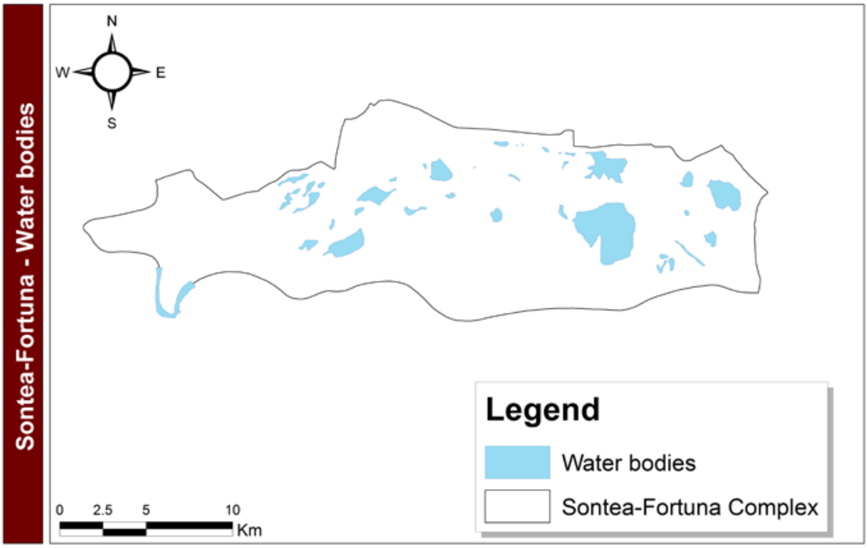
After digitizing these contours it was calculated the maximal and minimal values from the elevation model of the DDBR in the specific studied area that were intersected with these contours in order to establish the relative elevation level of the water surface. These touching points (intersecting points) were considered as referencing points. For each referencing point it was calculated the level of amplitude in order to calculate the tenth part of this value to reach to a pseudo-hydrograd. Having al these reference points and their values it could be elaborated the map of pseudo-hydrograds for the studied area.

To have the most accurate values for the elevation model it was created the contour lines of the elevation with a small step, but the initial degree of error remains due to the scale of the initial map from 1983. The contour lines were created from the grid elevation file for the studied area, grid with cells with 5 m in the field as length. The contour line step was established at 0.1 m.

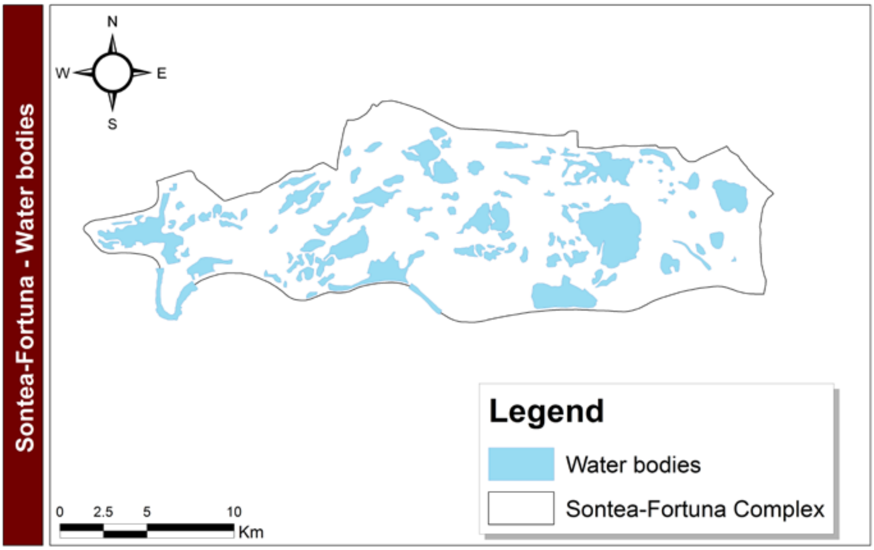
3. RESULTS AND DISCUSSIONS

In the first place there were built two files in GIS format (.shp file format) as a result of the digitizing of the main water bodies in different time period (20th of September 2003 and 13th of July 2010)(fig.2 a, b).

It is possible to see in figure 2 that there are some water bodies that are present in September 2003 and also in July 2010. These water bodies (fig.2 a) are consistent because they still have water even the levels of Danube waters are very low. In July 2010 there are much more water bodies than in September 2003 due the fact that in 2010 the Danube water levels were high. Those common water bodies have bigger surfaces in 2010 than in 2003 from the same reasons. For demonstration purpose it had been taken into account a small part of Danube River close to Tulcea Town.



a



b

Figure 2. ***Water bodies in different time (a. the 20th of September 2003 ; b. 13th of July 2010)***

Another result is the .shp file format (GIS layer) that represents the isolines of the elevation of the studied area. These isolines delineate the difference about 0.1 m (figure 3). For saving the time there had been used the grid at 5 m length in the field. These two parameters (5 m and 0.1) could be improved in order to obtain a more accurate results.

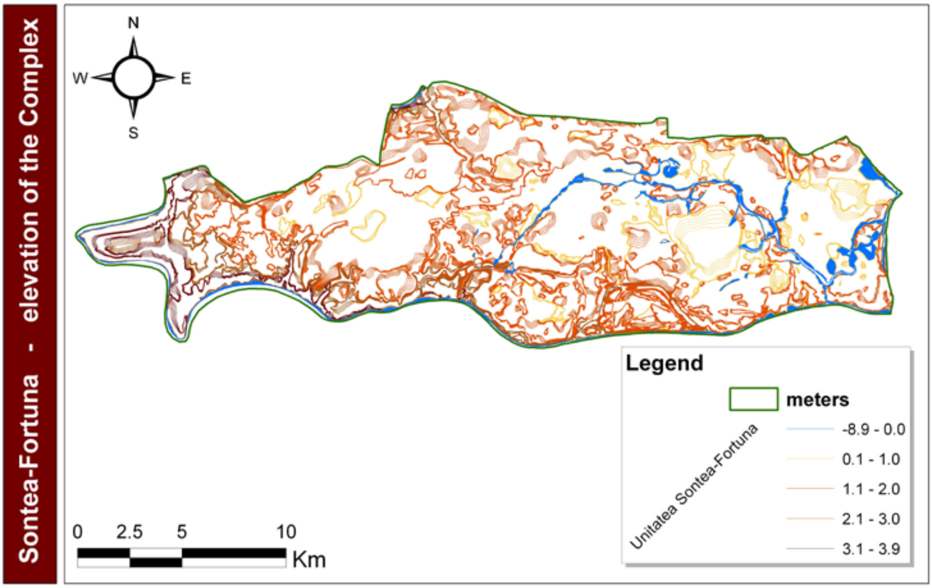


Figure 3. ***Isolines of elevation for Sontea-Fortuna lacustrine Complex***

There are lots of flat surfaces in the Sontea-Fortuna Lacustrine Complex as it can be seen from the fig.3. Also it can be seen the characteristic of a delta area related to the elevation pattern and this can be summarized as follows: small isles, the existence of levees (natural and artificial ones), depressions etc.

Land-surface elevation is the dominant influence on the location of the simulated shoreline of the flooded area (Bales and Wagner, 2009). Thus, the quality of the topographic data gives a good representation of the shoreline (Horitt and Bates, 2001).

The elevation isolines combined with the delineation of the extension of the high water levels and low water levels give information about the relative amplitude of the water levels for a region without having measurements data from the gauge stations.

Such kind of combination it is shown in the figure 4, where all the amplitude values were interpolated within the studied area. The interpolation method used is Inverse Distance Weighted (IDW). This method is "one of the most commonly used techniques for interpolation of scatter points. Inverse distance weighted methods are based on the assumption that the interpolating surface should be influenced most by the nearby points and less by the more distant points. The interpolating surface is a weighted average of the scatter points and the weight assigned to each scatter point diminishes as the distance from the interpolation point to the scatter point increases" (web site).

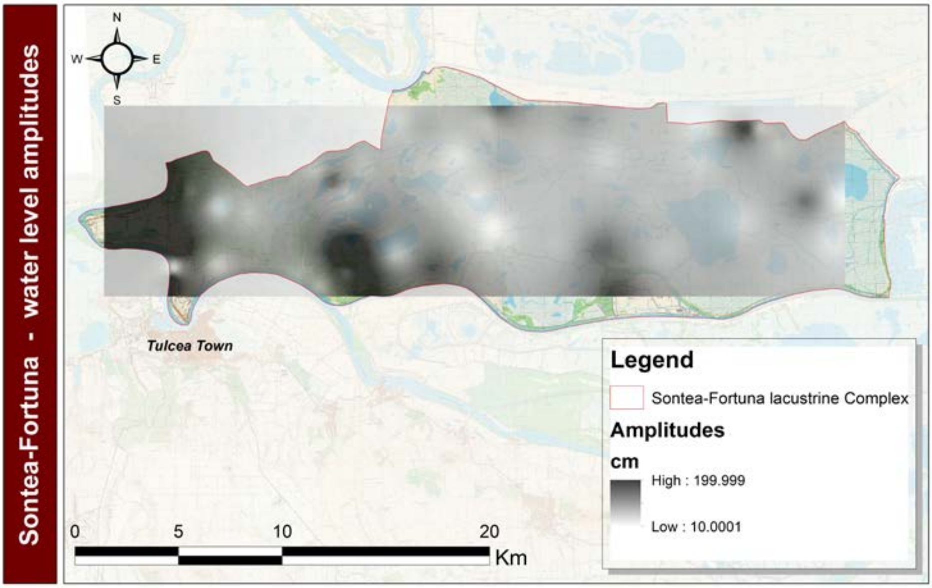


Figure 4. ***The map of water maximal levels amplitudes for Sontea-Fortuna Complex***

The values of the amplitudes are not equal dispersed in the whole studied area. There are some zones that have values close to 2 m and others that have at most 0.1 m. The dark grey represents the high values of the amplitudes (2 meters) and the light grey to white represents the lower values of the amplitudes (0.1 meters). The map presented in the figure 4 was built by using 56 points of amplitude calculation.

CONCLUSIONS

The highest values of the water levels amplitudes (2 meters) occurred in the West part of the studied area. There is the locality Patlageanca that was flooded in the last extreme hydrological event (July 2010). Also in the South-West part of the studied area is the locality named Partizani. In this locality there was no flooding due to the existence of some protection dykes. It is good to be mentioned at this moment the fact that the elevation made after the map from 1983 does not contain all the dykes or other artificial means to obtain protection against floods.

The lowest values of the water levels amplitude (o.1 meters) occurred in the flat and wide zones like the areas with big lakes or with great density of lakes. This can be explained by the fact that the amount of water is more or less uniform distributed for the whole aquatic surface. The aquatic surface being big makes the levels to vary not so much.

For better results (more accurate as values and distribution) it is needed a more precise elevation component (the best would be that resulted from LiDAR data) and high-resolution images (satellite or ortophotos).

As a method, this way of assess the extreme events in sense of knowing where they could happen and with what water level difference, is an operative one for small areas. For bigger area some of the actions should be automated in order to reduce the time consuming and to decrease the chances of errors.

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