# Anthropic induced gullies on old anthropic lake beds in Romania

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## Introduction

The Northeastern Romania lowland is well known for its reservoir construction history and sedimentation all over the last 600 years.

These reservoirs were in general small (under 1 million m$^3$), shallow (4 – 5 m in depth, but with water levels of up to 35 m) and frequently dry during the summer or winter.

Their construction was requested by the dryness of the climate (350 to 550 mm mean annual rainfall), the reservoirs being used for water storage, pisciculture, for cereals and fuller mills. The lack of forests, the clayey lithology and the agricultural practices, coupled with a dry continental climate, characterized by strong summer rainstorms is responsible for the quick filling of these reservoirs (in 20 to 50 years).

After their filling, the dam morphology was kept and became smooth over time. The dams were also cut in the spillway area in order to evacuate the groundwater, so the reservoir bottom could be used as pasture.

This anthropic intervention created a concentration of flow at high water discharges in the spillway area, which allowed the evolution of gullies on the flat lacustrine bottom. In other cases for the same effect, groundwater excess drainage, linear channels were cut along the median line of the reservoir bottom.

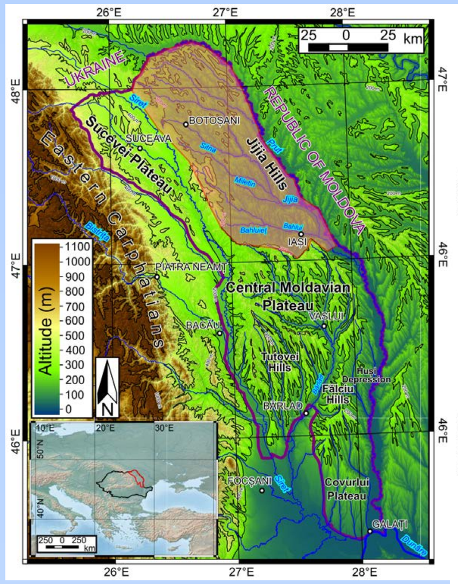

Fig. 1. The geographic localization of the studied area

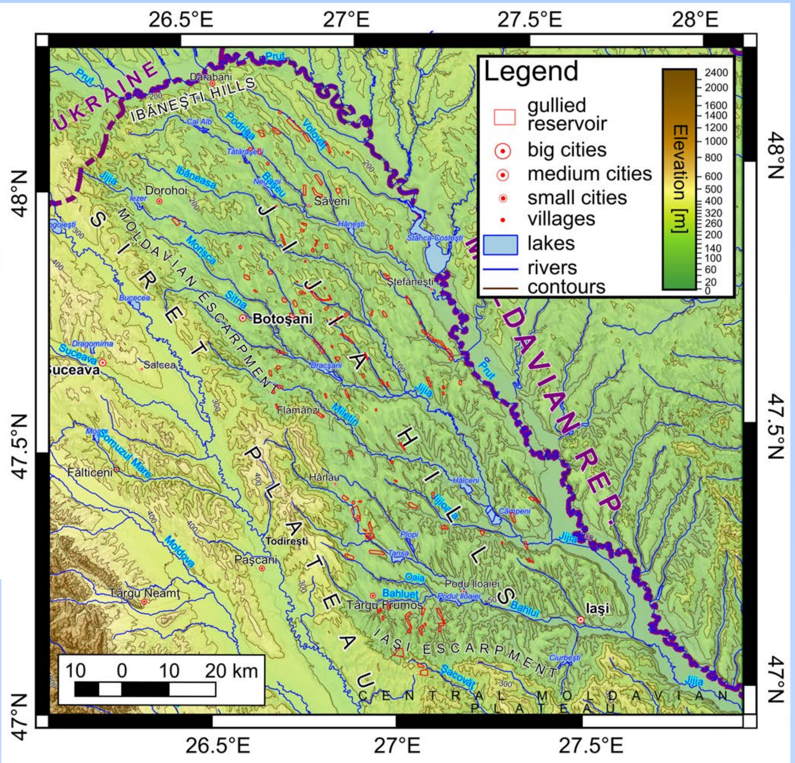


Fig. 2. The localization of the reservoirs with bottom gullies

## Materials

The Northeastern Romania lowland is well known for its reservoir construction history and sedimentation all over the last 500 years.

These reservoirs were in general small (under 1 million m3), shallow (4 – 5 m in depth, but with water levels of up to 3 m) and frequently dry during the summer or winter.

Their construction was requested by the dryness of the climate, the reservoirs being used for water storage, pisciculture, for cereals and fuller mills. After their filling, the dam morphology was kept and became smooth over time. The dams were also cut in the spillway area in order to evacuate the groundwater, so the reservoir bottom could be used as pasture.

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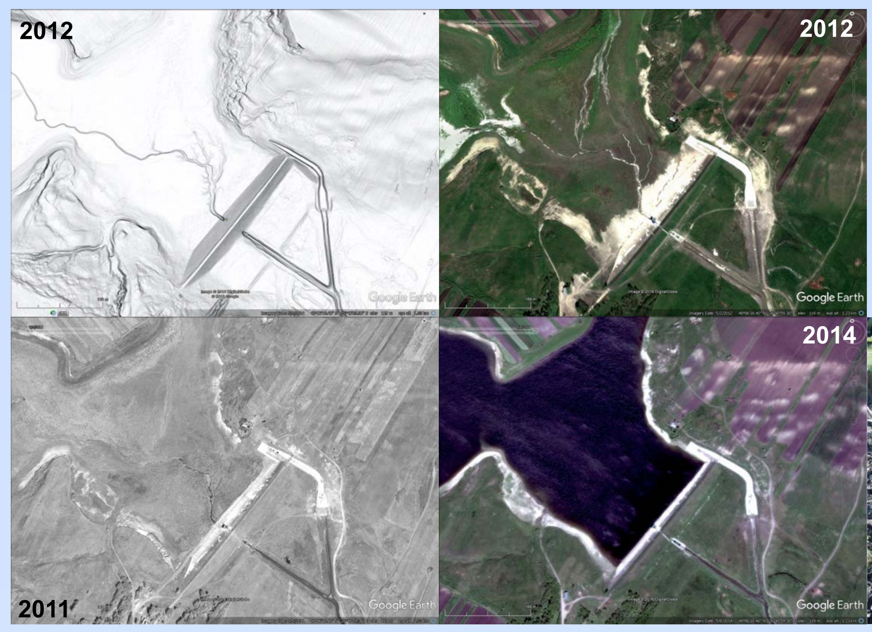



Fig. 3. Aerial imagery and LiDAR used to delineate bottom gullies

Fig. 4. Field recognaissance of bottom gullies

## Methods

The extraction of the gully was done manually from a Digital Terrain Model (DTM) having a cell size of 0.5 m supported by contour lines, slope maps and Edge Detection derivative. Although there are much faster semi-automatic and automatic ways used for the extraction of the geomorphometric features such as Relative Elevation Attribute (REA) or based on landform curvature, the manual extraction was preferred for its high accuracy results. After the identification of site, the gully shape was delineated having as background the previous mentioned layers and continuously verified in 3D perspective and by topographic profile checking.

We identified around 200 sites where this process of gullies affecting reservoir bottoms occurred in the last 75 years. For 50 of the sites we estimated the volumes and mass of the eroded sediments and of reservoir sediments using LIDAR DEMs, and established a temporal scale of gully activity using aerial imagery for estimating the rate of process.

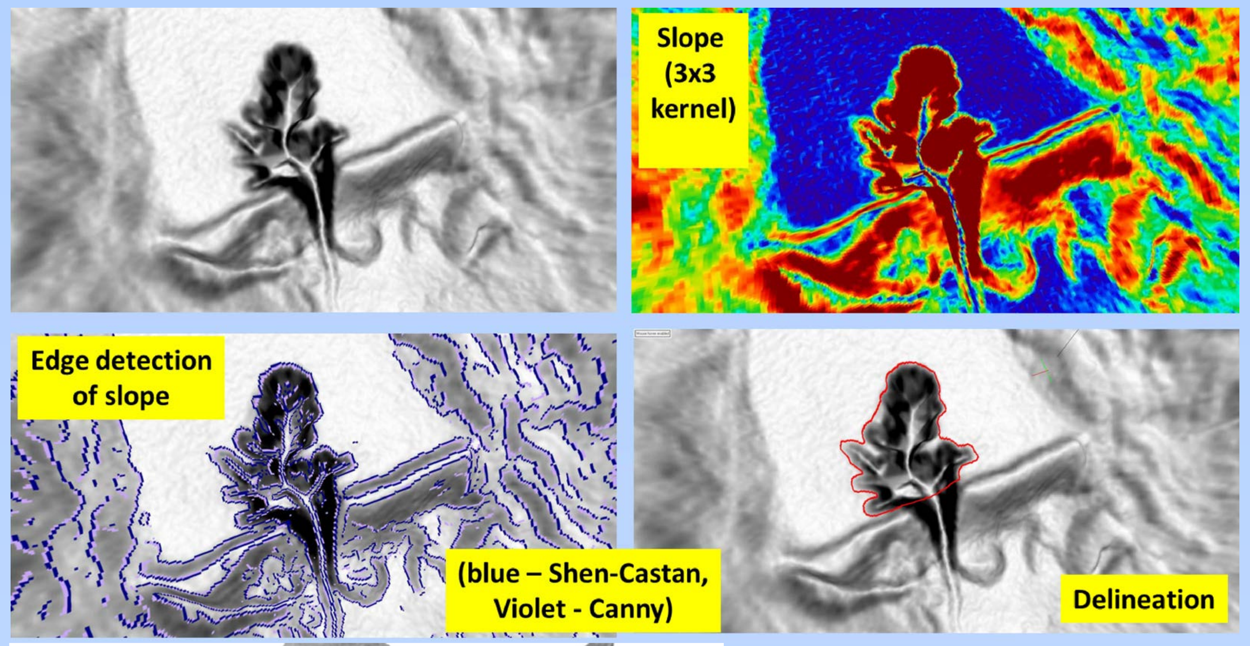



Fig. 5. Automatic edge detection

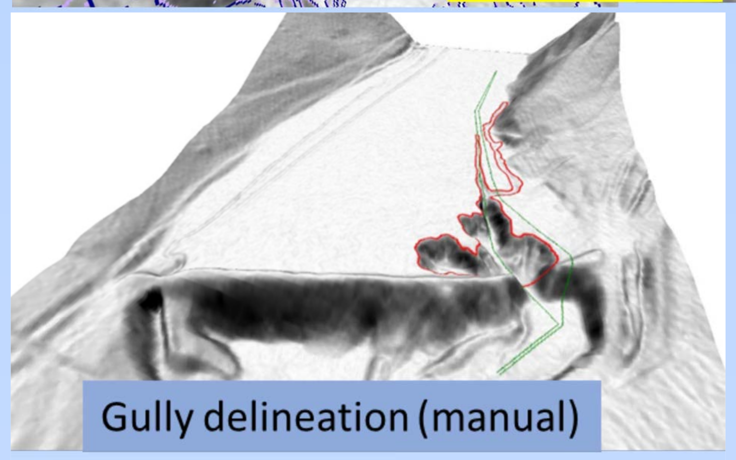



Fig. 6. Manual delineation of bottom gullies

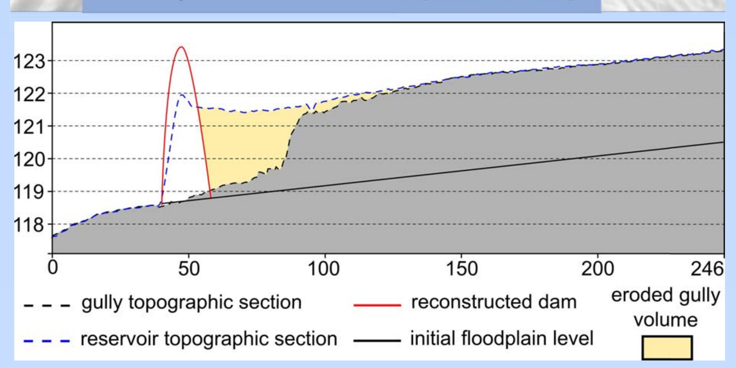
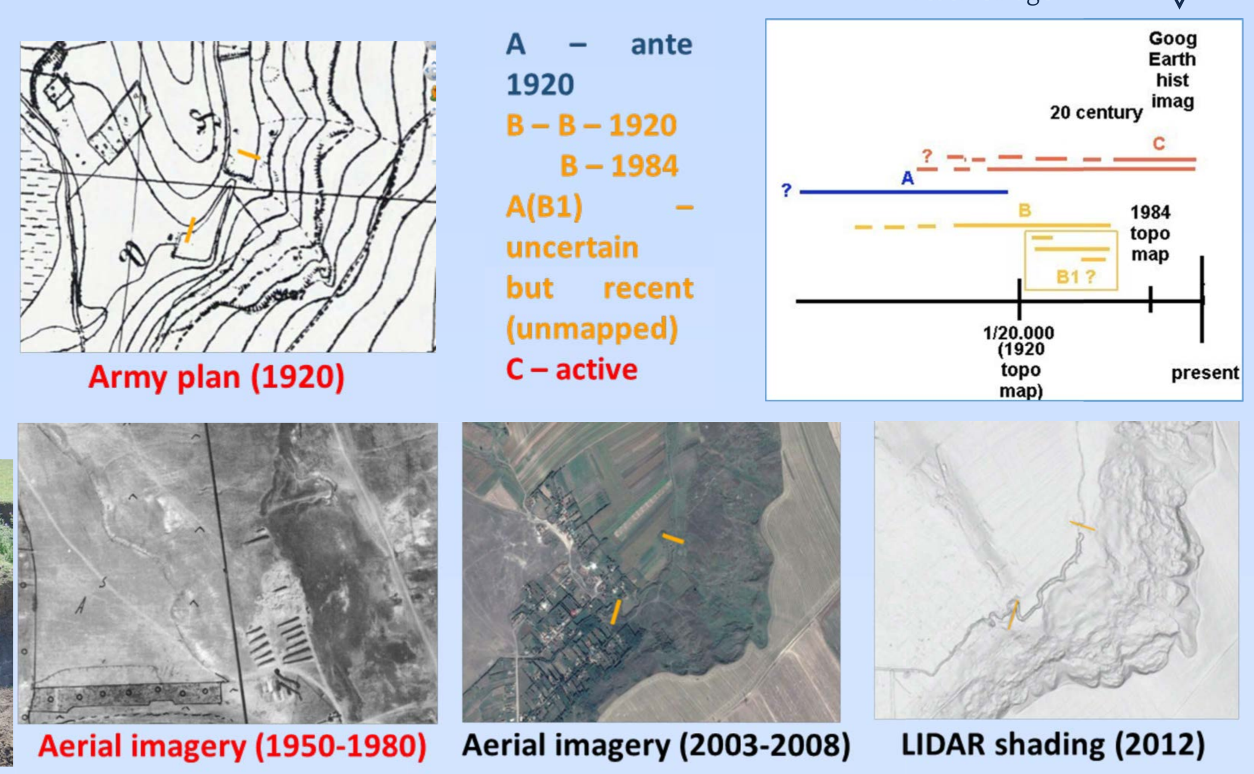



Fig. 7. Volume estimation

The edge of the gullies was used to interpolate an upper surface. The upper surface was substracted from the basal surface of the gully and by multiplication with the surface of the pixel we obtained the gully volume. The upper surface was interpolated using TIN and several runs were required to retrace the edge of the gully, in order to obtain a surface that closely estimate the initial surface of the reservoir bottom.

Fig. 8. Age estimation based on reservoir age




## Results

The created inventory consists of more than 500 gullies found mostly on the second and third Strahler order whose morphometric variables are directly related to the dimension of sedimented reservoir. Thus, there are recorded lengths of 1-2 meters for newly created gullies of up to 800-1000 meters for the most developed ones, with big variations of the width depending on the shape of the gully channel and the evolution stage of the gully. The depth of the gullies is ranging from 20-30 centimeters to 4-5 meters and is depending by the initial size of the reservoir and by the height of the dam. The volume of eroded sediments varies from few cube meters of up to 10000 m3 for individual gullies, with a total volume of eroded area over 100000 m3, and is the most important parameter which is to be considered in the characterization of potential sediment source areas in Jijia Hills region.

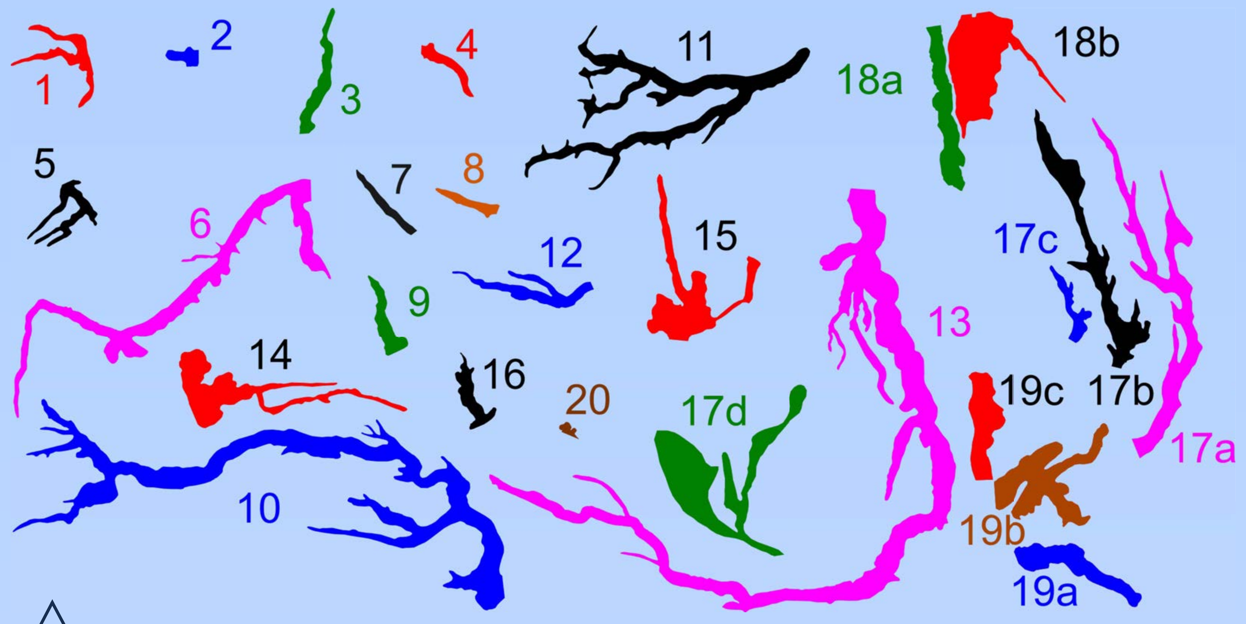



Fig. 9. Various shapes of reservoir bottom gullies

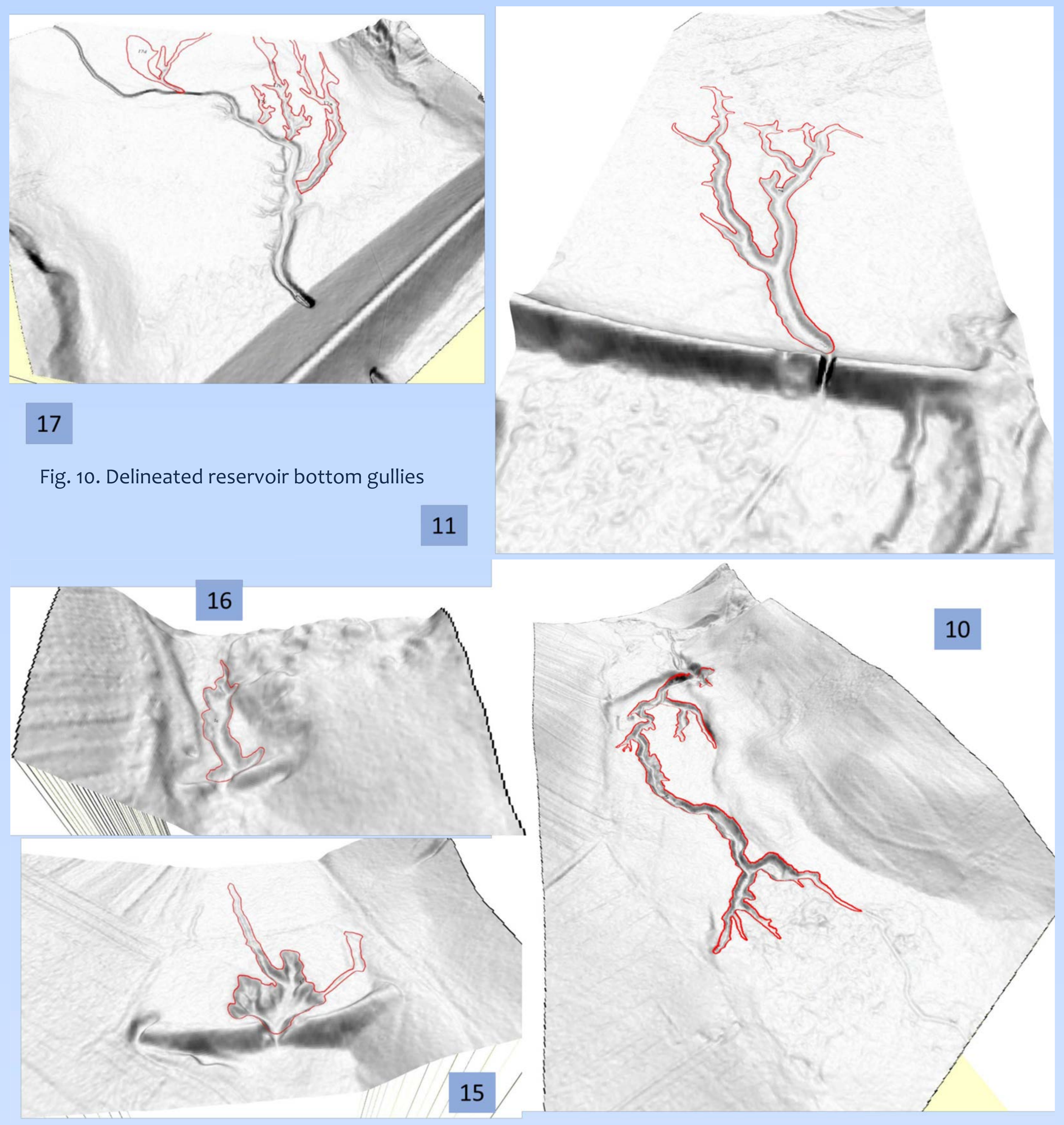
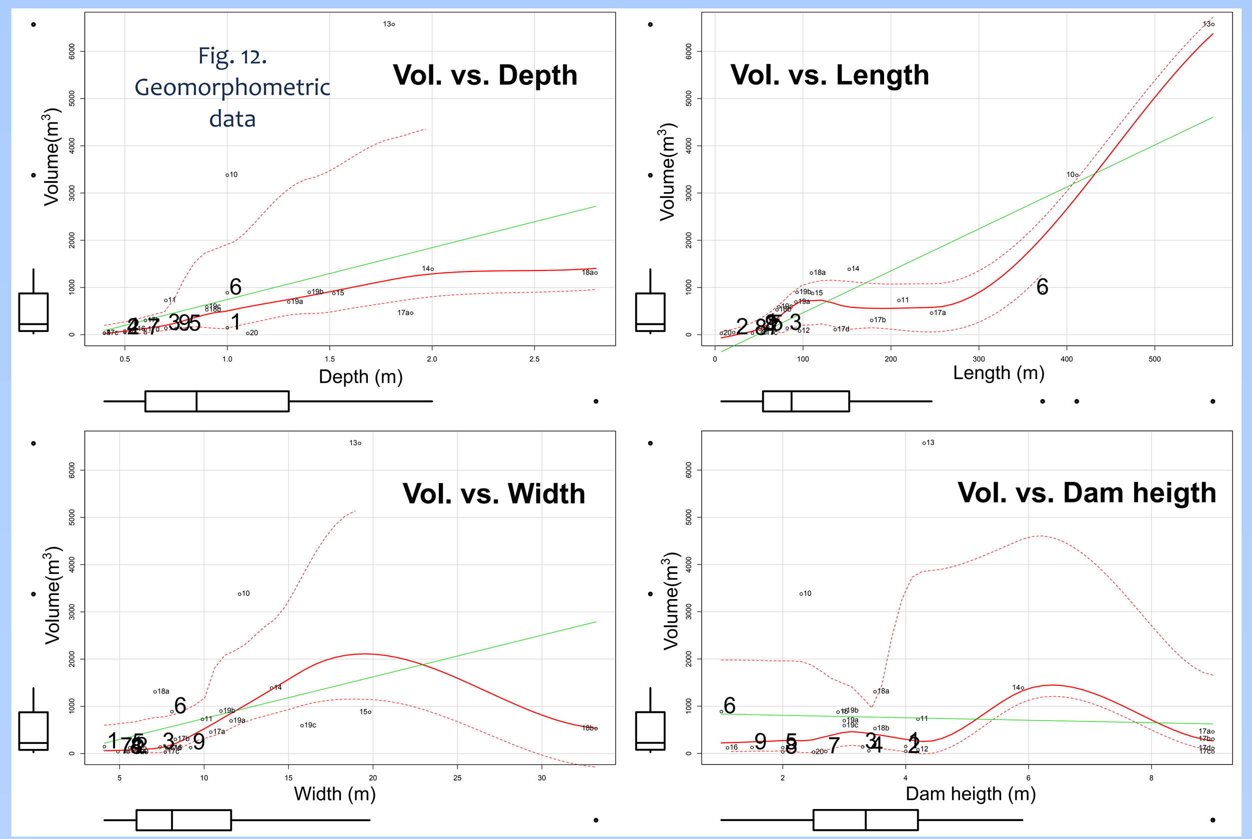



Fig. 10. Delineated reservoir bottom gullies

Fig. 11. Field situation with a reservoir bottom gully




## Conclusions

The created inventory of 550 bottom reservoir gullies is further on going to be used to perform a cluster analysis in order to have a grasp of the critical areas/hot-spots of sediment sources of north-eastern Romania lowland which might present a real danger/big problem in the future.

This aspect is important for several reasons:

(i) first, a major proportion of the identified gullies are not fully developed, further evolution process is going to be taking on and this concludes that this part of gullies will become an important source of sediment production;

(ii) second reason is given by the actual reservoirs which are almost filled and close to be abandoned and next up are going to be affected by this erosional process which will lead to the creation of these geomorphological landforms is big (~650), and thus the density will increase;

(iii) both of the above aspects are accentuated by the climate change state which may aggravates the situation (accelerate the erosional processes) in our study area as the precipitations are uneven distributed during the year and in recent years there is an increasing of intense rainfalls.

Hydraulic models are needed in order to assess how the gullies initiated and evolved in order to predict the future events

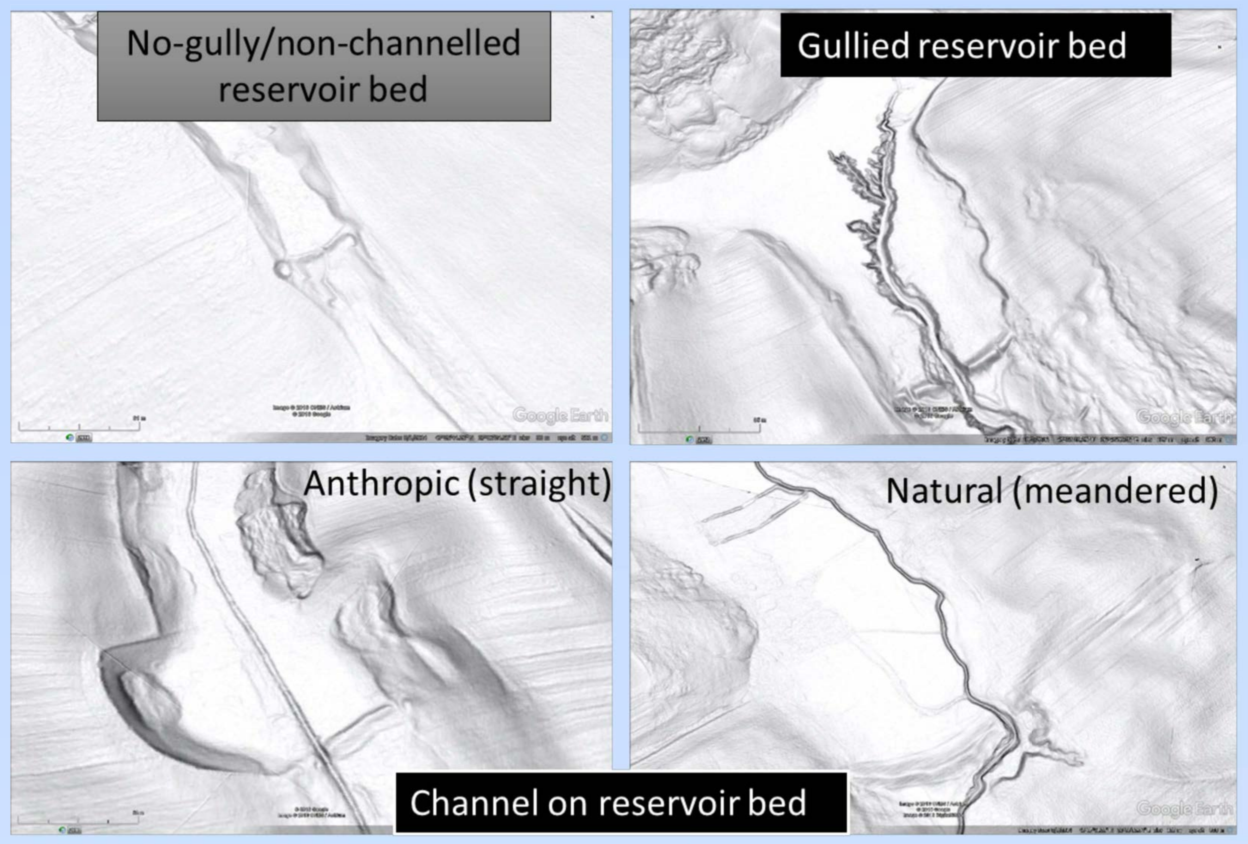



Fig. 13. Conceptual evolution from breached dam to gullied reservoir bottom and to continuous channel

## Aknowledgements

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