

# Anthropic induced gullies on old anthropic lake beds in Romania

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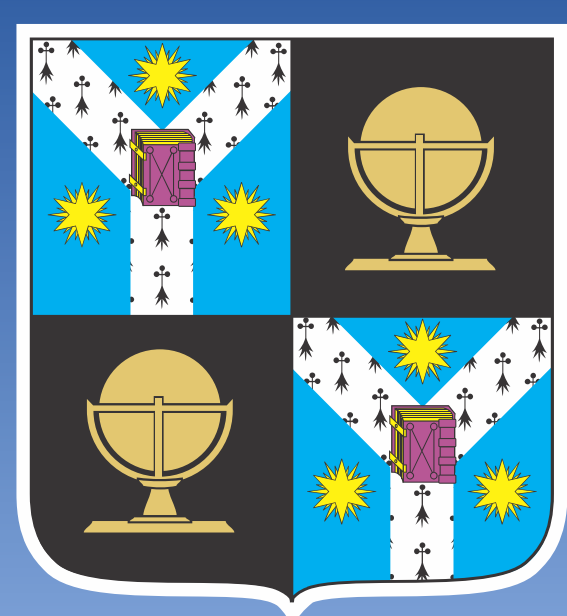
<sup>2</sup>University of Padova

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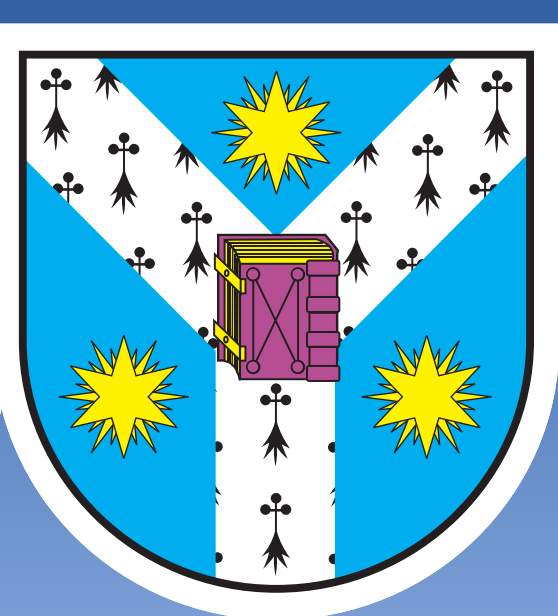
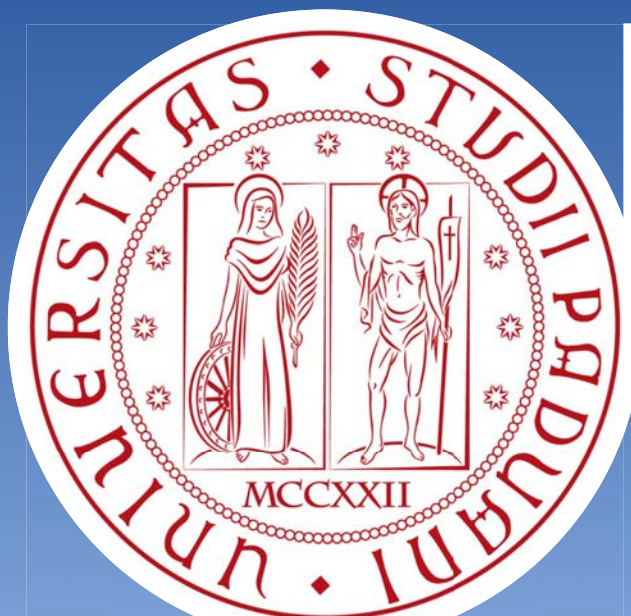
## Abstract

Anthropic interventions at catchment level modify the hydrological morphology and fluxes, especially in the last 50-60 years. In the North-Eastern Romania hilly area for various reasons (the dry conditions - 400-500 mm multiannual rainfall amount – and the need for water, for wetland to arable land conversion and for flooding control), especially in the last 60 years, a big number of reservoirs were built (about 1000 in an 8000 km<sup>2</sup> area). These reservoirs were mostly shallow (under 5 m depth) and small in volume (under 10 mil m<sup>3</sup>) and were filled in 10 to 30 years. The decommissioning of these reservoirs was made mainly through dam breaching in the median part in order to recover the filled reservoir bottom for pastures. This intervention created the conditions of channel incision of these flat surfaces and the development of gully system which tend to evolve toward continuous channels. In the present study we present a database of gullies affecting the dry bottom of decommissioned anthropic lakes from Jijia Hills, north-eastern Romania. The gullies were manually extracted from a Digital Terrain Model (DTM) with 0.5 m cell size. The extraction was performed using shading maps, with support from contour lines maps, slope maps and maps with the edge detection of slope. The gully delineation was also verified through 3D perspective view and through topographic sections, in order to obtain good delineation. We delineated more than 500 gullies, which are predominantly found on dry bottom reservoirs of 2d and 3rd Strahler order catchments. The morphometry of the gullies (length, depth, volume) is directly related to the dimension of the filled reservoir. Thus, there are lengths of 1-2 m for newly created gullies, and up to 800-1000 m for the most developed ones, with big variations of the width as a function of the shape of the gully channel and the evolution stage of gully (newly incised, evolving, fully developed). The depth of gullies ranges from 20-30 cm to 4-5 m and depends on the initial size of the reservoir, the depth of sediment fill and on the dam height. The volume of eroded sediments varies from 20 m<sup>3</sup> to up to 70 000 m<sup>3</sup> for individual gullies, with a total volume of eroded deposits over 1,000,000 m<sup>3</sup>. Considering the resulted volumes these types of gullies are one of the most important sediment sources in Jijia Hills region. The bottom reservoir gullies inventory and the estimated sediment volumes provide a database of hot-spots of sediment sources in the north-eastern Romania lowland. This aspect has a great practical importance considering that the majority of these gullies are not fully developed, and their further evolution implies the production of important quantities of sediments in the fluvial system. Furthermore, the same study area is defined by the presence of many dry abandoned reservoirs where the studied types of gullies can appear in the near future in the context of climate change that will increase the torrential rainfall. The presented study is a case of anthropic induced morphology and sediments accumulation (the filled reservoirs) which, through further induced anthropic decommissioning, generated gully morphology and produced sediments through erosion.





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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<sup>3</sup>), 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.

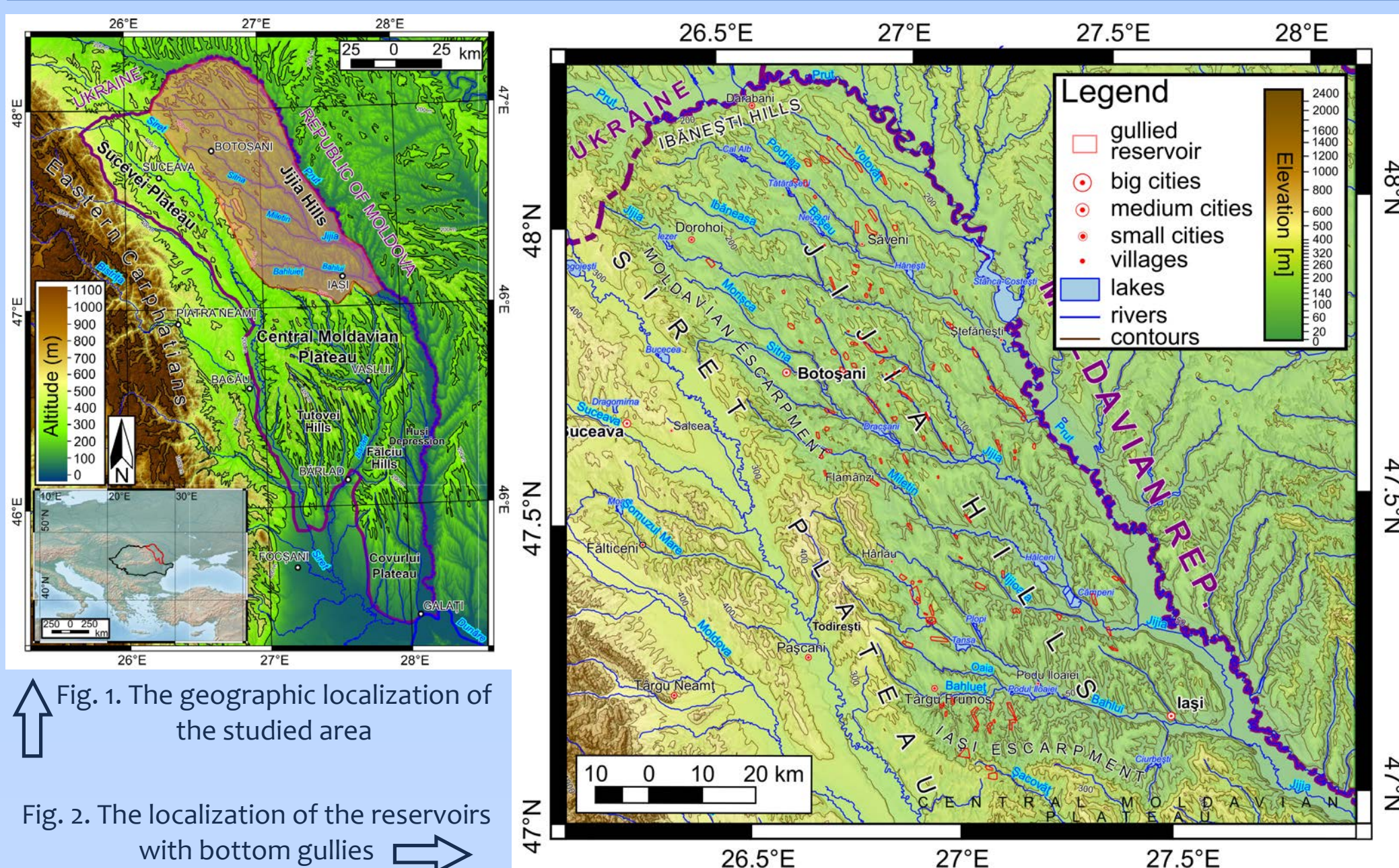


Fig. 1. The geographic localization of the studied area

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 m<sup>3</sup>), shallow (4 – 5 m in depth, but with water levels of up to 3 m) and frequently dry during the summer or winter.

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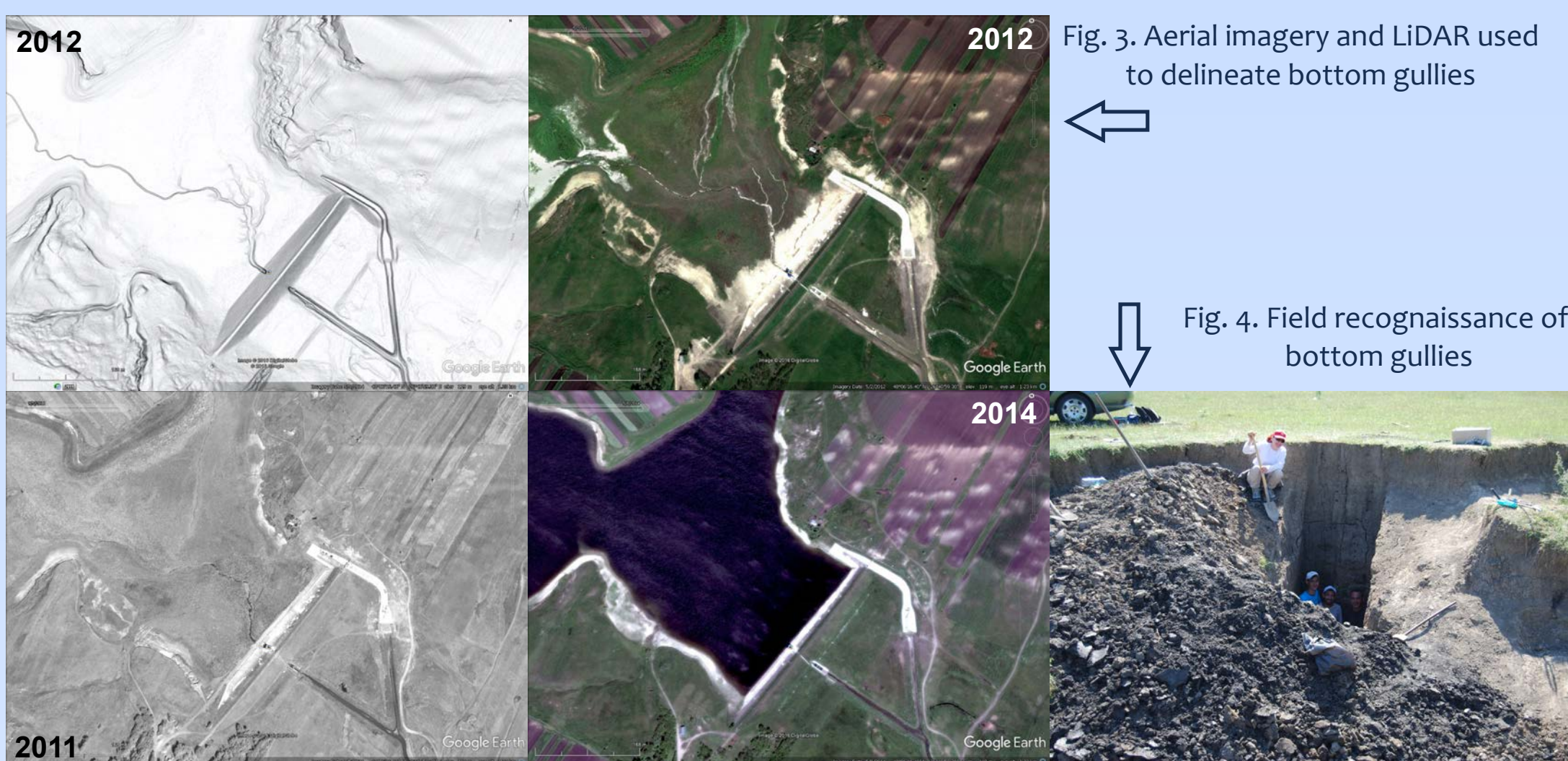


Fig. 3. Aerial imagery and LiDAR used to delineate bottom gullies

Fig. 4. Field reconnaissance 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.

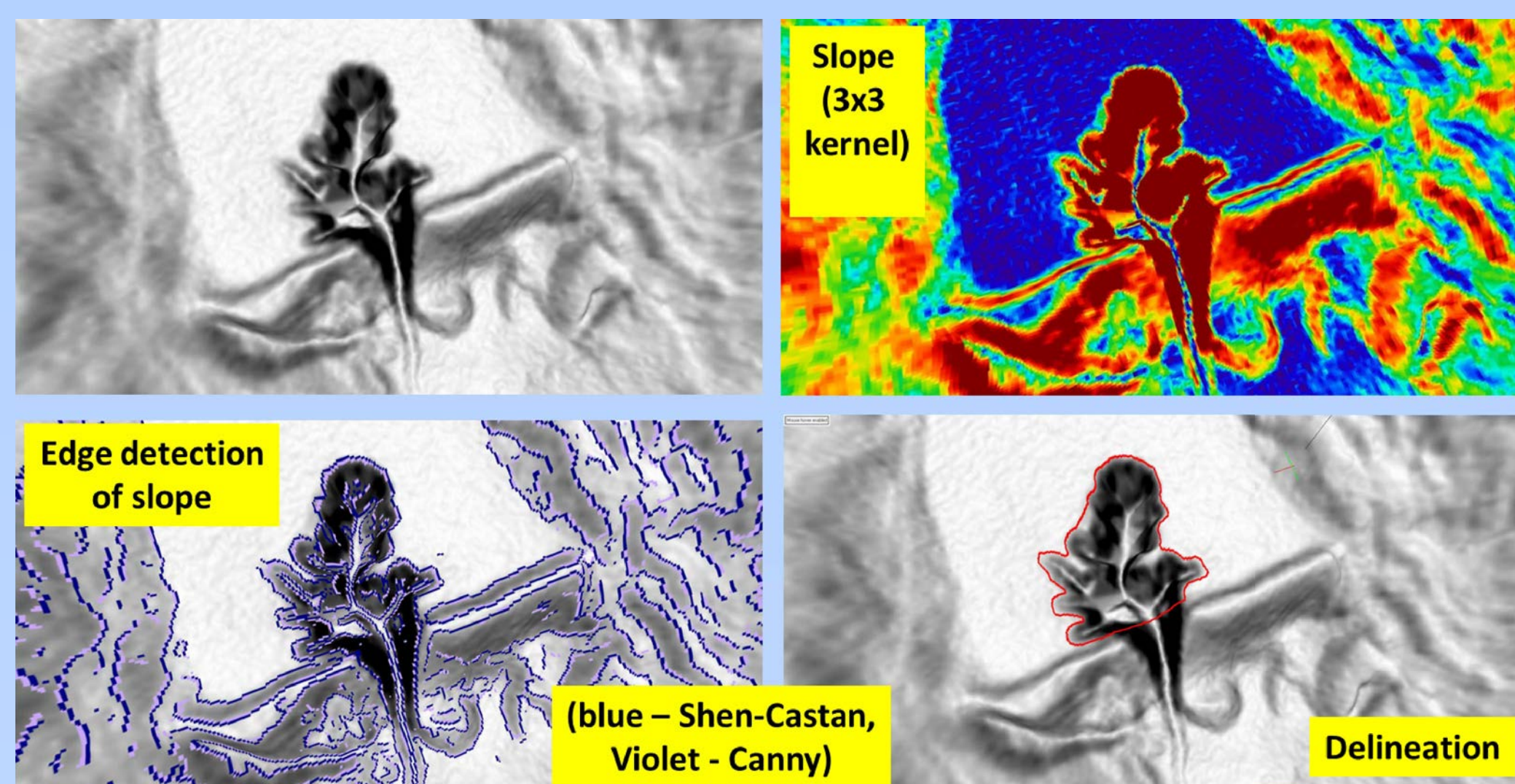


Fig. 5. Automatic edge detection

Fig. 6. Manual delineation of bottom gullies

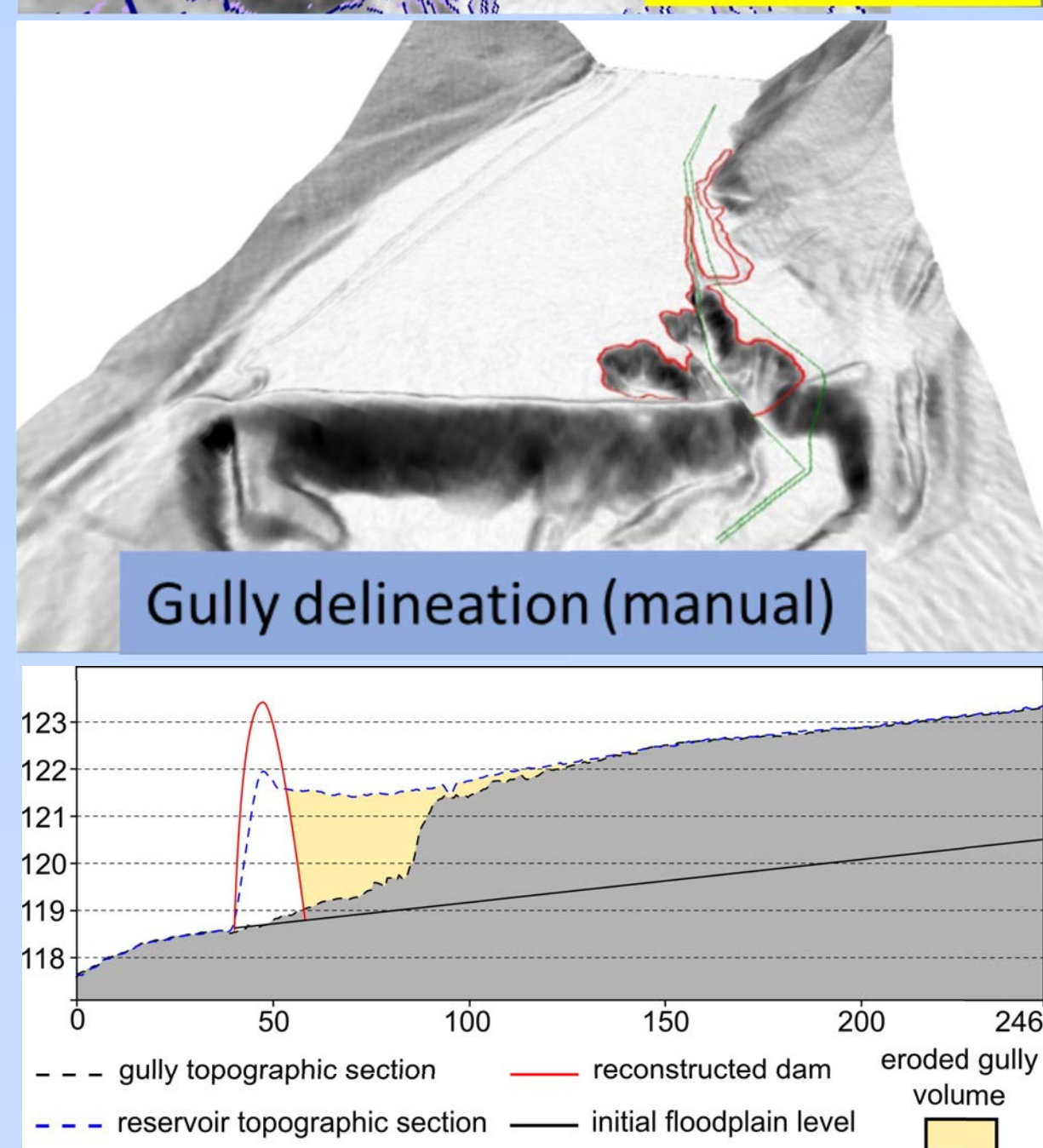
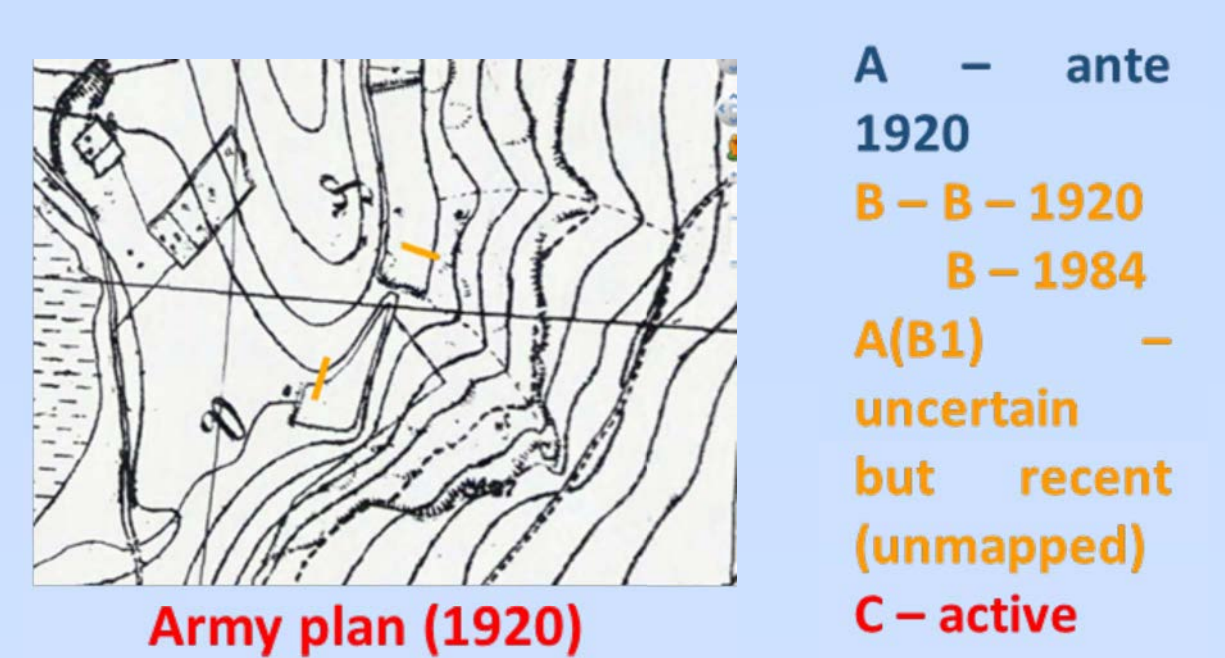
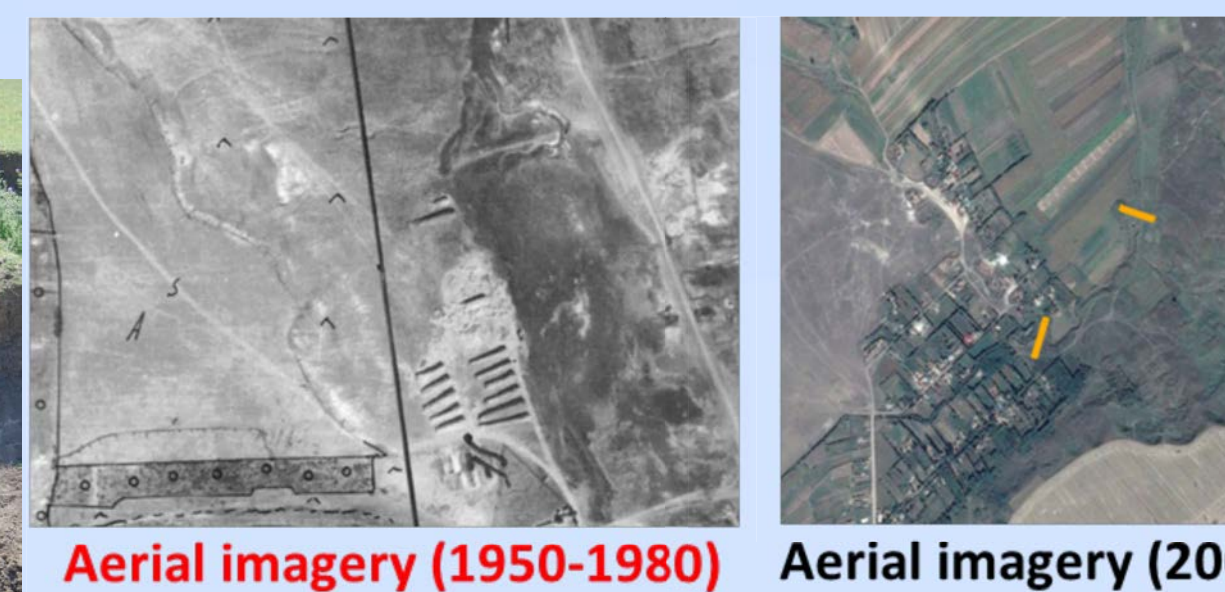


Fig. 7. Volume estimation



Army plan (1920)



Aerial imagery (1950-1980)

Aerial imagery (2003-2008)

LIDAR shading (2012)

## 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 m<sup>3</sup> for individual gullies, with a total volume of eroded area over 100000 m<sup>3</sup>, and is the most important parameter which is to be considered in the characterization of potential sediment source areas in Jijia Hills region.

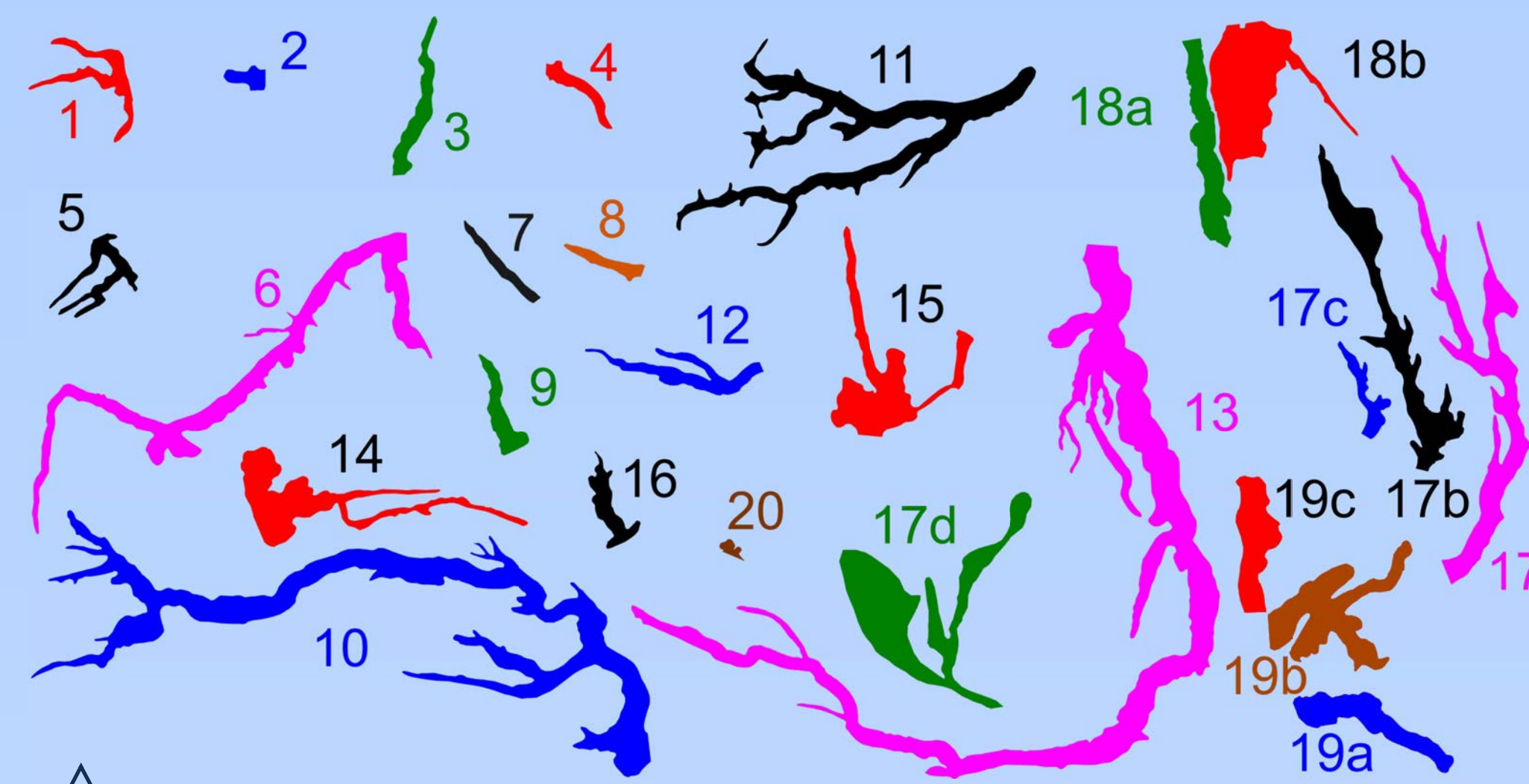


Fig. 9. Various shapes of reservoir bottom gullies

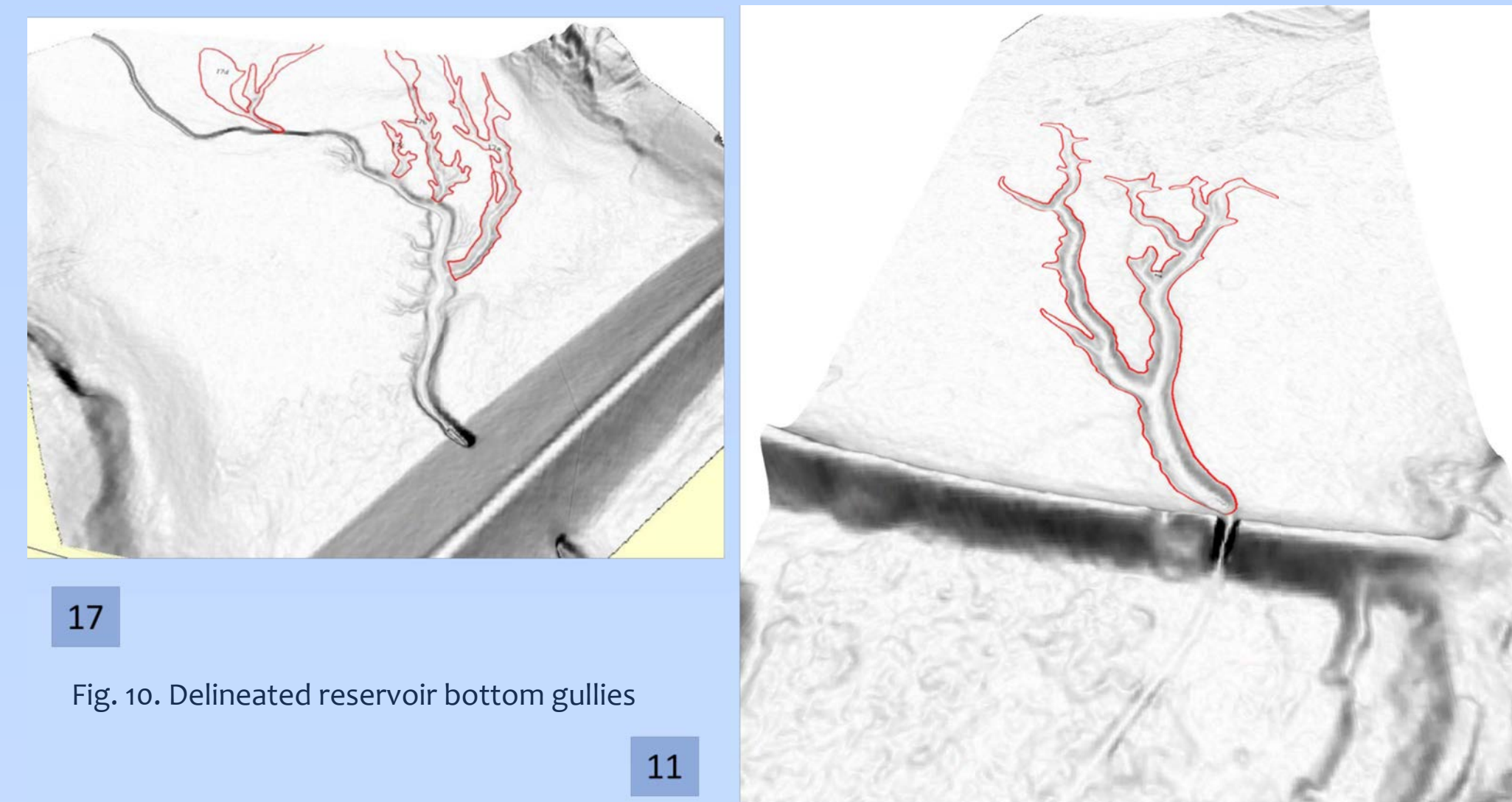


Fig. 10. Delineated reservoir bottom gullies

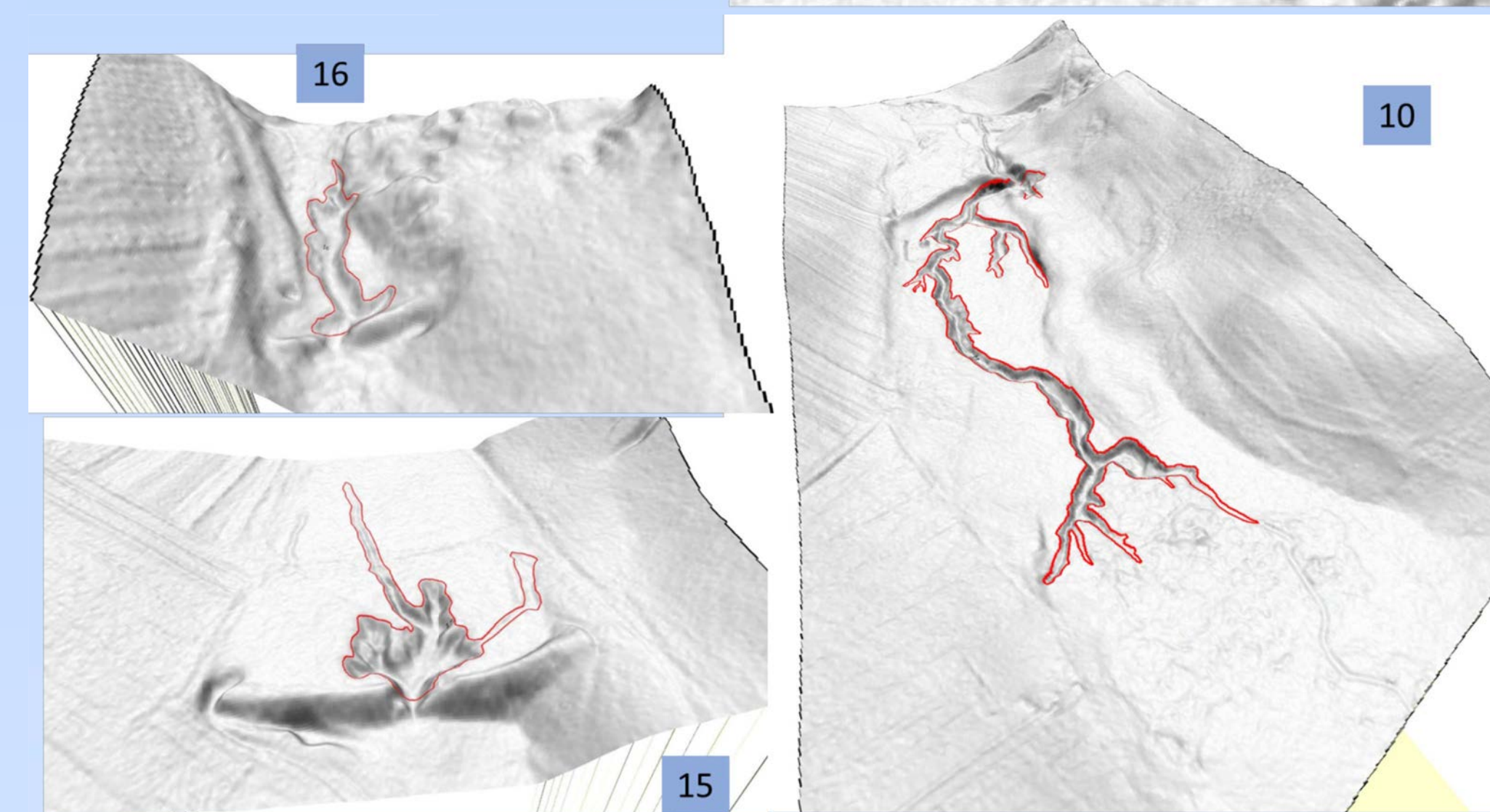
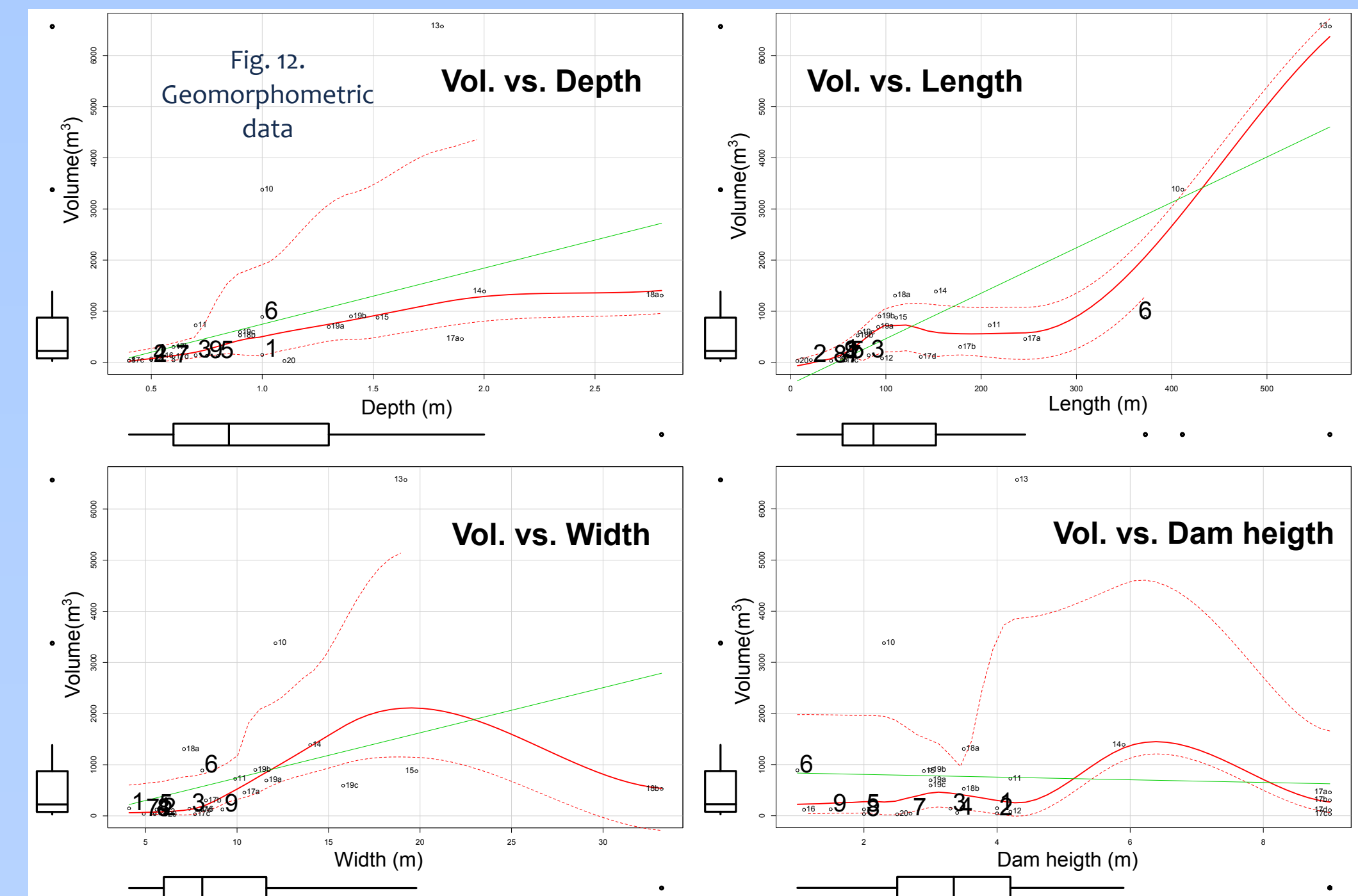


Fig. 11. Field situation with a reservoir bottom gully



## 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:

- 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;
- 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;
- 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

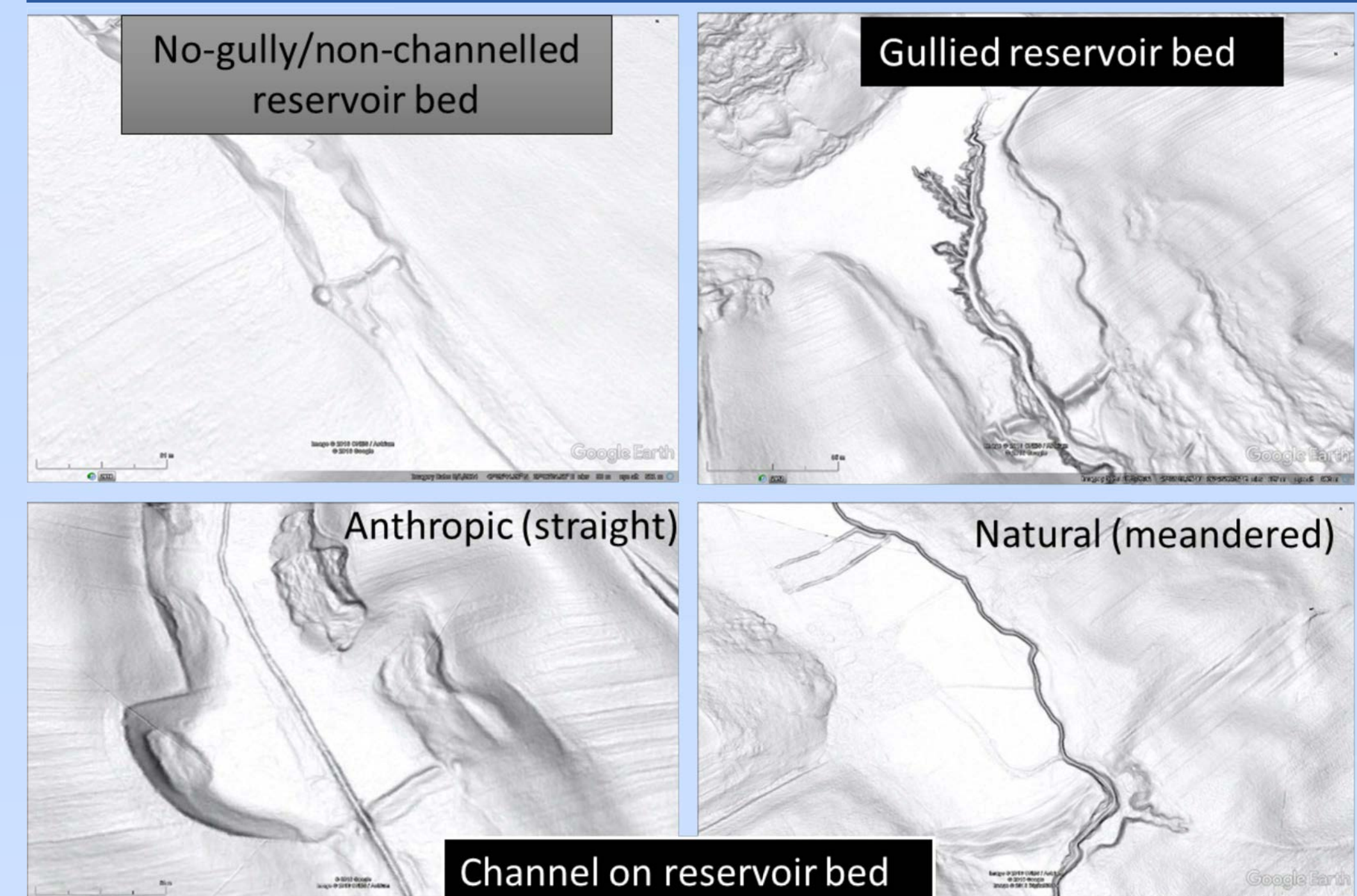


Fig. 13. Conceptual evolution from breached dam to gullied reservoir bottom and to continuous channel

## Aknowledgements

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