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GIS approximation of how land use/cover changes affect the hydrological system in a Mediterranean mountain catchment

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INTRODUCTION

Sediment connectivity has an important effect on the development of morphological landform features being one of the greatest conditioning factors on the development of hydrological networks. The steep slope agriculture has affected connectivity during the last centuries in Mediterranean landscapes. Our objective is to assess the variation of connectivity produced by land cover changes during the last 50 years in a mountain catchment.

STUDY AREA

The Barués stream valley (23 km^2) is located in the central part of the Ebro Basin, NE Spain, in the distal part of the Pre-Pyrenean range (Figure 1). The catchment has characteristically S-SW low bedding between 5°- 8° resulting an easy farmable terrain for rudimentary agriculture.

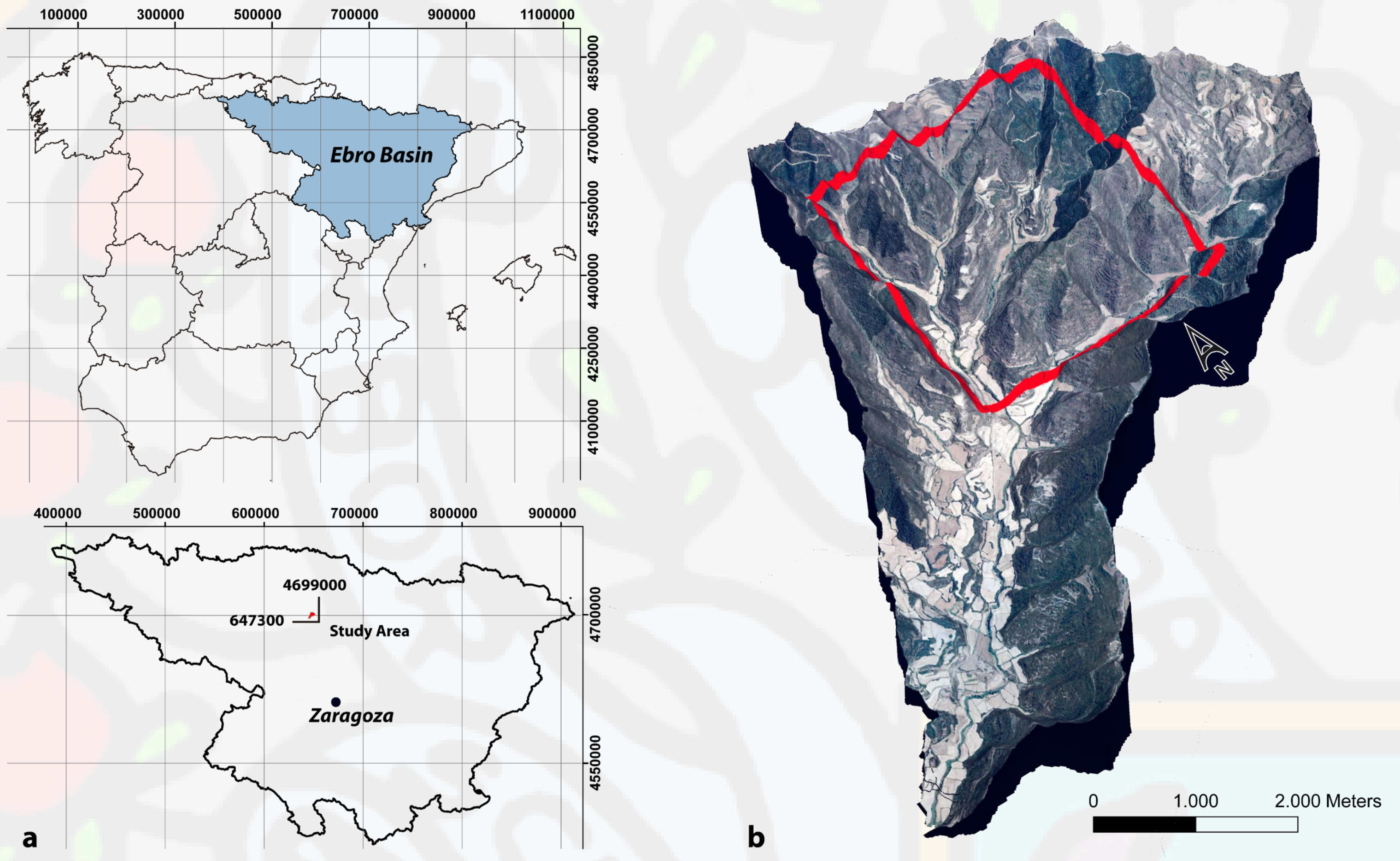

FIGURE 1. *(a) Location of the study catchment in the central part of the Ebro Basin (NE Spain). (b) Detailed orthophotography of Vandunchil Catchment. Red square delimits visualization of Figures 2 and 4.*

MATERIALS AND METHODS

The assessment of sediment connectivity was carried out by applying a topography - based index complemented by two land use maps for 1957 and 2012. Sediment connectivity was estimated using a numerical modeling approach to simulate how connectivity changes under different land covers. We apply the connectivity index (Eq. 1) proposed by Borselli et al. (2008) using the C-factor from RUSLE as a weight factors (W) and land use maps (Figure 2).

$$IC = log_{10} \frac{D_{up}}{D_{dn}} \tag{1}$$

Where D_{up} and D_{dn} are the upslope and downslope component defined by:

$$D_{up} = \overline{WS}\sqrt{A} \tag{2}$$

where W is the average weighting factor of the upslope contributing area, S is the average slope gradient of the upslope contributing area (m/m) and A is the upslope contributing area (m2).

$$D_{dn} = \sum_i \frac{d_i S_i}{W_i} \tag{3}$$

where d_i is the length of the flow path along each i cell according to the steepest downslope direction (m), W_i and S_i are the weighting factors and the slope gradient of the i cell, respectively.

RESULTS

A decrease in cultivated land was observed between 1957 to present, when the area dedicated to agriculture dropped from 12.3 to 3.8 km^2, i.e. 53% and 16% of the total area. On the other hand, forested areas increased from 9.2 km^2 in 1957 to 15.8 km^2 at present.

The steep slope agriculture practiced in the area not only increases erosion and runoff ratios on the hillslopes but also produces slope instability fostering the probability of mass movements due to the absence of vegetation cover that protects soil from erosion and raindrop impacts (Llorens et al., 1995)(Figure 3).

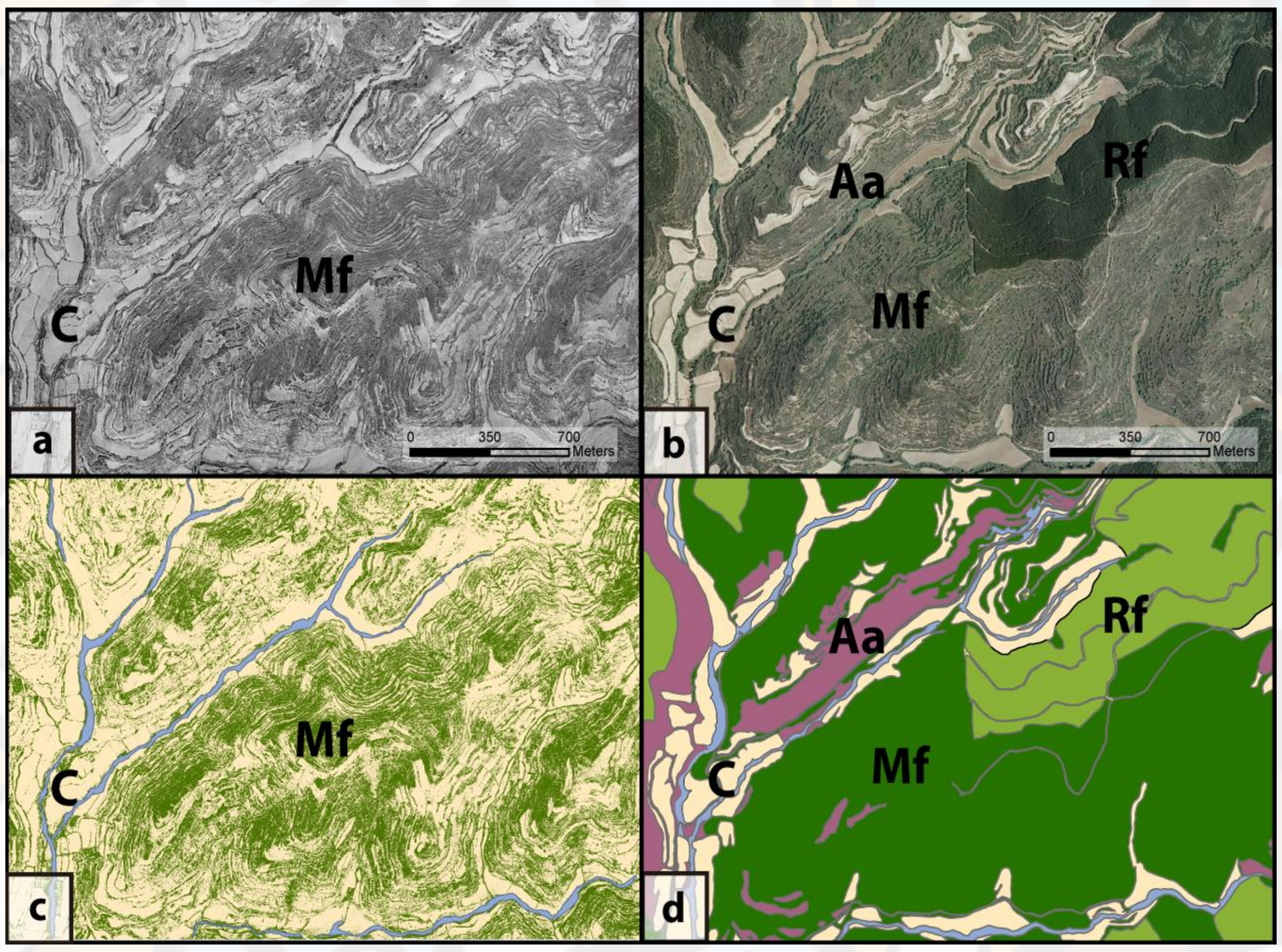

FIGURE 2. *(a) 1957 Aerial photograph. (b) 2012 Orthophotography (c) Land cover map developed using a supervised classification of (a). 2010 land cover map. Cultivated land (C), Mediterranean forest (Mf), Reforestation forest (Rf), Abandoned agriculture (Aa).*

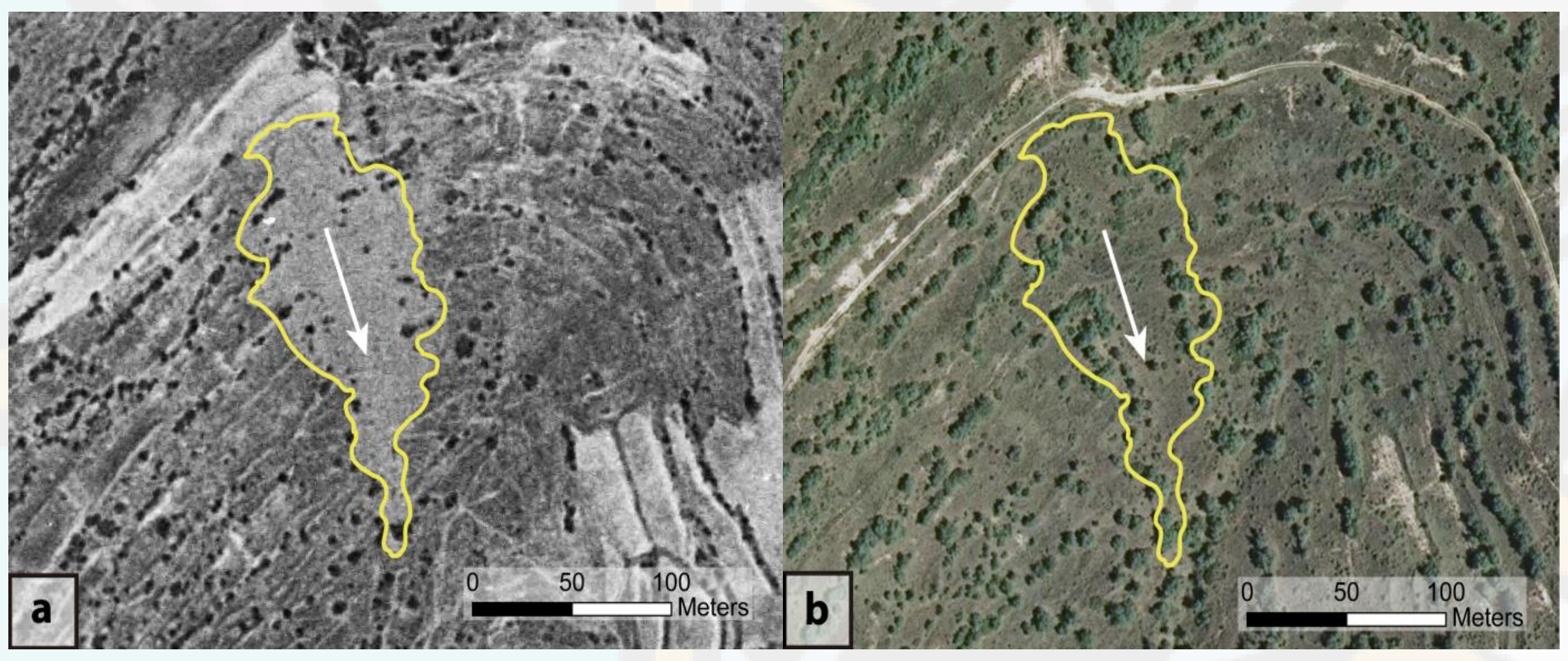

FIGURE 3. *(a) Elongated slide-flow-type slope movement detected on 1957 aerial photography, likely developed during a storm event and favored by the absence of vegetation cover, high slope and the upper dryland crops. (b) Same area stabilized by the revegetated cover.*

Strong changes in reforestation cover, land abandonment, natural revegetation and especially the reversal to Mediterranean forest had a great effect on the loss of coupling and as a consequence on the decrease of runoff. In Figure 4 it can be easily recognized that the connectivity decreased due to new land uses and land covers.

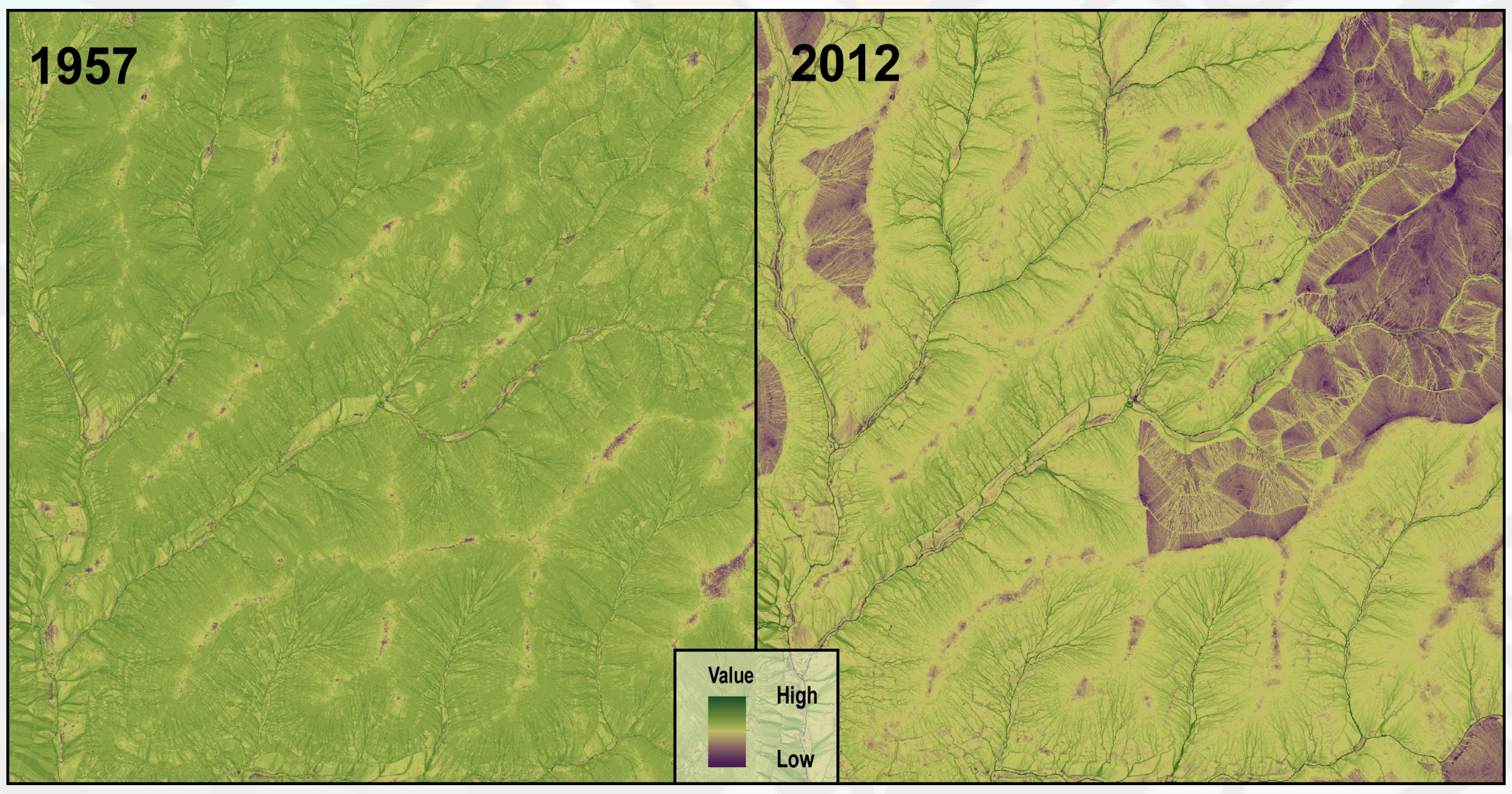

FIGURE 4. *Connectivity index for 1957 and 2012. These figures correspond to the red square on Figure 1 to improve visualization of a representative part of the catchment affected by changes in land cover.*

CONCLUSIONS

Land use/cover changes since 1957 by human intervention have probably increased connectivity and runoff in Barués Catchment, mostly due to tillage and geomorphological processes such as landsliding, gullying incised streams and severe soil erosion whilst abandoned arable lands and reforested areas seems to be very efficient in reducing runoff and connectivity. Besides reforestation has reduced connectivity likely contributing to limit soil erosion.

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