Analysis and assessment of ephemeral gully erosion in wide areas of Navarre (Spain) from routinely obtained ortophotographs

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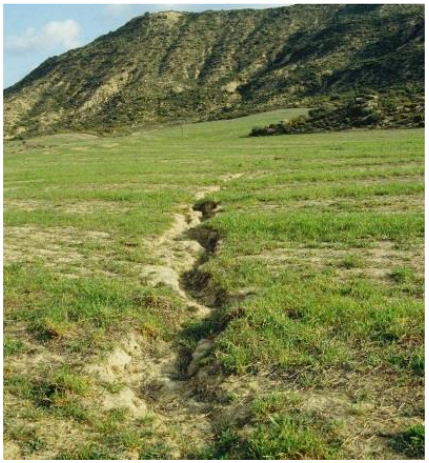
1. Introduction and objectives

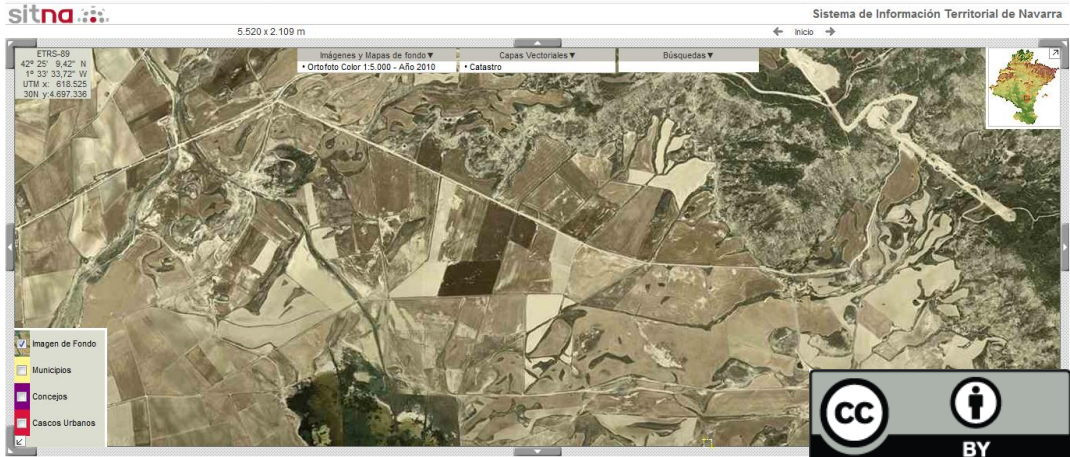
For an adequate knowledge of the importance and characteristics of ephemeral gully (EG) erosion, continuous observations and measurements for long periods of time are required. In this sense, the information obtained from aerial photographs can be of great value. In some parts of the world, orthophotos are available on a detailed scale and taken with a relatively high frequency. This allows to identify the presence of EGs at the appropriate moments as well as to determine its characteristics (i.e. location, length, width…).

The main objective of this work is to evaluate the possibility of making an exhaustive characterization of the space-time evolution of ephemeral gullies in a relatively large area from color orthophotographs. The effect of precipitation on the EG will be also analyzed.

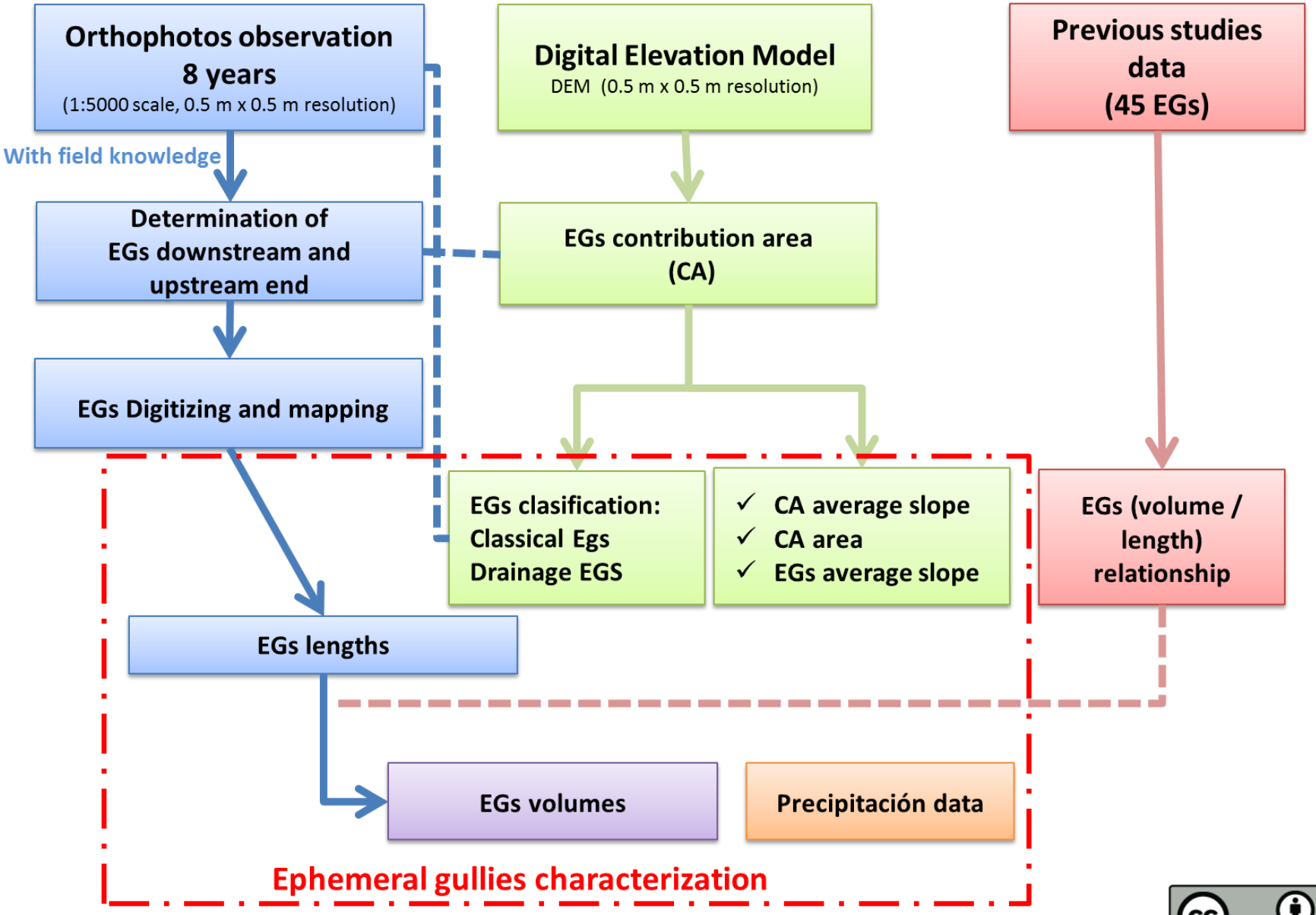
2. Study area

The study area comprises 570 ha, of which 310 are agricultural fields frequently affected by EGs, situated 5 km from the Pitillas village, southern Navarre, located 50 km south from Pamplona, Spain. The climate is continental Mediterranean moderately wet in spring and dry in summer, with a mean temperature of 13 ºC and an annual rainfall of about 500 mm.





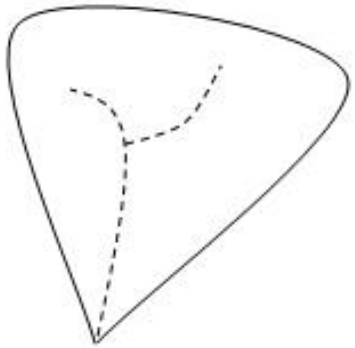
3. Chart showing the procedure followed



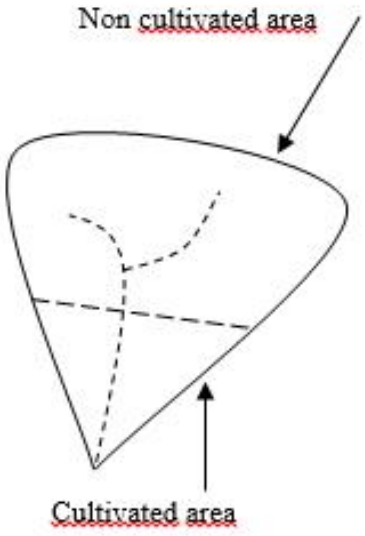
Example of EG determination within an orthophotograph

EGs classification to classical or drainage EG according to Casalí et al. (1999)

Classical EG, considered the prototype EG, formed by concentrated runoff flows within the same field where runoff started. Flowing water promoted regions of local scour.



Drainage EG, created by concentrated flows draining areas upstream from the field. Drainage flows reached the upstream end of fields and eroded cultivated plots downstream.



4. Results

- Throughout the study years, 57 small watersheds affected by EGs were identified, evenly spread across the study area.
- The number of drainage EGs was higher (39 EGs) than the number of classical EGs (18 EGs).
- The appearance of EGs presented high inter-annual variability. For the 57 EGs observed, the number of appearance times was distributed as

Times of EGs appearance	1	2	3	4	5	6	7
Nº of EGs	40	5	6	2	2	1	1

- Most drainage EGs 87% appeared only once.

- Inter-annual variation is observed for the positions and trajectories of EGs within the same EG watershed (the flow paths, trajectories, lengths, starting and ending locations throughout the years).
- A positive correlation was observed between the total precipitation during the period when EGs were formed and total EG length (L) for the same period, with a determination coefficient R^2= 0.84
- A positive relationship was verified between the number of events with cumulative depth 12.7 mm and the total annual length of EGs, with R^2 = 0.86.
- The average erosion rate (considering only the EG contribution area) in classical EGs is approximately 1.1 kg m^{-2} $year^{-1}$. Previous assessments using accurate direct methods reported an average value of 0.8 kg m^{-2} $year^{-1}$ for very similar watersheds in the same area.
- Considering all EGs types, soil loss caused by EGs, estimated from the aerial photographs for the studied area and during the studied period, is approximately 2,74 kg m^{-2} $year^{-1}$.