GULLY EROSION IN CAATINGA BIOME - BRAZIL: MEASUREMENT AND MODELLING

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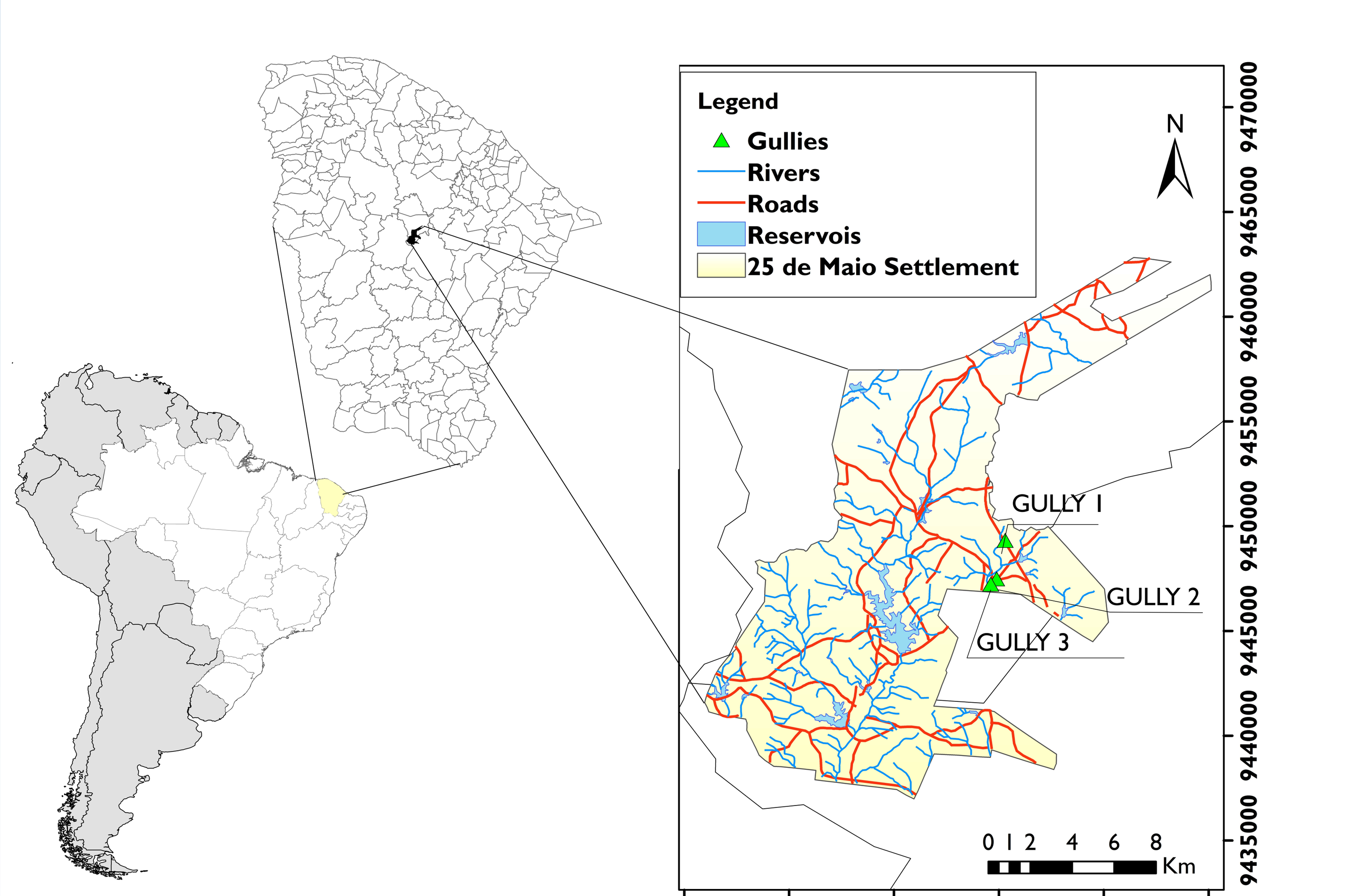
I. INTRODUCTION

Gullies are characterised by one-D erosions, which usually occur when there is concentration of runoff due to natural microrelief, initially producing rills and reaching large dimensions.

The Caatinga biome is in the Brazillian Semiarid region (one million km^2 and 25 million inhabitants) with mean anual precipitation around 600mm and pan evaporation around 2300mm. Its raining season is concentrated (3-4 months) with high spatial and temporal variability. The most important economic activities in the Caatinga biome are agriculture (*Phaseolus Vulgaris* and *Zea May*) and raise of cattle in open meadow, causing deforestation and consequent damage to soil.

The occurence of gully erosion has increased in the last twenty years due to land-use change and degradation. Most models adapted to Caatinga tackle primarily inter-rill erosion and there is a lack of routines to assess gully erosion. This work aims at measuring on-field gully evolution, at estimating its processes using physical models, and at improving the physical models merging them with probabilistic concepts (particularly the Principle of Maximum Entropy).

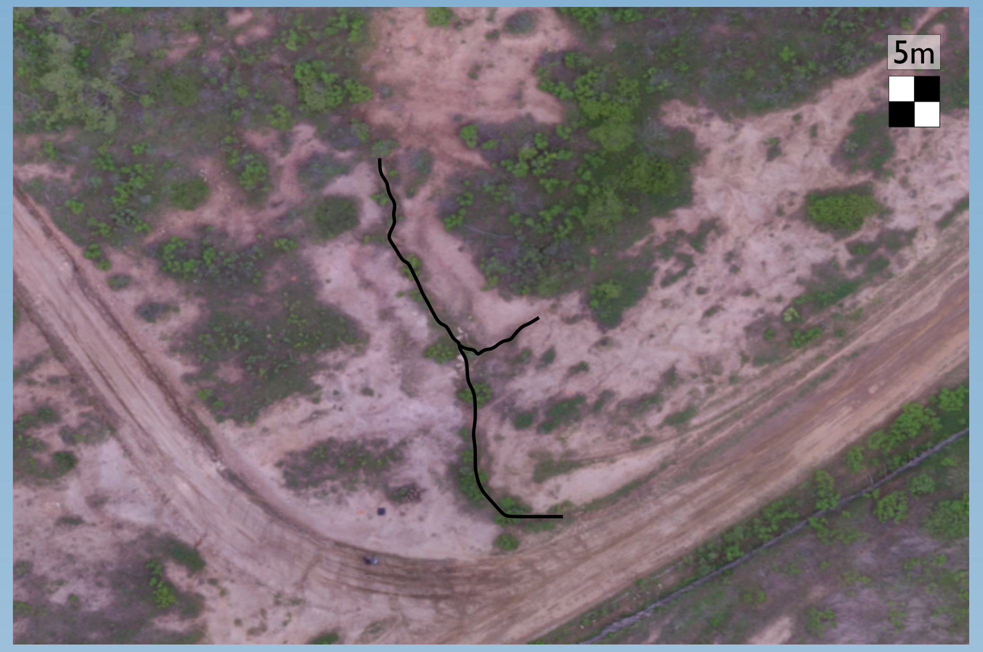
Because the Caatinga biome is on top of crystalline shallow bedrock (< 2m), gully erosions do not reach great depth and are usually limited to ephemeral gullies, which represent a relevant source of sediment, increasing local reservoir siltation.



Coordinate system: SIRGAS 2000 - UTM - 24S
Projection: Transverse Mercator

III. RESULTS

Gully site 1



Gully site 2

Gully site 3

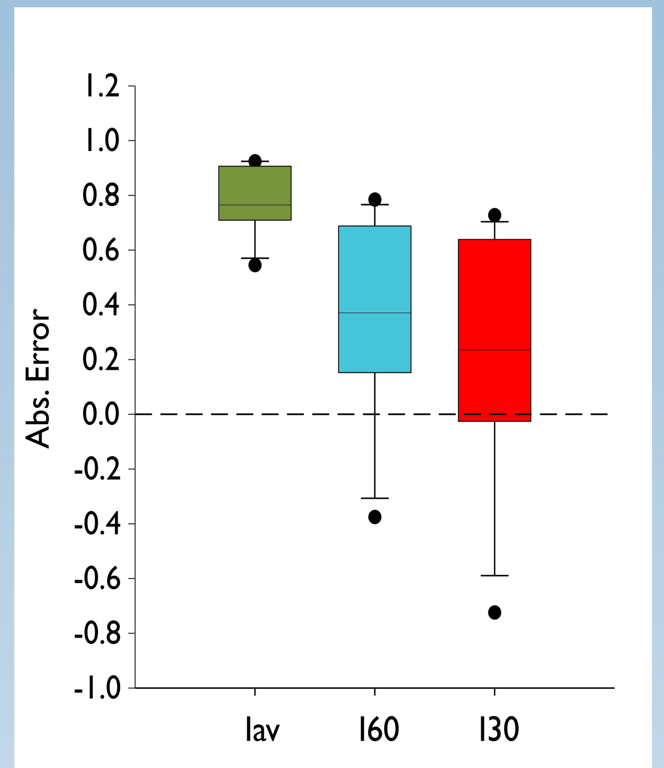


Chart I - Boxplot

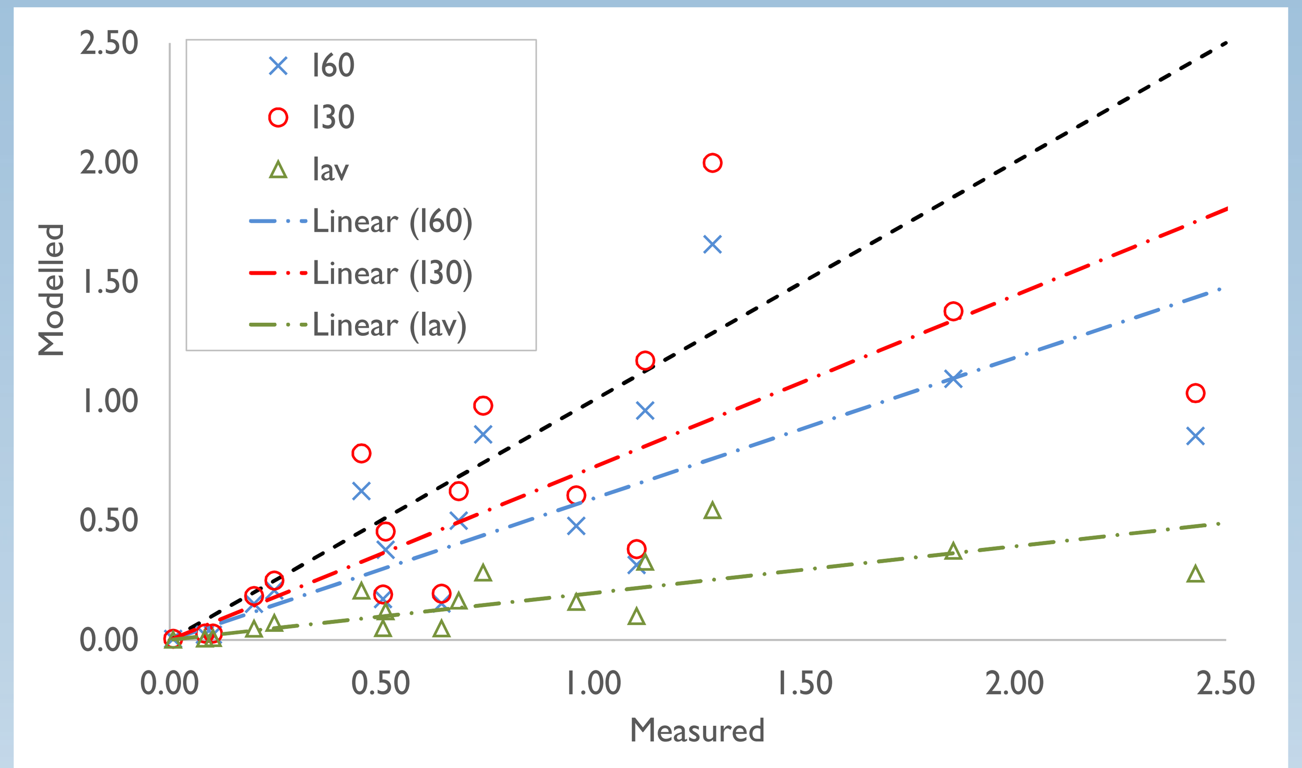


Chart III - Measured area x Model results - Dispersion

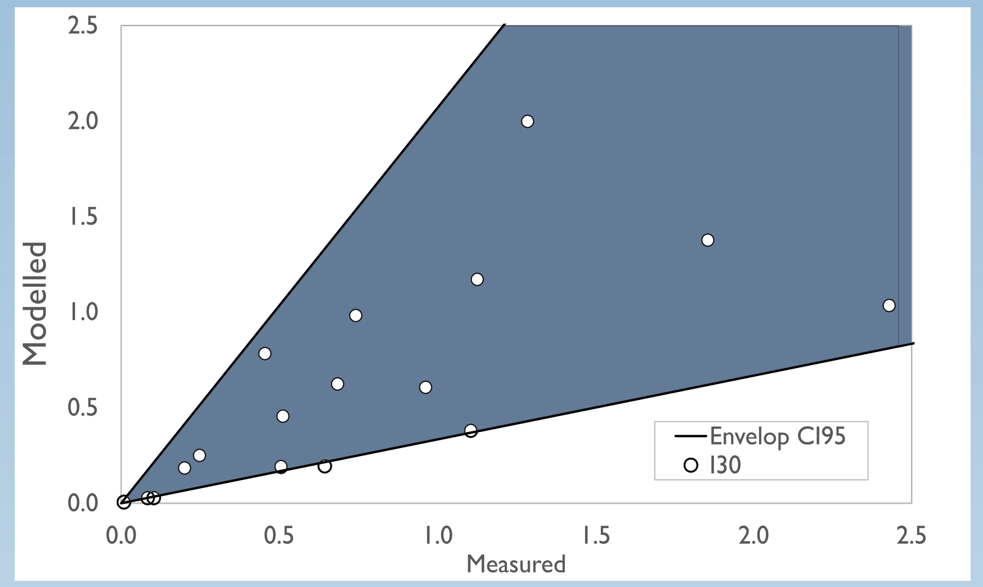


Chart IV - Measured area x Model results - Envelop

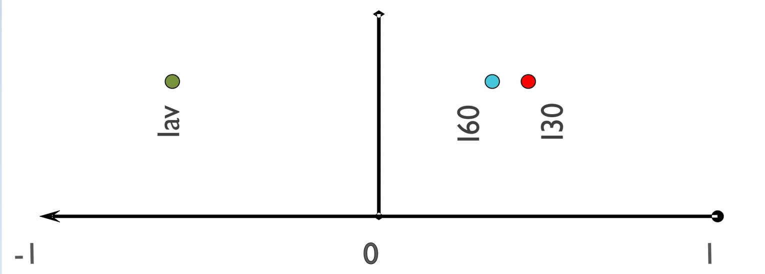


Chart II - NSE values

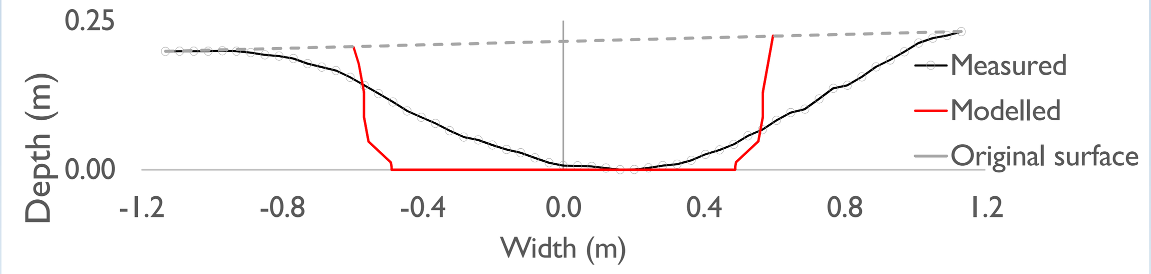


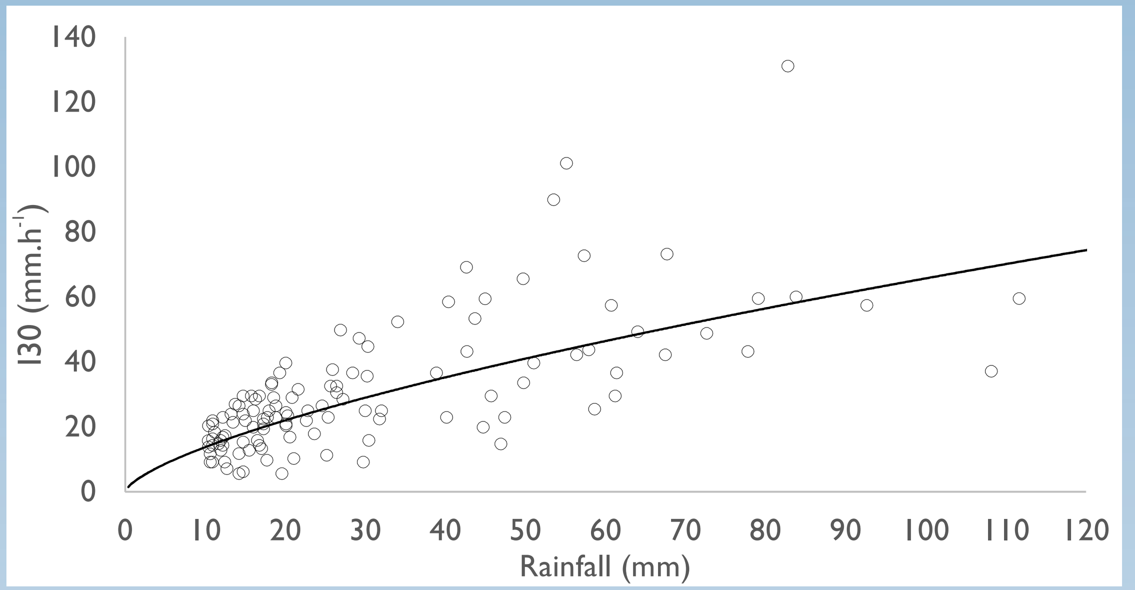
Chart V - Cross section

Confidence interval	Area - I30 rainfall serie %	Limits	Interval
CI99	0.5% 99.5%	-0.928 1.325	0.198 ± 1.126
CI95	2.5% 97.5%	-0.666 1.068	0.201 ± 0.867
CI90	5.0% 95.0%	-0.526 0.930	0.202 ± 0.728
CI80	10.0% 90.0%	-0.366 0.769	0.201 ± 0.567

II. METHOD

We selected three sites (0.3 ha on average) in Madalena basin, where well-developed ephemeral gullies were found. We have used two methods to take measures of the gullies dimentions: **Total Station** and **UAV** (*Unmanned Aerial Vehicle*).

Daily rainfall data were provided by the Brazilian National Water Agency (ANA), whereas rainfall intensity values were obtained by empirical equations from the Aiuaba Experimental Basin (Figueiredo et al., 2016). Both watersheds have the same hydrological and pluviometric behavior (Mendes, 2006).



To calculate the runoff yield in the gully basin, we used the SCS-CN model. The soil properties related to rill erosion (**rill erodibility** and **critic shear stress**) were estimated by the **WEPP** equations. We tested the model performance for three characteristic rainfall intensities: average (Iav), 60 min (I60) and 30 min (I30).

The **Foster and Lane** model (1983) was applied to 17 sections in three gully sites. We used a series of 58 years of daily rainfall as model input. The results of the model were compared with the measured data in terms of area, perimeter and width of the gully sections.

IV. DISCUSSION

- The **Foster and Lane** model (1983) has presented a good aproximation to the area field data.
- The highest model eficiency was obtained for the 30-minute intensity: the Nash-Sutcliffe efficiency coefficient was 0.441 and the Pearson coefficient was 0.720.
- Both responses to 60-minute and 30-minute intensity have not shown statistical difference between measured and modelled area.
- Notwithstanding, there are many uncertanties concerning the model. The rainfall data has a great variability in semiarid regions and that could induce or bias the model to underestimate the results. The soil parameters, as rill erodibility and critical shear stress are also uncertainty sources.
- However, a relevant input of uncertainties is the **Stream Power** ($\Omega = \gamma.S.R_h.U_{av}$), which has been already analyzed as a key factor to explain inter-rill erosion (de Araujo, 2007).
- The observed tendency of the model to underestimate the eroded volume can be attibuted to the field conditions, that differ from the model assumption that land use is cropland. In all three sites, there are roads, which concentrate the flow and generate higher runoff produced by the upslope areas.

Acknowledgments

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