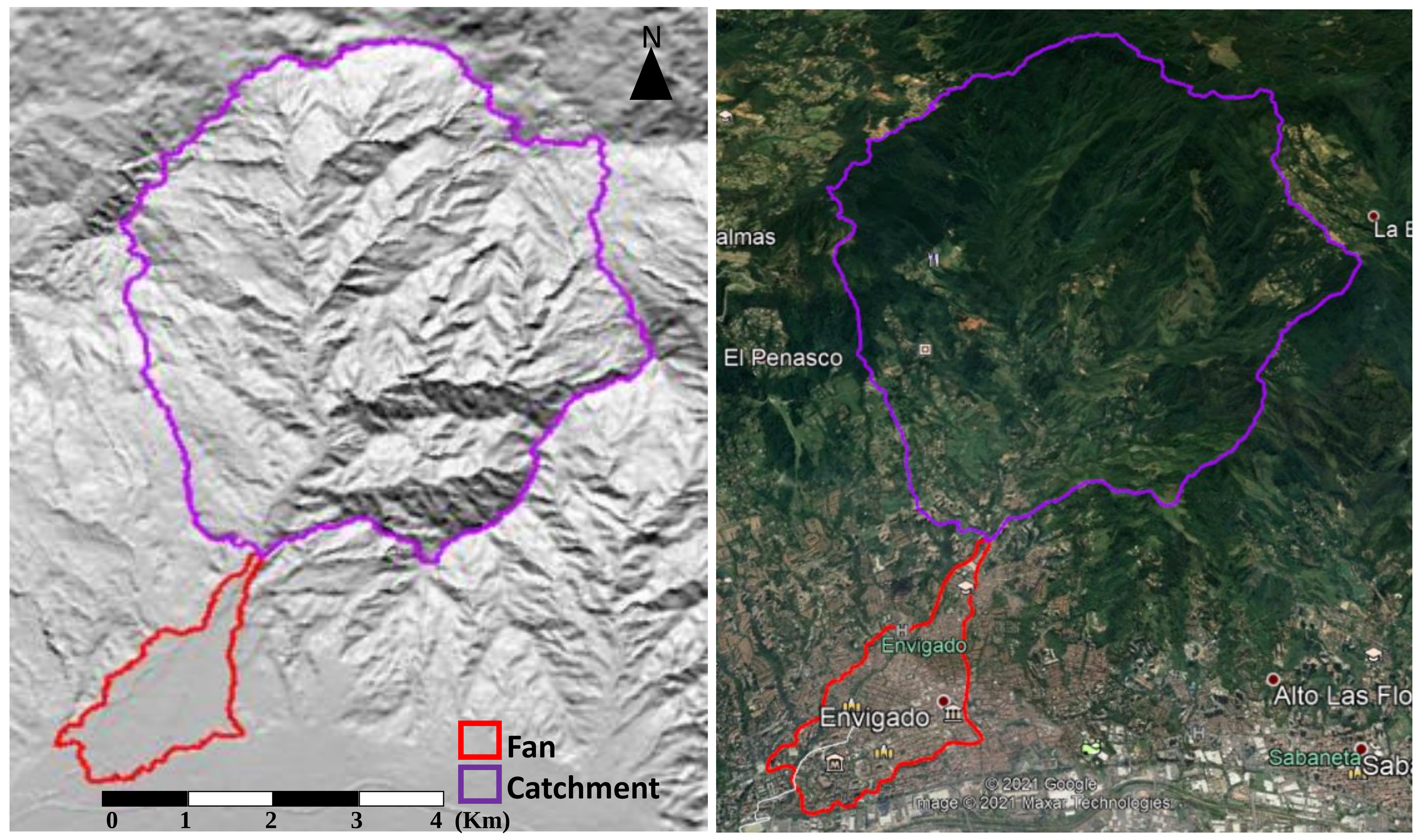
Morphometrical analysis of fans and torrential catchments in mountainous terrain in the northern Colombian Andes by machine learning techniques.

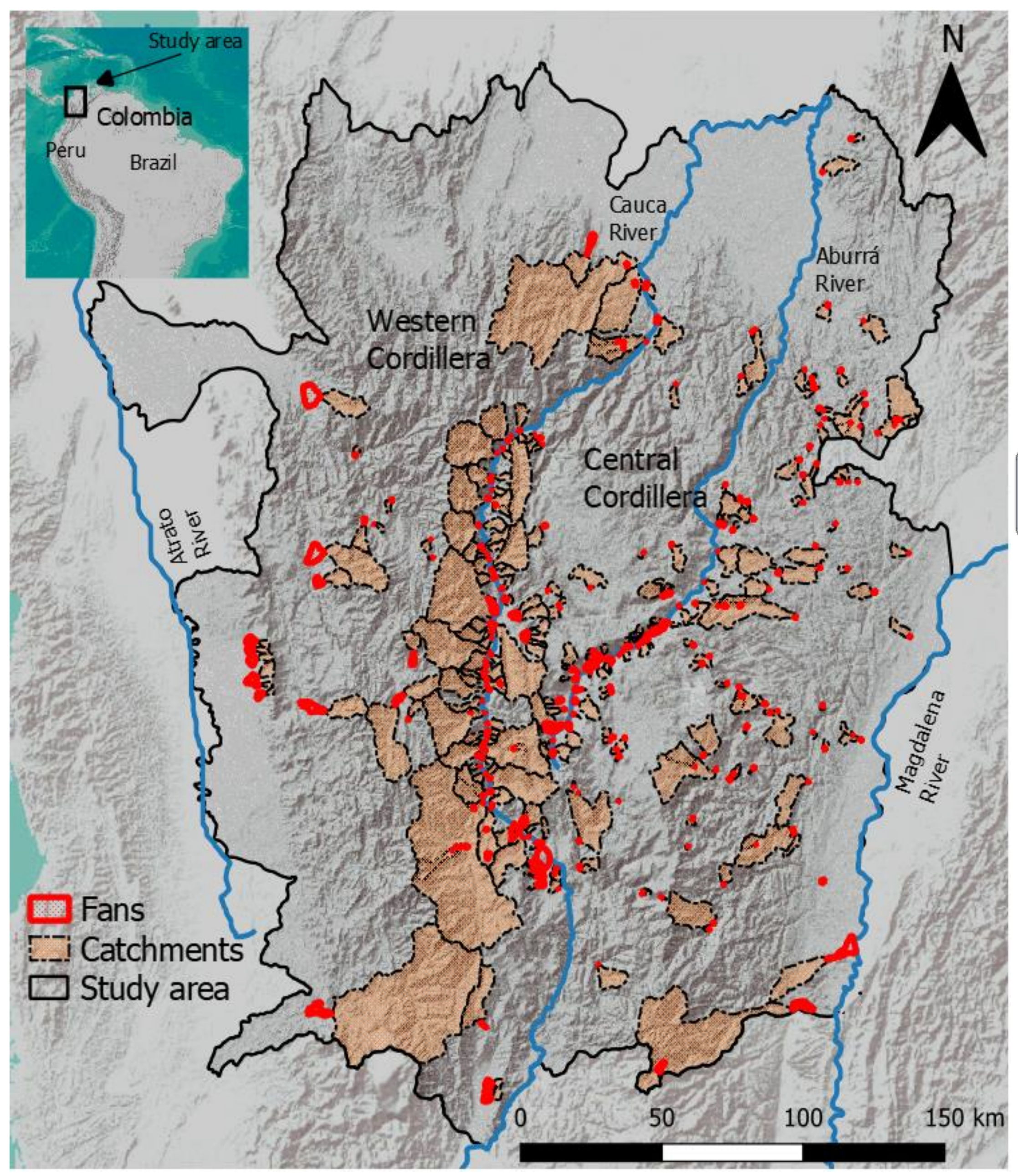
Emanuel Castillo Cardona[1], eecastilloc@unal.edu.co; Edier Aristizábal[1], evaristizabalg@unal.edu.co
[1] Universidad Nacional de Colombia, Sede Medellín, Departamento de Geociencias y Medio Ambiente.

OVERVIEW

Debris flow fans are commonly occupied by urban and rural settlements in mountainous regions such as in the northern Colombian Andes (Arango & Aristizábal, 2020). Characterization and understanding of the dynamics that give rise to fans in tropical and mountainous regions such as in the study area is a fundamental tool for land use planning (Welsh & Davies, 2010). This research focuses on cartography of fans and catchments using digital elevation models in the central and western mountain range of the northern part of the Andean mountain belt. The aspects considered in this research are morphometric measurements of the fans (Grelle & Rossi, 2019) and catchments (Strahler,1952; Horton, 1955), and second data exploration and machine learning techniques

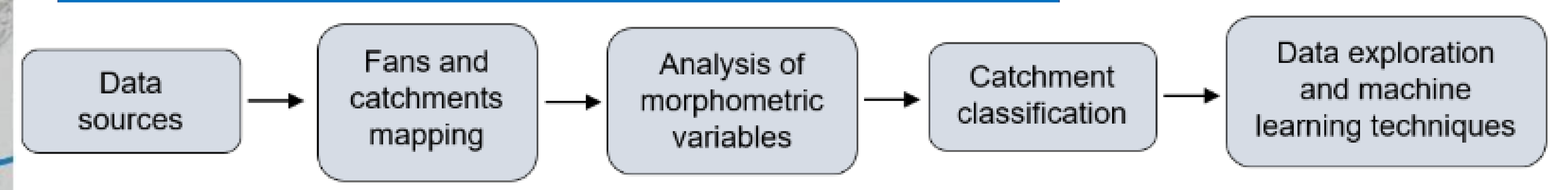


STUDY AREA



The study area is located within the Colombia Andes, in the northern part of the central and western mountain range of the Andes mountain belt, study area cover a total area close to 90,000 km^2, including the geomorphological depressions of the Magdalena river valley , Cauca river canyon, Aburrá river valley and Atrato river valley; where there are many fans from catchments that are part of these previous large rivers (Parra et al., 2012).

METHODOLOGY



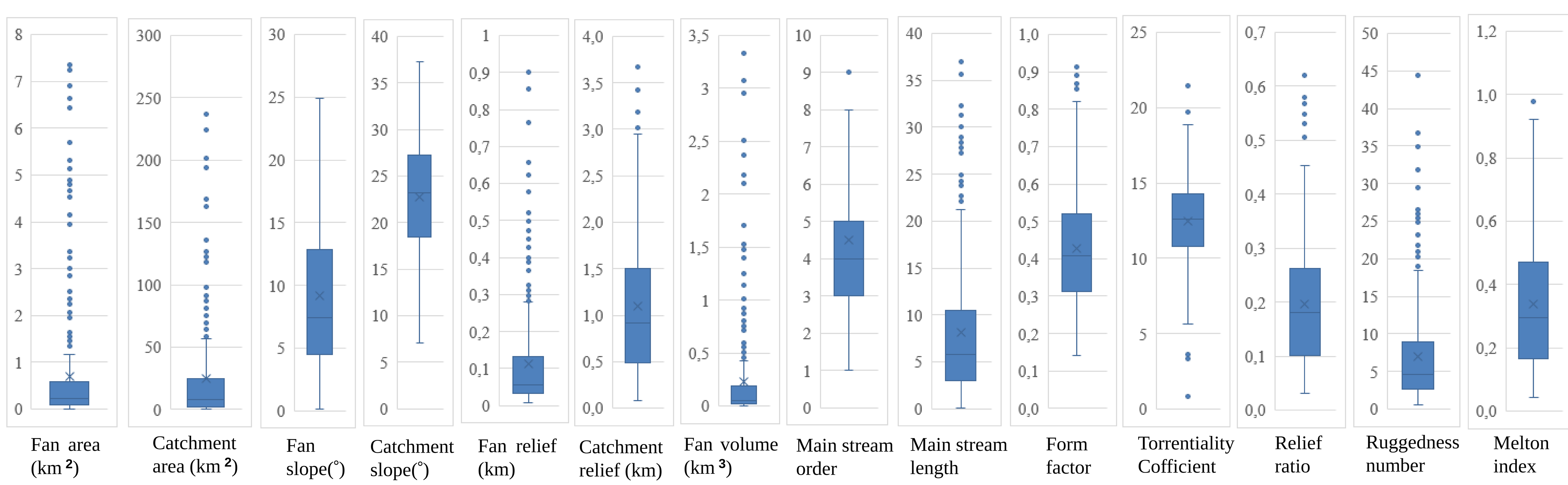
In this study, a simple flowchart was followed to achieve analysis of morphometric variables through machine learning techniques in fans and catchments. The fans are collected in mountainous terrain on a scale 1:15,000 - 1:20,000 with remote tools such as the digital elevation model, as well as other supporting cartographic tools such as geology and topographic maps.

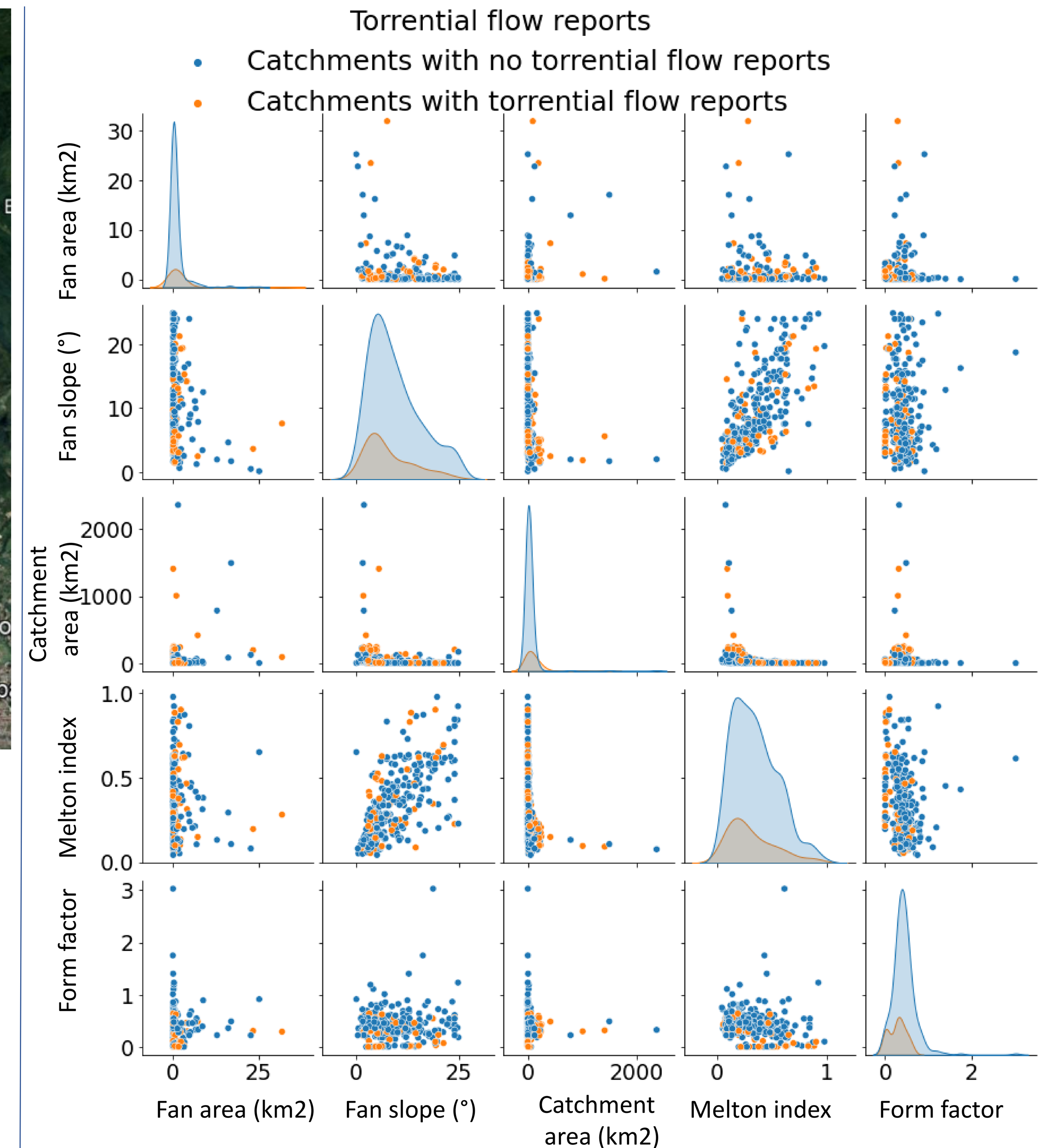
DATA

In total, 304 fans and catchments are mapped, which are subsequently analyzed by morphometry. Finally, bivariate and multivariate statistical analyzes of classification and grouping are applied, as well as machine learning techniques. Data exploration is carried out through boxplot and scatter matrix.

304

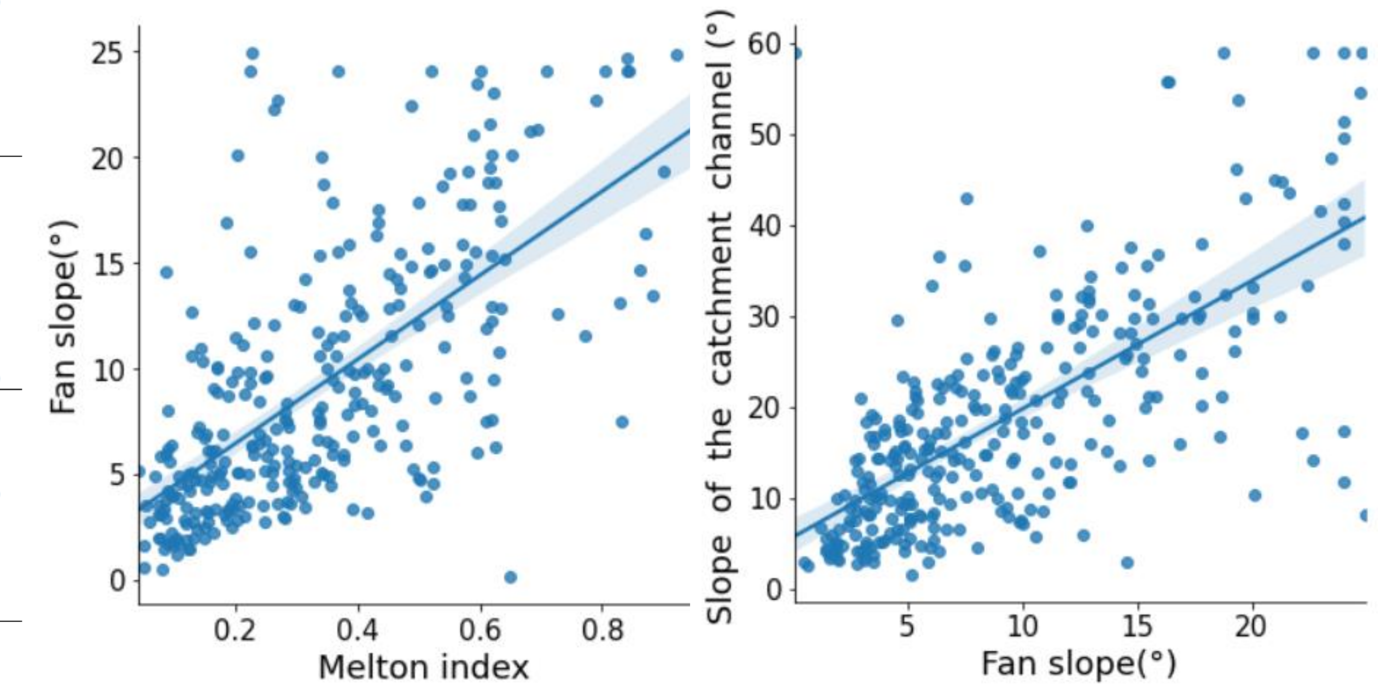
Fans & their Catchments are collected.



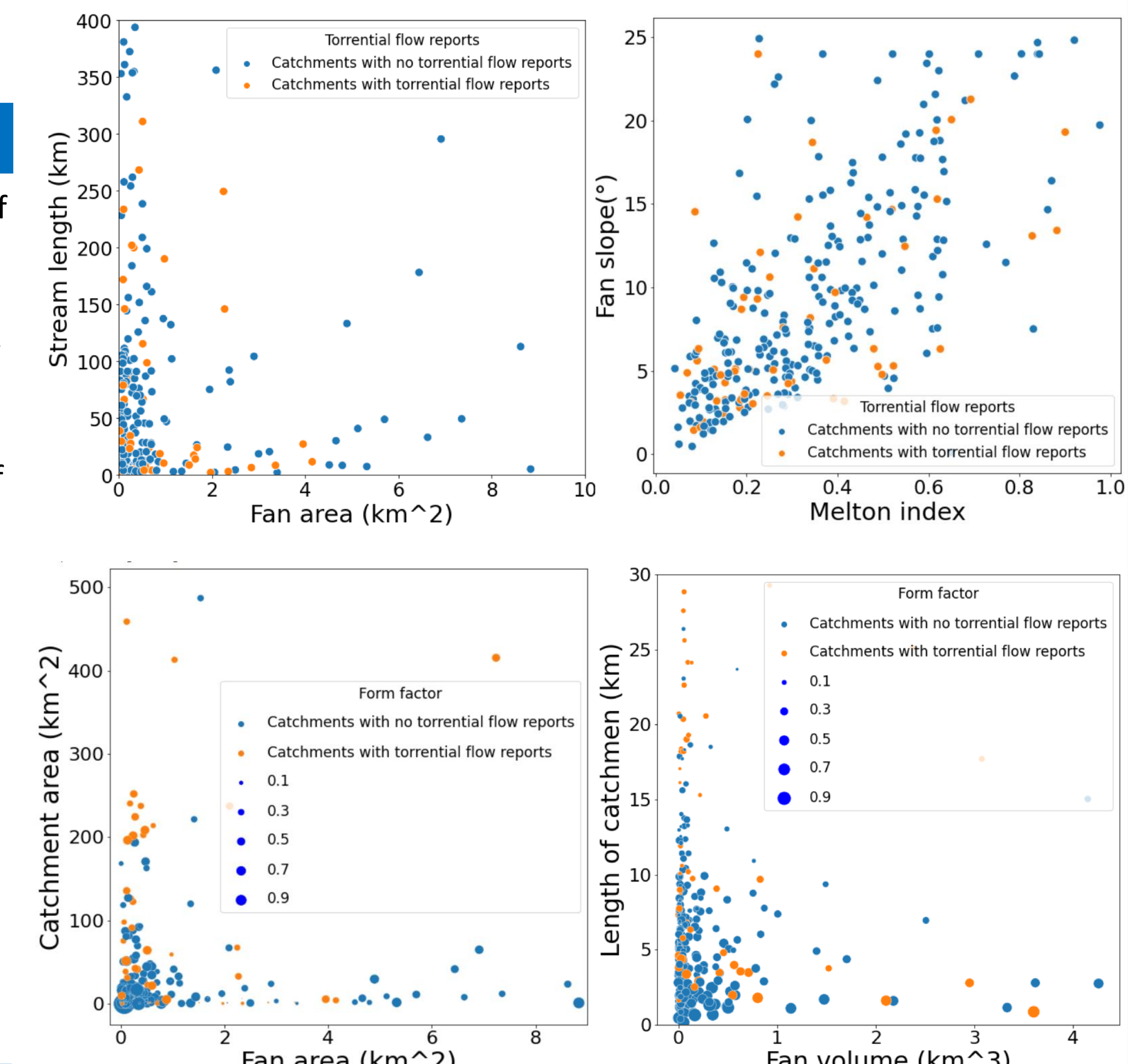


LINEAR ANALYSIS

The correlation of the slope of the fan and the Melton index is 0.70, the trend of the data is observed, where the increase in the slope of the fan has ahigh correlation with the increase in the Melton index number. Another important aspect is the relationship between fan slope and catchment slope channel with a correlation of 0.71.



Relationships are carried out in scatter diagrams of three and four variables



MACHINE LEARNING TECHNIQUES

Prediction of torrential catchments through morphometry of catchmets and fans by machine learning techniques:

1-Morphometric parameters selection: Table shows the result of the feature selection procedure using two tools provided by the Scikit-learn library in Python: RFE (recursive feature selector) and selectKBest.

2-Partition of data sets: Data set consists of 304 catchments of which 69 are classified as non-torrential and 235 as torrential.

	Morphometric parameters	Score SelectK Best	Score RFE
1	Number of streams	92003,33	0,773
2	Stream length	8666,23	0.781
3	Catchment area	3762,705	0.789
4	catchment perimeter	888,834	0.789
5	Bifurcation ratio	418,996	0.785
6	Main stream length	277,172	0.798
7	Texture ratio	180,062	0.797
8	Ruggedness number	161,045	0.797
9	Slope of the channel	52,042	0.797
10	Infiltration number	28,398	0.789
11	Ro coefficient	19,622	0.785
12	Stream frequency	18,909	0.822
13	Fan slope	16,064	0.798
14	Fan perimeter	14,982	0.806
15	Fan area	12,424	0.806
16	Fan volume	4,551	0.802
17	Wandering ratio	0,447	0.818

CONCLUSIONS

We have analyzed which are the morphometric characteristics of the fans and catchments that distinguish the torrential catchments in the northern zone of the Andes. In terms of relative importance for morphometric parameters selection in base in REF(recursive feature selector) and selectKBest, the most important morphometric parameters are number of streams, stream length, stream frequency, fan area and catchment area when distinguishing torrential catchments with torrential flow reports. These results improve the general understanding of morphometric parameters of fans and catchments in the Colombian Andes, the analysis presented is simple to use and appears reasonably reliable in identifying morphometric parameters of fans in torrential catchments, an important step in the prioritization of areas for hazard analysis.

References:

Arango, M., Aristizábal, E., Gomez, F. (2020). Morphometrical analysis of torrential flows-prone catchments in tropical and mountainous terrain of the Colombian Andes by machine learning techniques:. *Natural Hazards (2021) 105:983–1012.* Grelle, G; Rossi, A; Revellino, P. Assessment of Debris-Flow Erosion and Deposit areas by Morphometric Analysis and a GIS-Based Simplified Procedure: A Case Study of Paupisi in the Southern Apennines. Sustainability 2019, 11, 2382; doi:10.3390/su11082382. Horton RF (1955) Erosional development of streams and their drainage basins, hydrophysical approach to quantitive morphology. J Jpn For Soc 37(2):79–82. Parra, M., Mora, A., Lopez, C., Rojas, L. E., & Horton, B. K. (2012). Detecting earliest shortening and deformation advance in thrust belt hinterlands: Example from the Colombian Andes. *Geology*, *40*(2), 175–178. Strahler AN (1952) Hypsometric (area-altitude) analysis of erosional topography. Bull Geol Soc Am 63(11):1117–1142. Welsh, A; Davies, T. Identification of alluvial fans susceptible to debris-flow hazards. Landslides (2011) 8:183–194