

Testing the environmental flow allocation requirements in Colombia through the HeCCA 1.0 tool

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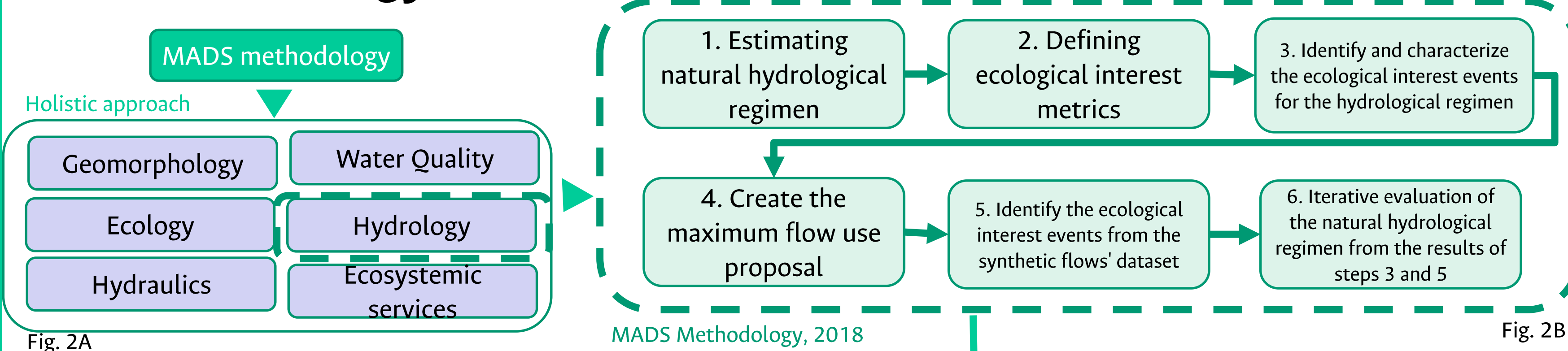
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1. Introduction

Nowadays, 69,93% of energy supply in Colombia comes from hydropower sources. The hydroelectric generation is focused on the Caribe and Orinoco Basins (Fig. 1), but specially at the Magdalena-Cauca river basin (MCRB), where the water demand reaches the 70% of the total national amount, but also most of the projects are located. However, their infrastructure and operation rules affect the natural regime of flows and sediments, that is the case for 41 of the 105 hydrographic subzones of MCRB, which during a medium hydrologic year, count on a water use index High to critic, and during a dry hydrologic year, 76 subzones have the same indexes (IDEAM, 2018), . Considering this great potential to expand hydropower generation as well as there is a growing demand from other water users, it is necessary to improve the water management in order to avoid irreversible environmental impacts and governance problems.

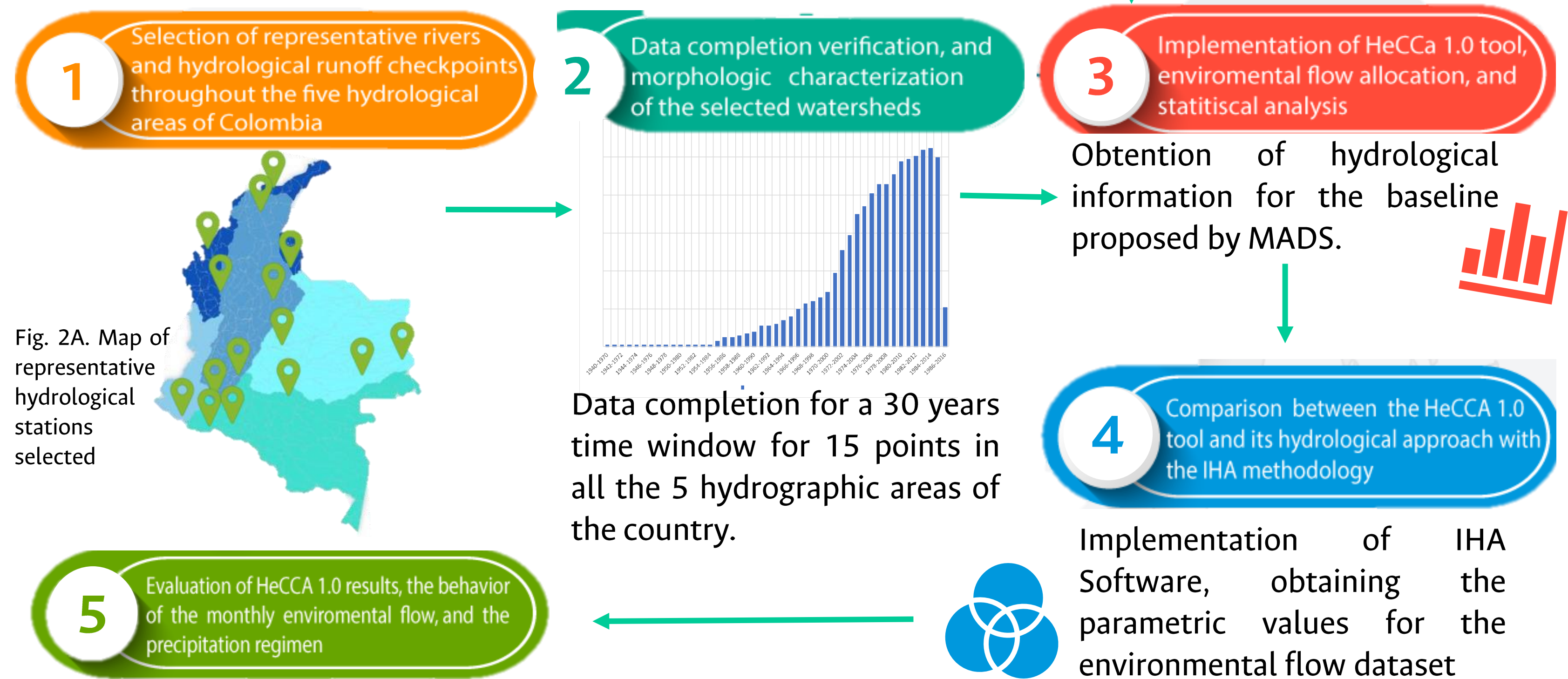
In 2018, the Colombian Ministry of Environmental and Sustainable Development (MADS) developed a methodology to consider environmental flows both in the water management decisions and in the environmental impact assessment of new projects with impacts on hydrologic regimen. The objective of this work was to evaluate the results of implementing the environmental flow methodology proposed by the MADS in 15 watersheds with contrasting conditions and to compare these results with other methodologies known worldwide, such as the Indicators of Hydrological Alteration - IHA.

2. Methodology

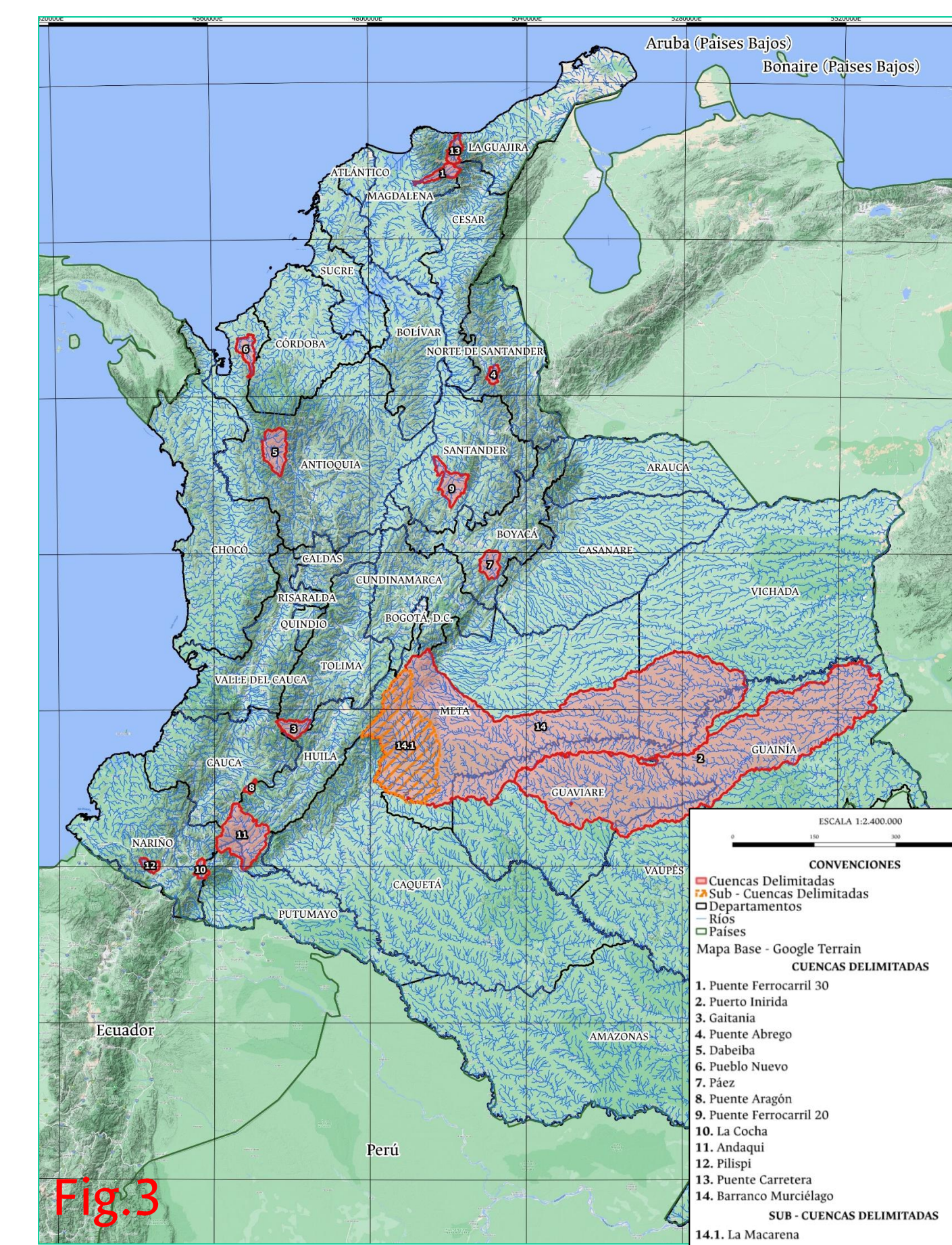


The MADS methodology is composed of two sequential levels (Estimation and Implementation). In the first level there is a phase of characterization of the water bodies, another of estimation of the environmental flow from a holistic approach and then another of evaluation of the ecosystem services considering the environmental flow and the demands of users. The present work has focused on the environmental flow estimation phase following the first 6 steps set out therein (see Figure 2B).

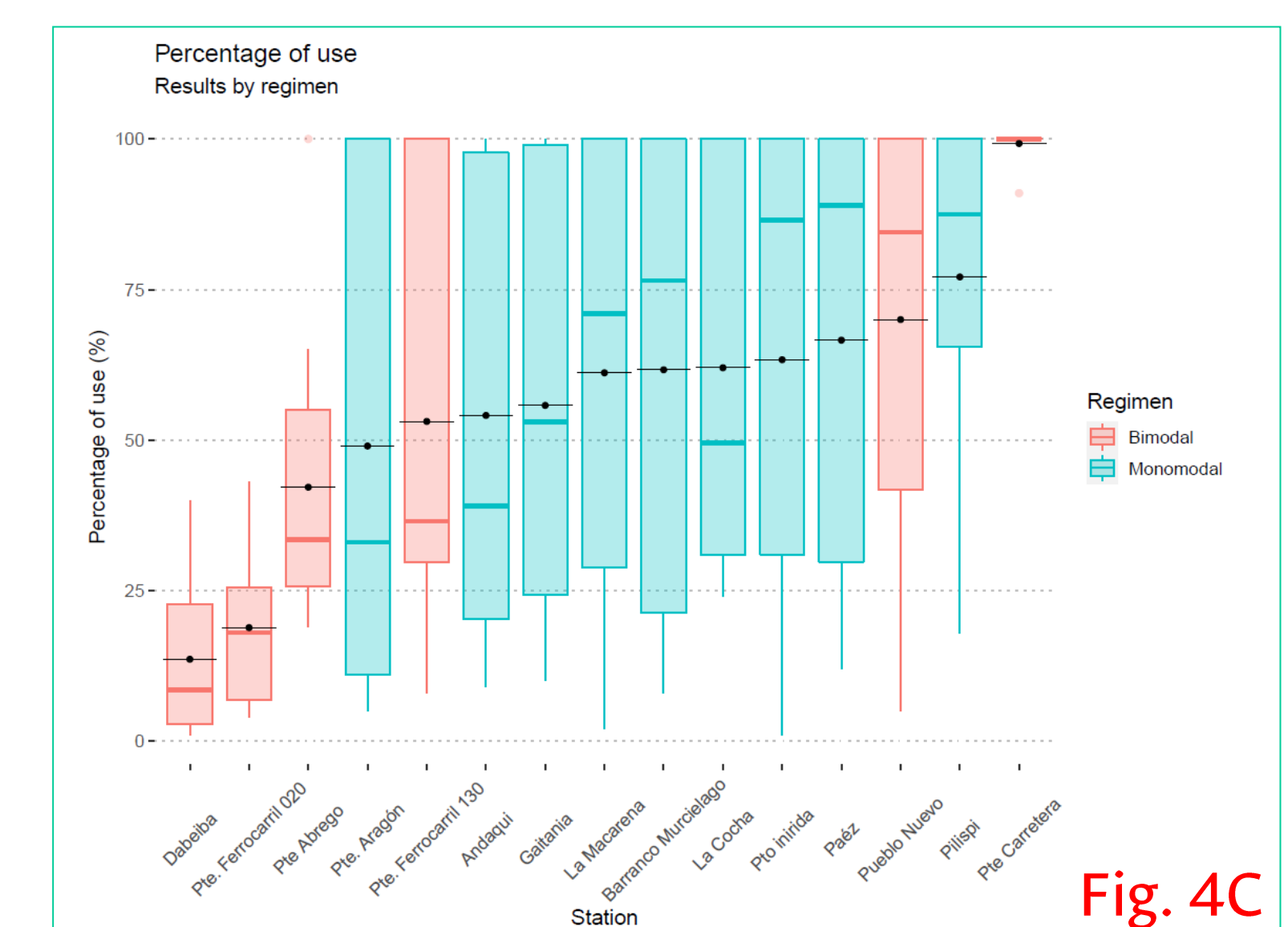
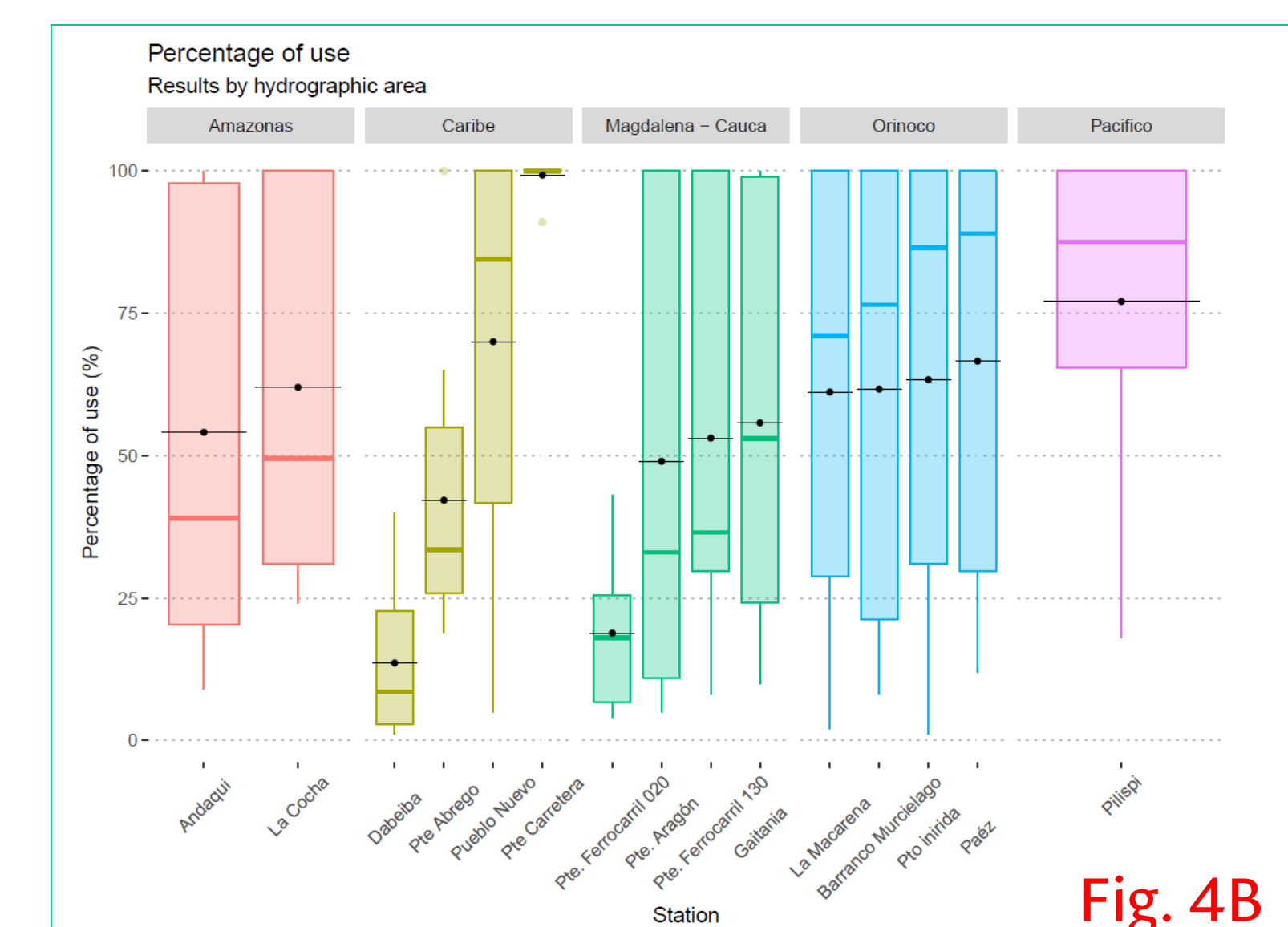
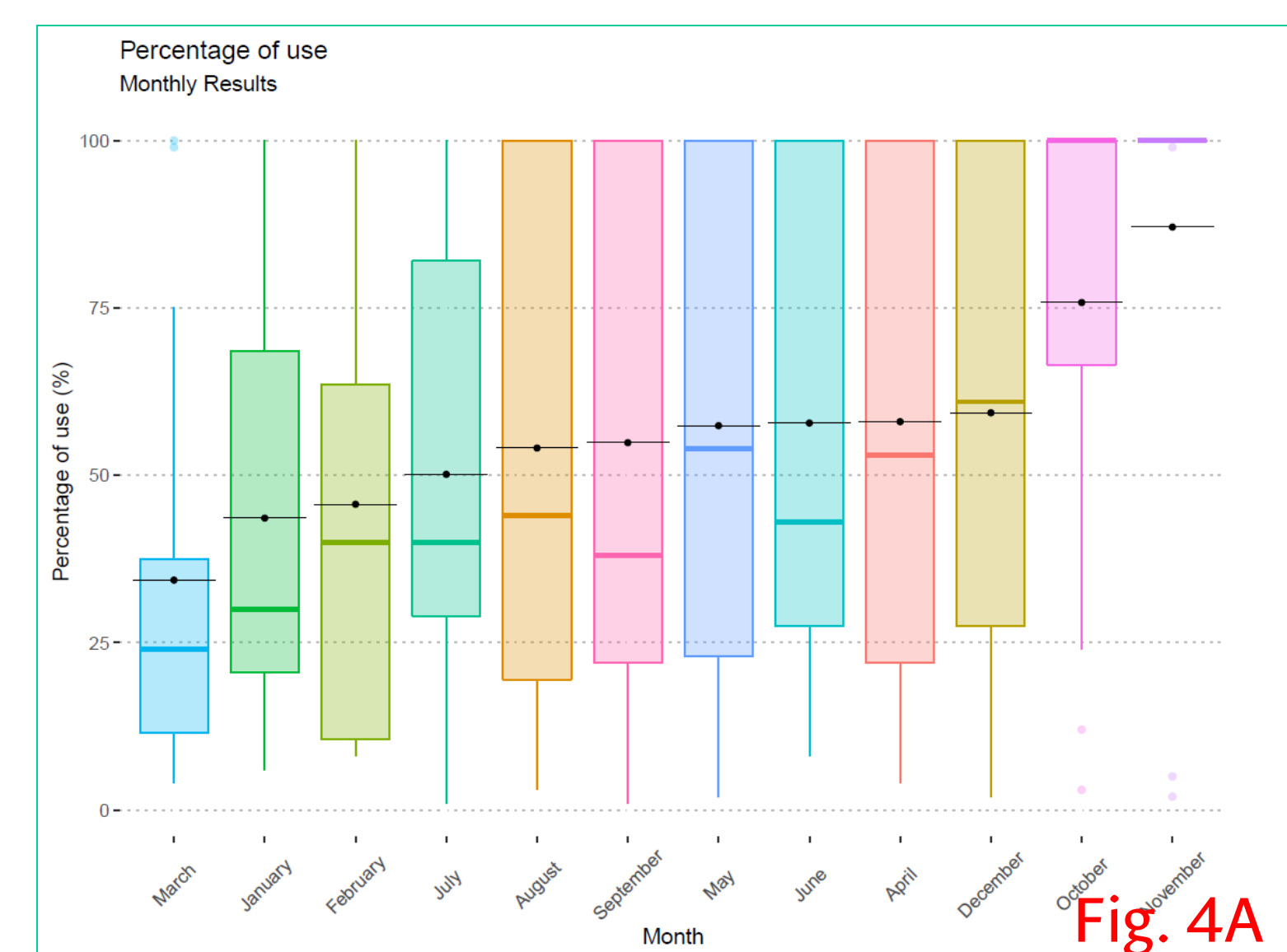
Methods



3. Case Studies



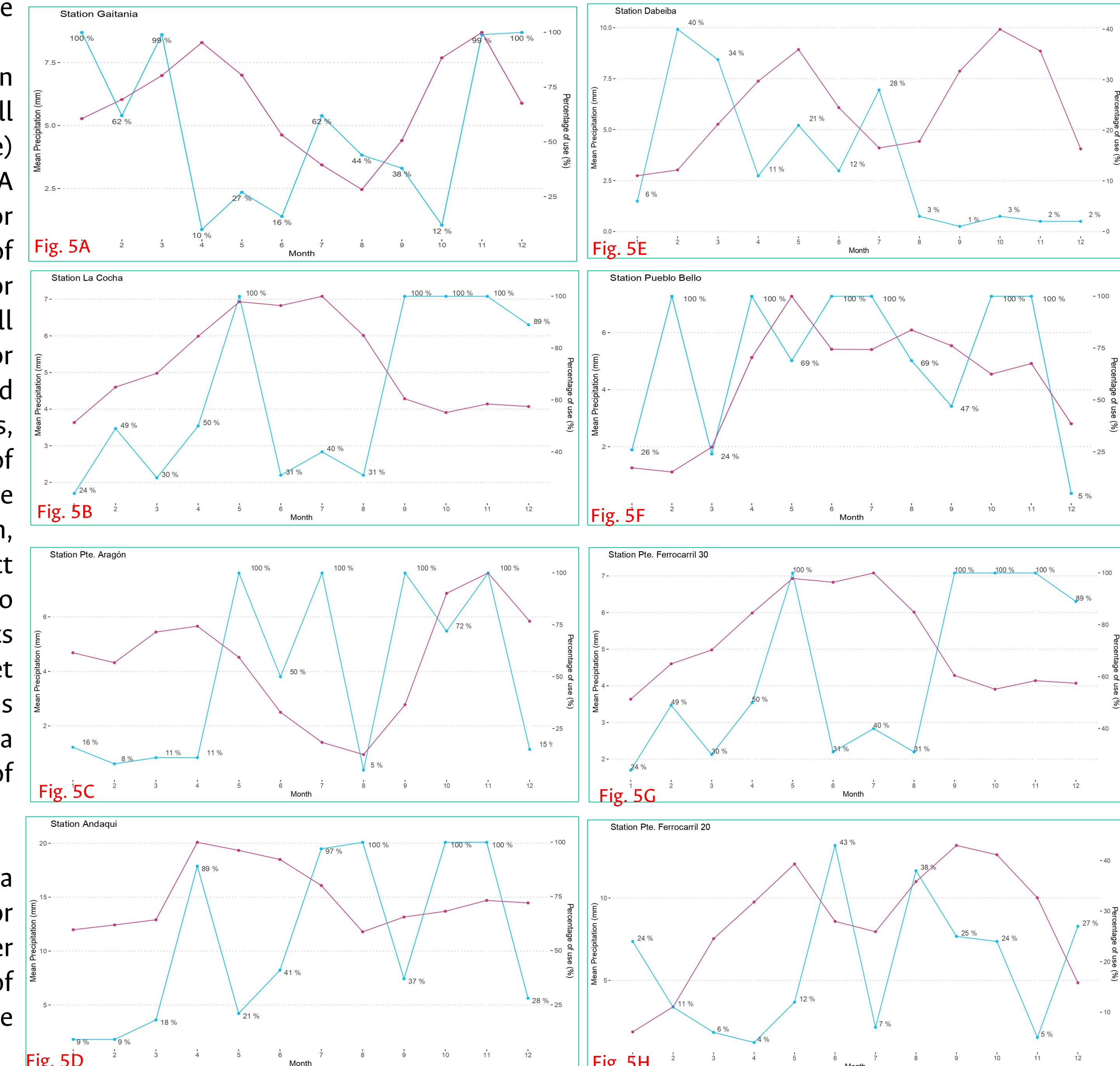
4. Results



Figures 4A, 4B and 4C show the percentage of the multiannual mean monthly flow that is permitted for any water use in a hydrological station of interest. Such a result has been found from the iteration that allows the fulfillment of metrics of ecological interest for each of the months of the year. The month which most water is available according to the IQR (See fig. 4A) corresponds to October, this is the most wet month for 5 of the 15 stations: all of them in bimodal regimen (see Fig. 4C) at Pacific and Magdalena-Cauca Hydrographic Area. Otherwise, March is the month which less percentage of use is available.

The median value of 6 stations is higher than 75% (See Fig. 4B), it means that those stations count on high percentage of use most of the year, and correspond to Pacific Hydrographic area, Orinoco, and Northern Caribbean. Just 2 stations count on values under 50% and median values under 25%. The station located in the Pacific Area shows the highest quantile values, as well as a short IQR, indicating small variation of the percentages, as well as an absence of outlier values under 20%.

The graphics 5A to 5H show the relationship between the mean monthly rainfall pattern (purple line) and the HeCCA results for percentage of available water for use (blue line). In all cases, for monomodal and bimodal systems, the percentage of use increases before the drought season, showing a direct response to precipitation events and during the wet season, it is guaranteed a minimum amount of water (Environmental Flow) but also a percentage for developing other activities for the stakeholders.



6. Conclusions

- The behavior of the percentage of use depends on the rainfall regimen and the location by hydrographic area. According to the rainfall distribution and the wet and dry seasons, the HeCCA tool shows a trend behavior for all the stations.
- All the geomorphological features mentioned in 3 were evaluated in order to define its relationship with the results obtained in HeCCA. Thus, there is a different setting of features which may affect the results of each watershed.
- The HECCA tool allows the further implementation in specific hydrographical areas from a hydrological approach. This way, it is paramount the improvement of the performance for this tool from a holistic point of view, including in the management plan not only the allocation of available amount of water for anthropic intervention, but also, since a biological ecological, ecosystemic and hydraulic interaction is affecting the watershed.
- The implementation of national policies for water resources managements through informatic tools provide important information to stakeholders for the solving of hydrological problems of different water systems across the country.

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