# Understanding variability in water yield of small catchments feeding potable water systems in the Colombian Andes

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The overall objective of this work was to develop a semi-automated process for comparing precipitation and streamflow (i.e. water yield) utilizing commonly available software. Due to the large size of streamflow datasets, developing a standard “program” for data analysis permits community partners to easily synthesis their precipitation and streamflow data in standard formats, and subsequently utilize that data to better understand variability in the water sources and potential water scarcity.

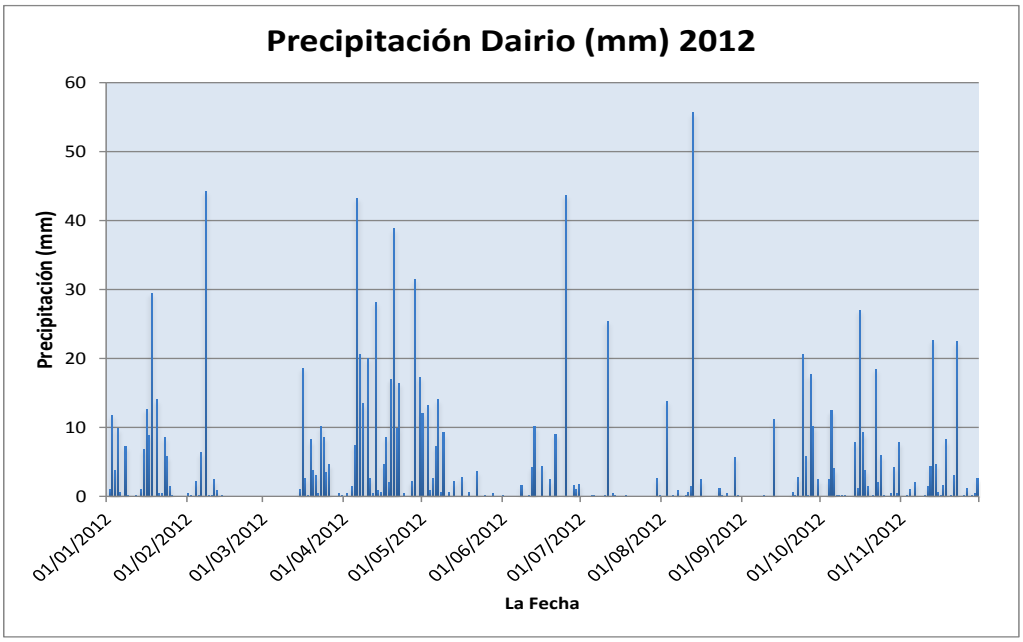
Excel was chosen as it is widely available, commonly used by community groups, despite some drawbacks in terms of analytical capability and speed.

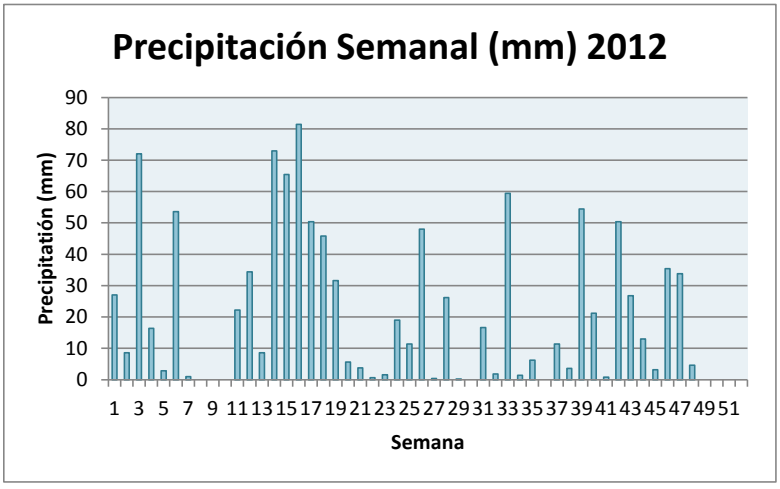
The analysis was undertaken for 2 watersheds, Golondrinas in the western branch and Sonora in the central branch of the Andes with the idea to setup a template where data can be updated or data from other watersheds can be “plugged-in”. These 2 watersheds were selected due to the relative completeness of their datasets at the time of analysis.

Data was analyzed at 4 time steps, daily, weekly, monthly and annual, to permit analysis of variability, wet / dry season comparisons, comparison to monthly water use and the calculation of annual water yield.

## 1. **Precipitation data**

Precipitation data was summarized daily, weekly and monthly using pivot tables in excel. Example graphs for Golondrinas in 2012 are shown. Note that for precipitation data to be considered "complete" and used, 27 out of 30 [31] days per month of data was set as the cutoff. Sites with <27 days of data per month were not included in the analysis.



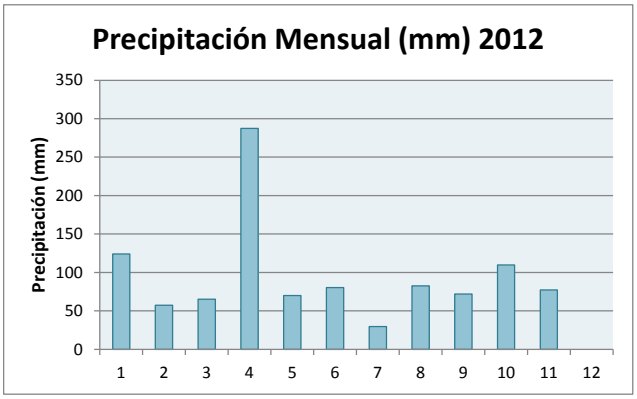




Figure 1 a) Daily, b) weekly and c) monthly precipitation data for Golondrinas.

## 2. **Stream flow analysis**

Stream flow data was analyzed on daily, weekly and monthly time steps using an excel macro. Individual sites contain some 12,000 to 15,000 data records per year. Data were summarized in both m3/s (standard for hydrometric analysis) and m3 (e.g. m3/month) for comparison with water use. Example graphs generated by the macro for Sonora in 2012 are shown.

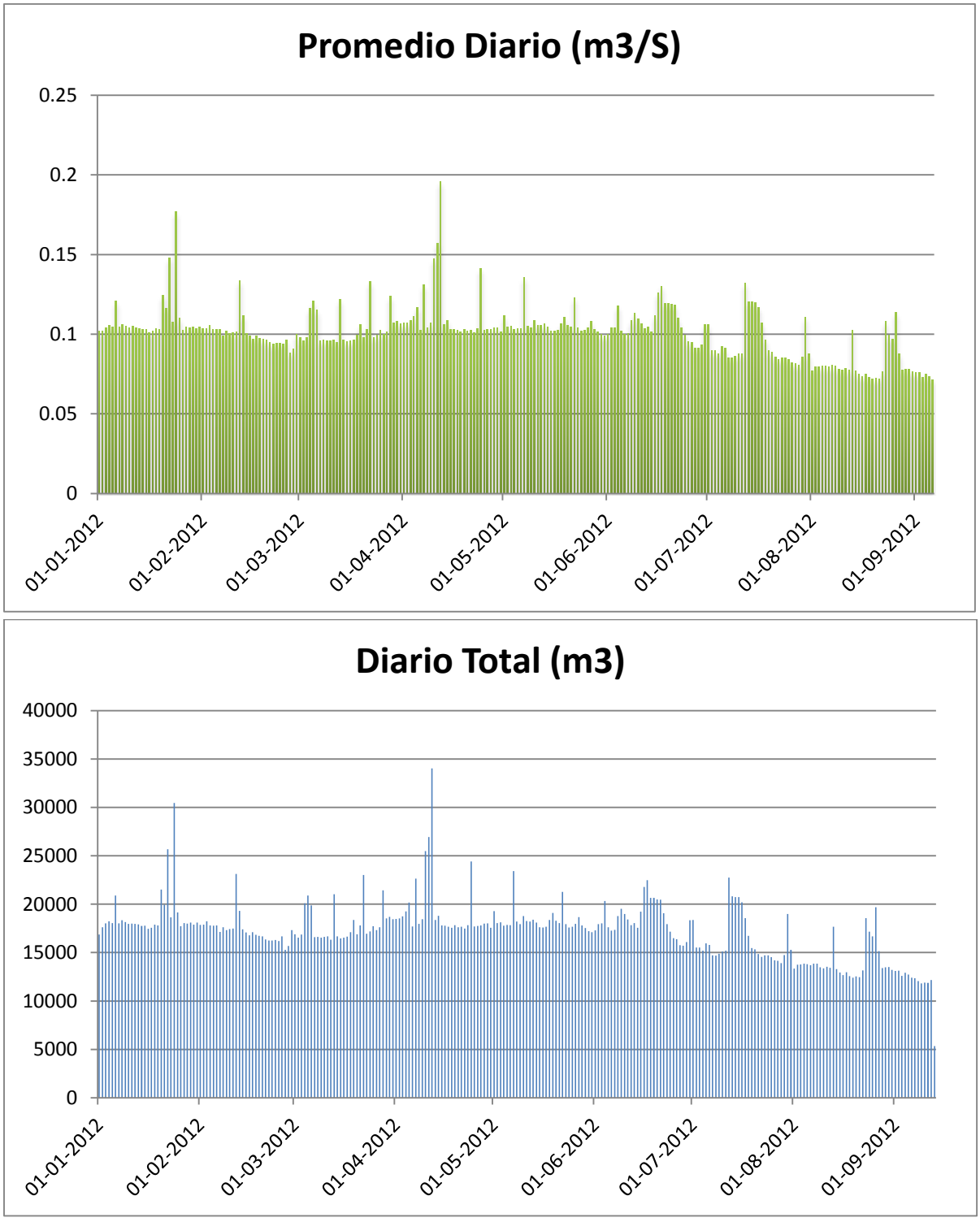
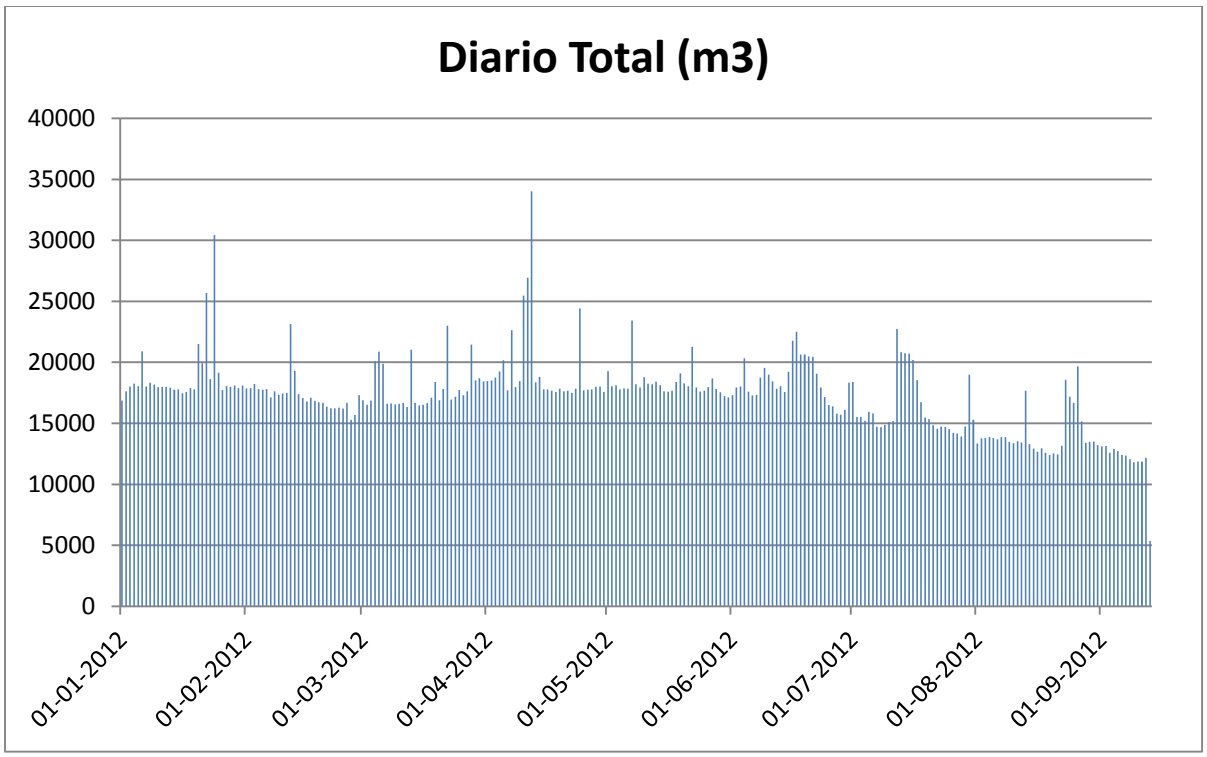
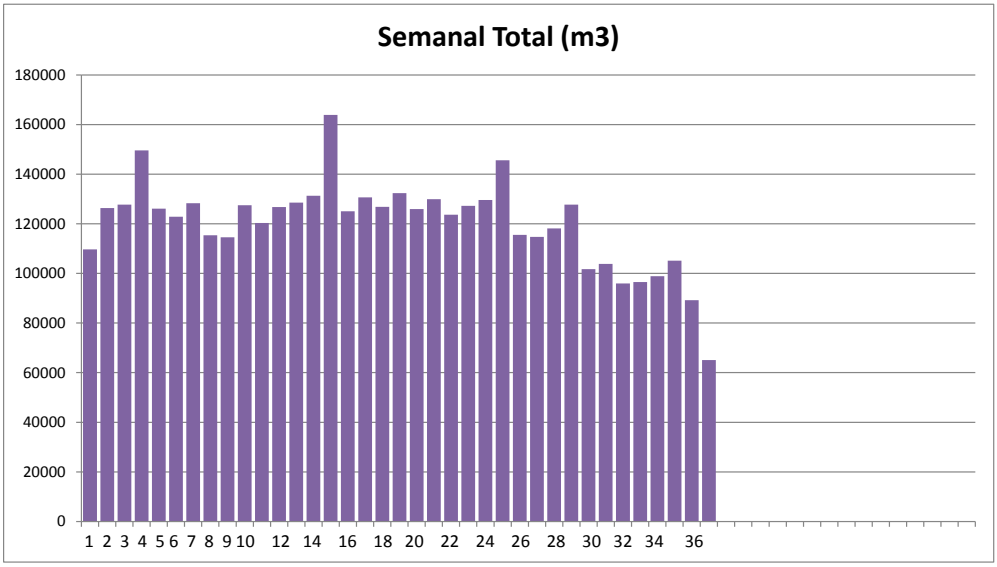



Figure 2 a) daily streamflow (m3/s) and b) m3/day for Sonora 2012



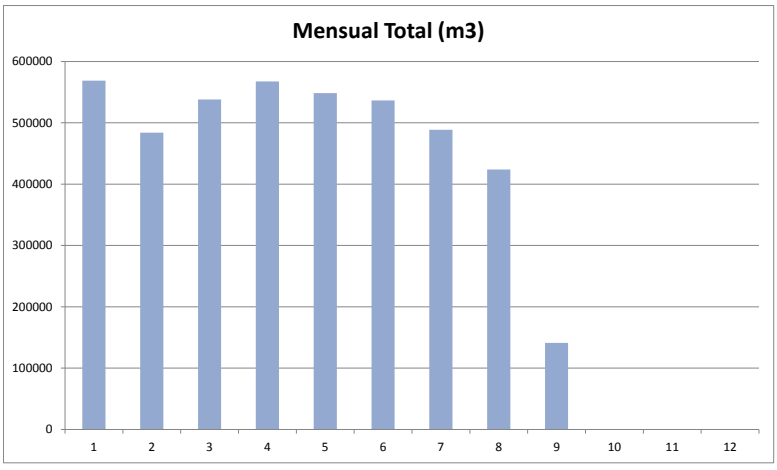




Figure 3 a) daily b) weekly and c) monthly total stream flow (m3) for Sonora January to August 2012.

3. **Future data uses**

Water Yield

Water yield refers to the proportion of precipitation falling on a watershed which runs off as stream flow. For years with complete (12 month) data on both stream flow and precipitation, % water yield can be determined using the precipitation and stream flow data analyzed. This information is useful in understanding effects of land use (e.g. pasture versus forest) on overland flow and the flashiness of streams (high variability associated with high water yields and intense precipitation)

Water Scarcity

Comparing monthly stream flow (L/month) with water consumption (L/month) provides an assessment of water availability and/or scarcity. This analysis is conducted on a monthly basis as water use data (metered) is only available at this time step. Typically metered water use + leakage (non-revenue water) is compared to stream flow as volume of treated water may be up to 55% greater than metered water use. Dry season data, late July through September is critical for evaluating water allocation (or over allocation).

Water scarcity may occur from physical water shortages or from plant closures. Plant closures may be related to maintenance, or to high stream flow which causes high turbidity. Turbidity is an issue for treatment, and smaller plants which do not have sufficient settling tank storage, will by-pass the treatment plant during high turbidity events. This is particularly an issue in Golondrinas who closed their plant 20 days in the 1st 8 months of 2012 due to high turbidity. With the available data, days where service is suspended may be compared to stream flow and/or precipitation, and treated water in those time periods to water use.

4. **Challenges**

Data formatting must be 100% consistent for automated / semi-automated analysis. Small changes (e.g. 1 record) in a large dataset (e.g. 15,000 records) will cause the macros not “crash”. Finding such errors is time consuming and tedious. Thus consistency and standardization are critical. The data summary protocols developed by the team are a vital step, but follow-up data checking is also necessary.

Excel, while advantageous in its ubiquitous use has speed limitations when working with large datasets. This trade-off between accessible software and other freeware options such as R (which requires programming knowledge) may be revisited. For community / small organizations xls is a reasonable option.

Data completeness may also be a challenge. The small water providers working with the IDRC project Adapatación Cambio Climatico en Colombia Rural are all working at different levels, have encountered different data collection challenges and thus have datasets at different levels of completeness. Developing semi-automated analysis techniques (as was done here) is useful in permitting groups assess their data periodically.

Finally data verification is critical. Datasets and analysis should be reviewed by an individual with experience to cross check results within expected values for this region. This can be somewhat challenging for regions such as Colombia where local level data analysis is limited.