# Strategies to monitor hydrologic ecosystem services in the heterogeneous landscape of the Guapi-Macacu Basin, Atlantic Forest, Rio de Janeiro, Brazil

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**Abstract -** Hydrologic ecosystem services are defined as the benefits provided by freshwater and terrestrial ecosystems which include freshwater supply, water quality regulation, flood mitigation, erosion control and water-related cultural services (Brauman et al. 2007, Terrado et al. 2014). They are very susceptible to land use and land cover (LULC) changes, that were recognized in the last decade as the most ancient human-induced impact on the environment (Turner 2002, Lepers et al. 2005, Foley et al. 2005, Kepner et al. 2012). Several studies have sought to assess the impact of LULC changes on hydrologic ecosystem services (Qiu and Turner 2015, Nosetto et al. 2012, Prado and Novo 2007, Menezes et al., 2009). However, many difficulties have been encountered while studying heterogeneous landscapes (Lovett et al., 2005). The Atlantic Forest biome in Brazil has undergone serious LULC changes (BMBF 2002, Webb et al. 2005, Joly et al. 2014). The Guapi-Macacu basin (GMB) is located in this biome and has great importance for the water supply of Rio de Janeiro state providing 2.5 million people with drinking water (Benavides et al. 2009). It presents heterogeneous landscape with remnants of natural vegetation in the midst of urbanized areas, pastures and family agriculture (Fidalgo et al. 2008) (Table 1). This study presents strategies to monitor hydrologic ecosystem services in GMB. Three micro-basins with different LULC and relief, but representatives in terms of agricultural production systems and urbanized areas, were monitored for hydrologic parameters. This strategy was adopted considering that it is very difficult to find homogeneous micro-basins in terms of land use and management in a heterogeneous landscape. Satellite image, digital elevation model and several field trips were carried out during the selection process. The Manuel Alexandre micro-basin, predominantly forested, was taken as a reference; Caboclo presented forest in the high parts and annual/perennial crops and small urbanized areas on the bottom and Batatal exhibited forest and banana in the high parts and annual crops on the bottom, in addiction to bigger urbanized areas. In terms of water quality, three points in each micro-basin were monitored at the: upper, middle and lower part and four sampling points more were monitored to quantify the influence of pollution from more urbanized areas (Guapiaçu, Macacu and CEDAE), bi-monthly for 2 years (Figure 1). The flow and precipitation were monitored by a water level logger as well as a climate station in each micro-basin. Heterogeneous hydrologic responses can be seen in Manuel Alexandre, Caboclo and Batatal in the base level height, dynamic of water level rise, fall and amplitude (Figure 2). This can be explained through the topography and the LULC. Water quality results captured the influence of agriculture and urban settlements. Nevertheless, still more data is needed to better describe with a higher confidence the system behavior.

Table 1. Land use surface and percentages of the selected micro-basins and GMB.

| Basin | Surface [km²] | Land Use [%] | | | | | |
|---|---|---|---|---|---|---|---|
| | | Pasture | Agriculture | Forest (Initial) | Forest (Intermediary) | Forest (Advanced) | Others |
| **Batatal** | 31.8 | 23.7 | 3.1 | 23.9 | 28.8 | 20.5 | - |
| **Caboclo** | 12.5 | 7.5 | 8.9 | 1.2 | 6.2 | 76.2 | 0.1 |
| **Manuel Alexandre** | 18.5 | 0.5 | - | 2.9 | 2.3 | 83.8 | 10.5 |
| **GMB** | 1,263.6 | 41.4 | 4.4 | 8.0 | 11.9 | 28.9 | 5.4 |

Source: Penedo et al., 2011.

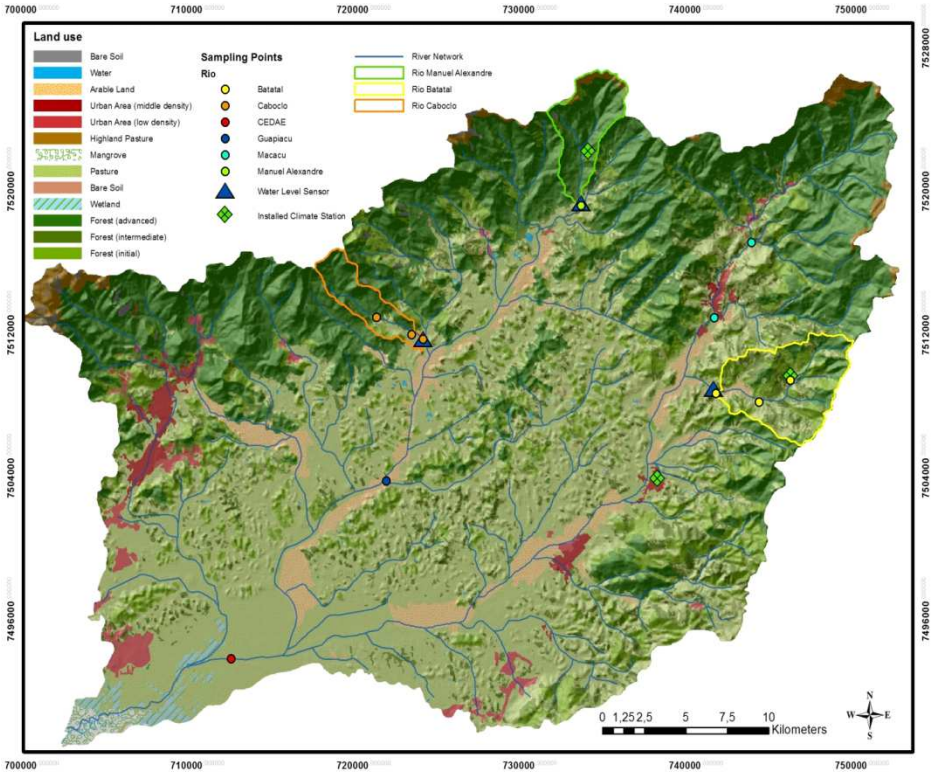


Figure 1. Design of hydrologic ecosystem services monitoring in the GMB and micro-basins.
Source of the land use map: Fidalgo at al., 2008.

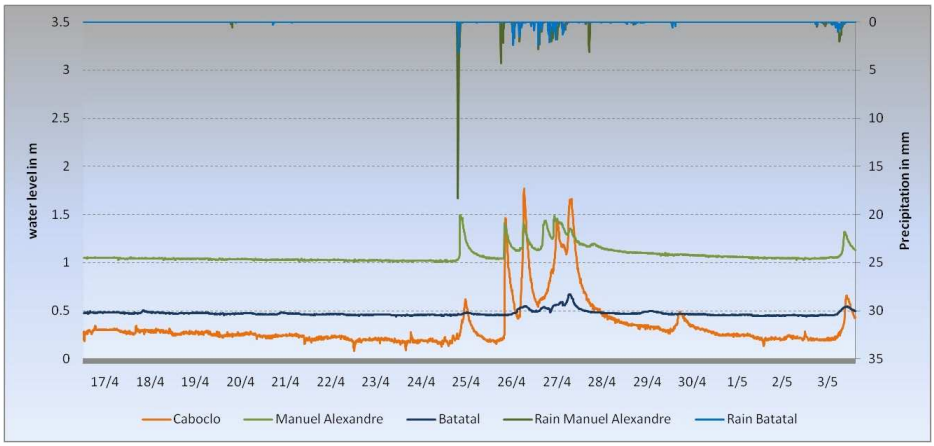


Figure 2. Water level at the measuring stations of Batatal (blue line), Caboclo (orange line) and Manuel Alexandre (green line) and precipitation of the climate stations in the catchment of Manuel Alexandre (dark green bars) and Batatal (blue bars) from 16th of April 2011 until 3rd of May 2011.
Source: Penedo et al., 2011.

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