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Water resources modeling under Climate Change scenarios of Maule River Basin (Chile) with two main water intensive and competing sectors: Agriculture and Hydropower Generation

David N Poblete, Sebastián Vicuña, Francisco J Meza, Eduardo Bustos[1]
David N Poblete
[1]Centro de Cambio Global UC, Santiago, Región Metropolitana, Chile

Extended Abstract

The study *La Economía del Cambio Climático en Chile* (Economy of Climate Change in Chile) (CEPAL, 2009) shows the impacts of Climate Change in Chile using the results from the GCM model HadCM3, with two GHG scenarios (A2 and B2). As projected in these scenarios, for the near future period it is expected a raise in temperature in Central and South Chile in the order of 1-2°C and a decrease in rainfall in the order of 10% to 20%, depending on the scenario. In terms of impacts in water resources, it can be expected a reduction in streamflow in rivers and a change in their seasonality.

The present work develops, through an hydrological and water allocation modeling approach, the climate change impacts of the Maule River Basin highlighting the competence between two economic and water use sectors in this region: hydropower and agriculture.

The approach is done using the WEAP (Yates et al, 2005) model that has been extensively used in Climate Change studies in Chile and other regions of the world (Vicuña et al, 2011). The inputs of this model are the projected climate scenarios from three GCMs: ECHAM5-OM (MPI-M), CM2.0 (GFDL) and HadCM3 (UKMO), using two emission scenarios: A1B and B1. Through a statistical downscaling process these scenarios are applied to recreate temperature and precipitation time series, main inputs of the WEAP model. The results of the modeling give information about streamflow, snow melt and accumulation, hydropower generation, allocation of water for the agriculture sector, storage in reservoirs and lakes, among others.

The work is centered in the Maule River Basin, located between 35°S and 36°30'S, central Chile. It has an approximate area of 21,054 km^2, where Maule River is the main water course in the basin. The river originates in the Maule Lake, a water body of 1,570 millions of m^3, which is the main regulator of the basin, located at 2,170 m above sea level in the Andes. The hydrologic regime of the watershed varies from nival regime in the mountainous area (from 450 – 3,900 m), a mix of pluvial and nival in the middle zone, to a complete pluvial regime in the lower part of the catchment. The watershed' water demand is mainly due to two activities: Agriculture and Hydropower Generation. On one hand, agriculture land use represents 12% of the total area in the basin, and 12% of the total of agriculture land in Chile. On the other hand, hydropower generation in the Maule Watershed represents a third of the total hydropower generation and 12% (7,800 GWh/year, 2009) of the energy production of the main electric system in Chile. According to CEPAL (2009), both sectors would be impacted due to drop in water resources in streamflows and by a drop in snow accumulation and melt process.

The calibration follows the logic of calibrating first the higher catchments, so the natural hydrology is well represented. The mean value for the Nash coefficient for the four natural catchments chosen was 0.62, in the period from 1967 to 1999. The Nash value for the validation period (2000-2007) was 0.71, higher due mainly to a more stable historic hydrology and less high and low peaks. The later calibration includes lower zones of the upper Maule basin, which take into account historic hydropower generation in each hydropower station since 1990, the stage level in Maule Lake and the legal water allocation for agriculture, which is the main constrain for hydropower use.

The results for an early period (2010-2040), obtained using the inputs of the GCM models are in concordance with the predictions made in earlier studies. For precipitation, results range in changes from 1.2% to -25% and an average of -10% and for temperature, increases from 0.3°C to 0.93°C, with an average of 0.7°C. In terms of streamflow in the middle section of the basin (below major hydropower facilities) the results show a reduction between 10% and 34% of the annual amount and a decrease in the mean annual reservoir storage above that point ranging between 3% and 38%.

And last, for the competing sectors of agriculture and hydropower generation, the results show that the agriculture is less vulnerable than the hydropower sector due to the legal agreement that ensures a minimal monthly water allocation throughout the year. For this early period, the agriculture requirements show 30-year average reductions between 0% and 3% depending on the scenario, with a maximum of 20% drop for a single year. At a monthly scale the results can be more abrupt with reductions in the order of 80% in some cases. Hydropower generation as a 30-year average falls more dramatically with an average drop of 9%.

Future works includes the development of dynamic demand of water and energy. Water demand by crops will be modeled coupling an agriculture/crop model with WEAP and the energy demand will be modeled considering the whole country electricity demand using the software LEAP, a flexible tool for long-range integrated energy planning. Other work will be to assess different adaptation measures as improvements in irrigation efficiency in agriculture and the purchase of water rights from one sector to another, among others. An important component of the road ahead will be the transfer of knowledge from the scientific sector to the community incorporating references to the reduction of vulnerability.

Keywords: water resources modeling, competing sectors, climate change, downscaling

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