SYSTEM OF ENVIRONMENTAL ECONOMIC ACCOUNTING

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Water Accounts and Earth observation in Canada: The potential and challenges

Canada may have one of the most complicated water regimes on the planet. With a landmass of nearly 10 million square kilometers, with over 1 million square kilometer of freshwater surface, 3 500 cubic kilometers of renewable water flowing through its rivers and lakes each year[1], glaciers, permanent snows, permafrost areas, and a complex and diversified array of ecosystem types ranging from rainforests to dry grasslands and countless permanent and seasonal wetlands, measuring water in Canada is by no means an easy task.

This already complex picture is compounded by the impacts of climate change and human landscape modifications. Once permanently frozen in glaciers and permafrost, water in the North is now melting, evaporating and moving. Countless lakes and peatlands have been exposed to increasing temperatures over the last decades including areas where winter temperature increases have exceeded 6 degrees over long term averages. Statistics Canada recently reported that in the Mackenzie and Northwestern Forest climate regions of north-central Canada, over 450,000 km^2 of peatlands, more than 20% larger than the area of Germany, have been exposed to average winter temperature increases of over 4 degrees. These factors add to the challenge of accounting for water in Canada.

Statistics Canada has been producing partial water asset and physical flow accounts for many years. Given the complexities described above, it was decided early on that tracking renewable water flows by drainage area was a good first step with regards to the water asset account[2] - as opposed to measuring all stocks and flows - and that it would help set the context for the physical flow account for water.[3] These two accounts are now produced on a regular basis.

[1] Source: https://www.statcan.gc.ca/eng/dai/smr08/2017/smr08_215_2017 (consulted March 7, 2019); https://www150.statcan.gc.ca/n1/pub/16-201-x/16-201-x2017000-eng.htm (consulted March 7, 2019)
[2] Source: https://www150.statcan.gc.ca/t1/tbl1/en/tv.action?pid=3810028301 (consulted June 7, 2019)
[3] Source: https://www150.statcan.gc.ca/t1/tbl1/en/tv.action?pid=3810025001 (consulted June 7, 2019)

Asset accounts (*millions of cubic metres*)

	EA.131. Surface water						
	EA.1311 Artificial reservoirs	EA.1312 Lakes	EA.1313 Rivers	EA.1314 Snow, ice and glaciers	EA.132 Groundwater	EA.133 Soil water	Total
1. Opening stocks	**1 500**	**2 700**	**5 000**	**0**	**100 000**	**500**	**109 700**
Increases in stocks							
2. Returns	300	0	53		315	0	**669**
3. Precipitation	124	246	50			23 015	**23 435**
4. Inflows	1 054	339	20 137		437	0	**21 967**
4.a. From upstream territories			17 650				**17 650**
4.b. From other resources in the territory	1 054	339	2 487	0	437	0	**4 317**
Decreases in stocks							
5. Abstraction	280	20	141		476	50	**967**
6. Evaporation/actual evapotranspiration	80	215	54			21 125	**21 474**
7. Outflows	1 000	100	20 773	0	87	1 787	**23 747**
7.a. To downstream territories			9 430				**9 430**
7.b. To the sea			10 000				**10 000**
7.c. To other resources in the territory	1 000	100	1 343	0	87	1 787	**4 317**
8. Other changes in volume							**0**
9. Closing stocks	**1 618**	**2 950**	**4 272**		**100 189**	**553**	**109 583**

Source: SEEA-Water-land database.
Note: Dark grey cells indicate zero entries by definition.

Figure 1: Table reproduced from the SEEA Water System of Environmental-Economic Accounting for Water. Data are for demonstration purpose only.

However, the other elements of the water asset account (water stock, precipitation, evapotranspiration, soil moisture - see figure 1) cannot currently be measured with enough certainty to provide reliable opening and closing stock estimates and measures of change over time. However, this may improve in the future with more sophisticated modelling and availability of alternate data sources, including satellite Earth observation data.

For example, Statistics Canada is exploring the use of data from the Gravity Recovery and Climate Experiment (GRACE), from NASA[4] (in collaboration with NRCan). These data provide measures of change in total water storage, and will be used to provide an estimate of the change over time of the total stock of water. It does not allow, however, for an evaluation of the size of the stock itself.

We are also looking into using the Global Surface Water (GSW) database. The GSW, produced by the European Commission's Joint Research Centre, provides useful information on the water occurrence and annual water recurrence at pixel level over the past 32 years at a 30-metre resolution[5]. Analysis for Canada shows that most of the water area visible at the resolution of 30 metre is captured. This may serve various purposes such as helping to create a reference data set measuring permanent water extent.

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[4] https://www.nasa.gov/mission_pages/Grace/index.html (Consulted June 7, 2019)

[5] https://global-surface-water.appspot.com/ (consulted June 7, 2019).

However, the producers of the GSW recognize that various issues remain. For example, the identification of seasonal water is less precise than that of permanent water. Also, water area obscured by floating, overhanging and standing vegetation, or hidden by infrastructure (such as bridges) is not captured. The fact that water located below floating vegetation is not captured makes the analysis of water extent change over time problematic and overly sensitive to weather-related events such as floods and droughts. Moreover, the time periods are not long enough to capture real change in water, an issue common to all satellite Earth observation data sets. Also, water bodies smaller than 30 x 30 meters are not captured due to the resolution of the input images. Tracking these small water bodies is an important aspect of the changing characteristics of water in Canada, since they are the most affected by changes in the hydrologic regime. However, it is expected that, over time, the GSW will use higher resolution data and this particular issue will be resolved.

The use of the GSW and other global Earth observation datasets (both satellite and *in*-situ) will likely become a key part of making progress on the SEEA and especially the land, water and ecosystem accounts. The increasing volume of Earth observation data openly available, combined with open source solutions for processing, will enable the production of regularly updated global geospatial dataset. For example, the Canadian Space Agency has recently released over 37,000 RADARSAT-1 images acquired from 1995 to 2013 for public use, free of charge. Also, in March 2019, the first Canada-wide wetland inventory using Landsat-8 imagery and innovative image processing techniques available within Google Earth Engine was published. An improved version of this preliminary wetland map, integrating optical and radar data, is currently being worked on and expected soon.

In conclusion, satellite Earth observation data products have the advantage of offering a uniform basis for global comparison, but need to be carefully vetted for subnational analysis in terms of spatial and temporal precision. Users need to understand the limitations of the products and their fitness of purpose for the intended use. The global data should always be compared to national data to understand discrepancies. In fact, the most important aspect to emphasize here is the need to integrate satellite Earth observation datasets with other data sources and expert knowledge to capture real change and draw valid conclusions from the accounts. Given the increasingly rapid changes to the Canadian hydrology caused by climate change and other factors, a national statistical spatial data infrastructure informed and improved by Earth observation data, is a required asset to efficiently compile land, water and ecosystem accounts.