**Virtual water: Outsourcing water consumption and pollution of cities of the Global South**

**Abstract**

The world’s population is becoming increasingly dependent on water resource.

To compute cities’ virtual water,

To put the climate-induced uncertainties in perspective, it is better to act in a pro-active approach and to carefully select products and services that are associated with less virtual water footprints.

**Keywords**

Virtual water; water footprint, water security; urban sustainability; input-output analysis; global south

1. **Introduction**

**The status of water and the role of global warming**

Water is a finite resource and plays a major role in urban development and ecosystems sustainability.

97% of the water on Earth is saltwater, leaving only 3% as freshwater, only 1% of which is readily available for human consumption including power generation, irrigation, industrial activities, and daily use.

The world’s population is becoming increasingly dependent on this valuable resource. Water is considered to be a *“human right”* that is currently under sever strikes. The Millennium Development Goal defined *water security* as *“access to safe drinking water and sanitation”*.

Unfortunately, we’re living in a changing climate, climate change is currently effecting water planning include changes in precipitation events, runoff patterns, and droughts. Despite recent advancements in climate research, there is still a lot of uncertainty about how and when the climate will change, and how these changes will affect water availability within an increasing demand for water, worldwide.

Many areas around the world are facing water-related issues such as Cape Twon in 2018 where the city experienced the Day-Zero.

**The role of water in urban development and sustainability future (urban metabolism approach)**

Supply and demand for water encompasses other non-climatic factors that might have a considerable effect on water including demographic growth, economic growth, affluence, and geopolitics.

In addition, water pollution is increasing across the world which further shrink the available water for anthropogenic activities.

**Virtual water, what does it means?**

Cities are hyper-complex system that require inputs from the national and international markets to satisfy their development needs.

However, virtual water (also including virtual carbon and energy) is not yet regulated by any national or international protocol.

**The novelty of this article**

The novelty of this study is that it computes the different types of virtual water namely Blue and Grey water for 197 cities belonging to the Global South and decomposes each water footprint by major final consumptions categories (Food, Goods, Services, Transport, and Others) in order to allocate responsibilities to final demand sectors and trigger potential policy leverages.

1. **Methods and Materials** 
   1. **Data collection**

To answer our research questions we needed two types of data. The first is urban expenditures surveys (also denoted as city final demand vector - -) following COICOP-categorization of the 197 selected cities belonging to 24 Middle-Income Countries (MICs). Data were retrieved from the office of statistics of each host-country. Notice that data collection methods and quality may vary from a country to country (took as-is). Because of data scarcity in the Global South, cities final demand vectors were not taken at the same year because of the internal protocol of each host-country to establish and deploy the consumer expenditures surveys, some countries establish them annually, while others quinquennial as such several limitations are to encounter while comparing results among selected cities. The second is global Multi-Regional Input-Output (MRIO) tables which were retrieved from Eora database (Lenzen et al., 2013, 2012). We used Input-Output tables (version 199.82) harmonized to 26 sectors to enable an accurate comparisons across selected cities.

* 1. **Method**

For this study we used Environmental Extended Input-Output Analysis (EE-IOA). The analysis process is divided into two parallel phases (Fig.1). The first in which we collected cities final demand vectors (yi) in local currencies, next we aggregated the values (via a distributive process) to match Eora 26 sector classification, after we converted the final demand arrays from local currencies into $US using the WorldBank exchange rates (WorldBank, 2021). The second phase in which we computed the direct intensity vectors (f) as shown in Eq.1 (for each year corresponding the selected city’s final demand vector) for each virtual water category (green, gray, and blue water), after we computed the final demand vector (F) using the Leontief inverse as shown in Eq.2.

To compute cities’ virtual water footprints, we multiplied element wise the total demand vector (f) with the city final demand vector (yi) as shown in Eq.3.

... (Eq.3)

**Insert the graph here**

1. **Results and discussions**
   1. **Urban virtual water of the Global South: Learning from contexts**
   2. **Urban virtual water policy: Hotspots and architectures of handicaps**
2. **Conclusions**

Most of the water humanity is currently consuming is invisible. It is embedded within goods and services.

1. **References**

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