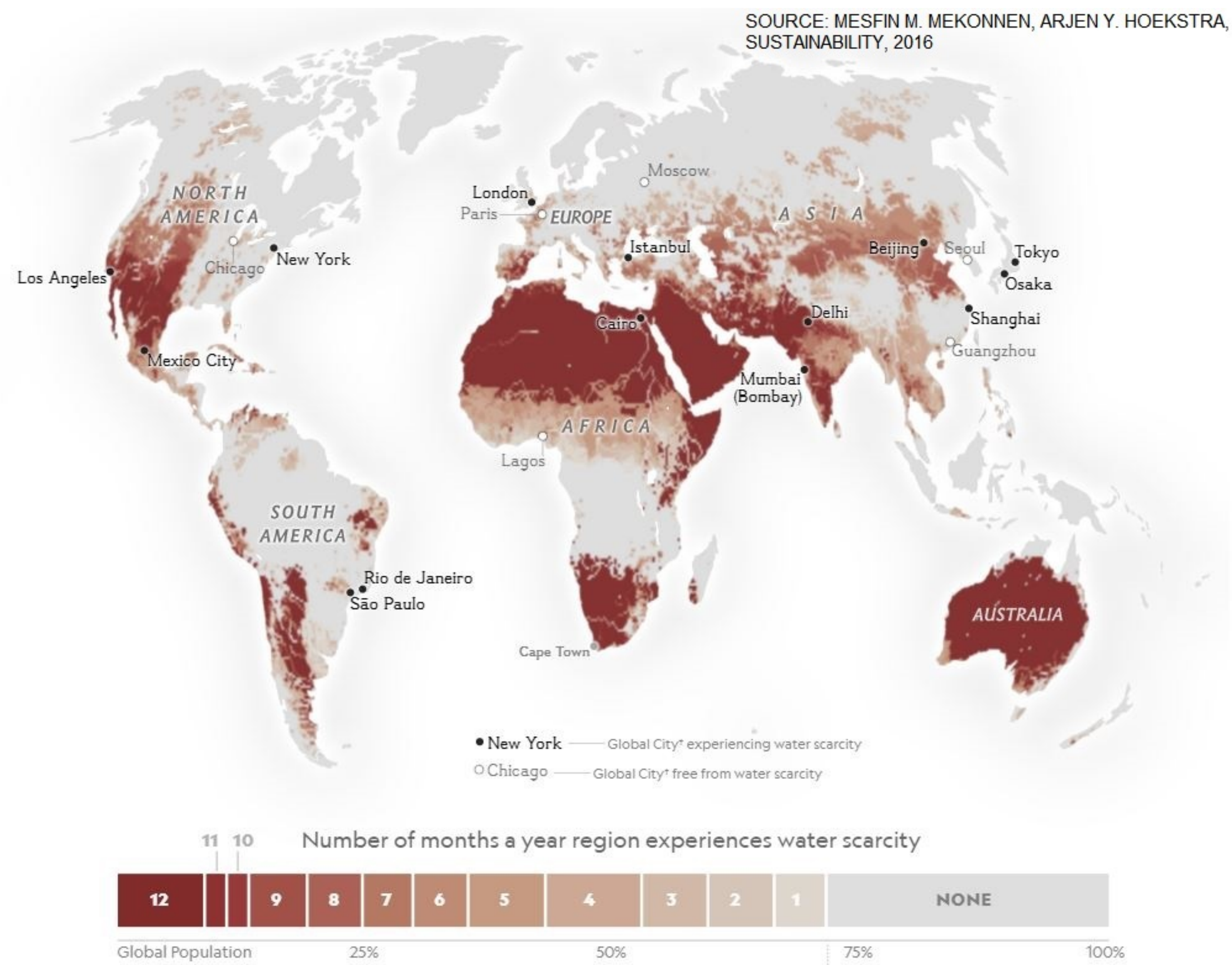
Copernicus Hackathon Sweden 2020

<u>Solution to global water scarcity using space products and services</u>



Miracle Israel Nazarious

June 2020

Introduction

The Earth has oceans occupying approximately 70% of its total surface. However, 96.5% of the total water mass of our planet is seawater, and an additional 1% has a variable amount of salinity, acidity, and other physicochemicals making it unsuitable for human consumption. Only 2.5% of the entire volume of water on Earth is drinkable freshwater (Shiklomanov, 1993). Approximately 70% of freshwater is stored in the polar regions and in mountain glaciers as ice.

Groundwater, the major source for human and animal use, accounts for 30% of the total freshwater, so water destined for human consumption can be considered scarce. Water scarcity is further accentuated in some regions due to uneven distribution of rain and snow affecting the recharge of groundwater reservoirs called aquifers. In addition, only 10% of global precipitation penetrates through soil and rocks and reaches the water table, with 66% lost through evaporation, and more than 20% falling directly onto rivers and lakes (RobecoSAM, 2015). The zoning of land surrounding the water reservoir recharge areas to establish new industrial and residential outposts, further decreases the amount of water that can percolate through soil and rock to feed the water table. Water that cannot return to the normal water cycle remains on the surface, where it can potentially cause floods or stagnate and become a breeding ground for mosquitos and other pests.

Population growth (currently 7.8 billion and projected to be 10 billion in 2050), economic development, accelerated pace of urbanization, increased food consumption, land clearing, climate change and pollution increase the pressures on an already scarce resource (Leahy, 2018, Sun R. and Chen L., 2012). The artificial environments where most urban populations live also promote behaviors that contribute to water shortages and pollution. The convenience of opening a water tap in our homes removes us from an intuitive understanding of the natural water cycle and the related need to preserve a scarce resource.

The certain imbalance in the water utilization and distribution have significantly affected the water security globally including megacities like New York, Chicago in the United States, Brazil's São Paulo, South Africa's Cape Town and various parts of China and India. Water management is therefore an integral part of urban planning and regional management to ensure the sustainable use of this resource. Globally, we use water mainly for residential use (10%), agriculture (70%) (OECD, 2019), and industrial development and energy production (20%) (European Environment Agency, 2019). Agricultural consumption of water is even higher in the developing countries of Asia and Africa, where water scarcity is most severe. Close to two-thirds of the global population (4.0 billion people) live under conditions of severe water scarcity at least 1 month of the year. Nearly half of those people live in India and China. Half a billion people in the world face severe water scarcity all year round. (Mekonnen and Hoekstra, 2016).

Innovation in space products and services have provided the potential to address this pressing problem and find new solutions, not only to diagnose them.

Motivation

The issue of global water scarcity is largely tied to the timely utilization and distribution of water to the human masses, agriculture and industries. Therefore, monitoring the availability of water resources and their sources and sinks are very essential for an efficient water management. The strategies applied for water management also affects the urban planning as a whole and hence careful consideration and inputs about water delivery, usage, and recycling plays a key role.

Urban areas obtain drinking water from surface water sources such as lakes, rivers, ponds, etc., and underground aquifers that is recharged by seasonal rainfall. Coastal cities could obtain additional water by desalinating sea water at a higher cost that the previously mentioned natural fresh water sources. Water recycle and reuse plants may also be included in the supply chain where the domestic wastewater may be treated and used for agriculture. In case of industries, tracking the water supply and treating industrial wastes is another major issue. The main problem with efficiently managing all these processes where water resources are being used, is its proper monitoring. There is still a lot of efforts required to monitor the water availability, usage and predicting the future trends in order to be prepared.

Satellite image data can be used for monitoring the land and water-use practices in a particular region, country or globally. Monitoring the water availability and usage may require understanding the past trends by constructing a time sequential model to signify the changing area of surface water storage reservoirs and the occupation of those land with constructions in reservoirs along the years providing the maximum and the minimum extent of the water surface as well as the seasonal dynamics. The prediction about future trends can also be done with this approach.

Satellite image data can also be used to classify different surface water sources and sinks to manage water resources for various purposes. Generally, calculating the area of surface water and occupied concrete can be classified with mNDWI (Modified Normalized Difference Water Index) and NDBI (Normalized Difference Built-up Index). Within the scope of the Copernicus Hackathon Sweden 2020, the following objectives are provided to set the context.

1. Mapping the area of water bodies – to calculate the available water reservoir area.
2. Mapping the built-up area – to calculate the area available for rainwater to reach the ground water table.
3. Temperature – to predict the extent of water evaporation

Challenge

The following challenges are provided as a guidance, but the participants are encouraged to work on any complex solution deriving from them.

- Construct a decades long time sequential model of changing area of surface water storage reservoirs to provide a regularly updated database for water resource management showing the water availability considering the human (population flux) and environment (rainfall, temperature, etc.) factors.
- Develop an algorithm to classify and catalog in real-time, different surface water sources and sinks (lakes, ponds, rivers, backwater, etc.) in urban areas to manage water resources for various purposes like drinking and other domestic uses, and agricultural and industrial uses to help the local authorities plan the utilization and distribution strategies in a constant basis.
- a platform for citizens inputs regarding the localized water usage to construct a large data set of individual users.
- Evaluate alternative methods for supplying water (e.g., from the atmosphere using low energy means) and its sustainability by retrieving high resolution T/RH map for the region using satellite data. Compute the feasibility and efficiency of such methods which rely on T/RH changes through the day and seasons. A prototype of a technology that would contribute to solving the global water scarcity may be built that also utilizes satellite data for its validation and implementation.

A business solution is expected in the form of product or service for customers ranging from local government to public citizens.

Data

Time sequential model:

LandSat 4-8 – Water area change – Earth Explorer (since 1982)

MODIS (Aqua and Terra) – Surface Temperature and Relative humidity – Earth Explorer (Since 1999)

Latest data:

LandSat 8 or Sentinel-1A and Sentinel-1B – Land-use change – ONDA DIAS (since 2013)

PROBA -V or Sentinel-2A and Sentinel-2B – Water bodies classification - Data based on Sentinel-2 will be available from October 2020 but for demonstration during the hackathon PROBA-V can be used – ONDA DIAS (Since 2013)

ENVISAT or Sentinel-3A and Sentinel-3B or MODIS (Aqua and Terra) – Surface Temperature and Relative humidity – ONDA DIAS and Earth Explorer (Since 1999)

Programming Skills

MATLAB or Python and any GIS program can be used.

Computing Infrastructure

All satellite image data are available via ONDA DIAS (https://www.onda-dias.eu/cms/data/catalogue/) and Earth Explorer (https://earthexplorer.usgs.gov/).

References

European Environment Agency, 2019. Industrial waste water treatment pressures on Europe's environment. Luxembourg: Publications Office of the European Union.

Leahy, S., 2018. From Not Enough to Too Much, the World's Water Crisis Explained.

National Geographic, [online] Available at:

<https://news.nationalgeographic.com/2018/03/world-water-day-water-crisis-explained

(https://news.nationalgeographic.com/2018/03/world-water-day-water-crisis-explained)

> [Accessed on 22 July 2019].

Mekonnen, M. M. and Hoekstra, A. Y., 2016. Four billion people facing severe water

scarcity. Science Advances, [e-journal] 2(2). https://doi.org/10.1126/sciadv.1500323

Organisation for Economic Co-operation and Development, 2019. Managing water sustainably is key to the future of food and agriculture. [online] Available at: [Accessed 7 August 2019].

RobecoSAM, 2015. RobecoSAM Study. Water: the market of the future. [pdf] RobecoSAM. Available at: [Accessed 08 August 2019].

Shiklomanov, I., 1993. World Water Resources. In: Gleick, P., ed. Water in Crisis. Oxford, New York.

Sun R. and Chen L., 2012. How can urban water bodies be designed for climate adaptation? Landscape and Urban Planning, [e-journal] 105(1-2), pp.27-33. https://doi.org/10.1016/j.landurbplan.2011.11.018