An open source tool for water balance estimation

Launch | 30 November 2021, Tuesday
Centre for Social and Environmental Innovation at ATREE invites you to the launch of

**JALTOL**

*A free, opensource, digital tool for easy water balance estimation*

**Agenda**

<table>
<thead>
<tr>
<th>Time</th>
<th>Event</th>
</tr>
</thead>
<tbody>
<tr>
<td>3:00 - 3:05 pm</td>
<td><strong>Opening remarks:</strong> Edel Monteiro, ICC</td>
</tr>
<tr>
<td>3:05 - 3:15 pm</td>
<td><strong>On the need for digital tools in rural water security</strong></td>
</tr>
<tr>
<td></td>
<td><em>Dr. Veena Srinivasan, CSEI-ATREE</em></td>
</tr>
<tr>
<td>3:15 - 3:20 pm</td>
<td><strong>Introduction to Jaltol and feedback from early users</strong></td>
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<tr>
<td></td>
<td><em>Anjali Neelakantan, CSEI-ATREE</em></td>
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<tr>
<td>3:20 - 3:35 pm</td>
<td><strong>Tool Demo: Water Balance Estimation with Jaltol</strong></td>
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<td></td>
<td><em>Craig D’Souza, CSEI-ATREE/Connected Farms</em></td>
</tr>
<tr>
<td>3:35 - 3:55 pm</td>
<td><strong>Case Studies</strong></td>
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<tr>
<td></td>
<td><em>Case study 1: Application of Jaltol for govt. agencies</em></td>
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<tr>
<td></td>
<td><em>Dr. Sashikumar N &amp; MS Raviprakash, ACIWRM</em></td>
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<td></td>
<td><strong>Case study 2: Application of Jaltol for rural drinking water</strong></td>
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<tr>
<td></td>
<td><em>Jeff Albert, Aquaya</em></td>
</tr>
<tr>
<td>3:55 - 4:05 pm</td>
<td><strong>Discussions</strong></td>
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<tr>
<td></td>
<td><em>Discussion 1: How to use Jaltol for behaviour change on the ground?</em></td>
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<tr>
<td></td>
<td><em>Harold Lockwood, Aguaconsult</em></td>
</tr>
<tr>
<td></td>
<td><em>Discussion 2: How to maintain open source tools like Jaltol?</em></td>
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<td></td>
<td><em>Ujaval Gandhi, Spatial Thoughts</em></td>
</tr>
<tr>
<td>4:05 - 4:20 pm</td>
<td><strong>Q&amp;A with Jaltol team</strong></td>
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<tr>
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<td><em>Craig D’Souza and Surabhi Singh, CSEI-ATREE</em></td>
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<tr>
<td>4:20 - 4:30 pm</td>
<td><strong>Closing remarks</strong></td>
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<td><em>Dr. Veena Srinivasan, CSEI-ATREE</em></td>
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</table>

**30 November Tuesday**

3:00 p.m. to 4:30 p.m.

**RSVP:** bit.ly/JaltolRSVP
We are grateful to the India Climate Collaborative and their partner organisations Edelgive Foundation and Tata Trusts who funded this tool.
CSEI-ATREE finds solutions to environmental AND developmental challenges

To make an impact today, we need to design solutions for the “first-mile” in both the environment AND human development.

Today people are either specialised in either the environment or development, but rarely both. A new approach is needed to accomplish both.
We build communities of **early adopters**, to scale science backed solutions

We are bringing the best, multidisciplinary minds together to solve the most pressing environmental challenges India faces today.

Our non profit nature allows us to

**Ideate**

**Co-create**

**Scale**

unbiased science backed solutions to solve systemic environmental challenges.
India ranks at No.13 in the top most water stressed countries in the world.

100M acre of degraded agricultural land exists in India today. Farmer incomes have been stagnating.

Invasive species of lantana invades 13M+ hectare of forest in India. The average income of the 60M indigenous peoples is less than Rs 200 per day.

By 2030 we will improve freshwater availability for 6M people and restore 10,000 Ha of degraded land and water bodies.

By 2030 we will provide livelihoods for 150,000 farmers while securing water resources in 2000 communities.

By 2030 we will create livelihoods for 10K people through the removal of 500,00 hectares of invasives.

By 2030 we will improve freshwater availability for 6M people and restore 10,000 Ha of degraded land and water bodies.
FOOD FUTURES INITIATIVE

PROBLEM
Can we enable communities to restore degraded agricultural land while improving the lives of farmers?

GOAL
By 2030 we will provide livelihoods for 150,000 farmers while securing water resources in 2000 communities.
On the need for digital tools in rural water security
India is facing a looming water crisis

54% of India faces high to extremely high water stress

36% of blocks or taluks assessed by CGWB are over-exploited, critical or semi-critical

Source: World Resources Institute, India Water Tool -Baseline Water Stress (2019)

Source: CGWB - Dynamic groundwater resources of India (March 2017)
And a farmer income problem

Climate change could result in a 15% loss in farmers’ incomes in India by 2050.

(G20 Climate Impacts Atlas by the Euro-Mediterranean Center on Climate Change (CMCC))
How can we increase farmer incomes while managing water sustainably?

India has already spent 32,000 CR between 2017-2018 on water security interventions.
The foundation of all rural water security programmes is a water security plan.
These water security plans are now a critical part of government programmes like Atal Bhujal Yojana and Jal Jeevan Mission.
Water security plans are a part of the planning stage of a rural water security programme.

### Phases

<table>
<thead>
<tr>
<th>PHASES</th>
<th>PREPARE</th>
<th>PLAN</th>
<th>IMPLEMENT</th>
<th>ASSESS</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACTIVITIES</td>
<td>Define scale and scope</td>
<td>Set up local committee</td>
<td>Collect data for planning</td>
<td>Conduct PRA</td>
</tr>
<tr>
<td>DURATION</td>
<td>1-2 months</td>
<td>2 months - 12 months</td>
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</table>

WSPs record findings from collected data and PRAs, based on which they build an understanding of water demand. That is matched against water availability (ground and surface water sources). They then recommend interventions for the implementation phase.
We reviewed around 25 WSPs to understand how they are used to decide and design rural interventions.
Water balances/budgets are a critical part of WSPs

Data on village profile, climate, hydrogeology, water resources, agriculture

Detailed Project Reports

Water security plans

Details of PRA exercises

Interventions/programmes details

Water balance/budget estimation
A water balance is merely an accounting of flows

Mass Balance: **Input - Output = Change in Storage**

Water Balance Equation: $P - ET - Q = \Delta S$

- $P$ = Precipitation
- $ET$ = Evapotranspiration
- $Q$ = Runoff
- $\Delta S$ = Change in Storage (Groundwater, Surface water and Soil Moisture)

Methodologically the components of the water balance can be either

1. Estimated from primary or secondary data
2. Modelled from other variables and known equations
From our review, it seems that there are different approaches to estimating the water balance/budget.
<table>
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<th>Particulars</th>
<th>Description</th>
<th>Quantity (in million m³)</th>
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<td>Requirement of water</td>
<td>Human consumption and domestic use @ 80 liters per person</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td>Drinking water for animals @ 40 liters per animal</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>Irrigation requirement (as per crop specific irrigation requirement per Ha.)</td>
<td>930</td>
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<tr>
<td></td>
<td><strong>Total Requirement of Water</strong></td>
<td><strong>942</strong></td>
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<tr>
<td>Availability of Water</td>
<td>Geological setup wise total percolation as groundwater</td>
<td>92</td>
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<td>Surface water storage capacity of pond, farm pond, earthen dam, and percolation tanks etc.</td>
<td>150</td>
</tr>
<tr>
<td></td>
<td><strong>Total Availability of Water</strong></td>
<td><strong>242</strong></td>
</tr>
<tr>
<td>Water Balance</td>
<td>(Availability of water – Requirement of water)</td>
<td>-700</td>
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## Water Budget at a Glance

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<td>(Availability of water – Requirement of water)</td>
<td><strong>-700</strong></td>
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# Issue 1: Stock vs flow

Flows are annual inflows (rain) and outflows (evapotranspiration/flow leaving the watershed) and are measured in $M^3/\text{year}$.

Stocks are volumes of water stored in reservoirs measured in $M^3$.

A water balance should only consist of flows.
# Issue 2: Available water

Of the rainfall, falling on land, some runs off into surface water bodies (~5-40%).

Of the water that infiltrates and becomes soil moisture, a portion, makes it past the root zone and recharges the aquifer (~1-15%).

But the vast majority of the soil moisture can only be accessed by plants (~40-90%).

This component called “green water” is not abstractable for drinking water, livestock or irrigation.
Overall, there are two big challenges with water budgets

1. **The data gap:** Data to estimate water budgets are spread across multiple sources - so gathering them together on one single platform is a painful process.

2. **The capacity gap:** At the CSO level, they often don’t have hydrologists to develop robust and technically sound water budgets.
We developed Jaltol, an open source QGIS plugin, that addresses both the data gap, and the capacity gap.
Jaltol QGIS plugin for water balance estimation
Jaltol (version 1) - QGIS plugin architecture

Pre-Loaded Data Layers (at annual scale)
- Rainfall
- Evapotranspiration
- Change in Storage
- Surface water
- Groundwater
- Soil moisture
- Base Layer - Land Use/Land Cover

User Input Data
- Village Shapefiles
- Custom Shapefile
- Watershed Shapefile

Annual Water Balance
## Overview of Data layers used in Jaltol QGIS plugin

<table>
<thead>
<tr>
<th>S.N</th>
<th>Data Layer</th>
<th>Source</th>
<th>Data Availability</th>
<th>Unit</th>
<th>Spatial Resolution</th>
<th>Temporal Resolution</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Rainfall (P)</td>
<td>IMD</td>
<td>2000 to 2020</td>
<td>mm</td>
<td>0.25 degree</td>
<td>Daily rainfall dataset aggregated to water year</td>
</tr>
<tr>
<td>2</td>
<td>Actual Evapotranspiration (ETa)</td>
<td>SSEBop Model</td>
<td>2003 to 2020</td>
<td>mm</td>
<td>1 km</td>
<td>Monthly ETa data used to compute ET for a water year (June-May)</td>
</tr>
<tr>
<td>3</td>
<td>Change in soil moisture storage (ΔSM)</td>
<td>NASA SMAP</td>
<td>2015 to 2020</td>
<td>mm</td>
<td>10 km</td>
<td>Daily soil moisture data used to compute yearly change in subsurface soil moisture</td>
</tr>
<tr>
<td>4</td>
<td>Change in surface water storage (ΔSW)</td>
<td>JRC Global Surface Water Explorer</td>
<td>2000 to 2020</td>
<td>mm</td>
<td>30 m</td>
<td>Monthly water history dataset used to compute change in surface water storage in a water year</td>
</tr>
<tr>
<td>5</td>
<td>Change in groundwater storage (ΔGW)</td>
<td>CGWB (Central Groundwater Board)</td>
<td>1996 to 2016</td>
<td>mm</td>
<td>10km (developed using point locations)</td>
<td>Monthly groundwater level data is used to compute change in groundwater storage in a water year</td>
</tr>
</tbody>
</table>
Feedback from Jaltol training sessions
Types of early users

16 Training Sessions

- CSOs (16)
  - Frank Water
  - SOPPECOM
  - PRADAN
  - ARGHYAM
  - WASSAN
  - Jal Smruti Foundation
  - Srijan India
  - Raah Foundation
  - Pragati Abhiyan
  - WOTR
  - Gram Vikas
  - Development Support Centre
  - Gram Gourav Pratishthan
  - MYRADA
  - Rotary Club
  - Pani Panchayat

51 Participants

- State Government institutions (3)
  - ACIWRM, Karnataka (10)
  - Public Water Supply, Rajasthan (1)
  - CWRDM, Kerala (2)

- Researchers (5)
  - IIT Delhi
  - IGCS, Chennai
  - Independent consultant

- Startups (2)
  - Oceo Water
  - Nature Dots

16 Training Sessions
51 Participants
Positive feedback from early users

“‘If we can do this for Kathmandu (Nepal) it would be a major contribution to the water sector there.’”
— Sachin Tiwari, Frank Water

“‘Amazing work! Tool will be of great help to CSOs.’”
— Dr. Sarika Kulkarni, Raah Foundation

“‘Very useful tool! Reduces time and effort in adding data from different sources.’”
— Dr Sashikumar N, ACIWRM

The Jaltol tool gives CSOs an understanding of the water budget in a region with minimal effort. Most of the open source datasets are not available to them in usable formats.
— James Wescoat, MIT

Data necessary for water balance estimation is easily available in usable formats through the Jaltol plugin. This saves a lot of time and effort in preparing water budgets for multiple districts.
— Vivek B, CWRDM
Jaltol is not just useful for water balance estimation, Jaltol’s individual data layers on rainfall, ET, changes in GW, SW and SM, and LU/LC have also proven to be useful to CSOs.
Key takeaways

Simplicity over precision: Thumb rules are good enough
CSOs are not interested in complicated, high precision water budgeting tools. They need simple tools to estimate the water balance, which are understandable and usable by the local community.

Actionable insights from water budget
Interpreting water budget estimates generated from Jaltol plugin and planning water interventions based on that is a challenge highlighted by many organizations.
Our interns, Maithili Khapre and Gurleen Kaur improved the quality of village shapefiles for Maharashtra.
Here’s a quick demo of Jaltol.
JALTOL

An open source tool for water balance estimation

Launch | 30 November 2021, Tuesday
Case studies
Case study 1: Application of Jaltol for rural water service provision
USAID’s REAL-Water research project is now exploring where and how rural water supply is under threat due to problematic water resource management.

India offers an ideal real-world laboratory, for two reasons:

1. Groundwater extractions for irrigation already are impacting small-town supplies

2. There are abundant, detailed local data that track water quantity and quality changes across the country, including the India WRIS and the Online Monitoring System of Groundwater Management and Regulation
Jaltol does two essential things:

1. It follows the JJM imperative to make the water balance a lynchpin of local and regional planning
2. It seeks to equip responsible authorities with the information they need to make water-related planning decisions

The crucial next step: Making sure these authorities are equipped, incentivized, and empowered to act upon the information generated by Jaltol for decision-making.
Case study 2: Application of Jaltol for Govt. Water Resources Depts. (ACIWRM)
Discussions
1. How to use Jaltol for behaviour change on the ground?
2. How to maintain open source tools like Jaltol?
Introduction

● Background in GIS and Remote Sensing
  ○ Masters in Geospatial Information Engineering from University of Wisconsin - Madison, USA
● 15 years of professional experience
  ○ One of the early employees at Google Inc.
    ■ Moved to India in 2006
    ■ Migrated internal teams to QGIS
    ■ Led the GIS and Aerial Imagery team in India from 2007-2019
  ○ Developed ‘Google Maps Engine for QGIS’ plugin
● Active QGIS Contributor and Trainer
  ○ Founder @ Spatial Thoughts Academy
  ○ Publish free and open-source tutorials at qgistutorials.com
  ○ Publish free and open-source courses at spatialthoughts.com
  ○ QGIS.org certified trainer

Ujaval Gandhi
What is Open Source Software?

Source-code of the software is available to anyone to view, modify and re-use
Why Open Source?

- No lock-in or dependence on a single organization
  - Any skilled developer can add features and fix bugs. No need to depend on a particular vendor

- Flexibility in use
  - Can install multiple instances without worrying about licenses
  - Can be used offline, and in environments that may not be suited for proprietary software

- Proven to be more secure
  - More eyes on the code. Easier to discover and fix bugs
  - Easy to audit and ensure compliance to policies

- Cost
  - Significantly less total cost
  - Benefit from investments and contributions of a large number of people
QGIS

- Popular open-source desktop GIS software
  - Estimated 2M+ users (source)
- Project is over 15 years old and is very actively developed
- Mature organization structure
  - Registered non-profit in Switzerland. Project Steering Committee, large community of users and developers
QGIS Plugins

- Plugins allow users and organizations to customize and extend the functionality of QGIS.
- Easy way to distribute data and new features to users
- Written in Python
- Hosted on plugins.qgis.org
How to Contribute to Jaltol?

- Test and report issues
  - https://github.com/atreebangalore/jaltol/issues

- Request for new features
  - https://github.com/atreebangalore/jaltol/issues

- Contribute code
  - Open a Pull Request
  - https://github.com/atreebangalore/jaltol/pulls
We will be working on Jaltol (version 2) from December 2021 onwards.
In the coming months we would like to:

1. Actively engage with 30 CSOs in 7 states to use the Jaltol v1, to prepare water balances for 500+ villages/watersheds.

2. Further develop Jaltol v2, to include the following features requested by early users
<table>
<thead>
<tr>
<th>Categories</th>
<th>Features</th>
</tr>
</thead>
<tbody>
<tr>
<td>Include primary data</td>
<td>- Incorporate ground data for accurate water balance estimation</td>
</tr>
<tr>
<td>Improve data quality (secondary layers)</td>
<td>- Offer alternate data layers for more accurate water balances</td>
</tr>
<tr>
<td></td>
<td>- Develop data quality standards for shape files</td>
</tr>
<tr>
<td>Optimise UI/UX</td>
<td>- Add output in regional languages (focus on kannada)</td>
</tr>
<tr>
<td>Provide other analyses (water balance related)</td>
<td>Provide the following analyses:</td>
</tr>
<tr>
<td></td>
<td>- Annual trend analysis of water balance</td>
</tr>
<tr>
<td></td>
<td>- Monthly/seasonal water balance</td>
</tr>
<tr>
<td></td>
<td>- Wet/dry year comparison</td>
</tr>
<tr>
<td>Incorporate typologies</td>
<td>- Incorporate typologies into the plugin</td>
</tr>
</tbody>
</table>
## Jaltol Version 2

<table>
<thead>
<tr>
<th>Categories</th>
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<tbody>
<tr>
<td>Offer virtual training</td>
<td>- Develop training material for allowing CSOs to be able to use the tool easily with little assistance</td>
</tr>
<tr>
<td>Offer customer Support</td>
<td>- Set up a customer support contact with resources so CSOs can reach out to us for troubleshooting.</td>
</tr>
</tbody>
</table>
Q&A with the Jaltol team
Closing remarks
From December 2021 onwards, we would love to have you partner with us so you can benefit in the following ways:

1) **Collaborate to build Jaltol version 2:** We are happy to announce that we can conduct Jaltol workshops for organisations where we can demo the tool to your teams and receive feedback on additional features that you will find useful. Once you sign up, we can conduct a training session for your organisation. [Sign up form is in the chat window.]

2) **Participate in live meetings:** We will conduct live meetings once a month where users (both current and prospective) can join and have their questions answered.

3) **Receive regular updates:** We are working towards jaltol version 2 that will incorporate some additional features that CSOs have requested for. Please sign up with us to receive regular production/feature updates. [Sign up form in the chat window.]
Thank You

for feedback or concerns, please email us at

jaltol@atree.org