

AI driven Digital Twin for Water Management for Limpopo River Basin and Inclusive Integration with Citizen Science

(WMI)

Gaborone, Botswana
9-11 June 2025



Online Agenda

bit.ly/4jVtXgR



DIWASA

Supported by



In collaboration with



Day 1



Digital Twin Hands on

Listening Session for
Data Challenges

Digital Twin Concept

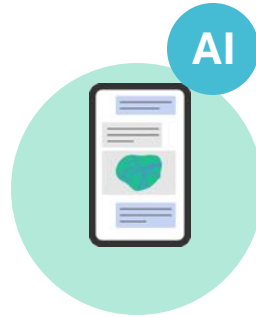
Hands on:

Water Availability

Irrigation Water Use

Droughts Index

Day 2



AI for Water Management

AI and Data
Governance

101 generative AI

Prompt engineering

Hands On:

Limpopo

Water Copilot

Day 3



Citizen Science Co-designs

Creating trust on
citizen science data



Listening Session

Stakeholder
consultation scaling
opportunities



DIWASA Training

Use cases from DEA

[Tentative_schedule.docx](#)

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Digital Innovations for Water Secure Africa (DIWASA)

The project aims to enhance water security across scales in Africa through improved water data availability, accessibility, and institutional capacity and to leverage on innovative digital techniques for sustainable water resources management. It is structured as four pillars with user engagement and capacity development (Pillar 2) taking the bulk of the project budget. Within Pillar 1, the data products and tools developed under Phase I will be further enhanced and, more importantly, user application cases (use cases) developed together with end users.

Pillar 2 will involve activities that will help integrate the data layers and products into DEA and other ODC platforms. A fully dedicated Pillar 3 is included in the project to strengthen the integration of the datasets and tools in the Digital Earth Africa platform. Under Pillar 4, the prototype of river basin Digital Twin (for the Limpopo basin) will be developed to demonstrate the use of advanced technology in water resources decision-making.



February 2024 to January 2027



Active

Locations

[Africa](#) > [Burkina Faso](#), [Ghana](#), [Kenya](#),
[Mozambique](#), [South Africa](#), [Uganda](#), [Zambia](#),
[Zimbabwe](#)

Funders

[Helmsley Charitable Trust](#)

Partners

[Digital Earth Africa](#)

Project leader

[Abdulkarim Seid](#)

Team

[Mariangel Garcia Andarcia](#)



<https://www.iwmi.org/projects/diwasa/>

Recent drought dynamics in the Limpopo River Basin

JFM 2024



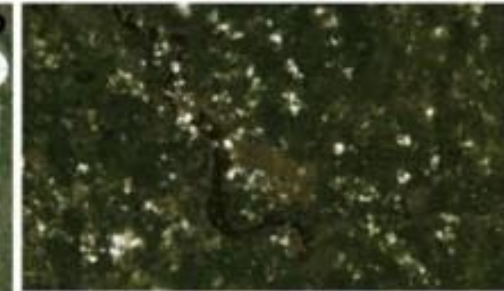
JFM 2023



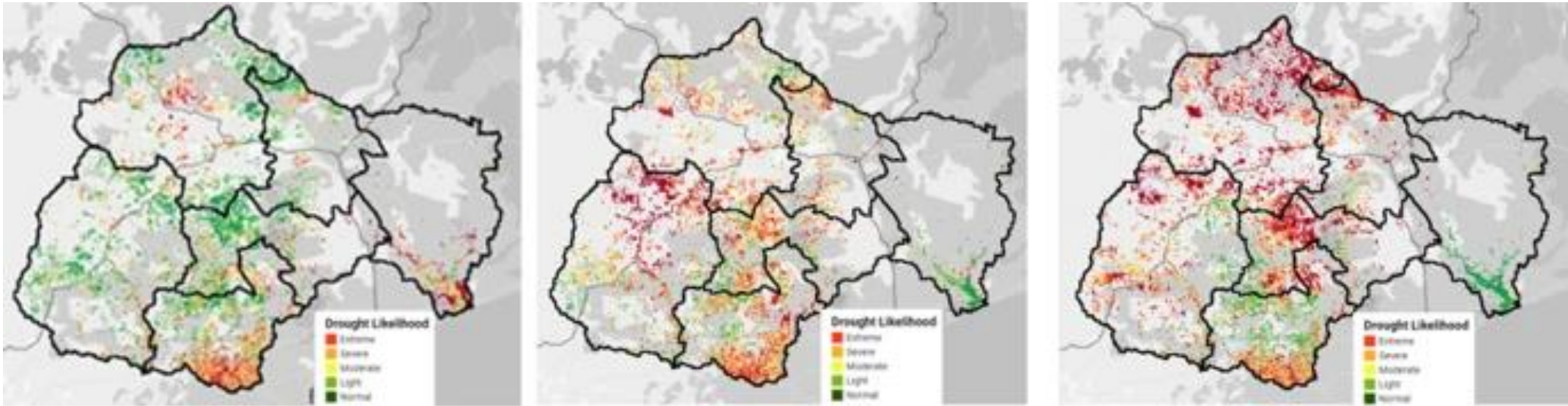
JFM 2022



Accumulated rainfall (JFM)

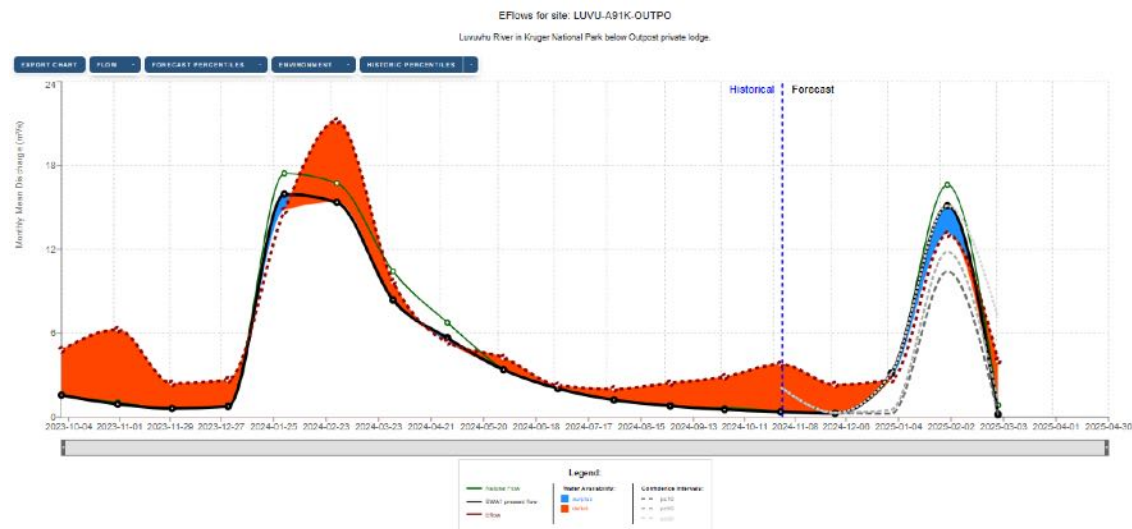


Recent drought dynamics in the Limpopo River Basin



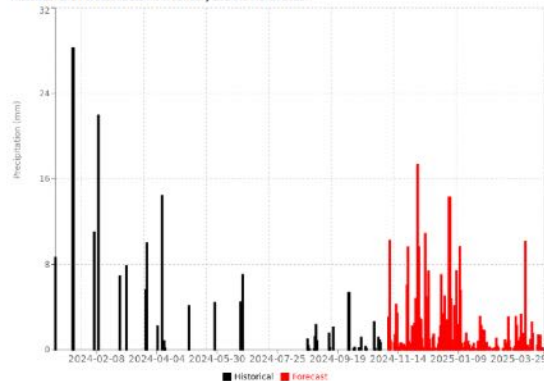
VCI of April 2022, 2023, and 2024 (left to right) for the Limpopo River Basin shows continued deterioration in vegetation conditions

Analyzing Luvuvu River

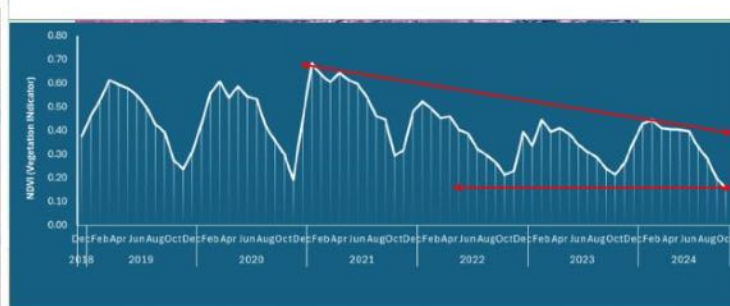
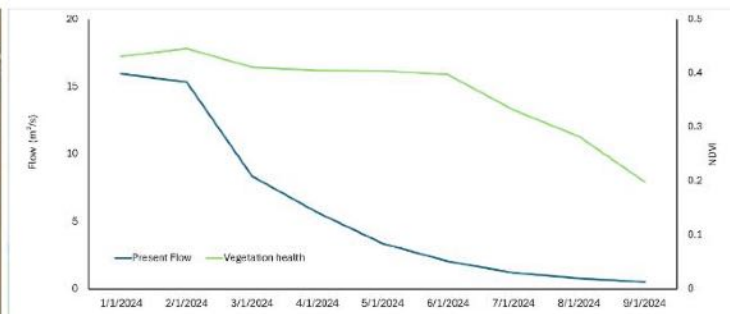


Assistant: WRF Rainfall Data for Luvuvu River (Station: s22605s30573e, Channel ID: cha0578)

Historical and Forecast Data from January 2024 to March 2025:

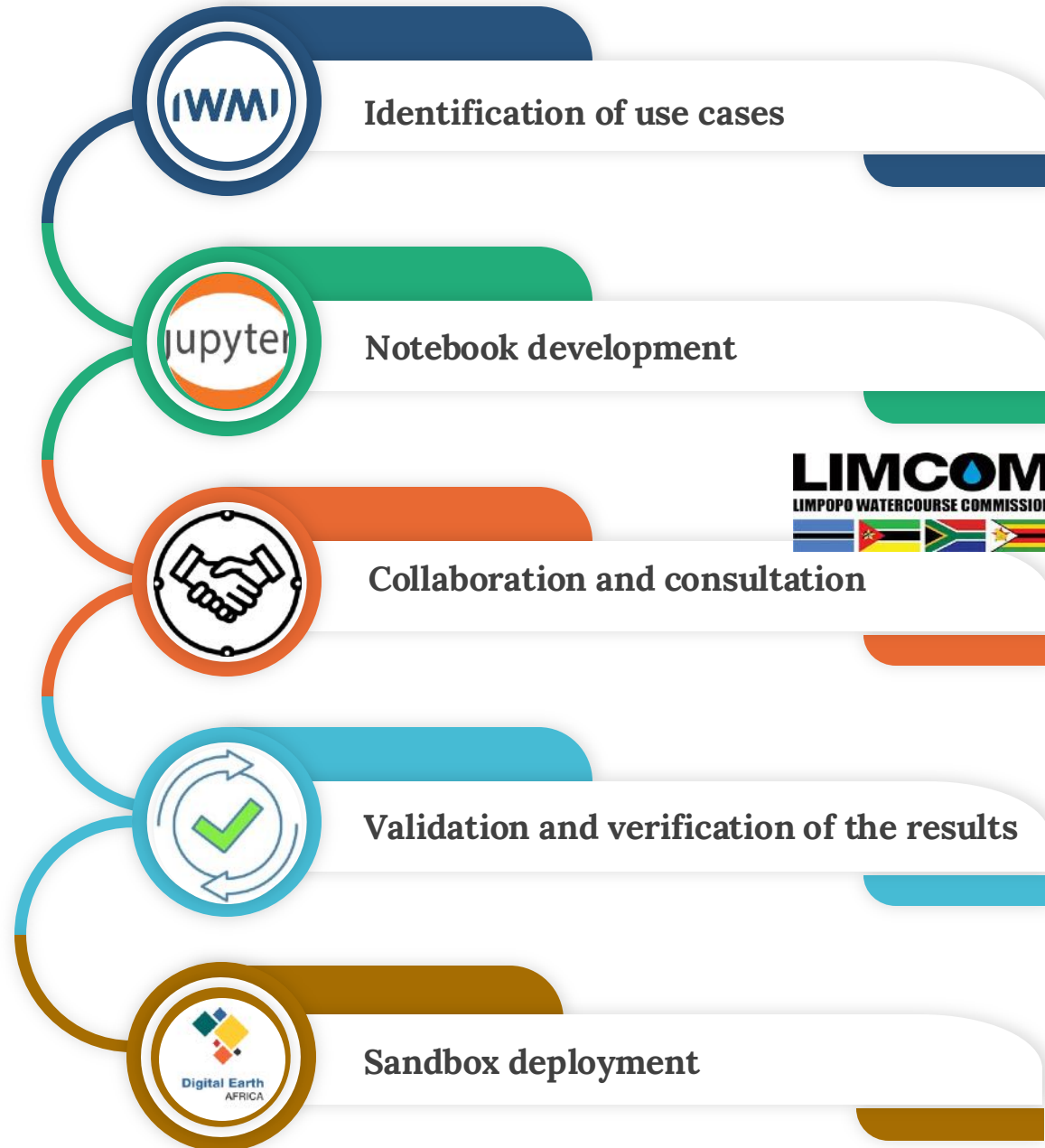
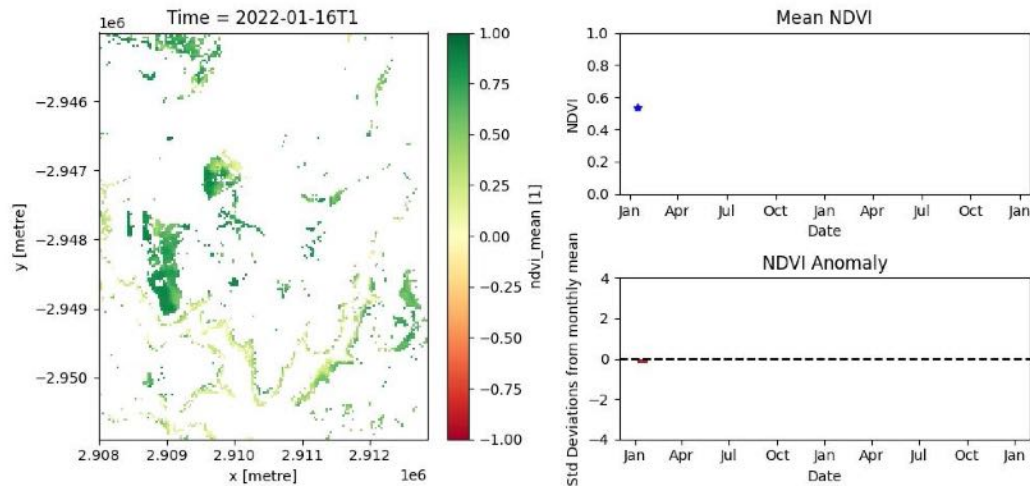


This chart includes both the historical rainfall data for the year 2024 and the forecast data up to March 2025 for the Luvuvu River.



Data source: Limpopo Digital Twin, Sentinel-2 and ArcGIS Basemap

DEA – Use Cases Hands on!





Digital Earth Africa

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 [deafrica-sandbox-notebooks](#) Public

Repository for Digital Earth Africa Sandbox, including: Jupyter notebooks, scripts, tools and workflows for geospatial analysis with Open Data Cube and xarray

🟠 Jupyter Notebook ⭐ 203 🍴 149

 [deafrica-extent](#) Public

A process of identifying a boundary polygon for working with satellite data over Africa

🟢 Python 🍴 1

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Top languages



<https://github.com/digitalearthafrika>

Files

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> SDGs

> Supplementary_data

> Tools

▼ Use_cases

> Coastlines_change_and_impact

> Lake_baringo_grazing

▼ Limpopo_River_Basin/01_Dam_...

deafrica-sandbox-notebooks / Use_cases / Limpopo_River_Basin / 01_Dam_Volume_Prediction /

KayathrilWMI reference updates ✓

8dc48f8 · last month History

Name	Last commit message	Last commit date
..		
data	folder_structure correction	2 months ago
trained_models	folder structuring	2 months ago
01_dam_volume_data_preprocessing.ipynb	reference updates	last month
02_dam_volume_model_training.ipynb	reference updates	last month
03_dam_volume_model_prediction.ipynb	reference updates	last month

<https://bit.ly/43Aowif>

[Link](#)

Overview

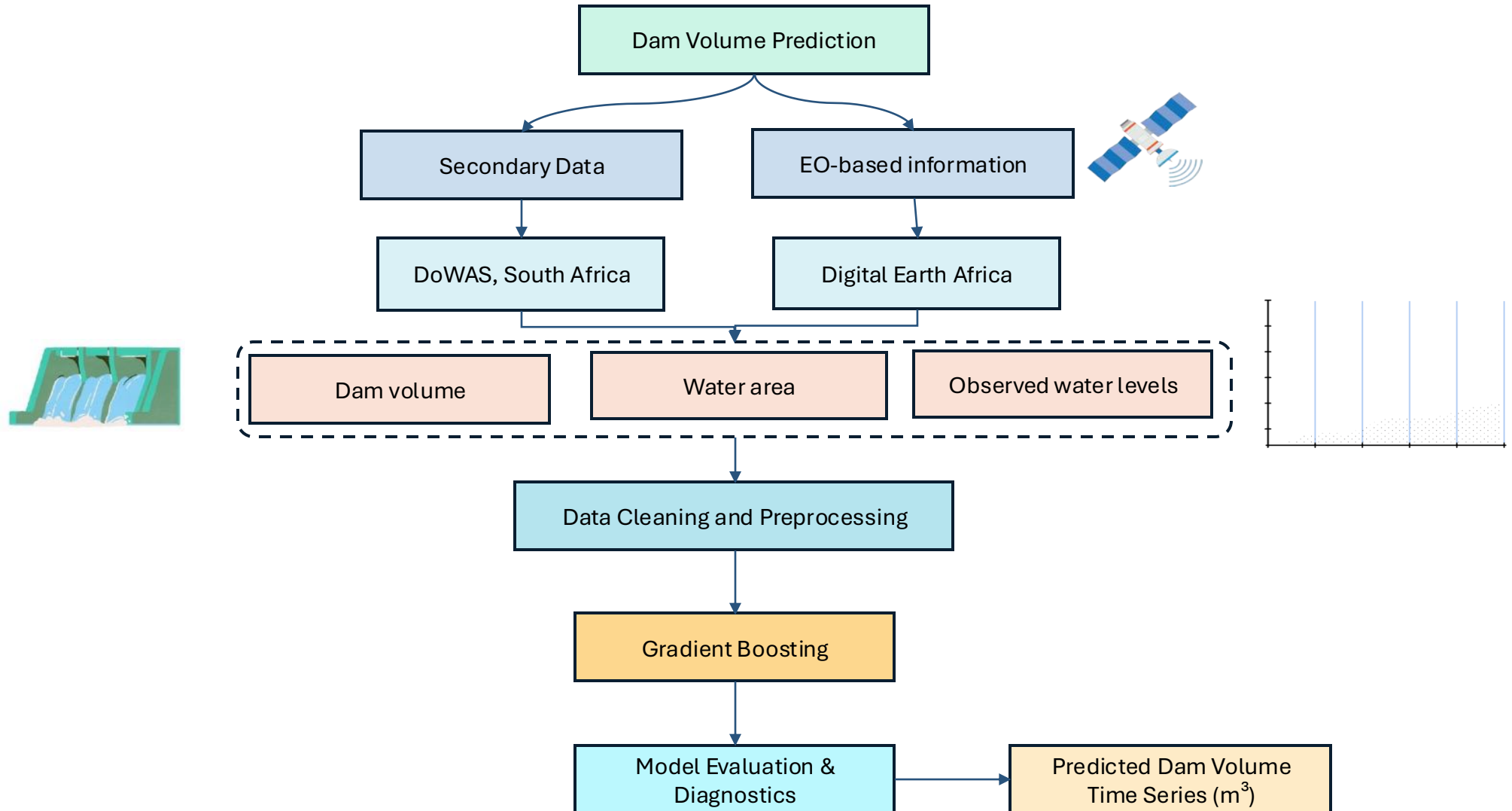
Module	Objective	Data Used	Method	Key Output	Application
1. Dam Volume Estimation	Prediction of dam Volume using EO data & ML	DE Africa Waterbodies (surface area)	Gradient Boosting ML model	Predicted dam volume(m ³), Wet Surface Area Time Series	Reservoir management, drought early warning, storage monitoring
2. Irrigation Water Use Tracking	Assess water use in irrigated farmlands	Irrigated area mask (binary raster), WaPOR AETI-M data (evapotranspiration)	Spatial overlay in Jupyter Notebook	Irrigation water use (m ³) by region/date, irrigation footprint (ha)	Agricultural water accounting, Seasonal monitoring
3. Water Availability Estimation	Water stress in river channels using SWAT & EO data	SWAT flow output + NDVI + rainfall	Time-series & map overlays	Flow forecasts, rainfall/NDVI insights	Basin-wide planning, Digital Twins, Climate risk analysis

Use Case I – Predicting Dam Volume

IMPORTANCE

- **Water Management Efficiency:** Accurate dam volume estimation supports the **efficient allocation of water** for agricultural, industrial, and domestic needs. It ensures water is used sustainably and **reduces conflicts between sectors** during periods of scarcity ([Fuentes et al., 2021](#)).
- **Disaster Risk Mitigation:** **Helps mitigate disasters such as floods and droughts.** During heavy rainfall, it enables **timely reservoir release** to prevent overflow and downstream flooding. During dry periods, it aids **in drought preparedness by forecasting declining water availability and enabling early interventions** (Enayati et al., [2024](#)).
- **Ecosystem and Environmental Flow Management:** **Predicting water volumes helps ensure that** environmental flow requirements are **maintained to support aquatic ecosystems.** This helps in **conserving biodiversity, maintaining river health, and avoiding the negative impacts** of abrupt flow alterations([Kumar & Jayakumar, 2021](#)).

Workflow Overview



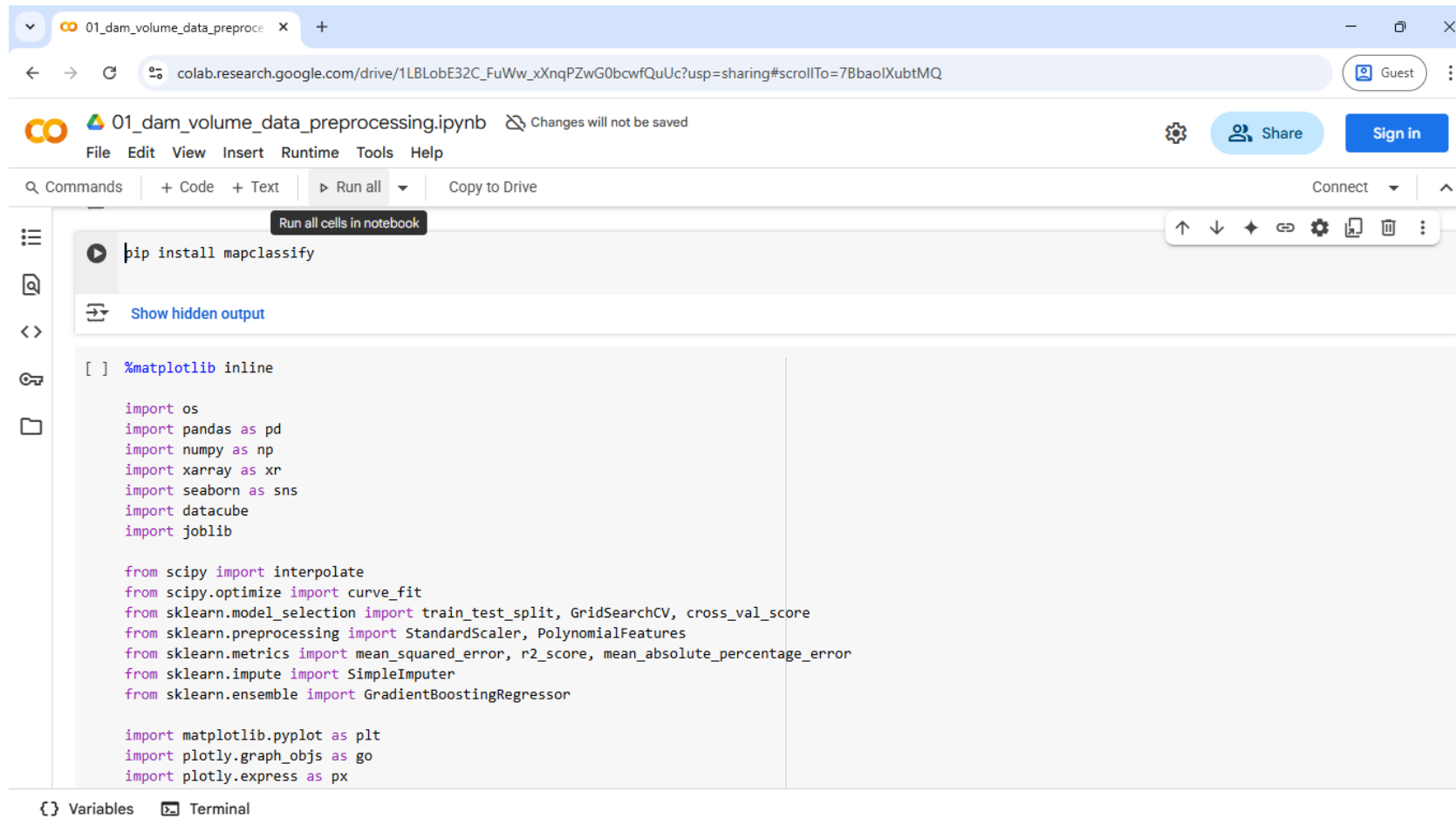
Steps to Use Google Collab

1. Go to by this link <https://colab.research.google.com/>
2. **Sign in** with your Google account
3. Click “**New Notebook**”
4. Change runtime type (optional)
5. Write and run Python code in cells
6. Install required packages using **!pip** install
7. Upload files using **files.upload()** or mount Google Drive
8. Import the necessary Python libraries
9. **Save** the notebook to Google Drive or download it



Google Colab

Open the **Google Colab notebook** and run all cells



The screenshot shows a Google Colab notebook in a web browser. The browser's address bar displays the URL: `colab.research.google.com/drive/1LBlobE32C_FuWw_xXnqPZwG0bcwfQuUc?usp=sharing#scrollTo=7BbaolXubtMQ`. The notebook's title bar indicates the file name is `01_dam_volume_data_preprocessing.ipynb` and shows a warning that "Changes will not be saved". The interface includes a menu bar with options like File, Edit, View, Insert, Runtime, Tools, and Help. Below the menu, there are buttons for "Run all", "Copy to Drive", and "Connect". A sidebar on the left contains icons for file management and a search bar. The main area displays a code cell with the following Python code:

```
!pip install mapclassify

[ ] %matplotlib inline

import os
import pandas as pd
import numpy as np
import xarray as xr
import seaborn as sns
import datacube
import joblib

from scipy import interpolate
from scipy.optimize import curve_fit
from sklearn.model_selection import train_test_split, GridSearchCV, cross_val_score
from sklearn.preprocessing import StandardScaler, PolynomialFeatures
from sklearn.metrics import mean_squared_error, r2_score, mean_absolute_percentage_error
from sklearn.impute import SimpleImputer
from sklearn.ensemble import GradientBoostingRegressor

import matplotlib.pyplot as plt
import plotly.graph_objs as go
import plotly.express as px
```

At the bottom of the interface, there are tabs for "Variables" and "Terminal".

Data Flow

Colab Notebook

01_dam_volume_data_preprocessing

- **Downloaded CSV**
 - preprocess_data.csv

Colab Notebook

02_dam_volume_data_training

- **Uploaded CSV**
 - preprocess_data.csv
- **Downloaded CSVs**
 - prediction_data.csv
 - test_data.csv

Colab Notebook

03_dam_volume_data_prediction

- **Uploaded CSVs**
 - preprocess_data.csv
 - prediction_data.csv
 - test_data.csv

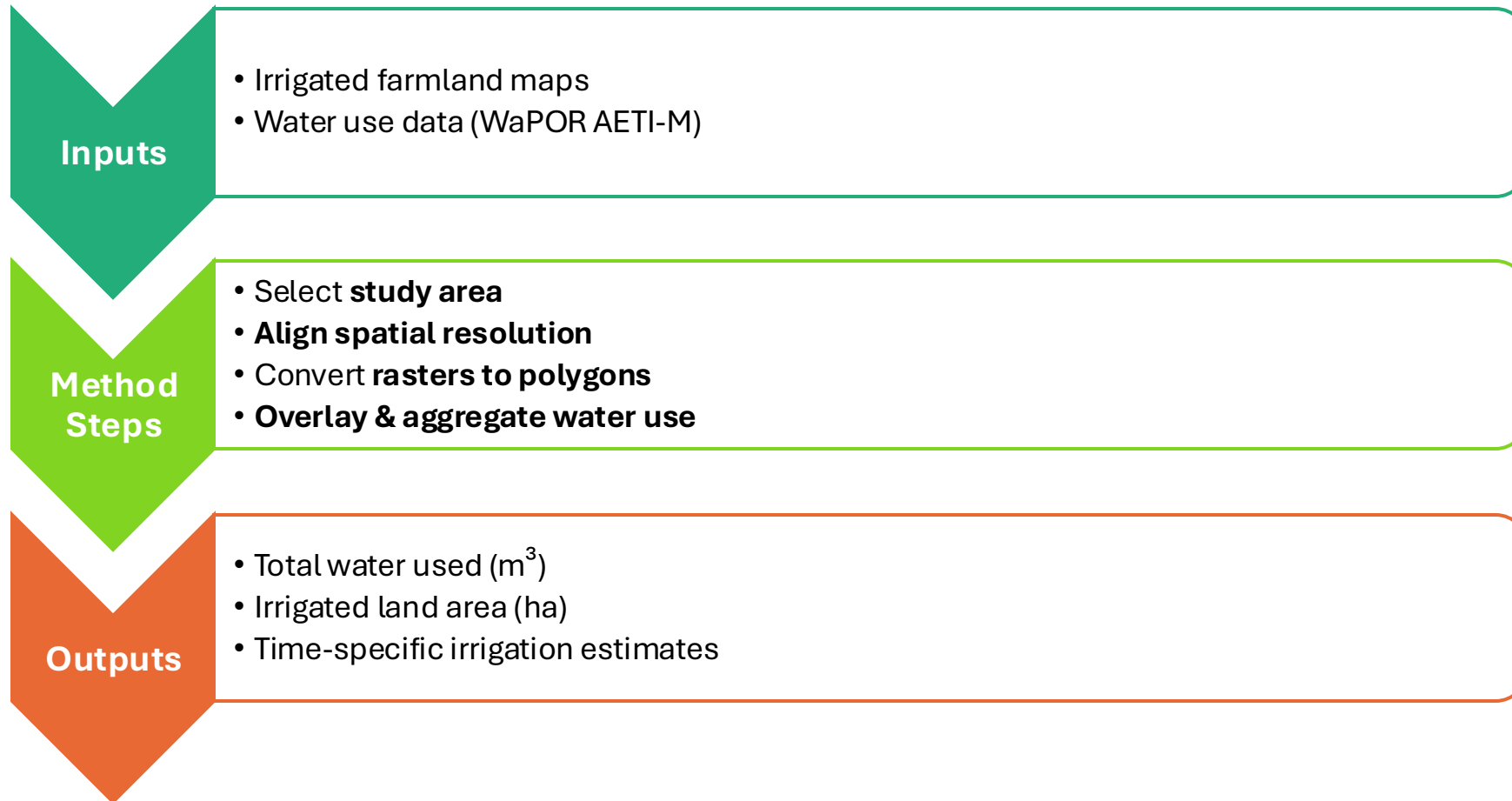


Use Case II – Monitoring Irrigation Water

IMPORTANCE

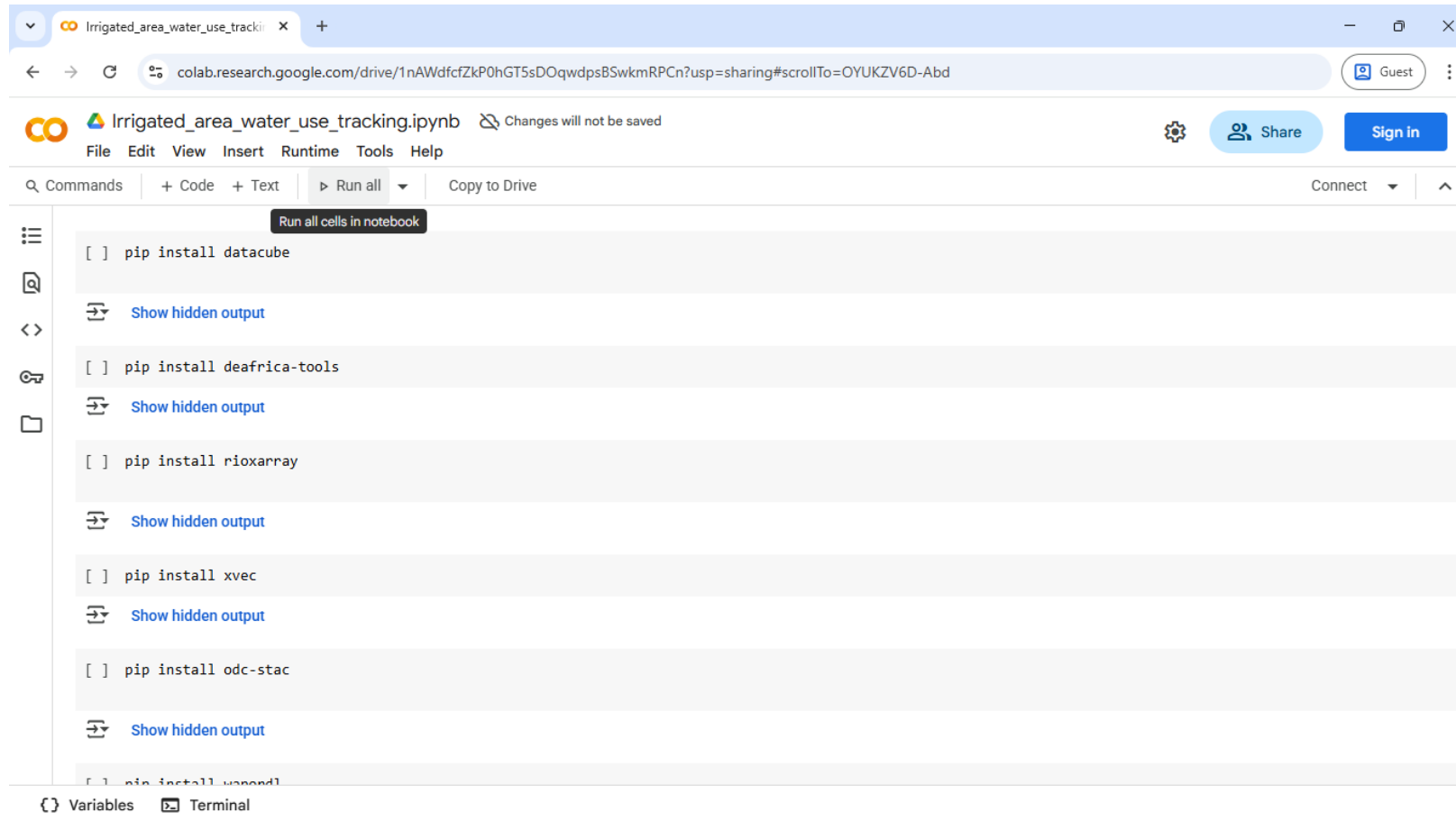
- **Water Resource Planning and Management:** Mapping irrigated areas helps **estimate agricultural water demand**, which is essential for **efficient allocation of irrigation water** from sources like dams, canals, and groundwater([Abd-Elaty et al., 2024](#)).
- **Agricultural Productivity Monitoring:** By mapping irrigated lands, **monitoring crop performance, assessing yield potential, and identifying areas of low productivity** can be done. This supports the design of targeted interventions to **improve food security and agricultural resilience** ([Abiri et al.,2024](#)).
- **Drought Impact Assessment:** Accurate maps of irrigated areas allow for assessing the **vulnerability of agricultural zones to climate extremes**, such as droughts and heatwaves. This enables **better adaptation strategies and climate-resilient planning in agriculture**([Ambika et al.,2016](#)).

Overview



Google Colab

Open the **Google Colab notebook** and run all cells

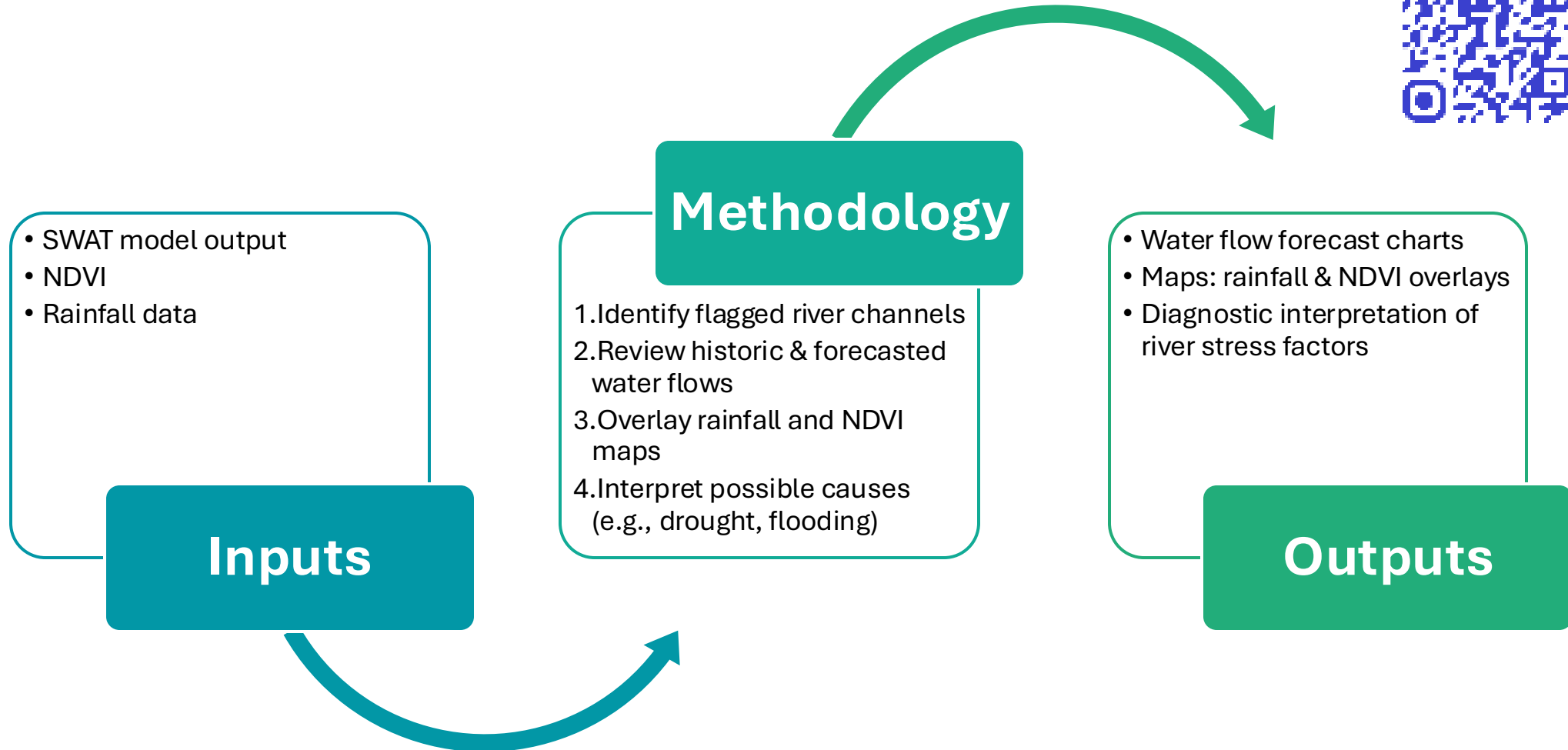


Use Case III – Water Availability

IMPORTANCE

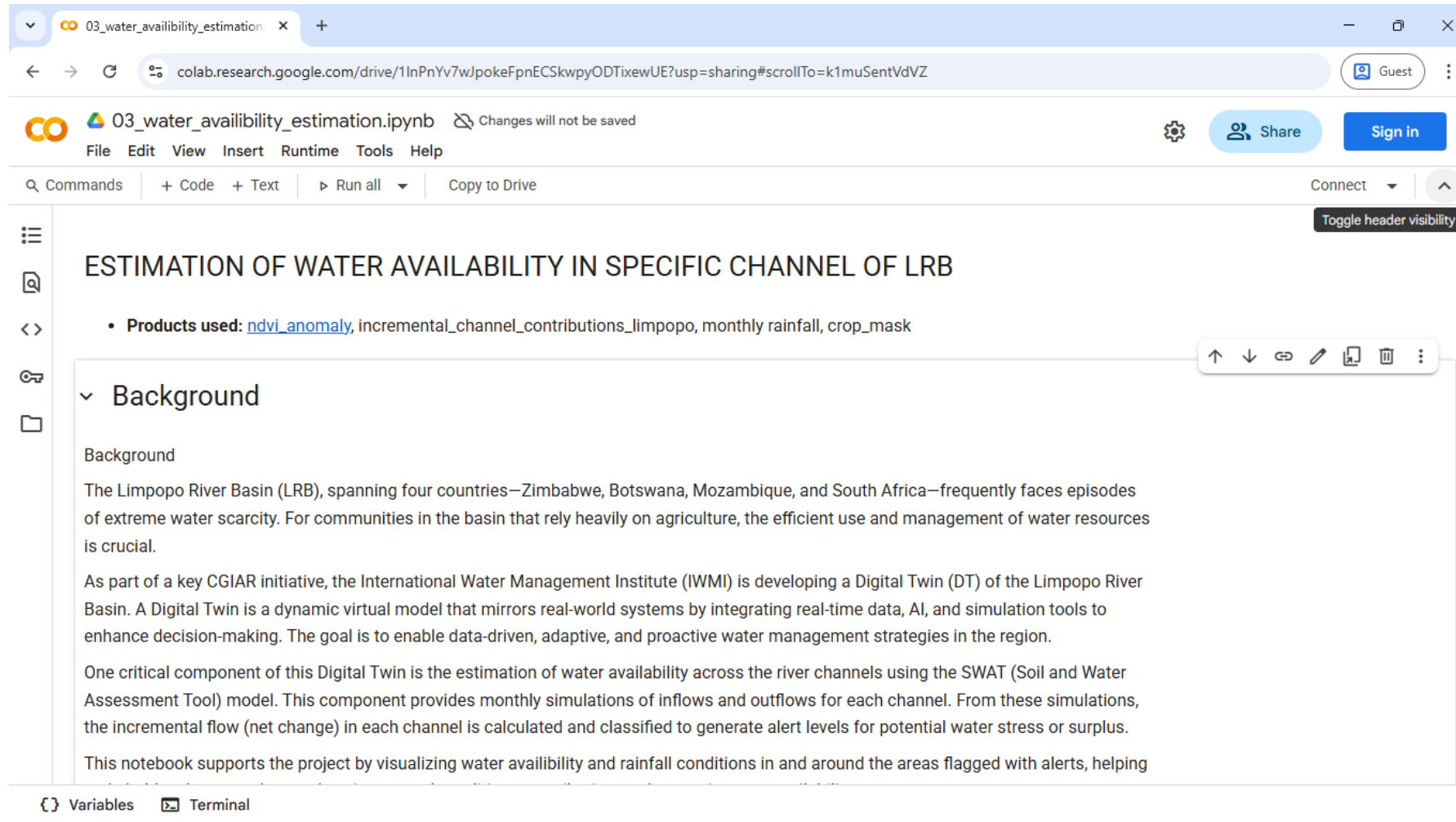
- **Water Resource Planning:** Long-term simulation of water flows across large river basins helps in **planning and estimating** available water for **agriculture, drinking, and industrial uses**. This supports **strategic allocation** and sustainable development.
- **Disaster Risk Mitigation: Forecasting and simulating flood and drought scenarios**, issuing early warnings based on real-time and forecasted data, can help in **preparedness and support climate-resilient water management**. This can also support Digital Twin-based alert systems.

Overview



Google Colab

Open the **Google Colab notebook** and run all cells



The screenshot shows a Google Colab notebook interface. The browser address bar displays the URL: `colab.research.google.com/drive/1InPnYv7wJpokeFpnECSkwpYODTixewUE?usp=sharing#scrollTo=k1muSentVdVZ`. The notebook title is `03_water_availability_estimation.ipynb`, and a warning indicates "Changes will not be saved". The menu bar includes File, Edit, View, Insert, Runtime, Tools, and Help. Below the menu, there are buttons for "Commands", "+ Code", "+ Text", "Run all", and "Copy to Drive". On the right, there are "Share" and "Sign in" buttons, along with a "Connect" dropdown and a "Toggle header visibility" button.

The notebook content is titled "ESTIMATION OF WATER AVAILABILITY IN SPECIFIC CHANNEL OF LRB". It lists products used: `ndvi_anomaly`, `incremental_channel_contributions_limpopo`, `monthly_rainfall`, and `crop_mask`.

The "Background" section is expanded, showing the following text:

Background

The Limpopo River Basin (LRB), spanning four countries—Zimbabwe, Botswana, Mozambique, and South Africa—frequently faces episodes of extreme water scarcity. For communities in the basin that rely heavily on agriculture, the efficient use and management of water resources is crucial.

As part of a key CGIAR initiative, the International Water Management Institute (IWMI) is developing a Digital Twin (DT) of the Limpopo River Basin. A Digital Twin is a dynamic virtual model that mirrors real-world systems by integrating real-time data, AI, and simulation tools to enhance decision-making. The goal is to enable data-driven, adaptive, and proactive water management strategies in the region.

One critical component of this Digital Twin is the estimation of water availability across the river channels using the SWAT (Soil and Water Assessment Tool) model. This component provides monthly simulations of inflows and outflows for each channel. From these simulations, the incremental flow (net change) in each channel is calculated and classified to generate alert levels for potential water stress or surplus.

This notebook supports the project by visualizing water availability and rainfall conditions in and around the areas flagged with alerts, helping

At the bottom, there are tabs for "Variables" and "Terminal".

Notebook Links

1. [Dam Volume Data Pre Processing 01](#)
2. [Dam Volume Model Training 02](#)
3. [Dam Volume Prediction 03](#)
4. [Irrigation Water Use Tracking](#)
5. [Water Availability Estimation](#)

Published Documents & Further Reading

[Digital Twin for management of water resources in the Limpopo River Basin: a concept. Colombo, Sri Lanka: International Water Management Institute \(IWMI\)](#) Documentation & Articles: [Topic A] –

Garcia Andarcia, M., Dickens, C., Silva, P., Matheswaran, K., & Koo, J. (2024). Digital Twin for management of water resources in the Limpopo River Basin: a concept. Colombo, Sri Lanka: International Water Management Institute (IWMI). CGIAR Initiative on Digital Innovation. 4p.

[Limpopo River Basin Digital Twin Open Data Cube Catalog](#)

Afham, Abdul; Silva, Paulo; Ghosh, Surajit; Kiala, Zolo; Retief, H.; Dickens, Chris; Garcia Andarcia, Mariangel. 2024. Limpopo River Basin Digital Twin Open Data Cube Catalog. Colombo, Sri Lanka: International Water Management Institute (IWMI). CGIAR Initiative on Digital Innovation. 22p.

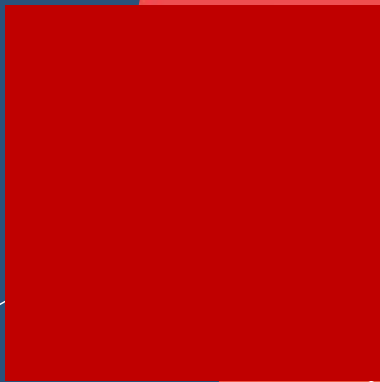
[Status of irrigated area in the Limpopo River Basin: July 2024](#)

Kiala, Zolo; Matheswaran, Karthikeyan. 2024. Status of irrigated area in the Limpopo River Basin: July 2024. Colombo, Sri Lanka: International Water Management Institute (IWMI). CGIAR Initiative on Digital Innovation. 5p.



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