



HYDROLOGICAL INFORMATION MANAGEMENT SYSTEMS FOR WATER RESOURCE MODELLING

Sospeter Wekesa

Francis Oloo, PhD

Godwin Murithi

Team



Sospeter Wekesa

Position: Hydrologist and Water Resource Engineer

Organization: Technical University of Kenya

Country: Kenya

Email: soswek@yahoo.com



Francis Oloo, PhD

Position: Postdoctoral Researcher/GIS Analyst

Organization: GeoPsy Multidisciplinary Research

Country: Kenya

Email: oloofrank@gmail.com



Godwin Murithi

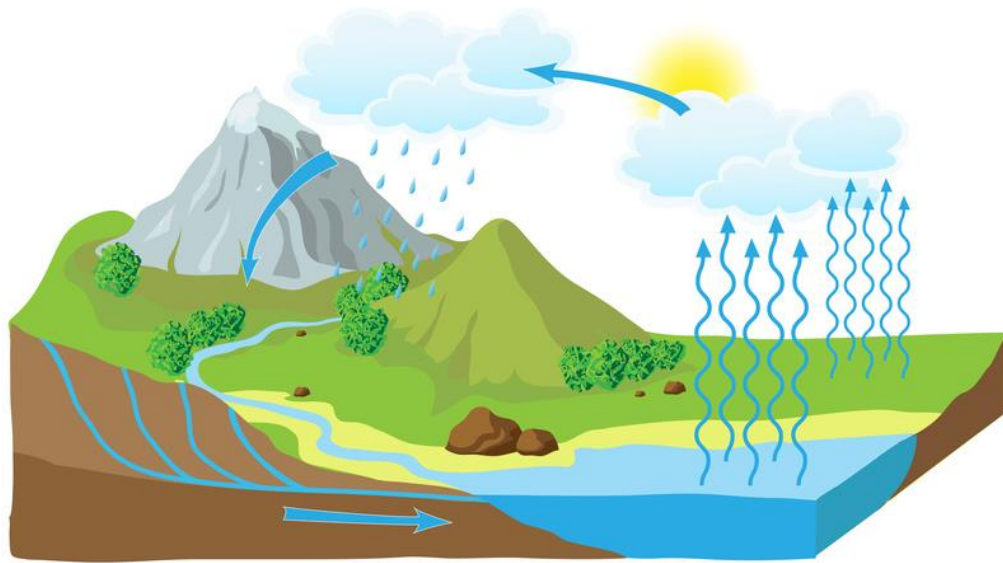
Position: Student Assistant

Organization: Technical University of Kenya

Country: Kenya

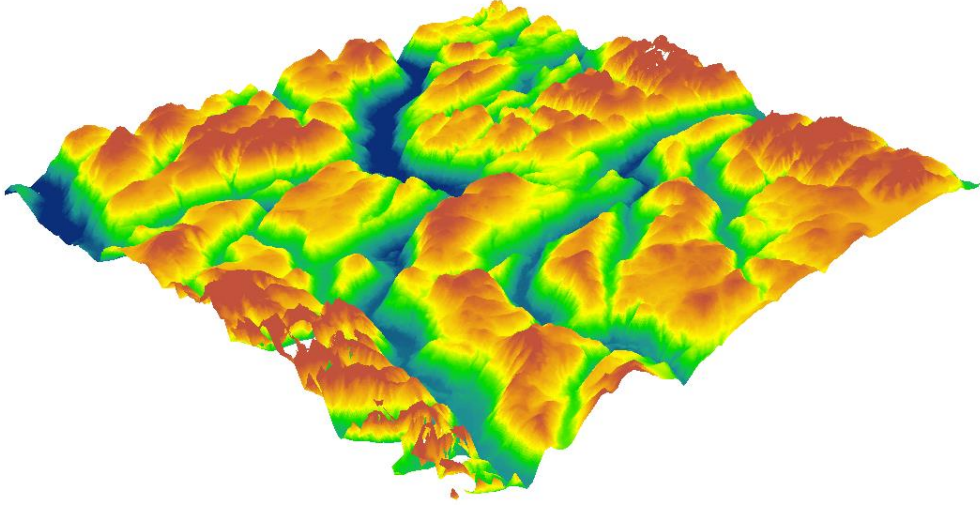
Email: godiewyn54@gmail.com

INTRODUCTION

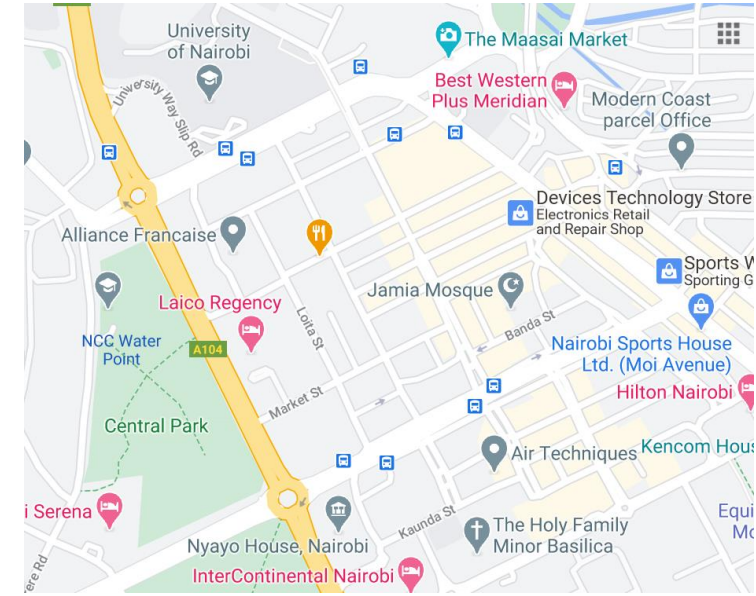


- A hydrologic model simplifies the real-world system (e.g., surface water, soil water, wetland, groundwater, estuary)
- It aids in understanding, predicting, and managing water resources.
- Both the flow and quality of water are commonly studied using hydrologic models.

DATA TYPES

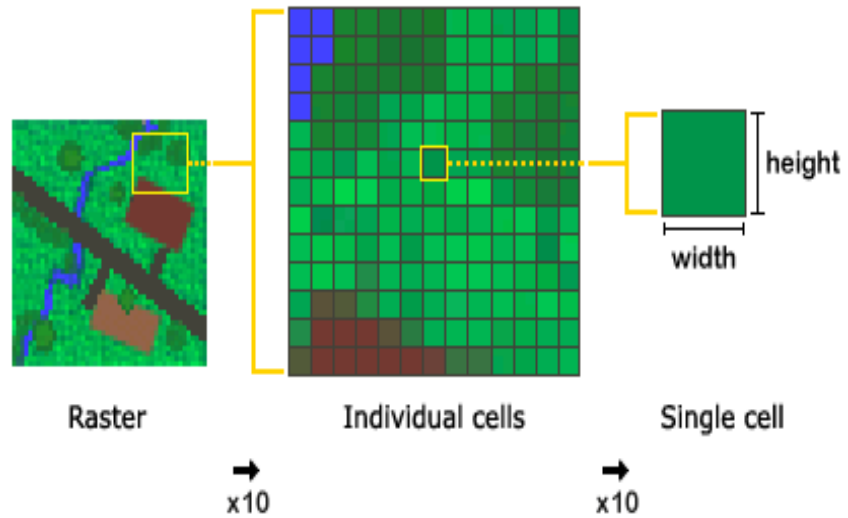


Topographic data refers to information about elevation including the shape and features of the land surface.

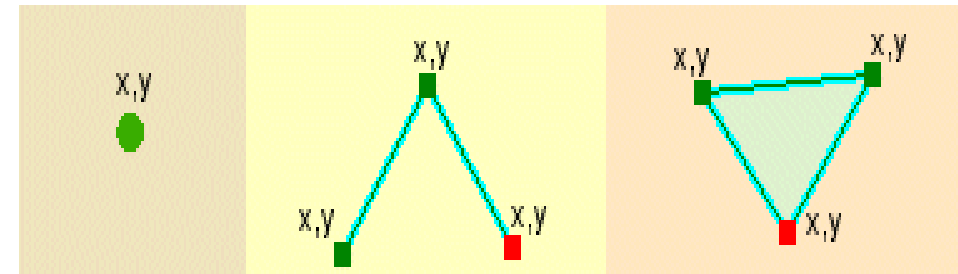


Topologic data provide information on location and relationships between spatial objects.

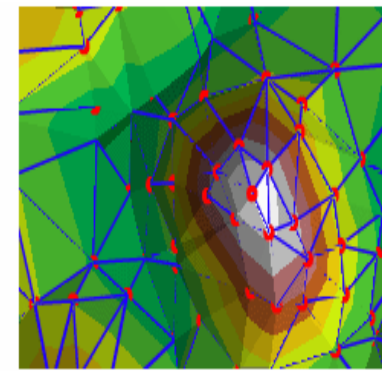
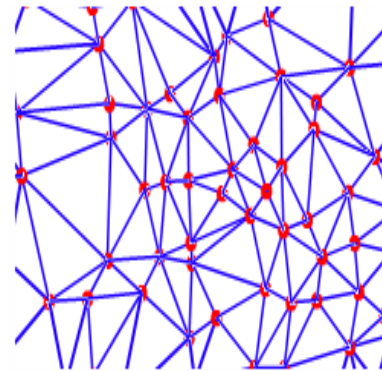
DATA STRUCTURES



a) Raster

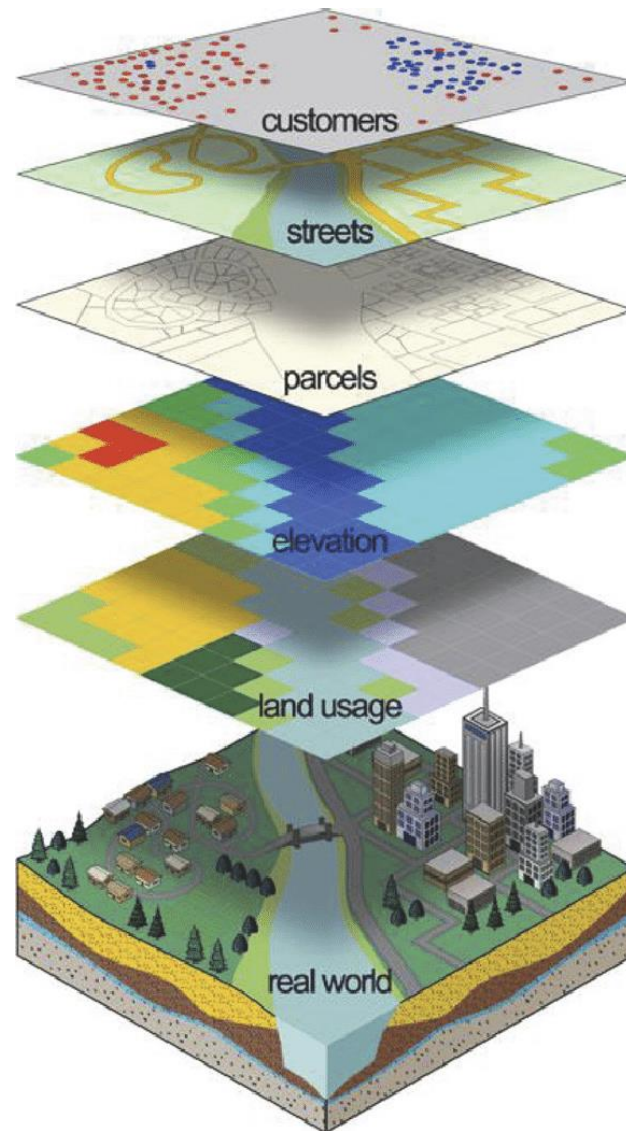


a) Vector



a) TIN

SOURCES OF GEOSPATIAL DATA



DATA TYPE	DATA SOURCE AND RANGE	SCALE	DESCRIPTION
Digital Elevation Model	Aster-GDEM (30 m) https://earthexplorer.usgs.gov/	Grid cell: 30 X 30 m	ASTER-GDEM of USGS
	ASF DEM (12.5 m) https://asf.alaska.edu/	Grid cell: 12.5 X 12.5 m	Radiometrically terrain-correct ALOS PALSAR data
Land-use	Land-use TM data https://earthexplorer.usgs.gov/	Grid cell: 30 X 30 m	Landsat TM 30X30 m-resolution data sets
	Sentinel data https://www.sentinel-hub.com/	Grid cell: 10 X 10 m	Land-use derived from 10 X 10 m resolution Sentinel datasets
Soils	FAO Soil http://www.fao.org/soils-portal/soil-survey/en/	1:5,000,000	FAO Digital soil map
Weather Data	Global Weather Data https://globalweather.tamu.edu/	0.05° resolution	Climate Forecast System Reanalysis (CFSR)
	CHIRPS https://www.chc.ucsb.edu/data/chirps	0.05° resolution	Climate Hazards Group InfraRed Precipitation with Station data (CHIRPS)
	TRMM https://gpm.nasa.gov/data	0.05° resolution	Tropical Rainfall Measuring Mission
Stream Network	HydroSHED www.hydrosheds.org	-	Mapping product that provides hydrographic information in a consistent format

GIS TOOLS/ SOFTWARE



ArcGIS



GRASS GIS



QGIS



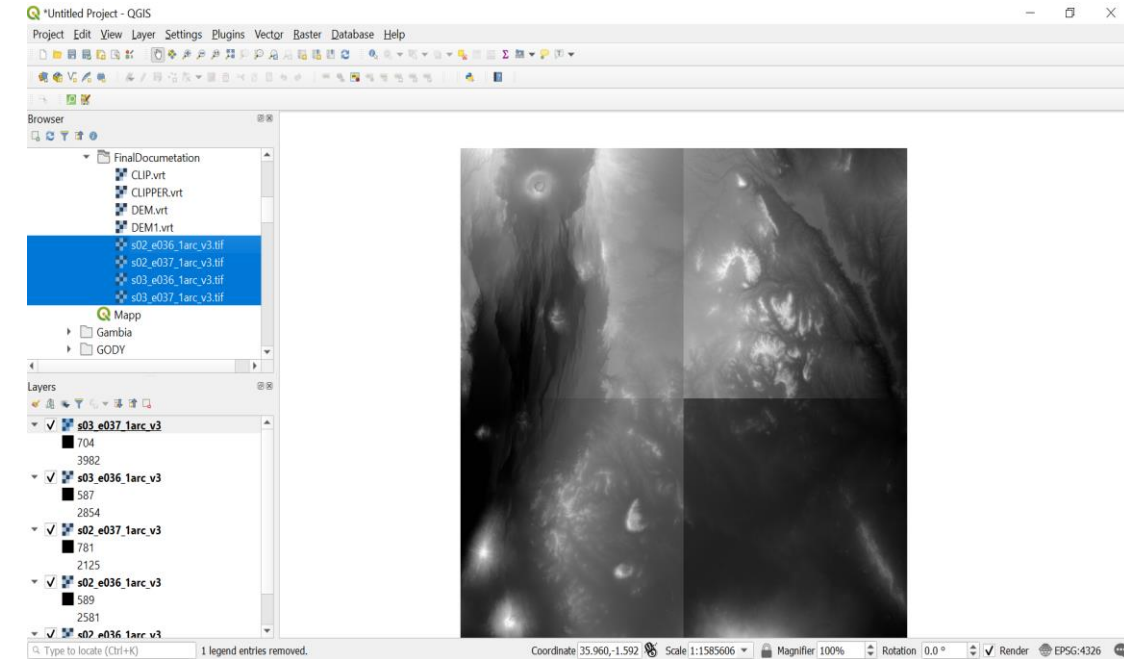
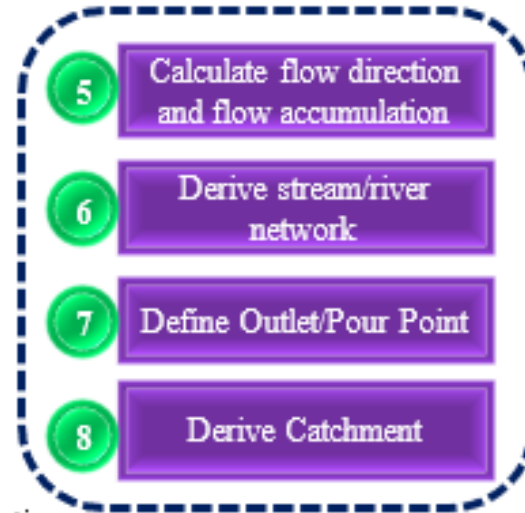
CATCHMENT & STREAM DELINEATION IN QGIS

The generic workflow for catchment delineation

DEM download and Correction



Watershed and Stream Derivation

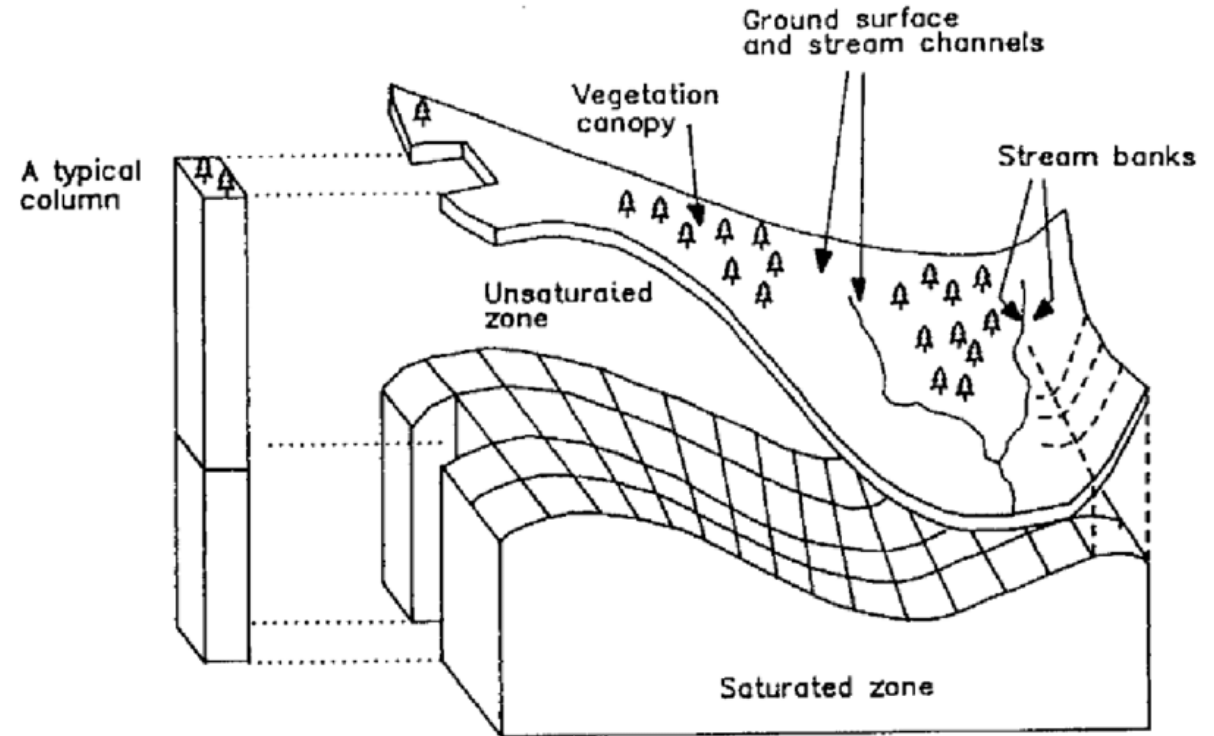


GIS tools offer flexible capabilities to derive these topological characteristics, using DEM as main Data.

TYPES HYDROLOGICAL MODELS

Fully Distributed Models

Explicitly consider the spatial distribution of physical properties across the catchment, providing that realistic relationships between model parameters and spatial properties



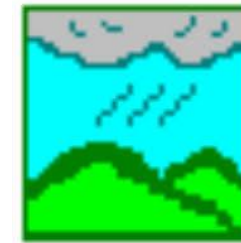
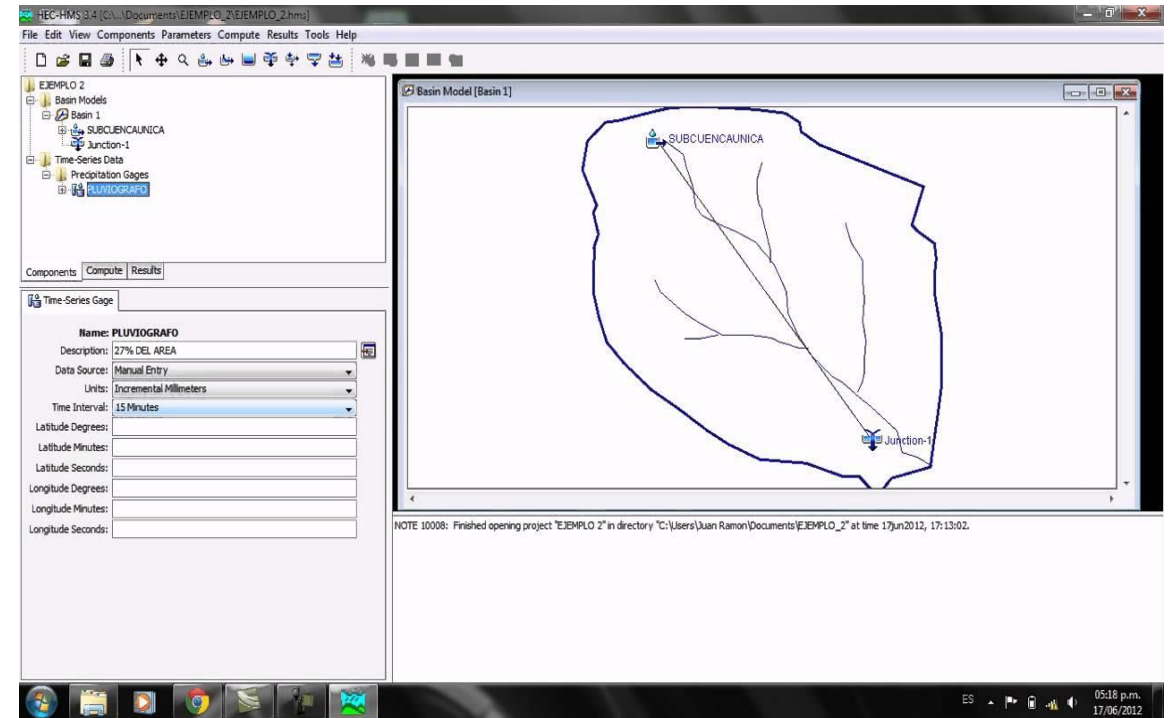
e.g. SHETRAN - physically-based spatially-distributed hydrological model.

Lumped Models

Applied in a single point or a region for the simulation of various hydrologic processes.

Parameters used represent spatially averaged characteristics in a hydrologic system

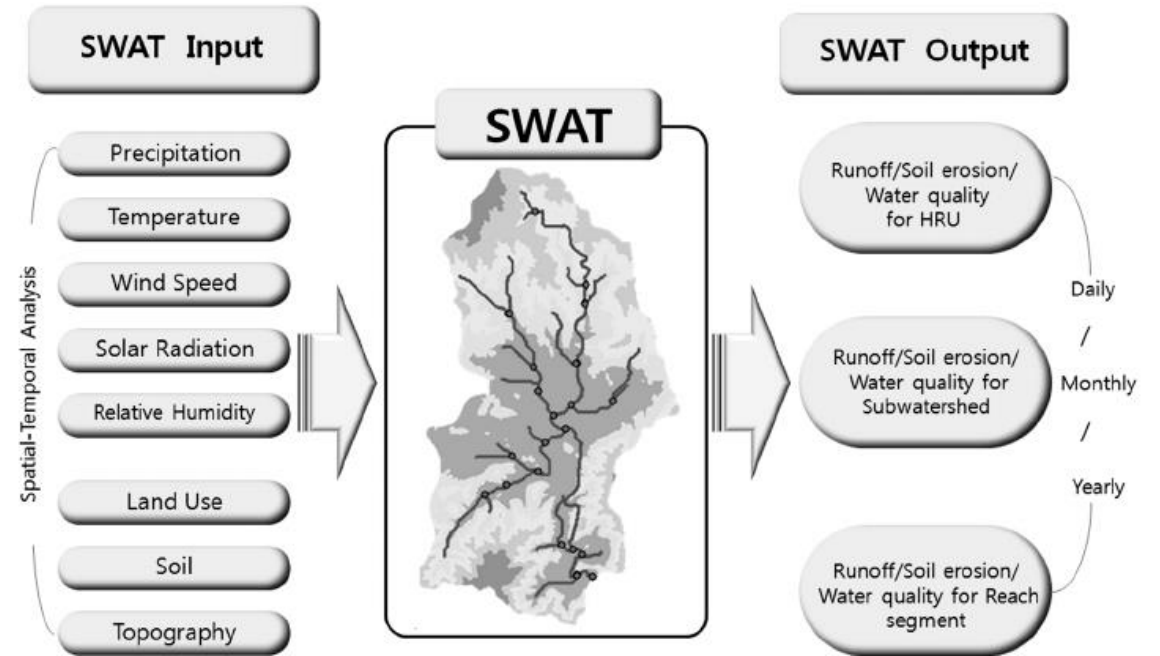
e.g. HEC-HMS



Semi-Distributed Models

Present small individual units
watershed/catchments

The algorithms are simple but
physically based



e.g. SWAT

SWAT FOR HYDROLOGICAL MODELLING

- SWAT stands for Soil and Water Assessment Tool;
- Developed by United States Department of Agriculture (USDA);
- It's a river basin scale model developed to: **to predict the impact of land management practices on water, sediment, and agricultural chemical yields in large, complex watersheds with varying soils, land use management conditions over long periods of time.**



The SWAT model is:

- **Rainfall-Runoff model:** climate data as dynamical inputs;
- **Semi-distributed:** sub-basins or hydrologic response units (HRU's);
- **Physically based;**
- **Based on a daily scale,** not for a single event

HOW DOES IT WORK? (ARNOLD AND AL.)

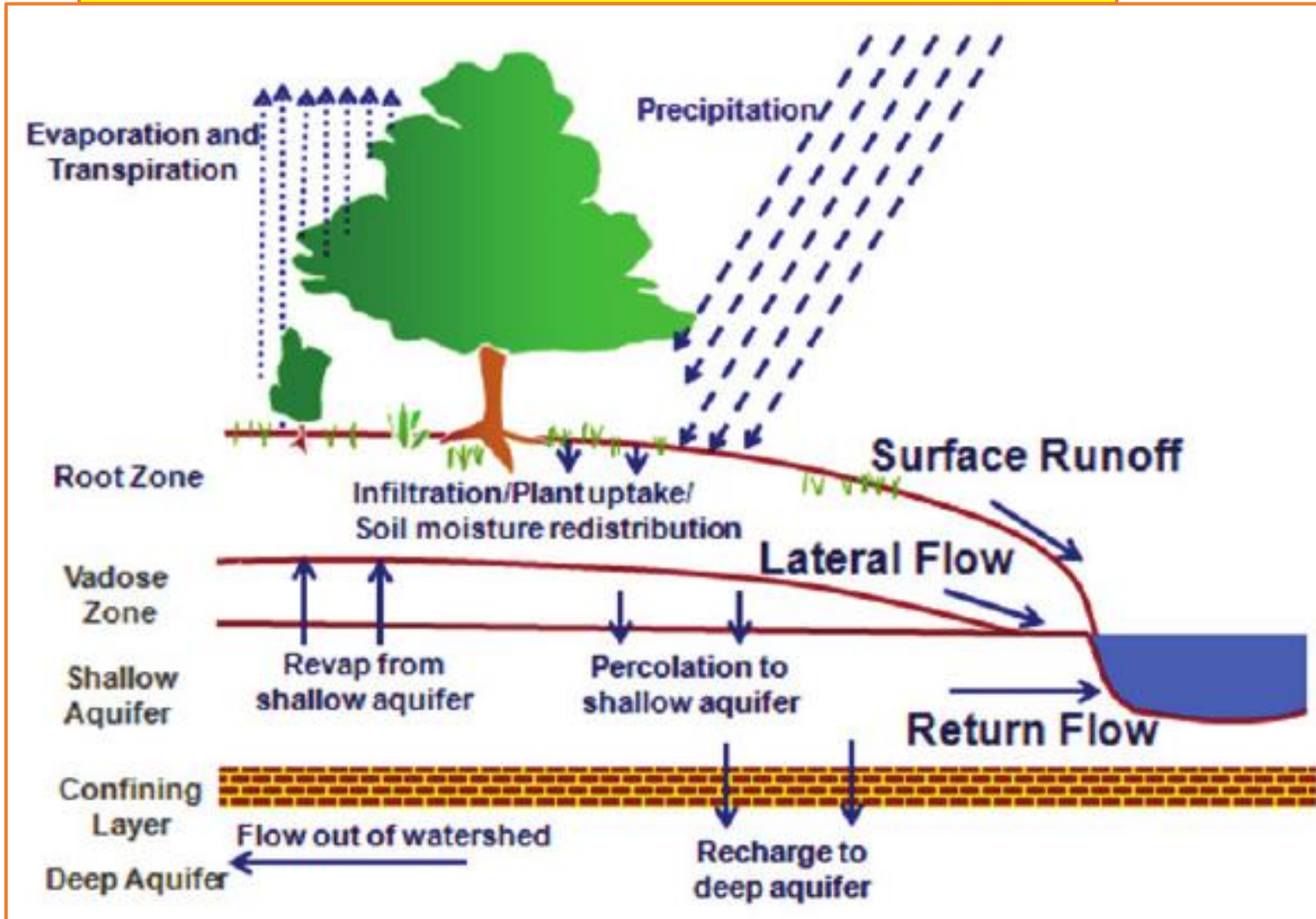
The hydrological cycle simulated by SWAT is based on the water balance equation:

$$SW_t = SW_o + \sum_i^t (R_{day} - Q_{surf} - ET_i - W_{seep} - Q_{gw})$$

- where, SW_t is the final soil water content (mm H₂O),
- SW_o is the initial soil water content on day i (mm H₂O),
- t is the time (days),
- R_{day} is the amount of precipitation on day i (mm H₂O),
- Q_{surf} is the amount of surface runoff on day i (mm H₂O),
- E_a is the amount of evapotranspiration on day i (mm H₂O),
- W_{seep} is the amount of water entering the vadose zone from the soil profile on day i (mm H₂O)
- and Q_{gw} is the amount of groundwater exfiltration on day i (mm H₂O).

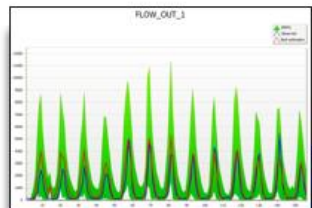
CONT.

$$SW_t = SW_o + \Sigma_i (R_{day} - Q_{surf} - ET_i - W_{seep} - Q_{gw})$$



(Neitsch, Arnold, Kiniry, Williams, & King, 2005).

WHAT IS SWAT USEFUL FOR?



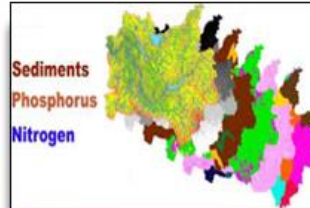
Discharge
simulation

01



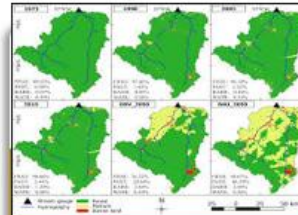
Sediment
transport

02



Water quality
(nutrients,
pesticides,
heavy metals)

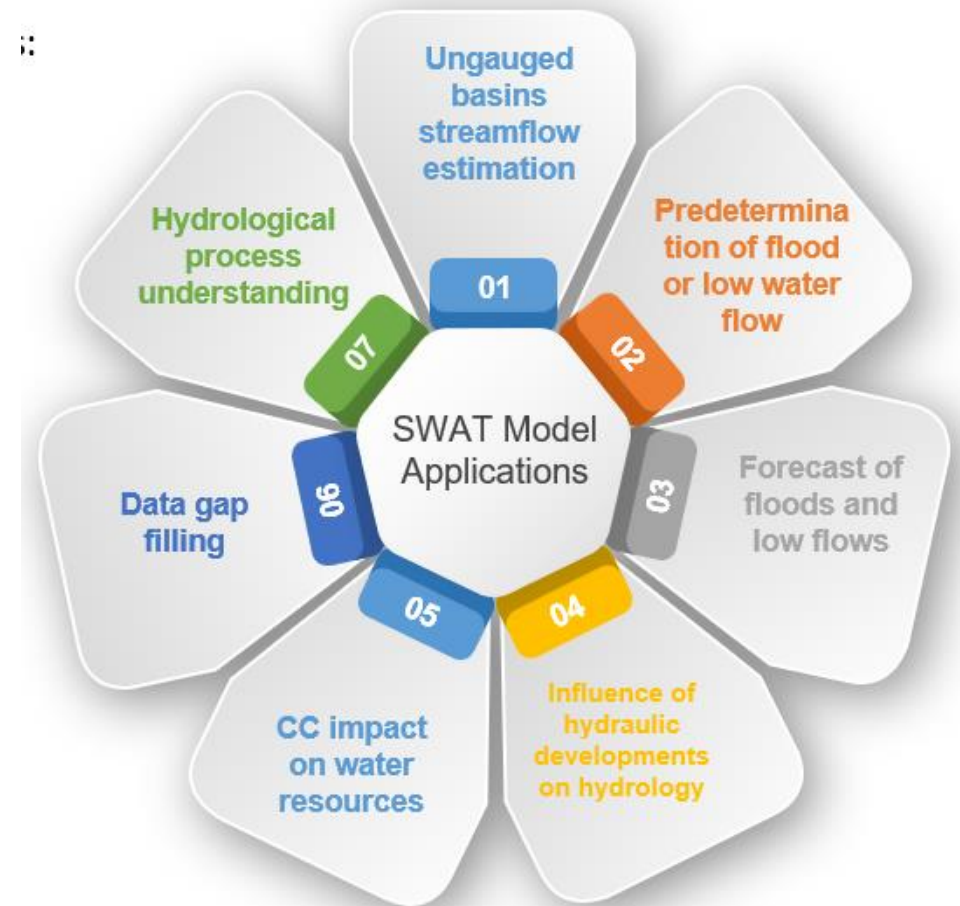
03



Evolution of
Land Use
Land Cover

04

⋮



DATA AND SYSTEM REQUIREMENT

Data requirements

1

GEOSPATIAL DATA

- ❖ Digital Elevation Model (DEM)
- ❖ Land Use Land Cover
- ❖ Soil

2

HYDRO-CLIMATIC DATA

- ❖ Precipitation
- ❖ Temperatures (mini, maxi)
- ❖ Relative Humidity;
- ❖ Solar Radiation
- ❖ Wind speed
- ❖ Streamflow

IT requirements for SWAT in QGIS

- Microsoft Windows (any version, as far as we are aware);
- Microsoft Access, as the interface uses an Access Database;
- Text editor and a tool to unzip archived files
- SWAT Editor - requirements include:
 - Microsoft Windows XP to 8.1
 - Microsoft .NET Framework 3.5
 - Adobe Acrobat Reader version 7 or higher

HOW TO BUILD A SWAT MODEL

