National Institute of Geophysics, Geodesy and Geography

swan Sustainable Water ActioN

QUANTIFICATION OF WATER-RELATED ECOSYSTEM SERVICES IN THE UPPER SANTA CRUZ WATERSHED, ARIZONA, USA

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6th SWAN Progress Meeting

21-24 April 2015, Sofia Bulgaria

MODELING WRES

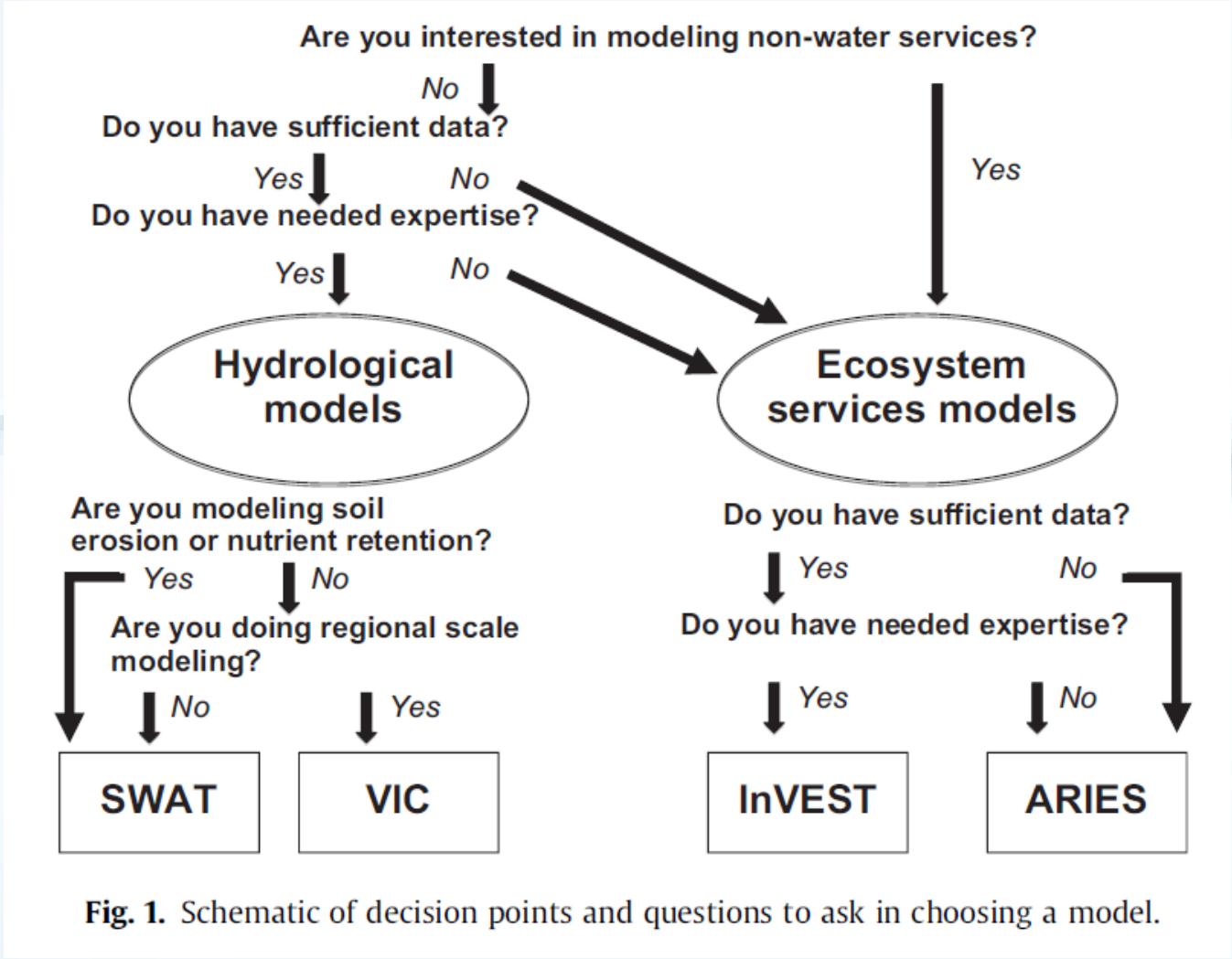


Fig. 1. Schematic of decision points and questions to ask in choosing a model.

K.L. Vigerstol, J.E. Aukema, 2011. *A comparison of tools for modeling freshwater ecosystem services.* Journal of Environmental Management 92, 2403-2409

SWAT HYDROLOGICAL MODEL

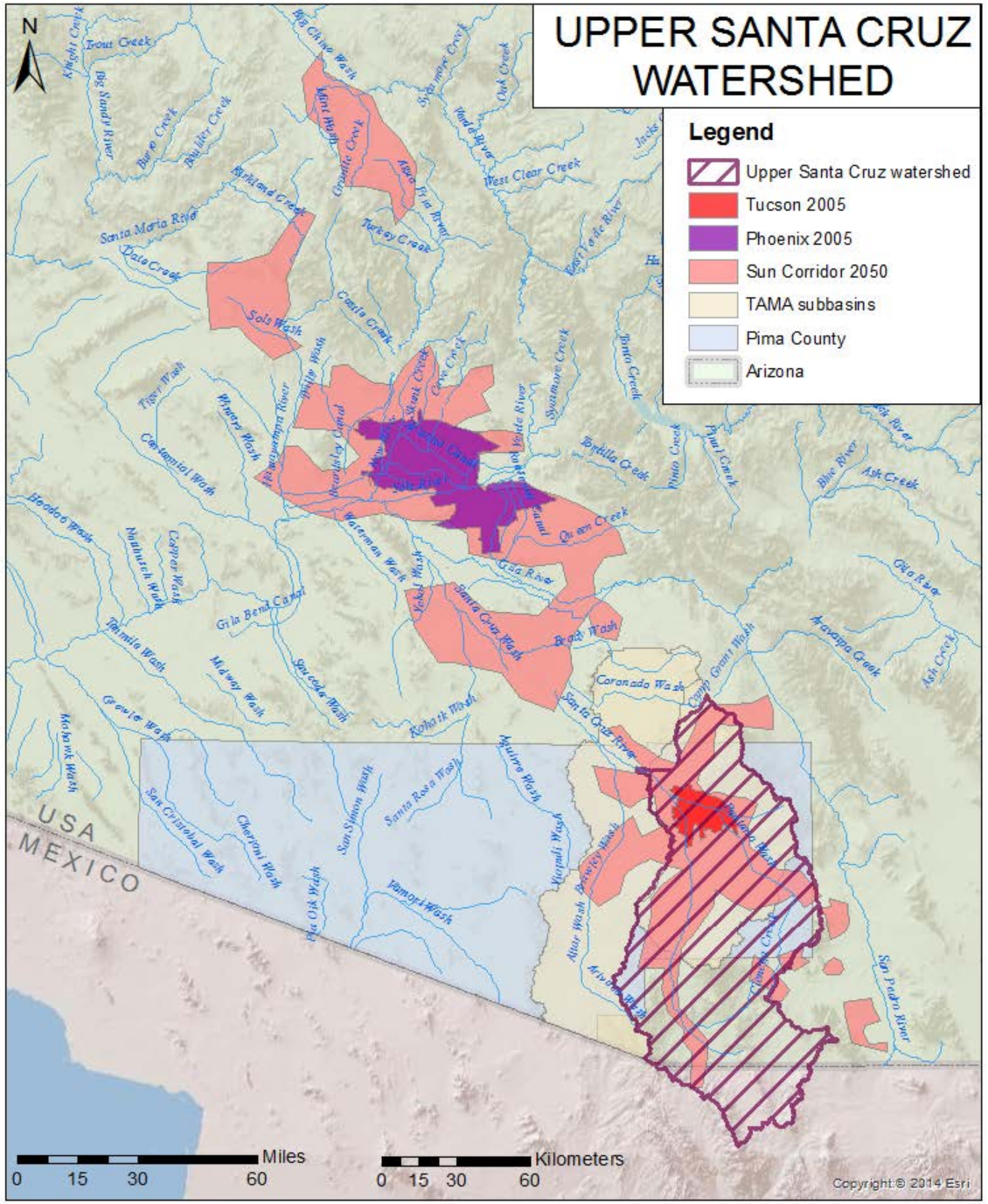
SWAT Soil & Water Assessment Tool

Jointly developed by **USDA Agricultural Research Service (USDA-ARS)** and **Texas A&M AgriLife Research**

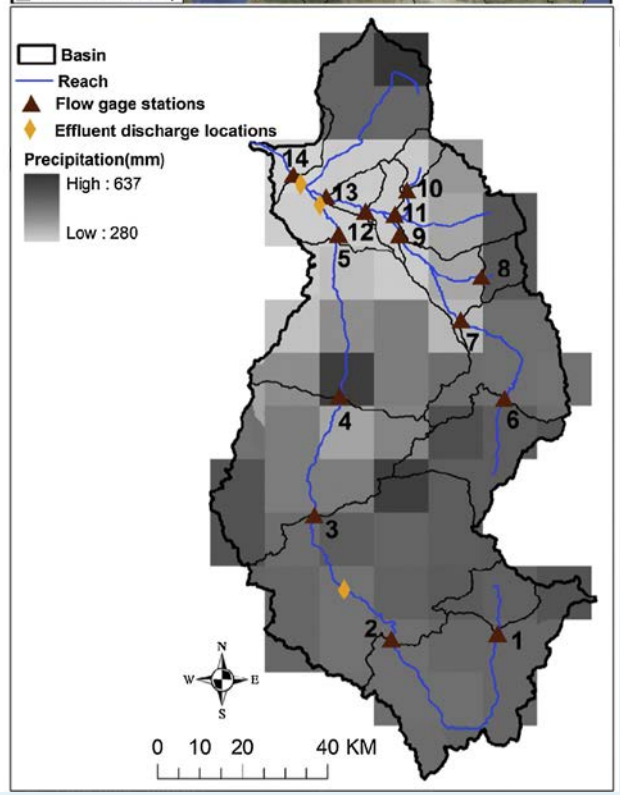
Objective - to simulate the **quality and quantity of surface and ground water** and predict the **environmental impact of land use, land management practices, and climate change** in small watershed to river basin-scale

ArcSWAT - ArcGIS extension with a graphical user interface for the SWAT

http://swat.tamu.edu/



THE CASE STUDY
Upper Santa Cruz Watershed
USA/Mexico



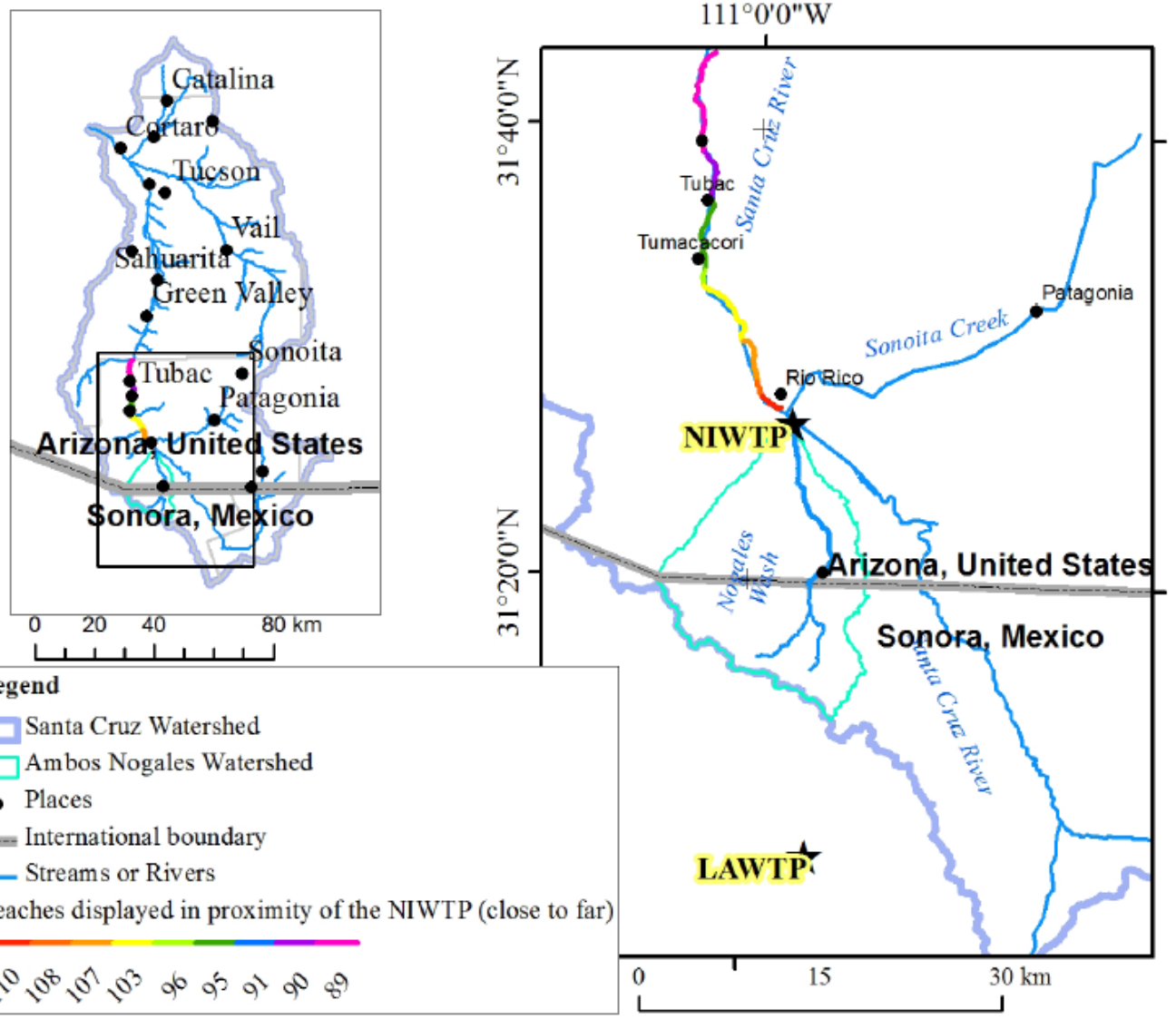
Niraula et al., 2015

Upper Santa Cruz Watershed Data

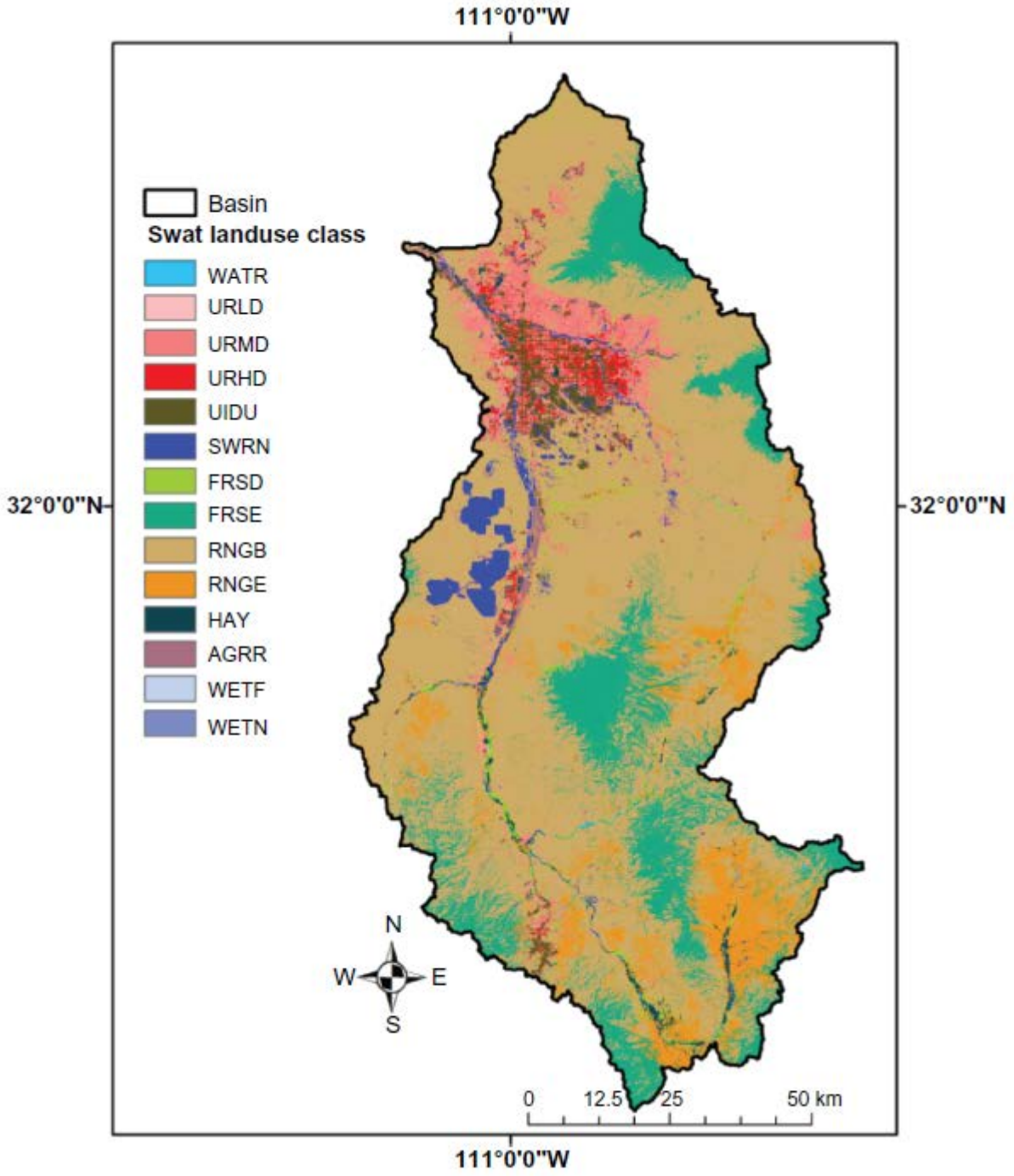
Data	Source
	US section
DEM	USGS
Land use	USGS
Soil	STATSGO II: NRCS
Weather	NOAA
Discharge from waste water treatment plant	IBWC and ADEQ
Observed flow	USGS

- Nogales International Wastewater Treatment Plant (NIWTP) - 56,000 m3/day
- Los Alisos Wastewater Treatment Plant (LAWTP) – 2012

Average daily loading data (discharge volume in cubic meters) - added for the WWTPs at Nogales, Ina Road, and Roger Road. Continuous **discharge from these WWTPs** is **responsible** for **perennial flow** in several segments in the Santa Cruz watershed and **SWAT integrates them** with the loadings generated from the land areas.



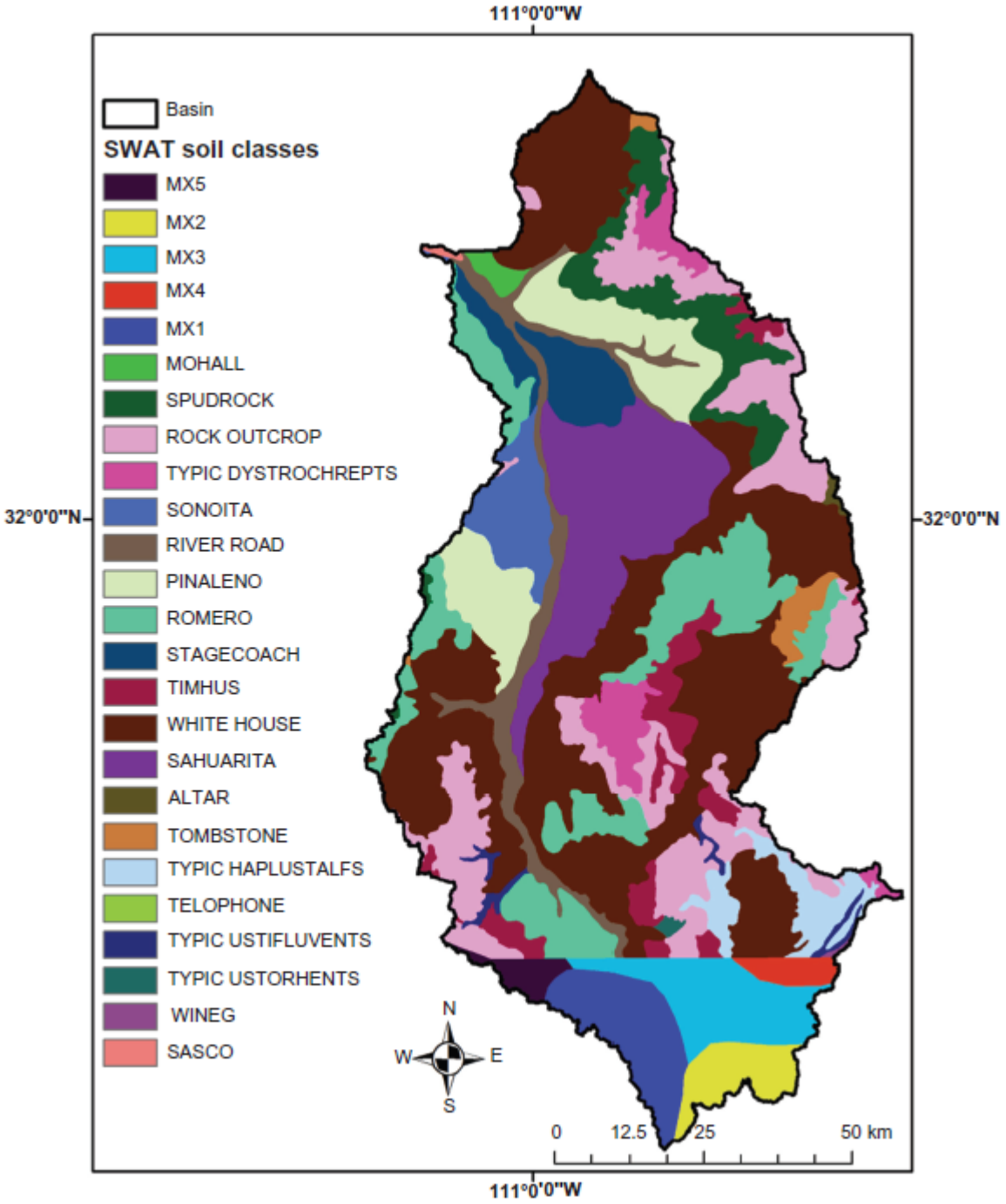
Norman et al., 2013; Niraula et al., 2012



Upper Santa Cruz Watershed Land Use (1999)

Landuse	Area (km^2)	% watershed area
Water (WATR)	2.8	0.03
Residential-Low Density (URLD)	22.4	0.25
Residential-Medium Density (URMD)	593.5	6.53
Residential-High Density (URHD)	86.4	0.95
Industrial (UIDU)	213.8	2.35
Southwestern US (Arid) Range (SWRN)	216.0	2.38
Forest-Deciduous (FRSD)	105.1	1.16
Forest-Evergreen (FRSE)	1280.0	14.08
Range-Brush (RNGB)	5742.9	63.18
Range-Grasses (RNGE)	707.6	7.78
Hay (HAY)	84.7	0.93
Agricultural Land-Row Crops (AGRR)	23.8	0.26
Wetlands-Forested (WETF)	9.5	0.1
Wetlands-Non-Forested (WETN)	1.4	0.02

Niraula et al., 2012



Upper Santa Cruz Watershed Soil (1999)

Soils	Area (km²)	% watershed area	Texture
ALTAR	11.7	0.13	Sandy loam
MOHALL	38.7	0.43	Loam
MX1	321.7	3.54	Sandy clay loam
MX2	182.6	2.01	Loam
MX3	360.4	3.96	Loam
MX4	69.0	0.76	Sandy clay loam
MX5	70.7	0.78	Sandy loam
PINALENO	561.2	6.17	Sandy loam
RIVER ROAD	371.9	4.09	Clay loam
ROCK OUTCROP	1059.9	11.66	Loamy sand
ROMERO	892.3	9.82	Sandy loam
SAHUARITA	815.7	8.97	Sandy loam
SASCO	8.6	0.09	Silt loam
SONOITA	241.9	2.66	Sandy loam
SPUDROCK	402.9	4.43	Sandy loam
STAGECOACH	261.8	2.88	Sandy loam
TELOPHONE	0.002	Negligible	Sandy loam
TIMHUS	323.2	3.56	Loam
TOMBSTONE	83.2	0.92	Loam
TYPIC DYSTROCHREPTS	228.2	2.51	Sandy loam
TYPIC HAPLUSTALFS	208.6	2.3	Loam
TYPIC USTIFLUVENTS	59.9	0.66	Sandy loam
TYPIC USTORHENTS	10.9	0.12	Sandy loam
WHITE HOUSE	2500.5	27.51	Loam
WINEG	4.5	0.05	Sandy loam

Texture	% watershed area
Loam	40.7
Sandy loam	39.2
Loamy sand	11.6
Sandy clay loam	4.3
Clay loam	4.1
Silt loam	0.1

Niraula et al., 2012

RESULTS
SWAT model

Spatial

- 131 subbasins
- 7702 Hydrological Response Units (HRU)
  - 13 land use classes
  - 23 soils
  - 3 slopes

Temporal

- Daily
- **Monthly**
- Seasonal
- Yearly
- **Other period (1982(7)-2007)**

Variables

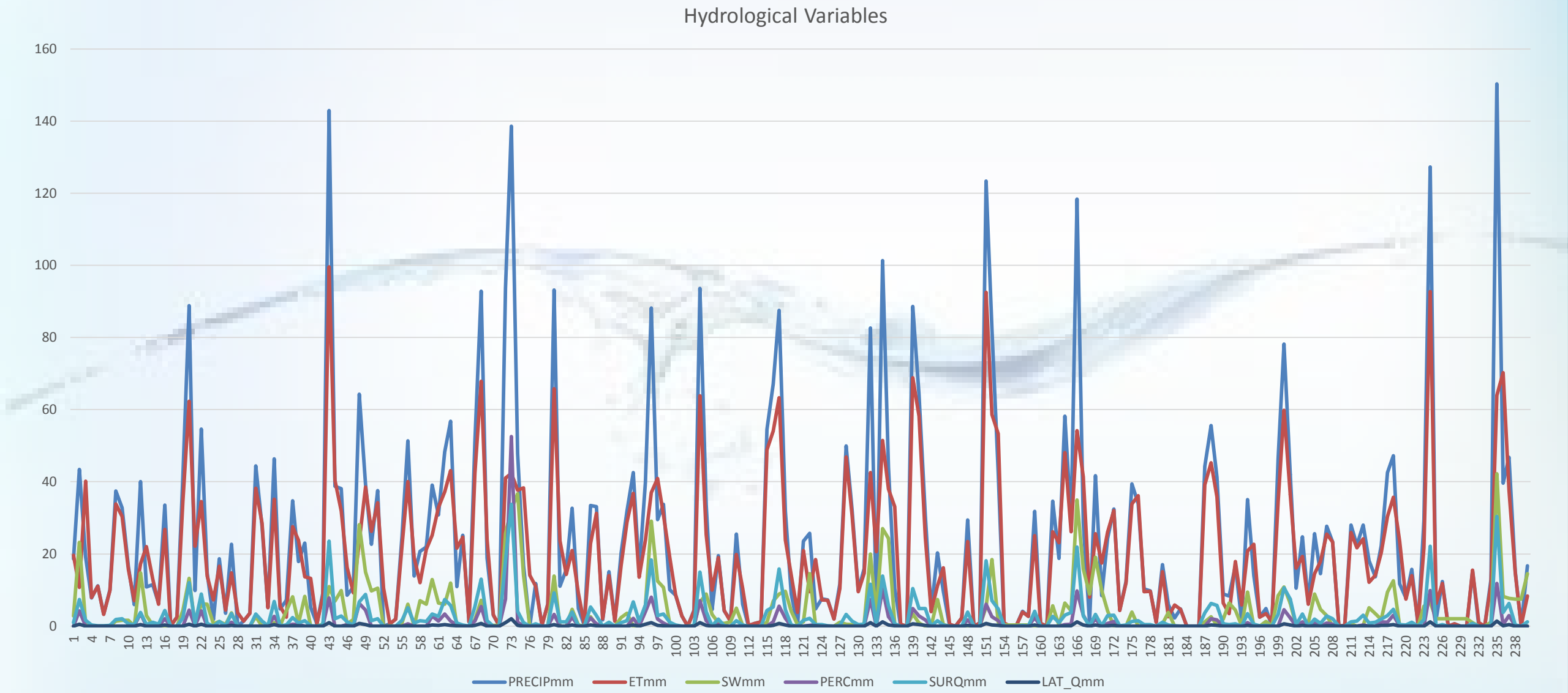
- ET
- Water yield
- Lateral flow
- Percolation
- …

RESULTS
SWAT model

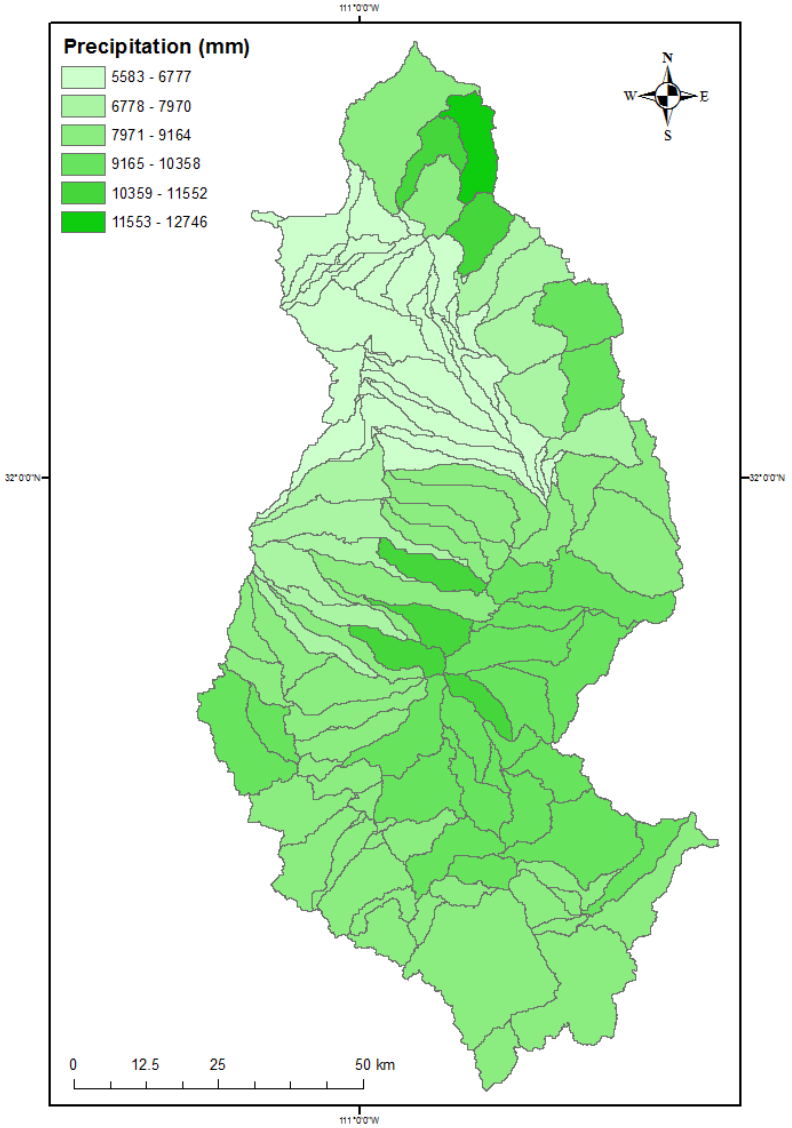
$$\text{Soil water}_i = \text{Soil water}_0 + \sum(\text{Precipitation} - \text{Surface runoff} - \text{Evapotranspiration} - \text{Percolation} - \text{Lateral flow})$$

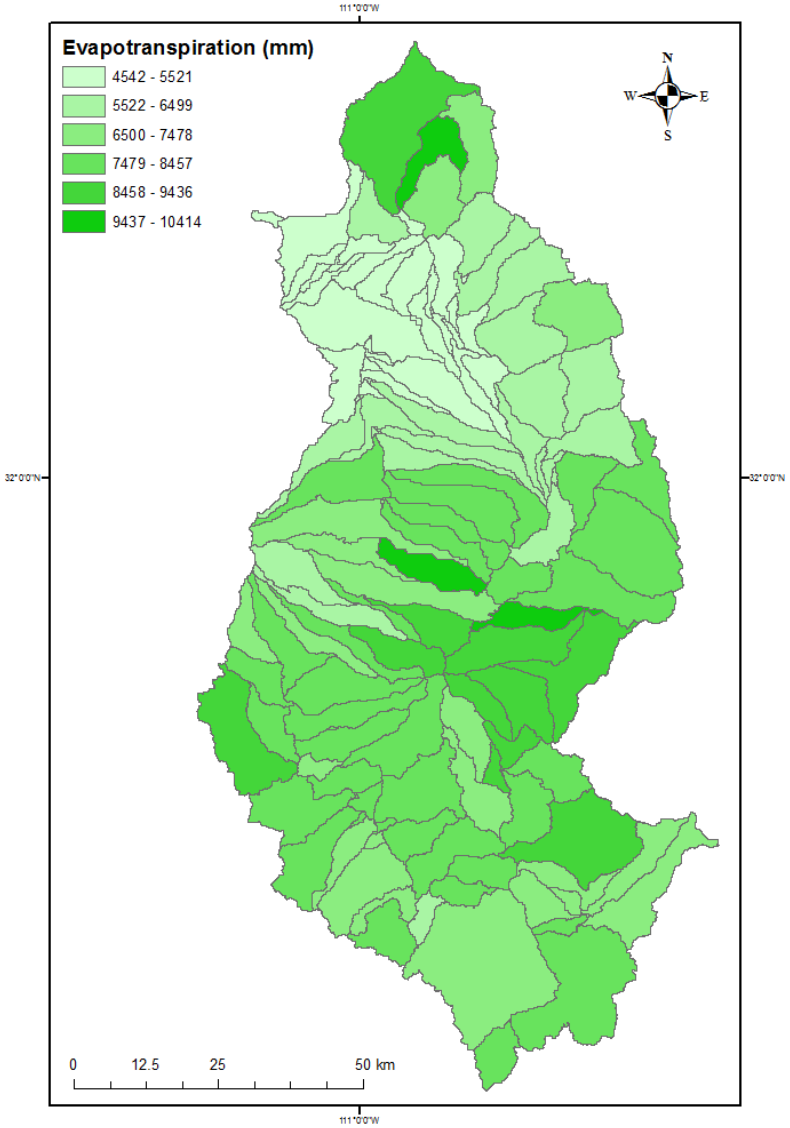
- **Soil water** - soil water content;
- **Surface runoff** - surface runoff contribution to streamflow during time step;
- **Evapotranspiration** - actual evapotranspiration from the subbasin during the time step;
- **Percolation** - Water that percolates past the root zone during the time step. There is potentially a lag between the time the water leaves the bottom of the root zone and reaches the shallow aquifer. Over a long period of time, this variable should equal groundwater percolation.
- **Lateral flow** - Lateral flow contribution to streamflow.

RESULTS
SWAT model



MAPPING (WRES)





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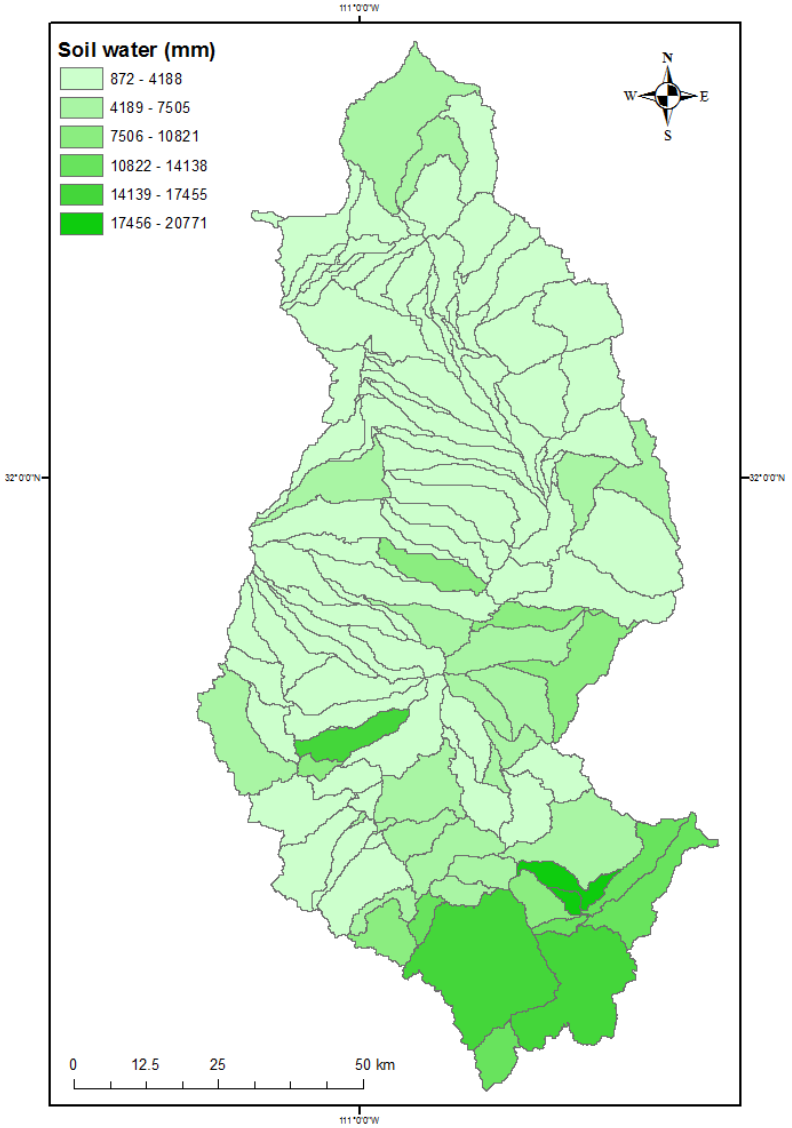

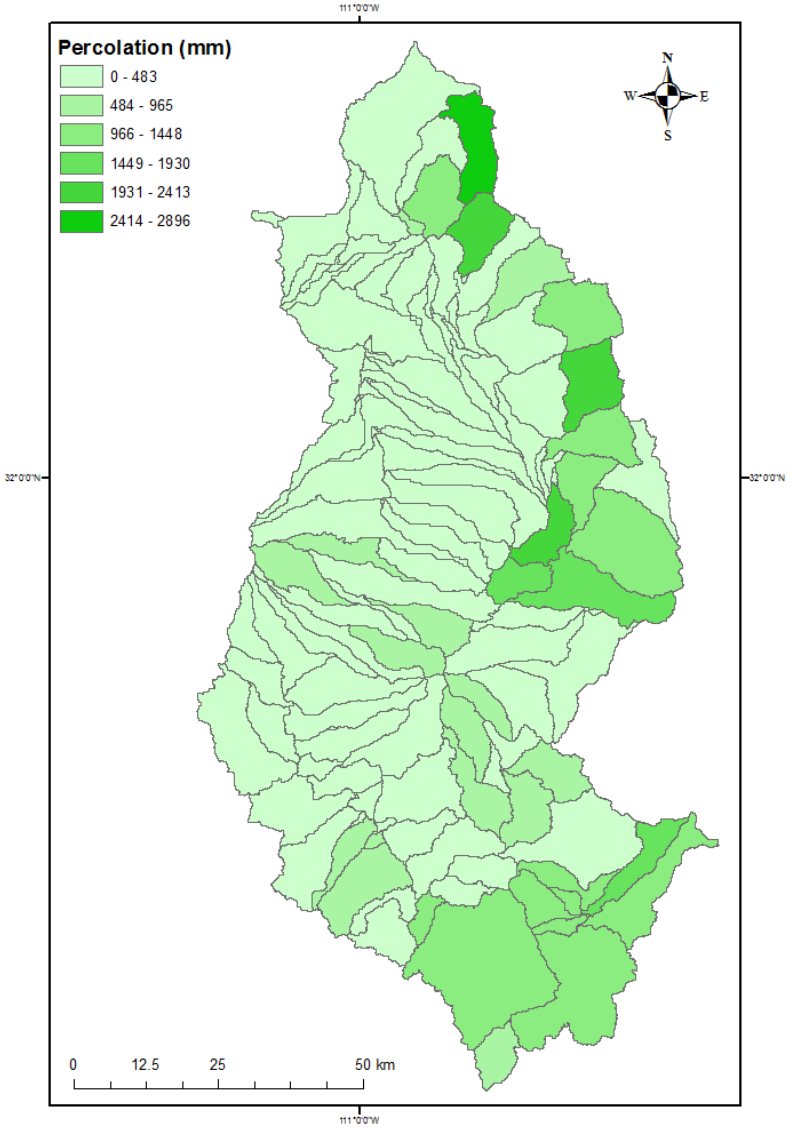

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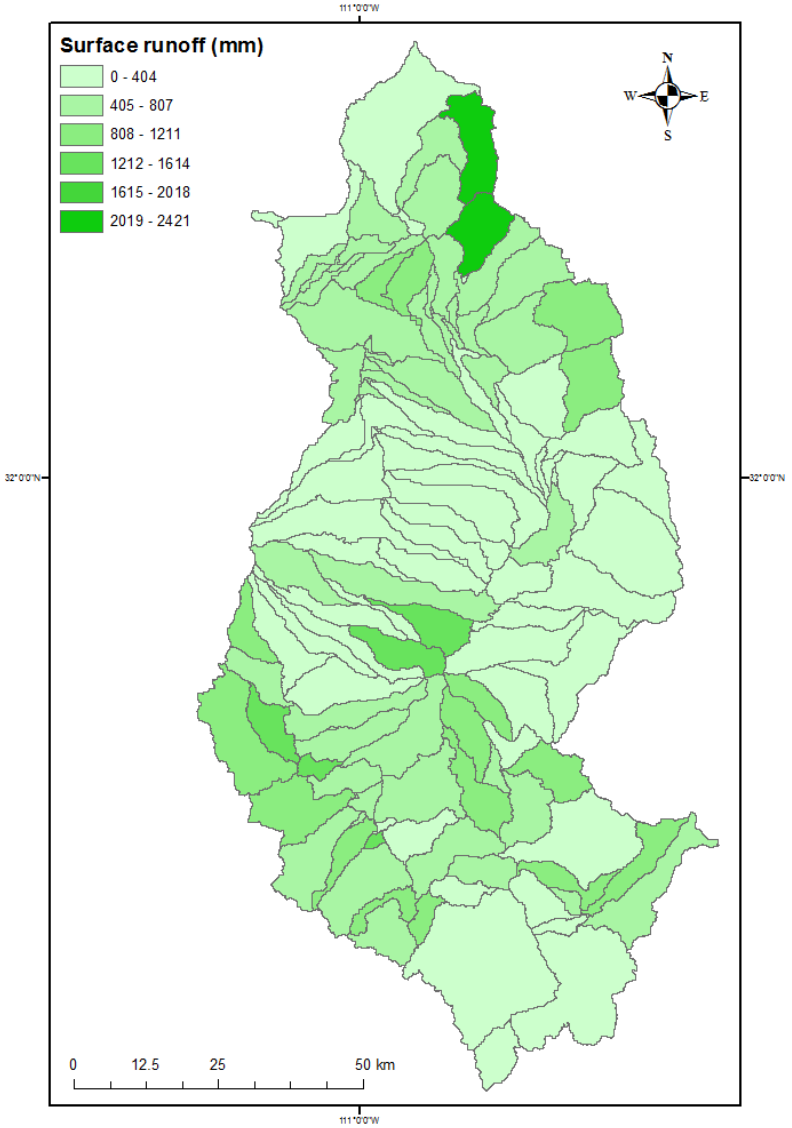

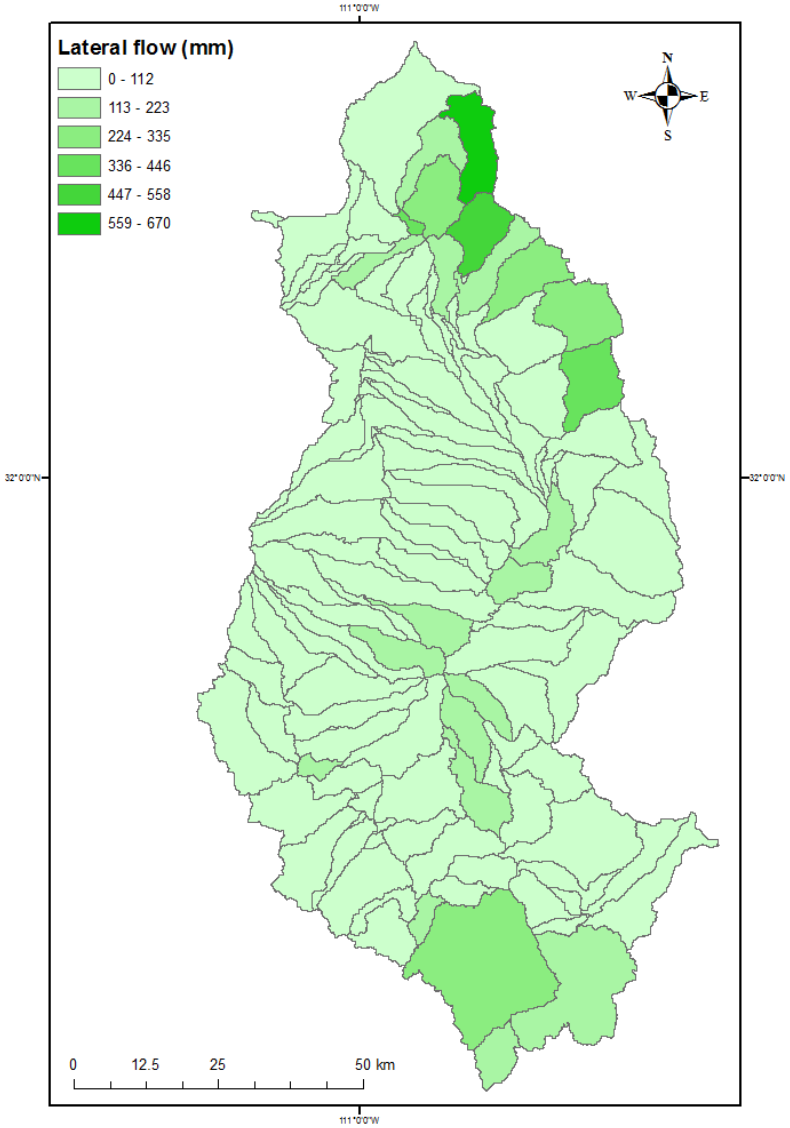

SCENARIOS

Descriptions of land-use scenarios.

Scenario	Name	Description
I	Current Trend Scenario (CRT)	Based on historic trends in land-use management, settlement patterns and direction
II	Conservation Scenario (CNS)	Emphasized on managed growth to protect the environment
III	Megalopolis Scenario (MGP)	Considering that growth is accentuated around a defined international trade corridor

LULC composition of the 3 future scenarios.

	Current 1999	Conservation 2050	Current trend 2050	Megalopolis 2050
Open water	0.04	0.04	0.03	0.03
Urban	11.82	35.02	38.45	34.09
Barren	2.44	1.2	0.65	0.69
Deciduous forest	1.69	0.53	0.15	0.2
Evergreen forest	14.55	11.95	5.19	6.18
Shrub/Scrub	59.1	47.37	54.95	58.07
Grass	9.17	3.59	0.38	0.45
Crops	0.9	0.23	0.16	0.24
Wetland	0.29	0.08	0.03	0.04

Descriptions of precipitation scenarios.

Scenario	Description
I	10% increase in current P over entire watershed
II	25% increase in current P over entire watershed
III	10% decrease in current P over entire watershed

Descriptions of temperature scenarios.

Scenario	Description
I	1 °C increase in current T over entire watershed
II	2 °C increase in current T over entire watershed
III	5 °C increase in current T over entire watershed

Niraula et al., 2015

Thank you for your attention!
Благодаря за вниманието!

http://www.masaru-emoto.net/english/water-crystal.html