Assessing Land Use Impacts on Water Resources and Non-Point Source Pollution in a Mountainous Watershed: A Case Study of the Wu River Basin

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Introduction

Climate change has made the impact of different land use types on watershed hydrology more evident, and ignoring these effects can cause simulation errors (Shadmehri Toosi et al., 2025).

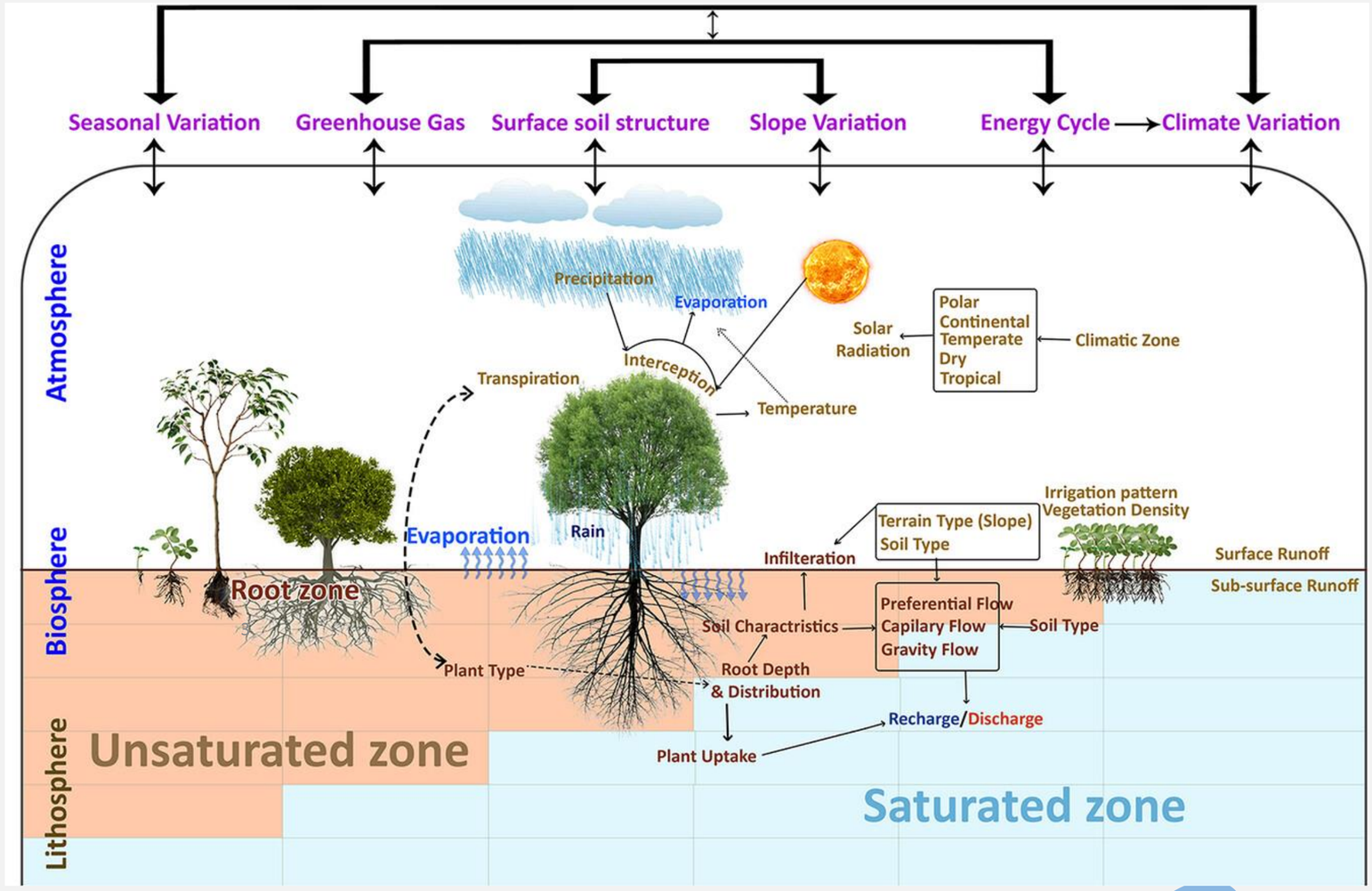
Land use is a key factor influencing non-point source pollution, which directly affects reservoir water quality and drinking water safety for nearby communities (Shen et al., 2010; Zhang & Zhang, 2020).

With intensified human activities increasing pollution risks, analyzing the relationships between land use, hydrology, and non-point source pollution is crucial for water management and policy development.

Land Use and Hydrology

Land use influences watershed water movement by affecting ET, runoff, and infiltration, with factors like soil type, vegetation, farming, and urban development playing key roles. (Shadmehri Toosi et al., 2025).

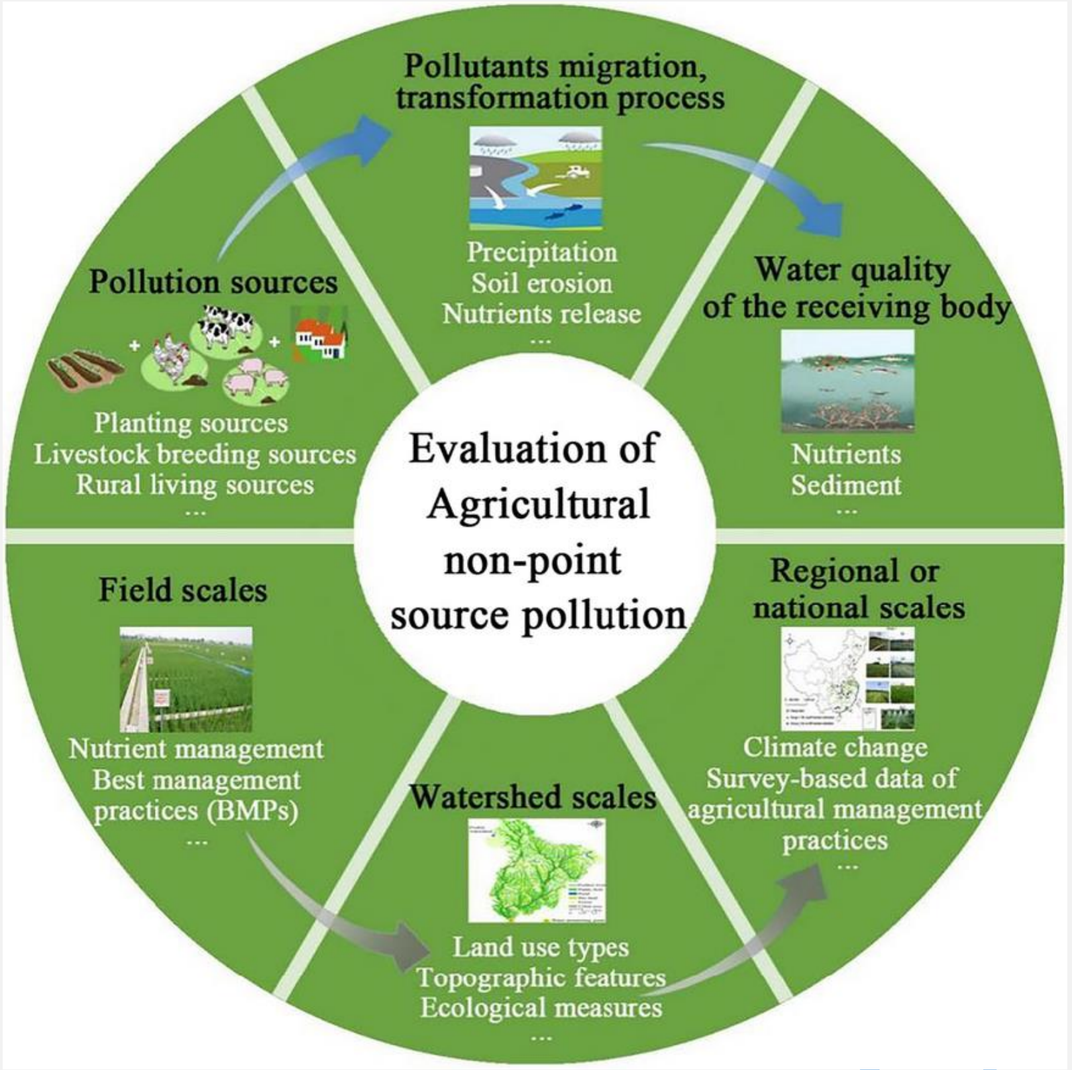
Research Focus:
This study examines how ET, runoff, and infiltration respond to different land use types.



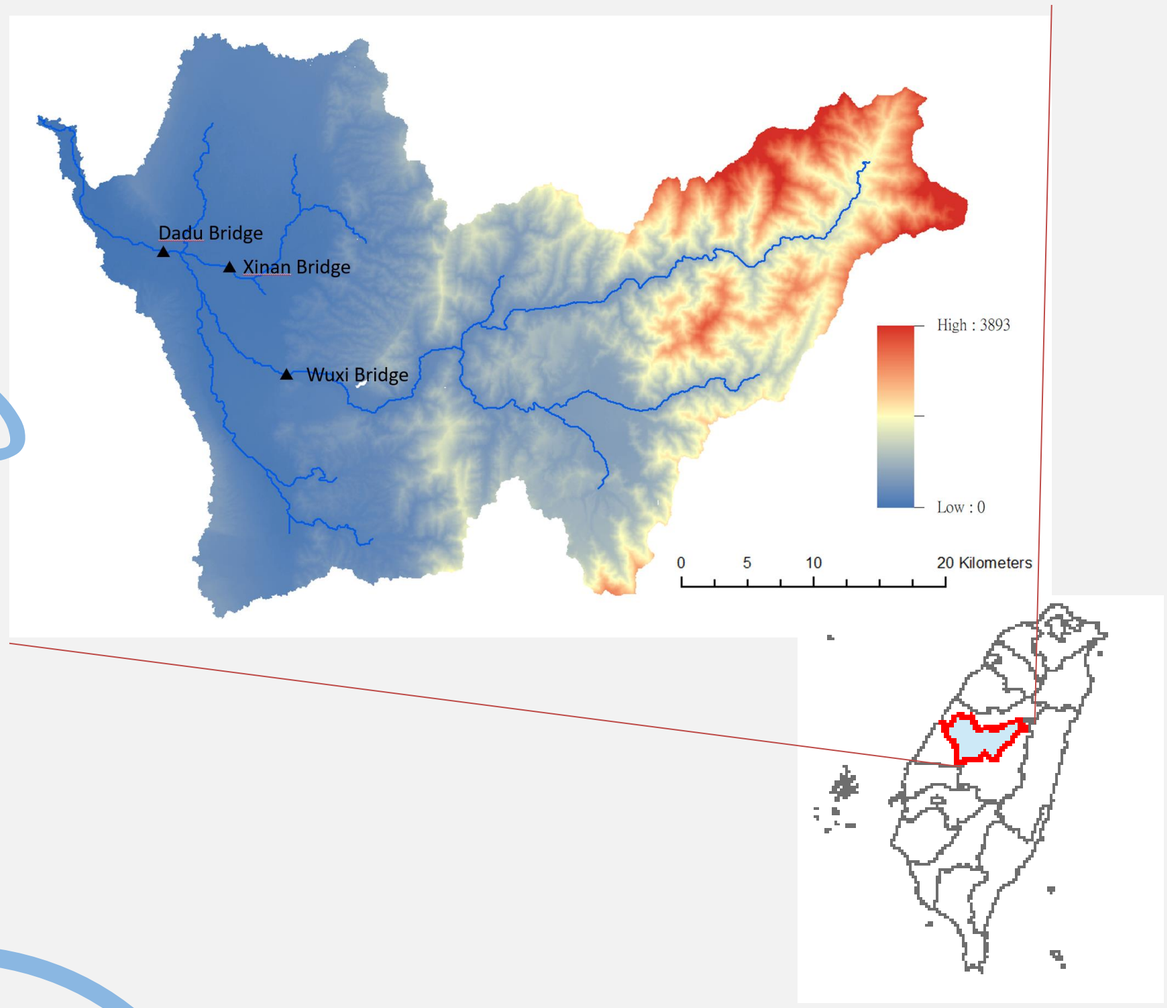
Land Use and Water Quality

Land use strongly influences non-point source pollution, with farming runoff carrying nutrients and sediments into rivers, and sensitivity analysis helping identify key land uses affecting pollution (Shen et al., 2010; Zhang & Zhang, 2020).

Research Focus:
This study uses sediment data to analyze NPS pollution in the Wu River Basin.

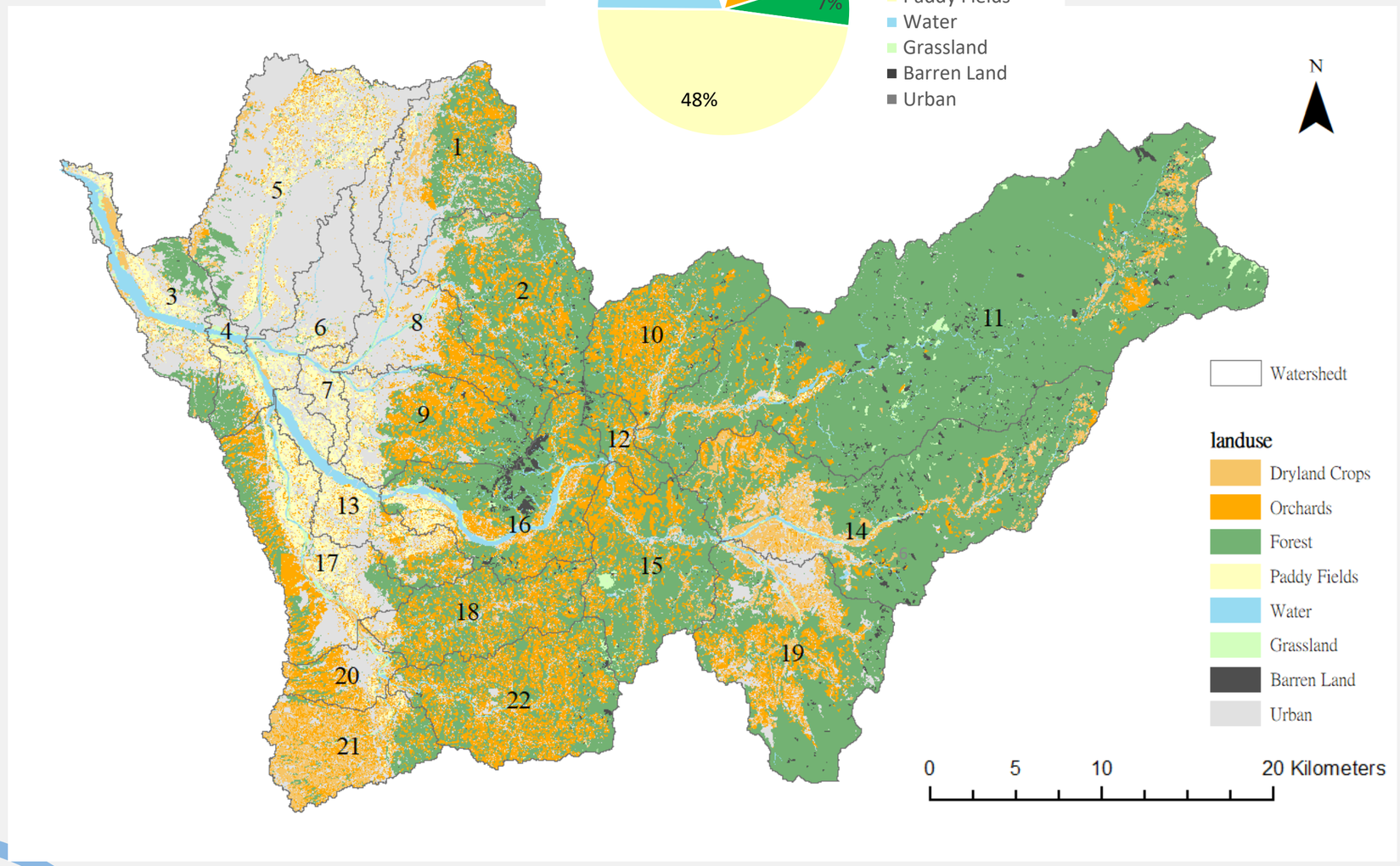


Study Area



- **Wu River Basin**
  1. Covers ~2,033 km² across Nantou County and Taichung City
  2. Mountainous and hilly terrain with large elevation differences
  3. **Annual rainfall**: ~2,087 mm
- The monitoring stations are located at **Wuxi Bridge**, **Xinan Bridge**, and **Dadu Bridge**.

Land Use and Subbasins

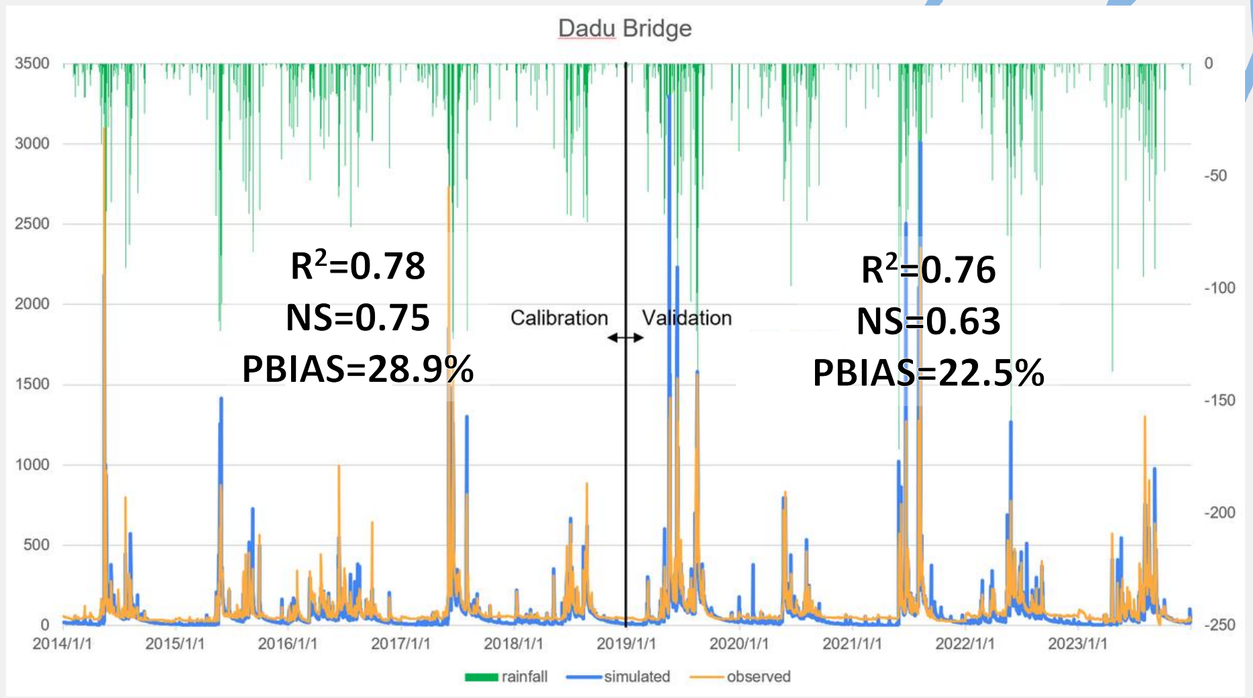


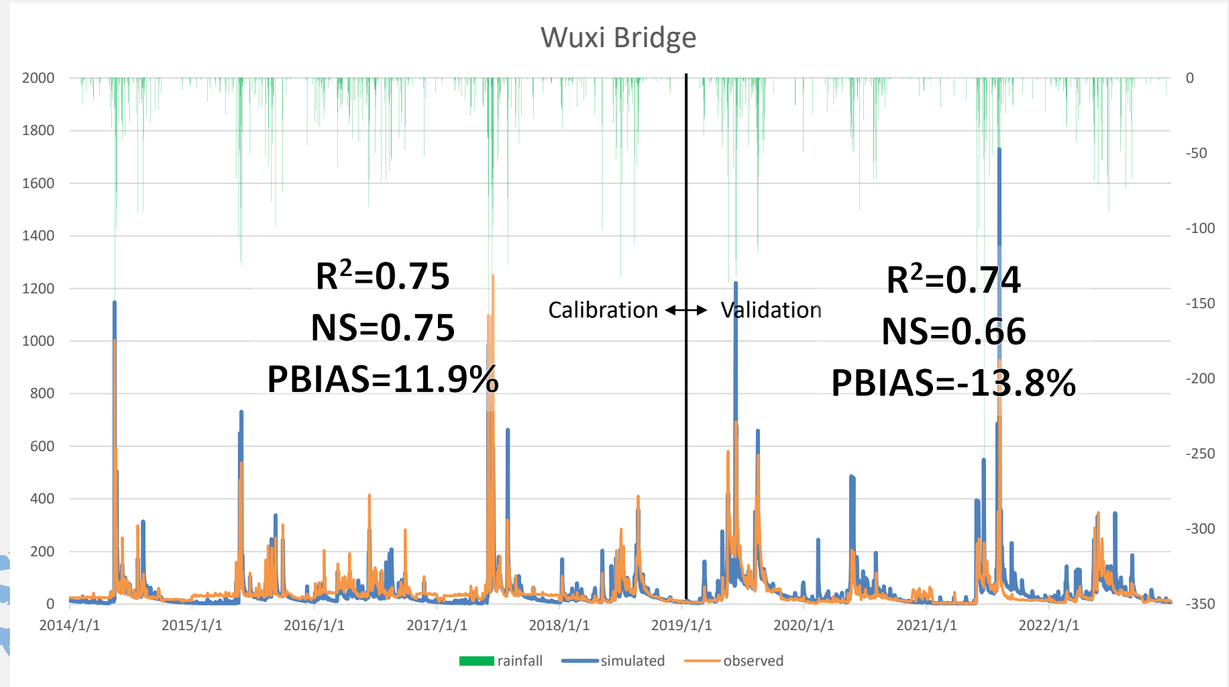
- Land use data were used to classify the watershed, which influence hydrological processes like runoff and erosion.

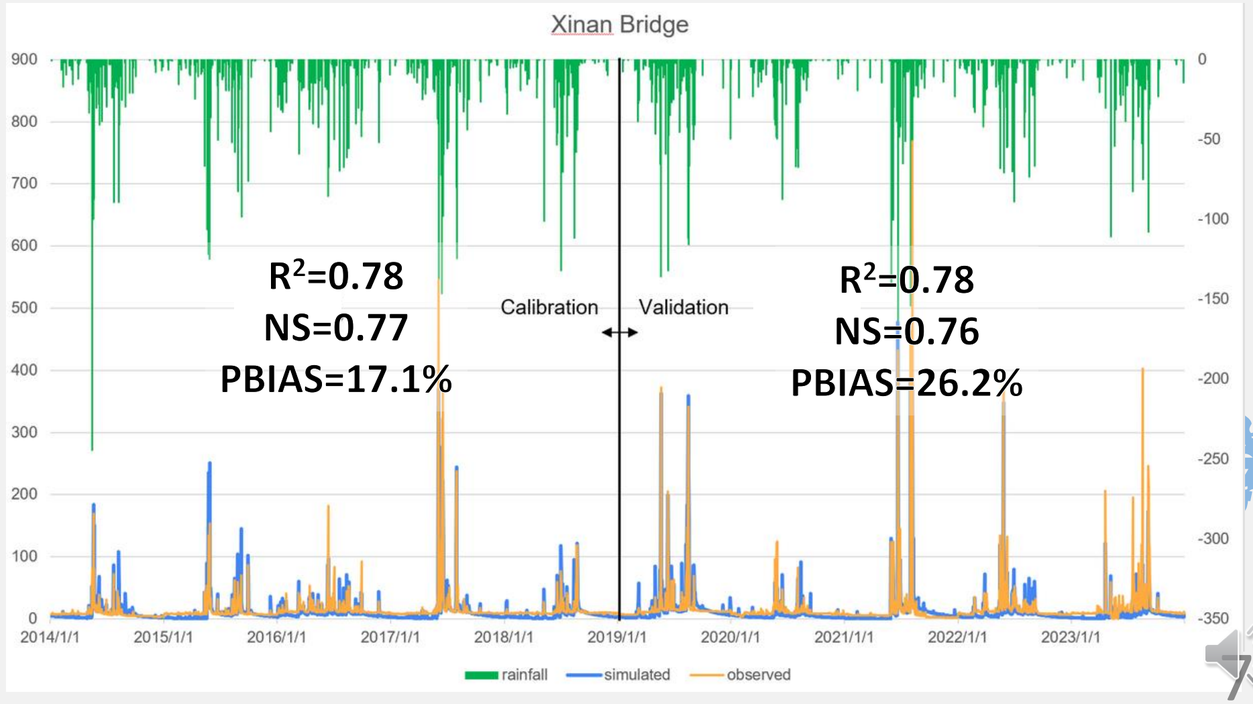
- Diverse land use:
  1. **Upstream**: forests and conservation zones
  2. **Mid- & downstream**: agriculture and urban areas

Streamflow Calibration and Validation

- Calibration Period : 2014/1/1 ~ 2018/12/31
- Validation Period : 2019/1/1 ~ 2023/12/31

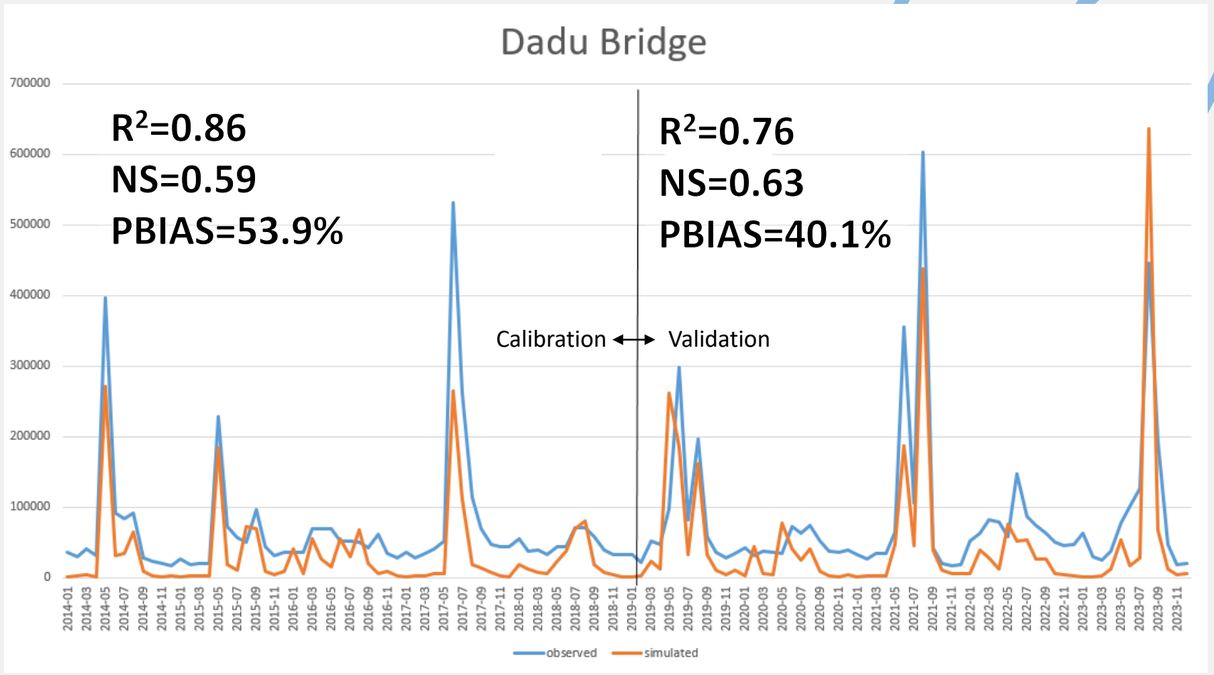


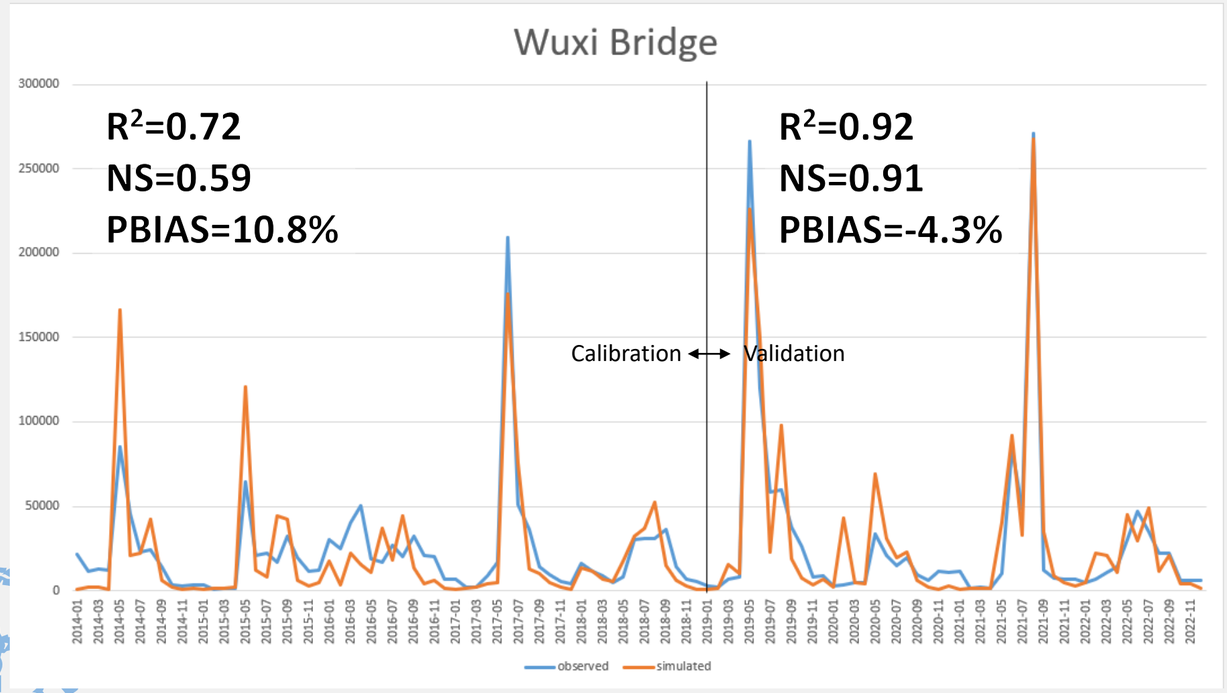


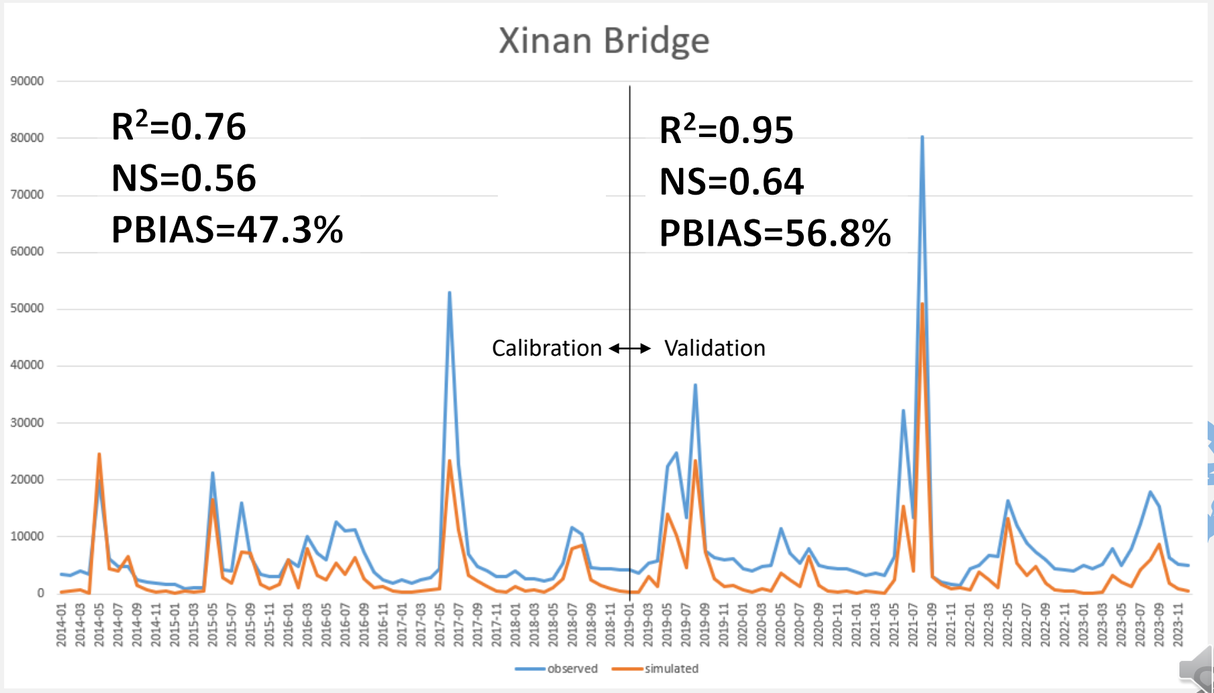


Sediment Calibration and Validation

- Calibration Period : 2014/1/1 ~ 2018/12/31
- Validation Period : 2019/1/1 ~ 2023/12/31







Sensitivity Analysis of **Streamflow** Parameters

Rank	Parameter Name	Method	p-Value	Fitted Value	Min_value	Max_value
1	GW_DELAY.gw	Replace	0.00	26.46 day	25.56 day	28.69 day
2	ALPHA_BF.gw	Replace	0.00	0.70 /day	0.68 /day	0.70 /day
3	RCHRG_DP.gw	Replace	0.00	0.40	0.39	0.40
4	GWQMN.gw	Replace	0.03	488.26 mm	480.39 mm	516.02 mm

- The sensitivity analysis identified **GW_DELAY.gw, ALPHA_BF.gw**, and **RCHRG_DP.gw** as the three most influential parameters in the simulation, all of which are directly related to groundwater processes.

  1. **GW_DELAY**: Delayed groundwater response
  2. **ALPHA_BF**: Important baseflow contribution
  3. **RCHRG_DP**: Deep percolation reduces surface flow

Sensitivity Analysis of **Sediment** Parameters

Rank	Parameter Name	Method	p-Value	Fitted Value	Min_value	Max_value
1	USLE_P.mgt__BARR	Replace	0.000	0.052	0.050	0.089
2	USLE_P.mgt__AGRR	Replace	0.000	0.007	0.000	0.033
3	USLE_P.mgt__FRST	Replace	0.000	0.001	0.000	0.026
4	USLE_P.mgt__URHD	Replace	0.000	0.111	0.095	0.143
5	LAT_SED.hru	Replace	0.003	237.071 day	234.746 day	238.516 day

- **USLE_P parameters** for different land uses significantly influence sediment simulation.

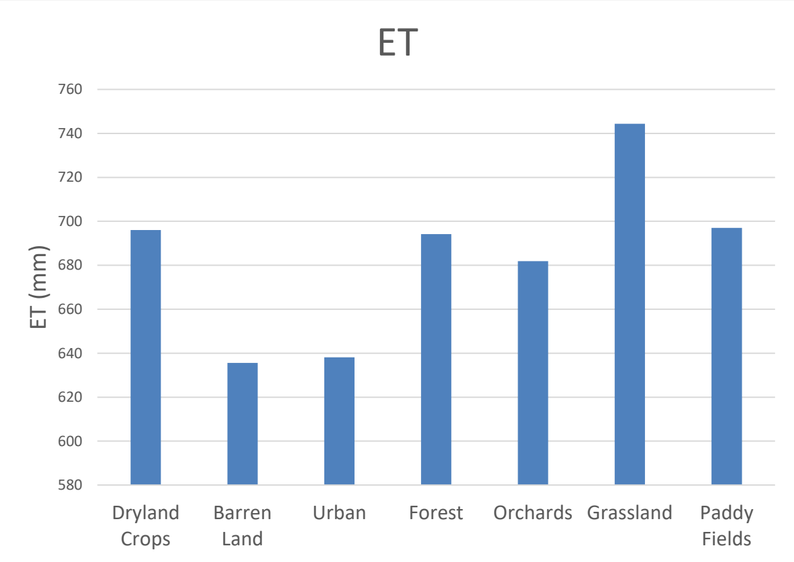
1. **Bare land (BARR)**
   - Small changes in erosion control greatly impact sediment yield
   - Reflects lack of vegetation and high erosion potential

2. **Agricultural land (AGRR)**
   - Management practices (e.g., tillage, crop cover) are critical

3. **Forest land (FRST)**
   - Steep slopes or disturbances may still cause erosion

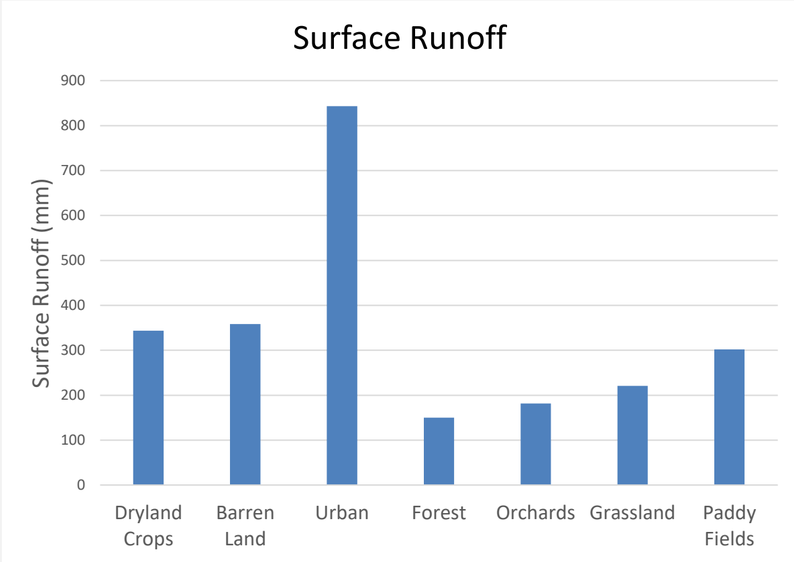
4. **Urban land (URHD)**
   - Impervious surfaces and runoff can increase sediment transport

Water Balance Analysis

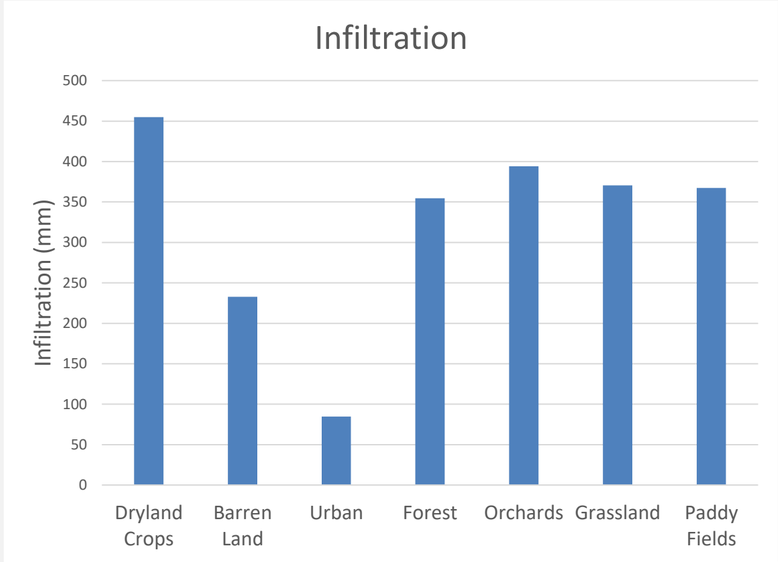


- Vegetated areas had higher **evapotranspiration**, with **grasslands** being the highest.

  → Related to higher **Leaf Area Index (LAI)**

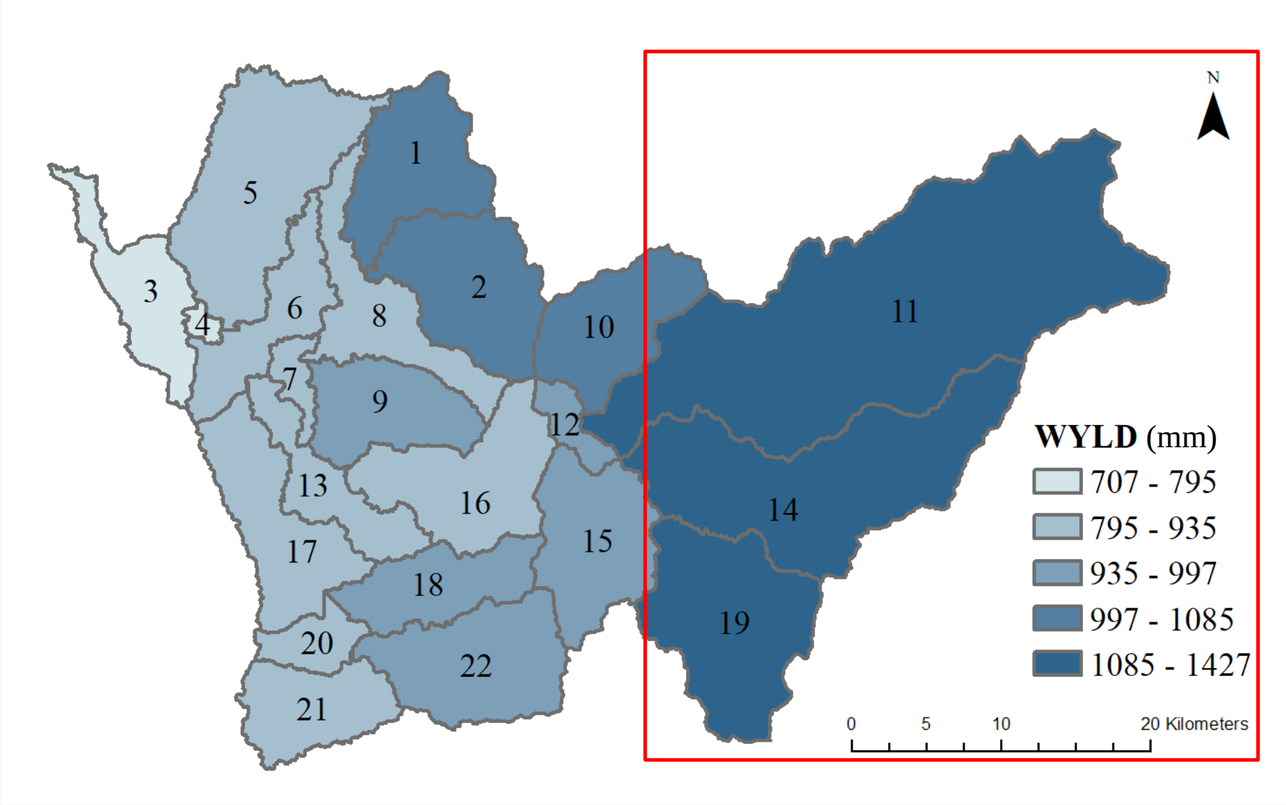


- **Urban areas** produced the most **runoff.**

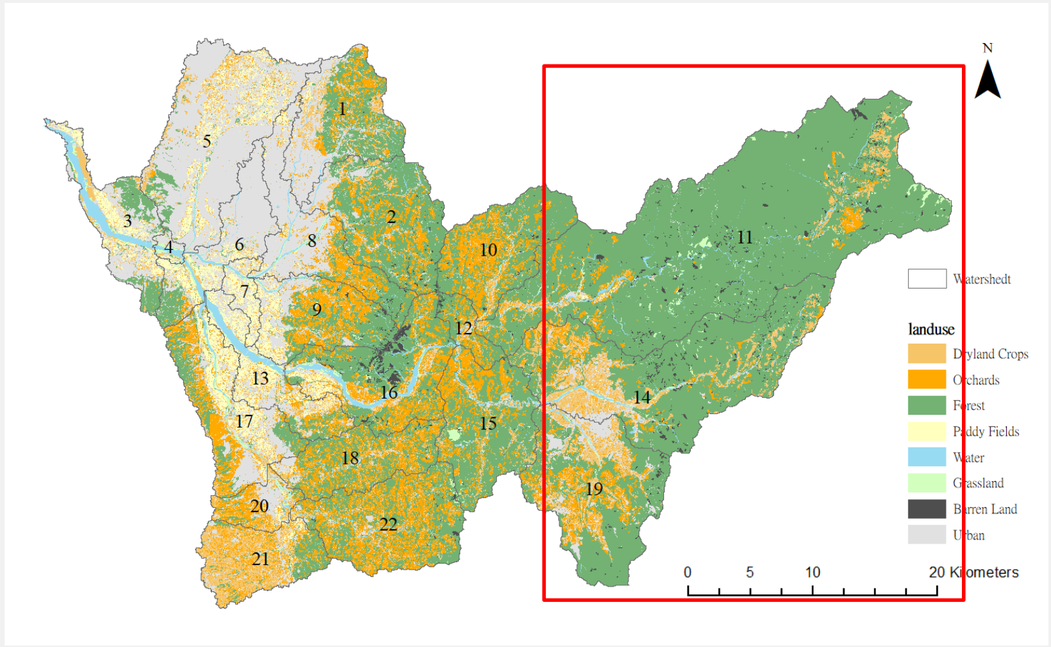


- **Dryland farming** showed higher **infiltration**
- **Urban areas** had the lowest, due to impervious surfaces.

Average Annual Total Water Yield (1/4)

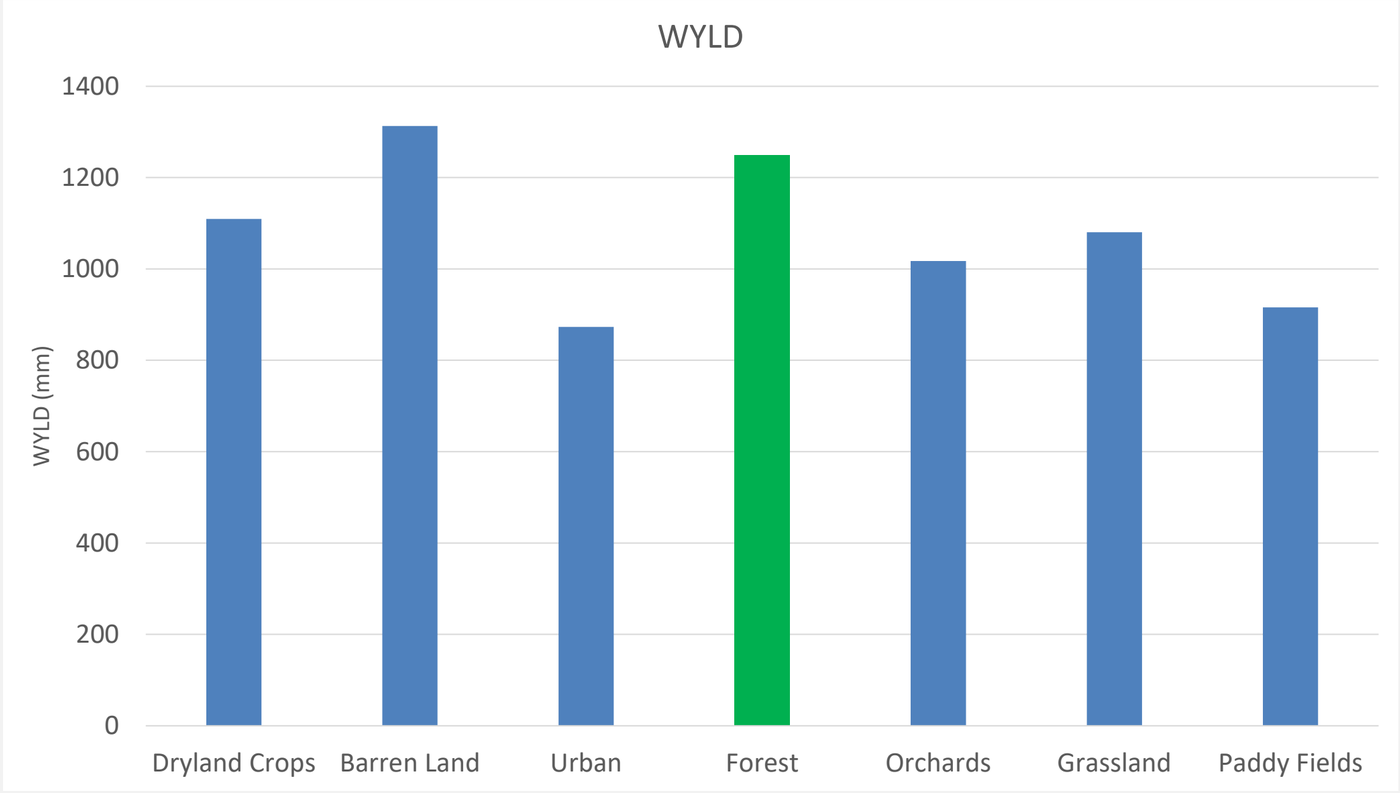


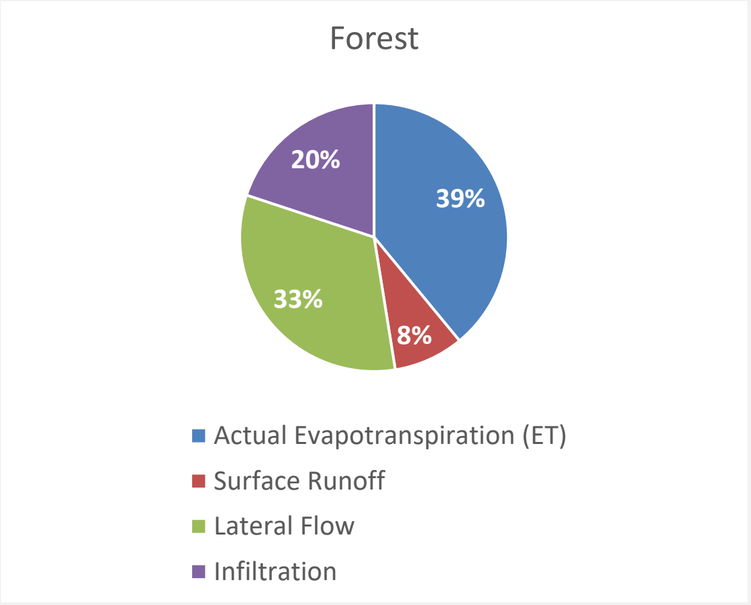
- In the **upstream** region of the watershed—specifically subbasins 11, 14, and 19—**water yield is relatively high**. These areas also have a high percentage of **forest cover**.



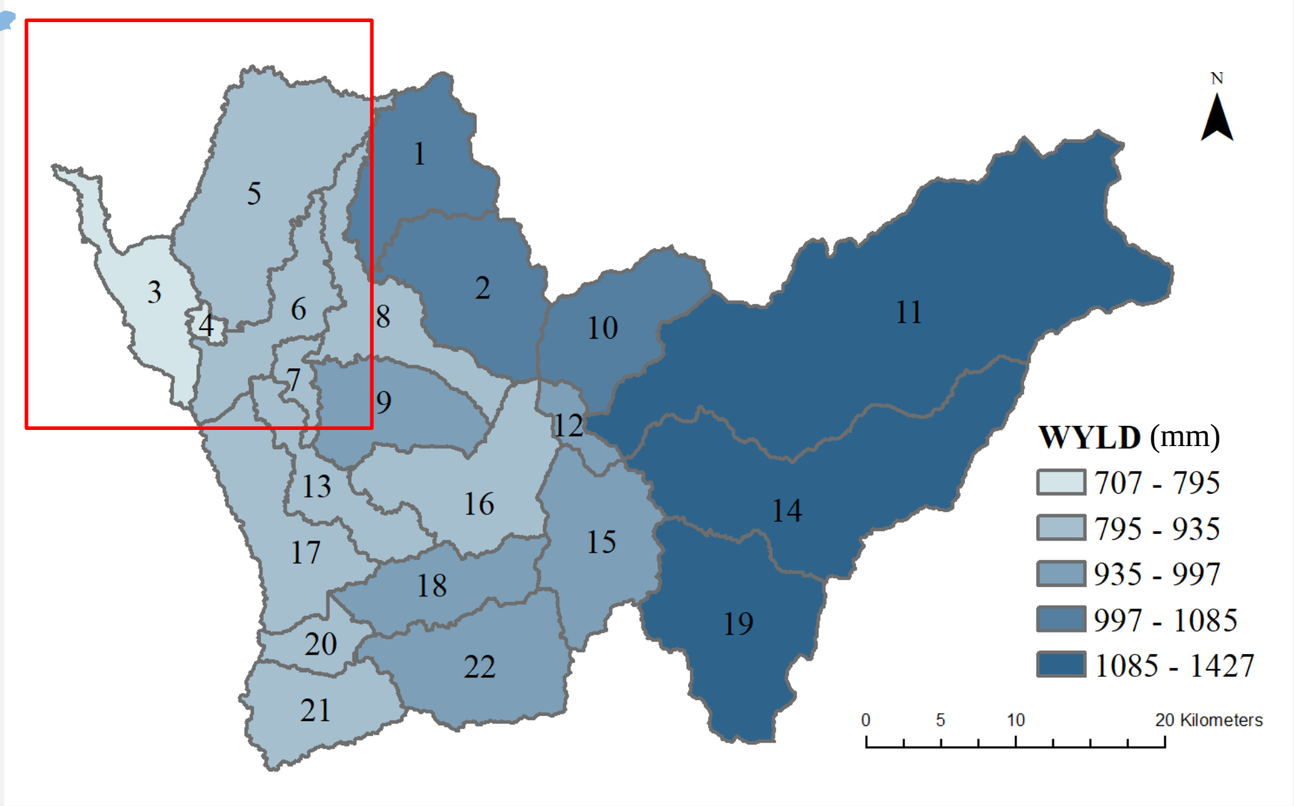
Average Annual Total Water Yield (2/4)

- **Forested areas** tend to produce greater water yield, largely due to higher **lateral flow** contributions.

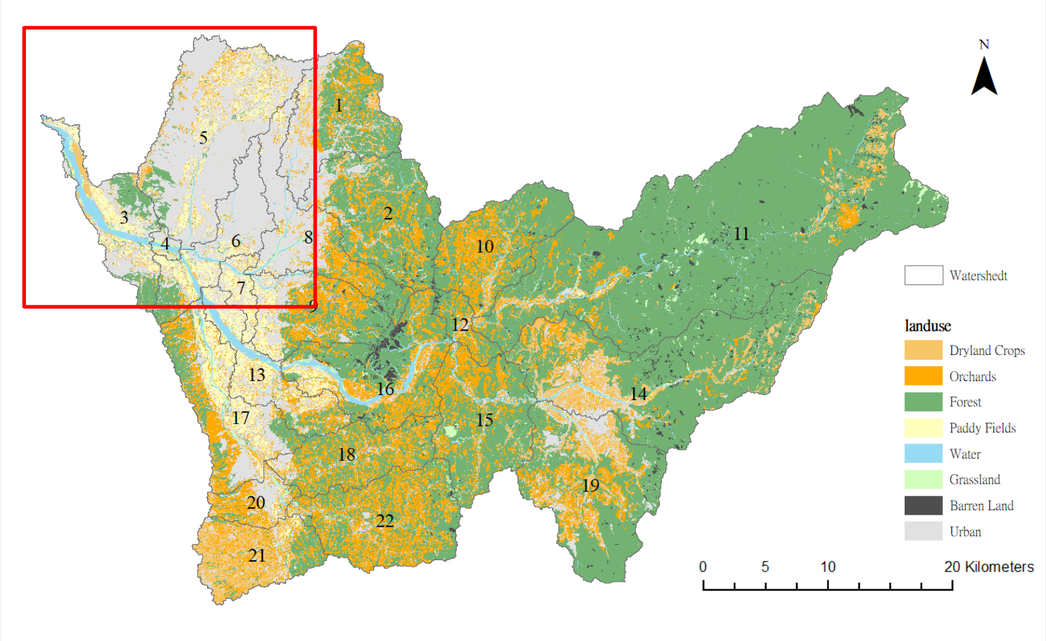




Average Annual Total Water Yield (3/4)

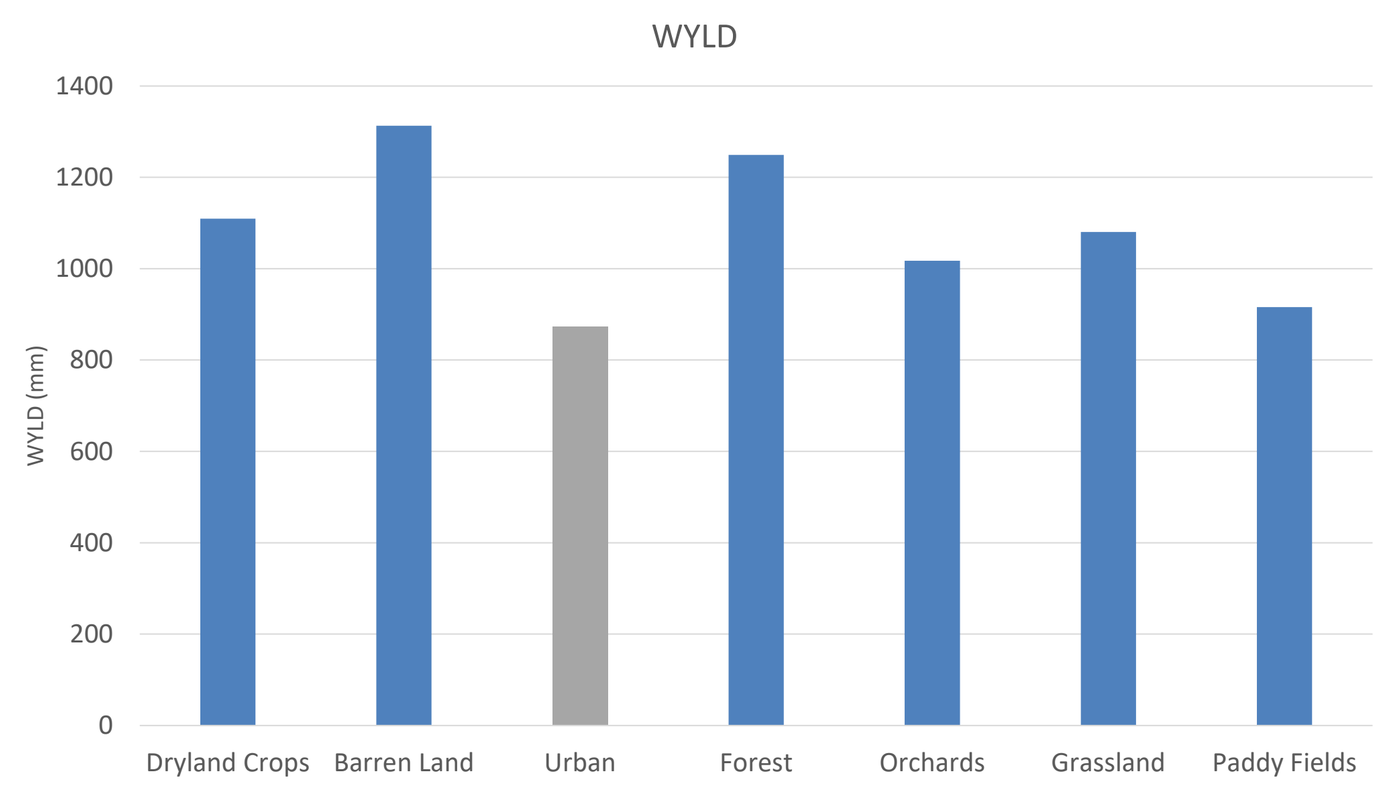


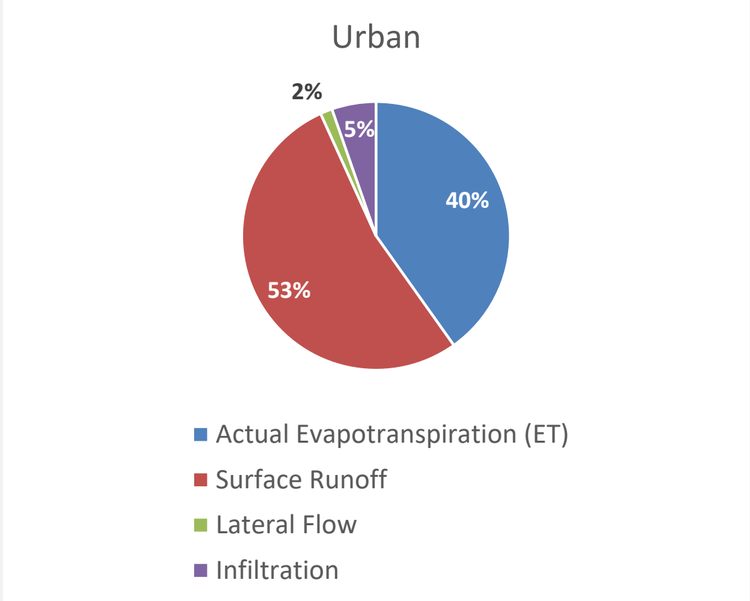
- In contrast, the **downstream** portions of the watershed exhibit **lower water yield** and are dominated by **urban** land use.



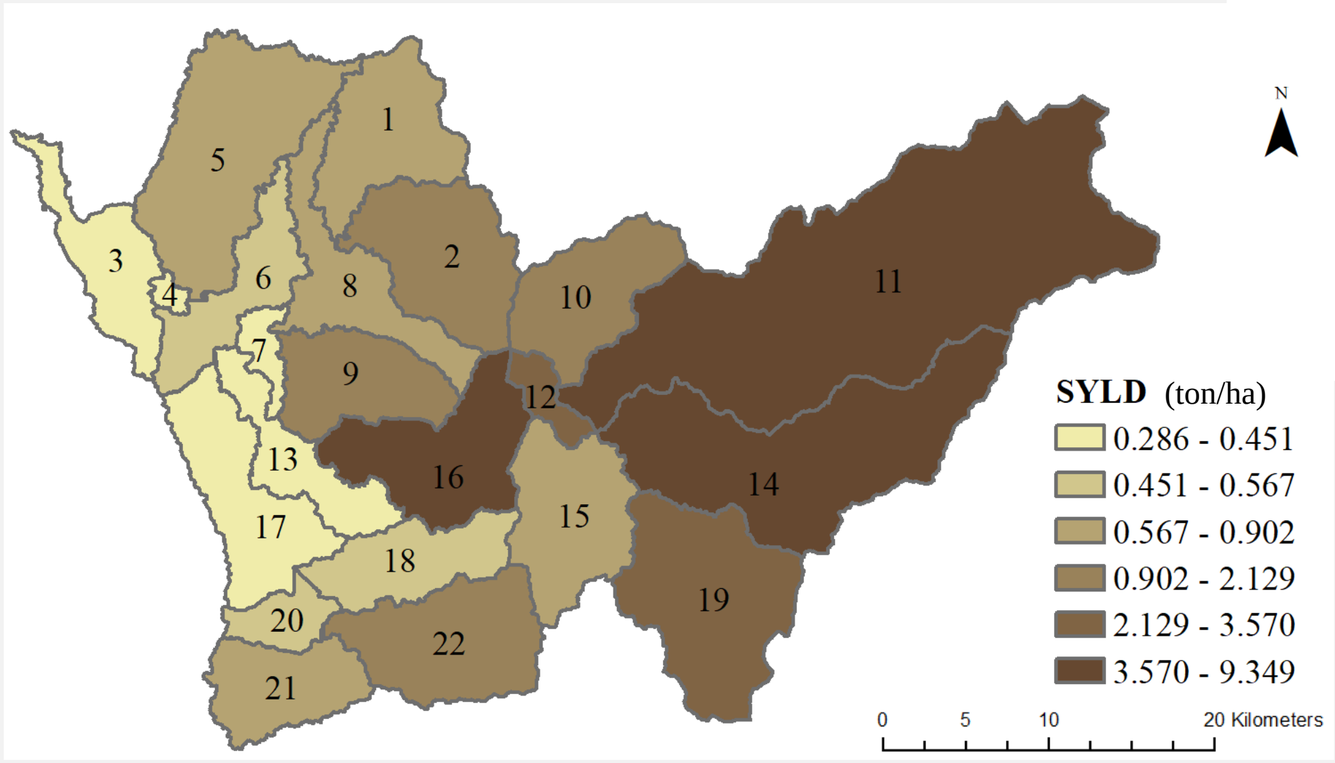
Average Annual Total Water Yield (4/4)

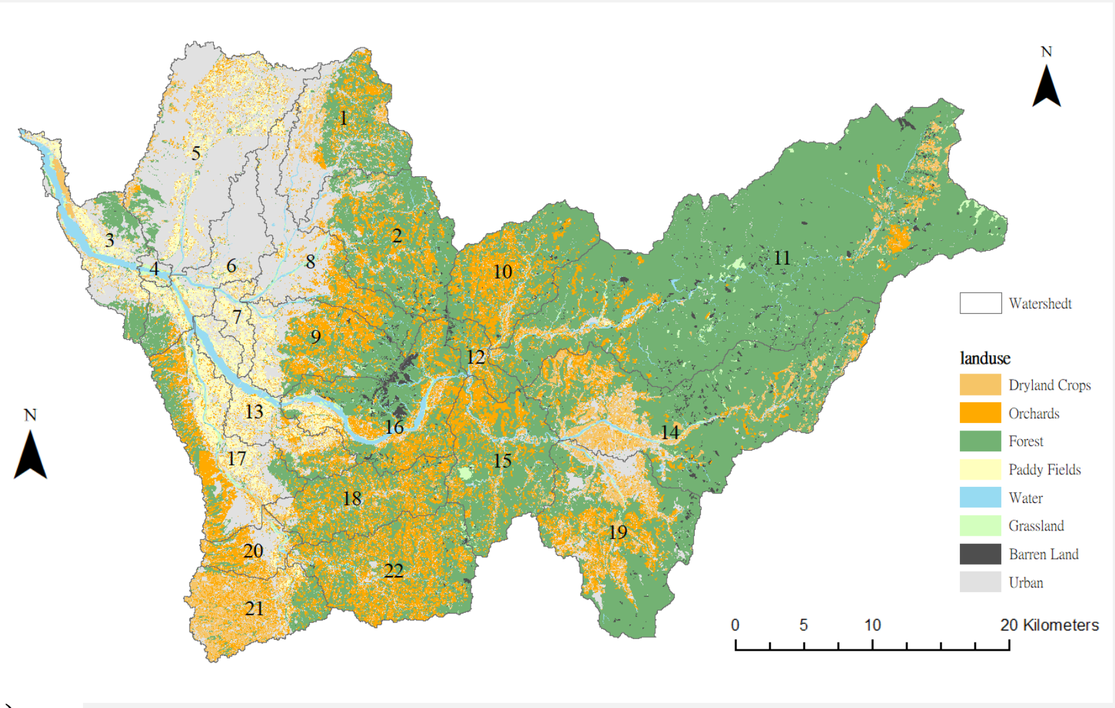
- **Urban** areas have the lowest water yield among all land use types, with a high proportion of **surface runoff**.





Average Annual Total Sediment Yield





- The highest sediment yields were found in sub-watersheds 11, 14, and 16.
- These areas contain landslide sites and hillside agricultural development, both of which significantly contribute to increased sediment output.

Conclusion

- The sensitivity analysis showed that groundwater-related parameters (GW_DELAY.gw, ALPHA_BF.gw, and RCHRG_DP.gw) are most influential for streamflow, indicating the watershed is groundwater-dominated with delayed runoff and strong baseflow.

- USLE_P parameters are critical for sediment simulation and should be calibrated based on land use, especially for bare and agricultural areas.

- High water yield occurs mainly in upstream forested areas due to lateral flow, while urban downstream areas have the lowest yield.

- Sediment hotspots in sub-watersheds 11, 14, and 16 are linked to landslides and hillside farming, highlighting surface disturbances and unstable terrain as main causes.

Thanks everyone for your time and attention !

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