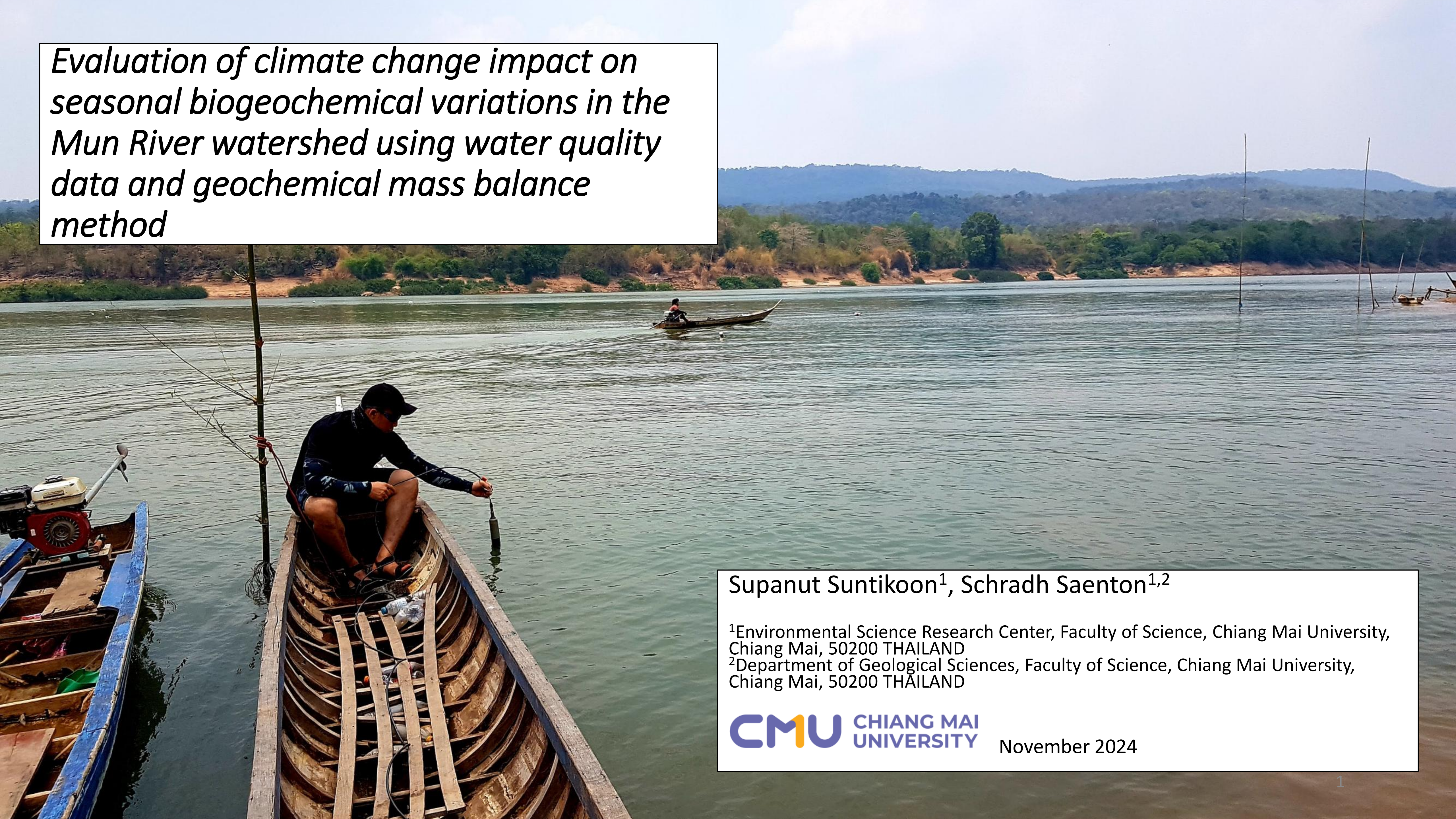

Evaluation of climate change impact on seasonal biogeochemical variations in the Mun River watershed using water quality data and geochemical mass balance method

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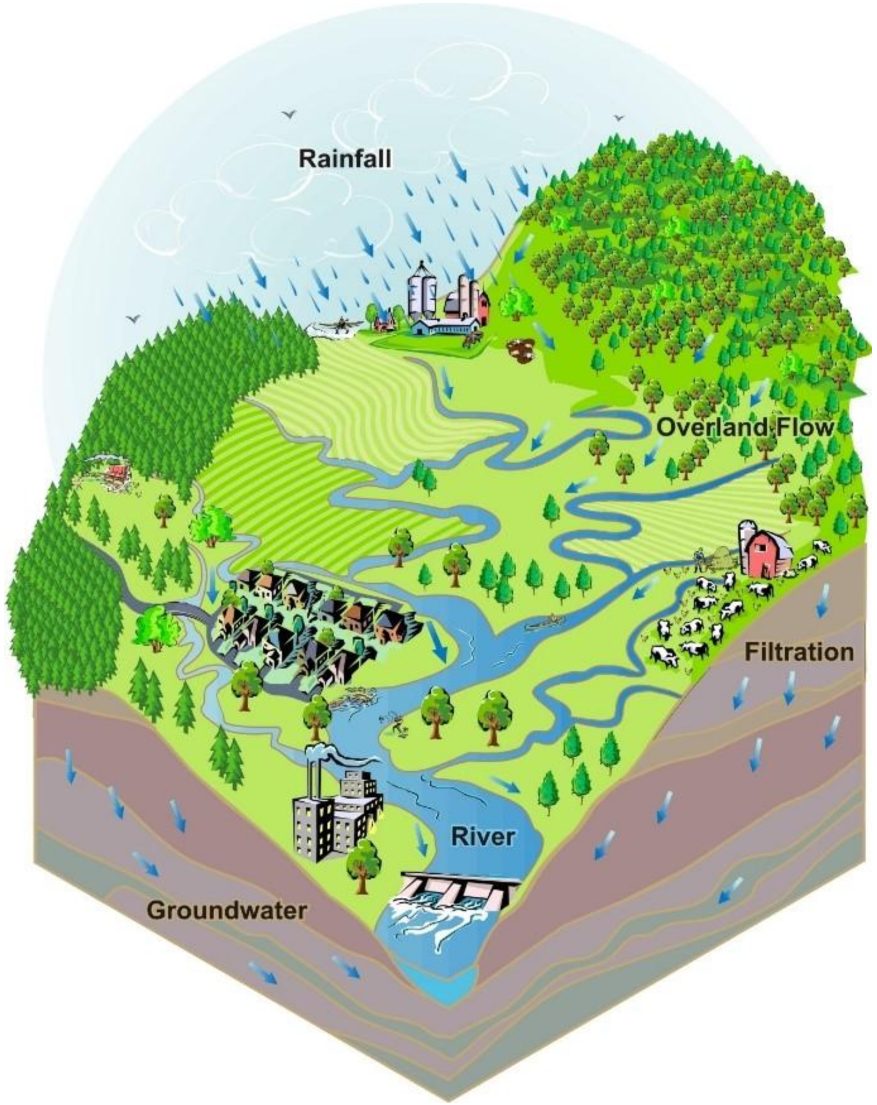
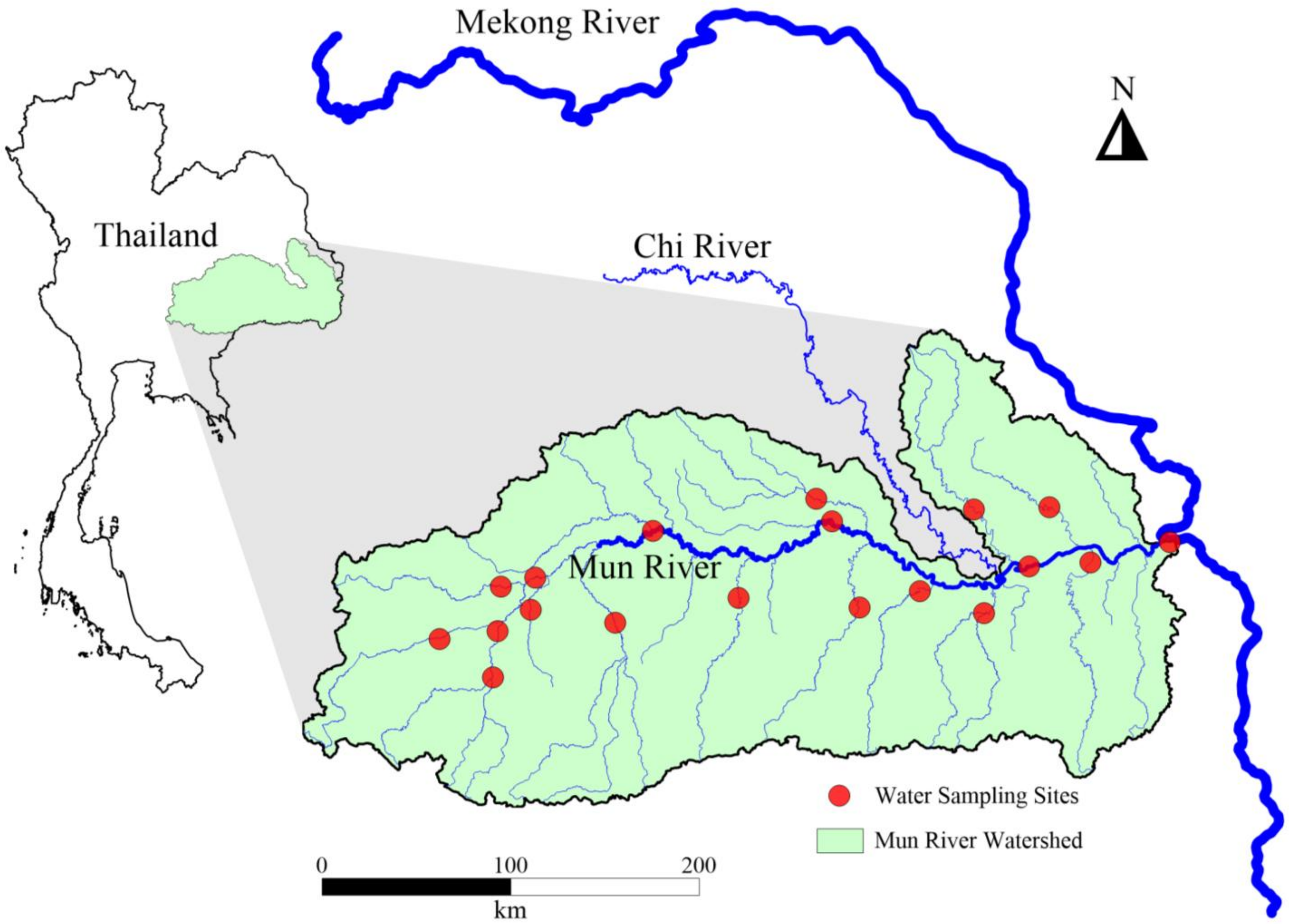
Research Question



- How do biogeochemical cycles in the Mun River watershed vary between the dry and wet seasons?
- How do human activities, such as agriculture and deforestation, interact with natural geological processes to affect water quality?
- How might future changes in temperature and precipitation patterns intensify existing water quality challenges in the watershed?
- What role do mineral weathering and biomass degradation play in the carbon cycle within the Mun River watershed?

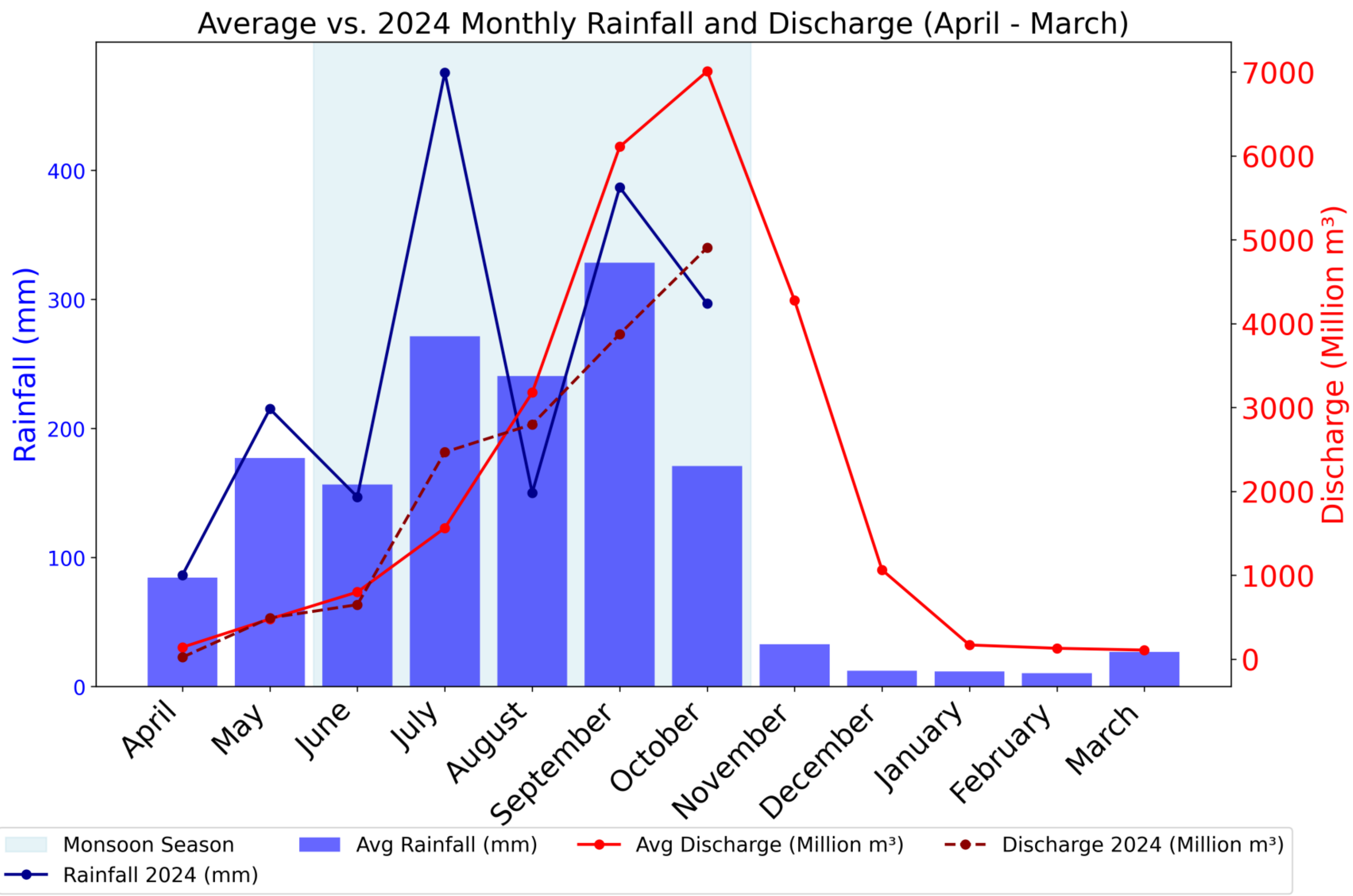
Mun River Watershed



- **Total Area:** ~71,000 km² (significant portion of Northeastern Thailand).
- **River Length:** ~900 km from its source to the confluence with the Mekong River.
- **Annual Rainfall:** ~1,200–1,300 mm/year, concentrated in June–October.
- **Annual Discharge:** ~26 billion m³ flows into the Mekong at Ubon Ratchathani.
- **Agricultural Role:** Crucial for irrigating extensive rice paddies.
- **Seasonal Variability:** Peak flow in rainy season; significant drop in dry season.

MRW Climate

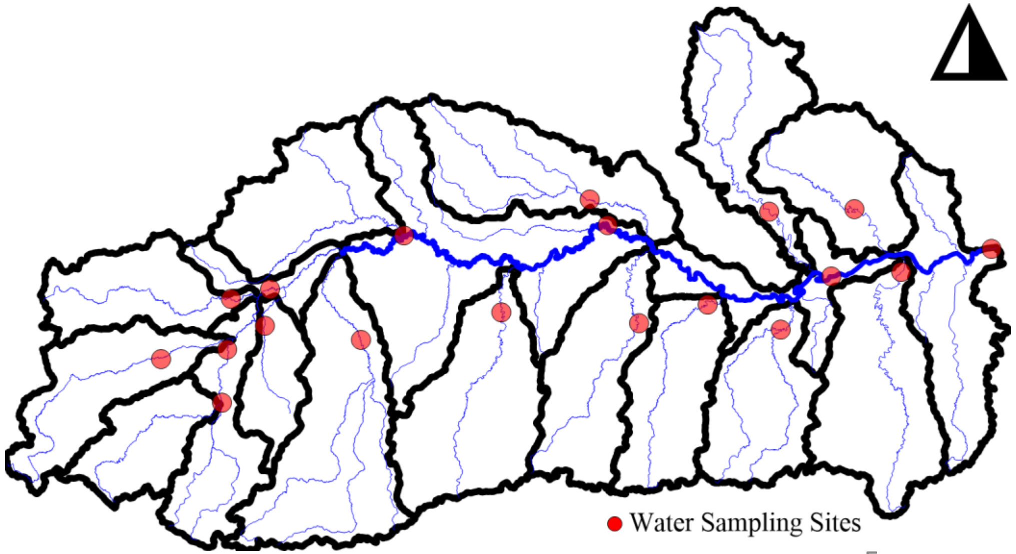
- Distinct wet and dry seasons.
- Monsoonal rains dominate June–October (rainy season).
- Majority of annual precipitation (~80%) occurs in the rainy season.



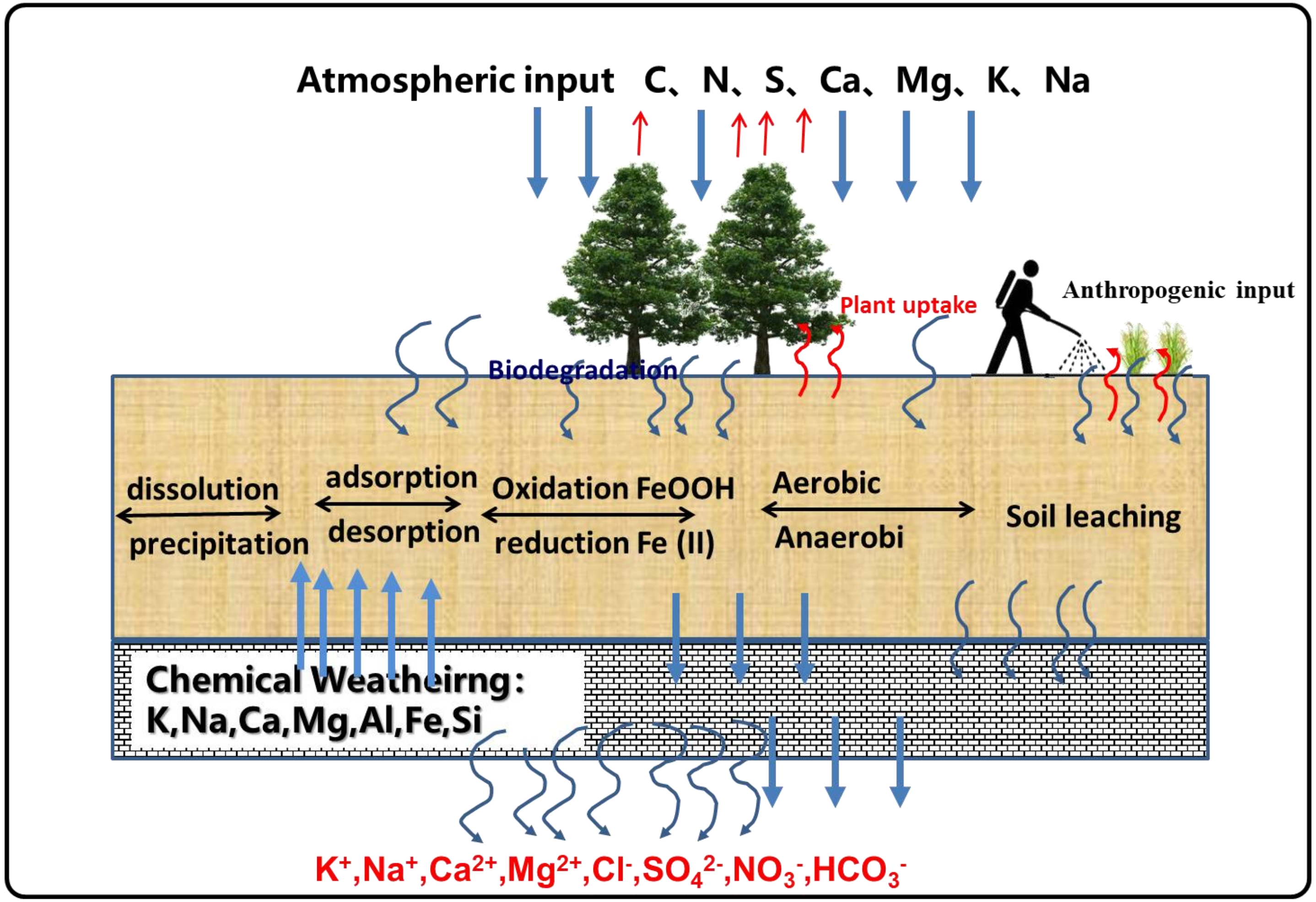
Data source: Hydro-4.com

Field Methods

- **Seasonal Sampling:** Conducted during both dry and wet seasons to assess seasonal variability in water chemistry.
- **Strategic Site Selection:** Samples collected from upstream, midstream, and downstream locations to capture spatial variability in the Mun River basin.
- **Parameters Measured:** Analyzed for major ions (e.g., Na^+, K^+, Ca^{2+}, Mg^{2+}, Cl^-, HCO_3^-, SO_4^{2-}, NO_3^-) and nutrients (e.g., silica).
- **Instrumentation:** Used YSI multiparameter probe for in-situ measurements, including pH, temperature, dissolved oxygen, and conductivity.
- **Flux Calculations:** Integrated water discharge data to determine the fluxes of dissolved species.
- **Lab-Based Analyses:** Conducted precise quantification of ions and nutrients to understand their seasonal and spatial distribution.



Geochemical Mass Balance Method



- **Key Concepts**
  - Quantifies mineral weathering and biomass degradation rates.
  - Tracks major dissolved ions (e.g., K^+, Na^+, Ca^{2+}, Mg^{2+}, Cl^-, SO_4^{2-}, NO_3^-, HCO_3^-).
- **Processes Shown in Diagram**
  - Chemical Weathering: Minerals dissolve, releasing ions.
  - Biodegradation: Organic matter breaks down, cycling nutrients.
  - Soil Leaching: Water transports dissolved ions to streams.
- **Applications**
  - Combines field data and discharge to calculate fluxes.
  - Uses matrix (Ax = b) to solve for weathering and biomass rates.

GMB Model

$$
\begin{array}{rc}
 & \begin{array}{ccccccc} \text{Quartz} & \text{Halite} & \text{Feldspar} & \text{Garnet} & \text{Biotite} & \text{Vermiculite} & \text{Biomass} \end{array} \\
\begin{array}{r} \text{Na}: \\ \text{Mg}: \\ \text{Ca}: \\ \text{K}: \\ \text{SiO}_2: \end{array} &
\underbrace{\begin{bmatrix} 0 & 1 & 0.68 & 0 & 0.02 & 0.06 & x \\ 0 & 0 & 0 & 0.5 & 1.2 & 1.1 & y \\ 0 & 0 & 0.32 & 0.2 & 0 & 0.016 & z \\ 0 & 0 & 0 & 0 & 0.85 & 0.25 & w \\ 1 & 0 & 2.68 & 3 & 2.8 & 2.8 & 0 \end{bmatrix}_{5\times7}}_{\text{Matrix A} = \mathbf{A}}
\end{array}
\underbrace{\begin{bmatrix} \alpha_1 \\ \alpha_2 \\ \alpha_3 \\ \alpha_4 \\ \alpha_5 \\ \alpha_6 \\ \alpha_7 \end{bmatrix}_{7\times1}}_{\text{Vector Alpha} = \vec{\mathbf{x}}}
=
\underbrace{\begin{bmatrix} \Delta m_{\text{Na}} \\ \Delta m_{\text{Mg}} \\ \Delta m_{\text{Ca}} \\ \Delta m_{\text{K}} \\ \Delta m_{\text{SiO}_2} \end{bmatrix}_{5\times1}}_{\text{Vector Flux} = \vec{\mathbf{b}}}
$$

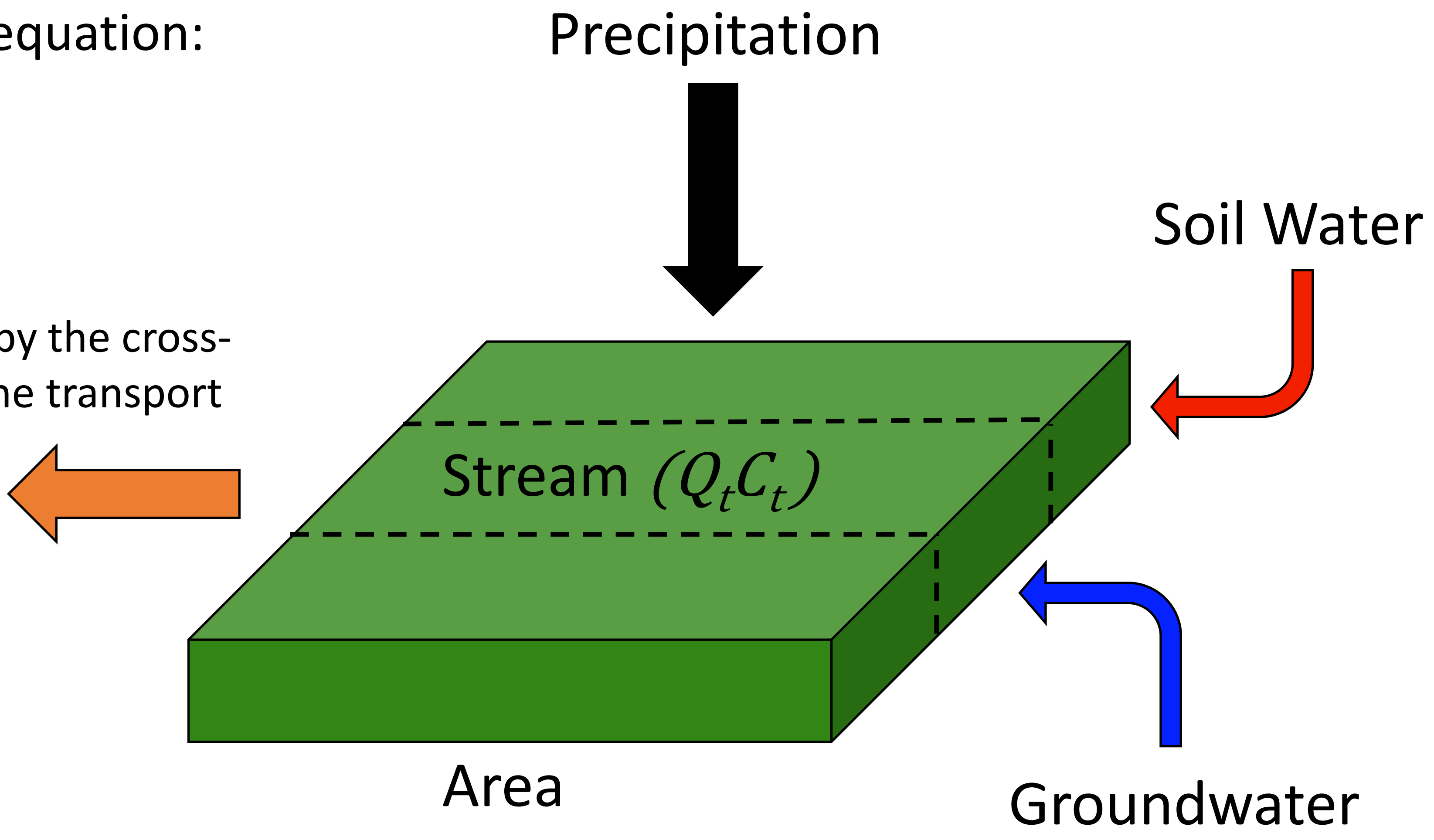
- **Goal:** Calculate mineral weathering rates (α1–α6) and biomass degradation (α7).
- **Minerals:** Quartz, Halite, Feldspar, Garnet, Biotite, Vermiculite.
- **Input Data:**
  - **Matrix A:** Stoichiometric coefficients from XRD analysis.
  - **Vector b:** Measured fluxes of Na^+, Mg^{2+}, Ca^{2+}, K^+, and SiO_2.
- **Implementation:**
  - Used PEST optimization to solve for all unknowns.
- **Output:**
  - Mineral weathering rates and biomass degradation quantified per subwatershed.

Dissolved Fluxes

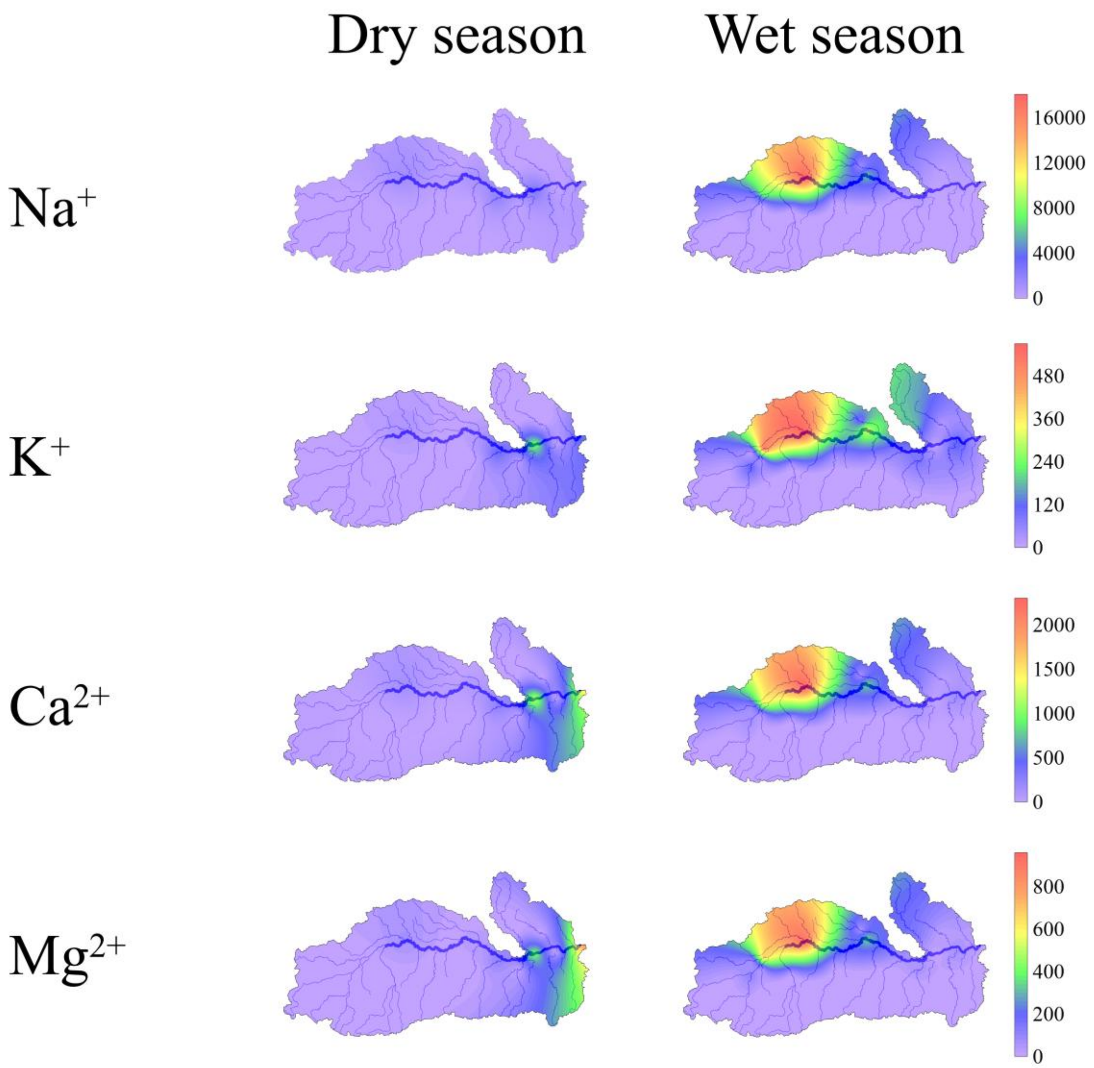
The flux of dissolved species (Δm_c) was calculated using the equation:

$$\Delta m_c = \frac{[c] \times Q}{A}$$

Fluxes (Δm_c) were normalized by the cross-sectional area to standardize the transport rates.

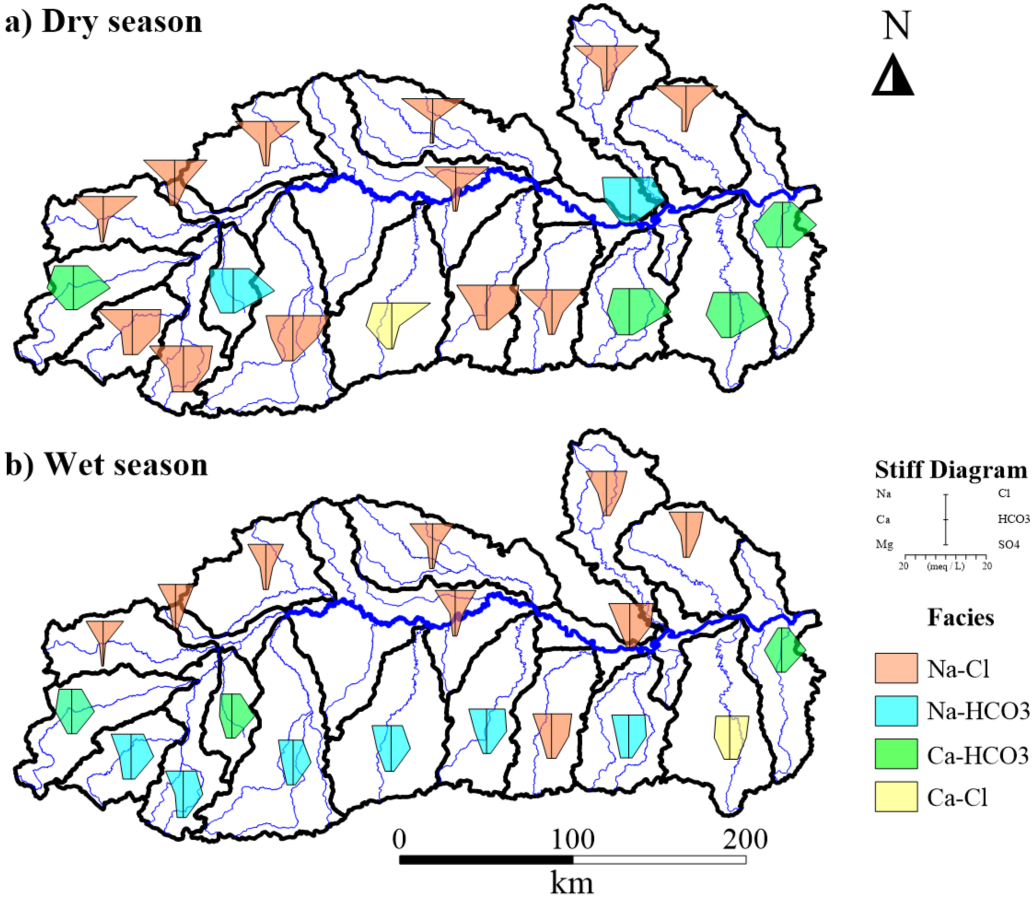


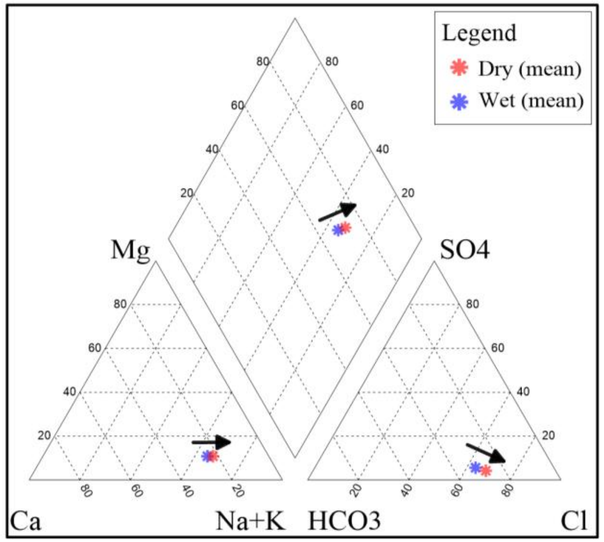
Results



- **Seasonal Variation:** Fluxes are much higher in the wet season, driven by increased discharge, showing the role of hydrology.
- **Spatial Patterns:** Hotspots in northern subwatersheds suggest geological influence (e.g., evaporite dissolution) and anthropogenic inputs.
- **Implications:** Enhanced weathering rates and solute transport during the wet season impact downstream water quality.

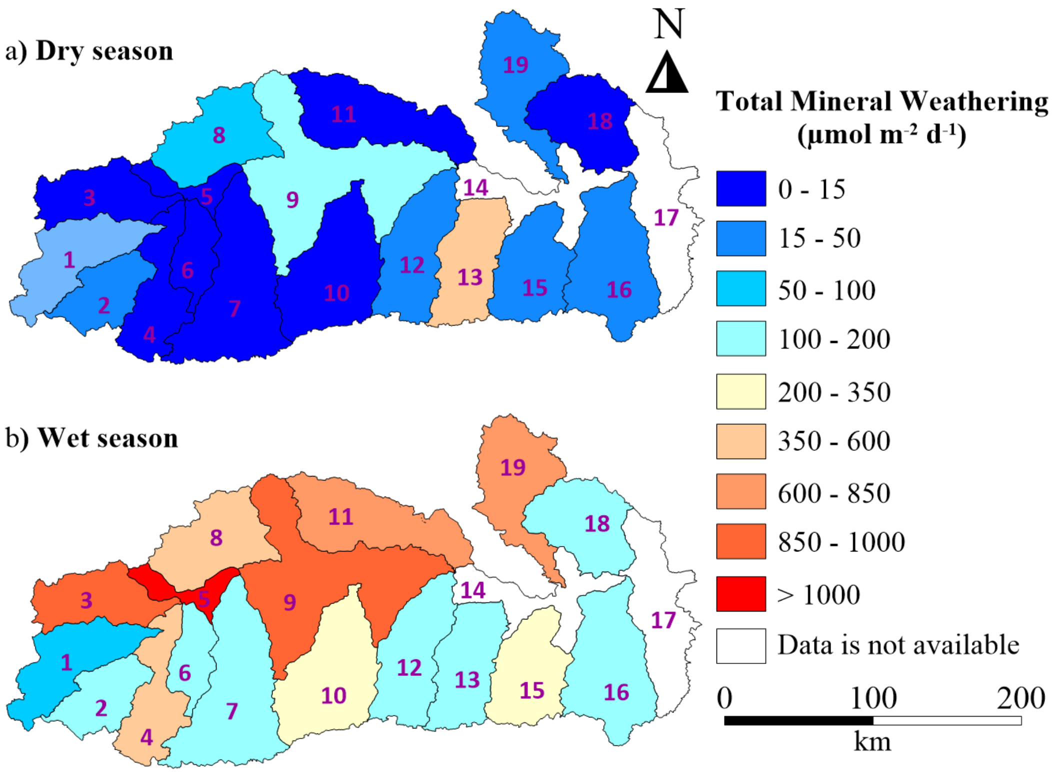
Hydrogeochemical Shifts

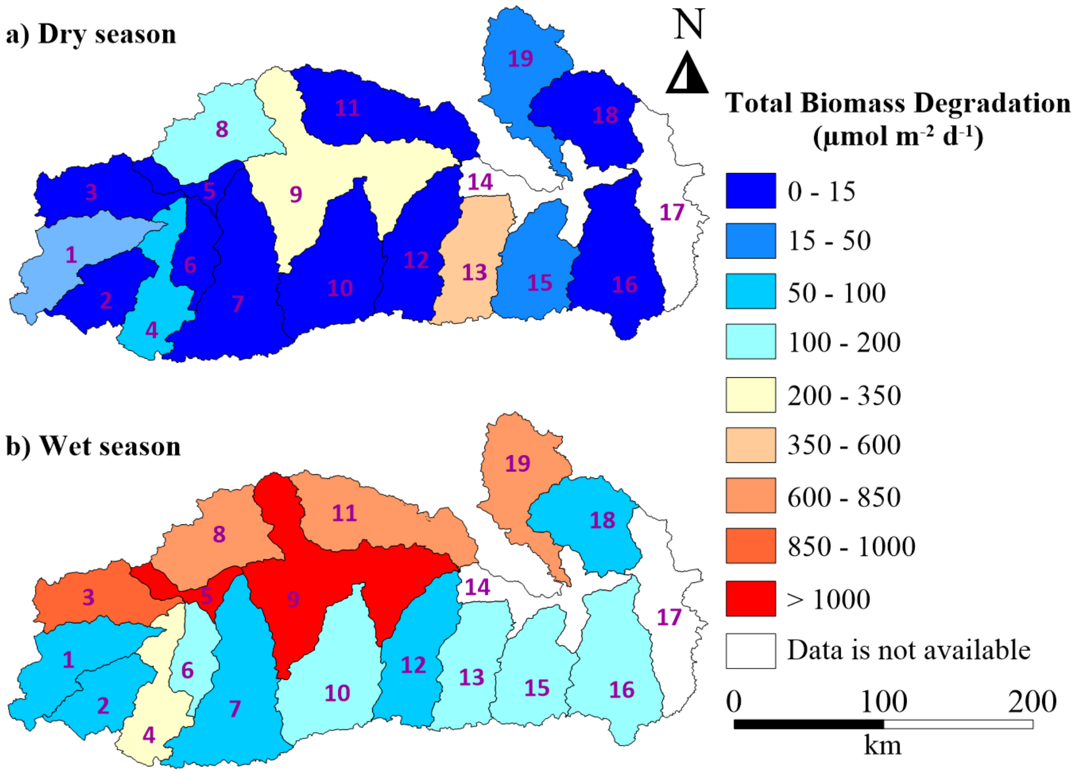




- **Piper Diagram:** Shift from pristine to contaminated water in the dry season due to higher ion concentrations.
- **Stiff Maps:**
  - **Dry season:** Na^+-Cl^- facies dominate (evaporation, human impact).
  - **Wet season:** Ca^{2+}-HCO_3^- facies dominate (dilution, weathering).
- Seasonal changes show hydrology and human activity influence.

Weathering & Biomass degradation rates

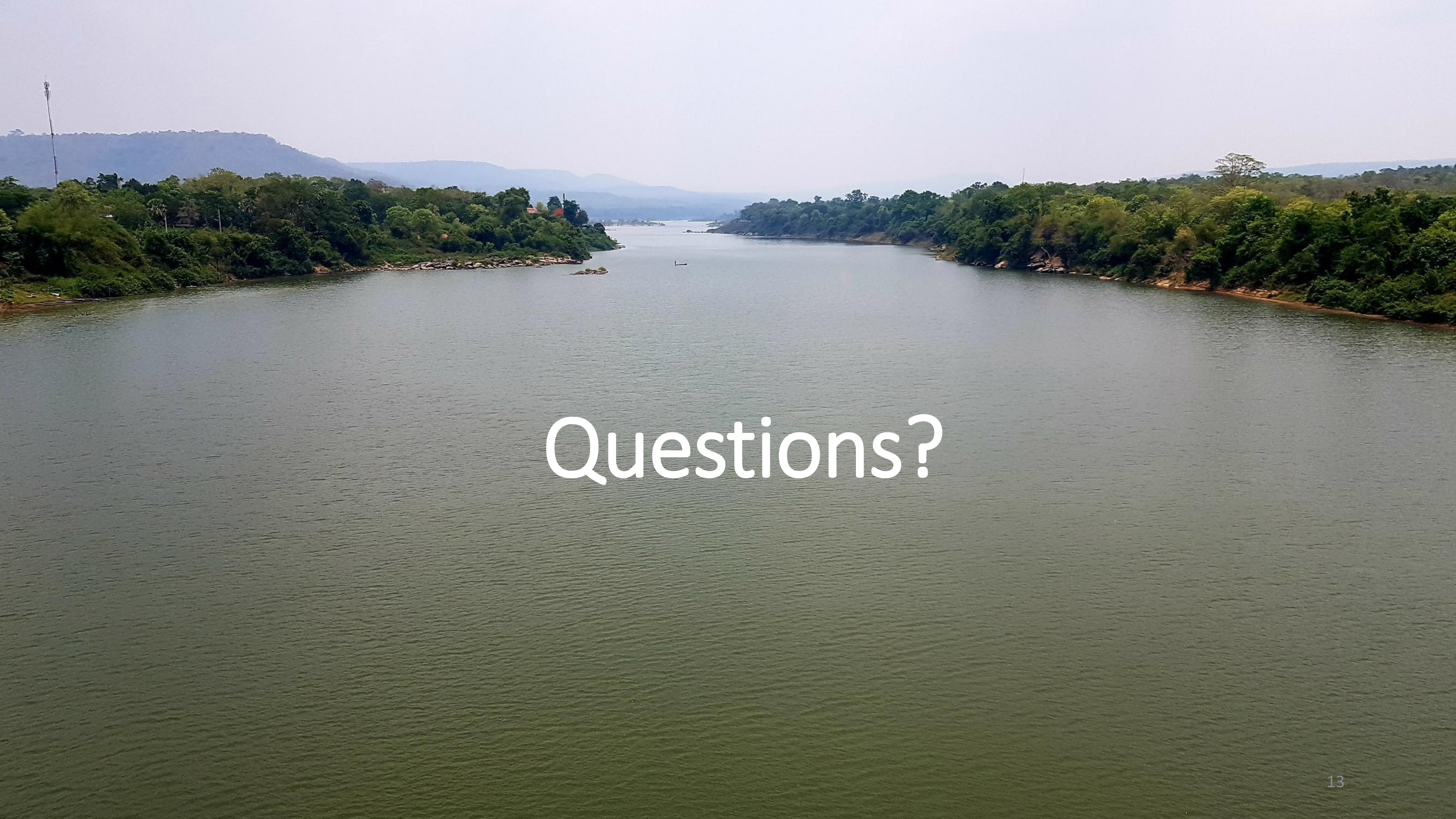




- **Spatial Variability:** Rates vary across subwatersheds, driven by land use and lithology.
- **Northern Hotspots:** Higher rates due to intense agriculture and weathering-prone rocks.
- **Southern Areas:** Lower rates linked to forest cover and minimal human impact.
- **Key Drivers:** Local geology, hydrology, and human activities shape these patterns.

Conclusions

- **Seasonal Flux Variations:** Dissolved species fluxes are significantly higher in the wet season, highlighting the influence of hydrology and discharge on solute transport.
- **Hotspot Identification:** Northern subwatersheds emerge as hotspots for dissolved species, driven by intensive agriculture and weathering-prone lithology.
- **Water Type Transition:** Piper diagrams reveal a seasonal shift in water type, indicating increasing contamination during the dry season.
- **Weathering and Biomass Insights:** Variations in weathering and biomass degradation rates across subwatersheds emphasize the impact of local geology, land use, and hydrology.
- **Future Management:** These findings stress the need for adaptive watershed management to mitigate anthropogenic impacts and address climate-driven challenges.



Questions?