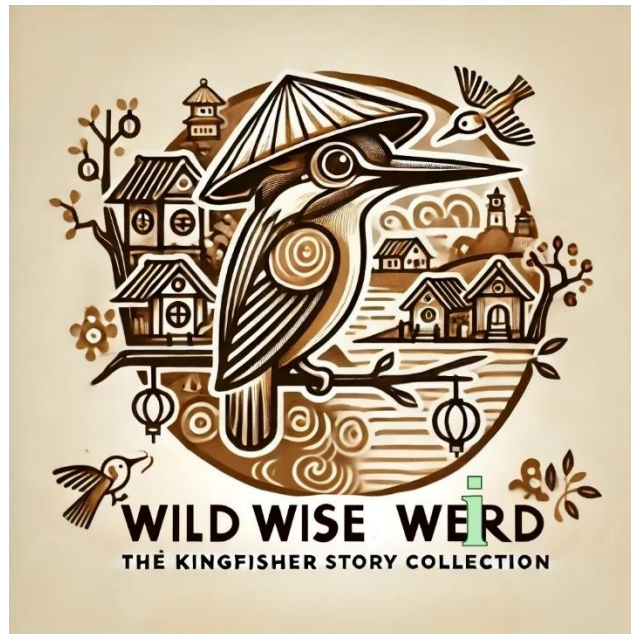


Beneath the Surface: How Soil Moisture Governs Climate Futures

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“With only his beak, he utilizes every readily available material in nature, such as grass and soil, and there we have a talented artist. With his useful talent, he has become the go-to man for everyone in the village.”

In “Contentment”; *Wild Wise Weird* [1]



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Soil moisture—often overlooked in climate conversations—profoundly influences whether ecosystems store carbon or emit greenhouse gases. A comprehensive global review by Hao et al. (2025) reveals how finely tuned balances in soil water content shape the capacity of land to mitigate or exacerbate climate change.

Moderate levels of soil moisture support essential ecological functions: they enhance plant photosynthesis and sustain microbial processes that convert atmospheric CO₂ into stable soil carbon [3,4]. However, moisture extremes—either drought or waterlogging—disrupt these mechanisms. Dry conditions suppress plant respiration and microbial activity, reducing carbon uptake. Conversely, saturated soils create oxygen-poor environments that favor anaerobic microbes, which produce methane (CH₄) and nitrous oxide (N₂O)—two greenhouse gases far more potent than CO₂ [5,6].

The study identifies distinct thresholds for emissions: CO₂ release peaks at around 40% water-filled pore space (WFPS), whereas CH₄ and N₂O emissions rise significantly at 60–80% and near 80% WFPS, respectively. These insights underscore the importance of maintaining soil moisture within optimal ranges to balance carbon storage with minimal greenhouse emissions [2].

Sustainable land practices can help maintain this balance. Conservation agriculture, agroforestry, and improved water management—such as alternate wetting and drying in rice fields—enhance soil structure, regulate moisture levels, and reduce GHG emissions. These approaches not only sequester carbon but also build resilience against climate extremes. Advanced remote sensing tools and ground-based monitoring networks, such as FLUXNET, are improving our ability to observe soil moisture and carbon dynamics in real-time. Combined with hybrid modeling frameworks, they offer more precise and predictive insights for land management [2].

Ultimately, the study calls for a shift in policy priorities—from maximizing short-term yields to fostering long-term ecosystem health. Financial incentives, robust monitoring, and inclusive stakeholder engagement will be crucial to align soil moisture management with global climate goals.

The water beneath our feet connects human action to planetary outcomes. By stewarding soil moisture wisely, we honor the interdependence of natural processes and human futures [7,8].

References

- [1] Vuong QH. (2024). *Wild Wise Weird*. <https://www.amazon.com/dp/B0BG2NNHY6/>
- [2] Hao Y, et al. (2025). Soil moisture controls over carbon sequestration and greenhouse gas emissions: a review. *npj Climate and Atmospheric Science*, 8, 16. <https://www.nature.com/articles/s41612-024-00888-8>
- [3] Leifeld J, Menichetti L. (2018). The underappreciated potential of peatlands in global climate change mitigation strategies. *Nature Communications*, 9, 1071. <https://www.nature.com/articles/s41467-018-03406-6>
- [4] Li Y, et al. (2023). Trends in drought and effects on carbon sequestration over the Chinese mainland. *Science of The Total Environment*, 856, 159075. <https://doi.org/10.1016/j.scitotenv.2022.159075>
- [5] Yang F, et al. (2023). Desert abiotic carbon sequestration weakening by precipitation. *Environmental Science & Technology*, 57, 7174-7184. <https://doi.org/10.1021/acs.est.2c09470>
- [6] Li Y, et al. (2019). Enhancement of methane production in anaerobic digestion process: A review. *Applied Energy*, 240, 120-137. <https://doi.org/10.1016/j.apenergy.2019.01.243>
- [7] Ho MT, Nguyen DH. (2025). Of Kingfisher and Man. <https://philarchive.org/rec/HOOKAW>
- [8] Nguyen MH. (2024). How can satirical fables offer us a vision for sustainability? *Visions for Sustainability*. <https://ojs.unito.it/index.php/visions/article/view/11267>