

Reviving Diminishing Small Streams: A Multimodal Approach to Surface and Subsurface Water Augmentation

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Abstract--Small streams are critical ecological corridors that support hydrological connectivity, biodiversity, and local livelihoods i.e. Water supply schemes, irrigation schemes. However, these systems are increasingly under threat from urban expansion, deforestation, groundwater over-extraction, and climate variability, resulting in diminished flow, degraded habitats, and disrupted surface–subsurface interactions. This paper proposes a comprehensive, multimodal approach to revive diminishing small streams by integrating technical interventions with ecological restoration strategies.

The study investigates both structural and non-structural methods for augmenting surface and subsurface water availability. These include watershed-scale recharge structures (e.g., check dams, infiltration trenches), bioengineering solutions for streambank stabilization, and the reestablishment of natural flow regimes. Additionally, ecological interventions such as riparian vegetation restoration, in-stream habitat reconstruction, and biodiversity enhancement are employed to improve ecosystem resilience.

Using a combination of field-based hydrological measurements, GIS-based spatial analysis, and numerical groundwater modelling (e.g., MODFLOW), the paper evaluates the impact of these integrated strategies on streamflow permanence, aquifer recharge rates, and ecological indicators. Findings suggest that targeted interventions, especially when co-designed with local communities, can significantly enhance stream-aquifer connectivity, improve baseflow conditions, and support habitat diversity.

The research underscores the necessity of treating small streams not just as water channels but as complex socio-ecological systems. A transdisciplinary framework—combining hydrology, ecology, engineering, and participatory governance—is vital for long-term success. This work contributes practical insights and policy-relevant recommendations for scaling up stream restoration in semi-arid and sub-humid landscapes facing hydrological stress.

Keywords--Small Streams, Water Augmentation, Ecological Restoration, Surface–Subsurface Interaction.

I INTRODUCTION

Small streams, often termed first- and second-order streams, are the foundational units of freshwater ecosystems and play a crucial role in maintaining regional hydrological cycles, biodiversity, and ecosystem services (Leopold et al., 1964; Allan & Castillo, 2007). These headwater streams contribute significantly to groundwater recharge, sediment transport, nutrient cycling, and habitat connectivity. Despite their importance, they are frequently overlooked in water resource management and ecological planning frameworks (Meyer et al., 2007). In recent decades, rapid urbanization, unsustainable land use practices, and climate-induced shifts in precipitation have led to the degradation of many small streams worldwide (Palmer et al., 2010). Key impacts include channel incision, loss of baseflow, pollution accumulation, riparian vegetation decline, and disruption of surface–subsurface hydrological exchanges (Sophocleous, 2002; Wohl, 2017). In India, for example, small seasonal streams in semi-arid and sub-humid regions have exhibited alarming reductions in flow continuity and ecological health due to deforestation, agricultural runoff, and groundwater over-extraction (Sharma & Bharati, 2021).

Traditional stream restoration practices have often focused on isolated engineering solutions that overlook ecological dynamics and long-term sustainability. In contrast, a multimodal approach—which integrates technical interventions such as managed aquifer recharge and watershed-based planning with ecological measures like riparian zone rehabilitation and biodiversity restoration—offers a more holistic and resilient framework for stream revival (Bernhardt & Palmer, 2011).

This paper aims to explore the integration of such technical and ecological strategies to augment surface and subsurface water in small streams. Through an interdisciplinary lens combining hydrology, ecology,

and community-based management, the research addresses both the biophysical and socio-economic dimensions of stream restoration in water-stressed landscapes.

II. MEANING

I. Small Streams

Small streams are typically low-order (first- or second-order) freshwater channels that originate in the upper catchments of a watershed. Although often overlooked, they form the foundational elements of river networks and are critical to maintaining the ecological integrity of entire hydrological systems. These streams support essential functions such as sediment transport, nutrient cycling, and groundwater recharge (Allan & Castillo, 2007). Furthermore, they serve as habitats for a wide variety of aquatic and terrestrial species, contributing significantly to regional biodiversity. Their health is closely tied to the sustainability of larger water bodies downstream, making them vital indicators of overall watershed health and resilience (Meyer et al., 2007; Wohl, 2017).

II. Water Augmentation

Water augmentation refers to a set of natural or engineered interventions aimed at increasing the availability of surface and subsurface water resources. In the context of stream revival, this includes methods such as constructing check dams, infiltration trenches, and implementing managed aquifer recharge (MAR) strategies (Dillon et al., 2009). These techniques are particularly important in water-stressed regions where small streams have become seasonal or intermittent due to over-extraction of groundwater and changing rainfall patterns (Sharma & Bharati, 2021). By enhancing local recharge and sustaining baseflows, water augmentation directly supports the revival of stream ecosystems and improves water security for dependent communities.

III. Ecological Restoration

Ecological restoration is the process of rehabilitating degraded natural ecosystems to restore their original structure, function, and biodiversity. In small stream environments, this often involves replanting native riparian vegetation, removing invasive species, reconstructing in-stream habitats, and reestablishing

natural flow regimes (Palmer et al., 2005). These actions not only improve habitat quality but also increase the resilience of the stream system against hydrological and climatic disturbances. Ecological restoration is a key component of sustainable stream management, ensuring that technical interventions such as water augmentation are complemented by ecosystem-based approaches that support long-term ecological health (Bernhardt & Palmer, 2011).

IV. Surface–Subsurface Interaction

Surface–subsurface interaction refers to the bidirectional exchange of water between surface water bodies like streams and the underlying groundwater system. This interaction plays a crucial role in regulating stream baseflow, aquifer recharge, and the maintenance of ecological flow conditions (Winter et al., 1998). In degraded catchments, disruptions in this exchange—often caused by groundwater depletion or channel modifications—can lead to the drying of streams and loss of ecosystem services (Sophocleous, 2002). Understanding and restoring surface–subsurface hydrological connectivity is therefore essential for any integrated approach aimed at reviving small streams and enhancing water availability in the broader landscape.

III. HISTORICAL CONTEXT

Historically, small streams and headwater tributaries were integral to the development of agrarian societies, especially in monsoon-dependent regions such as South Asia, where decentralized water management practices like johads, baolis, and tankas were commonly used for harvesting and recharging water (Agarwal & Narain, 1997). These systems recognized the natural interlinkage between surface runoff and groundwater recharge, effectively sustaining both water supply and ecological health for centuries.

In Western contexts, early hydraulic civilizations in Mesopotamia, the Indus Valley, and later Europe understood the importance of channelling and preserving small streams for irrigation and urban water supply. However, with the onset of industrialization in the 18th and 19th centuries, stream systems began to be viewed predominantly as conduits for drainage, sanitation, and urban development (Gandy, 2004). This utilitarian view led to widespread channelization,

culverting, and disconnection of streams from their floodplains and aquifers.

During the mid-20th century, large-scale water infrastructure projects such as dams and diversion canals further marginalized small streams by altering flow regimes and fragmenting catchments (McCully, 1996). In many regions, groundwater extraction began to outpace natural recharge, leading to baseflow depletion and the drying of formerly perennial streams (Sophocleous, 2002).

By the 1990s, the ecological and hydrological importance of small streams began to gain recognition, spurred by scientific findings linking them to watershed-scale functions such as nutrient retention, sediment regulation, and biodiversity support (Meyer et al., 2007). Restoration movements, particularly in the United States and Europe, began to shift from purely engineering-centric approaches to more integrated, ecosystem-based methods (Palmer et al., 2005).

In recent decades, the need to address surface–subsurface hydrological disconnections and to revive small streams as part of climate resilience and water security strategies has re-emerged, especially in regions facing acute water stress (Wohl, 2017; Bharati et al., 2016). This shift has highlighted the importance of integrating traditional water wisdom with modern hydrological science and participatory governance.

1. Factors Affecting the Revival of Diminishing Small Streams: A Multimodal Approach

The successful revival of small streams using a multimodal approach—which combines engineering, hydrological, ecological, and social interventions—depends on a complex interplay of physical, environmental, socio-economic, and institutional factors. A comprehensive understanding of these drivers is essential for designing site-specific, adaptive, and long-term restoration strategies.

I. Watershed Characteristics and Geomorphology

The physical setting of the watershed, including topography, soil type, geology, and slope, significantly influences infiltration, runoff, and groundwater recharge potential (Allan & Castillo, 2007). Steep slopes may increase surface runoff and erosion, while permeable soils facilitate infiltration and aquifer

recharge. The historical and current geomorphological condition of the stream channel also determines restoration potential.

II. Land Use and Land Cover Changes

Land use changes such as deforestation, agricultural expansion, and urbanization alter hydrological regimes by increasing impervious surfaces, reducing evapotranspiration, and disrupting natural flow pathways (Foley et al., 2005). These changes lead to reduced baseflows, increased flash floods, and streambed incision, complicating revival efforts.

III. Groundwater Abstraction and Recharge Balance

Over-extraction of groundwater reduces the hydraulic gradient required for maintaining stream baseflow, resulting in stream desiccation during dry seasons (Sophocleous, 2002). The success of managed aquifer recharge (MAR) interventions depends on matching extraction with recharge and ensuring adequate aquifer storage.

IV. Climate Variability and Rainfall Patterns

Rainfall quantity, intensity, and distribution directly affect streamflow and recharge processes. Climate change has introduced increased variability in monsoonal systems, causing erratic flow regimes in small streams (IPCC, 2021). Prolonged droughts and extreme rainfall events can both undermine the effectiveness of stream restoration structures.

V. Ecological Health and Biodiversity

The presence of native vegetation in riparian zones and instream biodiversity improves the ecological resilience of the stream and supports nutrient cycling, sediment retention, and temperature regulation (Palmer et al., 2005). Degraded ecosystems are less responsive to technical interventions unless ecological parameters are simultaneously addressed.

VI. Technical Design and Implementation Quality

The effectiveness of water augmentation structures like check dams, infiltration trenches, and recharge wells relies heavily on proper design, siting, and long-term maintenance (Dillon et al., 2009). Inadequate

technical capacity or flawed designs may result in low recharge efficiency or structural failure.

VII. Community Participation and Local Knowledge

Community involvement in planning, implementing, and monitoring restoration efforts enhances sustainability and ensures context-specific adaptation. Local knowledge, such as traditional water harvesting techniques and seasonal flow behavior, can improve the design and acceptance of interventions (Agarwal & Narain, 1997).

VIII. Institutional Support and Governance Framework

Policy alignment, institutional coordination, and funding mechanisms are critical for stream revival. Fragmented responsibilities between water, forest, and rural development departments often lead to disjointed or duplicative efforts (Bharati et al., 2016). Integrated water resource management (IWRM) principles are essential for cohesive action.

IX. Monitoring, Data Availability, and Adaptive Management

Long-term hydrological and ecological monitoring is essential to evaluate the performance of interventions and make adaptive changes. The lack of high-resolution data on streamflow, groundwater levels, and land use patterns remains a significant barrier in many regions (Wohl et al., 2015).

2. Multimodal Intervention Strategies

Reviving small streams requires an integrated multimodal approach that blends engineering solutions, ecological restoration, and community-driven governance. Such a combination ensures both hydrological sustainability and ecological functionality, particularly in regions affected by water stress, land degradation, and climate change.

I. Technical Interventions (Hydrological and Engineering-Based)

a. Check Dams and Percolation Pits

These small structures slow down runoff, reduce erosion, and allow water to percolate into the ground,

enhancing subsurface recharge and baseflow in nearby streams.

(Dillon et al., 2009; Sharma & Bharati, 2021)

b. Recharge Shafts and Trenches

Infiltration trenches and recharge shafts are particularly useful in areas with hard rock geology to direct surface water into the aquifer. These are effective in monsoon-fed streams. (CGWB, 2015)

c. Streambank Stabilization and Channel Re-naturalization

Bioengineering solutions such as vegetative geotextiles or stone pitching can reduce erosion and restore natural flow paths. Meandering channels also slow down flow and increase groundwater interaction. (Palmer et al., 2005)

d. Rainwater Harvesting Structures

Rooftop and community-level harvesting reduces surface runoff and augments stream and aquifer systems when integrated with recharge zones.

II. Ecological Restoration Measures

a. Riparian Vegetation Restoration

Planting native trees and shrubs along streambanks improves soil stability, enhances biodiversity, and creates a buffer zone for filtering pollutants. (Bernhardt & Palmer, 2011)

b. In-stream Habitat Reconstruction

Structures like log jams, boulders, or riffles increase habitat complexity, which supports aquatic biodiversity and improves sediment dynamics. (Wohl et al., 2015)

c. Wetland Creation or Revival

Restored or constructed wetlands in headwaters and floodplains can act as natural sponges, storing floodwater and slowly releasing it into streams. (Mitsch & Gosselink, 2007)

III. Subsurface Interventions

a. Managed Aquifer Recharge (MAR)

MAR techniques—such as spreading basins, recharge wells, and induced bank filtration—intentionally enhance groundwater recharge to support streamflow during dry periods. (Dillon et al., 2009)

hyporheic Zone Protection

Protecting or restoring the streambed's hyporheic zone (where shallow groundwater and surface water mix) helps regulate temperature and support microbial

activity essential for stream health. (Hancock, 2002)

IV. Socio-Institutional and Participatory Approaches

a. Community Engagement and Traditional Knowledge

Involving local stakeholders in planning and implementation ensures that interventions are context-specific and socially accepted. Traditional water systems (e.g. Johads, khadins) offer valuable insight. (Agarwal & Narain, 1997)

integrated Watershed Management

Managing entire catchments through soil conservation, afforestation, and sustainable agriculture practices reduces runoff and sediment load, indirectly benefiting stream revival. (Sharma et al., 2010)

policy and Institutional Support

Cross-sectoral coordination among water, forestry, and rural development departments, supported by enabling policies and financial incentives, ensures long-term sustainability.

(Bharati et al., 2016)

Summary Table: Multimodal Strategies

Category	Strategy	Purpose/Benefit
Technical	Check dams, trenches	Recharge, flow moderation
	Streambank stabilization	Erosion control, flow re-naturalization
Ecological	Riparian restoration	Biodiversity, filtering pollutants
	In-stream habitat	Ecosystem structure, aquatic life support
Subsurface	Managed aquifer recharge (MAR)	Groundwater replenishment
	Hyporheic zone protection	Water quality and baseflow maintenance
Participatory	Community engagement	Local relevance, long-term maintenance
Institutional	Watershed planning, policy integration	Governance, scalability

3 Monitoring and Impact Evaluation of Multimodal Stream Revival Strategies

Effective monitoring and impact evaluation are crucial to assess the success of interventions aimed at reviving diminishing small streams. A structured, science-based framework helps track hydrological, ecological, and socio-economic outcomes, enabling adaptive management and policy refinement.

I. Hydrological Monitoring

a. Streamflow Measurements

Discharge monitoring at key points along the stream helps quantify improvements in baseflow and flow permanence. Flow gauging stations or pressure transducers can be used for real-time data.

b. Groundwater Levels

Piezometric readings and monitoring wells assess changes in aquifer recharge rates and groundwater-stream connectivity post-intervention (Sophocleous, 2002).

c. Rainfall and Recharge Correlation

Rain gauges, combined with infiltration data, help evaluate the effectiveness of managed aquifer recharge (MAR) structures under different rainfall events (Dillon et al., 2009).

II. Ecological Monitoring

a. Riparian Vegetation Index

Tracking vegetation cover and species composition along streambanks gives insights into the success of riparian restoration (Palmer et al., 2005).

b. Biodiversity and Habitat Quality

Biotic indices such as macroinvertebrate diversity, fish populations, and habitat complexity indicate ecosystem health and resilience (Wohl et al., 2015).

c. Water Quality Parameters

Monitoring temperature, dissolved oxygen (DO), turbidity, and nutrient levels reflects the stream's self-purification capacity and pollution stress.

III. Socio-Economic and Institutional Impact

a. Community Feedback and Participation Rates

Household surveys and focus group discussions help measure changes in water availability, perceptions of success, and community ownership.

b. Agricultural Productivity and Livelihood Indicators
Changes in irrigation reliability, crop yield, and seasonal migration are indirect indicators of

stream restoration impact.

c. Institutional Performance Metrics

Indicators such as inter-agency coordination, funding utilization, and policy implementation timelines can be tracked to assess governance efficiency (Bharati et al., 2016).

IV. Tools and Techniques for Evaluation

- GIS and Remote Sensing: Used for land cover change detection, stream morphology mapping, and vegetation analysis.
- Hydrological Models (e.g., MODFLOW, SWAT): Simulate groundwater–stream interactions and predict long-term impacts of interventions.
- Ecological Scorecards: Simplify biodiversity and habitat metrics for participatory monitoring.
- Before-After-Control-Impact (BACI) Design: Ensures robust evaluation by comparing changes in intervention and non-intervention sites over time (Downes et al., 2002).

Key Indicators Summary Table

Domain	Indicator	Purpose
Hydrological	Stream baseflow, groundwater levels	Assess recharge and flow enhancement
Ecological	Biodiversity index, vegetation health	Measure ecological response
Water Quality	DO, turbidity, temperature	Track pollution and stream health
Socio-Economic	Crop yield, migration, participation	Evaluate community impact
Institutional	Funding usage, coordination effectiveness	Assess policy and governance support

3. Challenges and Limitations

Despite growing recognition of the importance of small stream restoration, several technical, ecological, institutional, and socio-economic challenges constrain the effective implementation of multimodal intervention strategies:

I. Data Scarcity and Monitoring Gaps

Accurate data on streamflow, groundwater levels, soil characteristics, and land use changes are often unavailable or outdated. This hinders the design of site-specific interventions and limits the ability to track restoration success over time (Wohl et al., 2015).

II. Fragmented Institutional Framework

Restoration efforts are often undermined by overlapping mandates across departments (water, forestry, agriculture, etc.), leading to poor coordination, policy mismatches, and inefficient resource allocation (Bharati et al., 2016).

III. Technical Limitations

Improper design, poor siting, or inadequate maintenance of water augmentation structures like check dams or recharge wells can result in reduced recharge efficiency, siltation, or structural failure (Dillon et al., 2009).

IV. Climate Uncertainty

Increasing variability in rainfall patterns due to climate change poses a significant limitation to long-term planning. Prolonged droughts, intense rainfall, and erratic monsoon behavior reduce the predictability and effectiveness of recharge interventions (IPCC, 2021).

V. Limited Community Engagement

Lack of genuine participation from local communities, especially in post-project maintenance, monitoring, and adaptive management, often leads to the abandonment or misuse of restored streams (Agarwal & Narain, 1997).

VI. Ecological Restoration Lag

While hydrological improvements may be immediate, ecological recovery—such as biodiversity return or riparian health—can take years. This temporal disconnect often discourages investment and short-term evaluation may misrepresent success (Palmer et al., 2005).

VII. Funding and Long-Term Sustainability

Many restoration projects are constrained by short

funding cycles, with limited provisions for maintenance, monitoring, and adaptive management beyond the initial implementation phase.

VIII. Land Ownership and Encroachments

Encroachment in stream corridors and legal conflicts over land tenure complicate physical interventions and limit the scope of ecological restoration.

IX. Scaling and Replication Issues

Multimodal approaches are often context-specific. What works in one watershed may not be directly transferable to another due to differences in geology, climate, or socio-political conditions.

4. Recommendations for Reviving Diminishing Small Streams through a Multimodal Approach

Based on the findings, analysis, and challenges discussed, the following recommendations are proposed to enhance the success and scalability of multimodal interventions in small stream revival:

I. Adopt an Integrated Watershed-Based Approach

- Restoration efforts should be designed at the watershed scale, considering upstream-downstream hydrological connectivity and land use patterns.
- Integrate surface and subsurface water planning with land management for long-term sustainability.

II. Strengthen Data Collection and Monitoring Systems

- Establish real-time hydrological and ecological monitoring networks using remote sensing, GIS, and IoT-based sensors.
- Promote open data platforms to share monitoring results and inform adaptive management.

III. Promote Nature-Based Solutions Alongside Engineering

- Blend traditional grey infrastructure (e.g., check dams, recharge wells) with green infrastructure (e.g., riparian vegetation, bio-

swales).

- Prioritize ecological restoration to enhance stream resilience and biodiversity.

IV. Enhance Community Involvement and Local Knowledge Integration

- Actively engage local stakeholders in co-designing, implementing, and maintaining interventions.
- Leverage traditional water harvesting practices and indigenous ecological knowledge.

V. Improve Institutional Coordination and Policy Alignment

- Establish interdepartmental task forces or working groups for stream restoration governance.
- Align policies across water, environment, agriculture, and rural development sectors to avoid duplication and maximize impact.

VI. Mainstream Climate Resilience in Design

- Integrate climate projections and variability into the planning of water augmentation structures.
- Design for both drought resilience and flood mitigation.

VII. Ensure Long-Term Funding and Maintenance Plans

- Allocate dedicated operation and maintenance budgets post-project implementation.
- Encourage public-private partnerships and community-based financing mechanisms.

VIII. Build Local Technical Capacity

- Provide training and capacity-building programs for engineers, planners, and community leaders on stream hydrology, ecological restoration, and monitoring tools.

IX. Standardize Impact Evaluation Frameworks

- Use common performance indicators for hydrology, ecology, and socio-economic benefits.

- Implement Before–After–Control–Impact (BACI) models for robust, evidence-based evaluation.

X. Replicate Successful Models with Local Adaptation

- Identify and document successful case studies across different regions.
- Adapt restoration models to fit local geohydrological and socio-political contexts.

5. CONCLUSION

Small streams are vital ecological and hydrological systems that play a key role in sustaining biodiversity, supporting local livelihoods, and maintaining surface–subsurface water connectivity. However, these fragile systems are increasingly under stress due to land use change, groundwater over-extraction, climate variability, and institutional fragmentation. This paper emphasizes that a multimodal approach, integrating hydrological engineering, ecological restoration, community engagement, and policy support, is essential for the sustainable revival of diminishing small streams.

Through a combination of technical interventions (e.g., check dams, infiltration trenches, managed aquifer recharge) and ecological strategies (e.g., riparian vegetation, in-stream habitat restoration), it is possible to improve both baseflow conditions and ecological health. The effectiveness of these measures is further enhanced by long-term monitoring, community participation, and a transdisciplinary governance framework.

Despite promising outcomes, several challenges remain, including data gaps, climate unpredictability, fragmented institutions, and limited post-implementation support. Addressing these constraints requires adaptive, participatory, and evidence-based planning, grounded in both local knowledge and scientific research.

Ultimately, restoring small streams should not be viewed as isolated engineering projects, but as integrated efforts to regenerate socio-ecological systems. This approach not only supports water security and ecosystem services but also contributes to climate resilience and rural sustainability. The insights and recommendations provided in this study offer a practical framework for scaling up stream restoration

efforts across diverse geographies experiencing hydrological stress.

REFERENCES

- [1] Agarwal, A., & Narain, S. (1997). *Dying Wisdom: Rise, Fall and Potential of India's Traditional Water Harvesting Systems*. Centre for Science and Environment.
- [2] Allan, J. D., & Castillo, M. M. (2007). *Stream Ecology: Structure and Function of Running Waters*. Springer.
- [3] Bernhardt, E. S., & Palmer, M. A. (2011). River restoration: The fuzzy logic of repairing reaches to reverse catchment scale degradation. *Ecological Applications*, 21(6), 1926–1931.
- [4] Bharati, L., Sharma, B. R., Smakhtin, V., & Scott, C. A. (2016). Integrated water resources management for improving rural livelihoods in semi-arid India. *Agricultural Water Management*, 174, 1–3.
- [5] CGWB. (2015). *Manual on Artificial Recharge of Groundwater*. Central Ground Water Board, India.
- [6] Dillon, P., Pavelic, P., Page, D., Beringen, H., & Ward, J. (2009). *Managed Aquifer Recharge: An Introduction*. Waterlines Report Series No. 13, National Water Commission.
- [7] Downes, B. J., Barmuta, L. A., Fairweather, P. G., Faith, D. P., Keough, M. J., Lake, P. S., ... & Quinn, G. P. (2002). *Monitoring Ecological Impacts: Concepts and Practice in Flowing Waters*. Cambridge University Press.
- [8] Foley, J. A., DeFries, R., Asner, G. P., Barford, C., Bonan, G., Carpenter, S. R., ... & Snyder, P. K. (2005). Global consequences of land use. *Science*, 309(5734), 570–574.
- [9] Gandy M. (2004). Rethinking urban metabolism: Water, space and the modern city. *City*, 8(3), 363–379.
- [10] Hancock, P. J. (2002). Human impacts on the stream–groundwater exchange zone. *Environmental Management*, 29(6), 763–781.
- [11] IPCC. (2021). *Sixth Assessment Report*. Intergovernmental Panel on Climate Change.
- [12] Leopold, L. B., Wolman, M. G., & Miller, J. P. (1964). *Fluvial Processes in Geomorphology*. W.H. Freeman.
- [13] McCully, P. (1996). *Silenced Rivers: The Ecology and Politics of Large Dams*. Zed Books.

- [14] Meyer, J. L., Kaplan, L. A., Newbold, J. D., Strayer, D. L., Woltemade, C. J., Zedler, J. B., & Gilliam, J. W. (2007). Where rivers are born: The scientific imperative for defending small streams and wetlands. American Rivers and Sierra Club.
- [15] Meyer, J. L., Strayer, D. L., Wallace, J. B., Eggert, S. L., Helfman, G. S., & Leonard, N. E. (2007). The contribution of headwater streams to biodiversity in river networks. *Journal of the American Water Resources Association*, 43(1), 86–103.
- [16] Mitsch, W. J., & Gosselink, J. G. (2007). *Wetlands* (4th ed.). John Wiley & Sons.
- [17] Palmer, M. A., Bernhardt, E. S., Allan, J. D., Lake, P. S., Alexander, G., Brooks, S., & Galat, D. L. (2005). Standards for ecologically successful river restoration. *Journal of Applied Ecology*, 42(2), 208–217.
- [18] Palmer, M. A., Menninger, H. L., & Bernhardt, E. (2010). River restoration, habitat heterogeneity and biodiversity: A failure of theory or practice? *Freshwater Biology*, 55(s1), 205–222.
- [19] Sharma, B. R., & Bharati, L. (2021). Sustainable management of small streams in India: A catchment-based approach. *Water Policy*, 23(1), 131–145.
- [20] Sharma, B. R., Samra, J. S., & Scott, C. A. (2010). Watershed management challenges: Introduction and overview. *Hydrological Processes*, 24(19), 2671–2674.
- [21] Sophocleous, M. (2002). Interactions between groundwater and surface water: The state of the science. *Hydrogeology Journal*, 10(1), 52–67.
- [22] Winter, T. C., Harvey, J. W., Franke, O. L., & Alley, W. M. (1998). *Ground Water and Surface Water: A Single Resource*. US Geological Survey Circular 1139.
- [23] Wohl, E. (2017). The significance of small streams. *Frontiers of Earth Science*, 11(3), 447–456.
- [24] Wohl, E., Lane, S. N., & Wilcox, A. C. (2015). The science and practice of river restoration. *Water Resources Research*, 51(8), 5974–5997.