

1 Re-evaluating Keyline Design: Towards Functional Water Management in Agroforestry Systems

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1.1 Highlights

- A comparative assessment of documented agroforestry water management systems reveals recurring functional limitations in commonly applied Keyline-inspired designs.
- Observable indicators of concentrated surface runoff, erosion, and insufficient overflow stability can be identified through field- and image-based assessments.
- A preliminary functional evaluation framework is proposed to support the assessment and design of water management systems in agroforestry.



Figure 1: An agroforestry system with water retention and the criteria for functional water management.

1.2 The Keyline-approach: Conceptual ambiguity and insufficient stability

Keyline design is a planning approach that combines different elements such as soil surface manipulation and agroforestry plantings to enhance the sustainable provision of ecosystem services and farm productivity. It is widely discussed within the European agroforestry community as a promising approach for improving water retention, soil moisture distribution, and flood protection. However, despite its conceptual appeal and increasing visibility, its practical implementation in European agriculture remains limited. This raises a critical question: why has Keyline design not achieved broader adoption among farmers, and under which conditions can agroforestry systems effectively contribute to water management?

We argue that the classical interpretation of Keyline design, as commonly taught and applied, fails to meet essential functional requirements of agricultural water management systems. In many cases, it is

perceived by practitioners as overly stylized, insufficiently robust under real hydrological conditions, and difficult to integrate into standard farming operations. Furthermore, the discourse around and research on Keyline design are often characterized by conceptual ambiguity and a degree of mystification that hinders critical evaluation and adaptation.

1.3 Toward Functional Water Management in Agroforestry Systems

This contribution presents a comparative assessment of documented agroforestry water management systems designed according to the Keyline approach or related functional developments. The analysis is based on 14 systems in Central Europe, including seven systems described in scientific or technical literature and seven implemented field projects ^{e.g.1-3}. Systems were evaluated using field- and image-based assessments of observable indicators of concentrated surface runoff and erosion, as well as hydrological and operational criteria including overflow stability, water distribution patterns, storage capacity, and agricultural operability.

The comparative analysis indicates that several commonly applied interpretations of the Keyline approach show recurring functional limitations under Central European conditions. Observed challenges include insufficient handling of concentrated runoff, limited storage capacity during high-intensity rainfall events, unstable overflow situations, and geometries that are difficult to integrate into standard agricultural operations. At the same time, the analysis identifies design characteristics associated with improved water distribution, operational stability, and compatibility with agricultural management.

Based on these observations, the contribution develops a preliminary evaluation framework comprising six criteria for functional water management in agroforestry systems: (1) agricultural operability, (2) controlled distribution of low-intensity rainfall, (3) buffering capacity for high-intensity rainfall events, (4) structural and overflow stability, (5) compatibility with optional irrigation functions, and (6) compatibility with optional drainage functions.

The contribution aims to establish a structured comparative framework for evaluating functional water management performance in agroforestry systems. By linking empirical observations of hydrological functionality with ecosystem service considerations, the study aims to support a more rigorous discussion on water retention design in agroforestry research and implementation, and thus contribute to the enhancement of ecosystem service delivery.

Ultimately, the paper argues that the scalability and acceptance of agroforestry as a climate adaptation strategy depend on its ability to deliver clear, measurable, and operationally viable water management functions. Moving beyond Keyline as a fixed methodology toward adaptable, criteria-based system design is therefore a necessary step for both research and practice.

1.4 Keywords

water retention, agroforestry systems, gravity-driven water management, Keyline Design

1.5 Literature

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