Impact of Hydrographic Network Organization on the Morphology of the Kert Basin: Analysis of Consequences

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Abstract. This study investigates the intricate relationship between hydrographic network organization, geological faults, and regional dynamics within the Kert basin in the Eastern Rif region. Through GIS hydrographic analysis, we analyze the impact of the hydrographic network on landscape morphology and hydrological dynamics, emphasizing implications for sustainable water resource management. Results reveal the presence of dendritic and parallel hydrographic networks influenced by geological faults, which guide water flow and shape drainage patterns. Seasonal variations in sediment load show significant transport in September and May, indicating increased torrentiality in upstream areas. Fault structures play a crucial role in landscape formation and water quality, with tectonic movements contributing to the development of reliefs and valleys. Understanding these interactions is vital for developing effective strategies for flood mitigation, ecosystem conservation, and sustainable water supply in the Kert basin and similar regions worldwide. Keywords: hydrographic network, Kert basin, environmental morphology, soil erosion, sustainable water resource management.

1 Introduction

Watersheds, intricate hydrological ecosystems, reflect the interplay between geographical and hydrographic factors, influencing unique environmental characteristics [1–3]. Focused on the Kert basin in the Eastern Rif, our study explores the intrinsic connection between morphology and the specific organization of its hydrographic network [1, 4, 5]. By shedding light on these complexities, we draw insightful conclusions regarding environmental repercussions and implications for the communities in the Kert basin, contributing to a nuanced understanding of watersheds in the broader context of sustainable water resource management [6–8]. The hydrographic network’s organization is pivotal, shaping landscape morphology, influencing ecosystems, and impacting human activities [5, 9]. It determines water flow pathways, affecting drainage, river flow dynamics, and the formation of watersheds, with implications for water availability, terrain morphology, and biodiversity [10-12]. This research addresses the current knowledge gap by investigating how the specific organization of the hydrographic network in the Kert basin influences its morphology, aiming to provide crucial insights for sustainable water resource management and ecosystem preservation [13–15]. Academically, this study aims to address two main objectives. Firstly, it seeks to understand the impact of the hydrographic network organization on the morphology of the Kert basin. Secondly, it aims to assess the vulnerability of urban areas, particularly in places like Driouch and Midar. By exploring these dimensions, the study aims to provide insights crucial for urban planning and community protection [16-18].

2 Materiel et method

2.1. Geographic and Hydrographic Context of the Kert Basin

The hydrographic basin of the Kert River, situated in the northeastern region of Morocco, seamlessly extends between latitudes 34°33' and 35°14' N, and longitudes 3°00' and 3°49' W (Fig. 1). Its natural boundaries are defined by the Mediterranean to the north, the Moulouya River hydrographic basin to the south and east, while the coastal basins of the Nekor and Amekrane rivers delineate its limits to the west and northwest [16,17]. Encompassing an area of 2873 km², the Kert River basin is characterized by distinct basins separated by narrow ridges, with increasing altitude towards the south and southwest. Key orographic units include the Gourougou massif in the northeast, peaking at around 900 m and extending to Beni Bou Ifrour (697 m) crossed by the Omassine River. To the west, the Tamssamane-
Ben Saïd massif (922 m) dominates, and to the south and east, the Kebdani basin is established, drained by the Ourdane and El Maleh rivers [16–18].

Fig. 1. Geomorphological map of kert
In the center, an E-W oriented depressed ensemble includes the Ezlef basin to the west and the plains of Sepsa, Gareb, and Bou Areg to the east. To the south, a discontinuous barrier of E-W aligned ridges, including the Sierra de Driouch in the center with peaks exceeding 1200 m, presents itself. Finally, the Ain Zora basin to the south marks the border with the Moulouya basin, bordered to the southwest by the Jbel Tigni (1800 m), Jbel Fezzan (1200 m), and Jbel Kerker exceeding 700 m in altitude [16,18,19].

2.2. GIS Hydrographic Analysis

The study utilized ArcGIS for analyzing the hydrographic watershed of the Kert basin, drawing upon established methodologies and tools within the GIS framework. Digital elevation models were processed to delineate precise watershed boundaries, while ArcGIS hydrological tools were employed to map river courses and stream orders, enabling a detailed examination of drainage networks. This approach was complemented by the integration of ancillary data, such as land cover and soil types, to provide a comprehensive analysis of land characteristics' influence on hydrographic network organization.

By leveraging GIS techniques, the study established a robust framework for understanding the morphological impact of the hydrographic watershed in the Kert basin, aligning with recognized practices and procedures in hydrological analysis.

3 Results and discussion

3.1. Topographic characteristics and Hydrological Framework

An examination of the hydrology of the Kert River watershed provides insights into river dynamics and the erosive impact of water. It helps identify areas vulnerable to erosion and determine periods conducive to this phenomenon. Runoff [21], among other factors, influences sediment production and solid flux, playing a role in the intensity, duration, and volume of floods along the hydrographic network.

Fig. 2. Maps of Kert basin slopes
The main course of the Kert River originates in the mountainous region of Tizi Ouzli at an altitude of approximately 800 meters, manifesting as a mountain stream sporadically receiving water from precipitation and snowmelt. Analyzing the longitudinal profile of the Kert River reveals segments characterized by a decreasing slope from upstream to downstream (Fig 2): a slope of 7.5% over 1.5 km upstream, followed by 2.9% to Midar. The slope then decreases upstream of the Kert-Chemmar confluence (1.1%) to only 0.5% in the last section near the mouth. The overall high slope and marked breaks emphasize the relative youthfulness of the Kert River [21, 22]. The amount of sediment load depends on sediment production by slopes and the river's transport capacity [23–25].

Interactions between Hydrographic Network Organization and Morphology: In the Kert watershed, the interaction between landscape morphology and hydrographic network organization is key to understanding the hydrological dynamics of the region.
The steep reliefs of the Rif and Middle Atlas Mountains influence the formation of rivers and streams, dictating the direction and speed of water flow. Abundant precipitation in these mountains feeds the region's watercourses, while erosion, intensified by these rainy conditions, continually shapes the morphology of channels and riverbeds throughout the Quaternary. This interaction between topography, precipitation, erosion, and sedimentation is crucial for water resource management, particularly for agricultural irrigation and drinking water supply. The analysis of hydrographic morphology within the Kert basin unveiled significant insights into its spatial characteristics. The integration of slope data elucidated the role of terrain gradients in shaping river courses and channel patterns. Results highlighted distinct hydrographic features, such as meandering rivers in low-gradient areas and steep, confined channels in regions with higher slopes. This comprehensive understanding of hydrographic morphology provides valuable insights for watershed management and environmental conservation efforts in the Kert basin.

3.2. Hydrographic Network Organization

Types of Present Watercourses In the Kert basin, there is a presence of dendritic and parallel hydrographic networks, reflecting local geomorphological diversity. Dendritic networks feature numerous converging watercourses toward a main channel, while parallel networks have multiple watercourses flowing parallel to each other. These configurations are influenced by the topographical and geological characteristics of the region, where valleys carved by erosion or gently sloping plains may favor the emergence of such drainage patterns. Geological and hydrological processes that shaped the local landscape have also contributed to the formation of these hydrographic networks. Dendritic and parallel networks play a vital role in rainwater drainage, distribution of water resources, and structuring aquatic ecosystems in the region.

Connections Between Watercourses In the Kert basin, both dendritic and parallel hydrographic networks coexist, the role of faults is crucial for understanding the configuration and hydrological dynamics of the region. The presence of faults in the Kert basin, Carlier (1973) identified several faults that are integral to the region's geological structure. Among these faults are the Fault, each contributing to the basin's complex tectonic history. These fault systems exert a notable influence on the hydrographic network, delineating preferential drainage pathways and shaping the course of rivers and streams. Understanding the interplay between these fault systems and the hydrographic network is crucial for deciphering the basin's geological evolution and comprehending its hydrological dynamics. The hydrographic network suggests that the network is significantly shaped by tectonic activity, with normal and strike-slip faults playing a significant role. These structures guide the flow of rainwater and rivers along these geological discontinuities, contributing to the formation of parallel hydrographic networks. Watercourses appear to follow the trace of faults over long distances, reflecting the geological influence on the hydrographic network's configuration in the region. Second, faults may also play a role in the formation of dendritic hydrographic networks by influencing the morphology of the surrounding landscape.

3.3. Discussion

In the Kert basin, located in the northeast of Morocco, the interaction between the organization of the hydrographic network and the landscape morphology is a crucial study subject for understanding regional hydrological dynamics, dendritic and parallel hydrographic networks coexist in this region. Geological faults of Nekour, Azlaf and Driouch may also play a role in the geochemistry and water quality of watercourses. Faults can serve as infiltration pathways for surface water, facilitating the recharge of underground aquifers and influencing the chemical composition of groundwater and surface water. This can have significant implications for water supply and water resource management in the region.
watercourses [5,10,29]. These structures influence the direction and pathway of rainwater and river flow, contributing to the formation of parallel hydrographic networks over long distances. Morphological landscape features, such as the mountainous reliefs of the Rif and Middle Atlas, also have a significant impact on the organization of the hydrographic network [30, 31]. Mountains provide essential water sources and influence the direction of watercourse flow. Valleys and intermediate plains created by erosion host hydrographic networks that often follow dendritic patterns, converging toward main watercourses.

This interaction between the organization of the hydrographic network and landscape morphology has major implications for water resource management in the Kert basin. Planning water resources, flood management, and the conservation of aquatic ecosystems depend on a thorough understanding of these processes [32]. Furthermore, sustainable water resource management in the region must consider the complex geomorphological and hydrological factors shaping the hydrographic network of the Kert basin.

4 Conclusion

In conclusion, our investigation into the hydrography and landscape morphology of the Kert basin underscores the intricate relationship between hydrographic network organization, geological faults, and regional dynamics. The basin displays both dendritic and parallel hydrographic networks, with geological faults playing a crucial role in shaping drainage patterns. Serving as geomorphological guides, these faults significantly influence the development of parallel and dendritic networks, directing watercourses along distinct geological features. Additionally, our study reveals that geological faults not only dictate water flow but also wield substantial influence over landscape morphology. Tectonic movements along faults contribute to the creation of reliefs and valleys, impacting the convergence of watercourses and fostering the formation of dendritic networks. Furthermore, these faults act as vital infiltration pathways, influencing the geochemistry and water quality of the watercourses, thereby holding significant implications for water supply and resource management in the Kert basin. The findings emphasize the necessity of understanding the complex interplay between hydrographic network organization, geological features, and landscape morphology for effective water resource management and sustainable development in the region.

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