Recent morphological trajectories of the near-natural Vjosa river and its tributaries at the catchment scale

Dynamiques morphologiques récentes du fleuve quasi naturel Vjosa et de ses affluents à l'échelle du bassin versant

Marta Crivellaro[1], Livia Serrao[1], Walter Bertoldi[1], Alfonso Vitti[1], Bestar Cekrezi[1], Guido Zolezzi[1]

[1] University of Trento, Via Calepina, 14, 38122 Trento TN Italy
marta.crivellaro@unitn.it

RÉSUMÉ

Les grands fleuves quasi naturels sont très rares en Europe. Parmi eux, le fleuve Vjosa/Aoos (GR, AL) a été reconnu comme un grand corridor fluvial clé, un écosystème modèle significatif. Dans cette étude, nous considérons les trajectoires morphologiques récentes à l'échelle du bassin versant du fleuve Vjosa et de ses affluents. On couple la reconstruction des ajustements du canal actif au cours des 35 dernières années à partir d'images satellites Landsat avec l'analyse des facteurs de changement possibles à l'échelle du bassin versant. Bien qu'il soit largement reconnu comme un système fluvial "sauvage", le rétrécissement des chenaux et la simplification du modèle morphologique ont récemment eu lieu dans plusieurs tronçons analysés. Depuis la fin des années 1980s, des pressions anthropiques peuvent être identifiées à différentes échelles spatiales et temporelles, notamment l'extraction de sédiments, la modification du débit à la source du Vjosa, la protection des rives dans la plaine. Globalement, notre analyse met en évidence la présence des pressions anthropiques dans le bassin versant de la Vjosa agissant à différentes échelles spatiales, et elle représente un étude de base pour la gestion du cours d'eau.

ABSTRACT

Very few large near-natural rivers can still be found in Europe. Among them, the Vjosa/Aoos River (GR, AL) has been recently recognized as a key large fluvial corridor, a significant model ecosystem. In this work we investigate the catchment-scale recent morphological trajectories of the Vjosa river and ofits tributaries. We couple the reconstruction of channel adjustments over the past 35 years from Landsat satellite images with the analysis of the possible drivers of change at the catchment scale. Despite a widespread appearance as a "wild" river system, channel narrowing and simplification of the morphological pattern have recently occurred in several analyzed reaches. Especially from the late 1980s, human pressures can be identified at different spatial and temporal scales, including sediment mining, flow regime alteration at the headwaters, extensive bank protection of the lowland reaches. Overall, our analysis provides a supporting hydro-morphological baseline knowledge that was missing so far and that is crucial for the sustainable management of such a higly valuable an unique river corridor.

KEYWORDS

Hydromorphology, Human pressures, Multitemporal Analysis, Recent Morphological Trajectories, Vjosa River

1 EXTENDED ABSTRACT

1.1 Introduction

The interest in near-natural rivers has recently increased, together with the recognition of the dramatic decrease of freshwater biodiversity, linked to the growing extent of river fragmentation. This is of particular concern in densely populated regions of the world where human pressures have affected river systems, especially in larger catchments; thus, large free-flowing rivers are particularly rare.

Besides their natural value, these systems offer the opportunity to observe and investigate riverine processes as they would occur under minimal anthropic pressure and represent fundamental references for river management, particularly river restoration. At least in temperate climates, large free-flowing rivers still retain a high morphological dynamicity in their river corridors at multiple time and spatial scales. While studies on free-flowing rivers have mainly addressed connectivity, freshwater biodiversity, water, energy security, and ecosystem value, investigations of their natural morphological dynamics are quite rare.

Many studies have focused on the evolutionary trajectories of rivers subject to strong human modifications (Stecca et al. 2019, among others). Little is known, instead, on the natural trajectories of morphological evolution under minimal human effects - or near natural/near pristine conditions. In this work, we contribute to filling this gap by quantifying recent morphological trajectories of the Vjosa/Aoos river and its tributaries in Albania. We analyze the possible drivers of change, providing a supporting baseline for river management with an integrated approach, implementing a multitemporal analysis of channel changes (1985-2020) in a selected sample of reaches of the Vjosa river and its main tributaries and possible change drivers. To this aim we quantify human pressures - sediment mining, hydropower plants, land-use changes - and climate variability, integrating locally collected data with publicly available remote sensing information.

1.2 Methods

1.2.1 Study area

Aoos-Vjosa river originates at the base of Pindos mountains (GR) and extends over 272 km from its sources, through the south of Albania to the Adriatic sea, with a total catchment size of 6704 km2. Flowing in a SE-NW direction, the river is joined by several tributaries, among them, the most relevant are Voidomatis, Sarandoporo, Langarica, Drinos, Bënçë, Shushica. Most of the catchment is covered by carbonates overlain by flysch, and in the SE part of the catchment includes recent alluvial deposits. The climate shifts downstream from Alpine to Mediterranean and the hydrological regime is pluvio-nival. Our study focuses on eight reaches with different morphologies and confinement statuses. We analyzed four reaches along Vjosa's main course and four along its main tributaries (Sarandaporo, Shushica, two reaches along the Drinos river), proposing a reach scale approach to analyze the morphological trajectories behavior at the watershed scale.

1.2.2 Materials and methods

We identified the hydro-morphological dynamics of the river system reconstructing the channel adjustments over the past 35 years from Landsat satellite images. A semi-automatic procedure has been implemented, selecting one representative Landsat summer scene (one every 5 years) for the analysis. Thus, we integrated the planform analysis with available flow data of 3 gauging stations (1958-2000) and ERA5 total precipitation reanalysis (1950-2020). To quantify drivers of change at the watershed scale, Landsat temporal segmentation algorithm to reconstruct forest cover dynamics (1985-2020) was applied, along with an analysis of Google Earth available images to map in-channel sediment mining sites and riverbanks control works at the watershed scale. Finally, available literature was considered to assess operating hydropower plants' pressure.

1.3 Results and discussion

Channel narrowing, and possibly incision characterize the semiconfined braided reaches of Vjosa and Shushica. Channel narrowing, and/or simplification of the morphological pattern also occurs in reaches further downstream Vjosa river with a wandering and sinuous morphology, as well as in the analyzed reaches of the Drinos, while Sarandaporo shows no significant changes in the active channel but a great dynamicity of vegetation cover without any clear trend along the observed period. An increasing trend in vegetation cover can be noticed in the Shushica reach and Vjosa braided reaches, associated with the narrowing of the active channel. The only driving variable that shows quantifiable changes until the late 1980s is the flood regime, with a marked decrease in the frequency, duration, and volume

above the bankfull threshold of the winter - early spring floods in the 1958 - 1990 period, which are the events competent to drive morphological change. Climatic trends shown by 2 monthly and 1 daily flow records in 3 different hydrometric stations are highly coherent with those emerging from ERA5 rainfall reanalysis on the catchment. From the late 1980s, Human pressures can be identified at different spatial and temporal scales, with a flow regime alteration due to Pigai Hydropower Plant at Aoos Springs and an increase in sediment extractions and channelization along the hill-lowland course of Vjosa main course and Shushica river, due to the abrupt socio-economical system change in Albania.

The system appears to be sensitive to human intervention particularly in the lower part of the catchment, while in its the upper part some localized, minor human pressures can be identified in the main riverside villages, with no clear link to the river morphological response (Fig.1).

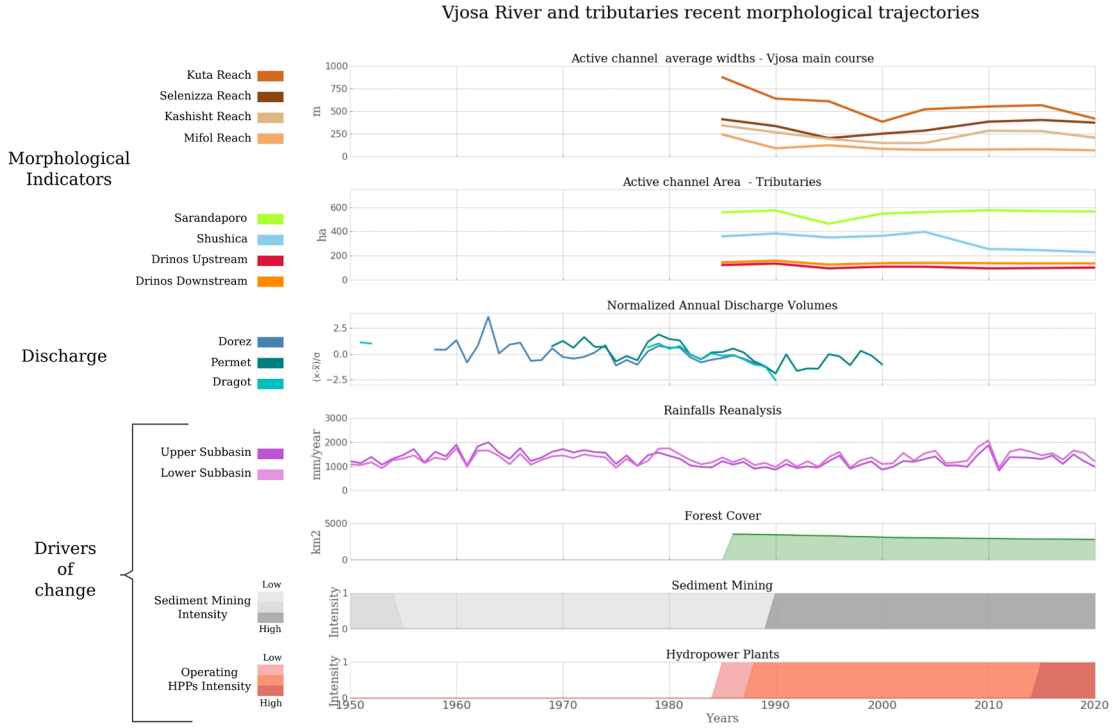

Fig.1 Morphological indicators, discharge, and analyzed drivers of change

1.4 Conclusion

Despite the Vjosa river system is considered near-natural (Schiemer et al., 2020), our analysis highlights the presence of anthropic pressures in the catchment acting at different spatial and time scales. While the river can be still considered free-flowing in terms of water discharge, our results show anthropic alterations of in-channel sediment sources and their importance in driving decadal-scale morphological change, along with changes in the flood regime. Coupled with the present fragmentation and paucity of hydromorphological information on the Vjosa river corridor, our results further underline the importance of improving regular monitoring of river flow and channel morphology. This would allow to build the needed knowledge base to address the management challenges posed by many proposed water infrastructures (especially hydropower reservoirs) that can threaten the unique environmental value and related ecosystem services within the Vjosa river corridor.

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