INTERACTIONS BETWEEN RIVER AND COASTAL SEDIMENTARY BALANCE AND EFFECTS OF HYDRAULIC WORKS ON SHORELINE CHANGES

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INTRODUCTION

After the end of the Second World War, a notable anthropogenic pressure was observed in most of the Mediterranean areas (Barragán and De Andrés, 2015). Consequently, the expansion of existing settlements and the construction of numerous new towns took place, often instead of dunes, beaches, and river areas (Foti et al., 2022a,b,c,d).

Another consequence of this process is the construction of infrastructures and hydraulic works, such as levees, dams, and check dams (Graf, 2006; Boix-Fayos et al., 2007; Ylla Arbos et al., 2021; Garcia-Martinez and Rinaldi, 2022). These works have often altered the river sedimentary balance with hydrological, sedimentological, and ecological consequences (Brown et al., 2018). This alteration also affects the coastal sedimentary balance. Indeed, the river sediments can reach the beaches near the river mouths and can act as a natural nourishment. On the contrary, a low sediment transport or a trapping of the sediments behind hydraulic works without reaching the mouth can cause shoreline erosions. Therefore, coastal and river dynamics should be analyzed as an integrated system (Acciarri et al., 2016; Besset et al., 2019; Bombino et al., 2022a).

The paper, through a case study, analyses the interactions between river and coastal sedimentary balance and the effects of the construction of hydraulic works on shoreline changes. The case study is Calabria in general and the Gallico River in particular. Calabria is a region of Southern Italy that is an interesting case study due to its geomorphological, climatic, hydrological, anthropogenic, and hydraulic works peculiarities (Petrucci and Polemio, 2007). Gallico River is an interesting case study because is affected by an intense hydraulic regulation program where 264 check dams were made (Bombino et al., 2022a).

METHODOLOGY

The methodology is divided into four main phases:

1) Estimate of the sediment trapped behind the check dams of the Gallico River using the approach of Bombino et al. (2022b).
2) Evaluation of the shoreline changes near the Gallico River mouth, based on the estimation of linear movement (LM), longshore width of the changed shoreline (LCW), eroded/increased beach area (A) and eroded/increased beach volume (EV) within various time periods.
3) Analysis of the correlations between sediment trapped behind the check dams of the Gallico River and the shoreline changes near the river mouth.
4) Extension of this analysis in river intensively regulated with check dams and in river with few check dams.

HYDRAULIC WORKS IN CALABRIA

In the first half of the 1950s a series of flood events affected most of the Calabrian territory causing economic and human losses. Consequentially, the Italian Government has issued Special Laws, also financing the construction of hydraulic works (first regulation program, occurred between the 50s and 60s). These funding were followed by a second regulation program in the 70s and by an integrative program occurred between the 80s and 90s (Bevilacqua, 1987; Petrucci and Polemio, 2007). The total funding from the 50s to the 70s, discounted to 2020, would have been equivalent to about 8 billion euros, and was used for the construction of hundreds of kilometers of embankments, about 150000 ha of reforestation, and more than 8000 check dams, especially in the Strait of Messina. About the 2/3 of these check dams are concentrated in the lower river areas with elevations between 0 and 350 m (Fig. 2) (Bombino et al., 2022a).

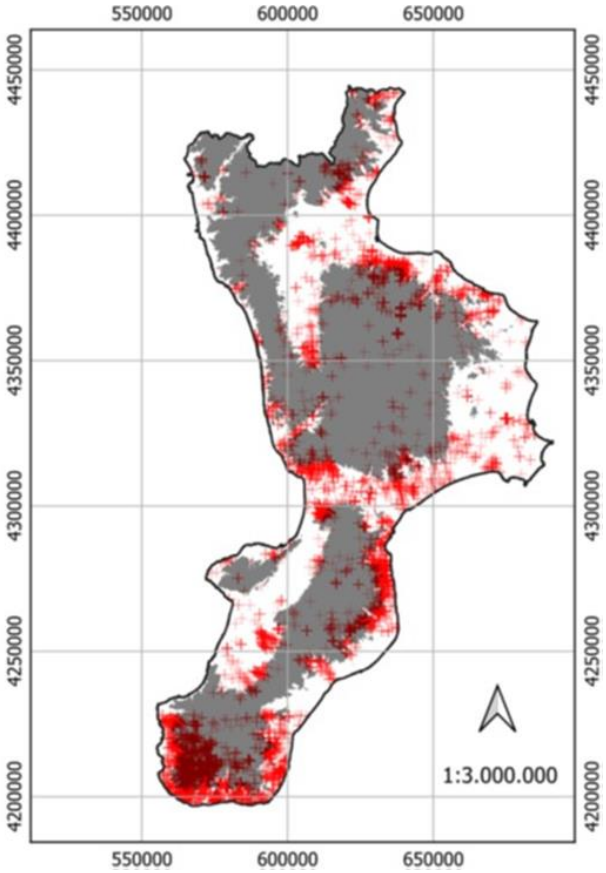

Figure 1 – Location of Calabrian check-dams. Legend: red = check dams; white = territories with elevations between 0 and 350 m; grey = territories with elevations greater than 350 m. (Source: Bombino et al., 2022a)

RESULTS AND DISCUSSION

264 check dams were built along the Gallico River, with a density of almost 5 check dams per square kilometer. 65 check dams are in the mountain reach, 40 are in the intermediate reach and 159 are in the valley reach. Of these, about 200 check dams were built during the first regulation program, about 50 check dams were built during the second regulation program and only 15 check dams were built during the integrative program. The estimated volume of sediment trapped behind the check dams is approximately 1 million cubic meters, more than half of which in the valley section alone.

Regarding shoreline changes, at the Gallico River mouth shoreline retreats are observed during all regulation programs, with values of about 15 m during the first program; of about 65 m during the second program; more than 20 m during the integrative program. From the end of the latter program up to date, a shoreline advancement of just over 5 m was observed, so the shoreline retreat from the start of the construction of the check dams to date is over 90 m while the overall eroded volume is greater than 400000 m^3.

Therefore, these changes show a strong correlation between the construction of check dams, with consequent accumulation of sediments behind them, and the shoreline changes. Further confirmation of this correlation can be observed by analyzing the effects of an intervention of recalibration and restoration of the riverbed carried out in 2015 in the two terminal kilometers of the Gallico River. With this intervention, more than 50000 m^3 of sediments were removed and a significant increase in the shoreline at the mouth was observed. To confirm the filling times behind the check dams and the quantity of sediments trapped, a survey was carried out in 2020 which showed that in just 5 years the pre-intervention longitudinal profile of the Gallico River was almost reached and that over 40000 m^3 of sediment were trapped behind the check dams.

This analysis has been extended to other Calabrian rivers considering rivers intensely settled with check dams, such as the Gallico River, and rivers with few check dams, used as a control group. Significant shoreline retreats were observed at the mouths of intensely settled rivers while such trend was not observed in the coastal area near the control group.

CONCLUSIONS

The paper, through a case study, analyses the interactions between river and coastal sedimentary balance and the effects of the construction of hydraulic works on shoreline changes. The case study is Calabria in general and the Gallico River in particular.

The main result of this analysis is that the alteration of the river sedimentary regime caused by the construction of check dams strongly influences the shoreline evolution near river mouths. Another important result is that the greatest negative effects induced by the construction of check dams are obtained if they are built in the river valley part. This result agrees with the very nature of these interventions, which are particularly useful for stabilizing river sections with steep slopes and erosion, but not very suitable for valley sections generally characterized by gentle slopes.

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