Effects of flow regulation on the Geomorphic Status of rivers in Spain


INTRODUCTION

- Channel forms
  - Water flow
  - Sediment flux
  - Basin landscape features

- Quasi-equilibrium through spatial and temporal dynamic balance

- Dams
  - Artificial flow regime
  - Interrupt sediment transfer
  - Change pattern erosion/deposition

- Mediterranean river’s
  - High variability

- Dams located Mediterranean river’s
  - Greater impact than in humid regions

- Hydrological regime
  - Geomorphological processes
INTRODUCTION

Objectives

Examine the effects of dams on channel geomorphology in 74 SCARCE river reaches

O1. Analyze physical and climate characteristics

O2. Hydrological and flow regimes changes

O3. Geomorphological changes ➔ Geomorphic Status (GS) Index

O4. Degree of impact, hydrologic and geomorphic responses

<table>
<thead>
<tr>
<th></th>
<th>Storage capacity (hm³)</th>
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<tbody>
<tr>
<td></td>
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<tr>
<td>Llobregat</td>
<td>1</td>
</tr>
<tr>
<td>Júcar</td>
<td>2</td>
</tr>
<tr>
<td>Guadalquivir</td>
<td>3</td>
</tr>
<tr>
<td>Ebro</td>
<td>3</td>
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</table>

47 sites downstream from dam

27 sites upstream from dams
Total sampling points

N = 74

O1. Multivariate analysis

N = 46

N = 42
O1. Analyse physical and climate characteristics

- 9 physical and climatic variables → Spearman correlation → PCA
- 5 remaining variables → 4 subregions by k-means clustering method
RESEARCH WORKFLOW

Total sampling points

O1. Multivariate analysis

O2. Hydrological analysis

Not Regulated

Regulated

N = 74
N = 46
N = 16
N = 30
O2. Hydrological and flow regimes changes

**Regulated sites**
- Hydrologic Alteration software (Richter et al., 1996)
- Day mean annual flow
- Return period of 2, 10 and 25 years

Ratio between post and pre-dam record  ➔ **Effect of regulation**

| 8 variables | Magnitude & Frequency |

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![Box plot graph](image_url)
O2. Hydrological and flow regimes changes

Not Regulated sites

- Hydrologic Alteration software
- Linear regression

Some sites have **significant changes** in the frequency and magnitude of annual floods.

<table>
<thead>
<tr>
<th>Site</th>
<th>DMF</th>
<th>NLF</th>
<th>NHF</th>
<th>NR</th>
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<tr>
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<td>0.056*</td>
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<tr>
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</table>

Reflect the influence of other factors:
- Climate variability
- Land uses changes
- Water abstractions
O2. Hydrological and flow regimes changes

Hydrologic characteristics of each cluster

Cluster 1:
• > number of low flow events
• > number of high flow events

Cluster 2:
• > day mean annual flow

Cluster 3:
• > day maximum flow
• < base flow
• < number of low flow events
• < number of high flow events

Cluster 4:
• intermediate behaviour
RESEARCH WORKFLOW

Total sampling points

O1. Multivariate analysis

O2. Hydrological analysis

O3. Geomorphological analysis

Not Regulated

Regulated

Regulated

Not Regulated
O3. Geomorphological analysis (Geomorphic Status index – GS)

1. Total number of bars (NB) → Channel complexity
2. Number of active bars (NA) → Unstable features → Inundated during high flows
3. Number of vegetated bars (NV) → Stable forms → Only inundated during larger floods
4. Mean active channel width (W)

\[ GS = SU + SA + BS + CF \]

Changes in Sedimentary Unities, Changes in Channel Flow Capacity

> 4 Increment of the geomorphological activity
= 4 No change in the sedimentary unities
< 4 Channel stabilization or degradation
O3. Geomorphological analysis

Historical

Current
O3. Geomorphological analysis

Results

- Rivers in cluster #1 showed the greater decline in the sedimentary activity
- Cluster #1 are headwater sites that generally have a great potential for bedload transport,
RESEARCH WORKFLOW

Total sampling points

N = 74

O1. Multivariate analysis

N = 46

O2. Hydrological analysis

N = 16

Not Regulated

Regulated

N = 30

O3. Geomorphological analysis

N = 42

Regulated

Not Regulated

N = 31

N = 11

O4. Degree of impact, hydrological and geomorphic responses

N = 19
## O4. Degree of impact, hydrologic and geomorphic responses

<table>
<thead>
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<th>DMF</th>
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<th>NHF</th>
<th>NR</th>
<th>Q₂</th>
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<th>Q₂₅</th>
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<td>0.09</td>
<td>0.57*</td>
<td>0.49</td>
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</tbody>
</table>

- **Reduction in reach complexity, active bars** and the increment in vegetated bars are positively correlated with a decrease in the magnitude relatively frequent floods (Q₂).
- Relatively frequent floods **transport** most of the sediment over the long term and perform most of the **geomorphic work** in the channel; it is related to the bankfull level.
CONCLUSIONS

1. Regulation of Iberian rivers causes long-term decrease in the annual stream flow and in the **magnitude and frequency of floods**. These hydrological changes result mainly in the **loss of active bars** as they are encroached by vegetation, to the point that only sites with little regulation display active bars.

2. **Headwaters** sites are especially affected by regulation, reducing their dynamism and pushing them to have low-energetic processes (somehow resembling the dynamics intensity of lowland rivers e.g. Cluster #2).

3. The **reduction in reach complexity** relates positively with the **decrease in the magnitude** and frequency of high flows \((Q_2)\) and the degree of regulation \((IR)\).

THANKS FOR YOUR ATTENTION