The impact of land use change, climate change and reservoir construction on ecosystem services in a Mediterranean catchment

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The **Mediterranean region** has been identified as one of the most affected global hot-spots for **climate change**, which is already manifested by faster increasing temperatures than the global mean and significant decreases in annual precipitation. Besides, over the past decades, important **land cover changes** have occurred, such as reforestation, agricultural intensification, urban expansion and the construction of many reservoirs.

Here we study the impacts of these changes in the **Segura River catchment** (16000 km², SE Spain), a typical large Mediterranean catchment, and focus on relevant **ecosystem services**, i.e. primary production, water supply, food production, water regulation, flood and erosion control, and cultural ecosystem services. These ecosystem services were quantified with 8 indicators, divided over spatially distributed and point indicators.

We applied the **hydrological model SPHY**, coupled with a **soil erosion** and **sediment transport** model for the period 1971-2010. We defined 4 scenario runs to allow to study the isolated impact of **land use change**, **climate change** and **reservoir construction**, as well as their **combined** impacts.

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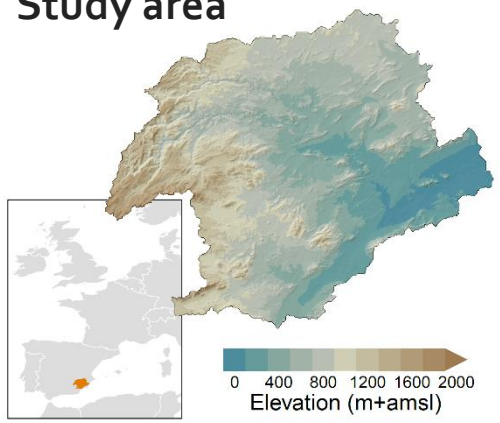
Study area

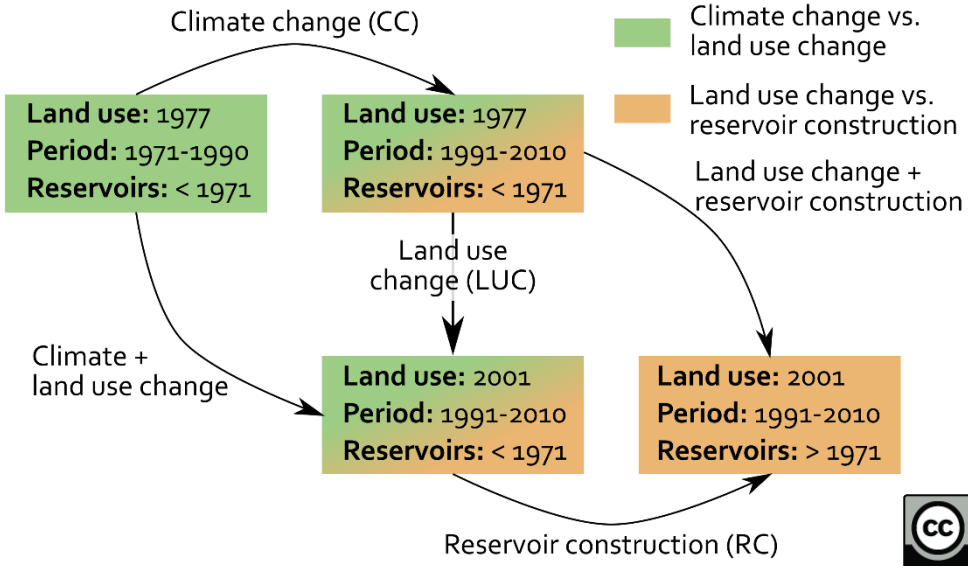


Ecosystem services and indicators

Ecosystem services		Indicator
Group	Subgroup	
Supporting	Primary production	Plant water stress[a]
Provisioning	Water supply	Runoff
		Reservoir storage
	Food production	Plant water stress[b]
Regulating	Water regulation	Low flows
	Flood control	Flood discharge
	Erosion control	Hillslope erosion
		Sediment yield
		Sediment concentration
Cultural[c]		Plant water stress[d]

[a] For natural land use classes, [b] for agricultural land use classes, [c] including the aesthetic and recreational subgroups, [d] for urban land use classes

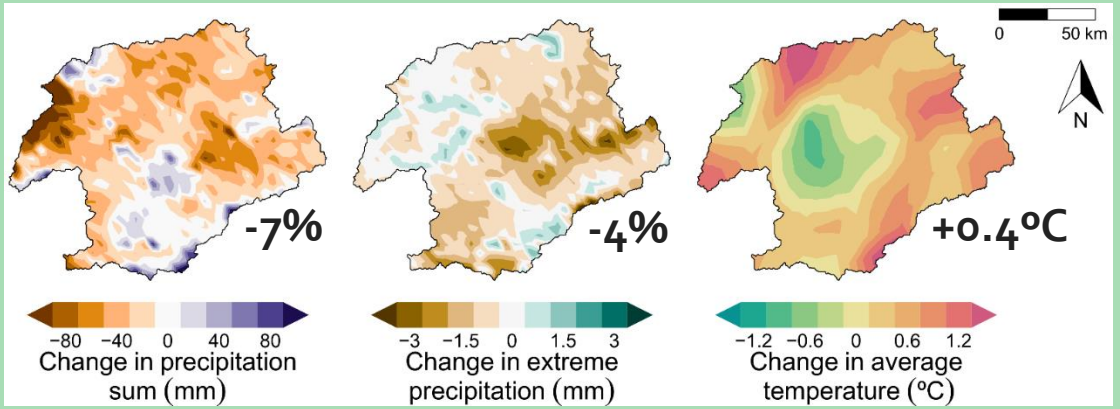
Scenario runs

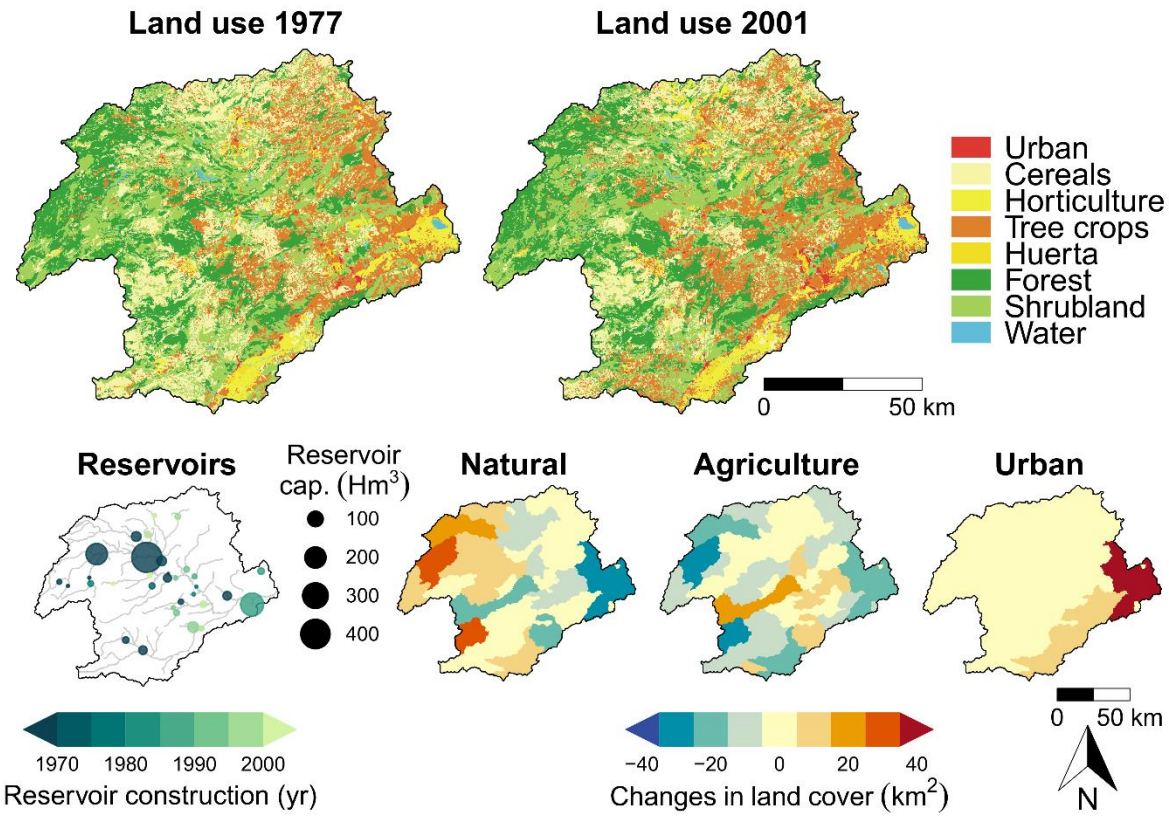


Climate change, land use change and reservoir construction

Historical climate change (1971-1990 vs. 1991-2010)

- **Annual precipitation sum** has **decreased** with 7%, from a catchment-average of 402 mm to 376 mm and most notably in the headwaters.
- **Extreme precipitation** also **decreased** in the same period, with a catchment-average decrease of 4.0%.
- The **average temperature** has **increased** with 0.4 °C from a catchment-average of 14.8 to 15.2 °C.

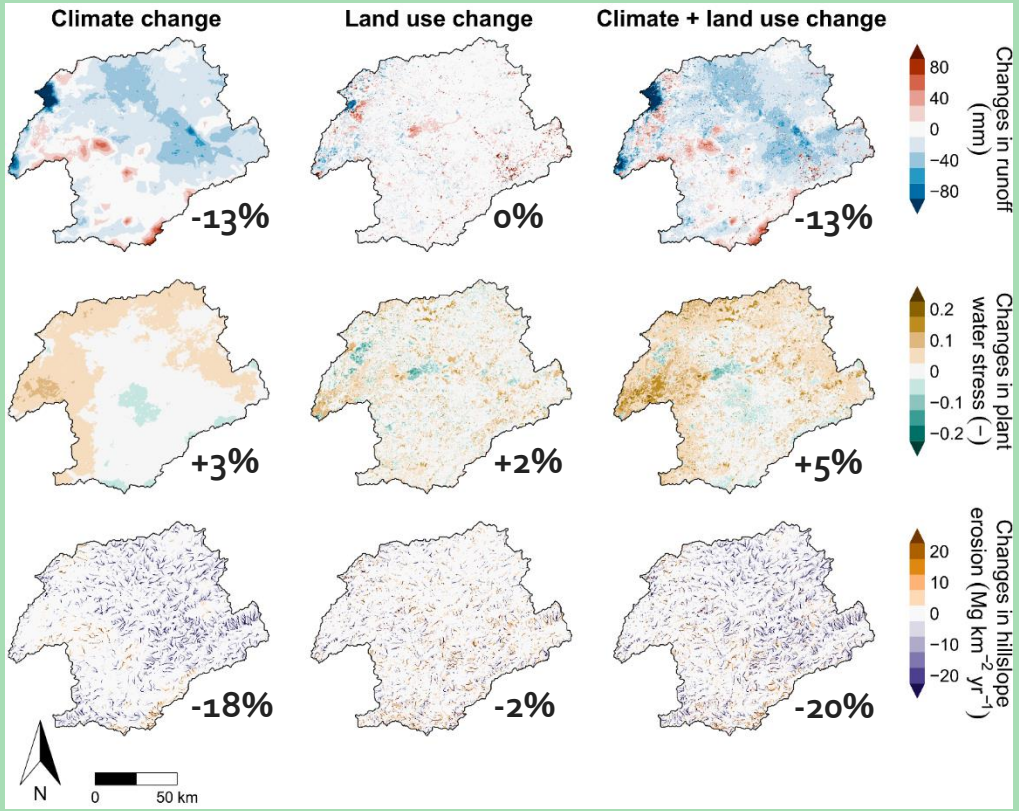




Land use change and reservoir construction

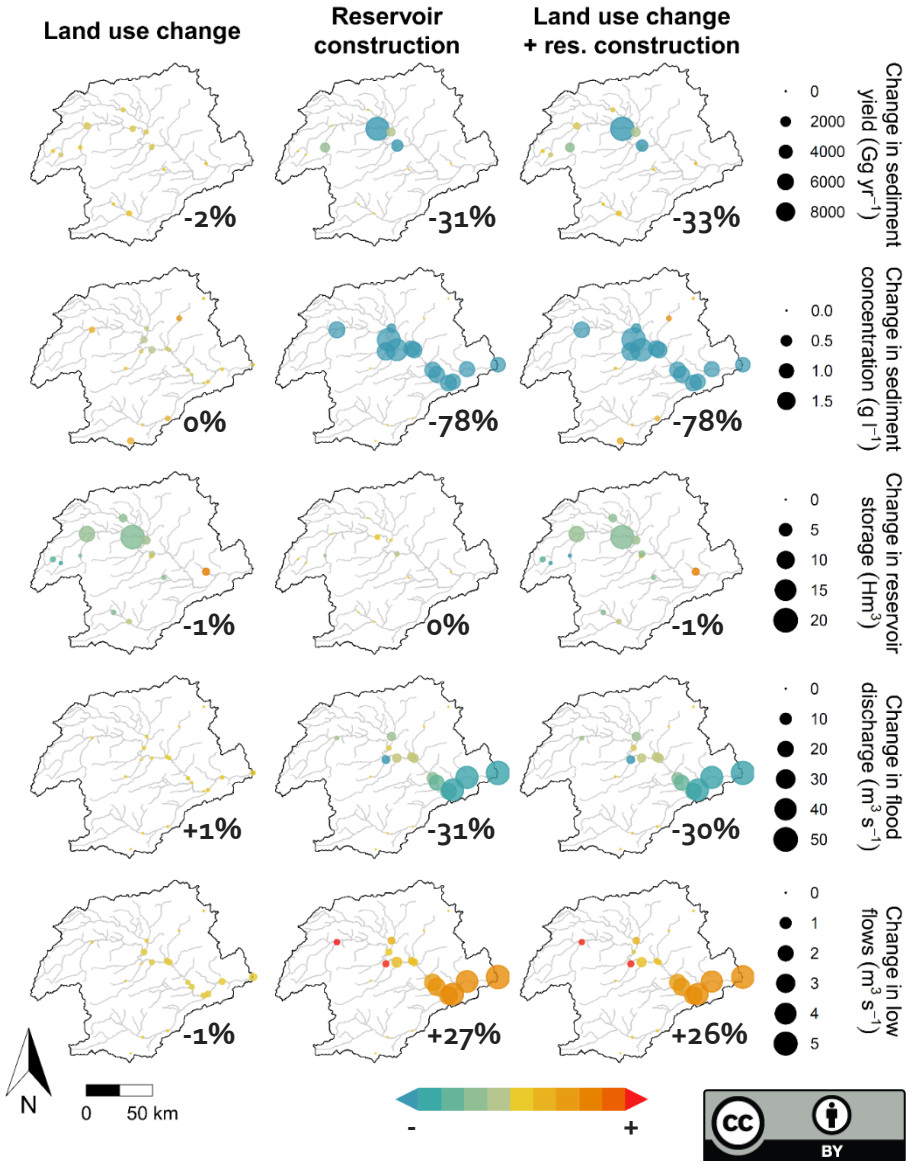
- The land use in the Segura River catchment is dominated by **natural** (53%) and **agricultural** land use (45%).
- Between 1977 and 2001, land use changed in **34%** of the catchment and can be characterized by a **agricultural land abandonment** and **reforestation** in the headwaters and **agricultural intensification** and **urban expansion** in the downstream areas.
- Since 1971, the number of **reservoirs increased** from 13 to 33, leading to an increase in the reservoir capacity from 820 to 1230 Hm^3.

Impacts on ecosystem services indicators



Impact on spatial distributed indicators

- **Climate change** had a **bigger impact** on the spatial distributed indicators than land use change over the study period, causing a **decrease in runoff** and **hillslope erosion**.
- **Plant water stress increased** in all scenarios, most strongly by the combined effect of climate and land use change.



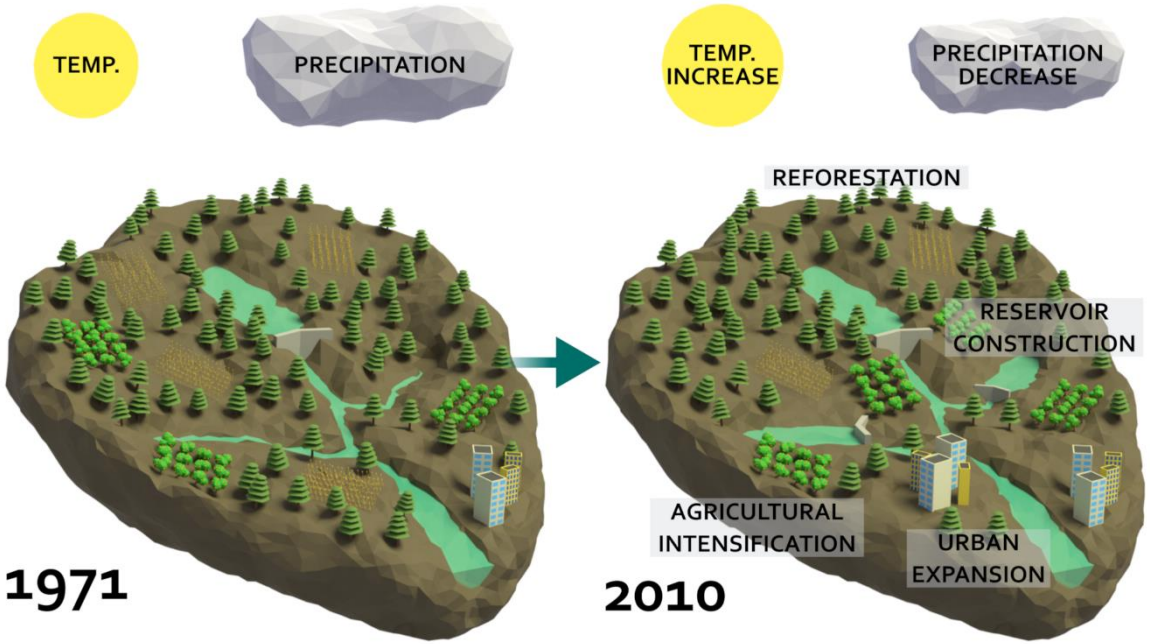
Impact on point indicators

- **Land use change** caused a **decrease** of reservoir storage in the headwater catchments.
- **Reservoir construction** had a more profound effect on all other indicators and included a **decrease** of sediment yield, sediment concentration and flood discharge and an **increase** in low flows.

Summary & conclusions

Summary

- Climate change in the period 1971-2010 is characterized by a **decrease in precipitation** and an **increase in temperature**.
- Land use change is characterized by **agricultural land abandonment** and **reforestation** in the headwaters and **agriculture intensification, urban expansion** and **reservoir construction** in the central and downstream part of the catchment.
- The changes that have occurred over the past 70 years can be considered **typical** for many **Mediterranean** catchments.



Conclusions

- These changes had **positive** (e.g. flood control, erosion control) and **negative** impacts (e.g. water supply, food production) on **ecosystem services** relevant for Mediterranean environments.
- **Grey infrastructure** (i.e. reservoir construction) may have had a **positive impact** on some of the ecosystem services considered here (e.g. flood discharge), however, it also increases the **dependency on reservoir storage** and may have led to an increase of **irrigated agriculture**, increasing the **pressure** on reservoir storage and groundwater resources.
- We argue that a shift is needed to **green infrastructure**, such as **reforestation** and **sustainable land management**, which may lead to similar benefits on ecosystem services, but **without the negative impacts** caused by grey infrastructure, such as habitat loss and an increase of water demand.

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