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INTRODUCTION

The Water, Energy, Food, and Ecosystem (WEFE) Nexus approach facilitates understanding the intrinsic linkages and daunting global challenges pertinent to water, energy, food, and ecosystem security. This approach was employed for system dynamic assessment of the 7 Sardinia subbasins, to provide a transparent and evidence-based framework for identifying synergies and trade-offs that support sustainable development.

RESEARCH SITE

Sardinia is the second biggest island of the Mediterranean Sea. Approximately 75% of the region's water supply is derived from surface water, which makes the region vulnerable to prolonged droughts. In the Sardinia region, the major consumer of water is agriculture (70%), and irrigated crop areas are notably increasing due to agriculture intensification. Under climate change, crops are demanding more water, especially during critical growth stages, worsening seasonal water scarcity in the region. The competition for surface water resources among the agriculture, domestic and tourism sectors, and environmental requirements implies challenges linked to water availability

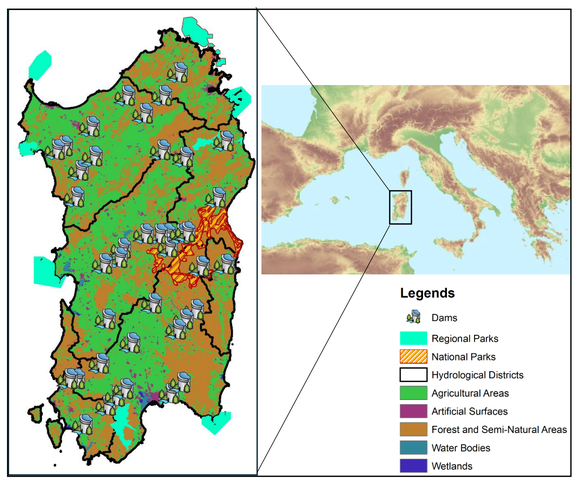

Fig 1. *Hydrological subbasins and land use of Sardinia.*

MATERIALS AND METHOD

The qualitative analysis within the WEFE nexus framework utilizes different tools to assess the WEFE systems. This research utilized the qualitative tools Hoff WEF Nexus analytical framework and Causal Loop Diagram (CLD) for the WEFE nexus assessment. In this study, the R – WEFE Nexus platform was utilized to analyse interlinkages and budgeting between WEFE sectors in seven hydrological subbasins of the Sardinia Region. The R – WEFE Nexus platform facilitated the comprehensive assessments of the water, energy, food, and ecosystem sectors in a holistic way in Sardinia region. Particular emphasis in this work highlights trade-offs to enforce strategic management of vital Minimum Environmental Flows (MEF) on water supplies and other sectors.

Strategic Management policies for Environmental flow management (MEF): when reservoir storage exceeds 20% of capacity, 20% of monthly basin runoff is released; if storage is between 10–20%, release 10%; below 10%, no release

RESULTS

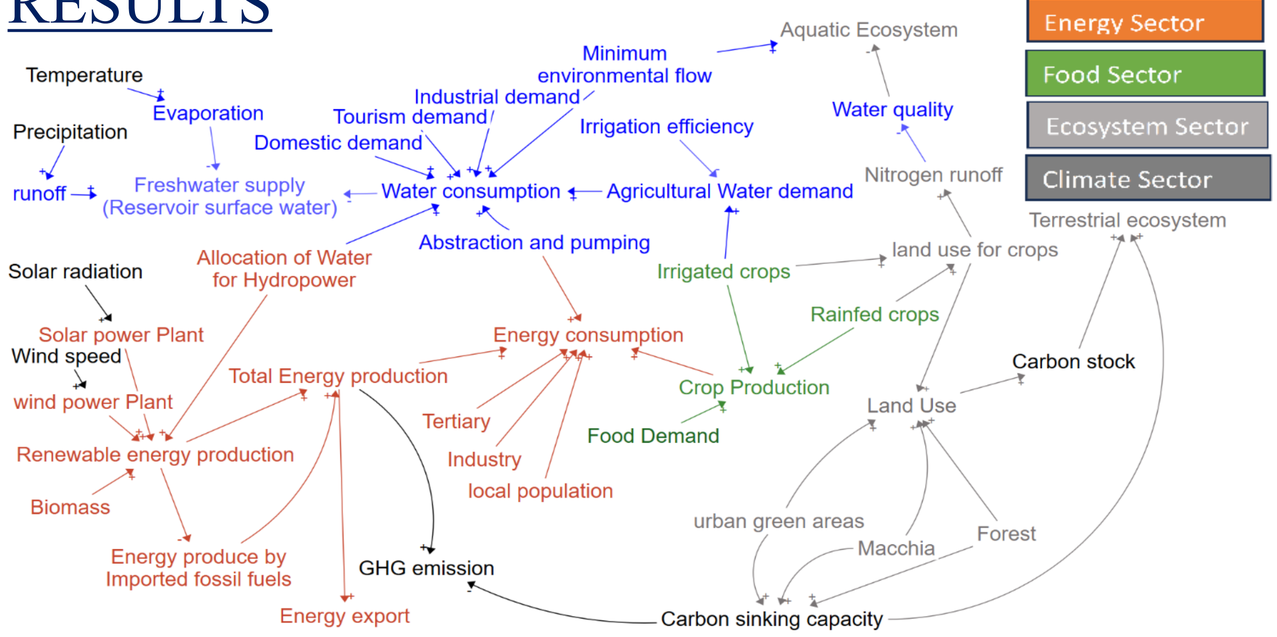

Fig 2. *Causal Loop Diagram (CLD) illustrating the core dynamic of the Sardinia region.*

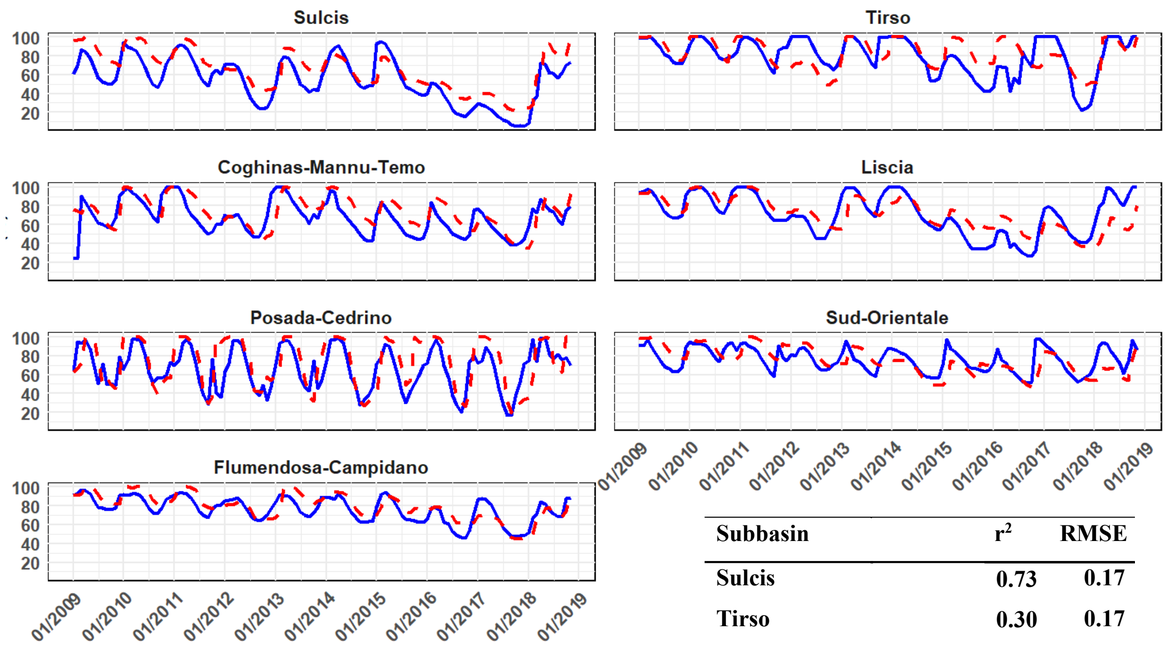

Fig 3. *Simulated (Red) vs Observed (Blue) reservoir water storage (%) across Sardinia hydrological subbasins.*

Subbasin	r^2	RMSE
Sulcis	0.73	0.17
Tirso	0.30	0.17
Coghinas-Mannu-Temo	0.43	0.16
Liscia	0.48	0.16
Posada-Cedrino	0.46	0.21
Sud-Orientale	0.25	0.14
Flumendosa-Campidano	0.61	0.09

Fig 4. *Reservoir status across hydrographic subbasins based on historical and future scenario (SSP126 and SSP585), without and considering MEF strategic management policies*

CONCLUSION

The assessment of WEFE Sectors in the Sardinia region highlights the critical interdependencies within the WEFE nexus framework and the challenges posed by socio-economic pressure, sectoral demand and climate change. Future climate conditions modelled under SSP126 and SSP585 are projected to precipitation decline, increasing variability, exacerbated water shortage and intensified competition between agricultural and urban water demand while maintaining the minimum environment flow for ecological functioning of ecosystems.

ACKNOWLEDGEMENTS

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