Supplementary Material S1. Complete list of variables, parameters and model equations

Stocks represent accumulative state variables, flows represent temporal exchanges between system components, auxiliaries correspond to intermediate calculations, and indicators synthesise system performance across WEFE dimensions. The conceptual equation column reports the analytical formulation used in the manuscript, while the implementation column summarises the corresponding representation in the Vensim model.

All references to CHS correspond to the Segura River Basin Management Plan 2022–2027 (Confederación Hidrográfica del Segura, 2022).

A. Water subsystem

Variable	Description	Units	Type	Subsystem	Source/Method	Conceptual equation	Vensim implementation
Sz	Regulated surface water availability in zone z	Mm^3 (million of cubic meters)	Stock	Water	Model output	$Sz(t+\Delta t)=Sz(t)+(Iz-Oz-Lz)$	Storage = INTEG(Inflow - Losses - Outflow)
GWup	Effective groundwater availability in the upper basin	hm^3	Stock	Water	Model output	Groundwater storage balance	Storage Aquifer = INTEG(Inflow Aquifer - Out Aquif)
Iz	Total inflows to basin zone z	hm^3/month	Flow	Water	TETIS outputs	River runoff + transfers	Includes runoff and TSA inflows
TSA	Tagus–Segura transfer inflow	hm^3/month	Flow	Water	TETIS outputs	Inter-basin transfer supply	ATS

B. Agricultural subsystem

Variable	Description	Units	Type	Subsystem	Source/Method	Conceptual equation	Vensim implementation
Ya	Actual crop yield	ton/ha	Auxiliary	Agriculture	FAO-33	Ya=Ym(1−RelativeLoss)	Computed through crop-specific production equations
Ky	Yield response factor	–	Parameter	Agriculture	FAO-33	Crop sensitivity to water stress	Crop-specific constants
Pag	Total agricultural production	ton/year	Indicator	Agriculture	Model output	Pag=ΣPc	Sum of production across crop groups

C. Energy subsystem

Variable	Description	Units	Type	Subsystem	Source/Method	Conceptual equation	Vensim implementation
EIi	Energy intensity coefficient of source i	kWh/m^3	Parameter	Energy	Melgarejo (2011); Morote et al. (2020); SCRATS (2021)	Energy consumed per unit of supplied water	Pump consump rate = 0.6; ATS consump rate = 1.2; Consump Rate Des = 4.17
E	Total energy consumption	GWh/year	Indicator	Energy	Model calculation	E=Σ(Volumei·EIi)	Sum of energy associated with pumping, desalination and transfers

D. Environmental subsystem

Variable	Description	Units	Type	Subsystem	Source/Method	Conceptual equation	Vensim implementation
EF	Ecological flow requirement	hm^3/month	Parameter	Environment	CHS RBMP 2022–2027	Minimum environmental flow thresholds	Defined according to RBMP ecological flow requirements
Defenv	Environmental water deficit	hm^3/month	Indicator	Environment	Model calculation	Defenv=Denv−Senv	Deficit UDAmb = Demand - Supply

E. Reliability and performance indicators

Variable	Description	Units	Type	Subsystem	Source/Method	Conceptual equation	Vensim implementation
Relst	Storage reliability	–	Indicator	Water	Reliability analysis	RelST=1−(Nfst/N)	Number of months below storage threshold
ThresholdST	Storage alert threshold	hm^3	Parameter	Water	CHS drought plan	Storage threshold used to classify failure conditions	Externally defined operational threshold

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