Data organization

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The present document summarizes the organization of the data for the WHAT-IF model and the HESS publication "WHAT-IF: an open-source decision support tool for water infrastructure investment planning within the Water-Energy-Food-Climate Nexus", it is a complement to the excel files. The data is divided into 5 excel files:

- MainFile: Is the configuration file, specifying the time steps, options and scenarios that are used by the model.
- WaterModule: Data supporting the Water module, including the hydrology (runoff, evapo-transpiration, precipitation, groundwater recharge, catchments …), the reservoirs and the environmental requirements
- AgricultureModule: Data supporting the Agriculture module, including farming zones, farm types, crops and cultures characteristics.
- CropMarketModule: Data supporting the crop market module, including crop markets, demands, value of crops, transport routes and food security constraints.
- EnergyModule: Data supporting the energy production and energy markets modules, including hydropower plants, other power plants, power technologies, fuels, energy markets, demands, value of energy and transmission lines.

The following sections detail all the parameters in the model, as presented in the HESS publication.

Water module

Table 1: Parameters of the Water module contained in the WaterModule.xlsx file. The parameters are called after their name in the HESS publication, but the name used in the python model is also indicated. The relevant pages of the sources are indicated in the excel files when available.

Notation in publication	Description	Parameter name in model	Excel sheet	Source
Indices				
c	Catchments	ncatch	Catchments	-
aq	Groundwater aquifers	naquifer	Aquifers	Not used
ts	Transfer schemes	ntransfer	TransferSchemes	Not used
r	Reservoirs	nres	Reservoirs	(World Bank, 2010)
u	Water users	nuser	WaterUsers	(World Bank, 2010)
Parameters				
q_{runoff}	Runoff	wRunOff	RunOff	(Cervigni et al., 2015)
$q_{recharge}$	Groundwater recharge	wGwRech	GroundRecharge	Not used
p	Rainfall	wRainFall	Precipitation	(Cervigni et al., 2015)
e_{T0}	Reference evapotranspiration	wET0	ET0	(Cervigni et al., 2015)
l_{river}	Water losses in the catchment	wFlowLoss	Catchments	Not used
$\bar{V}_{\mathrm{W}}$	Reservoir storage capacity	wResCap	Reservoirs	(World Bank, 2010)
k_{W}	Volume-Area linear coefficient	wkV	Reservoirs	(World Bank, 2010)
a_W	Volume-Area linear constant	wResArea	Reservoirs	(World Bank, 2010)
α_W	Reservoir outflow coefficient	wAlpha	Reservoirs	Not used
α_{GW}	Groundwater outflow coefficient	wGwFlow	Catchments	Not used
$l_{W,trans}$	Transfer scheme loss rate	wTransLoss	TransferSchemes	Not used
$\bar{T}_{\mathrm{W,trans}}$	Capacity of the transfer scheme	wTransCap	TransferSchemes	Not used
q_{env}	Environmental flow requirement	wEnvFlow	EnvFlow	(World Bank, 2010)
d_W	User net water demand	wUserDem	UserDemand	(World Bank, 2010)
l_{user}	User loss rate	wUserLoss	WaterUsers	(World Bank, 2010)
r_{user}	User return flow rate	wUserRturn	WaterUsers	(World Bank, 2010)
b_W	Marginal value of water use	wUserVal	WaterUsers	Empirical
c_W	Cost of surface water supply	wSupCost	Aquifers	Not used
c_{GW}	Cost of groundwater water supply	wGwCost	Aquifers	Not used

Agriculture production module

Table 2: Parameters of the Agriculture production module contained in the AgricultureModule.xlsx file. The parameters are called after their name in the HESS publication, but the name used in the python model is also indicated. The relevant pages of the sources are indicated in the excel files when available.

Notation in publication	Description	Parameter name in model	Excel sheet	Source
Indices				
fz	Farming zones	nfzone	FarmingZones	(World Bank, 2010)
ft	Farm types	nftype	FarmTypes	-
cr	Crops	ncrops	Crops	
cul	Cultures	nculture	Cultures	
ps	Phases	nyphase	GrowthPhases	
pt	Demand satisfaction paths	nypath	aYieldMat	
Parameters				
$\bar{A}$	Land capacity	aLandCap	FarmingZones	(World Bank, 2010)
y	Potential yield	aCulYield	Yields	(FAO, 2018)
a	Month to phase conversion coefficient	yphase_month	PhaseMonth	(World Bank, 2010)
k_c	Single crop coefficient	aKc	GrowthPhases	(World Bank, 2010)
k_Y	Yield water response factor	aYieldFactor	GrowthPhases	(Doorenbos and Kassam, 1979)
c_{cult}	Cultivation costs	aCulCost	CulCost	(IFPRI, 2015, 2017)
c_W	Irrigation costs	aIrrgCost	FarmingZones	Not used

Crop market module

Table 3: Parameters of the Crop market module contained in the CropMarketModule.xlsx file. The parameters are called after their name in the HESS publication, but the name used in the python model is also indicated. The relevant pages of the sources are indicated in the excel files when available.

Notation in publication	Description	Parameter name in model	Excel sheet	Source
Indices				
cm	Crop markets	ncmarket	CropMarkets	-
cds	Crop demand steps	ncdstep	-	Not used
tr	Transport routes	nctrans	CropTransport	-
Parameters				
d_C	Crop demand	aCropDem	CropDem	(FAO, 2018)
d_{min}	Crop minimum demand	aMinDem	CropMinDem	-
$l_{C,trans}$	Crop transport loss rate	aTransLoss	CropTransport	Not used
b_C	Crop marginal value	aCropVal	CropValue	(FAO, 2018)
c_{ext}	Crop external import costs	aCropVal	CropValue	(FAO, 2018)
$c_{C,trans}$	Crop transport costs	aTransCost	TransportCost	(FAO, 2018)

Energy production module

Table 4: Parameters of the Energy production module contained in the EnergyModule.xlsx file. The parameters are called after their name in the HESS publication, but the name used in the python model is also indicated. The relevant pages of the sources are indicated in the excel files when available.

Notation in publication	Description	Parameter name in model	Excel sheet	Source
Indices				
hp	Hydropower turbines	nhpp	Hydropower	
op	Other power plants	nopp	PowerPlants	
pt	Power technologies	nptech	PowerTechnologies	
fu	Fuels	nfuel	Fuels	
Parameters				
γ	Water-Energy equivalent	eHppProd	Hydropower	(World Bank, 2010)
$\bar{P}_{hydro}$	Capacity of hydropower turbine	eHppCap	Hydropower	(World Bank, 2010)
e_{hydro}	Efficiency of hydropower plants	eHppEff	Hydropower	(World Bank, 2010)
$\bar{P}_{plant}$	Capacity of other power plants	eOppCap	PowerPlants	(World Bank, 2010)
e_{plant}	Efficiency of other power plants	eOppEff	PowerPlants	(IRENA, 2013)
e_{tech}	Lifetime of power technologies	eLifeTime	PowerTechnologies	(IRENA, 2013)
e_{CO2}	CO_2 emission rate of fuels	eFuelCO2	FuelCO2	?
$c_{om,hydro}$	Operational costs of hydropower turbines	eHppCost	Hydropower	(IRENA, 2013)
$c_{om,plant}$	Operational costs of other power plants	eOppCost	PowerPlants	(IRENA, 2013)
$c_{cap,tech}$	Capital costs of generic technologies	eCAPEX	PowerTechnologies	(IRENA, 2013)
$c_{fix,tech}$	Fix operational costs of generic technologies	eFixOPEX	PowerTechnologies	(IRENA, 2013)
$c_{om,tech}$	Variable operational costs of generic technologies	eVarOPEX	PowerTechnologies	(IRENA, 2013)
c_{fuel}	Fuel costs	eFuelCost	Fuels	(IRENA, 2013)
c_{C02}	CO_2 emission costs	eFuelCO2	FuelCO2	(IRENA, 2013)

Energy market module

Table 5: Parameters of the Energy market module contained in the EnergyModule.xlsx file. The parameters are called after their name in the HESS publication, but the name used in the python model is also indicated. The relevant pages of the sources are indicated in the excel files when available.

Notation in publication	Description	Parameter name in model	Excel sheet	Source
Indices				
pm	Power markets	npmarket	PowerMarkets	-
ls	Load segments	npload	PowerLoads	SAPP
Parameters				
d_E	Power demand	eEngyDem	EnergyDemand	SAPP
d_{load}	Share of the demand per load segment	eLoadDem	PowerLoads	SAPP
t_{load}	Length of load segment	eLoadTime	PowerLoads	SAPP
e_{CF}	Load segment capacity factor	eLoadCap	LoadCapacity	(IRENA, 2013)
$\bar{T}_{E,trans}$	Capacity of the transmission line	eTransCap	EnergyTransmission	SAPP
$l_{E,trans}$	Power transmission losses	eTransLoss	EnergyTransmission	(IRENA, 2013)
$l_{E,supply}$	Local power supply losses	eSupLoss	PowerMarkets	(IRENA, 2013)
b_E	Marginal value of energy	eEngyVal	EnergyValue	Expert assumption
$c_{E,trans}$	Energy transmission costs	eTransCost	EnergyTransmission	(IRENA, 2013)