Quantifying and reducing uncertainty in the assessment of water-related risks in southern Europe and neighbouring countries

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CLIMB – in a nutshell...

- ***CL**imate **I**nduced Changes on the Hydrology of **M**editerranean **B**asins –*
  Reducing Uncertainty and Quantifying Risk
- funded under EU's FP7 Environment Theme
  (Theme: Climate, Water & Security, ENV.2009.1.1.5.2)
- funding period 48 months (01/2010 – 12/2013)
- 19 beneficiaries
- 9 countries:
  EU – Austria, France, Germany, Italy
  SICA – Egypt, Palest. Adm. Areas, Tunisia, Turkey
  Other – Canada




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Challenges & key RQs

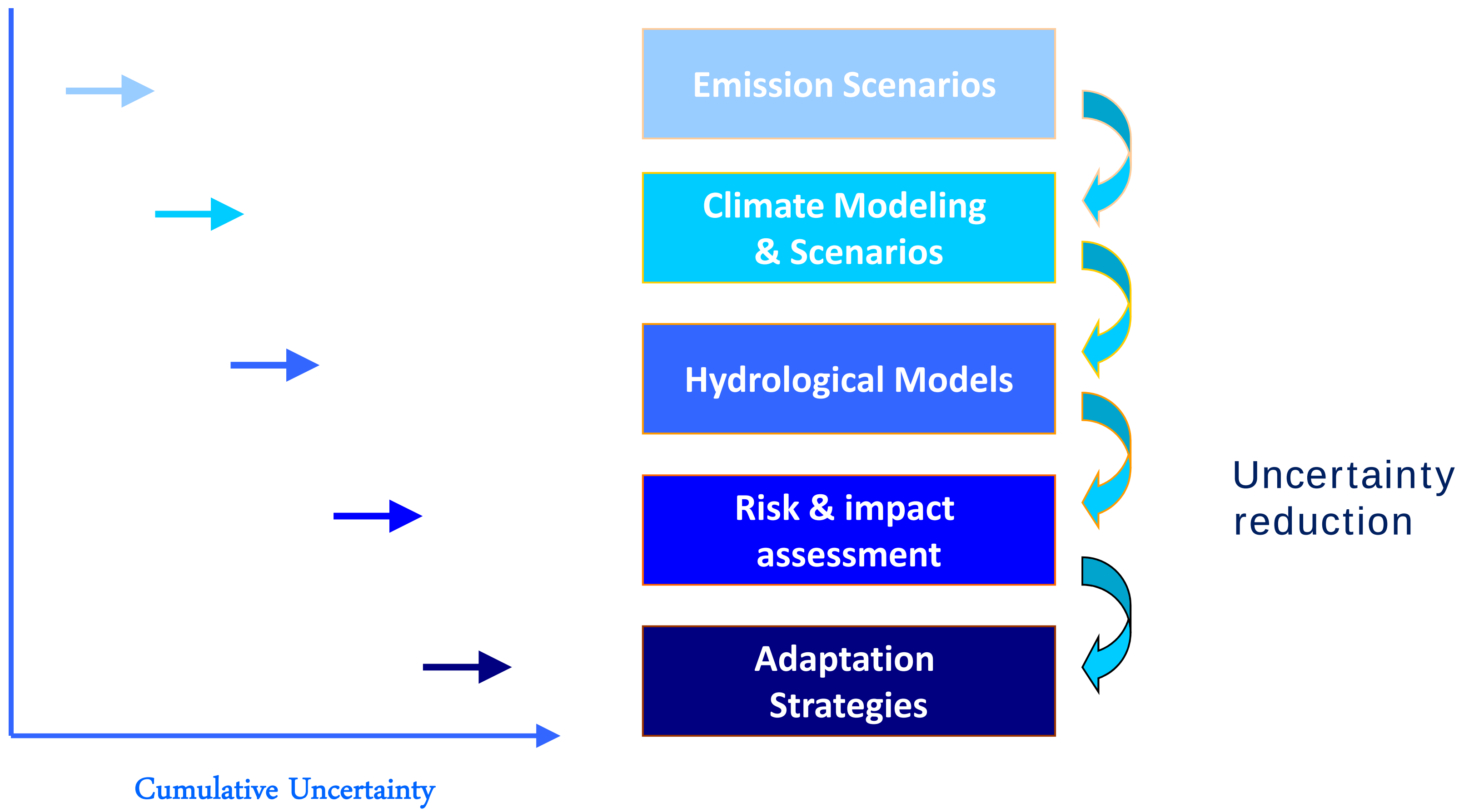
"Handling of Uncertainty in science is central to its support of sound policy making" (Smith & Stern, 2011)

- improved understanding of scientific uncertainties necessary
- knowing uncertainties and components
- communicating uncertainty
- robustness/certainty of scientific insights
- → especially relevant in risk management

Deduced key research questions (RQs):

- How to develop an appropriate uncertainty assessment?
- What are the key uncertainty components?
- How certain are the results?
- How to integrate into risk assessment in a coherent way?

Uncertainty in climate impact research and adaptation

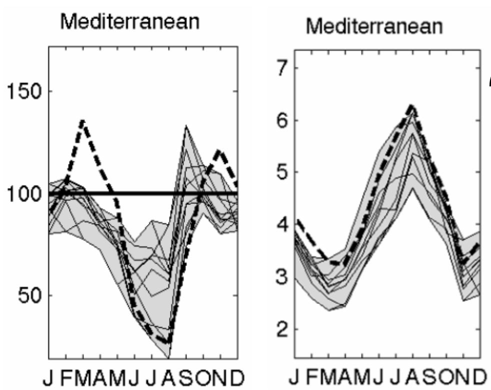


Uncertainty chain

Climate Change Signal Uncertainty

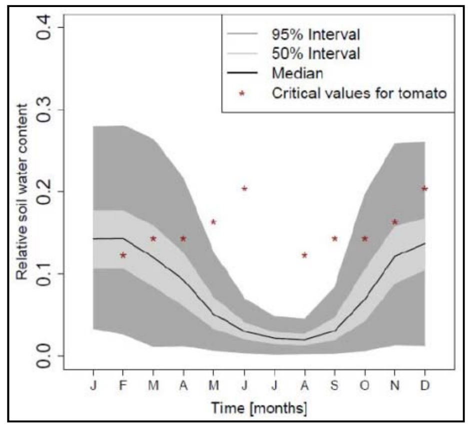
Hydrological Modelling Uncertainty

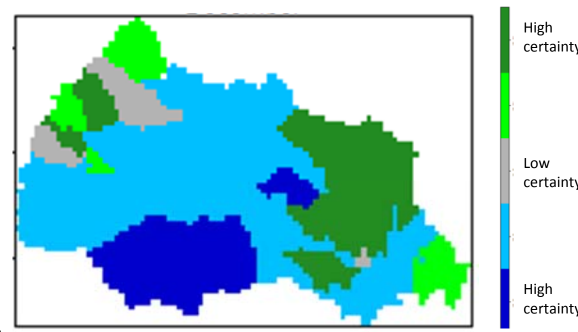
Risk & Vulnerability Modelling Uncertainty



Precip. Temp.

propagation





propagation

- **Decision support under (quantified) uncertainty**
- **Uncertainty reduction**

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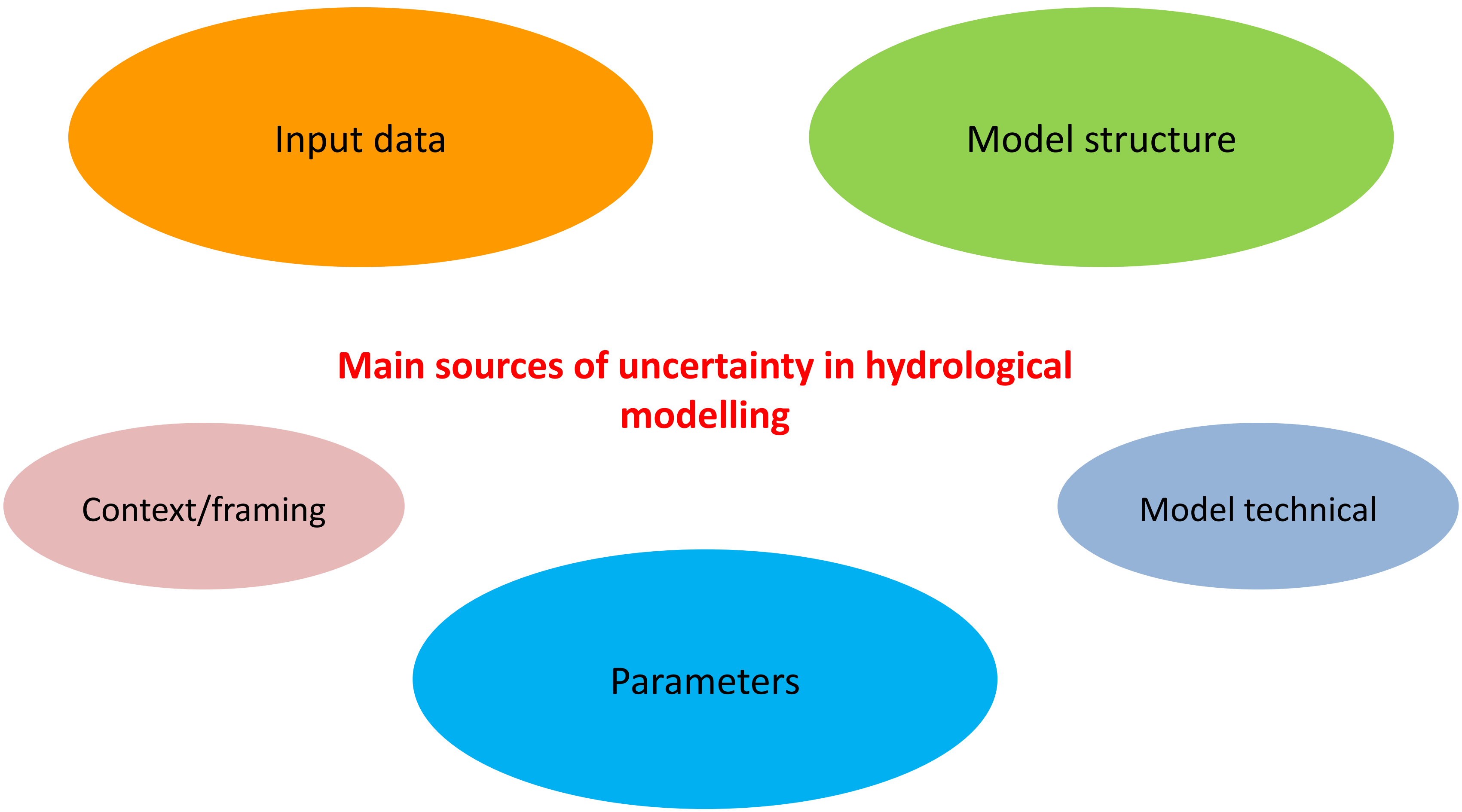
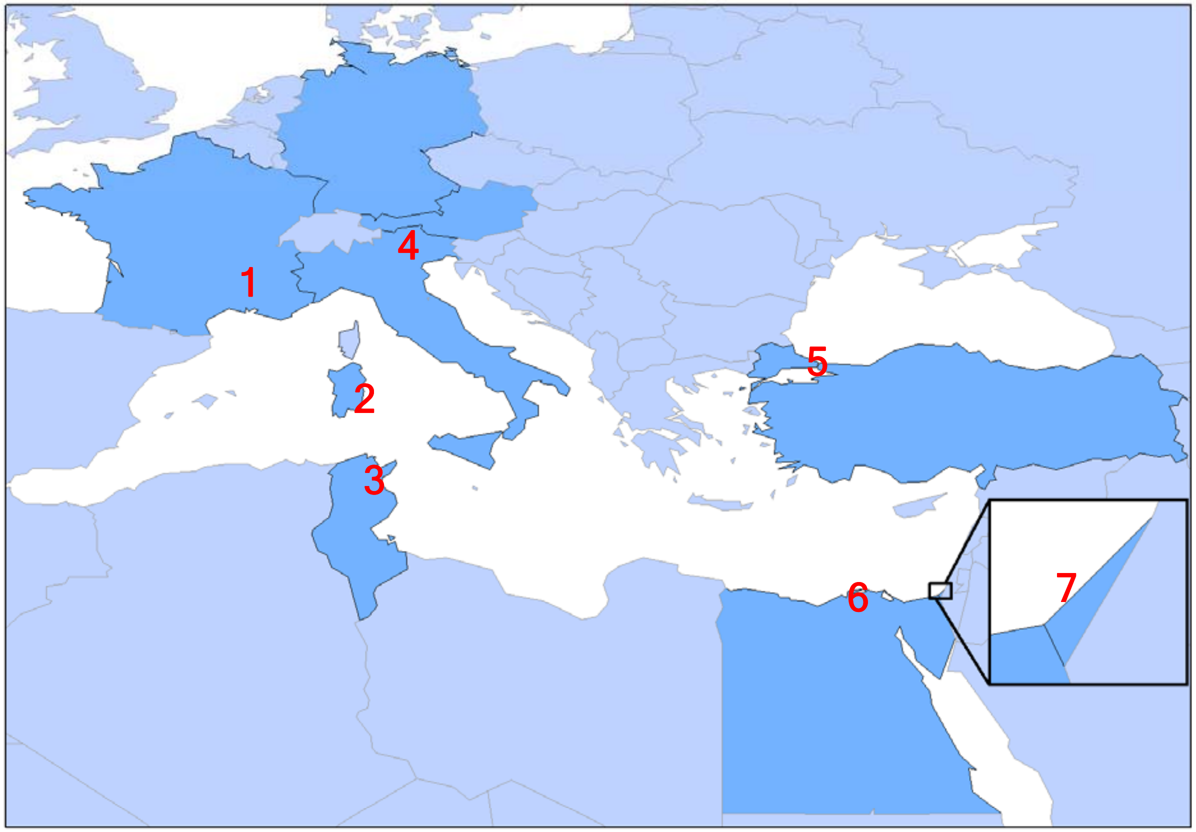
Uncertainty sources



CLIMB – case studies



1) Thau – 280 km² - Coastal Lagoon - France
2) **Rio Mannu – 473 km² - Sardinia, Italy**
3) **Chiba - 286 km² - Cap Bon – Tunisia**
4) Noce - 1367 km² – Southern Alps – Italy
5) Izmit Bay – 673 km² - Kocaeli - Turkey
6) Nile Delta – 1000 km² - Nile - Egypt
7) Gaza Aquifer – 365 km² - Gaza – Palest.-admin. areas

Challenges (some key words):

→ changes in water availability, runoff regimes, runoff extremes and water quality

→ high agricultural productivity, irrigation, heavy nutrient loads, pollution, salt water intrusion in near-coastal aquifers, multi-use water systems (consumption rivalries)

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CLIMB – uncertainty analysis – Chiba, Tunisia

Climate & Models structure uncertainty

- 8 model runs (Future 24 - GCM/RCM/downscaling)
- fixed set of parameters
- 2 climate models: KNMI-ECHAM5-RACMO and SMHI-ECHAM5-RCA (future 4);
- 2 time periods: reference period: 1971 – 2000, scenario: 2041 – 2070
- Wasim-ETH, Future Multi-model (hydro.)

Parameter uncertainty

- 50 model runs for reference and scenario period respectively
- Selected parameters in the domain of soil, land use, ground water and climate are varied in each model run
- WasimETH, Future: plus SWAT

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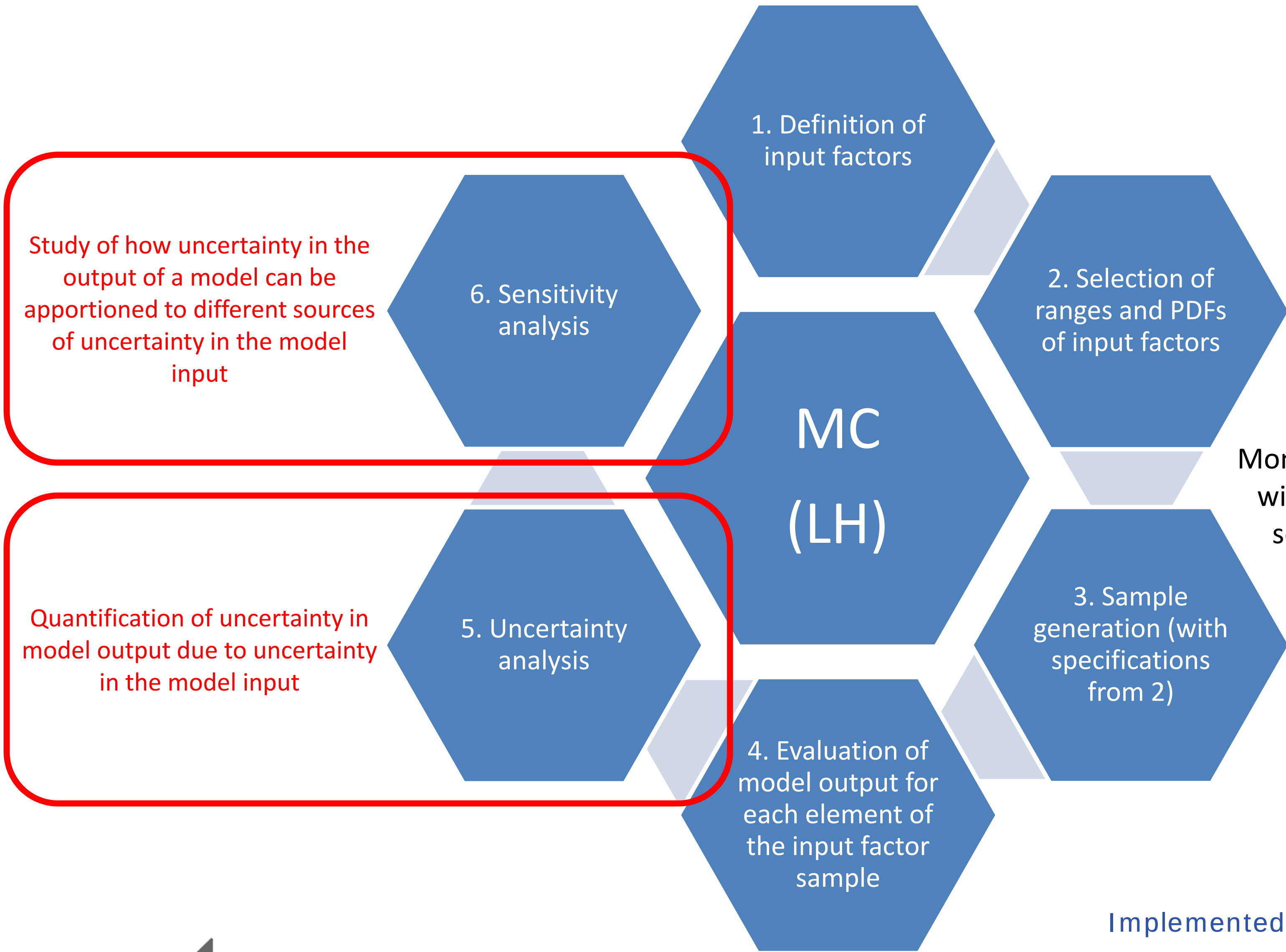
Approach for adressing parameter uncertainty



Monte Carlo framework with uncertainty and sensitivity analysis

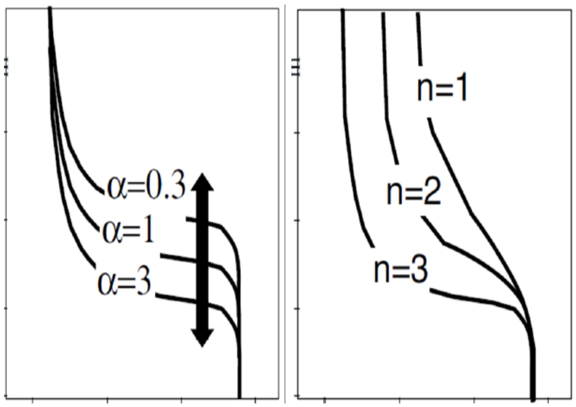
Implemented with Simlab 2.2, JRC

Approach for adressing parameter uncertainty

Parameter	Description	Units	Type	PDF	Range (reference value)	Source
Crop_Albedo	Albedo of crops	[-]	Land use	Normal	[0.64 : 1.39]	Reinery, 2011
Crop_RSC	Stomatal resistance of crops	[s/m]	Land use	Normal	[0.26 : 1.75]	Reinery, 2011
Crop_LAI	LAI of crops	$[m^2/m^2]$	Land use	Normal	[0.06 : 3.06]	Reinery, 2011
Crop_Z0	Aerodynamic roughness length of crops	[m]	Land use	Normal	[0.02 : 3.74]	Masson et al., 2003
Crop_VCF	Vegetation covered fraction of crops	[-]	Land use	Normal	[0.05 : 2.82]	Masson et al., 2003
Crop_RootDepth	Root depth of crops	[m]	Land use	Normal	[0.08 : 2.92]	FAO Cropwat simulations
Forest_Albedo	Albedo of forest	[-]	Land use	Normal	[0.40 : 1.59]	Reinery, 2011
Forest_RSC	Stomatal resistance of forest	[s/m]	Land use	Normal	[0.29 : 1.73]	Reinery, 2011
Forest_LAI	LAI of forest	$[m^2/m^2]$	Land use	Normal	[0.32 : 1.61]	Reinery, 2011
Forest_Z0	Aerodynamic roughness length of forest	[m]	Land use	Normal	[0.36 : 1.60]	Masson et al., 2003
Forest_VCF	Vegetation covered fraction of forest	[-]	Land use	Normal	[0.35 : 1.58]	Masson et al., 2003
Forest_RootDepth	Root depth of forest	[m]	Land use	Normal	[0.06 : 1.86]	FAO Cropwat simulations
Ksat	Saturated hydraulic conductivity	[m/s]	Soil	Normal	[0.03 : 4.46]	Schulla and Jasper, 2007
Theta_sat	Saturated water content in the soil	[-]	Soil	Normal	[0.78 : 1.18]	Schulla and Jasper, 2007
Theta_res	Residual water content in the soil	[-]	Soil	Normal	[0.00 : 1.97]	Schulla and Jasper, 2007
Alpha	Van Genuchten parameter	[-]	Soil	Normal	[0.00 : 3.51]	Schulla and Jasper, 2007
N	Van Genuchten parameter	[-]	Soil	Normal	[0.78 : 1.95]	Schulla and Jasper, 2007
Temp_Ref	Temperature in reference period	[°C]	Climate	Normal	[0.92 : 1.07]	KNMI and SMHI climate model data
Temp_Fut	Temperature in scenario period	[°C]	Climate	Normal	[0.93 : 1.08]	KNMI and SMHI climate model data
Prec_Ref	Precipitation in reference period	[mm]	Climate	Normal	[0.35 : 1.64]	KNMI and SMHI climate model data
Prec_Fut	Precipitation in scenario period	[mm]	Climate	Normal	[0.42 : 1.69]	KNMI and SMHI climate model data
Aquifer_Thickness	Thickness of the ground water aquifer	[m]	Ground water	Normal	[0.28 : 1.56] (45)	Zghibi et al., 2011
Gwst	Depth to ground water table	[m]	Ground water	Normal	[0.13 : 1.97] (8.5)	Zghibi et al., 2011
k_xy	Hydraulic conductivity within the aquifer	[m/s]	Ground water	Normal	[0.15 : 1.78] (2.5×10^{-06})	Zghibi et al., 2011

Model: WASIM-ETH

Sensitivity analysis



Rank	Factor 1971 - 2000	PCC ($R^2 = 0.94$)	Factor 2041 - 2070	PCC ($R^2 = 0.91$)
1	Prec_Ref	0.889	Prec_Fut	0.831
2	Theta_res	0.774	Theta_res	0.749
3	N	-0.704	N	-0.748
4	Crop_LAI	-0.581	Alpha	-0.583
5	Gwst	-0.516	Crop_LAI	-0.580
6	Alpha	-0.482	Crop_RSC	0.423
7	Forest_RootDepth	-0.451	Crop_Albedo	0.375
8	Crop_Albedo	0.372	Gwst	-0.315
9	Crop_RSC	0.356	Forest_RootDepth	-0.286
10	Temp_Ref	-0.302	Theta_sat	0.257
11	Forest_VCF	-0.260	Temp_Fut	0.222
12			Crop_Z0	0.211

Most important factors for "relative soil water content in the root zone"

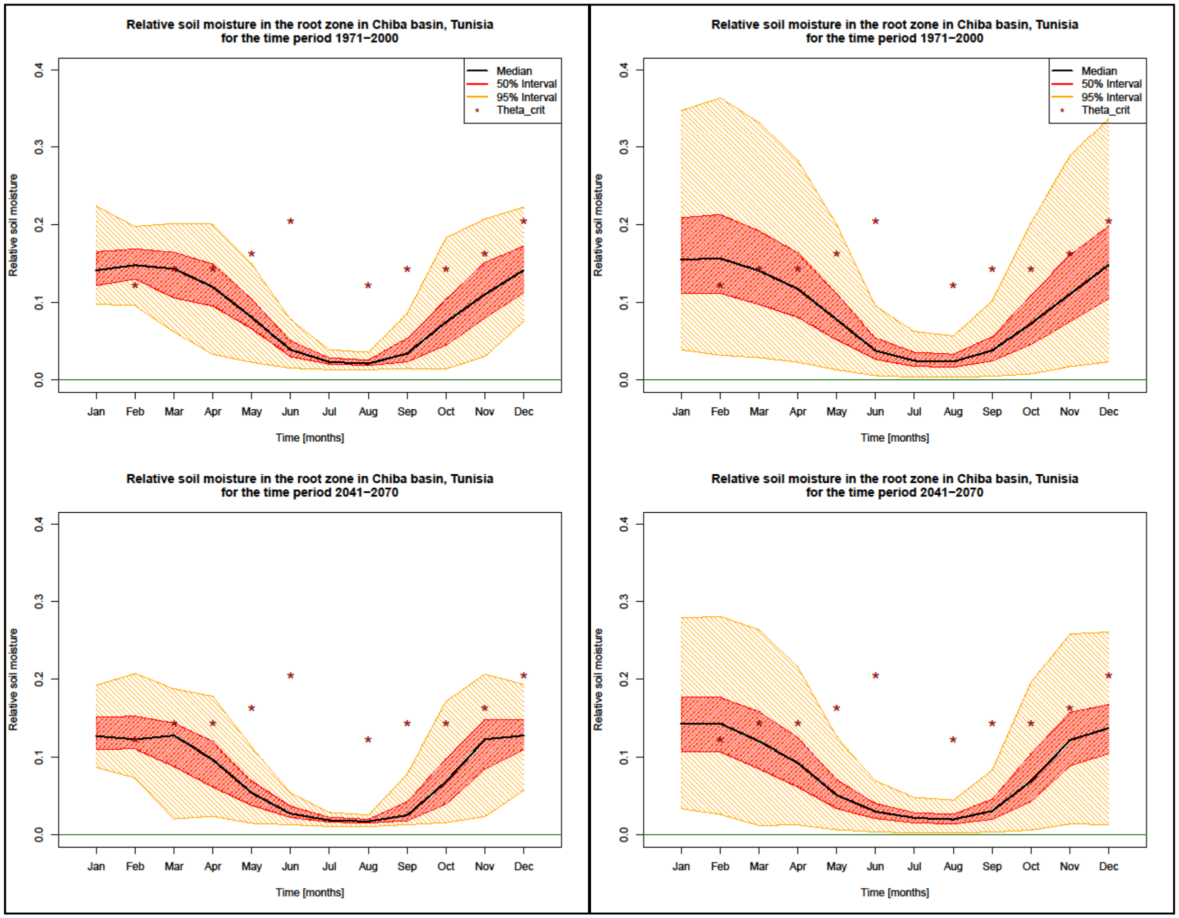
Parameter uncertainty study

Results for key outputs of interest

Simulated key outputs of interest for Chiba basin, Tunisia.

Key output	Units	1971-2000	2041-2070	Change	Change [%]
Temperature	[°C]	17 +/-0.51	18.8 +/- 0.62	+1.8 +/- 0.1	
Potential Evapotranspiration	[mm]	1987.7 +/- 101.4	2185.6 +/- 102.7	+197.9 +/- 9.7	+10.0 +/- 0.5
Precipitation	[mm]	351.3 +/- 105.4	292 +/- 81.8	-59.3 +/- 17.2	-16.9 +/- 4.9
Relative soil water content in the root zone	[-]	0.093 +/- 0.019	0.08 +/- 0.015	-0.013 +/- 2.5E-03	-14.0 +/- 2.7
Actual Evapotranspiration	[mm]	322.7+/- 61.3	282.3 +/- 56.5	-40.4 +/- 7.9	-12.5 +/- 2.4
Ground water recharge	[mm]	1.4 +/- 6.4	-0.66 +/- 1.4	-2.1 +/- 7.0	-147.1 +/- 502.5
Depth to ground water	[m]	-4.7 +/- 0.24	-4.9 +/- 0.011	-0.2 +/- 5.4E-03	-4.3 +/- 0.1

Uncertainty – soil water content



Climate uncertainty study

Parameter uncertainty study

Can tomatoes be grown in Chiba basin under climate change conditions?

Evaluation of model outputs

Probability of not reaching critical soil water contents increased

Probability of additional irrigation demands increased

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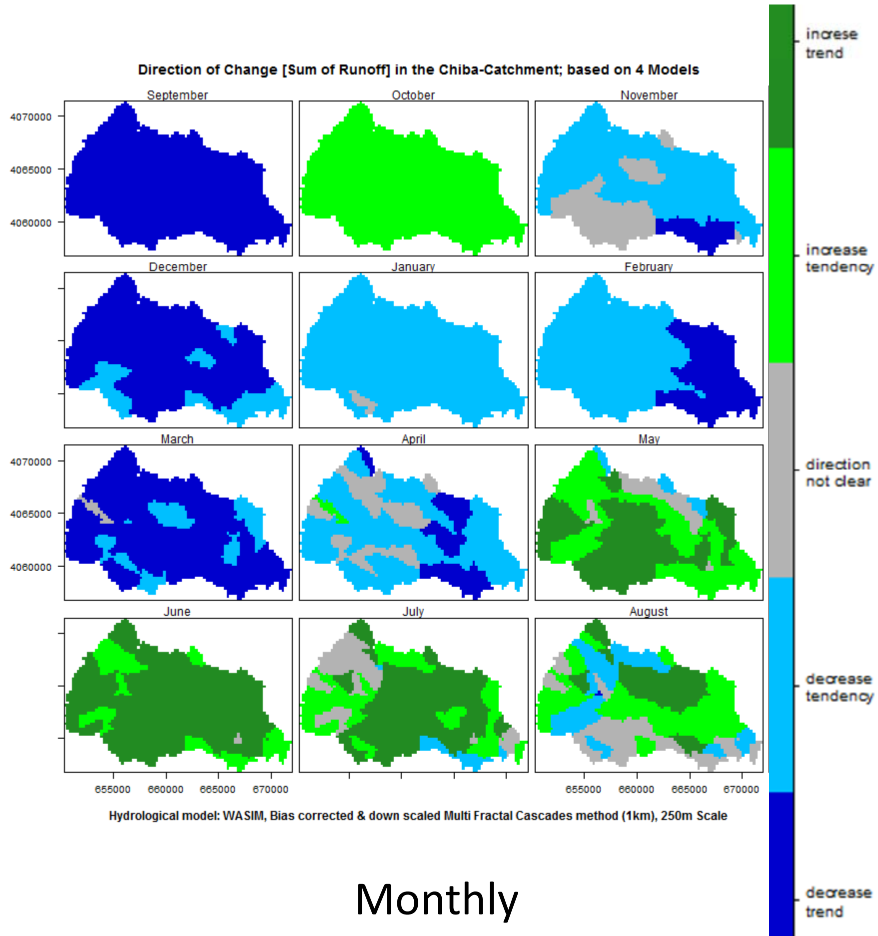
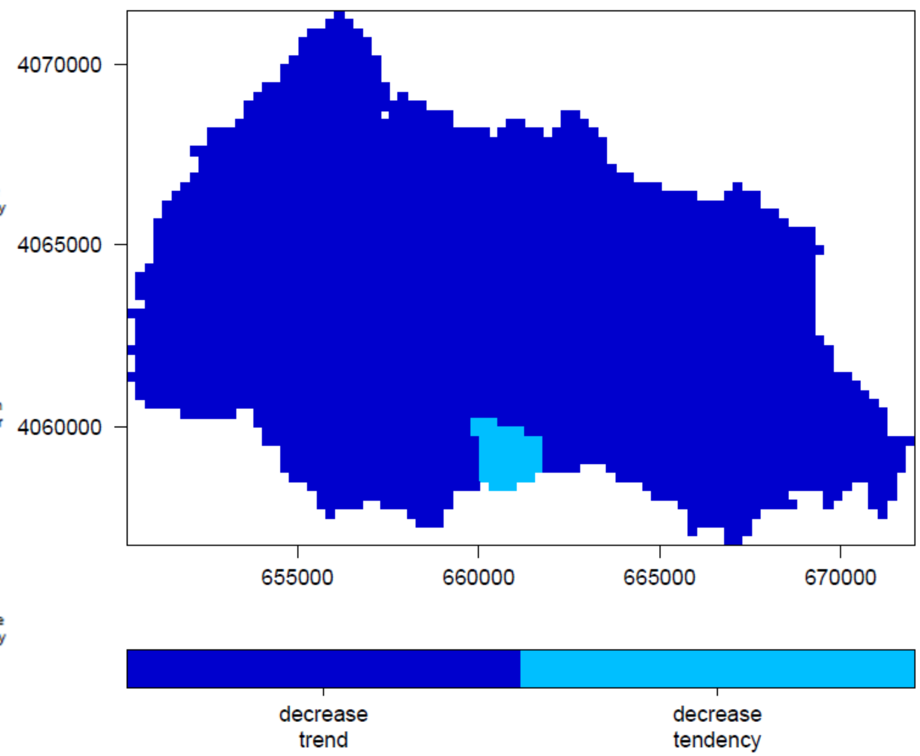
KEY RESULTS - III

Certainty Map of key indicators (here TAW)



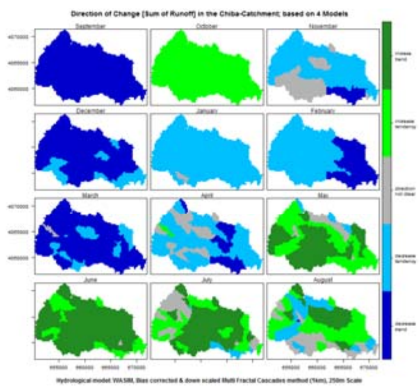
Monthly

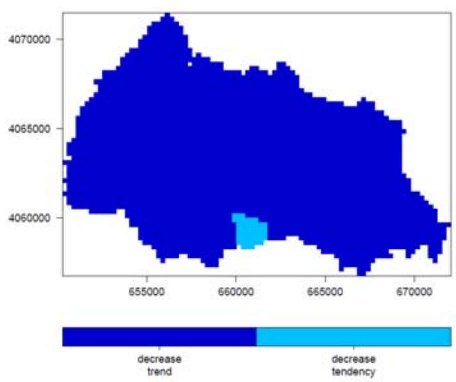


Annual

KEY RESULTS & FINDINGS - III

SCIENTIFIC RESULT



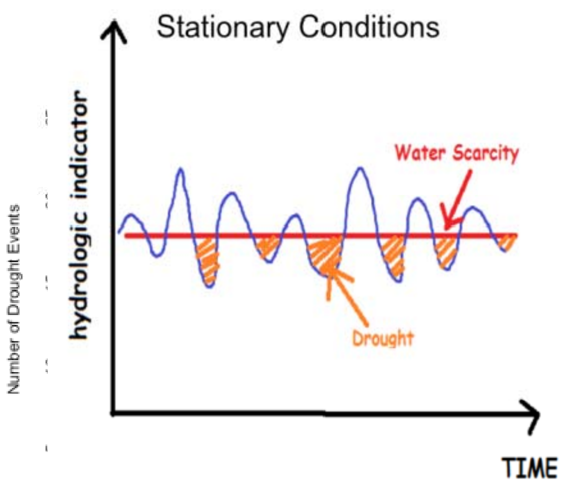


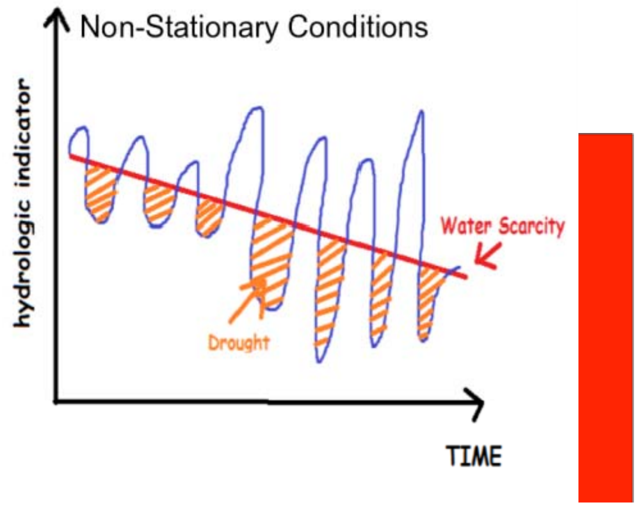
FINDINGS AND IMPLICATION:

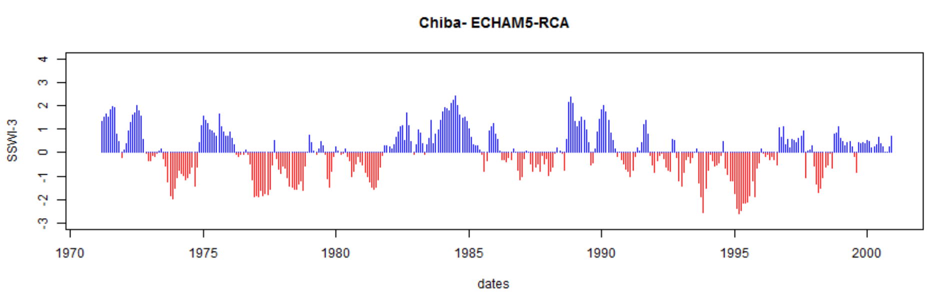
- Decrease trend of long-term annual TAW (all models and climate forcings)
- Monthly-based degree of certainty, more diverse
- Hotspot areas with confirmed trend and uncertain changes can be clearly identified

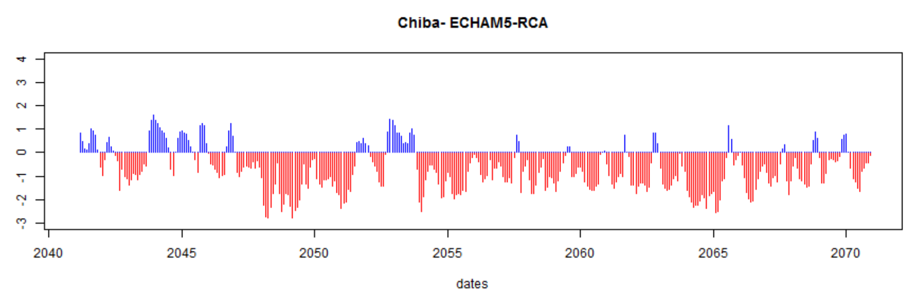
KEY RESULTS - V

Drought, water scarcity and surface drying hazard characteristics (Chiba)



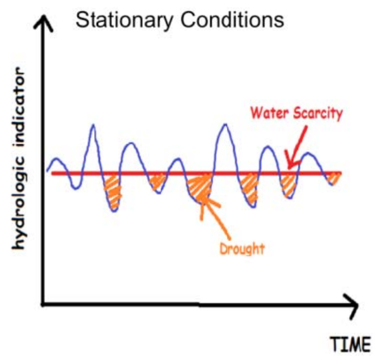


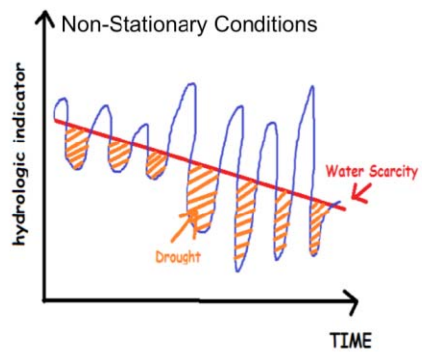




KEY RESULTS & FINDINGS - V

SCIENTIFIC RESULT



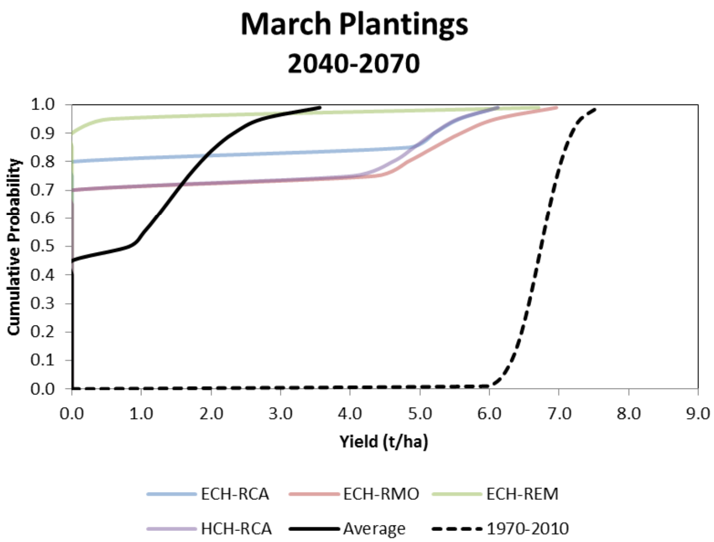


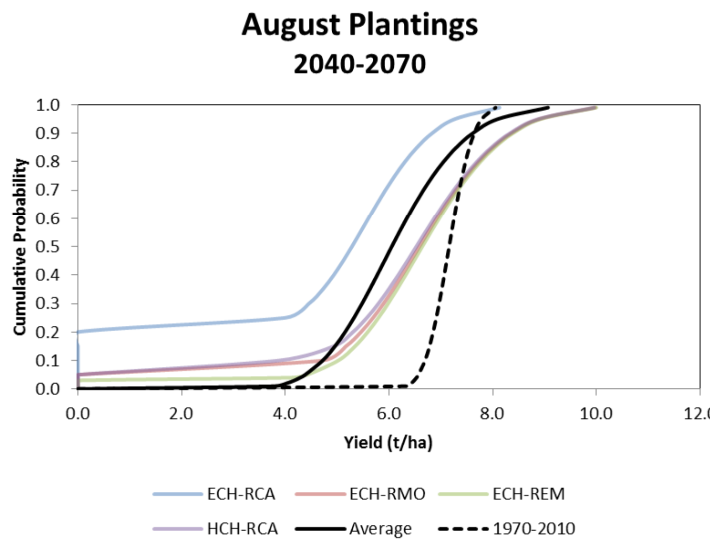
FINDINGS AND IMPLICATION:

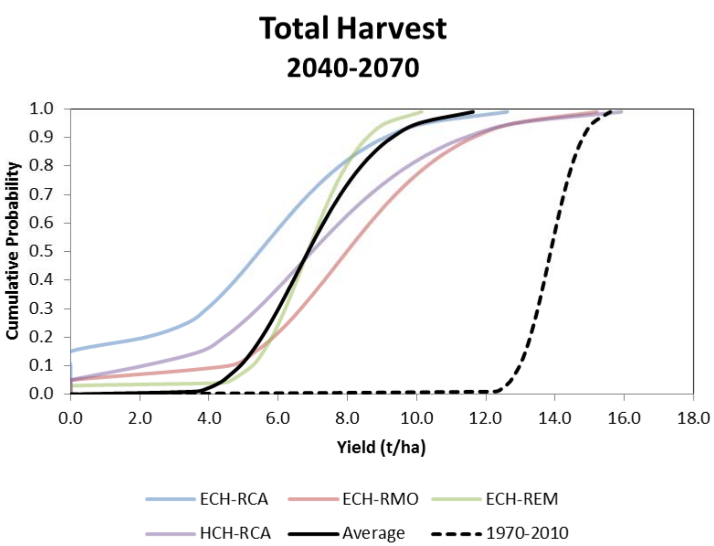
Both sites:

- Drought events affecting soil moisture and long-term water resources availability increase in FUT
- Water scarcity main problem in the future
- More sever surface drying

RESULTS – TOMATOES (10 % LESS WATER USAGE AS CURRENT)







- March plantings
  - Yield ↓ 86%
  - Crop failure 45%
- August planting
  - Yield ↓ 17%
- Total harvest
  - 50% less yield
- Results are soil dependent

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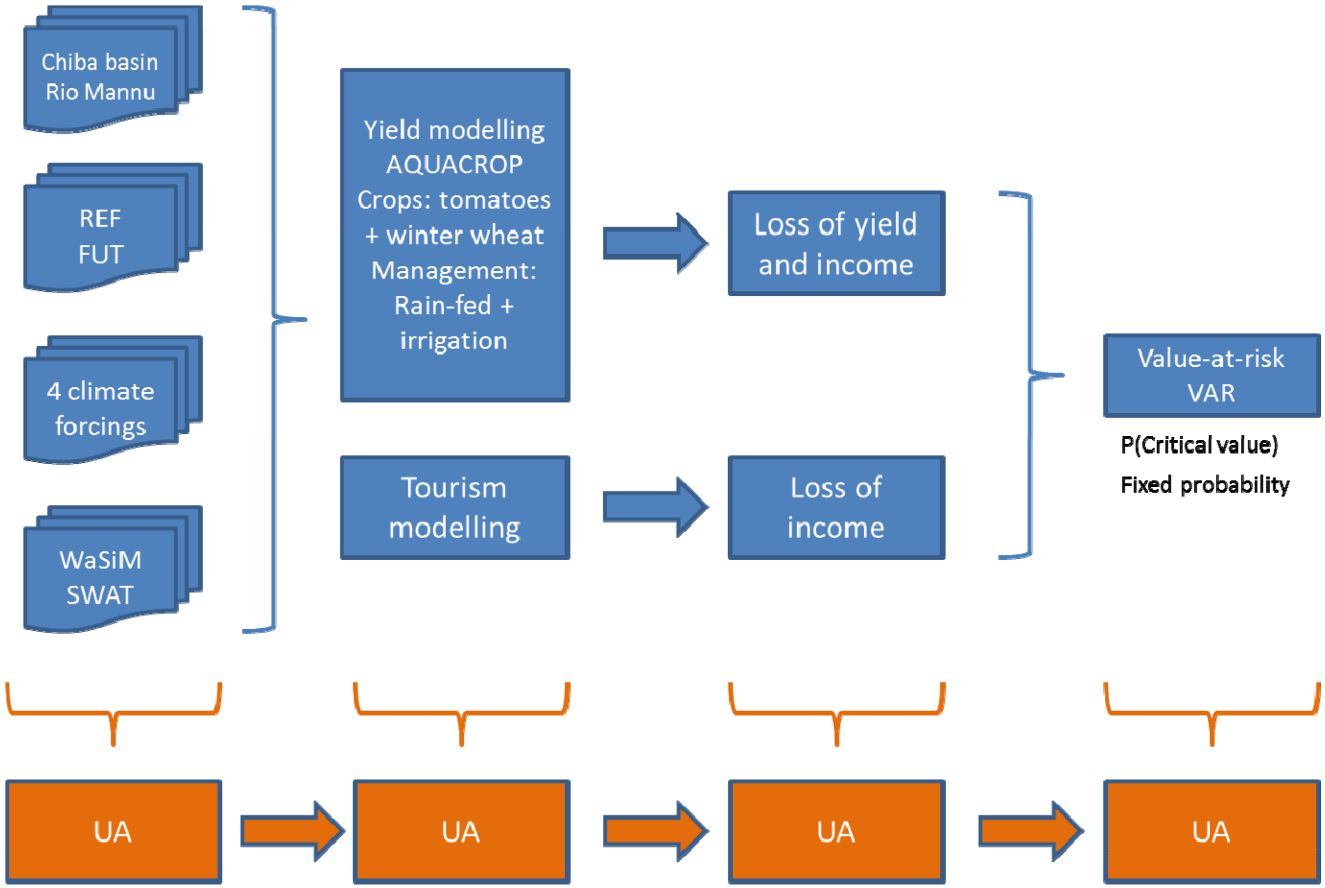
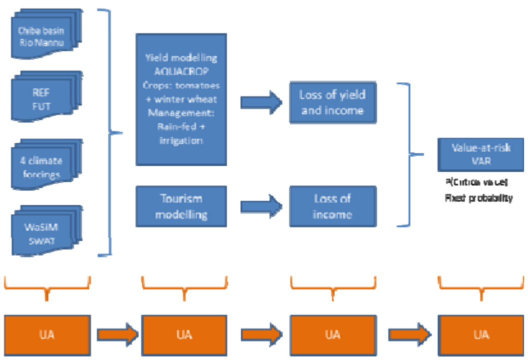
KEY RESULTS - VI

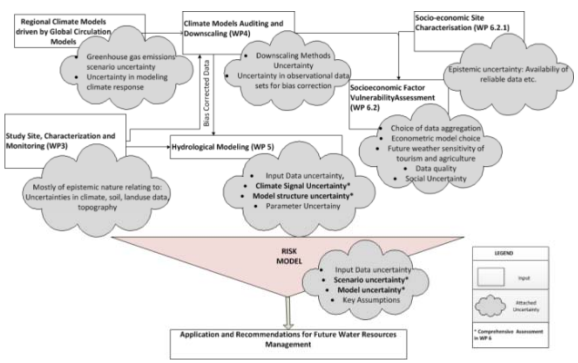
Risk and Uncertainty integration



KEY RESULTS & FINDINGS - VI

SCIENTIFIC RESULT





FINDINGS AND IMPLICATION:

- A new comprehensive uncertainty framework developed
- CC impacts on key water components and associated uncertainties quantified and evaluated
- Uncertainty assessment into comprehensive risk model integrated

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THANK YOU

VIELEN DANK