Improving water productivity on larger scales

FutureWater solutions and experiences

Gijs Simons

29 March 2017

Water Productivity Masterclass, Wageningen

FutureWater

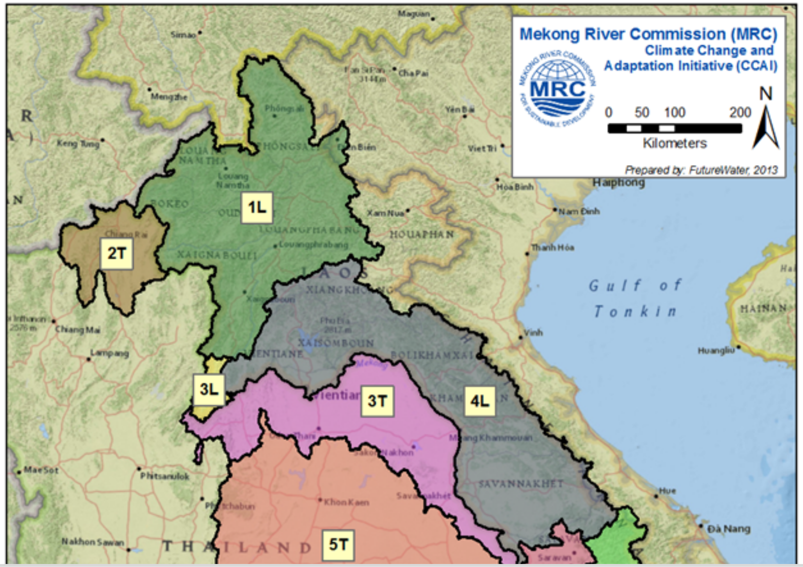
Research and consultancy for a sustainable future of our water resources

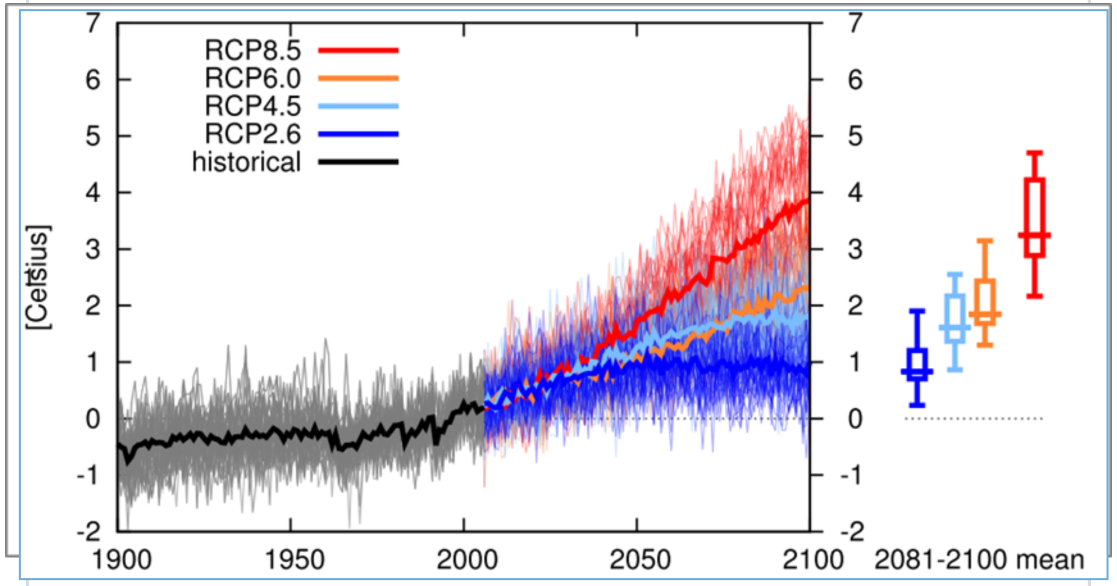
Options for improving yield and water productivity at the national / basin scale

- Previous FutureWater projects
- Typical questions of policy makers:
  - What are the potential impacts of climate change on agricultural systems at the national and agricultural region level, and what are potential adaptation and mitigation options? (National government, World Bank)
  - How are crop production, food demand and supply in the Lower Mekong Basin going to change in the future? (Mekong River Commission)
  - Where and in what activities should a Water Fund in Upper Tana, Kenya, invest its money to maximize upstream benefits? (The Nature Conservancy)

Crop Yield Modeling (AquaCrop)

- > Lower Mekong Basin: AquaCrop
  - – 15 sub-areas
  - – 5 crops
    - Paddy rice
    - Dry rice
    - Maize
    - Sugarcane
    - Cassava
  - – Time frames
    - Baseline Situation (=1981-2010)
    - Foreseeable Future Situation (=2026-2035)
    - Long-term Future Situation (=2046-2055)
    - Horizon Situation (=2090-2099)





Crop Yield Modeling (AquaCrop)

Rice

	H2026-2035_RCP2.6	H2046-2055_RCP2.6	H2090-2099_RCP2.6	H2026-2035_RCP4.5	H2046-2055_RCP4.5	H2090-2099_RCP4.5	H2026-2035_RCP6.0	H2046-2055_RCP6.0	H2090-2099_RCP6.0	H2026-2035_RCP8.8	H2046-2055_RCP8.8	H2090-2099_RCP8.8
10C	-1%	-1%	-2%	-1%	-2%	-3%	-2%	-2%	-4%	-3%	-4%	-10%
6C	0%	-1%	-2%	-1%	-2%	-3%	-1%	-2%	-4%	-2%	-5%	-13%
7C	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
8C	0%	0%	0%	0%	-1%	-1%	-1%	-1%	-1%	-1%	-1%	-8%
9C	-1%	-1%	-3%	-1%	-3%	-9%	-2%	-4%	-12%	-5%	-12%	-34%
1L	-1%	-1%	-2%	-1%	-2%	-4%	-2%	-3%	-6%	-3%	-7%	-28%
3L	-4%	-6%	-9%	-7%	-11%	-14%	-9%	-11%	-19%	-12%	-20%	-32%
4L	-1%	-2%	-2%	-2%	-3%	-5%	-2%	-4%	-7%	-4%	-9%	-17%
6L	-1%	-2%	-3%	-2%	-3%	-7%	-3%	-5%	-12%	-5%	-13%	-26%
7L	0%	0%	0%	0%	0%	-1%	0%	0%	-1%	0%	-1%	-2%
2T	-3%	-4%	-4%	-5%	-6%	-9%	-6%	-6%	-12%	-7%	-13%	-25%
3T	-2%	-3%	-5%	-3%	-5%	-10%	-4%	-6%	-14%	-6%	-15%	-23%
5T	-3%	-6%	-11%	-7%	-13%	-21%	-9%	-15%	-27%	-19%	-27%	-36%
10V	0%	-1%	-1%	-1%	-1%	-3%	-1%	-2%	-4%	-2%	-4%	-14%
7V	0%	-1%	-1%	-1%	-1%	-2%	-1%	-1%	-3%	-2%	-3%	-5%

Maize

Sub-area	H2026-2035_RCP2.6	H2046-2055_RCP2.6	H2090-2099_RCP2.6	H2026-2035_RCP4.5	H2046-2055_RCP4.5	H2090-2099_RCP4.5	H2026-2035_RCP6.0	H2046-2055_RCP6.0	H2090-2099_RCP6.0	H2026-2035_RCP8.8	H2046-2055_RCP8.8	H2090-2099_RCP8.8
10C	-1%	-1%	2%	-1%	-1%	-1%	-1%	-1%	-3%	-1%	-1%	-12%
6C	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	-1%	-4%
7C	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
8C	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	-9%
9C	-1%	-1%	-1%	-1%	-1%	-2%	-3%	-2%	-2%	-1%	-5%	-23%
1L	1%	-3%	1%	-1%	-3%	-7%	-8%	-8%	-21%	-13%	-12%	-83%
3L	1%	-2%	3%	1%	4%	2%	1%	3%	-7%	-4%	-9%	-27%
4L	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	-13%
6L	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	-5%
7L	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
2T	0%	0%	0%	0%	0%	0%	0%	0%	-1%	0%	0%	-7%
3T	0%	0%	0%	0%	0%	0%	0%	0%	-1%	0%	-1%	-10%
5T	-2%	-3%	-3%	-2%	-3%	0%	-2%	-3%	-3%	-2%	-5%	-25%
10V	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	-6%
7V	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%

Sugar cane

Sub-area	H2026-2035_RCP2.6	H2046-2055_RCP2.6	H2090-2099_RCP2.6	H2026-2035_RCP4.5	H2046-2055_RCP4.5	H2090-2099_RCP4.5	H2026-2035_RCP6.0	H2046-2055_RCP6.0	H2090-2099_RCP6.0	H2026-2035_RCP8.8	H2046-2055_RCP8.8	H2090-2099_RCP8.8
10C	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	-3%
6C	-8%	-11%	-12%	-8%	-5%	-6%	-11%	-12%	-10%	-9%	-6%	1%
7C	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
8C	0%	0%	0%	0%	0%	-1%	0%	-1%	-4%	-1%	-1%	-2%
9C	-5%	-1%	4%	-1%	3%	3%	-1%	3%	-3%	3%	-3%	11%
1L	-4%	-2%	-2%	-5%	2%	6%	-6%	6%	1%	6%	5%	0%
3L	0%	-1%	-1%	-4%	-5%	-5%	-1%	-5%	-2%	-1%	-2%	-11%
4L	0%	-1%	-1%	-1%	-1%	-1%	-1%	-2%	-6%	-2%	-10%	-11%
6L	3%	-1%	-5%	3%	-2%	2%	3%	2%	1%	2%	5%	14%
7L	0%	0%	0%	0%	0%	0%	0%	0%	-1%	0%	-1%	-5%
2T	0%	0%	-1%	0%	0%	0%	0%	0%	-10%	-1%	-1%	-6%
3T	3%	3%	11%	3%	11%	9%	6%	5%	-1%	5%	9%	3%
5T	4%	3%	-2%	3%	-3%	2%	-3%	-4%	-1%	-4%	-5%	-2%
10V	0%	0%	0%	0%	-1%	-1%	0%	-1%	-4%	-1%	-1%	-8%
7V	0%	0%	0%	0%	0%	-1%	0%	0%	-4%	0%	-4%	-8%

Cassava

Sub-area	H2026-2035_RCP2.6	H2046-2055_RCP2.6	H2090-2099_RCP2.6	H2026-2035_RCP4.5	H2046-2055_RCP4.5	H2090-2099_RCP4.5	H2026-2035_RCP6.0	H2046-2055_RCP6.0	H2090-2099_RCP6.0	H2026-2035_RCP8.8	H2046-2055_RCP8.8	H2090-2099_RCP8.8
10C	-2%	-2%	-2%	-3%	-3%	-1%	-2%	-2%	-3%	-2%	-1%	-3%
6C	-1%	-1%	0%	-1%	-1%	-1%	-1%	-1%	-1%	-1%	-1%	-1%
7C	0%	-1%	0%	0%	0%	1%	0%	0%	0%	0%	1%	-1%
8C	-1%	-1%	-2%	-1%	0%	0%	-1%	-1%	-3%	-1%	-2%	-1%
9C	-1%	-1%	-1%	-1%	-1%	-1%	-1%	-1%	-2%	-1%	-1%	-3%
1L	0%	-1%	-1%	0%	0%	1%	-1%	-1%	-2%	0%	-1%	-3%
3L	1%	-1%	-3%	1%	0%	2%	0%	1%	-3%	0%	-2%	2%
4L	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
6L	-1%	0%	-1%	-1%	0%	0%	-1%	0%	-2%	0%	-1%	-1%
7L	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	-1%
2T	0%	0%	0%	0%	0%	0%	0%	0%	-2%	0%	0%	-2%
3T	0%	0%	0%	0%	-1%	0%	-1%	-1%	-1%	0%	-1%	-1%
5T	-1%	-1%	-2%	-1%	-1%	0%	-1%	-1%	-3%	-1%	0%	0%
10V	-1%	-1%	0%	0%	0%	1%	-1%	0%	-1%	0%	-1%	0%
7V	0%	0%	0%	0%	0%	1%	0%	0%	0%	0%	0%	0%

Food Balance Sheet

FBS provide essential information on a country's food system:

Cambodia
2009

Food Balance Sheets

FILTER | EXPORT DATA

Population (Thousand): 13978.0

Single Items	Supply				Utilisation						Per Capita Supply			
	1000 Metric tons										Total		Prot.	Fat
	Prod.	Impo.	Stock Var.	Total	Exp.	Feed	Seed	Food Manu	Oth. Uses	Food	Kg / Yr	KCal / Day	Gr / Day	Gr / Day
Grand Total												2382	62.4	36.9
Vegetal Products												2152	44.3	20.5
Animal Products												230	18	16.3
Cereals - Excluding Beer	5984	66	-471	5224	354	194	125	25	1876	2498	178.7	1693	35.2	6.6
Starchy Roots	3616	1	0	3605	12	1			2957	466	33.3	91	0.7	0.3
Sugarcrops	350			350		20	18	127	115	70	5	4	0	0
Sugar & Sweeteners	11	496	-163	344	0			33	168	143	10.2	94		
Pulses	45	1	0	46	0		2			43	3.1	29	1.8	0.1
Treenuts	3	1		4	0					4	0.3	2	0	0.2
Oilcrops	260	1	-33	213	15		6	96	2	107	7.6	85	4.2	6.1
Vegetable Oils	27	18	9	44	10				10	33	2.4	57	0	6.5
Vegetables	469	2	0	470	0					423	30.3	18	1.2	0.2
Fruits - Excluding Wine	378	54	0	432	0					401	28.7	37	0.5	0.2

FBS: Scen_02: Population and CC

	Energy Intake (kCal/cap/d)				Protein Intake (g/cap/d)				Fat Intake (g/cap/d)			
	Base	FF	LF	H	Base	FF	LF	H	Base	FF	LF	H
10C	2383	1865	1737	1551	60	49	47	43	35	30	29	27
6C	2113	1656	1542	1378	54	45	42	39	32	28	27	25
7C	2043	1594	1482	1320	50	40	38	35	29	25	24	22
8C	2118	1694	1588	1435	55	47	45	42	42	38	37	36
9C	2071	1628	1518	1358	53	44	42	39	33	29	28	26
1L	2132	1623	1523	1404	48	39	37	35	36	31	30	29
3L	2106	1602	1503	1385	46	37	36	34	38	32	31	30
4L	2277	1723	1614	1484	54	43	41	38	35	30	29	27
6L	2470	1865	1746	1604	58	46	44	41	39	33	31	30
7L	2001	1510	1414	1299	46	37	35	33	32	26	25	24
2T	2536	2322	2371	2673	63	59	60	65	65	61	62	68
3T	2437	2228	2276	2571	63	58	59	65	64	60	60	66
5T	2635	2408	2460	2781	66	61	62	69	68	63	64	71
10V	2340	1947	1903	1920	58	50	49	49	39	35	34	35
7V	2111	1773	1736	1751	50	44	43	44	51	46	45	45

Base = current situation (2000-2009); FF = Foreseeable Future (2026-2035); LF = Long-term Future (2046-2055); H = Horizon (2090-2099).
Green = above recommended intake level; yellow = maximal 10% below recommended intake level, red = 10% or more below recommended intake level.

Intervention: increase agricultural area

RCP 2.6

	Energy Intake (kCal/cap/d)			
	Base	FF	LF	H
10C	2383	3087	3756	3298
6C	2113	2741	3335	2936
7C	2043	2669	3266	2886
8C	2118	2706	3266	2901
9C	2071	2677	3245	2842
1L	2132	2325	2668	2462
3L	2106	2304	2622	2449
4L	2277	2470	2864	2613
6L	2470	2687	3118	2824
7L	2001	2190	2550	2329
2T	2536	2789	3236	3671
3T	2437	2689	3130	3516
5T	2635	2894	3345	3705
10V	2340	2371	2646	2661
7V	2111	2143	2382	2401

RCP 8.8

	Energy Intake (kCal/cap/d)			
	Base	FF	LF	H
10C	2383	3045	3672	3103
6C	2113	2707	3247	2695
7C	2043	2669	3263	2879
8C	2118	2696	3245	2766
9C	2071	2597	2998	2186
1L	2132	2239	2544	1690
3L	2106	2223	2485	2007
4L	2277	2421	2718	2325
6L	2470	2608	2864	2364
7L	2001	2186	2541	2309
2T	2536	2747	3119	3340
3T	2437	2630	2942	3190
5T	2635	2694	3024	3249
10V	2340	2348	2581	2404
7V	2111	2136	2366	2365

Base = current situation (2000-2009); FF = Foreseeable Future (2026-2035); LF = Long-term Future (2046-2055); H = Horizon (2090-2099).
Green = above recommended intake level; yellow = maximal 10% below recommended intake level, yellow = 10% or more below recommended intake level.

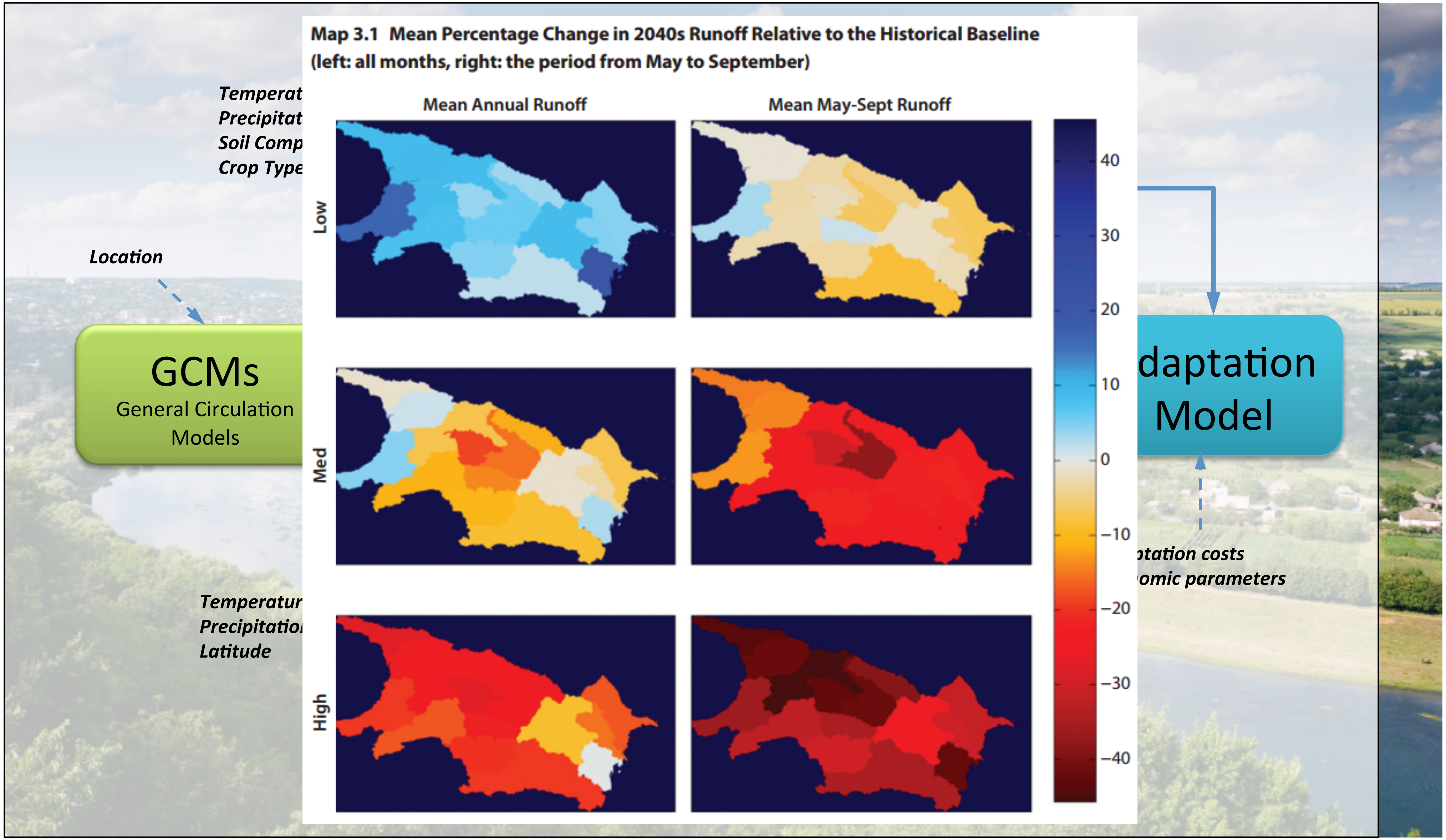
Irrigation water demand

> Assessed using an agro-hydrological model like AquaCrop
> But what about supply versus demand?

Table 5-9. Additional water demand for crop production by irrigation zone

Irrigation zones	Altitude from sea level, m	Additional water demand, million m^3
Ararat valley	900-1800	172,0
Shirak	1400-2200	13.2
Lake Sevan basin	1900-2200	2.04
Northeastern	400-1400	4.2
Lori-Pambak	900-1700	6.6
Vayots Dzor-Syunik	700-2200	4.04
Total		**202.08**

Coupling different models



Modelling yield, water demand and supply

Future crop yield changes towards 2040 (%/10yr) **assuming current irrigation applications**

Crop	Interme-diate	Coastal Lowlands	Northern Mountains	Southern Highlands
Alfalfa irrigated	2%	2%	4%	8%
Alfalfa non irrigated	-1%	-1%	4%	0%
Grapes	-8%	-10%	-6%	-10%
Grassland	-2%	1%	3%	1%
Maize	-1%	-2%	-4%	7%
Olives	-1%	-8%	-5%	-5%
Tomatoes	0%	-2%	-3%	-1%
Watermelons		-1%		
Wheat	4%	3%	11%	8%

Future irrigation water requirements towards 2040 (%/10yr), **assuming current yields**

Scenario	Crop	Interme-diate	Coastal Lowlands	Northern Mountains	Southern Highlands
MEDIAN	Alfalfa irrigated	-3%	-2%	-6%	-6%
	Maize	11%	7%	6%	9%
	Tomatoes	25%	14%	4%	24%
	Watermelons		9%		

Example options to improve water productivity

- Shift crops from areas that are vulnerable to drought
- Enhanced cultivars more tolerant to drought stress
- Fertilization
- Installation of small scale reservoirs on farmland and other rainwater harvesting measures
- Alter crop rotations
- Use of precision farming: tillage, leveling of land, etc
- Water charging or tradable permit schemes
- Deficit irrigation (crop-dependent)

Example Albania: adaptation assessment

> Impact on oliv… …nagement interventions

Scenario		…	…	…thern …ntains		Southern Highlands	
Current						1.2	
2040's	Impact				(-19%)	1.1	(-9%)
	Increased Fer…				(+9%)	1.3	(+12%)
	Enhanced Va…				(+0%)	1.3	(+10%)

Table 22. Impact on crop yields (ton/ha) of different adaptation options for the 4 AEZs in Albania

Scenario		Intermediate		Coastal Lowlands		Northern Mountains		Southern Highlands	
Alfalfa irrigated									
Current		**47.1**		**46.2**		**39.3**		**30.1**	
2040's	Impact	49.2	(+5%)	48.3	(+5%)	42.2	(+7%)	35.7	(+19%)
	Increased Fertilizer Use	50.3	(+7%)	48.1	(+4%)	42.0	(+7%)	36.4	(+21%)
	Enhanced Varieties	55.6	(+18%)	53.1	(+15%)	46.8	(+19%)	40.4	(+34%)
	Increased Irrigation	57.6	(+22%)	50.9	(+10%)	43.6	(+11%)	38.1	(+27%)
Alfalfa non irrigated									
Current		**33.4**		**22.5**		**17.3**		**15.0**	
2040's	Impact	31.4	(-6%)	21.9	(-3%)	16.9	(-2%)	16.0	(+7%)
	Increased Fertilizer Use	31.7	(-5%)	22.1	(-2%)	17.0	(-2%)	16.1	(+7%)
	Enhanced Varieties	35.7	(+7%)	24.9	(+10%)	19.5	(+12%)	18.0	(+20%)
Grapes									
Current		**11.0**		**5.7**		**4.6**		**7.5**	
2040's	Impact	9.2	(-17%)	4.5	(-20%)	3.6	(-21%)	6.1	(-18%)
	Increased Fertilizer Use	9.2	(-17%)	4.6	(-20%)	3.6	(-21%)	6.1	(-18%)
	Enhanced Varieties	11.6	(+6%)	5.7	(+1%)	5.0	(+10%)	7.8	(+4%)
Grassland									
Current		**14.9**		**9.6**		**8.3**		**5.6**	
2040's	Impact	14.1	(-5%)	9.3	(-3%)	7.7	(-7%)	6.2	(+10%)
	Increased Fertilizer Use	17.0	(+14%)	10.7	(+11%)	8.5	(+3%)	6.7	(+18%)
	Enhanced Varieties	16.2	(+9%)	10.5	(+9%)	8.8	(+6%)	7.0	(+24%)
Maize									
Current		**7.7**		**8.8**		**6.7**		**5.2**	
2040's	Impact	7.7	(+1%)	8.6	(-2%)	6.2	(-8%)	6.0	(+15%)
	Increased Fertilizer Use	9.7	(+27%)	8.9	(+2%)	6.9	(+2%)	8.2	(+57%)
	Enhanced Varieties	9.3	(+21%)	9.4	(+6%)	7.5	(+12%)	7.3	(+40%)
	Increased Irrigation	11.0	(+44%)	11.0	(+25%)	8.9	(+33%)	8.6	(+65%)
Olives									
Current		**1.3**		**1.1**		**1.0**		**1.2**	
2040's	Impact	1.2	(-3%)	0.9	(-21%)	0.8	(-19%)	1.1	(-9%)
	Increased Fertilizer Use	1.6	(+28%)	1.1	(+5%)	1.1	(+9%)	1.3	(+12%)
	Enhanced Varieties	1.4	(+13%)	1.1	(-1%)	1.0	(+0%)	1.3	(+10%)

Take-home messages

> Satellite-derived WP database is a huge information resource on past and current situation

> For planning interventions to improve WP, simulation models are needed to examine impact of different futures (farm management, water supply, climate change ....)

> Models can be effective on different spatial (country to field) and temporal (daily forecast to climate change) scales

> Based on outcomes of (agro-)hydrological models, policy makers can improve their decision making towards their goal of enhancing WP

Thank you for your attention!

g.simons@futurewater.nl