Water, trade and climate change

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Outline

- Virtual water
- Water in a CGE

- Impact of climate change

- Wrap-up

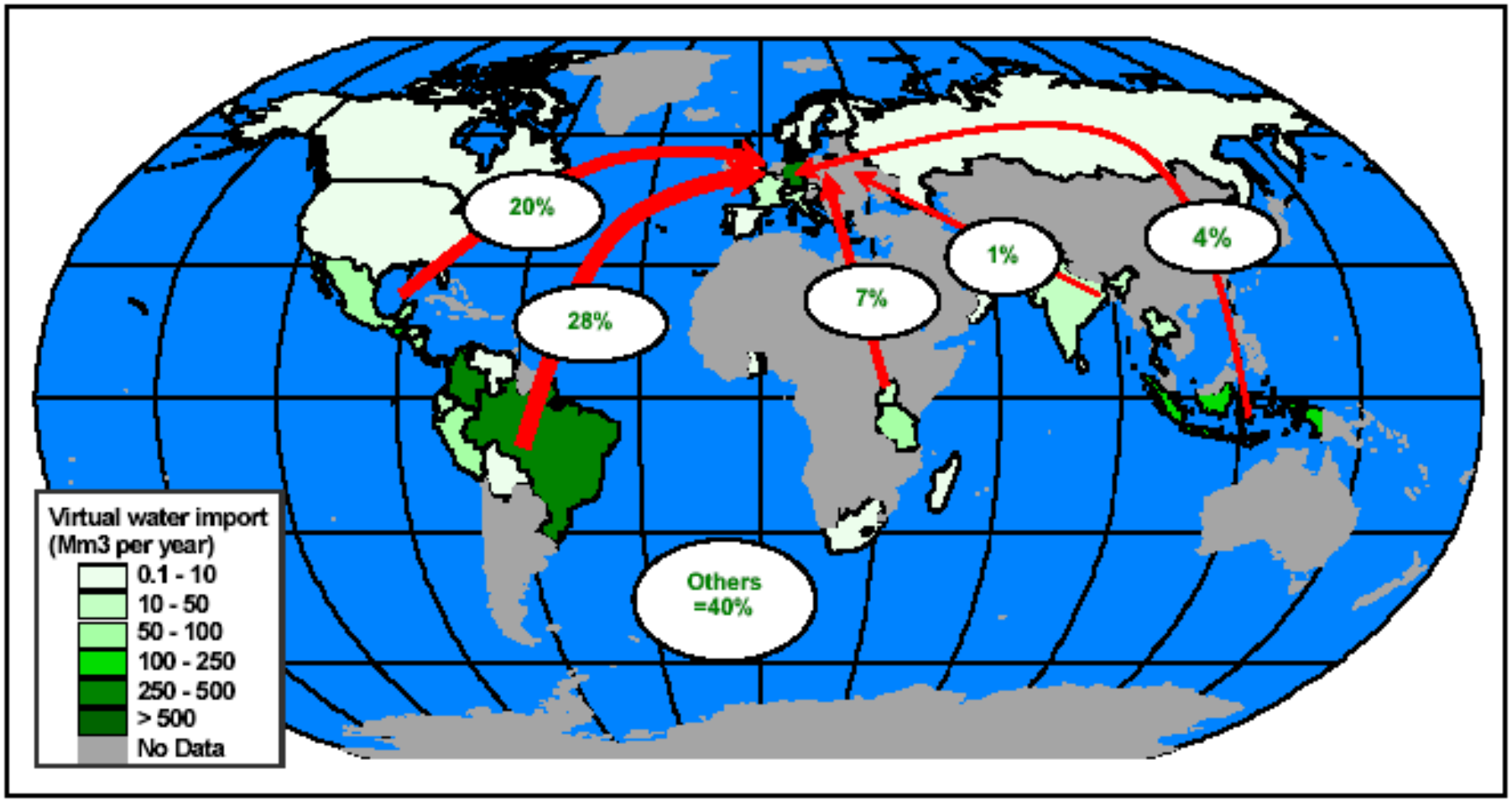
Water in GTAP

- The GTAP-CGE is based on the national accounts, which have data on water *services*, but not on water
- Water is free, a gift from Allah
- (Water services are not free)
- Therefore, one needs to construct a satellite account of water use, which gives, per sector and country, how much water is used
- Fortunately, FAO, UNESCO, IFPRI have gathered such data

Virtual Water

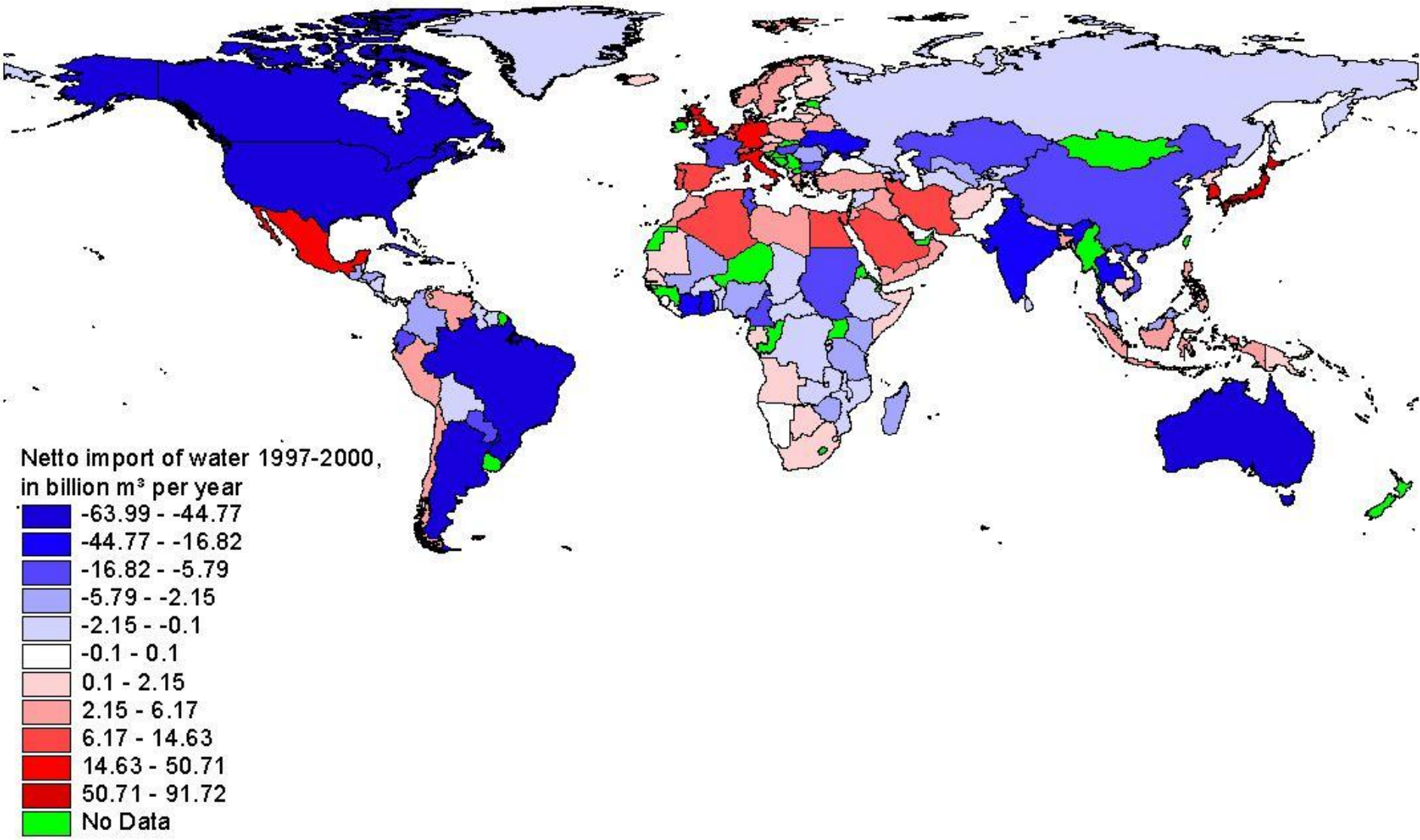
- How much water is needed for a cup of coffee?
- 125 ml water and 7 g coffee
- In Brasil, you need about 3000 m^3 water per tonne of coffee cherries
- After washing, drying, roasting etc., this makes 22500 m^3 water per tonne of coffee
- That makes 140 l water for 7 g coffee
- 14 buckets, 1100 cups: that is, 1101 cups of water for a cup of coffee
- This water is not from the environs of Amsterdam, however

Netherlands: Virtual import of water for coffee

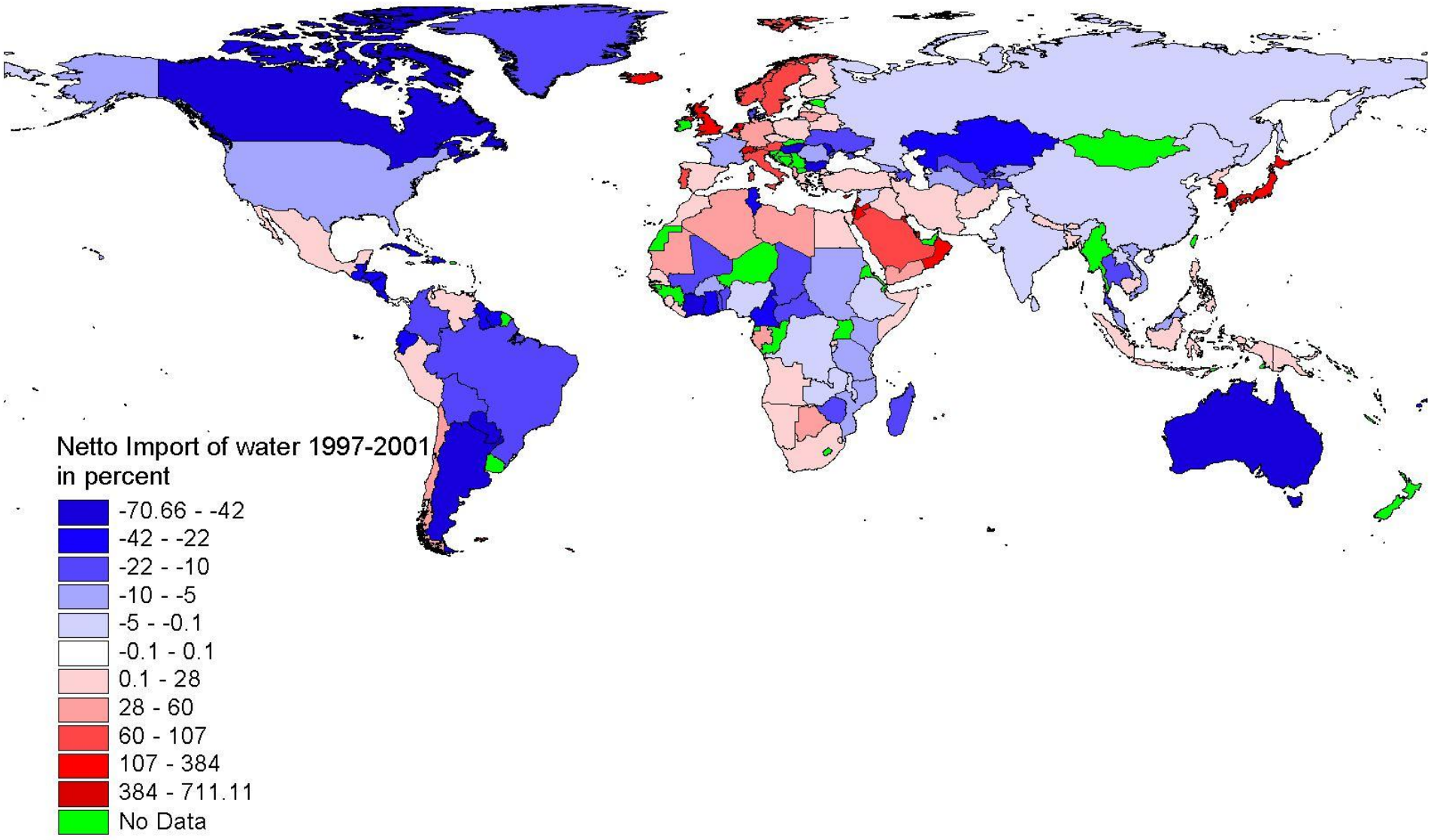


Besides for coffee, one could do this for tee, cotton, wheat and all other products.

Import and Export of virtual water (absolute)



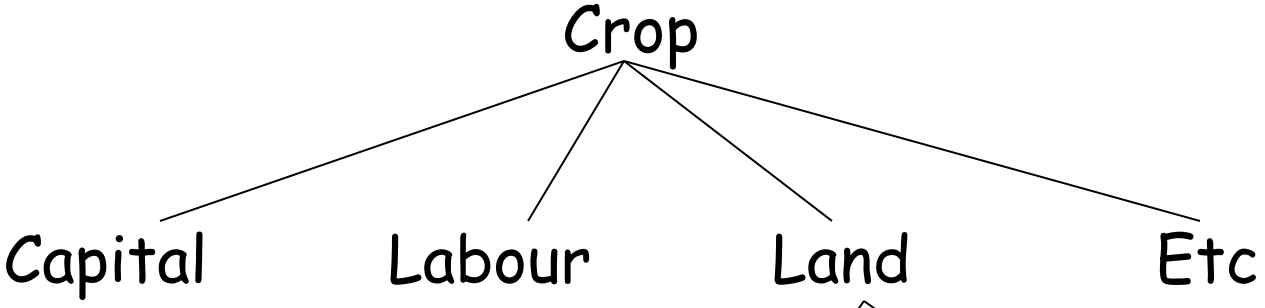
Import and Export of virtual water (relative)



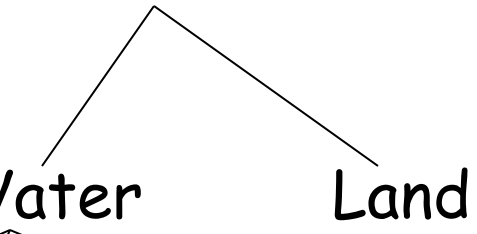
Water in GTAP

- Water is not in the national accounts, primarily because (in most countries) water is not traded
- Hence, water is no endowment in CGEs, although it is in reality
- There is a water services sector in the national accounts, but that is transport and purification rather than water

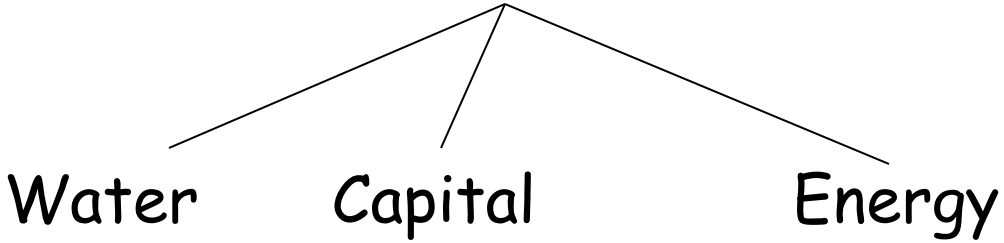
Standard GTAP



GTAP-W2



GTAP-W3



GTAP-W1: Split land-productivity into water and other-productivity

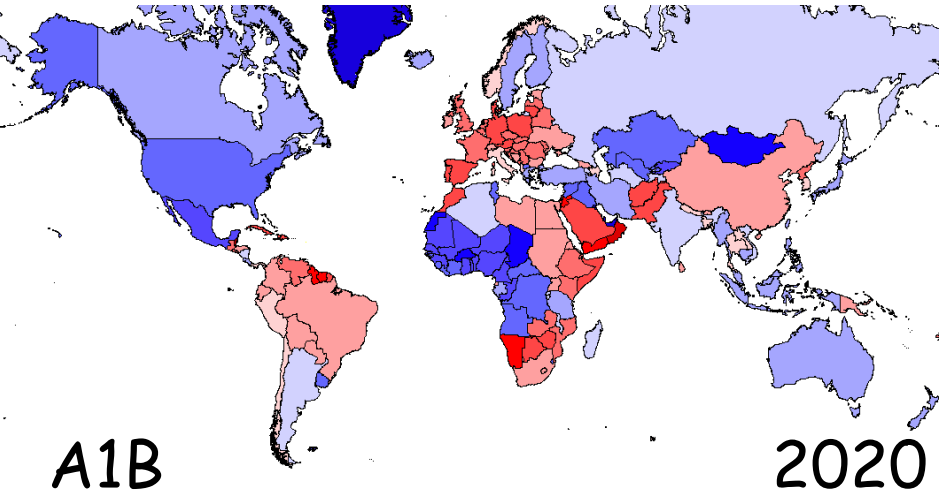
GTAP-W2: As W1 for rainfed agriculture, as above for irrigated agriculture

Impact of climate change

- The effect of climate change on water resources is typically listed among the worst impacts
- Water is indeed crucial, but previous research leaves much to be desired
  - Arnell's results are driven by population and water availability only – no adapation, no development, no technological progress
  - Impact of climate change on agriculture is typically driven by precipitation

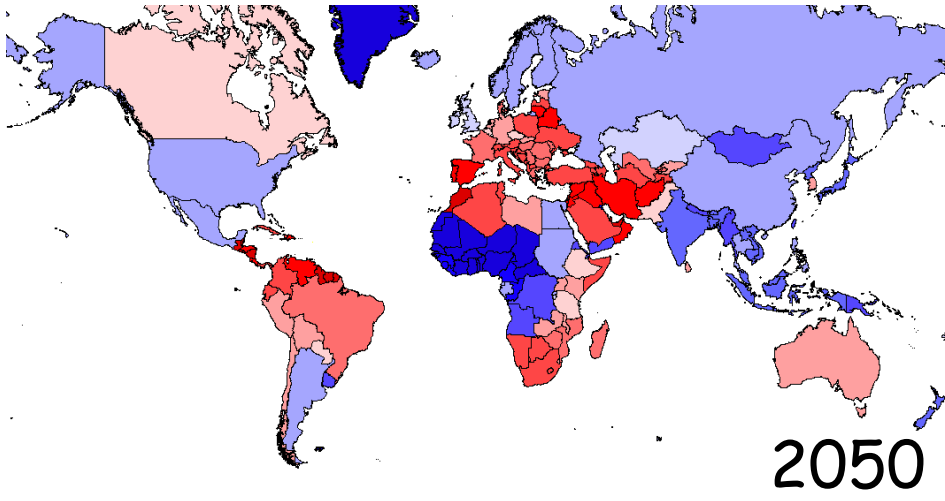
Impact of climate change

- We use a General Circulation Model with a River Routing model, that tracks the flows of water from one grid cell to the next, and that includes the moderating effects of reservoirs
- We use the results of this as input to a Computable General Equilibrium model that has rain and irrigation water as explicit factors of production in agriculture – and has all the "autonomous" adaptation of farmers changing behaviour and trade flows adjusting

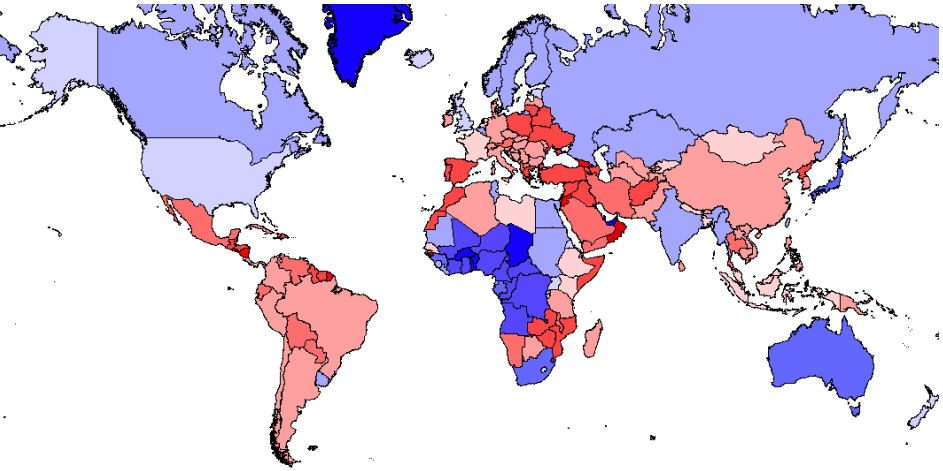


A1B

2020

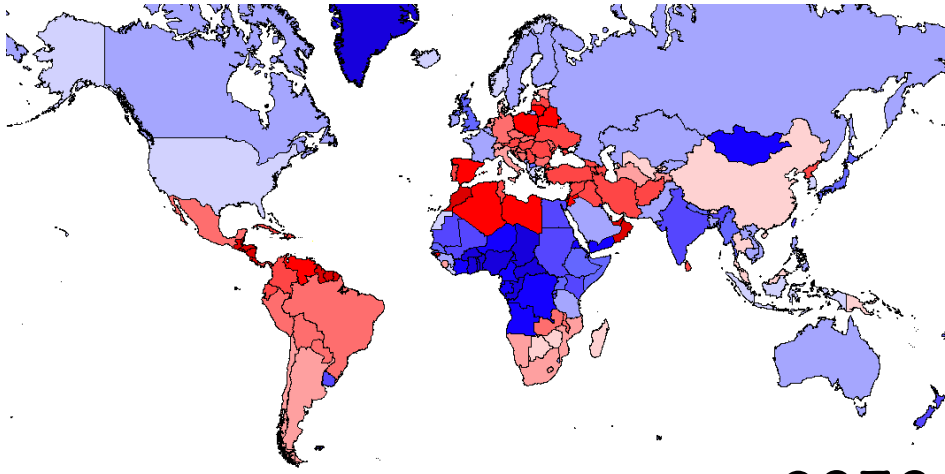


2050

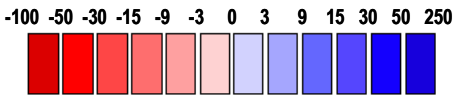


A2

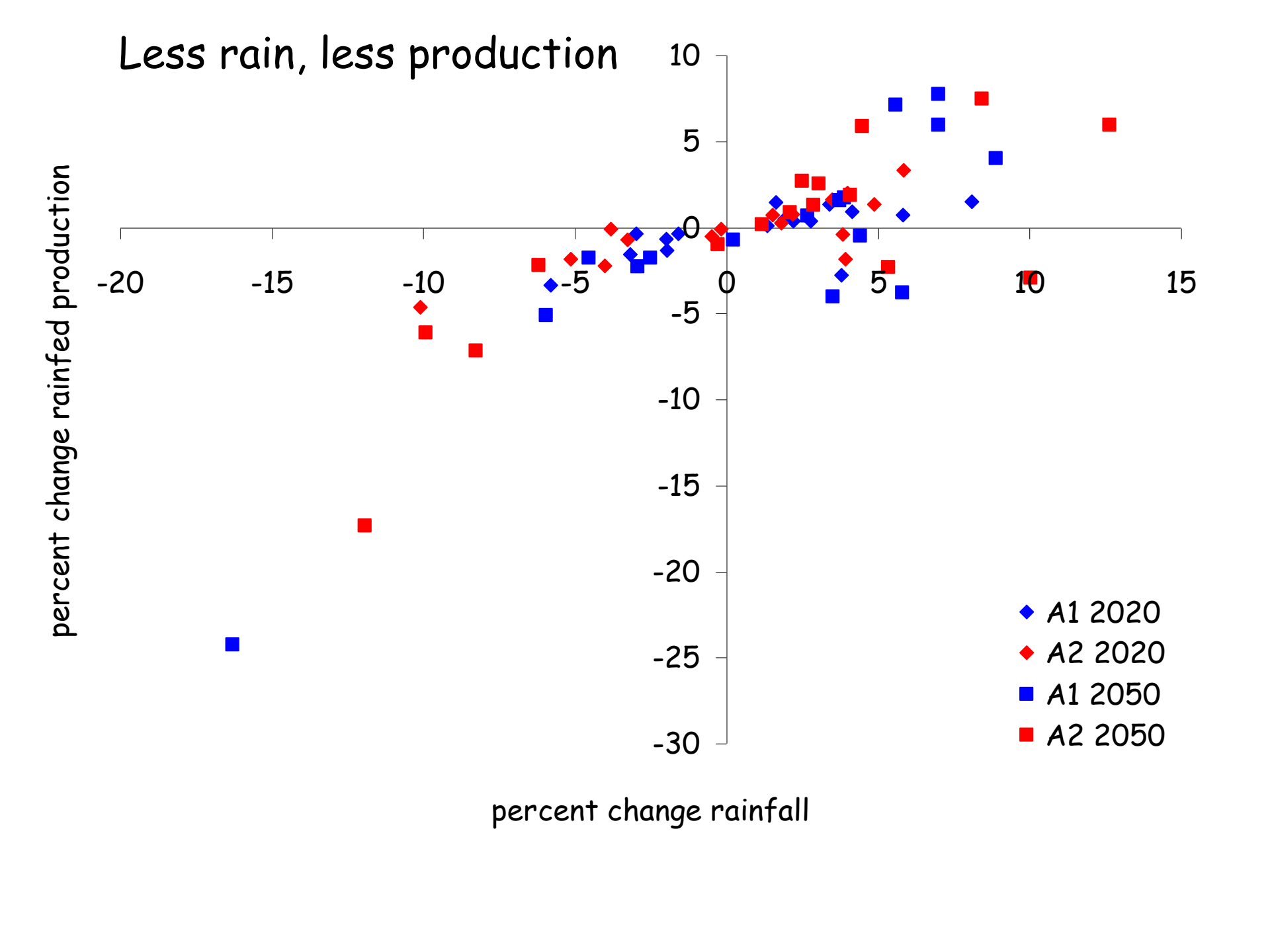
2020

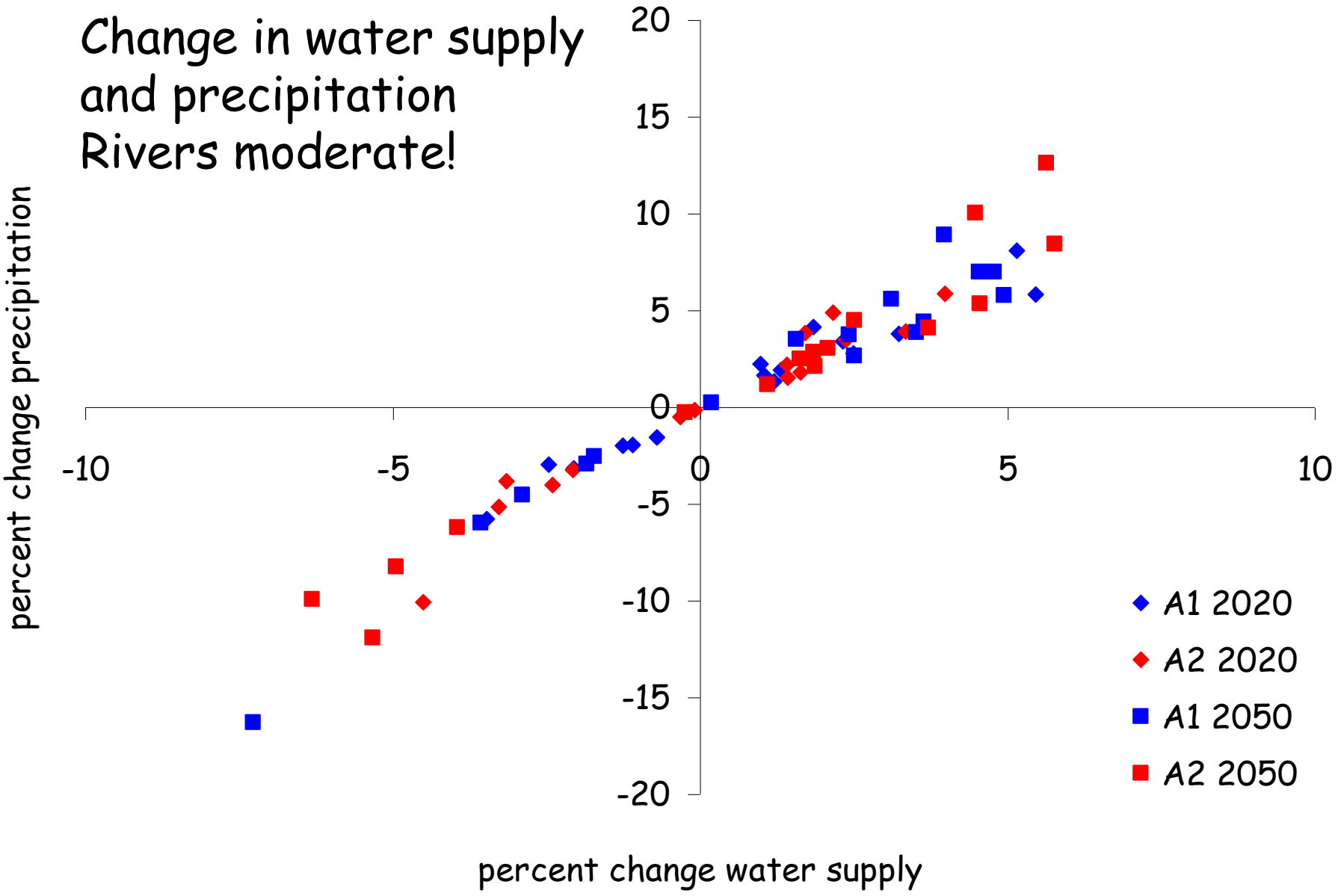


2050

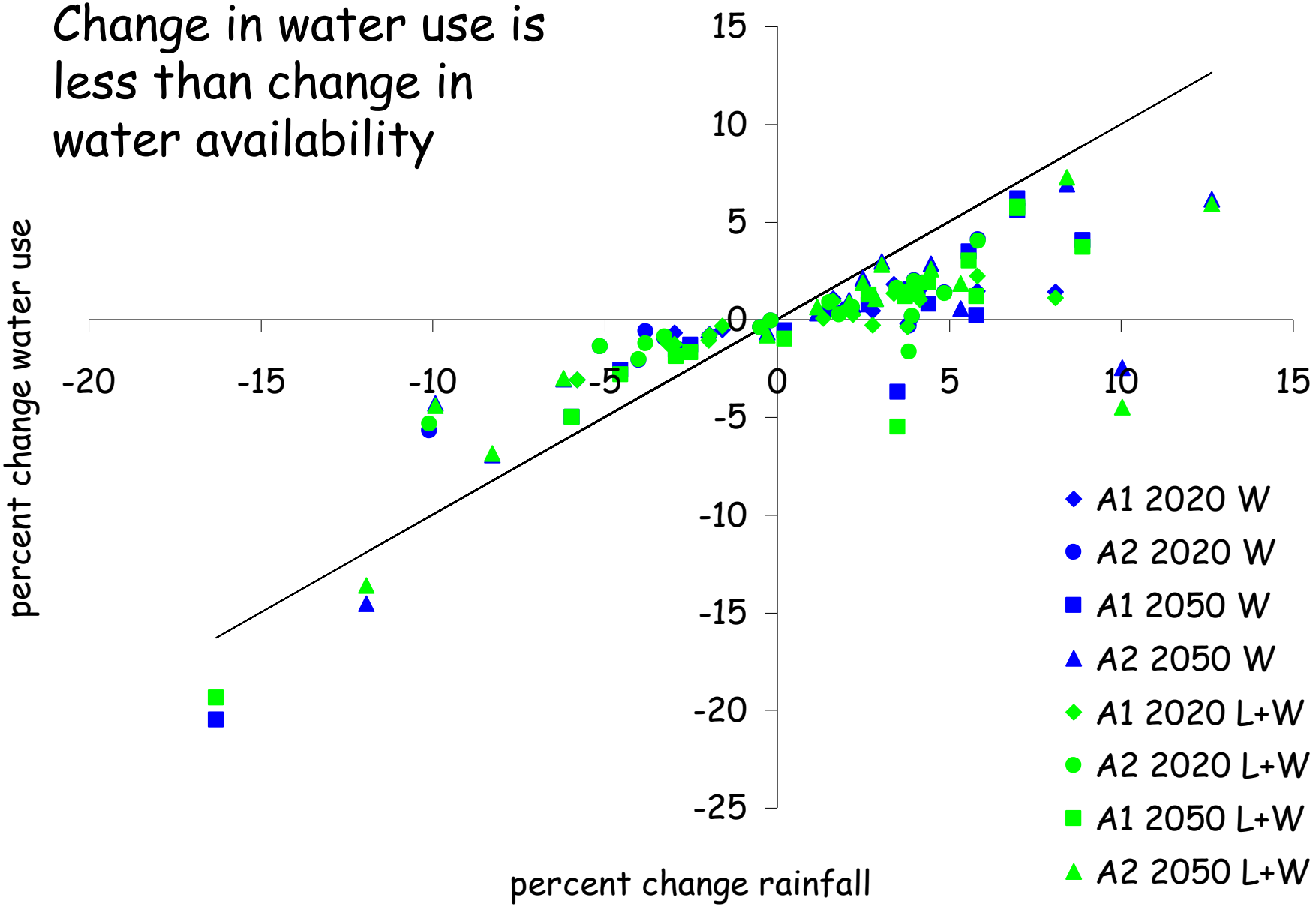


Percent change (from 1961-1990)
in annual average river flow

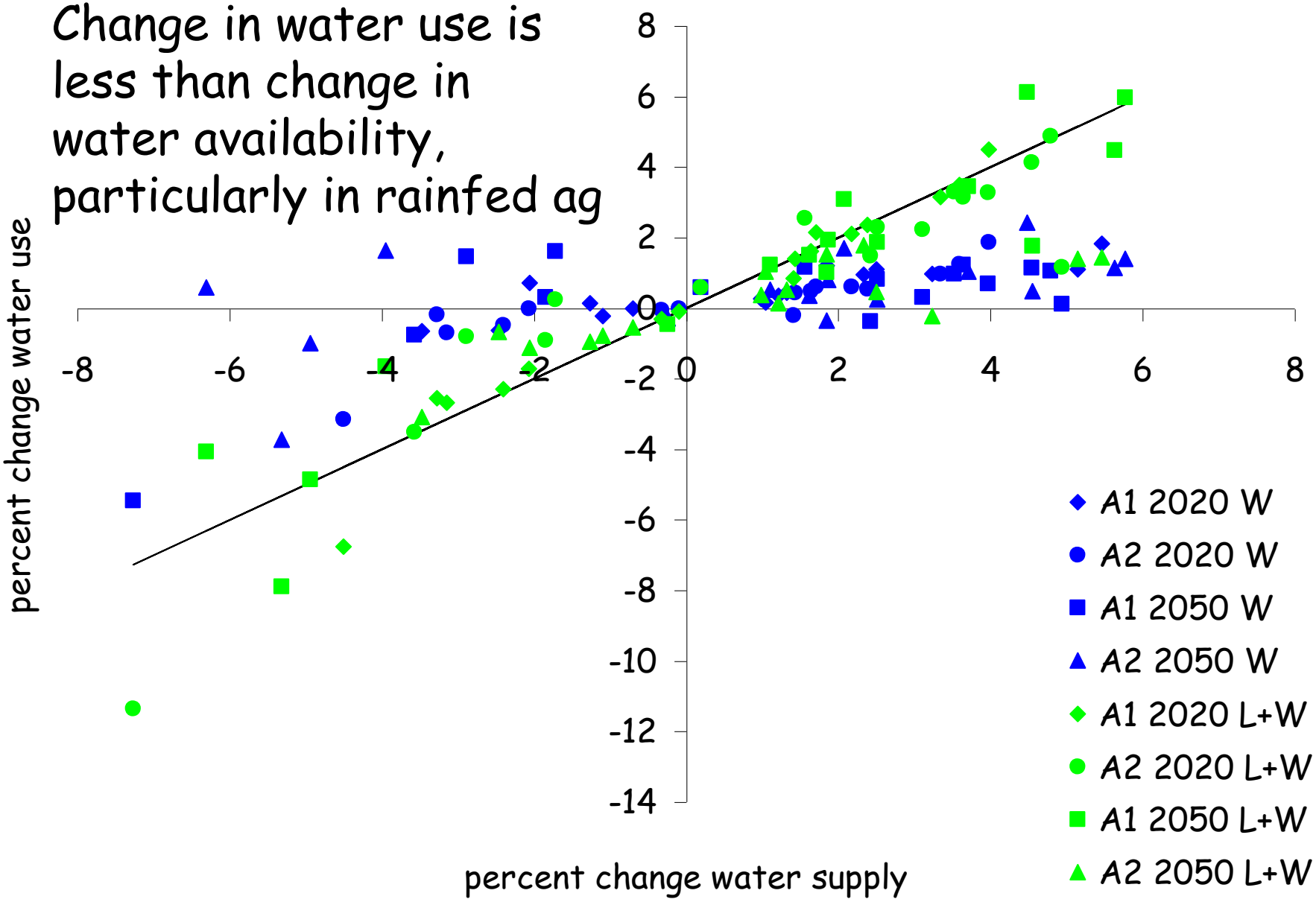

Less rain, less production
10
5
0
-5
-10
-15
-20
-20
-15
-10
-5
0
5
10
15
percent change rainfed production
percent change rainfall
A1 2020
A2 2020
A1 2050
A2 2050

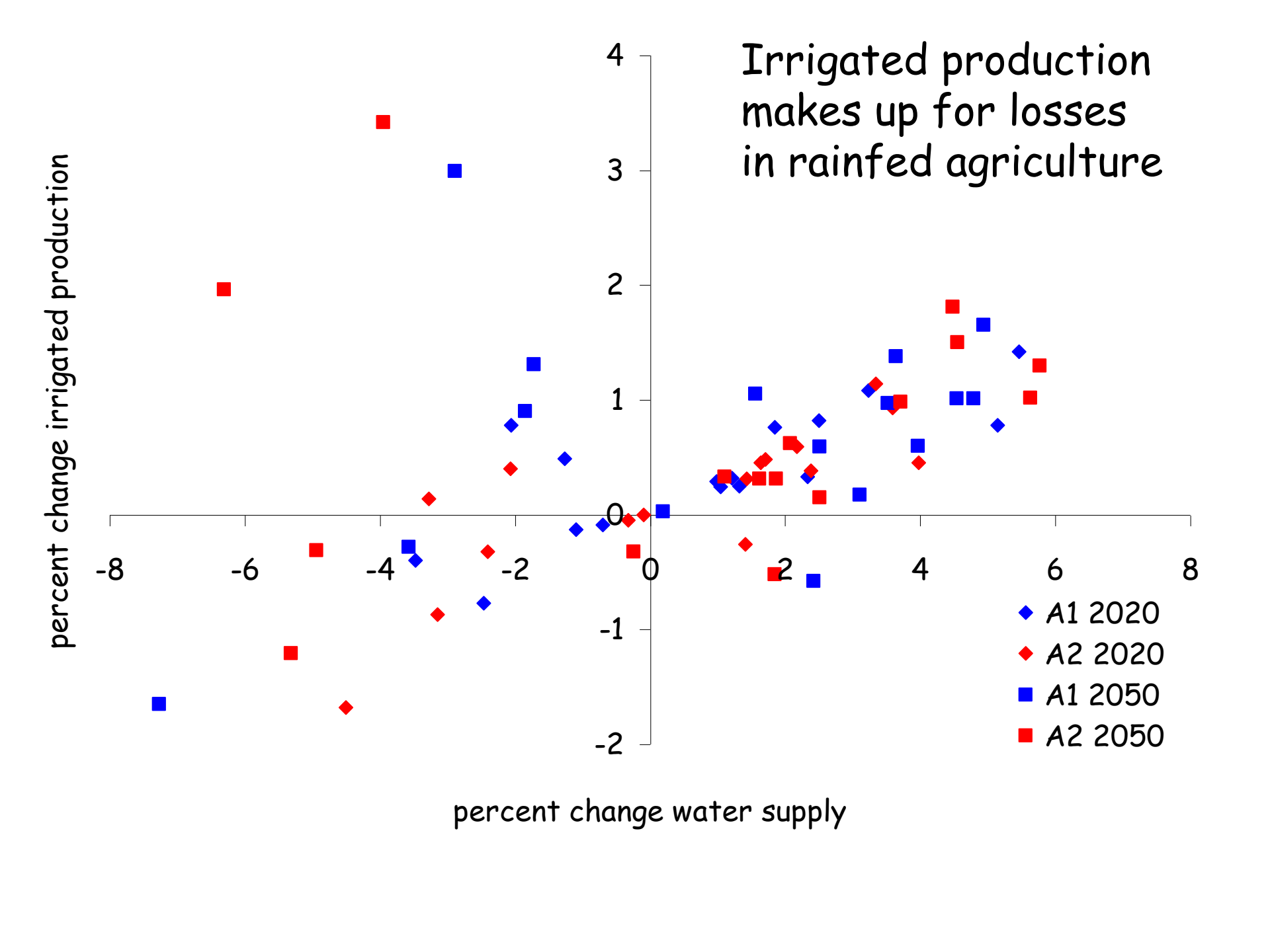

Change in water supply and precipitation
Rivers moderate!
20
15
10
5
0
-5
-10
-15
-20
-10
-5
0
5
10
percent change precipitation
percent change water supply
A1 2020
A2 2020
A1 2050
A2 2050

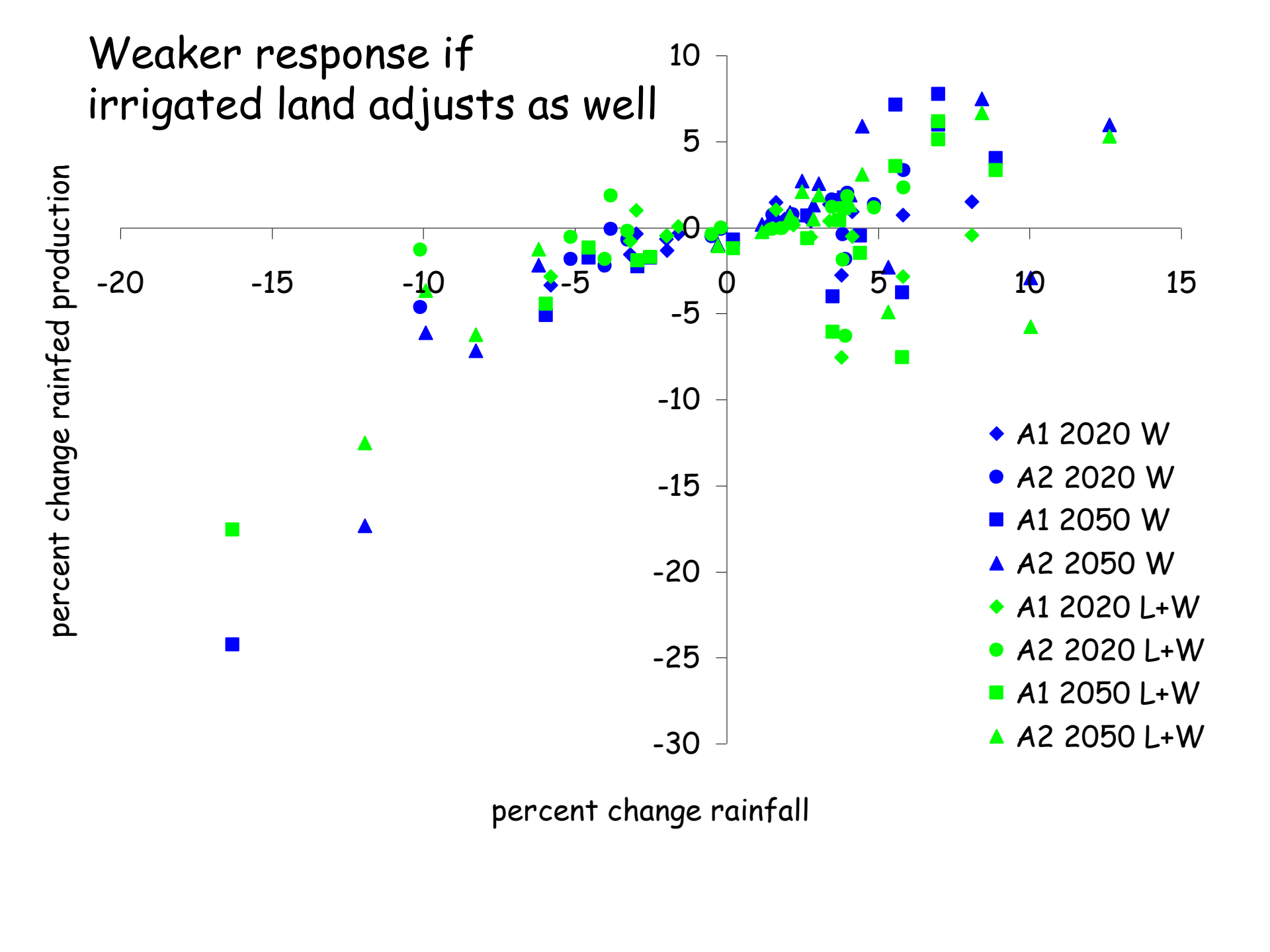
Change in water use is less than change in water availability

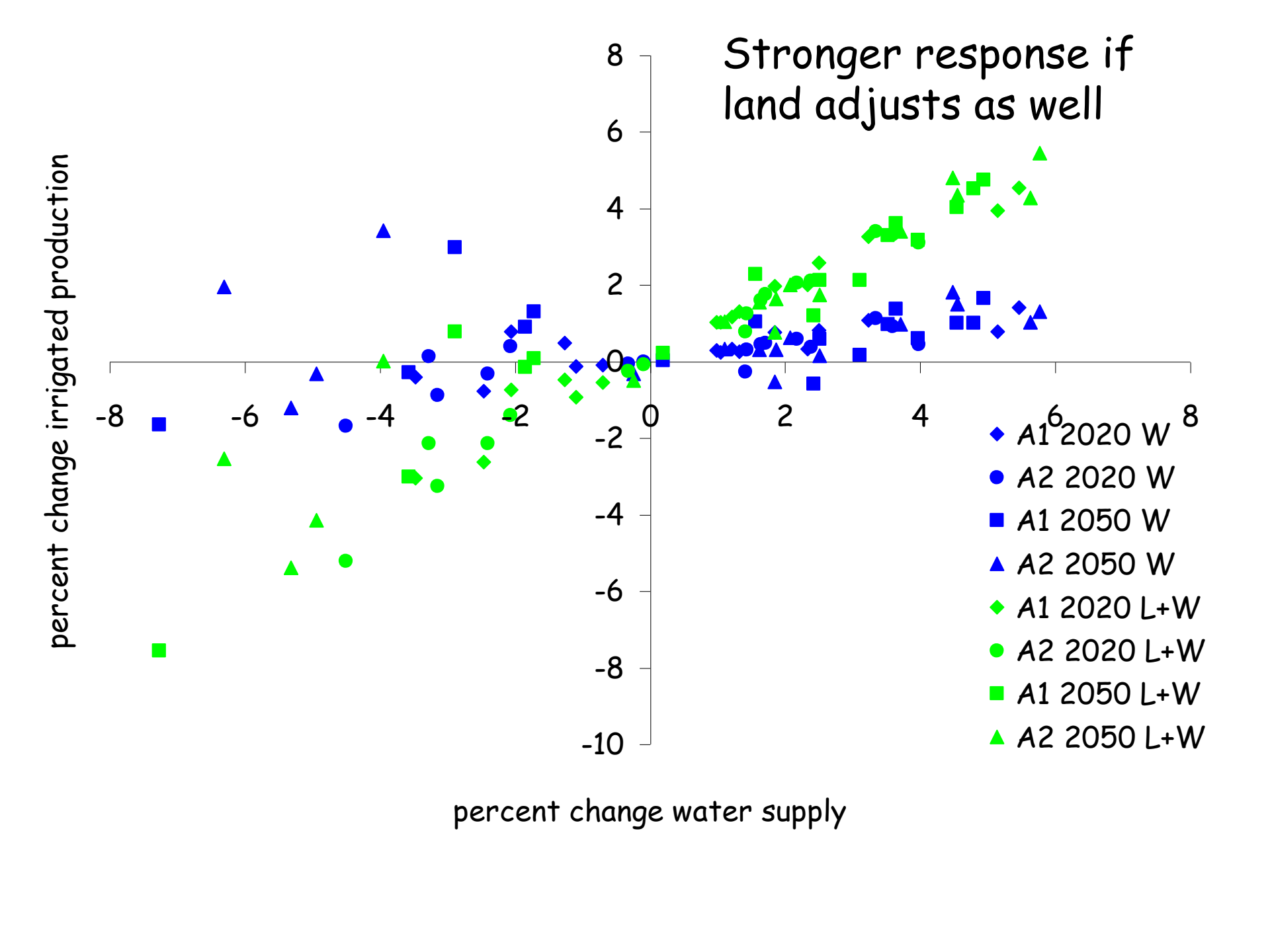


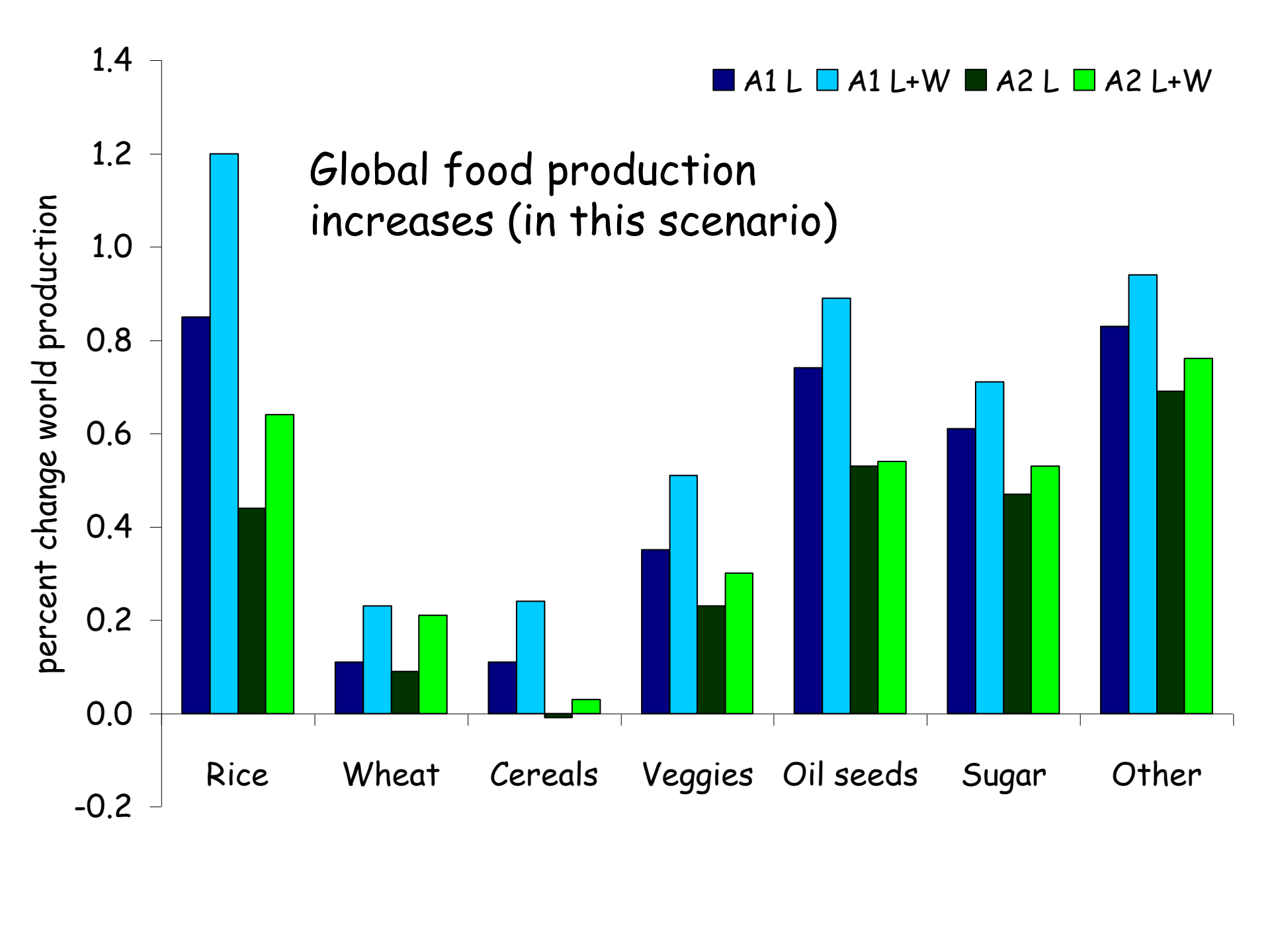
Change in water use is less than change in water availability, particularly in rainfed ag

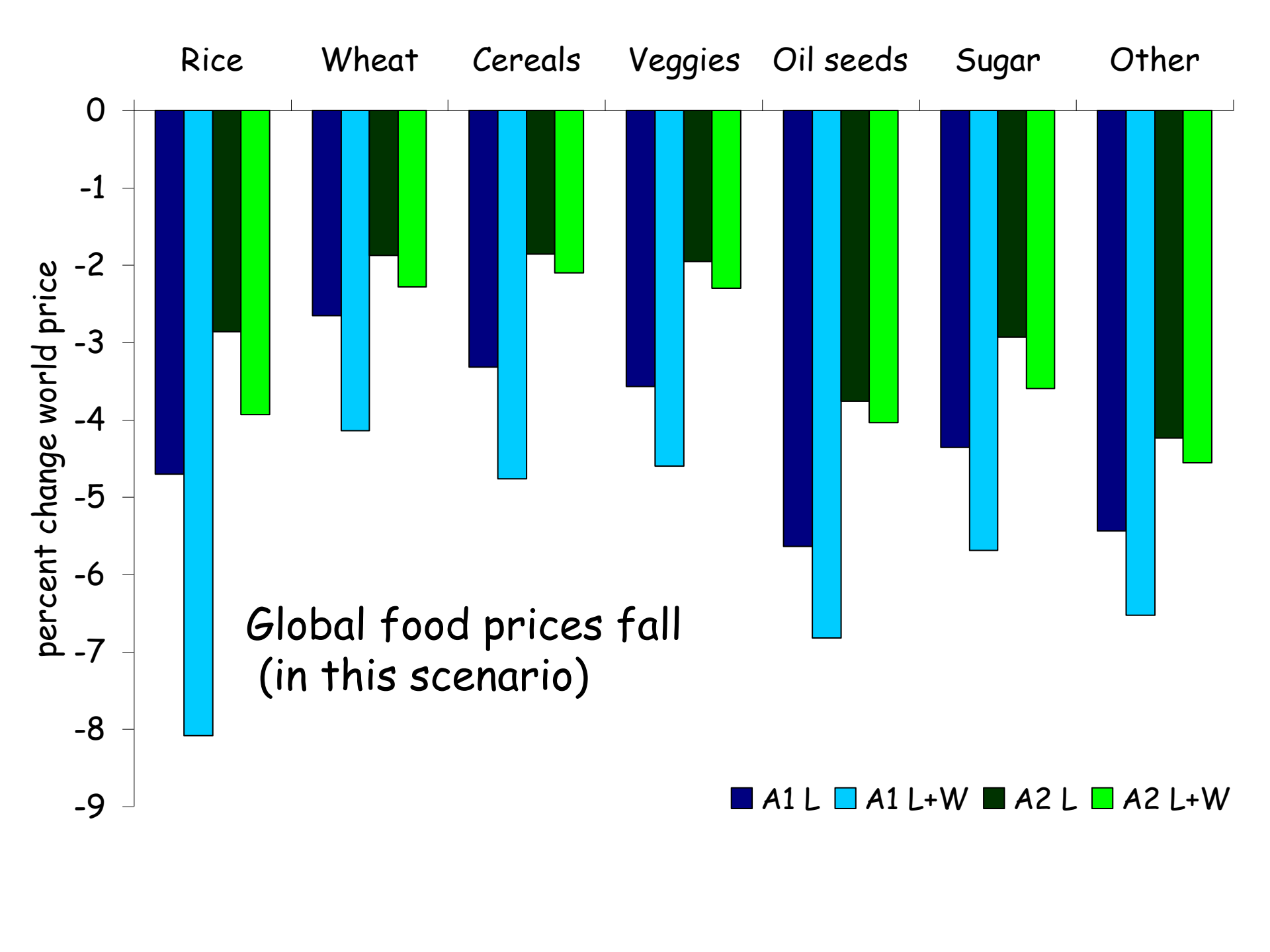


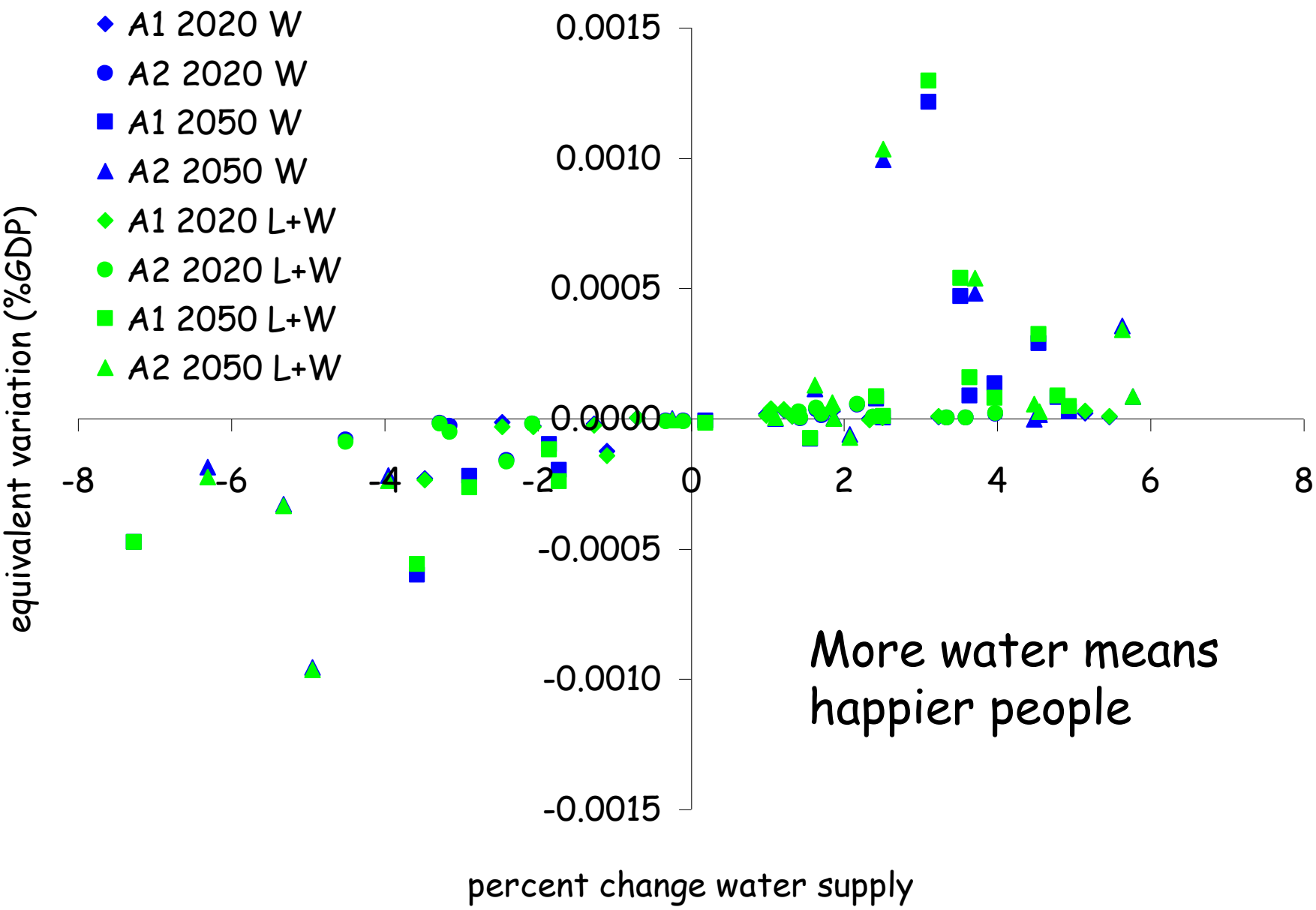

Irrigated production
makes up for losses
in rainfed agriculture
percent change irrigated production
percent change water supply
4
3
2
1
0
-1
-2
-8
-6
-4
-2
0
2
4
6
8
A1 2020
A2 2020
A1 2050
A2 2050


Weaker response if irrigated land adjusts as well
10
5
0
-5
-10
-15
-20
-25
-30
-20
-15
-10
-5
0
5
10
15
percent change rainfed production
percent change rainfall
A1 2020 W
A2 2020 W
A1 2050 W
A2 2050 W
A1 2020 L+W
A2 2020 L+W
A1 2050 L+W
A2 2050 L+W


Stronger response if land adjusts as well
percent change irrigated production
percent change water supply
8
6
4
2
0
-2
-4
-6
-8
-10
-8
-6
-4
-2
0
2
4
6
8
A1 2020 W
A2 2020 W
A1 2050 W
A2 2050 W
A1 2020 L+W
A2 2020 L+W
A1 2050 L+W
A2 2050 L+W

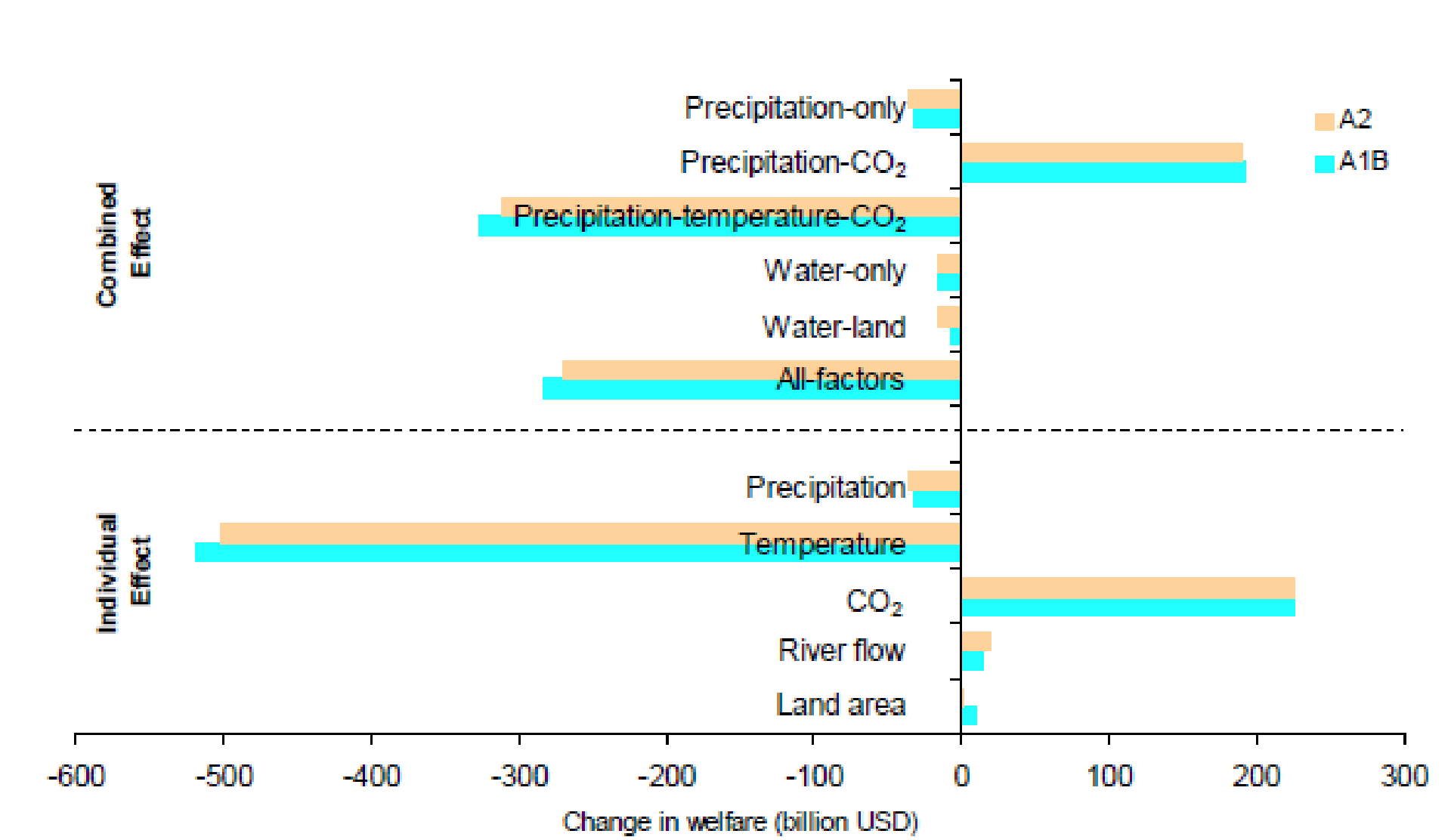

A1 L
A1 L+W
A2 L
A2 L+W
Global food production
increases (in this scenario)
percent change world production
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
-0.2
Rice
Wheat
Cereals
Veggies
Oil seeds
Sugar
Other


Rice
Wheat
Cereals
Veggies
Oil seeds
Sugar
Other
0
-1
-2
-3
-4
-5
-6
-7
-8
-9
percent change world price
Global food prices fall
(in this scenario)
A1 L
A1 L+W
A2 L
A2 L+W


A1 2020 W
A2 2020 W
A1 2050 W
A2 2050 W
A1 2020 L+W
A2 2020 L+W
A1 2050 L+W
A2 2050 L+W
0.0015
0.0010
0.0005
0.0000
-0.0005
-0.0010
-0.0015
-8
-6
-4
-2
0
2
4
6
8
equivalent variation (%GDP)
percent change water supply
More water means happier people

Findings

- Lots of adaptation
  - rivers moderate
  - Δ water use < Δ water availability
  - change in land use
  - substitution between irrigated and rainfed ag
  - shift in trade patterns
- Overall welfare impacts small and positive
  - 2050 only
  - Increase in water availability
- How does this compare to other studies?


Combined Effect
Individual Effect
Precipitation-only
Precipitation-CO_2
Precipitation-temperature-CO_2
Water-only
Water-land
All-factors
Precipitation
Temperature
CO_2
River flow
Land area
A2
A1B
-600
-500
-400
-300
-200
-100
0
100
200
300
Change in welfare (billion USD)

Conclusions

- There is a long and complex chain from greenhouse gas emissions to changes in rainfall patterns to water availability to food to welfare
- Today I emphasized the moderating effects – river transport, crop switching, irrigation, trade – and used a moderate, wet scenario
- That's not the whole story, of course