FARMD Webinar Series

Climate Change and Food Production in China

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Overview

- Climate change in China’s arable land.
- Did the change undermine food production?
- Will the change matter in the future?
- Does adaptation work?
- Key messages.

Climate change, why be so concerned?

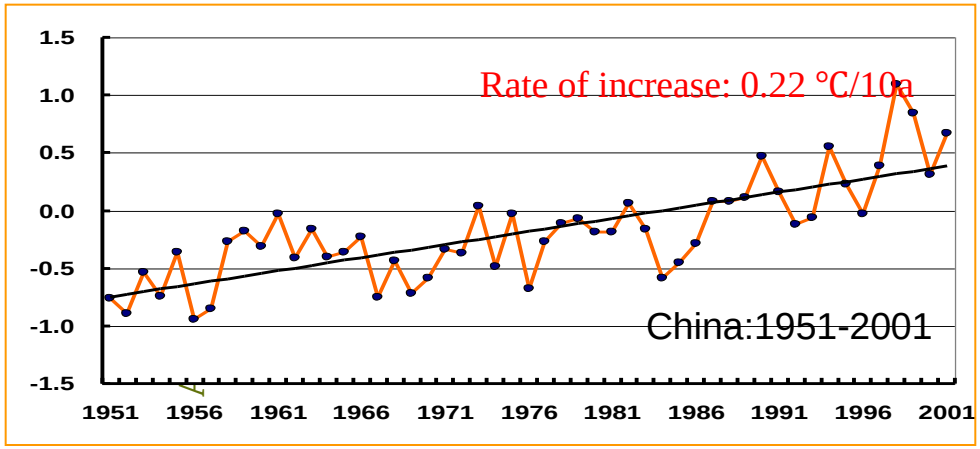
Why be so concerned?

- Less than 10% arable land feeds 22% of the world population.
- Agriculture is highly climate dependent.
- Decreasing arable land and increasing population in next decades.
- Climate change is an additional burden to food production.

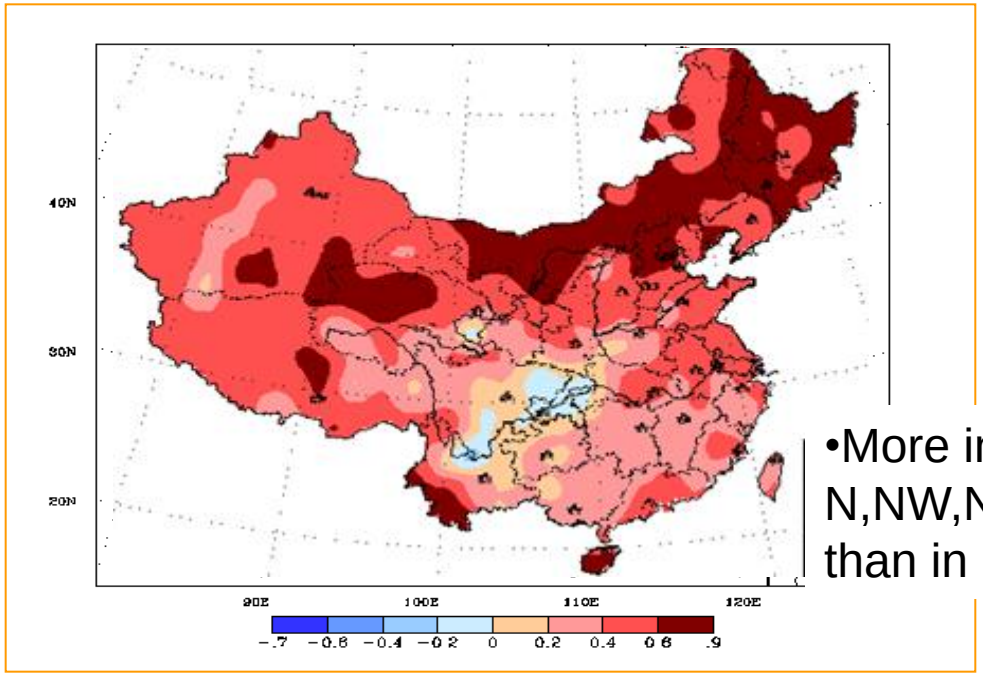
The reality of the climate change in China

T

Nation-averaged annual mean surface air temperature anomalies for period 1951-2001



Trends of annual mean surface air temperature of China during 1951-2001



T:

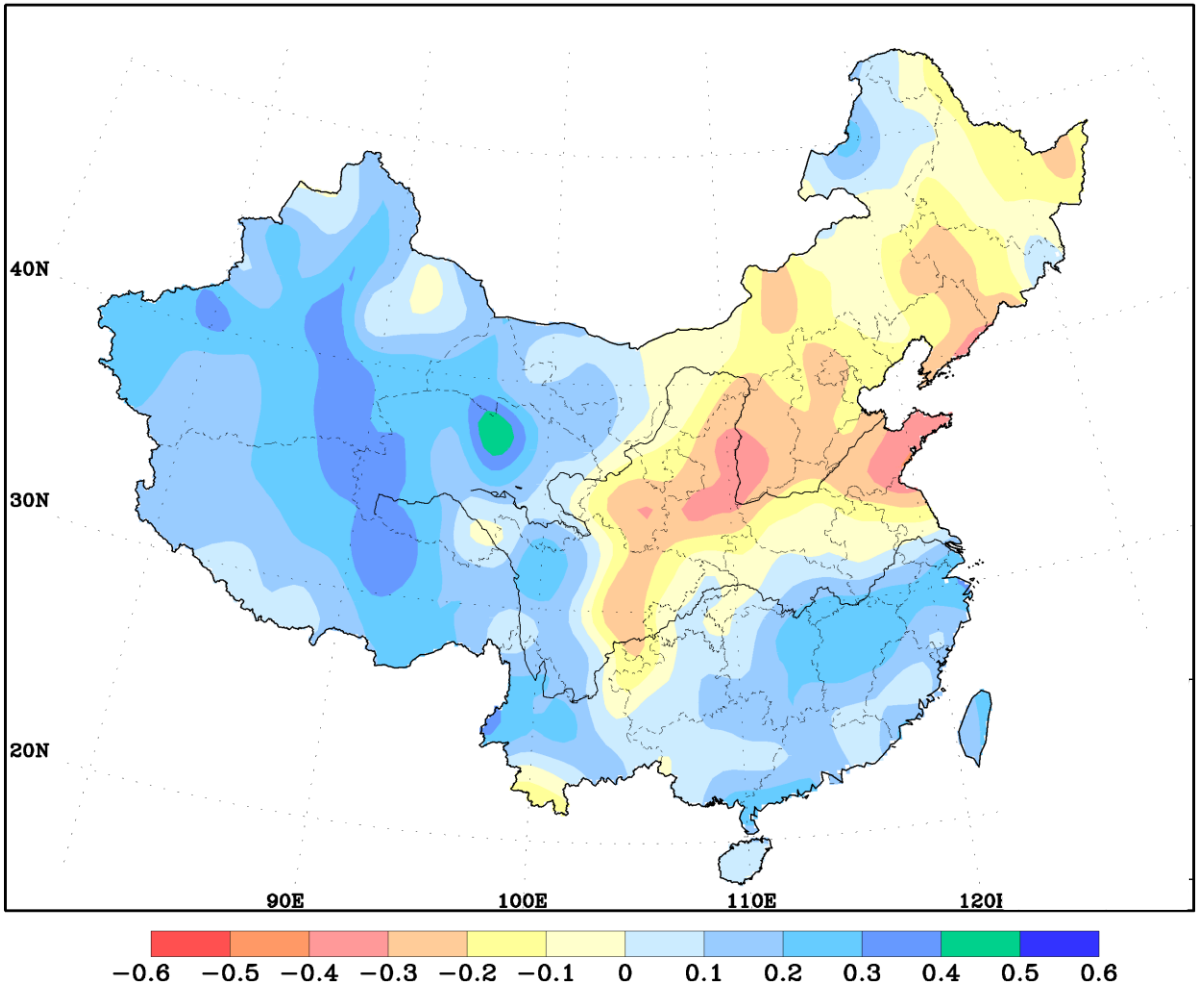
•The trend of annual 0.5~0.8 during the past 100 years.

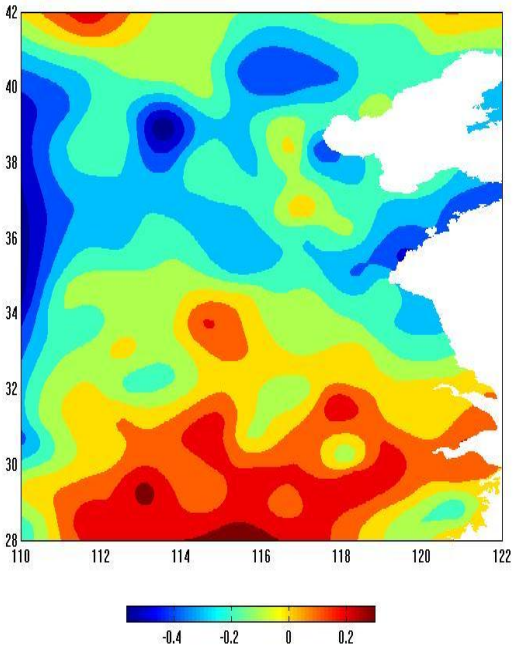
•More in N,NW,NE than in S

The reality of the climate change in China

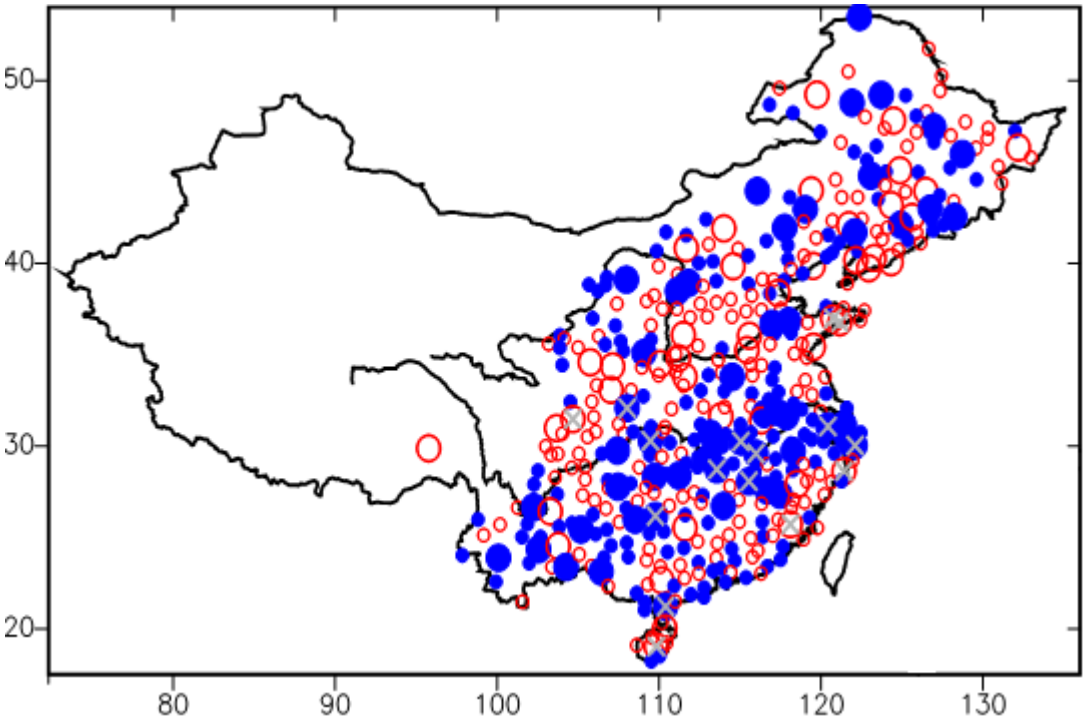
P

Trend of annual precipitation from 1956 to 2002 in China. Yellow and red color indicates decrease in annual precipitation.





Trend of precipitation change over eastern China from 1951 to 2004. Negative (blue) indicates a decreasing trend.

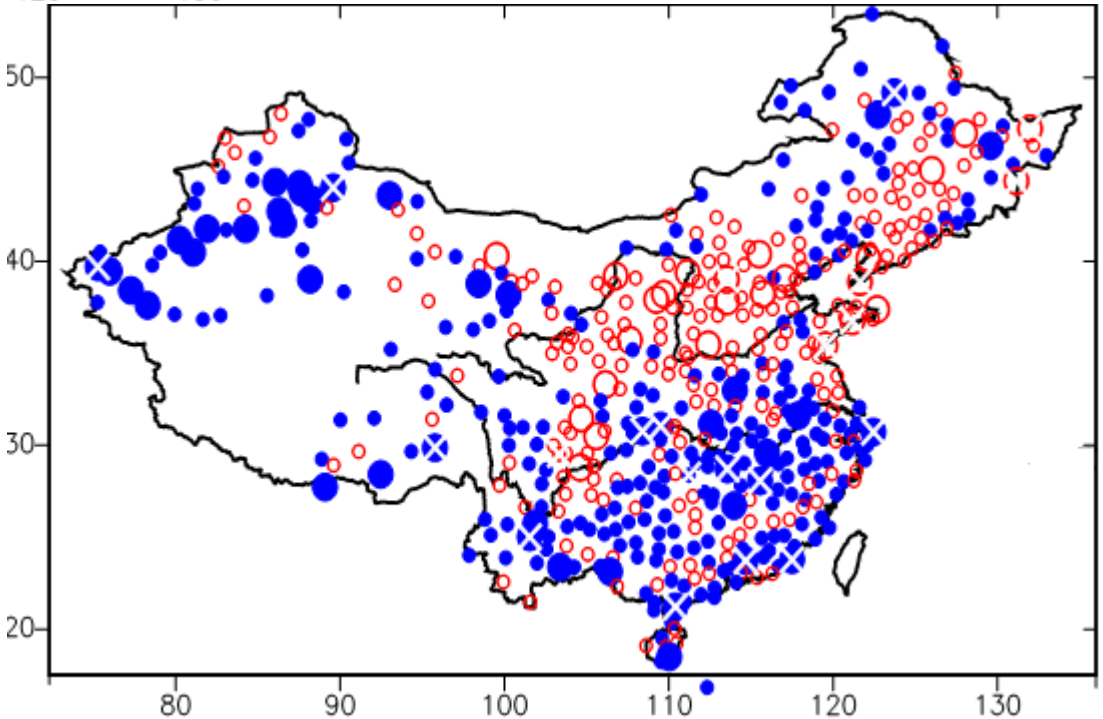


Trends of days with heavy rain in summertime (April to September) during 1951-2000. (Zhai, et al., 2004)

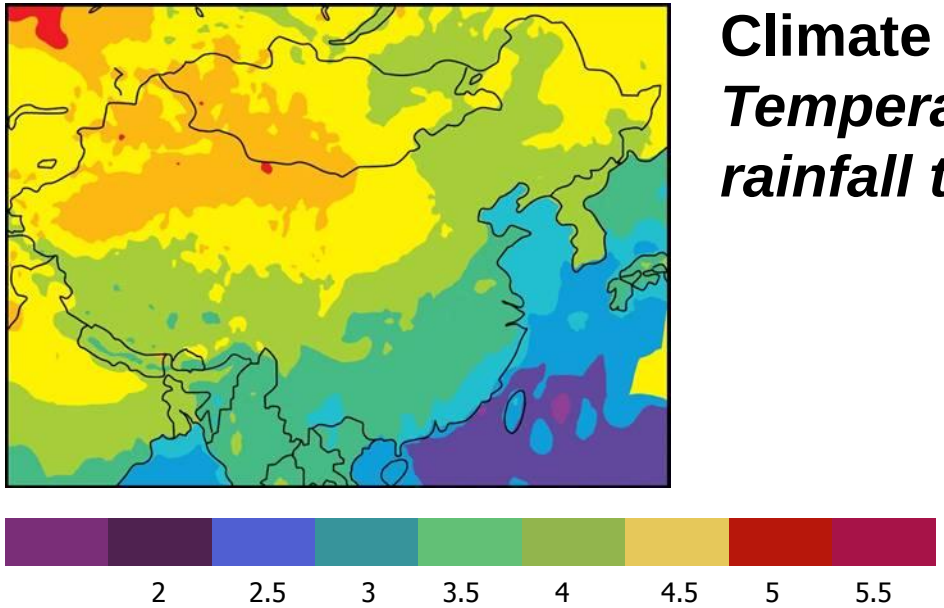
Blue color denotes increase, red color denotes decrease and cross denotes excess of the 95% significant level.

Trends of days with strong rain in summertime (April to September) during 1951-2000.

(Zhai, et al., 2004)



Trend of climate change

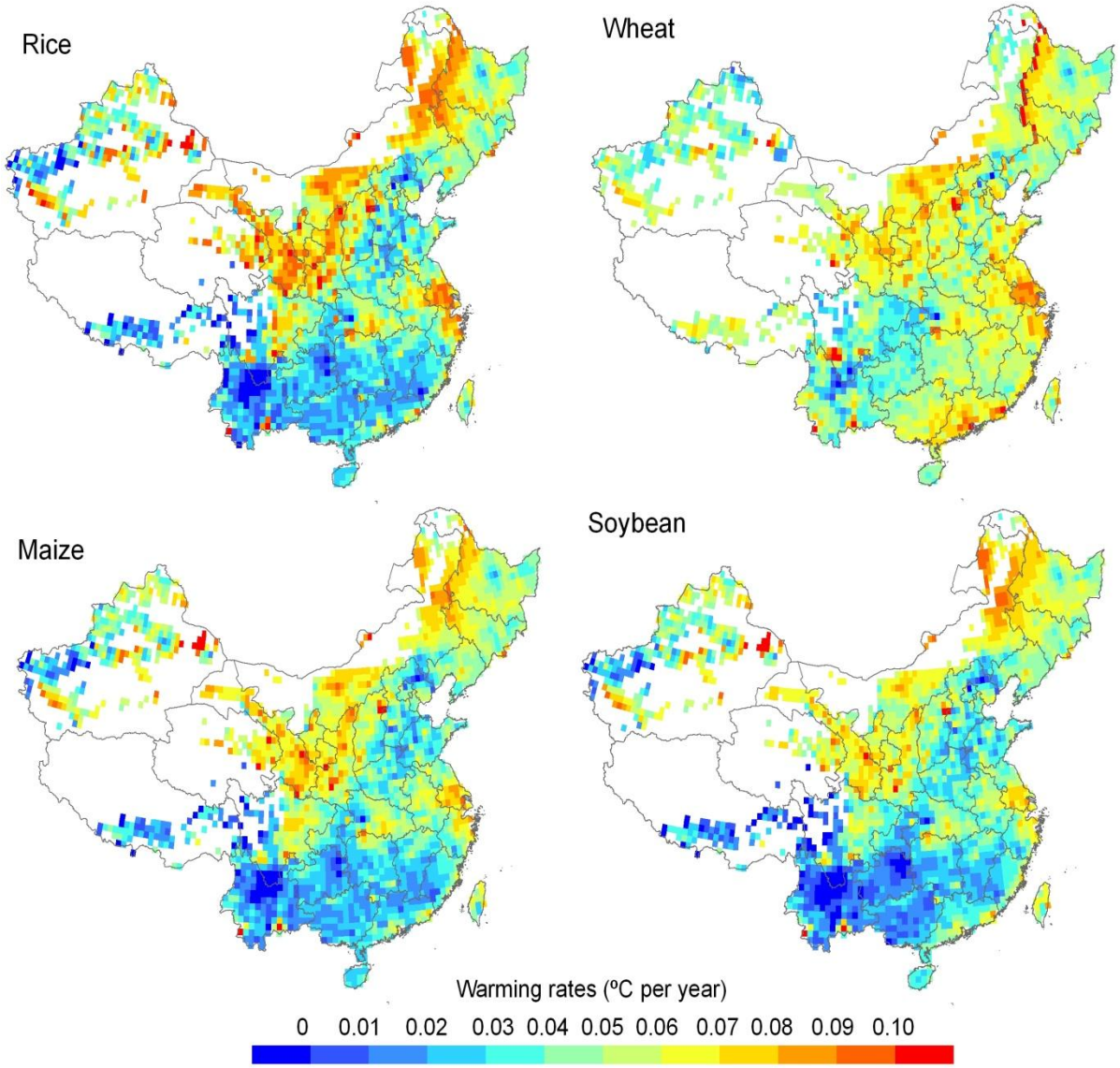


Climate Change Scenarios

Temperature to increase by 3~4℃ and rainfall to increase 10~12% by 2080s

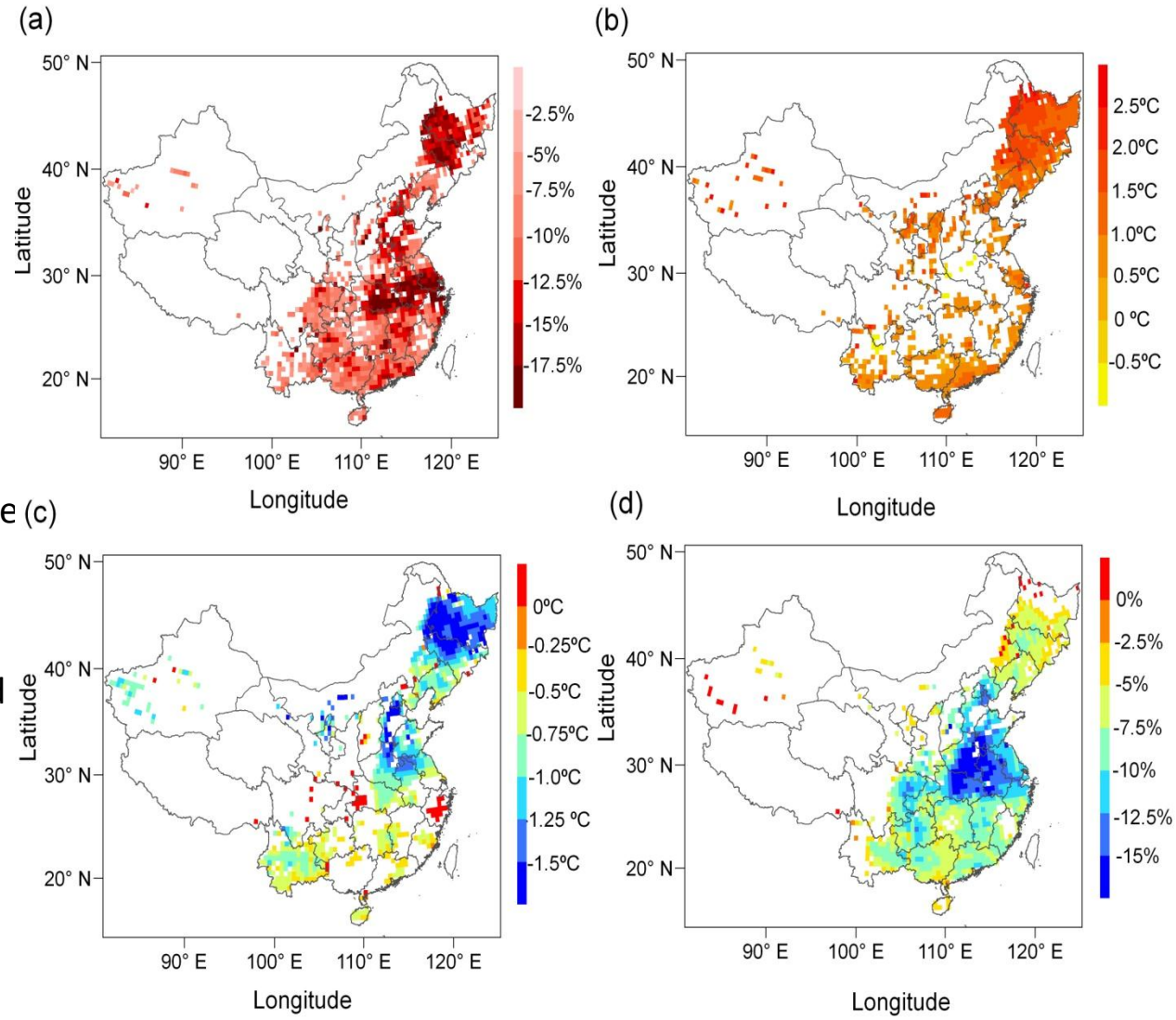
Climatic risks for the main food crops

- The growing- season warming was significant for all crops, with 0.43, 0.58, 0.45 and 0.45 ºC per 10 years since 1980, respectively, for rice, wheat, maize and soybean.
- Spatial differences are obvious for different crops.



Climatic risks for the main food crops

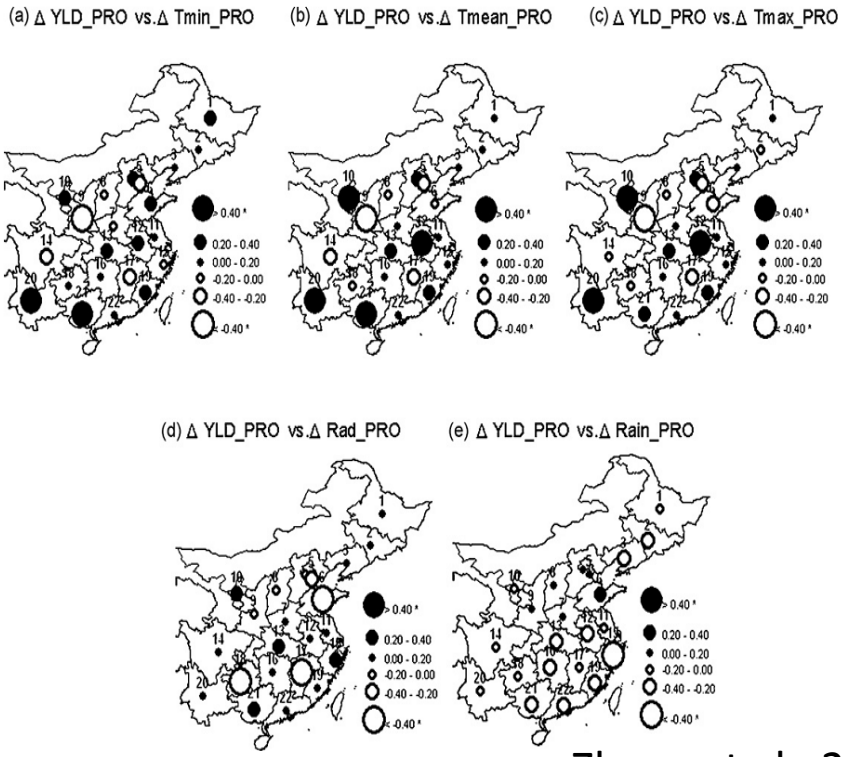
- Changes in other climatic variables are pronounced in some areas, implying specific risks for different crops and locations. E.g.
  - insufficient radiation for rice in east China
  - Increased extreme high temperature days (>35) during the flowering period for rice in Yangtze River Valley
  - Decrease DTR for maize, wheat, and rice, but with different spatial characteristics.



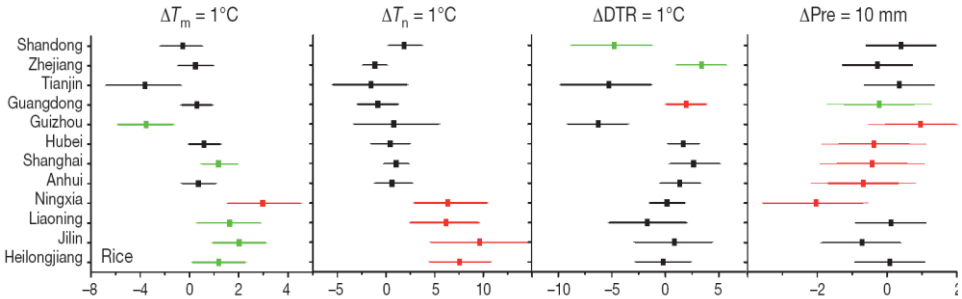
Has the change affected food production in China?

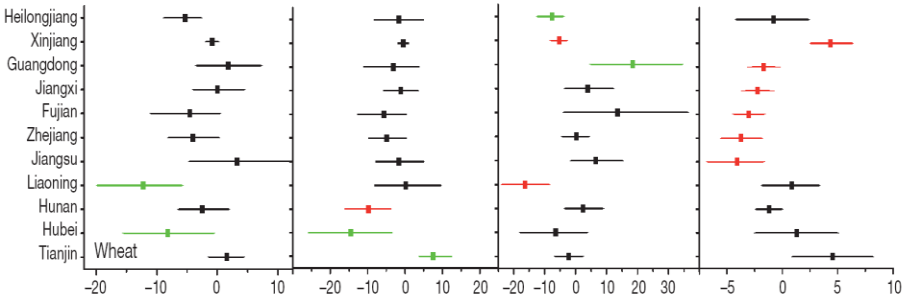
Empirical studies

- Crop yields increase substantially due to the technological improvement
- Impacts have been detected in other counties, significant relationships exist in only a few provinces



Zhang et al., 2010



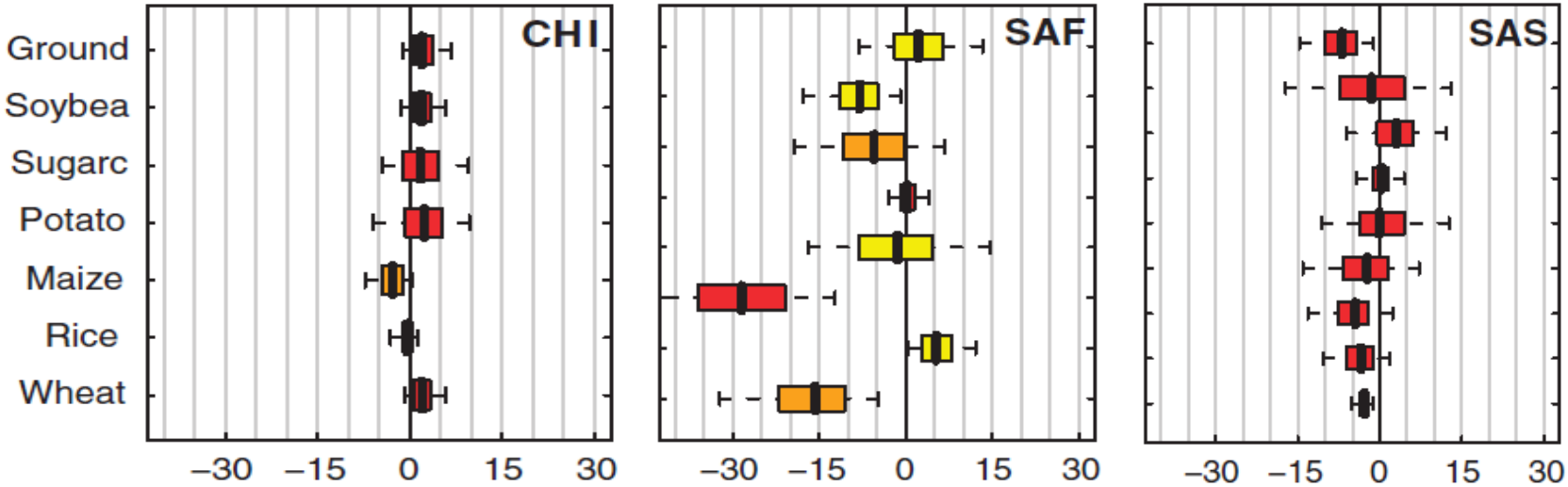


Tao et al., 2008

- Warming effect seems more benign than previously anticipated, the detrimental effects of warming were small compared to other developing counties

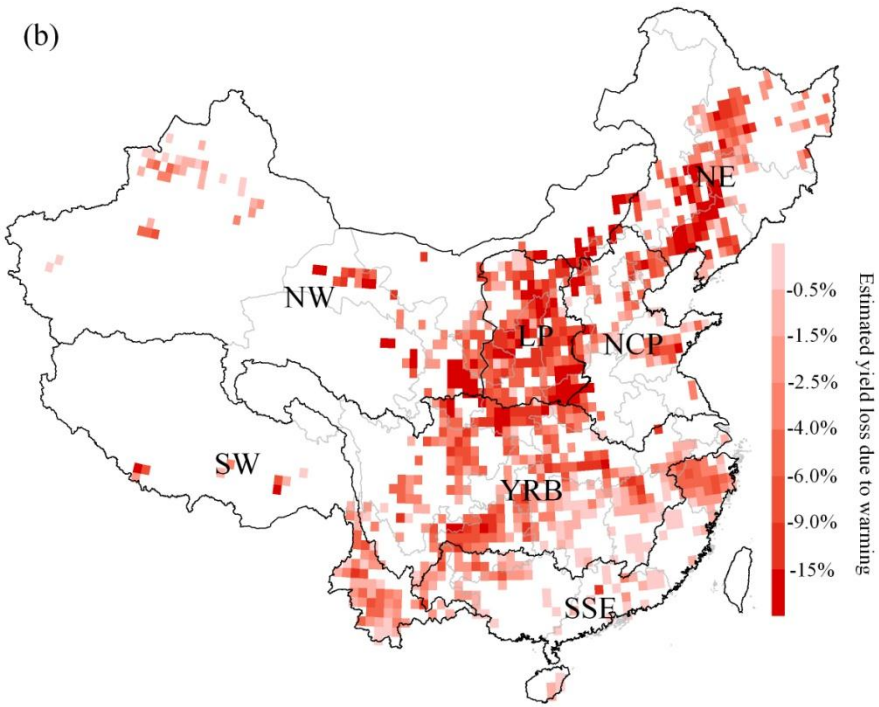
	Rice	Wheat	Maize	Soybean
Yield change (kg ha^{-1})	1510	1920	1850	537
Growing season T change (ºC)	0.98	1.52	0.95	1.05
Growing season P change (mm)	-19	7	-27	-10
Climate-driven yield change (kg ha^{-1})	124 (8.2%)	-103 (-5.4%)	-261 (-14.1%)	-24 (-4.5%)

(Xiong et al. 2013)



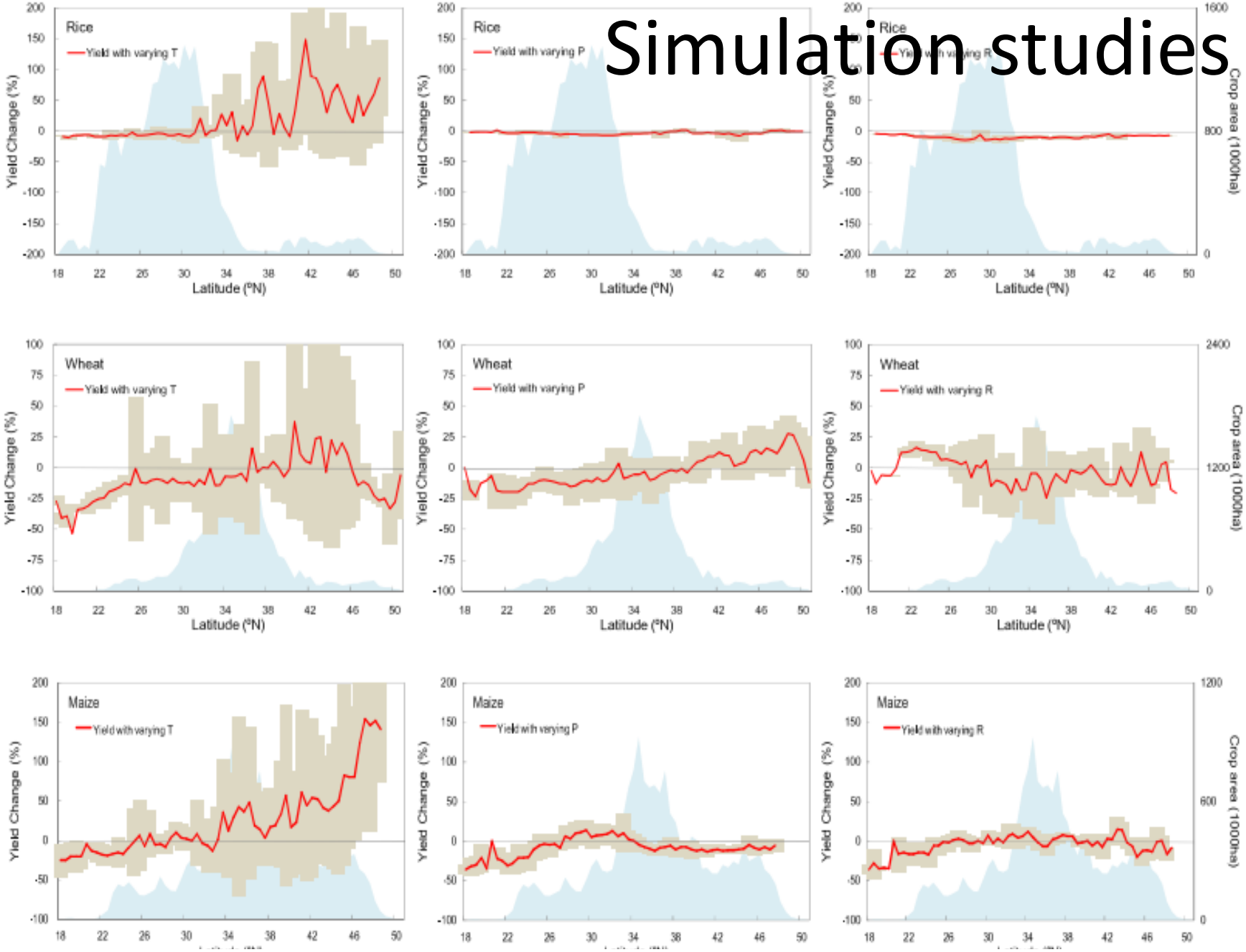
(Lobell et al. 2008)

- But warming damages were substantial in some areas, LP, central belt of NE, parts of RYB, although most of these areas are not critical food producing areas

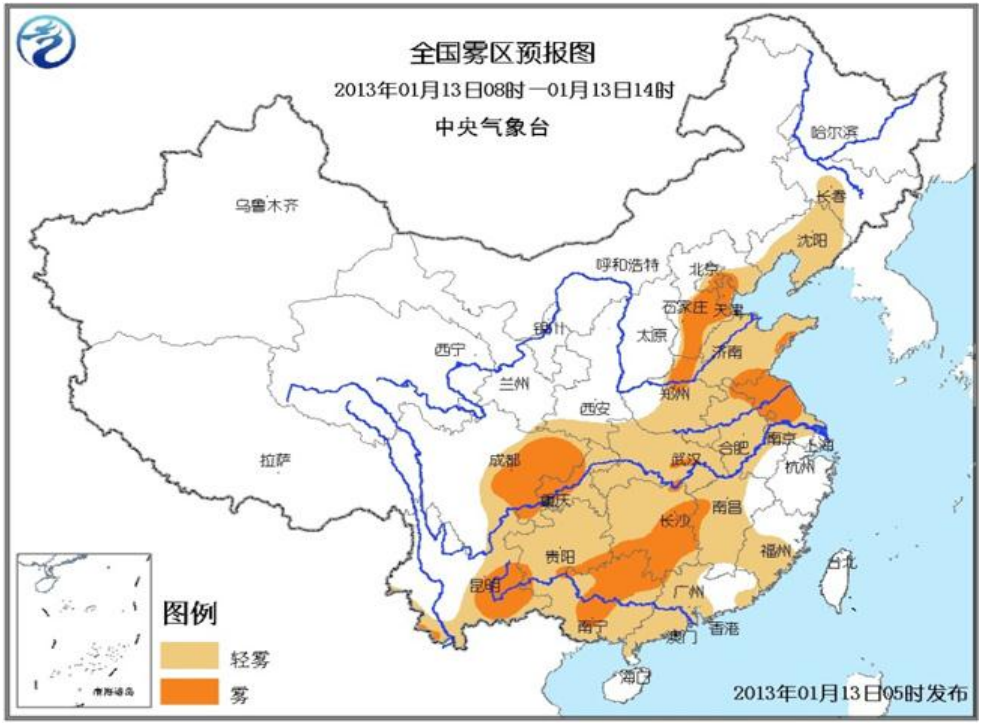


Damages in grain production damages caused by growing season warming 1981-2007

Simulation studies

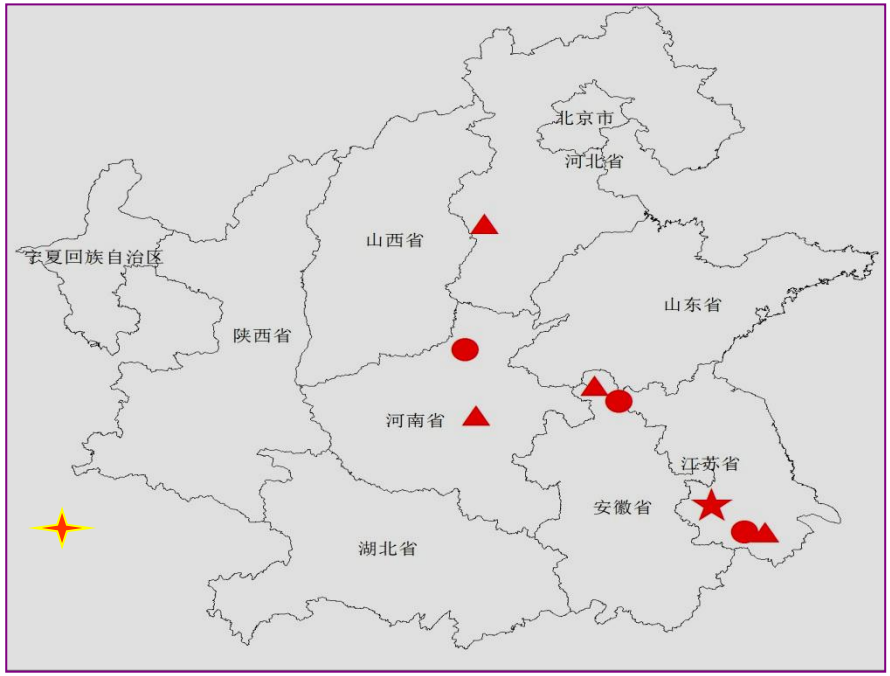


(Xiong et al. 2012)



The larger contribution of decreasing radiation (global dimming) reminds us of the importance of radiation, suggesting the increased risks on food production caused by air pollution in developing counties.

Experimental studies



T and FACE experiments demonstrate that some warming is likely promote the crop yields in China, particularly for wheat and rice, and so can elevated CO2.

Crop responding to artificial warming experiments

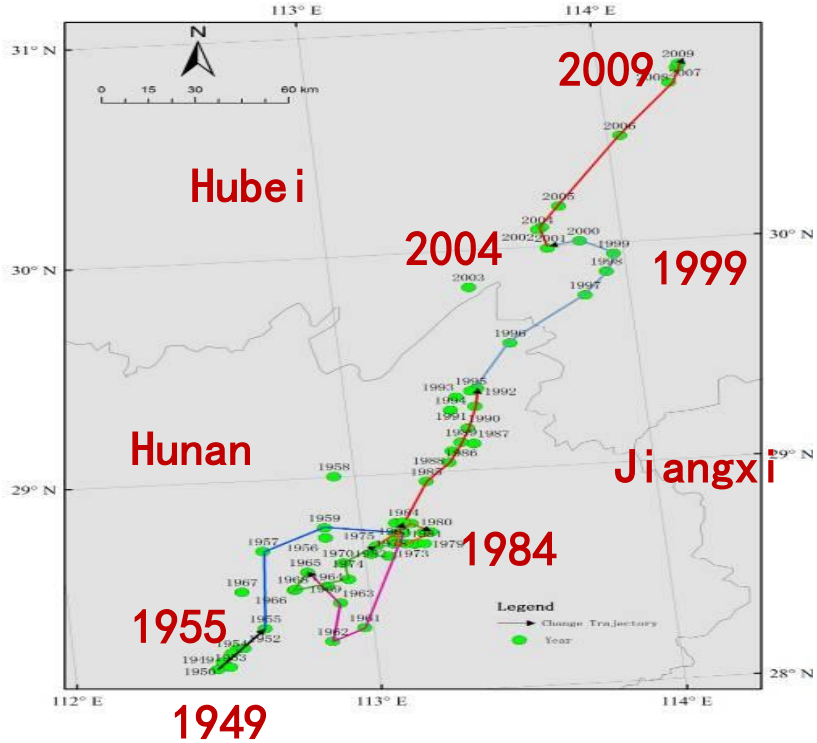
★ warming during different time (day vs. night)

● With different crop cultivars

▲ With different growth periods

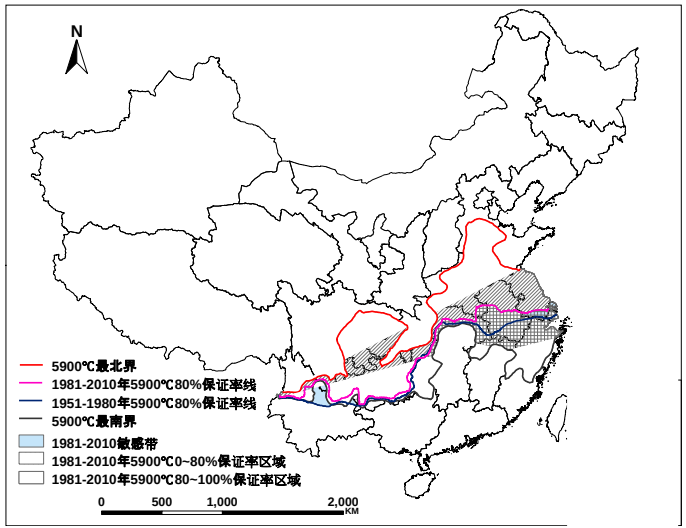
Observation and Meteorological analysis

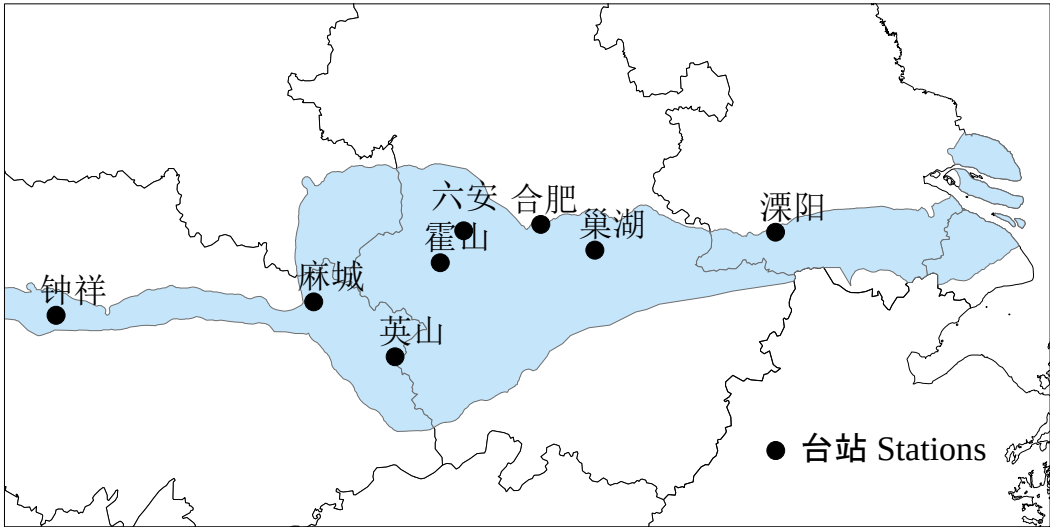
- Expansion of the food planting areas to the north is obvious
- Harvest times actually increase in number



Considering other adaptation measures (e.g. improved management), the impacts of past climate change on national food production is less than 4%, with detrimental effects in south, while gains in north

Changes of planting area for triple harvest per year during past 50 years

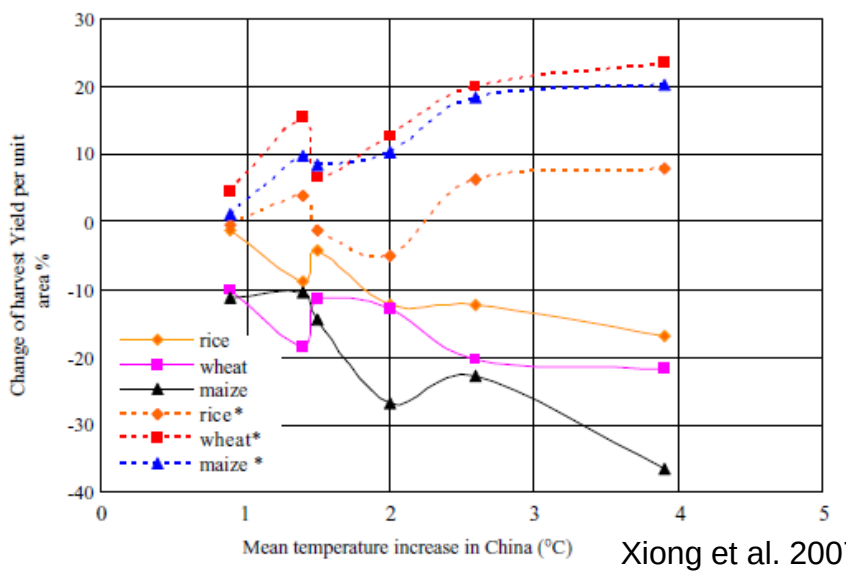




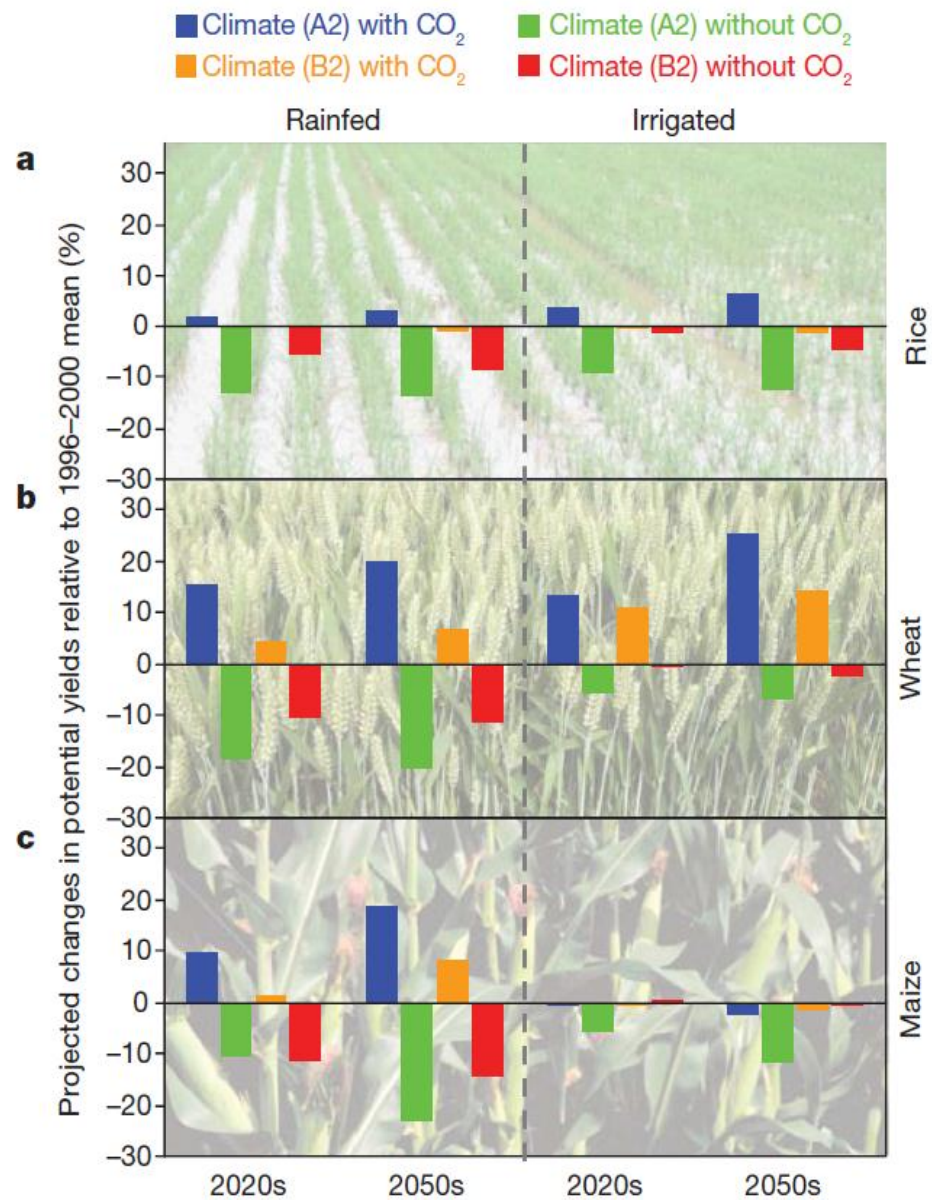
Will climate change undermine food production in the future?

Crop yields

- Estimated yield effects vary between scenarios and time periods, while CO2 is critical for the direction.
- Which warming degree will undermine food production in China?
  - A global warming of 2.5ºC will threat the food production in China (without considering CO2 effects),
  - but production will still increase even with a warming of 4ºC (with CO2 effects).



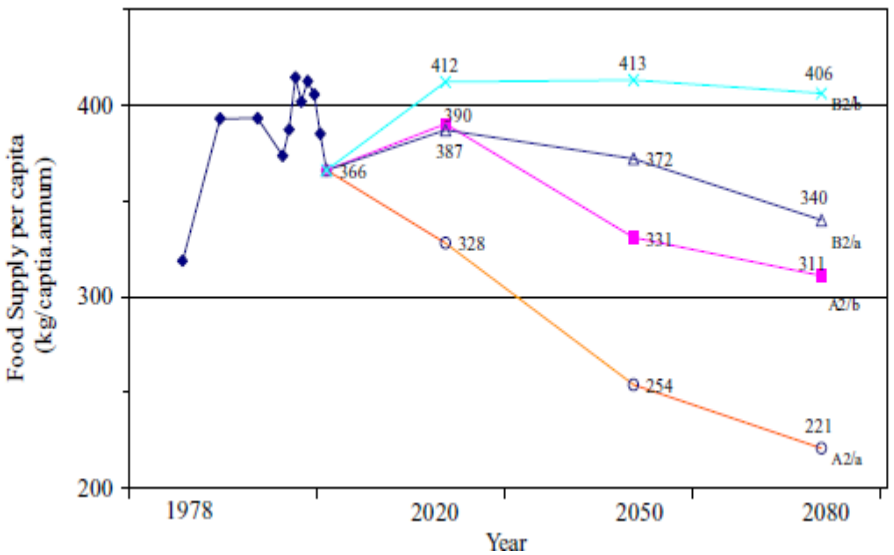
Xiong et al. 2007



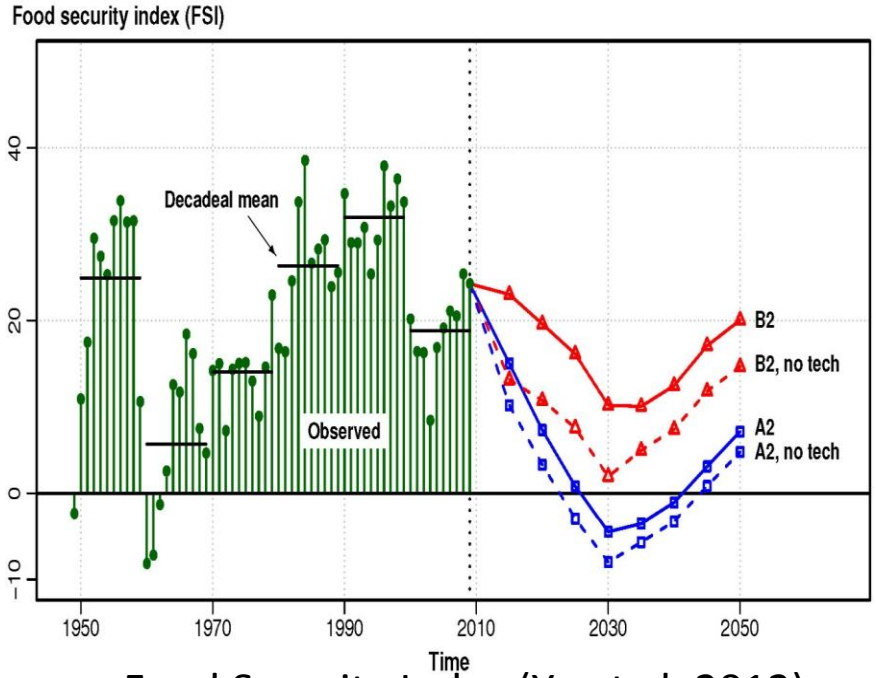
Piao et al. 2010 Nature

Food Security

- Per capita supply decreases in short term, and increases in the long term.
- On average, only the high population scenario (1.6 billion in 2030) will push the food security to the threshold (300kg/capita, FSI 0).
- Climate change will slightly favor China's food production, but food import would continually increase in the short term future.



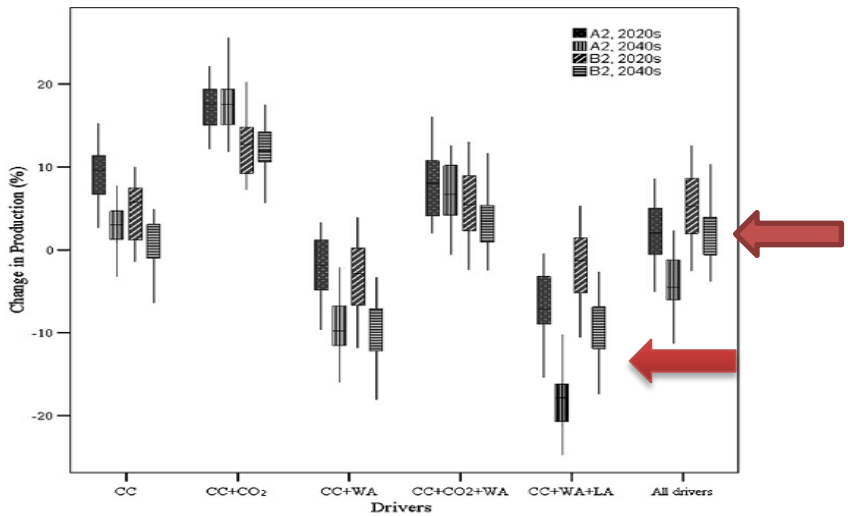
Food supply per capita (Xiong et al. 2007)



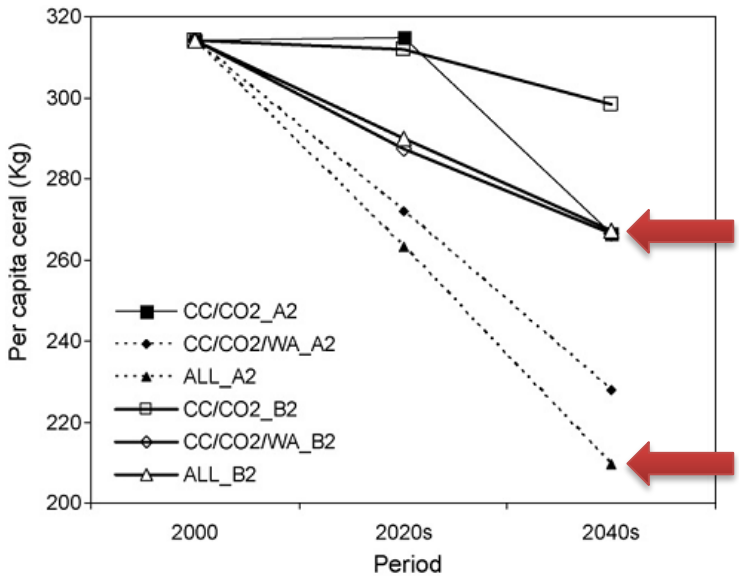
Food Security Index (Ye et al. 2012)

Food security combing other drivers

- Integrated assessment demonstrates the combining drivers pose slight positive to substantial negative effects on food production. (CO2++, Climate change--, Water availability---, land use change -, change in crop plantation areas+)
- Extreme events and diseases/pests will undermine the food production in some years and some areas.



Change in total cereal production under different combinations of drivers (CC, CO2, WA, LA, ALL) (Xiong et al. Global Envion. Change)



Changes in per capita cereal production under selected combinations of drivers

Increasing water scarcity in the future

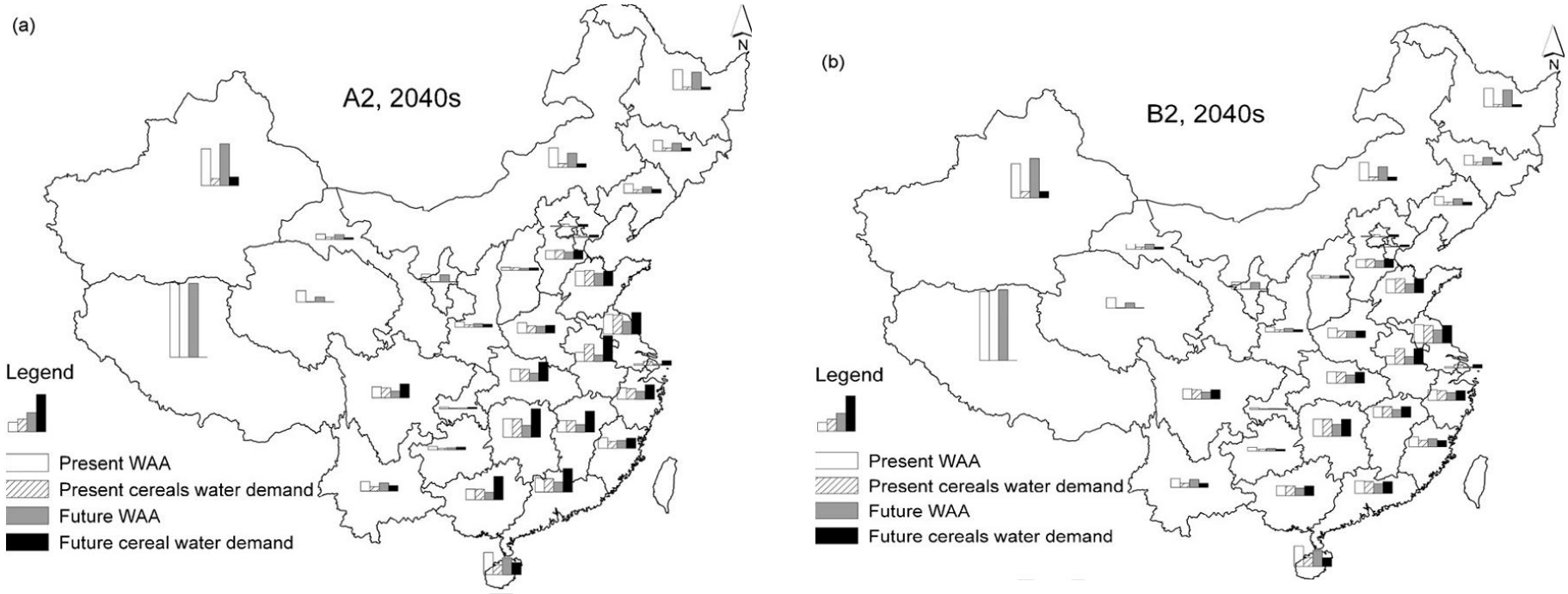
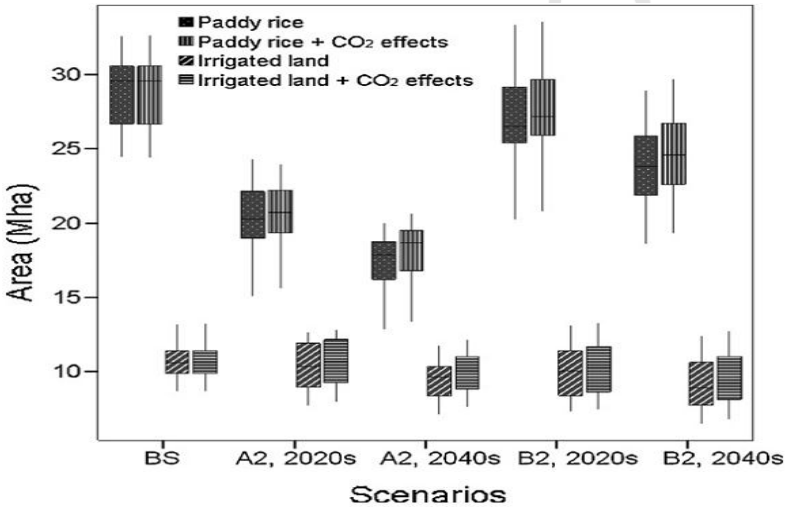
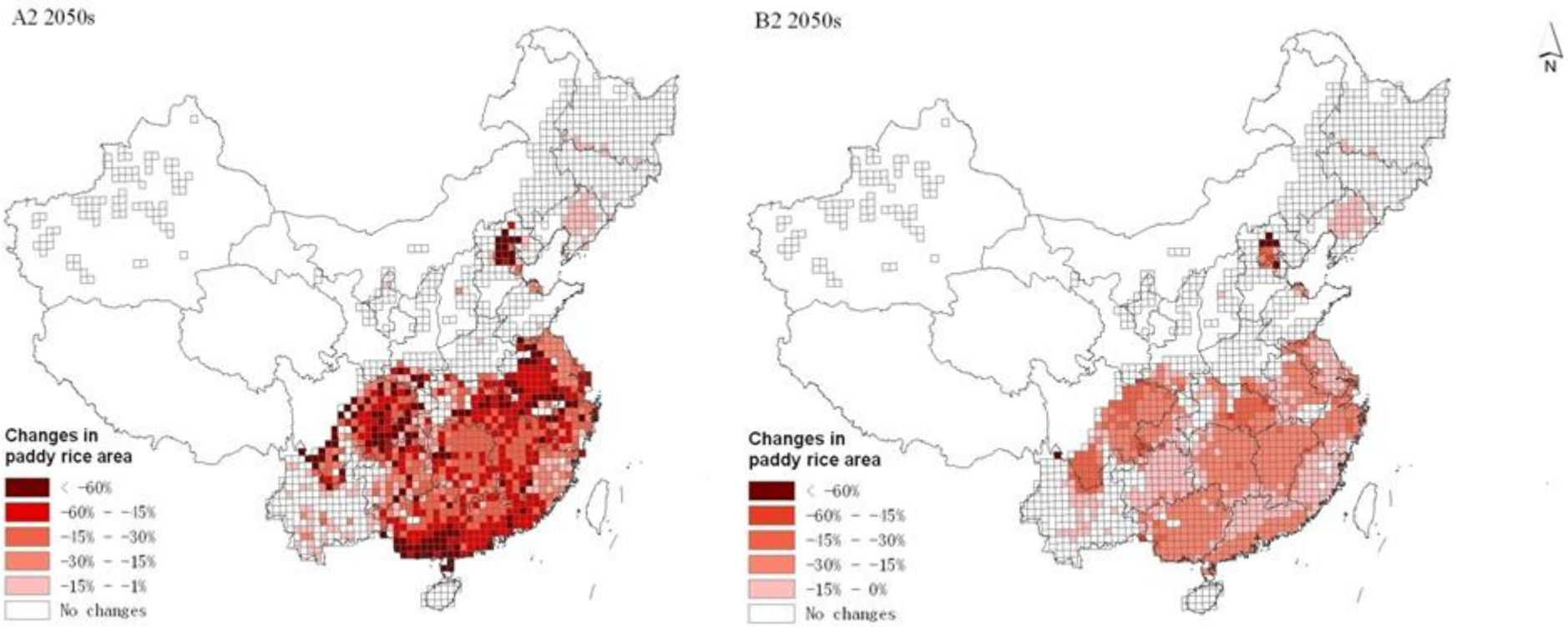


Fig. 6. Agricultural water availability for each province for the 2040s under A2, B2 and present (BS) (unit: Gm^3).



Changes in irrigation areas

- Water could be one big barrier for future food production
- Decreased agricultural water availability will significantly reduce rice cultivation areas in the south

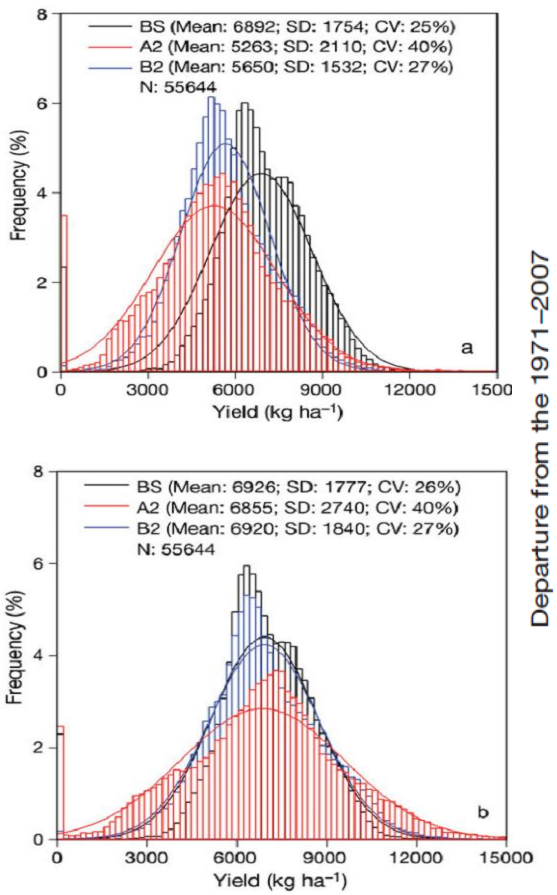


Percentage change in spatial patterns of irrigated paddy rice due to changes in future agricultural water availability (Xiong et al. 2010 AEE)

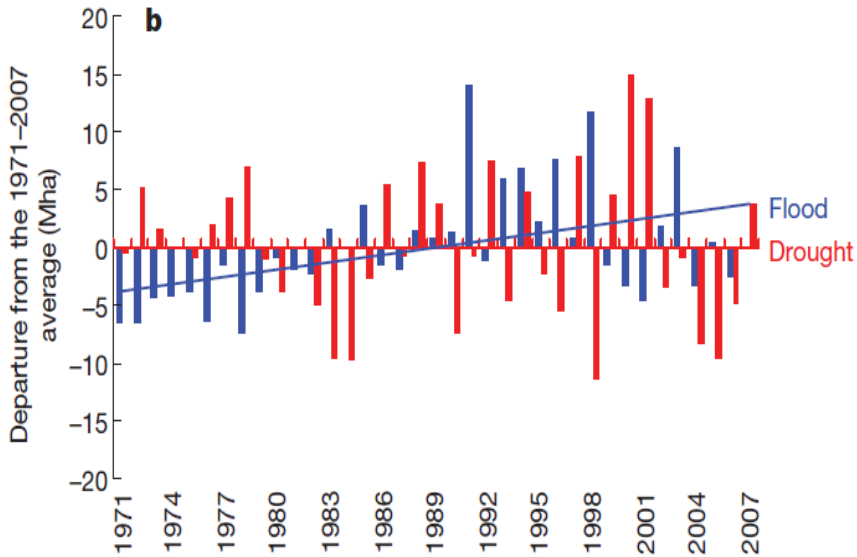
A integrated simulation combining climate, water and crop simulation revealed that rice area has to decrease substantially in the future in China, due to the decreasing agricultural water availability.

Enhanced weather variability and climate disasters

- A warmer climate triggers larger weather variability
- More frequent and severe climate disasters
- New climate disasters in some areas



Histograms of yield and their normal distribution curves for baseline, and A2 and B2 in 2080s

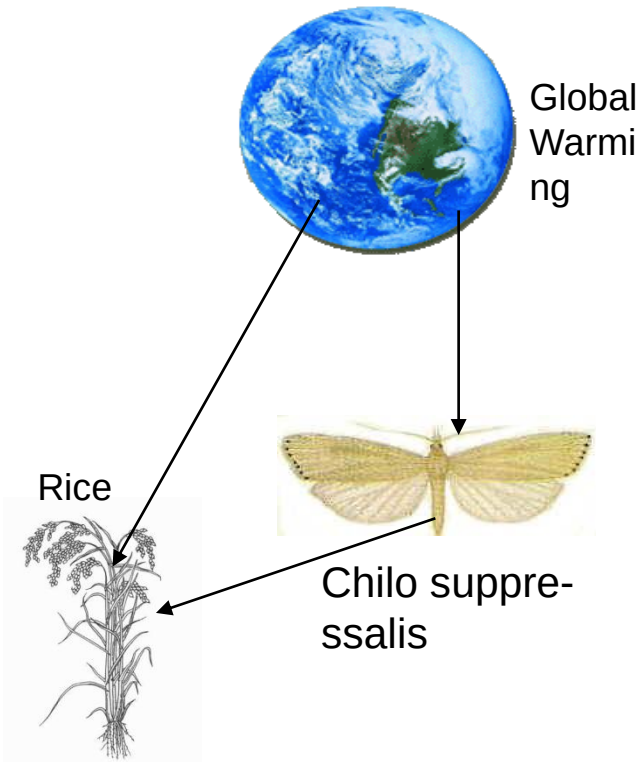


Changes in flooding and drought during 1971 to 2007

Freezing rain disaster in 2008
Freezing rain disaster in 2008

Snow disaster and cold spell affecting vegetatable

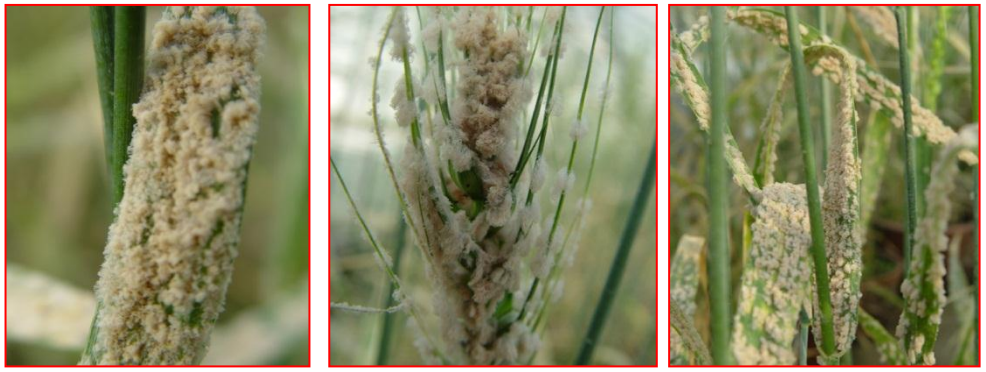
Pest/disease tend to increase under climate change

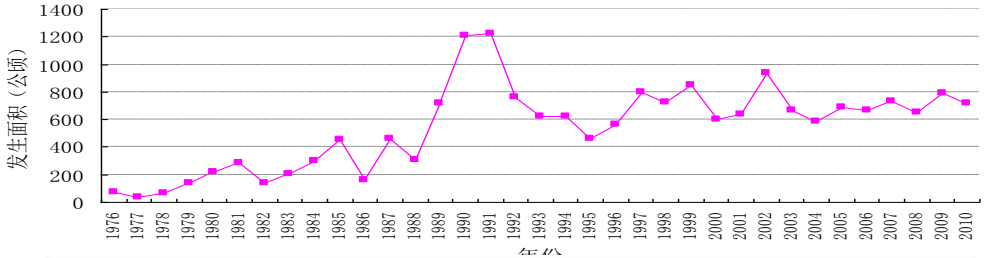


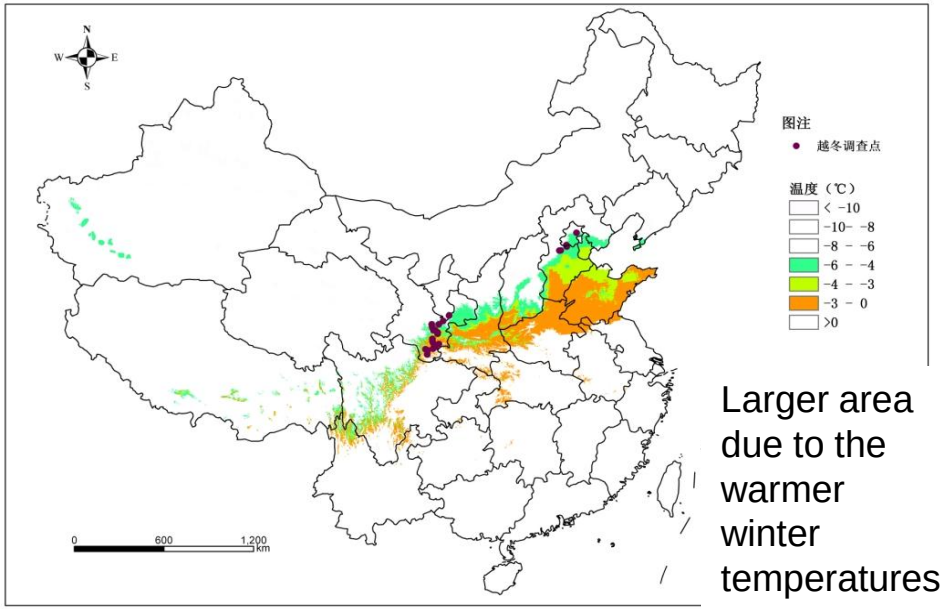
Rice stem borer (normally 5~15% yield loss)

Number of pest infestations (Chilo sppre-ssalis) will increase under climate change (2℃), combing with the higher temperature increase the loss goes up to 8%~25%.

Wheat Powdery Mildew (normally 10~30% yield loss)







Larger area due to the warmer winter temperatures

Does adaptation work?

- Adaptation is the solution for food security, but how best to adapt?

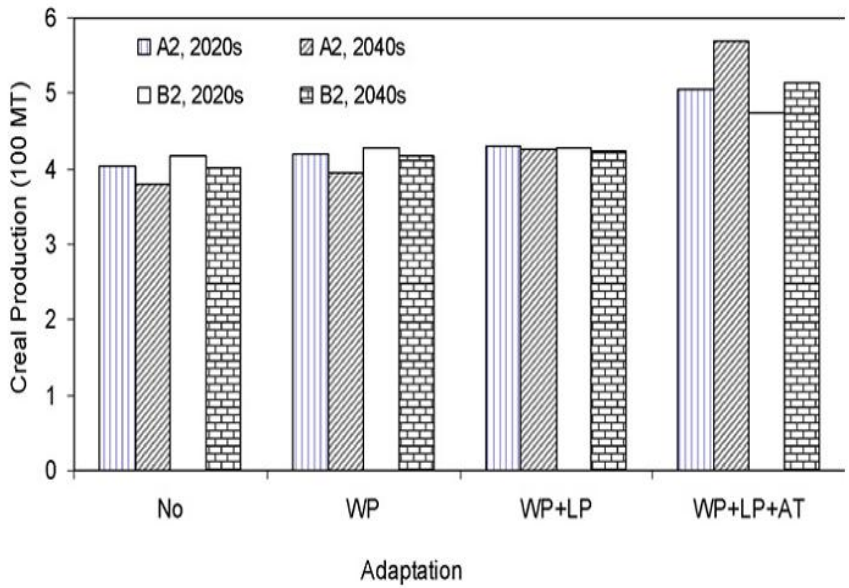


Fig. 8. National potential cereal production with and without adaptation (WP: water policies; LP: arable land conservation policies; AT: sustained improvements in agricultural technology).

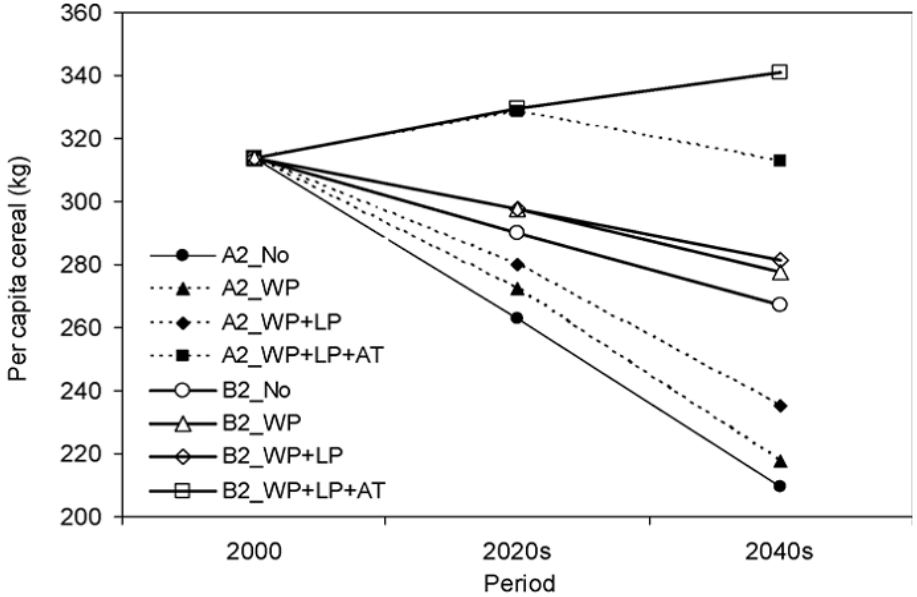


Fig. 9. The effect of adaptation strategies on per capita cereal production. See Fig. 8 for explanation of acronyms. No represents no adaptation scenarios.

Large number of adaptation options

Water cellar + film

Low pressure irrigation tube

Inserting irrigation before sowing

（a）暗式注水播种

Plastic film to deal with drought

Agro-forest

Plastic film between sowing rows

（b）玉米行间覆膜

Techniques for slope planting

(c)坡地种植

According the types of techniques, we established an adaptation option database (currently around 100 specific measures were included).

（planting structure adjustment）

（biological technology）

（agronomic technology）

（engineering technology）

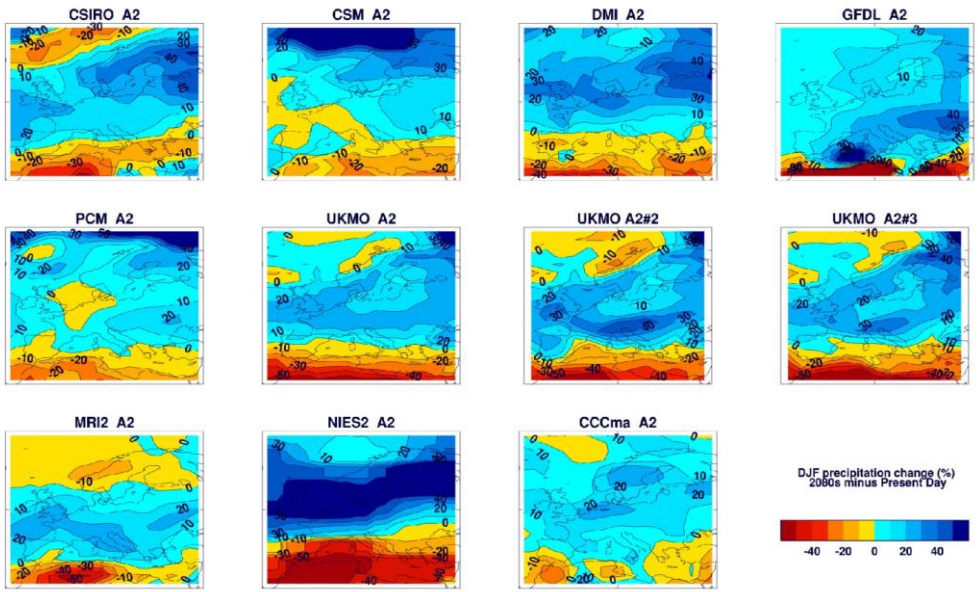
（irrigation technology）

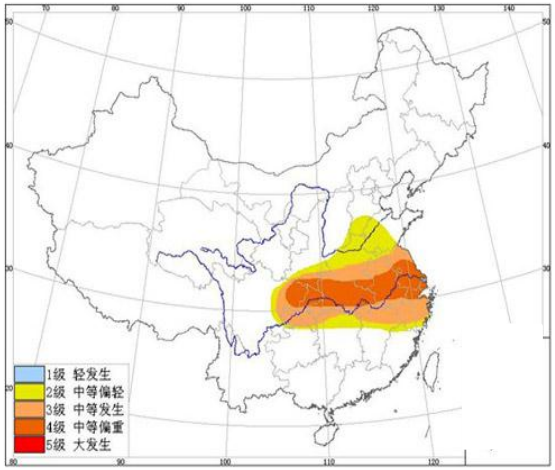
Microsoft Excel - 应对与适应气候变化农业技术清单20101229.xls

技术类型	技术名称	技术要点	主要功能	应对的问题
种植业结构调整		充分利用气候资源，提高复种指数，调整耕作制度。例如，华北地区应扩大小麦-玉米、小麦-棉花两熟制的种植面积。	充分利用光热资源，提高单位面积作物产量。	霜冻害等极端气候
	良种应用	1.有计划地培育和选用抗旱、抗涝、抗高温、抗低温等抗逆品种，加强稳产增产技术研究。2.播种时选用丰产性好、高产稳产、抗病、抗性强、适宜本地种植的杂交品种。	增强作物品种对气候变化和气象灾害的适应能力，达到增产的目的。	极端气候
秸秆覆盖技术		1. 秸秆覆盖。覆盖一般分两次进行，即6月和11月下旬，覆盖时先盖麦衣，再覆麦秆，并注意覆盖均匀。覆盖麦秆长一般在5cm以下，用量250kg-350kg/亩。2. 合理施肥与播种。临播前20天左右，施纯N8-12kg/亩、P2O5 6-8kg/亩、K2O 3-5kg/亩，撒施肥料后进行浅	阻断土壤-大气水分交换通道，抑制土壤无效蒸发，提高水利用率，改良	干旱
		1.整地施肥。一般以在9月下旬至10月上旬，雨后整地为宜。整地时先将肥料撒施于地表，然后耕翻。并耙耱两遍，使土壤达到细、平、实、墒。2.适时覆膜。一般在上年度秋末冬水结束后进行覆膜，采用宽膜伸幅1.4米，覆膜净宽度为1.2m，机械或人工覆膜。覆膜	充分积蓄休闲期降水，与春季覆膜相比，播种时2m土层土壤含水量多	季节性干旱
		。在施足底肥、耕翻整地、节水池田的同时施用化学除草剂。待泥足沉实后再 闲期水池插。2.适青期。适青期大约6-8天，控制灌溉标准上限为25-30mm。 天，尤其在阳光曝晒的中午，要求田间水层不过超过3cm。不淹苗心，最	减少棵间蒸发、田间渗漏耗水和水稻蒸腾耗水，节水约50%；使选根系生	水资源短缺
		……	……	……
		的设备（动力机、水泵、管道等）将具有一定压力的水（或利用水的自然落差）灌溉地段，并通过喷洒器（喷头）把水喷射到空中，形成小水滴，均匀洒落到土地上进行灌溉的一种灌水方法。在喷灌设备布设过程中要考虑：工作时水流的压力、流量和喷	节约用水，保证作物生长对水分的需要，改善土壤理化性状，加强通透性。	水资源短缺
	灌技术	通过安装在毛管上的滴头、孔口或滴灌带灌水器将水一滴一滴地、均匀而又缓慢地滴入作物根区附近土壤中的灌水形式。滴灌系统设计，由水源、首部枢纽、输水管道和滴头组成。滴灌系统布设要求：1. 选择符合的滴灌系统，2. 合理布设滴头及管道。	避免土地冲刷和土壤板结，促进作物生长发育，加速土壤养分的转化，提	水资源短缺
	……	……	……	……
工程技术	雨水集蓄工程	将雨水集中到水库、水窖、水池等中小型水利工程，再利用高效节水技术进行灌溉。技术关键点有：集水区的确定、集水面积的确定、水窖等小型水利工程的建造。	提高自然降水利用率，节约地表水，保护生态环境。	季节性干旱、水资源短缺
	渠道防渗工程	为了防止渠道的渗水损失、减少渠道的漏水，建立不易透水防护层。常见的工程措施包括：土料防渗、水泥土防渗、砌石防渗、膜料防渗、混泥土防渗和喷渠防渗。在实施工程过程中要注意几点：防渗材料的选择、工程建设区的实地条件、施工时间、渠道断面设计	提高过水能力，减小过水断面，节省土地，提高渠系水利用效率，减少渗漏	水资源短缺
	土地平整工程	通过人工平地、半人工平机械以及机械平地等多种手段提高田间土地的平整精度。主要实施过程包括：田间测量、设计相对高程、从平地起始位置点开始，利用机械挖高填低，搬运土方、地面夯实，评价平地效果。	扩大田块线宽，提高农业机械作业的适应性，减少水土流失和改善地面灌溉	水资源短缺
	……	……	……	……

Unwise adaptation increases the risks

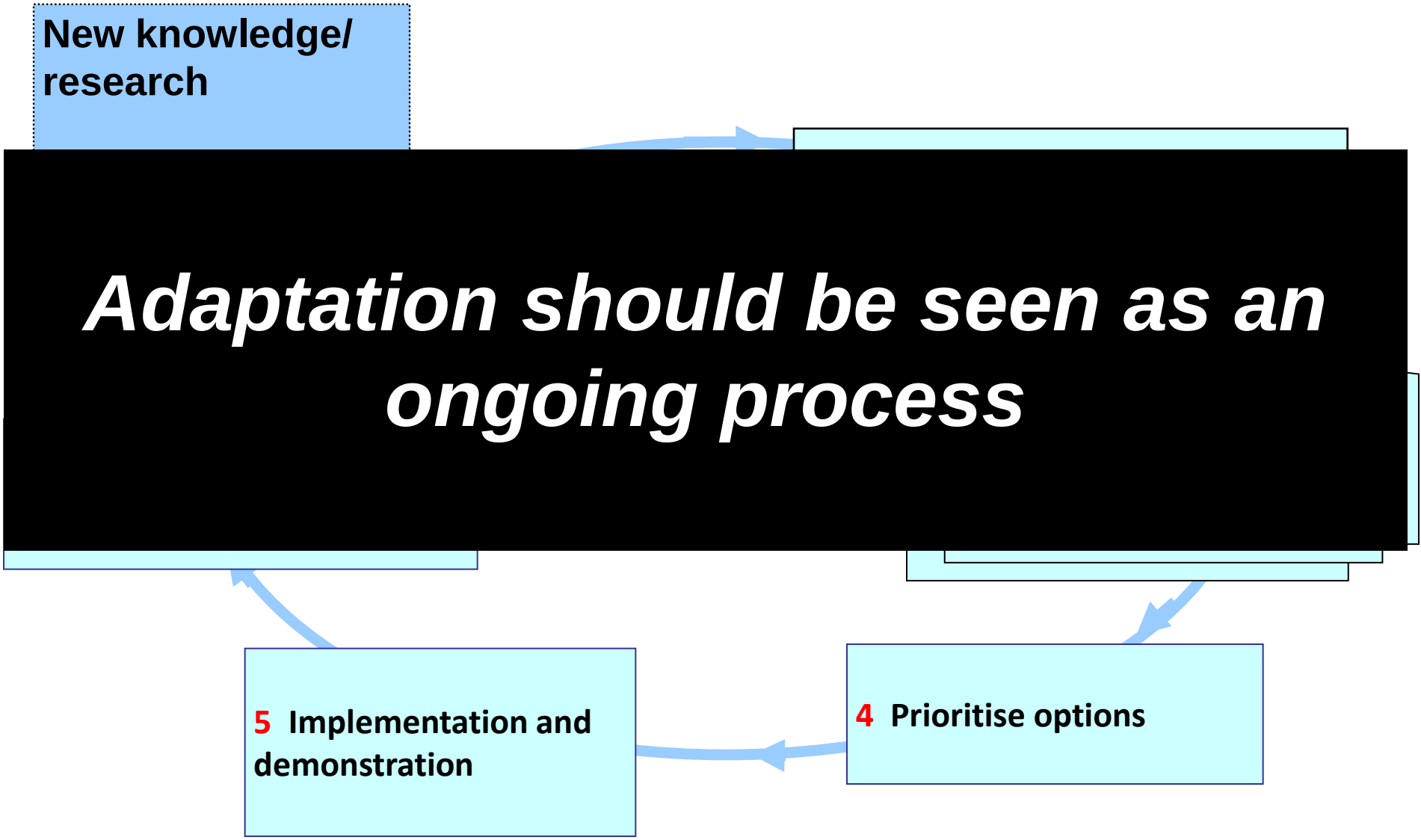
- Uncertain climate projections
- Unclear mechanisms
- Large cost and investment





No tillage and residue use increase the occurrence of pests/diseases (Zhang et al. 2012)

The adaptation framework



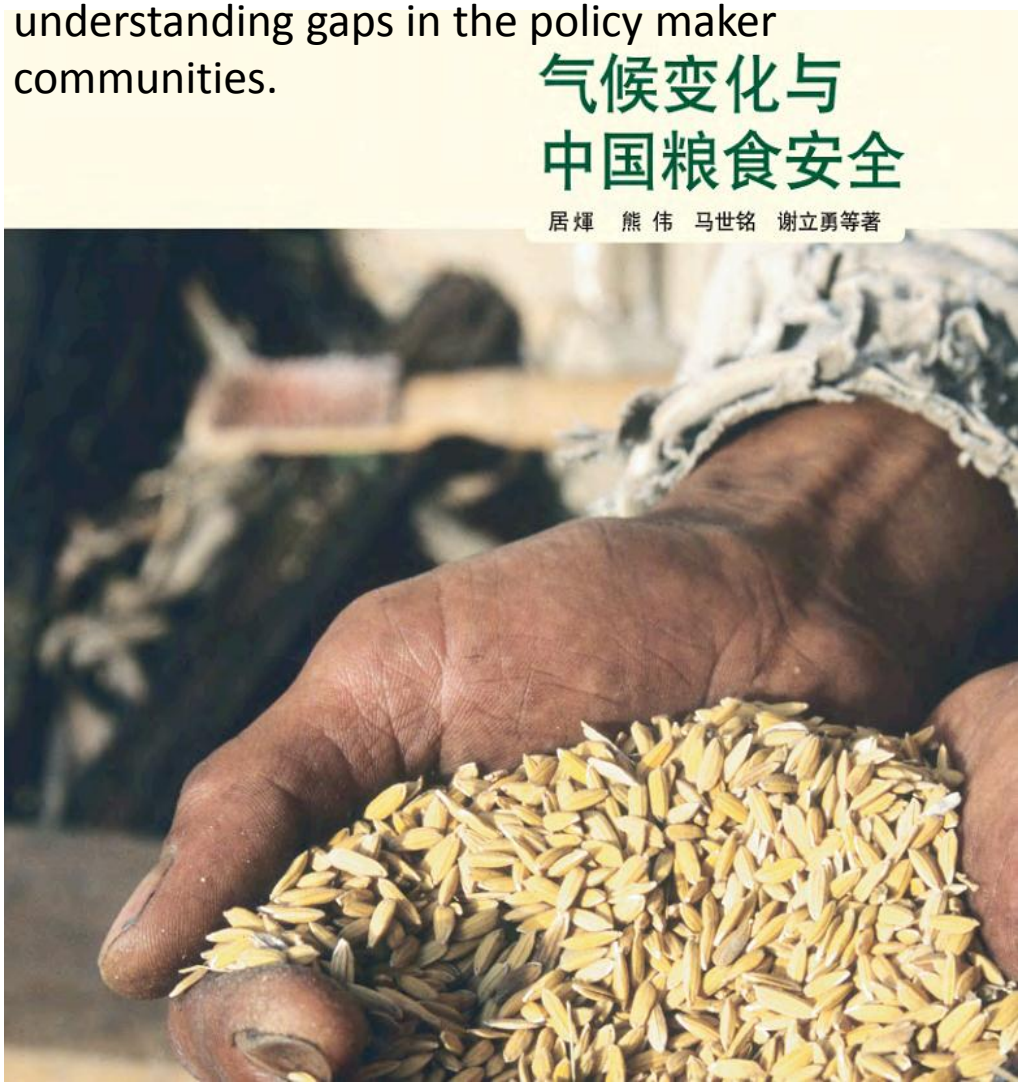
Key messages

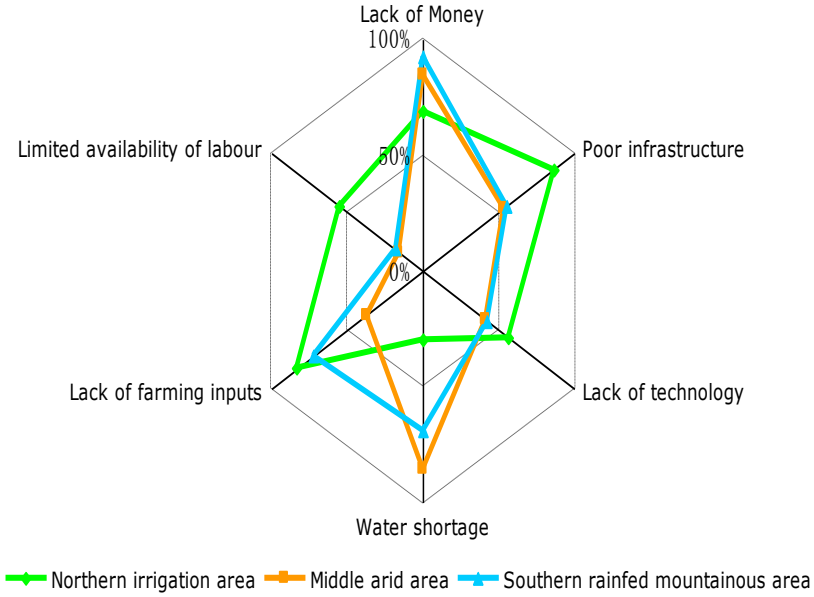
- Warming effects might not be so detrimental as previously anticipated in China, a warming of 2 ºC will not undermine the food production in China, other climatic factors may play a more important role, and should also be taken in account.
- Drivers combining with climate change may push China's food production to a new low, but a sustainable pathway is possible to keep current food demand and supply balance.
- Risks driven by warming will definitely increase in the future, which has larger implications than just a change in mean climate. Dealing with increased risks will be the main concern of adaptation in the future.

Key messages

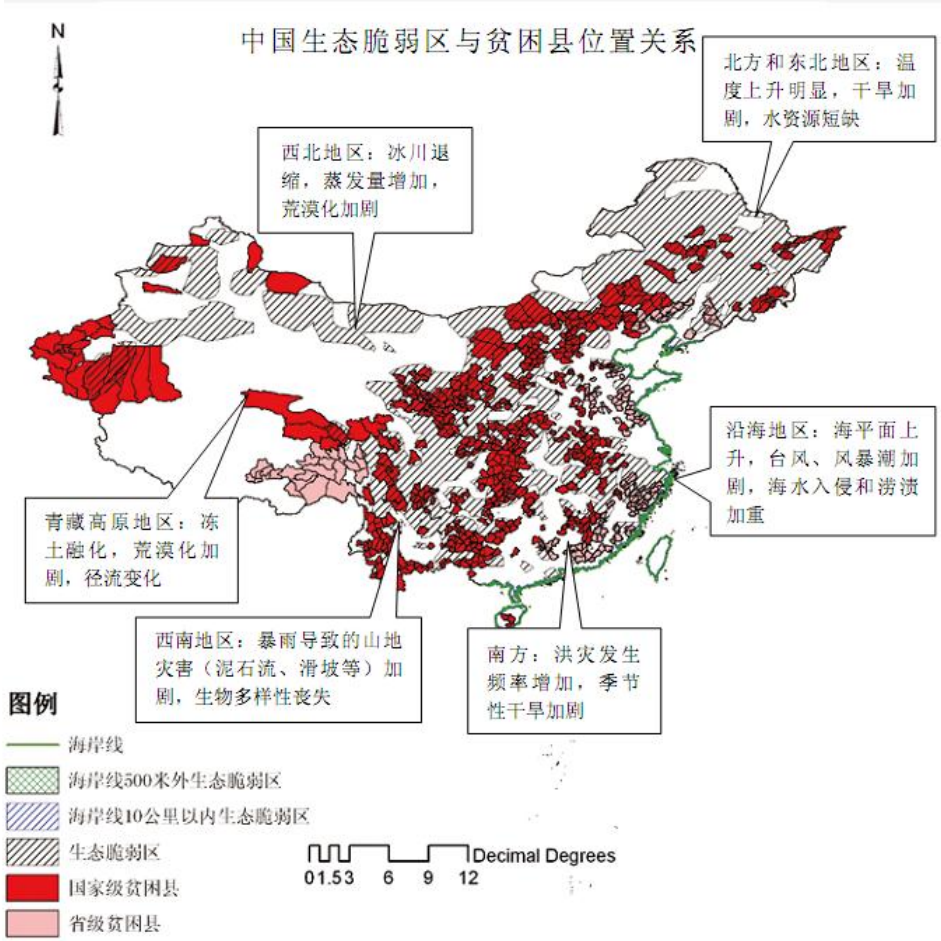
- Adaptation is needed urgently, particularly in the vulnerable regions and the poor communities, but how to do it wisely is unclear.
- Effective and wise adaptation needs information of climate risks, crop responses, and the implementing characteristics or requirements of the specific measures.
- Adaptation should be seen as ongoing process rather than a one time campaign.

Some disseminations increased public awareness, particularly decreased the understanding gaps in the policy maker communities.





The adaptation barrier for adaptation in Ningxia's farmer community



Addressing the poverty issues in climate change. （xu et al. 2009）

http://www.greenpeace.org/china/zh/press/reports/poverty-report2009

Thank You

Continue the Discussion at:
www.AgRiskManagementForum.org/group/climate-change-food-production-china