Water Availability and Global Land Use Change

By

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Revision 1
June 2012

Department of Agricultural Economics
Purdue University

To be presented at:
15th Annual Conference on Global Economic Analysis
"New Challenges for Global Trade and Sustainable Development"
Geneva, Switzerland June 27-29, 2012

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Introduction

The dual stressors of surging water demand and climate-induced variable water supply signal that global economy is entering an era of water scarcity. Under the scenario of average economic growth with no efficiency gains, global water requirements by 2030 would grow from 4,500 billion m^3 today to 6,900 billion m^3, which is a full 40 percent above current accessible, reliable supply (Addams, et al. 2009). In addition, water's two fundamental functions, the role as an essential requirement for life and its use as an economic input, are increasingly in conflict. If assume that water for agriculture is low-priority use and water demand-supply gap is closed by cutting down irrigation, the impact of water deficit on agriculture can be sizable given the fact that irrigated agriculture accounts for up to 70 percent of global water withdraw (FAO, Agriculture, food and water 2003).

Globally, 20 percent of the cultivated land is irrigated and contributes over 40 percent of the food supplies. On average, irrigated crop yield is 2.3 times higher than those from rainfed crop, globally (FAO, Irrigation Management Transfer 2007). Shortage of irrigation water under the business-as-usual scenario will slow down the expansion of irrigated agricultural and can even make it impossible. By implication, more rainfed land is needed to meet the demand for the same amount of food since the productivity of irrigated agriculture is generally higher than that of rainfed. The expansion of rainfed agriculture could lead a higher rate of deforestation and cause more induced land use emissions. Nevertheless, the feasibility of this solution is not universally guaranteed. The region where physical expansion is limited has to import more from or export less to global market to satisfy domestic demand. Water deficit thus speaks to global land use change and pattern of agricultural trade.

Literature review

Most of the existing research on global land use change commingled irrigated and rainfed production due to the lack of necessary data at international dimension. By doing so, the productivity of new lands is inflated. Land conversion and its impact tend to be understated. For example, Pfister et al. compare the trade-off between land and water consumption under four strategies to meet future world food demand. They find that land expansion on pastures is pretty low due to high-yield production (Pfister, et al. 2011)., The yield they considered, however, is averaged over two types of production,

Several studies emerged as the earliest attempts to distinguish crop production between irrigation conditions. IMPACT-WATER model has been used to explore the impact of water availability on food supply and demand (Rosegrant, Cai and Cline 2002) and virtual water trade (de Fraiture, et al. 2004). As a partial equilibrium model, it examines effects of policy action in the particular market which is directly affected, but ignores its effect on any other. A global CGE model GTAP-W developed by Calzadilla et al. discomposes land endowment used in crop industries into the contribution of water, irrigated land, and rainfed land, based on the ratio of yields and output by irrigation condition provided by IMPACT. Using this model, the authors investigate the potential global water savings and its economic implications by improving irrigation efficiency (Calzadilla, Rehdanz and Tol 2011). A major shortcoming of GTAP-W is that it is essentially built on value reallocation but does not consider physical change of land and water. For example, agricultural land is fixed; increase in irrigated land causes decrease in non-irrigated land by the same amount, and vice versa. Besides, land and water data serving the value split are uniform within FPUs (Food Production Unit), which is less satisfactory when FPU is large.

A recent paper by Taheripour et al. (henceforth THL) moves further in this direction (Taheripour, Hertel and Liu 2011). The paper investigated the role of irrigation in determining the global land conversion in the wake of increased ethanol production. In this work, crop industries in GTAP v.6 database are broken into irrigated and rainfed categories based on Portmann et al. (2010). Furthermore, the GTAP-BIO-AEZ model is modified and extended to handle production, consumption and trade of irrigated and rainfed crops, and to trace the allocation of irrigated and rainfed cropland among all crop activities at a global scale. In spite of its utility in the analysis that involves irrigated and rainfed agriculture, it fails to detach water from irrigated land and thus is limited in its use for examining the role of managed water in agriculture and land use change. The present research aims to address this deficiency and explicitly introduce managed water into database and modeling framework.

Data and modeling

We begin with a grid-based dataset containing crop specific global harvested area and yield, provided by Portmann et al. (Portmann, Siebert and Döll 2010). The original resolution (5 arc minute) was reduced to 30 arc minute (i.e. half degree) in order to accommodate other existing data. We identify country, AEZ and river basin associated with each grid cell in ArcGIS, and aggregate grid-based information up to region-AEZ-Basin by crop. Altogether, we have 6 crops, 19 regions, 18 AEZs and a maximum number of 20 basins per region in the base data (see Appendix for the basin names).

The result of above process, along with the region-AEZ indexed data developed in THL, is used to determine the value added of land at region-AEZ-Basin level. To be specific, we break region-AEZ value added of land into region-AEZ-Basin value added of land by multiplying the former with a production share that depicts the contribution of each basin within a certain AEZ. Then we extend GTAP regional input-out tables by considering water as a primary input of irrigated crop production functions.

Under the assumption that yield gap between irrigated and rainfed crops is totally attributed to irrigation, we use values-based productivity difference and area at each river basin to determine the cost share of water for irrigated crop productions. Utilizing another grid-based dataset developed by Siebert and Döll (Siebert and Döll 2010) on water used for irrigation, we aggregate quantity of water used by crop into basin-AEZ in each region. The procedure up to this point prepares us the quantity as well as value added of land and water by region-AEZ-river basin.

Next, the model used in THL is modified to handle competition for water among irrigated crops at river basin-AEZ in each region. Figure 1 displays the core structure we designed to incorporate land and water into the modeling framework. As defined, water is a quasi-mobile endowment. Competition for managed water occurs only within a basin by different AEZs and uses, but not among basins. In each river basin supply of water is assumed to be fixed. The modeling approach developed in this paper distinguishes between irrigated and rainfed agriculture and meanwhile handles allocation of managed water at a river basin-AEZ among crops. This is an important distinction from the approach adopted by Calzadilla, Rehdanz and Tol (2011), which assumes that irrigation water is simply one of many inputs into a national production function.

Experiment design

We are interested in implications of declining water availability for land use change and international trade. To develop a sample experiment, we apply negative shocks to water supply in China, in order to mimic a surge in water demand. As predicted by 2030 Water Resource Group, eight out of ten major basins in China will experience water shortage by 2030 (Addams, et al. 2009). In particular, water supplied by Yangtze Basin, Huang Basin and Hai Basin decreases by 20-80%, and water endowment reduces by 0-20% in five other basins, namely Huai Basin, Songhua Basin, Xilin Basin (lower-Mongolia), Yili Basin and Pearl Basin. We take the medians, i.e. 50% and 10% as the shocks.

China is chosen as the region of interest for two reasons. First, it is one of the major crop producing countries that heavily use water for irrigation (Figure 2). China, along with India, Rest of South Asia, Middle Eastern_North Africa and USA account for over three-quarters of global water withdraw for irrigation. Second, competition for water among different users is on rise in China. Although agriculture remains to be the largest water demand sector at 50 percent of total demand in 2030, its annual growth rate of 0.6 is relatively low compared to industrial and urban water demand that both grow at 3 percent per year. Assuming all the burdens are borne by agriculture provides an upper bound of the estimated impacts on land use change.

Results

Impacts on output and price of crops and other commodities

In China, crop production highly relies on irrigation. 44.8% of the harvested area is irrigated and 44.2% of the total crop output comes from land with irrigation. In addition, the country contributes a considerable share to the global irrigated crop production. For example, China produces almost 40% of irrigated rice, 36% of irrigated wheat and 37% of irrigated coarse grains of the world. In consequence, water shortage is expected to sharply reduce crop production in China and subsequently world food supply. According to our results (Table 1), paddy rice will see the most dramatic reduction in output (9.3 million m.t.), followed by other agricultural produces (mainly fruit and vegetables, 5.2 million m.t.) and wheat (3.2 million m.t.). This pattern of change is largely driven by two facts. First, the shocked basins represent major agricultural zones in China. 92% of the country's crop production is concentrated in these basins. Second, cereal grains and other agricultural produces take the lion's share of irrigation water within the basins. Figure 3 provides a "zoom-in" on each affected crops. As anticipated, irrigated production goes down, while rainfed production expands. Although output of rice sees the largest reduction in total, irrigated fruit and vegetable turn out to be the most affected sector in absolute terms.

At the same time, output of most crops in non-China countries raises slightly because of the lower endowment cost to produce the same amount of crops in these countries. The raise, however, can only partially offset what is lost in China, especially for rice, wheat and coarse grains, the major cereal grains that China accounts for over one third of the world irrigated production. Globally speaking, value based output drops by 0.71% for rice and 0.21% for wheat due to limited water supply in China (Table 2). Under the assumption that products are differentiated and price differs across regions, this set of result mingles changes of both price and quantity. It may draw a different picture from what implied by quantity alone. For example, using the tons measure, sugar production falls globally, but using the GTAP index it rises.

Downscaled crop production provides less input for processed food and less feed for livestock raising, leading to shrinking output in these industries as well. Prices go up as the supply of these commodities goes down. Opposite to what is generally observed for agricultural and food sectors, energy related and manufacturing industries thrive. Supply price of these commodities falls. The change is more pronounced in China than in the other regions.

Impacts on international trade

Table 3 summarizes change in trade balance for selected countries and commodities. A negative value indicates that the change in imports exceeds the change in exports. Table 4a and 4b present the percentage changes of China's food and agricultural products imports and exports with primary trade partners. Not surprisingly, reduction in crop output suppresses China's crop export to the world and, on the other hand, causes the country to import more agricultural commodities to meet domestic demand for food. Total trade gap in agriculture and food amounts to 1.9 billion US dollars, with more than half of it attributable to crop trade deficit. The biggest trade deficits are observed in the trade of fruit, vegetables and processed food, partly due to their high value compared to the other field crops. More importantly, it has been a basic policy for food security in China that maintaining a high level of grain self-sufficiency should not be compromised and all possible efforts will be made to ensure production of staple food. It's also worth noting that China tends to import more oilseeds and livestock from international market. Its domestic oilseed production has been on a declining trend in recent years as a result of reduced acreage devoted to oilseeds and little or no growth in average yields. For this reason, China's dependence on South America and US oilseeds is expected to increase. Rising consumption of meat, particularly of pork, is considered as a major driver for the widening trade deficit in livestock products. China's meat imports will continue to rise due to strong pork demand and competitive pricing on imports.

U.S. and EU, two key players in global agricultural market, will export more food (especially the processed food) to China and rest of the world. Total trade balance of U.S. and EU, however, would get worse due to the enlarged trade deficit in industrial goods. Other big economies such as Japan, Brazil and

Canada more or less tell the same story. China instead will expand its non-agricultural commodity export (primarily manufacturing exports) in order to keep its current account in surplus. The simulation results show a significant boost (3.1 billion USD) in the trade balance of manufacturing industries, followed by increased net exports in energy intensive industries (0.34 billion USD), crude oil, and petroleum and coal products sectors.

Land cover implications

Water scarcity can make irrigation physically impossible or so costly that producing irrigated crops is no longer economically viable. Comparatively, rainfed crop production can be more profitable and may crowd out the irrigated (if assume that climate change will not jeopardize rainfed agriculture). To compensate for the lost irrigated production, more rainfed land is needed because output per hectare is generally lower when crop growth relies solely on rainfall. Table 5 shows a production shift from the irrigated to the rainfed land in China. When confronted with water scarcity, irrigation will be discontinued for 7.5 million hectares of land. These parcels are turned into rainfed fields that are no longer able to output the same amount of food due to lower productivity. To maintain current level of crop production, this region needs an addition of 0.69 million hectares rainfed land, which is about 0.42% of the total harvested area in China. The relatively small amount of additional land needed can be explained by moderate yield gains when crops are irrigated in China. Among 6 major crops, irrigation matters most for sugar crops. With irrigation, output per hectare can be 1.73 times higher than if with no irrigation. Yield of irrigated rice is about 50% higher than that of the rainfed. For wheat, coarse grains, oil seeds and fruits and vegetables, this number is even lower. Irrigation means only 20% productivity gains.

As China shrinks its food supply to the world, the gap needs to be filled by harvest from other regions. This leads to 1.12 million hectares of new land to be cultivated globally for raising crops. The most significant expansion occurs in Sub-Saharan Africa, Canada, EU, Brazil and US. The expansion is mainly contributed by the enlargement of rainfed areas, which takes more than 85% of the total. This is sensible given that irrigation involves high investment. Figure 4 depicts total crop cover (irrigated plus rainfed) expansion of the world at river basin level. Apart from several major basins in China, Red River and Lake Winnipeg basins in North America, Paraná basin in South America and Niger basin in Africa will be the places where large crop land expansion is most likely to occur.

As for the composition of land conversion, over 60% of the new crop land in China comes at the expense of pasture land (Table 6). Globally, this number is even higher, up to 73%. It suggests that most regions will mainly convert grazing land to support crop production. A few exceptions are EU, Canada and Japan, where over half of the converted land used to be forestland, indicating that these regions may see more deforestation and exhibit higher emission factors.

Implications for water demand

Less water availability drives up water prices. Water becomes a more expensive input for irrigated crop production in the related basins. In our model, production function is allowed to be different across AEZs within a basin. The optimal level of water input is then determined at each AEZ depending on how efficiently water can be used. In other words, water use will be suppressed in the AEZs that have a higher cost share of water, and vice versa. Moreover, water for irrigation is competed by different crops within each basin-AEZ. The crop that takes the lion's share of irrigation will suffer most.

Table 7 and 8 paint a more nuanced picture of the changes described above by focusing on Yangtze basin, China. It is one of the basins that will see the greatest water supply shrinkage in the future. Besides, it irrigates the most important agricultural zone in China. Interestingly, although it is well known that rice production consumes lots of water, it turns out to be very efficient in water usage, probably because of better farming practice and knowledge, as well as the endogenous location choice. In contrast, water is a relatively costly input to produce sugar crops. As expected, water is released from the production of sugar crops to support cultivation of other crops. If look across AEZs, production tends to rise in zones that pay less for the water bills, and vice versa. Take coarse grain as an example. Production is attracted to AEZ 11, where water inputs accounts for a smaller cost compared to land rent, from the other AEZs where production is less water-efficient.

Implications for regional welfare

Table 9 shows the regional household Equivalent Variation, resulting from China water supply shock. Large welfare reduction is observed in China. Likewise, households in EU, East Asia are worse off. US will see a moderate utility gain. (Needs more work to show decomposition of EV.)

Conclusion

We present an improved general equilibrium model and the associated datasets that can be used to analyze water-related economic issues at global scale. This new framework tells apart two types of crop production activities, irrigated and rainfed that are featured by different productivity, cost structure and level of difficulty to expand. The distinction enables refined analysis of economic consequences caused by policy and environmental factors, which otherwise compounds the effects of the two. Furthermore, the present approach highlights the explicit inclusion of water as a production input. Quantity as well as value of water can be allocated to achieve economic equilibrium. These modifications significantly increase the flexibility of existing CGE modeling, especially when the application involves land and water use.

Utilizing the updated model and dataset, we experiment on water deficit in China and analyze its effects on global land use change and international trade. We assumed that widening water gap in China would cut back its irrigated crop production. Total crop output falls as non-irrigated field is not good enough to make up for the lost productivity. The country's balance of agricultural trade worsens. To even out the imbalance, a larger trade surplus in non-agricultural goods is needed. Crop production continues to compete for land from forestry and livestock sectors. Over one third of the converted crop land comes from deforestation.

The numerical results suggest that a localized shock to water availability affects global land cover. A portion of irrigated production, which is hard to expand in China, shifts towards other regions, primarily U.S. and Europe. Expansion of rainfed crop production appears to be more notable and happens almost everywhere but particularly in U.S., EU, Canada, Brazil and Sub-Saharan Africa. The new crop land mainly comes from grazing land and may put pressure on the livestock industry to grow.

Environmental concerns might rise due to deforestation and grassland conversion occurred in the areas that have high emission factors (e.g. Latin America). In conclusion, water shortage in China may significantly reduce the country's crop output and its food supply to the world. International trade buffers the shock of regional water supply variability, but the effects of shrinking irrigated areas in China spill over to other regions, causing worldwide crop land expansion.

Table 1. Crop Production Change (1000 metric tons)

Crop	USA	EU27	CHIHKG	INDIA	ROW	World
Paddy_Rice	27	31	-9362	83	346	-8875
Wheat	103	111	-3275	53	332	-2675
CrGrains	529	86	-2784	7	478	-1684
Oilseeds	354	129	-1496	12	762	-240
Sugar_Crop	0	28	-1098	-35	-230	-1334
OthAgri	325	1198	-5210	195	1788	-1704

Table 2. Percentage Change of Global Production by Crops

Crop	% change of global production
Paddy_Rice	-0.71
Wheat	-0.21
CrGrains	-0.08
Oilseeds	-0.09
Sugar_Crop	0.14
OthAgri	-0.10

Table 3. Trade Balance (million USD)

Commodity	USA	EU27	BRAZIL	CHIHKG	INDIA	ROW
Paddy_Rice	4.5	2.7	-0.5	-33.8	4.2	13.8
Wheat	24.4	10.8	-4.0	-95.1	10.6	51.8
CrGrains	72.2	4.0	11.6	-46.2	0.9	-41.8
Oilseeds	85.9	-2.7	49.0	-193.5	5.7	53.7
Sugar_Crop	0.0	0.4	0.0	-6.0	0.4	4.8
OthAgri	35.9	64.0	23.3	-593.5	29.6	434.0
CROP TOTAL	222.8	79.3	79.5	-968.1	51.5	516.3
Livestock	31.1	34.0	1.4	-179.1	5.8	103.4
Processed food	199.7	187.3	13.9	-717.4	26.9	300.4
Other food	14.8	35.5	-0.6	-49.6	-0.7	1.8
AG & FOOD TOTAL	468.4	336.1	94.2	-1914.2	83.5	922.0
Rest of the commodities	-847.9	-837.8	-121.3	3443.6	-76.6	-1550.0
TOTAL	-379.5	-501.7	-27.0	1529.3	6.9	-628.0

Table 4a. Percentage Change in China's Export to Major Trade Partners

Commodity	USA	EU27	BRAZIL	CAN	JAPAN	E_Asia
Paddy_Rice	-74.5	-74.4	-75.2	-74.8	-74.5	-70.3
Wheat	-49.1	-49.9	-49.7	-49.5	-48.7	-46.4
CrGrains	-15.3	-14.5	-15.6	-15.5	-14.5	-11.8
Oilseeds	-20.4	-19.9	-21.2	-19.1	-19.3	-18.4
Sugar_Crop	-62.5	-64.0	-64.4	-60.6	-42.5	-62.5
OthAgri	-14.4	-14.9	-13.8	-13.4	-11.8	-12.2
DairyFarms	-18.4	-18.5	-18.2	-18.1	-18.4	-17.2
Ruminant	-15.7	-15.1	-15.8	-15.8	-13.9	-12.1
NonRum	-4.3	-4.8	-4.9	-4.8	-3.9	-4.4
ProcDairy	-3.6	-3.8	-3.5	-3.6	-3.3	-2.9
ProcRum	-7.7	-7.9	-7.6	-7.4	-7.2	-6.6
ProcNonRum	-12.2	-11.9	-11.8	-12.3	-10.6	-10.1
Rveg_Oil	-3.1	-3.1	-2.8	-3.2	-2.3	-1.9
Proc_Rice	-4.0	-4.1	-4.0	-4.0	-4.0	-3.8
Bev_Sug	-22.3	-22.1	-24.1	-22.9	-18.7	-14.0
Proc_Food	-6.8	-6.9	-6.9	-6.8	-6.1	-5.5
Proc_Feed	-9.5	-10.0	-9.6	-9.6	-8.2	-7.1

Table 4b. Percentage Change in China's Imports from Major Trade Partners

Commodity	USA	EU27	BRAZIL	CAN	JAPAN	R_SE_Asia	Oceania
Paddy_Rice	98.6	104.2	99.4	108.8	108.9	92.1	95.7
Wheat	32.3	34.2	33.7	31.5	35.0	32.2	32.2
CrGrains	2.7	3.1	2.6	2.7	3.7	1.7	2.2
Oilseeds	2.9	4.1	3.6	3.3	6.0	2.2	2.7
Sugar_Crop	62.9	65.9	64.9	63.5	67.9	60.3	62.8
OthAgri	5.5	4.6	4.5	5.1	5.5	6.8	7.8
DairyFarms	9.4	9.5	8.7	8.6	9.3	7.2	8.5
Ruminant	8.5	8.7	7.9	7.6	7.8	6.3	7.4
NonRum	2.3	2.4	2.5	2.2	2.3	2.3	2.5
ProcDairy	1.7	1.7	1.3	1.5	1.8	1.2	0.9
ProcRum	2.0	2.2	1.6	1.2	1.5	1.6	1.3
ProcNonRum	6.4	6.4	6.0	6.1	6.5	6.1	5.8
Rveg_Oil	1.2	1.0	0.3	0.8	-0.6	0.9	0.6
Proc_Rice	1.9	1.9	1.7	1.8	1.9	1.5	1.7
Bev_Sug	15.5	15.3	14.7	14.2	15.6	12.2	14.9
Proc_Food	3.6	3.5	3.3	3.6	3.5	3.0	3.4
Proc_Feed	8.4	8.4	7.0	8.0	7.4	7.1	7.9

Table 5. Change in Irrigated and Rainfed Harvested Area (1000 ha)

Crops	USA	EU27	BRAZIL	CHIHKG	INDIA	R_Asia	R_America	ROW
Irrigated crops	21.3	31.8	0.8	-7538.6	12.1	16.8	-9.0	64.7
Rainfed crops	85.4	103.4	108.6	8227.7	40.5	9.0	225.5	413.7

Table 6. Land Cover Change (1000 ha)

Crop	USA	EU27	Brazil	CHIHKG	INDIA	World
Forestry	-29	-71	-51	-259	-25	-477
Crops	107	135	109	689	53	1814
Livestock	-77	-64	-58	-430	-28	-1336

Table 7. Cost share of water by crop, Yangtz Basin, China

AEZ	IPaddy_Rice	IWheat	ICrGrains	IOilseeds	ISugar_Crop	IOthAgri
AEZ 10	0.10	0.12	0.12	0.12	0.71	0.10
AEZ 11	0.04	0.04	0.05	0.24	0.87	0.02
AEZ 12	0.10	0.10	0.10	0.31	0.87	0.19
AEZ 13	0.10	0.12	0.10	0.32	0.95	0.10
AEZ 14	0.10	0.22	0.27	0.27	0.77	0.10
AEZ 15	0.03	0.11	0.18	0.10	0.72	0.10
AEZ 16	0.10	0.07	0.15	0.09	0.86	0.45

Table 8. Percentage change in water demand by crop and AEZ, Yangtze Basin, China

AEZ	IPaddy_Rice	IWheat	ICrGrains	IOilseeds	ISugar_Crop	IOthAgri
AEZ 10	-41	-45	-48	-53	-100	-52
AEZ 11	74	68	57	-12	-100	50
AEZ 12	-40	-42	-46	-83	-100	-61
AEZ 13	-82	-83	-84	-93	-100	-85
AEZ 14	59	23	-12	-32	-100	29
AEZ 15	46	30	5	14	-100	11
AEZ 16	-42	-42	-51	-50	-100	-100

Table 9. Change in regional welfare ($US million)

Region	EV	Region	EV
USA	226	**Mala_Indo**	-16
EU27	-177	**R_SE_Asia**	45
BRAZIL	59	**R_S_Asia**	-4
CAN	27	**Russia**	-11
JAPAN	-246	**Oth_CEE_CIS**	-3
CHIHKG	-1295	**Oth_Europe**	-14
INDIA	-8	**MEAS_NAfr**	-85
C_C_Amer	-9	**S_S_AFR**	34
S_o_Amer	82	**Oceania**	93
E_Asia	-366		

Figure 1. Nesting structure of water and land

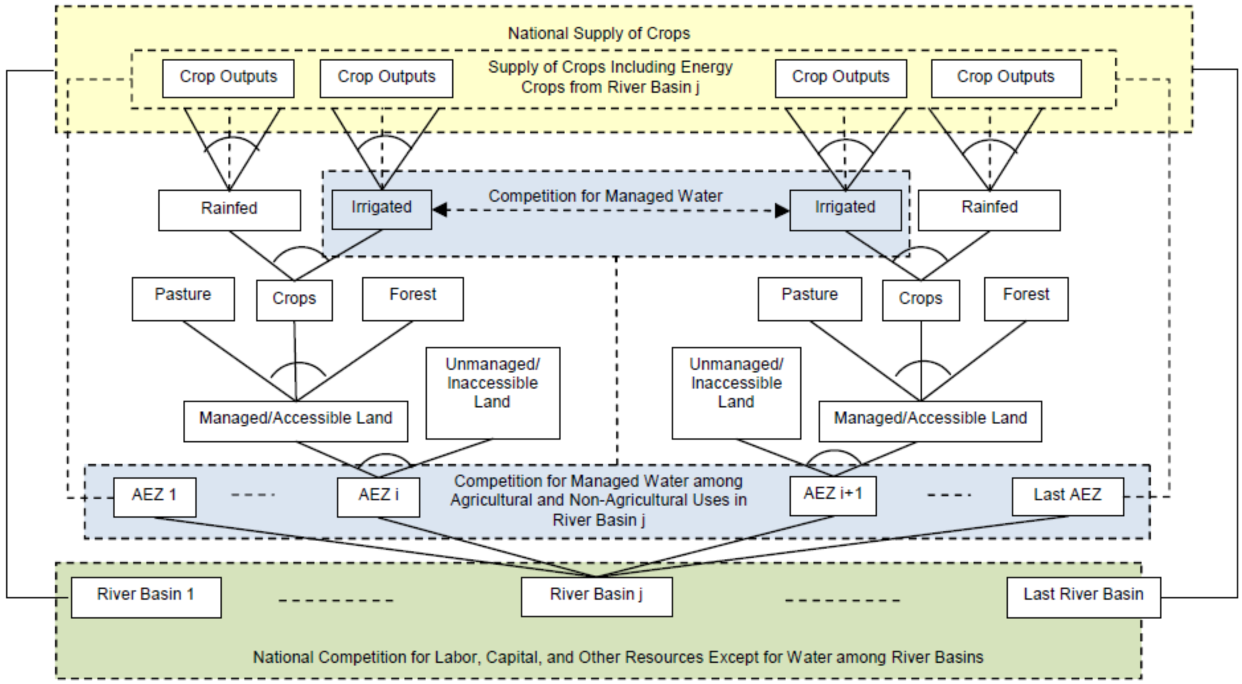


Figure 2. Global share of water for irrigation and crop production

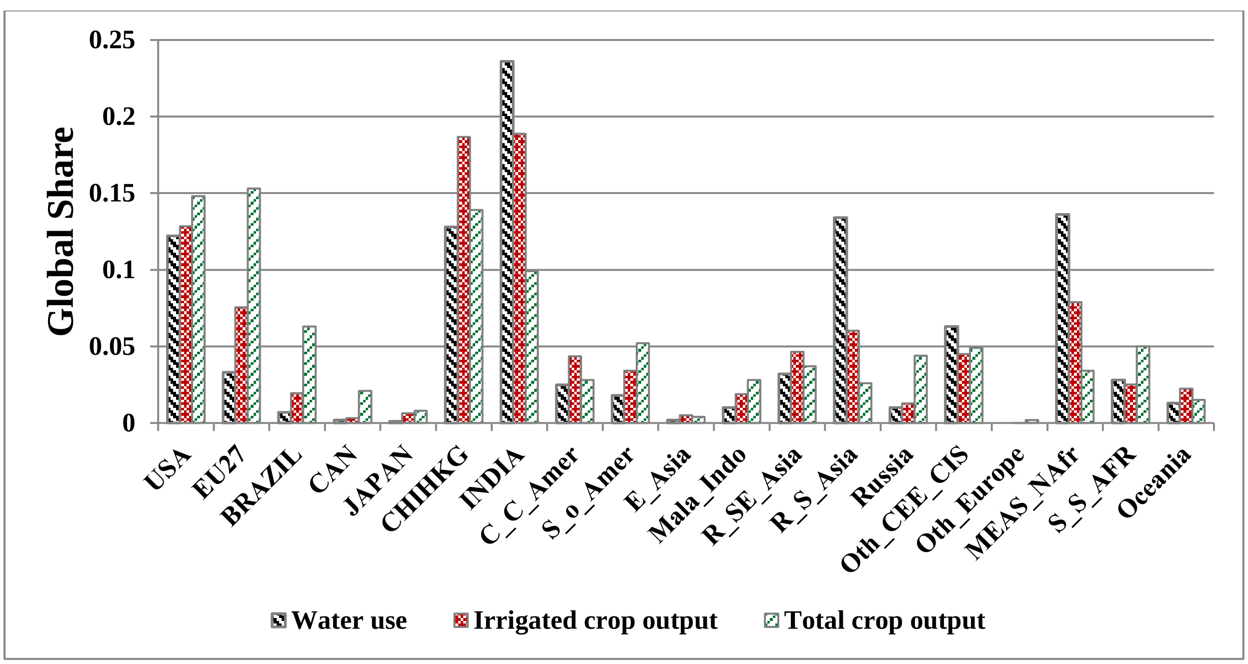


Figure 3. Change in irrigated and rainfed crop production, China

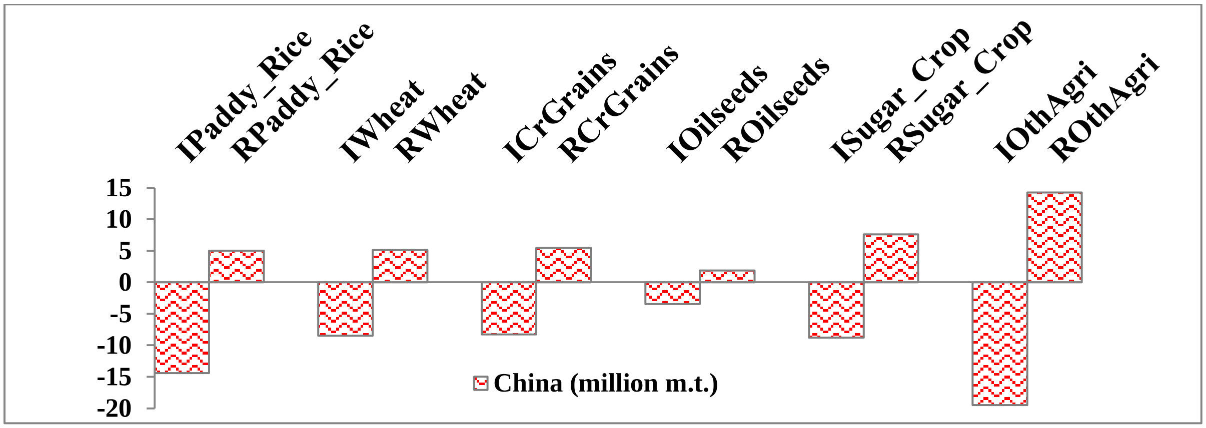
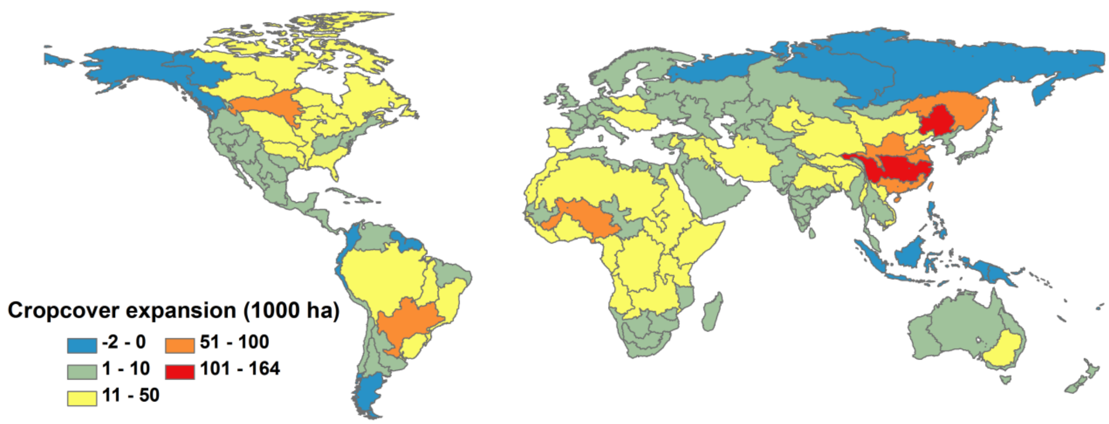


Figure 4. Global crop cover expansion at river basins



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Appendix. River basin names by region

Basin	USA	EU27	BRAZIL	CAN	JAPAN	CHIHKG	INDIA	C_C_Amer	S_o_Amer
B1	Arkansas	Baltic	Amazon	Canada_Arctic_At	Japan	Amur	Brahmaputra	Carribean	Amazon
B2	California	Britain	North_South_America_Coast	Central_Canada_Slave_Basin	NA	Brahmaputra	Brahmari	Central_America	Chile_Coast
B3	Canada_Arctic_At	Danube	Northeast_Brazil	Columbia	NA	Chang_Jiang	Cauvery	Cuba Carribean_Central_America	North_South_America_Coast
B4	Colorado	Dnieper	Orinoco	Great_Lakes	NA	Ganges	Chotanagpui	Middle_Mexico	Northwest_South_America
B5	Columbia	Elbe	Parana	Red_Winnipeg	NA	Hail_He	Easten_Ghats	Northwest_South_America	Orinoco
B6	Great_Basin	Iberia_East_Med	San_Francisco	US_Northeast	NA	Hual_He	Ganges	Rio_Grande	Parana
B7	Great_Lakes	Iberia_West_Atla	Toc	NA	NA	Huang_He	Godavari	Upper_Mexico	Peru_Coastal
B8	Mississippi	Ireland	Uruguay	NA	NA	Indus	India_East_Coast	Yucatan	Rio_Colorado
B9	Missouri	Italy	NA	NA	NA	Langcang_Jiang	Indus	NA	Salada_Tierra
B10	Ohio	Loire_Bordeaux	NA	NA	NA	Lower_Mongolia	Krishna	NA	Tierra
B11	Red_Winnipeg	North_Euro_Russia	NA	NA	NA	North_Korea_Peninsula	Langcang_Jiang	NA	Uruguay
B12	Rio_Grande	Oder	NA	NA	NA	Ob	Luni	NA	NA
B13	Southeast_US	Rhine	NA	NA	NA	SE_Asia_Coast	Mahi_Tapti	NA	NA
B14	US_Northeast	Rhone	NA	NA	NA	Songhua	Sahyada	NA	NA
B15	Upper_Mexico	Scandinavia	NA	NA	NA	Yili_He	Thai_Myan_Malay	NA	NA
B16	Western_Gulf_Mex	Seine	NA	NA	NA	Zhu_Jiang	NA	NA	NA
B17	NA	NA	NA	NA	NA	NA	NA	NA	NA
B18	NA	NA	NA	NA	NA	NA	NA	NA	NA
B19	NA	NA	NA	NA	NA	NA	NA	NA	NA
B20	NA	NA	NA	NA	NA	NA	NA	NA	NA

Basin	E_Asia	Mala_Indo	R_SE_Asia	R_S_Asia	Russia	Oth_CEE_CIS	Oth_Europe	MEAS_NAfr	S_S_AFR	Oceania
B1	Amur	Borneo	Borneo	Amudarja	Amur	Amudarja	Rhine	Arabian_Peninsul	Central_African_West_Coast	Central_Australia
B2	North_Korea_Peninsula	Indonesia_East	Langcang_Jiang	Brahmaputra	Baltic	Amur	Rhone	Black_Sea	Congo	Eastern_Australi
B3	South_Korea_Peninsula	Indonesia_West	Mekong	Ganges	Black_Sea	Baltic	Scandinavia	Eastern_Med	East_African_Coast	Murray_Australia
B4	NA	Papau_Oceania	Philippines	Indus	Dnieper	Black_Sea	NA	Nile	Horn_of_Africa	New_Zealand
B5	NA	Thai_Myan_Malay	SE_Asia_Coast	Sri_Lanka	Lower_Mongolia	Danube	NA	North_African_Coast	Kalahari	Papau_Oceania
B6	NA	NA	Thai_Myan_Malay	Thai_Myan_Malay	North_Euro_Russia	Dnieper	NA	Northwest_Africa	Lake_Chad_Basin	Sahara
B7	NA	NA	NA	Western_Asia_Iran	Ob	Eastern_Med	NA	Sahara	Limpopo	Western_Australia
B8	NA	NA	NA	NA	Scandinavia	Iberia_East_Med	NA	Tigris_Euphrates	Madagascar	NA
B9	NA	NA	NA	NA	Upper_Mongolia	Lake_Balkhash	NA	Western_Asia_Iran	Niger	NA
B10	NA	NA	NA	NA	Ural	Lower_Mongolia	NA	NA	Nile	NA
B11	NA	NA	NA	NA	Volga	Ob	NA	NA	Northwest_Africa	NA
B12	NA	NA	NA	NA	Western_Asia_Iran	Syrdarja	NA	NA	Orange	NA
B13	NA	NA	NA	NA	Yenisey	Tigris_Euphrates	NA	NA	Sahara	NA
B14	NA	NA	NA	NA	NA	Upper_Mongolia	NA	NA	Senegal	NA
B15	NA	NA	NA	NA	NA	Ural	NA	NA	South_African_Co	NA
B16	NA	NA	NA	NA	NA	Volga	NA	NA	Southeast_Africa_Coast	NA
B17	NA	NA	NA	NA	NA	Western_Asia_Iran	NA	NA	Volta	NA
B18	NA	NA	NA	NA	NA	Yenisey	NA	NA	West_African_Coastal	NA
B19	NA	NA	NA	NA	NA	Yili_He	NA	NA	Zambezi	NA
B20	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA