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ISSUES IN BRIEF

Governance Issues in China's Food Sufficiency vs. Virtual Water Debate

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Food or water? Rapid economic growth in China has led to an unprecedented improvement of livelihoods, but has also brought unprecedented dilemmas for China's development policymakers. Urbanization has raised the demand for processed foods and simultaneously limited the growth of agriculture by reallocating land, water and other resources away from agriculture to other sectors. As a result, China needs to increase its food supply during a time of diminishing availability of land, water, labor and other resources.

Historically, China has intentionally maintained a high degree of food self-sufficiency (Han 2014); however the "red line" of self-sufficiency has been gradually compromised. China's limited land and water resources prevent its food supply from keeping up with demand, forcing China to rely more on international food markets, and resulting in a debate about changing the red line policy.

The policy debate about the red line often focuses on arable land, but limited water also constrains food production. As a water-scarce country with already huge agricultural water consumption and growing urban water consumption, China would benefit from specializing in producing foods that require less water, importing those that use more water, and maximizing the degree of food sufficiency. The concept of "virtual water" can therefore be an effective tool to balance two important policy goals — achieving the maximum degree of food self-sufficiency and conserving water. However, China's fragmented agricultural regulatory system and conflicting policy goals make it difficult to maximize virtual water efficiency (VWE). This paper discusses the possibility of implementing policies suggested by virtual water studies in China.

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The Looming Challenge of Food Security

Recently, the Chinese government has acknowledged that "China's food production cannot meet the nutritional needs of its people" (National Health and Family Planning Commission PRC 2014), addressing an upcoming threat to food security.

Food security is defined by the UN Food and Agriculture Organization (FAO) as "a situation that exists when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life" (UNFAO 2002). In China's case, the current debate is mainly about food sufficiency, but concern about food safety is also growing.

From a historical perspective, food sufficiency is not a new challenge in China. Ancient Chinese empires regarded access to food as the vital factor of social stability, and famines as a "divine punishment" and a major source of uprising. In the 20th century, China experienced multiple nationwide food crises due to war, natural disasters, and mismanagement, which led to a traditional yet persistent mentality that links food sufficiency and prosperity. In the 1980s, the low agricultural productivity under the communal system drove Deng Xiaoping to decollectivize agricultural production, which in turn led to his economic reform. Elder Chinese people nowadays, including most of the top leaders in the Chinese government, personally experienced the famine in early 1960s and share a common concern for potential food shortages.

China currently supports 22 percent of the world population with seven percent of global arable land, and the burden is becoming heavier. A 2012 report indicates that China is using 40 percent of basic crops as industrial resources and 20 percent for animal feed, and those numbers are predicted to increase to 50 percent and 25 percent respectively by the end of the decade due to the increasing demand for protein (Xiong 2012). The indirect consumption of grains through animal protein is likely to further increase in both urban and rural China.

Diminishing resources already have severely hindered the growth of agricultural production. Currently in China, land, water, and even labor are gradually reallocated away from agriculture to the manufacturing and service sectors. Of all the resources, water is becoming one of the most explicit constraints: China's renewable water resource per capita is 2100 m^3, only 28 percent of the world average (UNFAO 2015), and the distribution of water resources in China is highly uneven, as 60 percent of China's arable land is located in water scarce areas (Smith 2012). In addition, up to 40 percent of China's rivers are "seriously polluted" and 20 percent are "too polluted to safely contact" (Economy 2013), which further limits the amount of useable water. Moreover, as traditional water-sufficient arable lands in the Yangtze River Delta and the Pearl River Delta have become urbanized, China's food production has to depend more on water-insufficient areas.

As the food demand grows and supply falls short, the country has started to rely more on imports. China's grain self-sufficiency (rice, wheat, and maize) has fallen below 95 percent since 2007 and below 90 percent since 2012; the water-intensive soybean has rapidly become a major component of China's agricultural imports since 1996 (Liu 2013). Intuitively, importing food is a straightforward answer to the domestic resource constraints. Still, the Chinese government fears the heavy dependence on international markets, and attempts to maintain its food sufficiency policy.

Minister of Finance Lou Jiwei, a promoter of agricultural liberalization, criticizes limiting reliance on food imports as "war-time thinking" (Lou 2015); however, it is likely that the Chinese government has various non-market reasons to maintain domestic food production. As a developing country, China still has a large population of rural citizens whose lives largely rely on agricultural production. China's National Bureau of Statistics indicates that 619 million Chinese, which is 45.23 percent of the population, are rural citizens (National Bureau of Statistics PRC 2015) and a large proportion of them work as farmers. The rural population has a relatively high Engel's coefficient of 37.7 (National Bureau of Statistics PRC 2015), which reflects high vulnerability to food price fluctuation. Furthermore, the agricultural production in China is highly fragmented and closely related to the employment of a large rural population. As a result, those policymakers aiming to adjust regional production will have to consider the impacts on local communities, which makes agricultural production a comprehensive social development issue. Han Changbin, Minister of Agriculture, argues that it is necessary for China to keep its production capacity because the international food market is not large enough to meet its needs; according to Han, the international food supply can only meet 50 percent of China's total food demand and 25 percent of China's rice demand at maximum (Han 2014).

However, USDA, FAPRI, and FAO predict that China will continue to rely heavily on international markets for soybean, and gradually increase the import of multiple products, including sugarcane, maize, wheat, barley, milk, and pork (Zhou, Tian, Wang, Liu, and Cao 2012). There are also legal considerations for maintaining food self-sufficiency: the domestic cost of certain foods is simply higher than their foreign counterparts, and subsidies cannot be raised as they have already reached the ceiling of China's WTO treaty (Cheng 2015). Even if the treaty can be circumvented, it has become difficult to use subsidies to keep up with market changes after 2009 for two reasons: increasing land rent and irrigation charges, and the emerging cost of factors such as fertilizer, which used to be produced by local farms but is recently being liberalized. Improving the efficiency of production thus becomes a priority for agricultural strategists.

Balancing Food and Water Challenges

Minister Han admits that the constraint of arable land and fresh water will inevitably limit food production (Han 2014). China needs to maximize agricultural output per water usage, which can be better understood using the virtual water analysis.

Virtual water is defined as the water required in the production of industrial or agricultural goods (Hoekstra 2003). While water cannot be directly traded in most cases, countries can transfer virtual water and save real water by trading water-consuming products. For agricultural strategists, China's production and trade can be further optimized to increase the overall food supply.

Virtual water efficiency can be illustrated by the comparative advantage principle in economics: with water as a constraint of production, specializing in the production of water-efficient food will maximize the utility of each food producer. Table 1 (p. 4) shows the water footprint of one metric ton of selected products in some of the world's top food exporters.

Less virtual water per unit of food production means higher VWE. China itself is water-efficient in growing grains compared to the world average, but not that efficient in growing soybeans. If other inputs such as land and labor are more flexible and water consumption is the main constraint, China should import products such as soybeans, since their "opportunity cost" — that is, the possible output of other products using the same land — would be higher. China can set up different trade relationships with countries that can produce certain foods more efficiently.

VWE can also be measured by water consumption per calories, which reflects China's growing demand for high-calorie foods. With simple transformations of Table 1, it is possible to calculate the agricultural product output given 1000 m^3 of water, and subsequently the dietary calories included in these products. Table 2 (p. 4) only focuses on eight products and compares the outputs and calories of these foods.

Table 1: Amount of Water Consumed per Unit Output

	CHN	USA	NED	BRA	IND	INA	World Avg
Unit (m^3 /metric ton)							
Soybean	2,617	1,869	—	1,076	4,124	2,030	1,789
Corn	801	489	408	1,180	1,937	1,285	909
Rice	1,972	1,903	—	4,600	4,254	3,209	3,419
Wheat	690	849	619	1,616	1,654	—	1,334
Beef	12,560	13,193	11,681	16,961	16,482	14,818	15,497
Pork	2,211	3,946	3,790	4,818	4,397	3,938	4,856
Milk	1,000	695	641	1,001	1,369	1,143	990
Egg	3,550	1,510	1,404	3,337	7,531	5,400	3,340

Source: http://www.lenntech.com/water-food-agriculture.htm. The rank of agricultural production can be found at http://www.mapsofworld.com/world-top-ten/world-top-ten-agricultural-exporters-map.html.
CHN = China, USA = United States, NED = Netherlands, BRA = Brazil, IND = India, INA = Indonesia

Table 2: Output and Calories Produced per Unit Water

	CHN	USA	NED	BRA	IND	INA	World Avg
Output (kg/m^3)							
Soybean	.382	.535	—	.929	.242	.493	.559
Corn	1.248	2.045	2.451	.847	.516	.778	1.100
Rice	.507	.525	—	.217	.235	.312	.292
Wheat	1.449	1.178	1.616	.619	.605	—	.750
Beef	.0796	.0758	.0856	.0590	.0607	.0675	.0645
Pork	.452	.289	.264	.208	.227	.254	.206
Milk	1	1.439	1.560	1	.730	.875	1.010
Egg	.282	.662	.712	.300	.133	.185	.299
Calories Contained (calories/m^3)							
Soybean	1589.12	2225.6	—	3864.64	1006.72	2050.88	2325.44
Corn	1073.28	1758.7	2107.86	728.42	443.76	669.08	946
Rice	654.03	677.25	—	279.93	303.15	402.48	376.68
Wheat	2869.02	2332.44	3199.68	1225.62	1197.9	1485	—
Beef	229.248	218.304	246.528	169.92	174.816	194.4	185.76
Pork	1224.92	783.19	715.44	563.68	615.17	688.34	558.26
Milk	600	863.4	936	600	438	525	606
Egg	414.54	973.14	1046.64	441	195.51	271.95	439.53

Source: Calories data (average value of each type of product) from Fat Secret, see http://www.fatsecret.com/calories-nutrition/.

A simple calculation of three major types of crops can show the difference: Table 3 shows the difference between actual production and hypothetical production where China only produces wheat. When China only produces wheat to match either the output or calorie output of actual production, the water consumption is drastically reduced.

Table 3: Hypothetical and Actual Crop Production Comparison, 2015

	Same Amount of Production (million ton)	Estimated Water Consumption (million m^3)
Actual (estimated)	226 (corn)	181,026
	209 (rice)	412,148
	125 (wheat)	86,250
Total	560 (mixed)	679,424
Hypothetical (matching output)	560 (wheat)	386,400
Hypothetical (matching calories)	359.33 (wheat)	247,936

Source: Production estimation from USDA GAIN, https://tinyurl.com/ybarwct6

From a pure VWE perspective, China should promote wheat, which produces more calories per water use; meanwhile, importing water-intensive foods such as soybeans will minimize agricultural water consumption. However, it is also worth noting that VWE calculations assume that all foods are replaceable in the long term, which ignores regional diet preference. Another practical criticism is that various regions of China have different VWE; thus, while theoretically possible, it is impractical for the country to produce a single type of crop in all provinces.

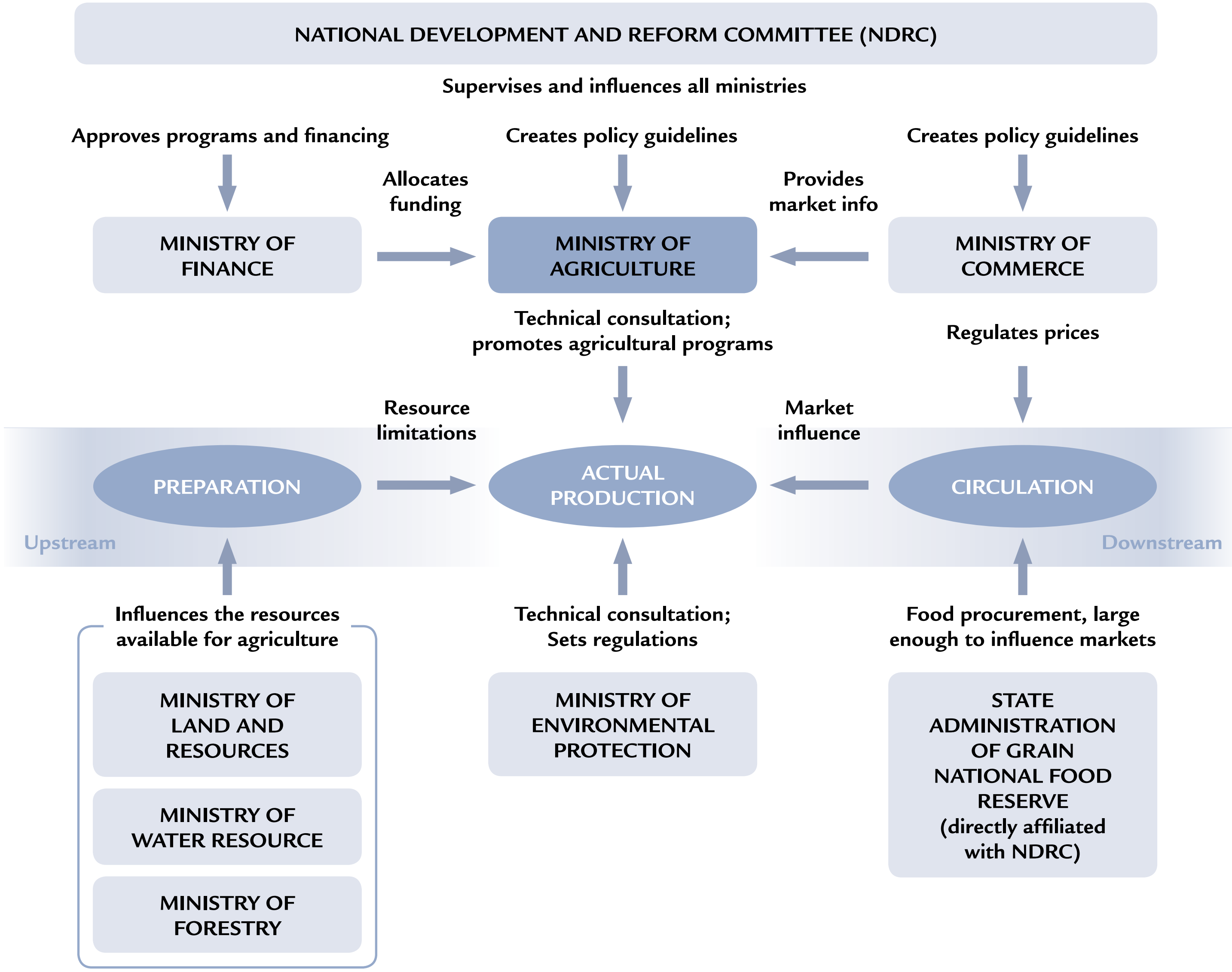
Difficulties of Implementing Virtual Water Policy

While useful as a guide to optimizing the use of water in agriculture and logical from the perspective of maximum efficiency, virtual water analysis is also criticized for ignoring the unequally-distributed and socially-vital nature of water in real life decision-making (Gawel and Bernsen 2013). While trade will maximize agricultural output with limited resources, the Chinese government also has concerns about heavy dependence on international markets; in addition, the change of production patterns directly influences the life of China's massive rural population, especially the smallest family farms. As a result, the opinions of various stakeholders in the Chinese government toward a production adjustment vastly differ; even with the coordination of top leaders, ministries might find it difficult to reach consensus and coherently implement policies.

Policy issues derived from virtual water analysis — namely international trade, production adjustment, and reducing water waste — require coordination among ministries. Unfortunately, the main coordinator of food security in China, the Ministry of Agriculture (MoA), has extremely limited authority over upstream and downstream stakeholders. Virtual water analysis can therefore be hard to transform into real life policy. Figure 1 (p. 6) shows the major stakeholders in the design and implementation of agricultural policies.

The National Development and Reform Committee (NDRC) is the main economic governor, decision-maker, and the supervisor of other ministries. NDRC assigns the MoA responsibility for all the production activities within the allocated arable land. However, the MoA was originally designed as a consultative agency. This leaves the relatively weak MoA to coordinate among ministries with more authority and better capacity.

Figure 1: Regulatory Structure of China's Food Production and Circulation



The upstream of agriculture production is controlled by the Agriculture Division of the Ministry of Finance and various resource regulators. The Ministry of Finance and NDRC have more administrative resources, but they are engaged in multiple tasks and might not sufficiently offer political support for agricultural adjustment. The Ministry of Land and Resources (MoLR) is the vital preserver of arable land and an "ally" of the MoA. As a strategic planner with relatively powerful enforcement, MoLR also serves as a channel between economic activity (production and land use) and governmental order. The Ministry of Water Resources and NDRC are responsible for allocating water resources for agricultural use, while the Ministry of Forestry occasionally competes for land with the MoA. Outside of the MoLR, the MoA does not have a reliable method to secure arable land.

The downstream, at the same time, is related to the market and cannot be controlled by the MoA. After the agricultural product is harvested and ready for sale, the responsibility of the MoA ends as the product goes to the market. As a direct affiliation of the NDRC, the State Administration of Grain (SAG) adjusts prices in coordination with its superior while staying independent from the MoA. Meanwhile, while not having a specific division for agricultural markets, the Ministry of Commerce (MOFCOM) is responsible for market monitoring and emergency measures in case of unexpected fluctuation. The MoA cooperates with the State Food and Drug Administration (SFDA) as food quality monitors, but it has limited influence on the food prices that incentivize farmer to produce certain types of foods.

Theoretically, the MoA can adjust agricultural output by overseeing the actual production. However, as the actual agricultural production also involves the local governments, which are completely independent from the central MoA and financially control the local branches (bureaus) of the MoA, it becomes even harder for the MoA to exert proper coordination when trying to fulfill its responsibility. On one hand, the Ministry of Environmental Protection, whose actual responsibility also falls into instructing and monitoring agricultural production, might compete with the MoA if the adjustment is deemed ecologically harmful. On the other hand, actual production is determined by markets, and the subsidies of the MoA do not change frequently enough to counter annual price fluctuations. As a result, the MoA might find it difficult to influence actual production.

Conclusion

Virtual water studies aim at optimizing production to achieve maximum production with minimum water usage. This concept can provide specific water-saving suggestions to adjust China's agricultural sector. The virtual water analyses concerning China have provided a straightforward answer to water scarcity, namely virtual water trade.

China is a country facing both water scarcity and potential food insecurity. While importing virtual water (food) provides a solution to both problems, it not only contradicts the self-sufficiency concern of the country, but also involves a variety of regulators. The fragmentation of agricultural governance in China has made it difficult to implement either policies supporting virtual water trade or those against it (maintaining food self-sufficiency). The fragmented governance structure hinders inter-ministry coordination and promotes the separation of agricultural production and circulation, the latter of which is especially at odds with market-oriented policies such as virtual water trade.

As the Chinese economy is strongly influenced by governmental actions, a less fragmented institutional arrangement is vital for a water-efficient plan that also increases the food supply. There is no clear solution to the coordination issue inside the Chinese government, but the decision makers in China have incentive to facilitate communication between regulators. It is possible that China may benefit more from expanding imports of water-intensive foods by simply liberalizing the food market; however, the lack of coordinated regulation is expected to hinder China's pursuit of food security and highlights the need for further institutional reform.

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