Six Puzzles in Indian Agriculture

Shoumitro Chatterjee
Princeton University

Devesh Kapur
University of Pennsylvania

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ABSTRACT

A quarter century after India's historic shift to a more market-oriented economy, the agriculture sector continues to be racked by severe policy distortions, despite its importance for the livelihoods of the majority of India's population and in addressing major long-term challenges facing the country, from food security to natural resource sustainability. The paper highlights some key empirical realities and data anomalies to raise some fundamental questions about Indian agriculture and anchors the analysis in six major puzzles: prices; procurement; political economy; trade; productivity; and exit. While the list is neither exhaustive nor original in and of itself, these puzzles raise important policy issues. We conclude by arguing that more unified frameworks of analysis are needed for effective policy in a much neglected but crucial sector for securing India's future.

JEL Codes: D43, D45, O1, Q11, Q12, Q13, Q18

Chatterjee: sc20@princeton.edu. Kapur: dkapur@upenn.edu. The authors would like to thank Amarsingh Gawande and Beeban Rai for excellent research assistance.

1. Introduction

A quarter century after India's historic shift to a more market-oriented economy, with industrial delicensing, trade liberalization and (more limited) reforms in factor markets, one sector continues to be plagued by severely intrusive government regulations in both factor and product markets, an arbitrary policy and regulatory environment and low public investment. Unfortunately, that sector—agriculture—not only accounts for the livelihoods of the majority of India's population, but also is critical to multiple long-term challenges facing the country, from food security to natural resource sustainability, especially soil and water.

The challenges facing Indian agriculture and its tens of millions of farmers have been well recognized, whether by the media attention and hand wringing on farmer suicides, the reports of the National Commission on Farmers (led by M. S. Swaminathan) or official government documents, such as the Economic Survey, 2016. Yet academic research has largely not kept pace with the most pressing challenges facing Indian agriculture, barring certain exceptions.[1] Given the increasing availability of computing power, novel geospatial datasets and new quantitative tools in trade, industrial organization, economic geography and political science, this might be an opportune moment to focus on some old and new puzzles in Indian agriculture—all of which have major welfare implications for the tens of millions of Indian farmers.

The primary purpose of this paper is to raise some fundamental questions about Indian agriculture by highlighting empirical realities and anomalies in the data. We discuss six major puzzles in Indian agriculture related to prices, procurement, political economy, trade, productivity, and the near-absence of exit. Our list is by no means exhaustive, nor do we claim to be the first ones to identify these issues, but these puzzles raise, we argue, important policy issues and are all the more salient when viewed through the lens of a unified framework. We argue that it is often simplistic and naïve to provide isolated answers to these questions. For example, a straightforward answer to high spatial variation in

[1] Examples include: Allen & Atkin, 2016; Banerji, Gupta, & Meenakshi, 2012; Banerji & Meenakshi, 2004, 2008;

farm gate prices is weak infrastructure. But one would find it hard to reconcile with the substantial investments in rural infrastructure in recent years, especially roads and cellphone connectivity.

More broadly, our goal is to assemble some of the building blocks for an internally consistent framework and, in doing so, also highlight the need for more quantitative macro research in agriculture. Much recent research in development (including on agriculture) has a micro focus. However, for policy it is essential to be able to build a macro framework which not only enables incorporation of key actors and modelling their interaction with each other but also helps to analyze meaningful policy counterfactuals with general equilibrium effects. Although the random and quasi-random experimental literature has been very insightful, its limitations for policy counterfactuals owing to external validity, general equilibrium effects and other issues are now well known (Cartwright, 2007; Deaton, 2010; Deaton & Cartwright, 2016; Monte, Redding, & Rossi-Hansberg, 2015; Redding & Rossi-Hansberg, 2016).

2. The Price Variation Puzzle

Economic theory predicts that spatial price dispersion is a function of trade costs (such as transport costs) and information asymmetries, and mark-ups charged by market intermediaries (the law of one price). Since the early 2000s, there have been large public investments in India in constructing highways and rural roads. The Pradhan Mantri Gram Sadak Yojana (PMGSY), launched in end-2000, aimed at providing all-weather road connectivity to every rural habitation with a minimum population of 500 in the plains (250-plus in hill states, tribal districts and desert areas). Of a total of 1,78,184 habitations identified, two-thirds were connected by mid-2016 with nearly half a million km of roads. In the case of telecommunications infrastructure, the investments were made by the private sector. According to the Socio-Economic and Caste Census 2011, 2 in every 3 rural Indian households have access to cellphones (from negligible numbers in 2000), and there have been active efforts by the central and state governments to inform farmers of mandi prices near them (Tewari, 2015). The twin investments in core connectivity infrastructure—roads and cell phones—have resulted in substantial reductions of both transport and information costs in India. Yet we do not see evidence of spatial price convergence in agriculture commodities during this time period. As we show below, using high frequency data, the variation in prices of commodities between agricultural markets or mandis has been stable over the past decade and is consistent across different crops.

Agarwal (2014) uses the road construction under the PMGSY program as a quasi-random experiment and does not find any significant effect on price variation.[2] Fafchamps and Minten (2012) found no evidence of impact of SMS-based information on the prices received by farmers in a field experiment in Maharashtra. Although Goyal (2010) finds mild effects on price increases for soyabean farmers because of the introduction of electronic kiosks in villages of Madhya Pradesh in early 2000 by ITC, the aggregate effects are negligible since the overall price variation has not gone down.

Before we look for possible answers, we explore the data in detail. We focus on average monthly price data for eight major non-perishable commodities—paddy, wheat, barley, maize, finger millet, pearl millet, sorghum and soybean—sold in any mandi in India between 2005–2014. It should be noted that the prices we analyze are wholesale prices observed at agricultural produce marketing committee (APMC) mandis. It is very likely that these are not prices received by farmers, especially since it is large farmers who sell in mandis whereas small farmers are more likely to sell to local village intermediaries (see Table 1). However, our price data has several advantages. They are actual prices recorded at a high frequency and at a crucial stage in the supply chain—mandis are key points of aggregation. Other sources of price data are usually recalled estimates of unit values, geographically aggregated and at very low in frequency.

[INSERT TABLE 1 HERE]

[2] See table 2 in Agarwal (2014) for details

We use log (real) prices (with the CPIAL (Food) as the deflator) so that the variance of log prices is unit-independent and compatible for pan-country comparisons. The average standard deviation of log (real) prices across mandis in a given month is 0.17. For comparative purposes, this is higher than the Philippines: for rice and corn (the country's principal home-grown food commodities), Allen (2014) found the standard deviation to be 0.15, this in a country formed by a group of islands, with high transport and information costs.

As stated earlier, we do not observe any trend in time-series of the standard deviation which implies that trade cost during this period does not appear to have had a causal effect on price variation in grains across India (see Figure 1). There is some heterogeneity in the price dispersion across commodities. It is lowest for soybean, which is chiefly grown in Madhya Pradesh as well as parts of Maharashtra, and higher for other cereals (see Table 2).

[INSERT FIGURE 1 HERE: Title: Spatial Price Variation over time]

[INSERT TABLE 2 HERE]

Some of the variation in price might be due to high value varieties—for example, basmati rice is more expensive than common rice. To control for that, we drop the top 5 percentile of our data by crop in terms of prices. That brings down the average annual variation only mildly. Most importantly, however, even in the trimmed sample, we do not see any evidence of reduction in spatial price variation over time (see Table 3).

[INSERT TABLE 3 HERE]

The average standard deviation of log (real) prices across mandis within states is also high. To the extent that high average standard deviation of log (real) prices across mandis in the country might be due to different varieties of wheat and rice grown in agro-ecological zones that vary across different states, this finding attenuates the concern. High within-state variation provides additional evidence that the variation is not entirely due to quality. We present the results for 2014 in Table 4. The results for previous years are similar.

[INSERT TABLE 4 HERE]

What is the relative weight of different factors in the variation in prices? To get at this, we performed a Shapley-Shorrocks decomposition. This procedure considers the various factors which together determine an indicator (such as the overall variation in prices), and assigns to each factor an average marginal contribution. This technique ensures that the decomposition is always exact and that the factors are treated symmetrically. The results from the Shapley-Shorrocks decomposition found that 37 per cent of the variation in log (real) prices is due to time-invariant district fixed effects (which in this case could be soil quality effecting yields and hence prices), 20 per cent is due to location-invariant aggregate time shocks (like global demand), 4 per cent is due to differences in monthly rainfall across districts, and 39 per cent remain unexplained. The residual time and location varying effects could be due to changes in connectivity, crop choice or the expansion of welfare schemes—such as the public distribution system (PDS) and National Rural Employment Guarantee Act (NREGA)—impacting agriculture.

This analysis is revealing because, if the law of one price is valid, then trade costs alone cannot create the binding constraint. Since law of one price is a function of trade costs and intermediary market power, it must be either that the market power of intermediaries has stayed constant over the years and/or that it interacts with trade costs in ways that we do need to understand.

In ongoing work, Chatterjee (2017) explores the role of spatial competition in price variation within mandis. Using a macro approach, the paper finds evidence that additional markets create more competition and hence increase the prices received by farmers. A causal border-discontinuity model, which exploits restrictions to inter-state movement of goods to tease out the competition effect, estimates price increases of 4 per cent for an additional mandi in the neighbourhood. The limitation of this approach is that it is unable to capture any within-mandi friction that might give rise to market power.[3] Understanding the mandi as an institution, and its internal political economy that gives market power to traders vis-à-vis farmers, is the logical analytical next step.

3. The Procurement Puzzle

Two key government interventions that affect agriculture markets and commodity prices in India are the Minimum Support Price (MSP) and procurement by government agencies. The MSP sets a floor price and thereby shapes the investment decisions of farmers. Its rationale is to ensure that farmers are not compelled to sell their produce below support price due to either exploitation by large market players or a bumper harvest. The MSP is effective mainly for four crops: wheat, paddy, cotton (albeit only to a modest degree) and sugarcane (for which mills are legally obligated to buy cane from farmers at government-fixed prices).

MSP-procurement practices and outcomes vary (i) across states, (ii) across districts within states, and (iii) across crops. Although we understand some of this variation, a large part of it is still left unexplained. To highlight this puzzle, we first consider an indirect measure: farmers' awareness about MSP. The reason to choose this measure over actual procurement is that the quantum of procurement

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[3] See Krishnamurthy, 2011, for any ethnographic study of the multiple ways in which market power works within a mandi.

is a choice of the farmer. If market prices are above MSP, then even in the presence of efforts by public agencies, farmers may choose not to sell since the MSP acts like an option. However, the farmer's awareness about MSP is more likely to reflect the presence of government agencies in his neighborhood.

Figure 2 shows that most farmers are not even aware of the existence of MSPs, and there is considerable variation across states. Whereas most farmers in Punjab and Haryana are aware of the MSP program, very few are aware in other states such as Gujarat, Maharashtra, Jharkhand or West Bengal. This is indicative of the absence of active government procurement efforts by public agencies in many parts of the country.

[INSERT FIGURE 2 HERE]

It follows, therefore, that there are large disparities across states in actual procurement. In Tables 5 and 6, not surprisingly, one observes that the states where awareness of MSP is high are also the states where there is heavy procurement of grains—both in absolute terms and relative to total production. Therefore, awareness is highly correlated to the intensity of procurement in a state (see Figure 3). Notice also that as paddy is more intensely procured than wheat (as a percentage of total production), the overall level of awareness is higher for paddy than for wheat.

[INSERT TABLE 5 HERE]

[INSERT TABLE 6 HERE]

[INSERT FIGURE 3 HERE]

While there has been considerable discussion on procurement of food grains by public agencies for the PDS, the key point that is often missed is that government procurement is a luxury for most farmers in the country. There are large differences not only across states but within them as well. And this variation in procurement has substantial consequences on the price that farmers receive and the crops they choose to produce.

The disparity in procurement within states can be seen in the maps in Figures 4 and 5. The figures plot, for each district, paddy and wheat procured as a percentage of total production for that district. Although there is uniformly high procurement across districts in Punjab and Haryana, there is large variation across districts in UP, MP, Maharashtra and Odisha.

[INSERT FIGURE 4 HERE]

[INSERT FIGURE 5 HERE]

What explains variation in procurement across districts? Potential explanations (all of which require careful research) include the following:

(i) In districts where procurement is low, market prices are above MSP such that it is not in the farmer's interest to sell to the government.

(ii) Output per person is relatively low in districts where procurement is low, indicating that low procurement reflects low marketable surplus. In other words, a larger fraction of production is used for self-consumption.

(iii) Variations in procurement could also reflect variations in the nodal procurement agencies. While the Food Corporation of India (FCI) is the principal storage and distribution agency for foodgrains, a substantial portion of the actual physical procurement is done by state agencies on behalf of the FCI. All procurement agencies—whether the FCI or state agencies—face resource constraints. However, since they must procure a target amount of grains for the PDS, they are likely to deploy limited resources efficiently by mobilizing them in spatially concentrated, high-productivity districts.

(iv) Procurement of grains can also be used by politicians to selectively channel resources towards their constituencies (or away from their rivals' constituencies) and thereby reward or penalize sections of the electorate. For instance, if the local politician is from the ruling party at the center, then he can potentially influence the FCI on the location and number of purchase centres or, if from the ruling party in the state, the state procurement agencies.

The first and second explanations are in line with government-mandated policies. The last two, however, can have important welfare and policy implications. If we regress fraction of output procured in each district on log yields and log population, we indeed find support for (ii) and (iii) (see Table 7). Districts with larger populations have relatively lower procurement, and districts with higher productivity have relatively greater procurement. Nonetheless, these regressions can only explain about 30 per cent of the cross-sectional variation in procurement, which leaves much scope for future research.

[INSERT TABLE 7 HERE]

4. Political Economy Puzzles

Historically, India has been seen as a rural society, with farming the dominant occupation and economic mainstay for the vast majority of the population. In the 1950s, agriculture accounted for more than half of India's gross domestic product (GDP) and cultivators accounted for half of the workforce. Since then, agriculture's share of GDP had declined by two-thirds (to about 16 percent), while the percentage of cultivators in the workforce has declined from nearly 50 percent in 1951 to 24 percent in 2011. Nonetheless, the absolute numbers are very large (118.6 million as per the 2011 Census), and if we add agriculture laborers (who account for 30 percent of the labor force—144 million in 2011), the two still constitute more than half of India's labor force. Furthermore, as per National Sample Survey (NSS) data (70th round), during the agricultural year July 2012–June 2013, rural India had an estimated total of 90.2 million agricultural households, which constituted about 57.8 per cent of all rural households and 37 per cent of all households. In a democracy, these massive numbers suggest that farmers should be a potent political force. But their economic travails suggest otherwise. Why have Indian farmers not leveraged their sheer numbers into pressuring governments to undertakes policies and programs that benefit them more?

An obvious counter to this question is that farmers do enjoy substantial political influence. Many of India's agriculture policies are in place precisely because of farmers' political clout. Subsidies on inputs—whether electricity, water, fertilizer or credit—or on outputs (especially price supports) are in place precisely because farmers matter politically. While there are many questions on the incidence and distributional impact of these subsidies, the reality that the vast majority of Indian farmers have low and volatile incomes is not in doubt. And yet, the reality is that famers' movements were much more politically salient in the 1970s and 1980s than in the last two decades.

In the early decades following India's independence, the Indian state enjoyed substantial autonomy from powerful rural interests, which, while they could thwart rural programs (such as land reforms or community development programs), had weak impact on agriculture policies and programs. This changed dramatically after the Green Revolution. Initially there were fears that the Green Revolution would "turn red", based on apprehensions that the gains would accrue disproportionally to large farmers, widening the gap with marginal farmers and landless laborers (Frankel, 1978). Instead, as the Green Revolution empowered the landed peasantry (owner-cultivators—so-called "bullock capitalists"), the focus shifted to rural farmer-led "demand groups" that had become an important political constituency shaping public spending on agriculture subsidies and pitting rural India against urban India (Rudolph & Rudolph, 1987). The "Bharat versus India" tension was especially manifest in pressures for higher MSPs, since these benefited producers (farmers) at the expense of consumers (or the public exchequer if consumer subsidies rose). This drove farmer movements to demand higher support prices (Varshney, 1995), but since then they have waned. This is even more puzzling since the 1990s saw marked growth in regional parties dominated by farmers. Why?

At one level, we should not expect agriculturists to be a cohesive force. As Olson (1965) has famously argued, large and dispersed groups are hard to organize anywhere. And, given the fragmented nature of Indian society, they are more susceptible to cross-cutting religious, caste and ethnic/linguistic appeals. But three developments of the 1990s appear to have further weakened collective action by farmers. The salient political issues of the 1990s, "Mandal and Masjid"—the implementation of reservations under the Mandal Report in 1990 and the subsequent Ayodhya agitation—crowded out agricultural issues. But since most farmers are Hindus, religious fault lines are unlikely to be an important source of cleavages within the farming community. On the other hand, with 45 per cent of agricultural households belonged to Other Backward Classes (OBCs), 16 per cent to Scheduled Castes (SCs) and 13 per cent to Scheduled Tribes (STs), with the rest upper and dominant castes, the sharpening post-Mandal caste cleavages may have caused the glue of common economic interests to come unstuck. A second possibility is the 73rd Amendment to the Indian Constitution, which made statutory provisions for the Panchayat Raj as the third level of administration in villages. This was a much-needed effort at administrative decentralization. But by mandating elections at the base of rural society (villages), it appears to have shifted political energies inwards—in the form of electoral competition within villages to capture increasing resources coming to villages—and thereby diluted efforts to project collecting farming interests outwards and upwards.

These factors, however, only explain the demand side of the story. They do not explain why politicians have been willing to spend vast resources and efforts on programs aimed at rural India for which there was pressure from civil society groups but little from rural voters (e.g., NREGA), while remaining unwilling to commit resources and efforts to improving farmer productivity and incomes, whether through rural markets, agriculture research and extension or better credit and irrigation systems.

Under the Indian Constitution, agriculture is a state subject. One might therefore expect considerable inter-state variation in agriculture policies stemming from differences in the politics and political economies of states. But, in fact, differences in the policy approaches of politicians across states in agriculture—be it taxes, subsidies or trade laws—are quite limited. Why?

To take one example: reforms to the Agricultural Produce Marketing Committee (APMC) Act. In 2003, recognizing that the role of the APMCs and the state agriculture marketing boards needed to change from market regulation to market development, which required removing trade barriers and creating a common market, the central government formulated a model APMC Act for adoption by the states.

The reality of the reforms carried out by the different states paint a different picture. Maharashtra, for example, went back on the reforms soon after they were announced.[4] U.P. has not yet adopted any of the main features of the model APMC act excepting giving permission to some big players for direct procurement of food grains (primarily wheat), on condition that total procurement in a season should exceed 50,000 tons. Crucially, this notification is issued year to year and no changes have been made in the legislation, thereby ensuring little private investment (and possibly annual rents). In other states, by putting in large up-front license fees to set up new markets or insisting that traders outside the market still pay market fees, the reforms have been effectively stymied. Even when licenses are awarded, they are for selected crops. For example, in Karnataka, of the 36 licenses awarded at the time of writing, all were either for cotton or fruits and vegetables.[5]

There are two plausible explanations for the limited inter-state variation in agriculture policies. First, multiple interventions by the Center on different issues have important consequences for agriculture. The National Food Security Act, 2013, for instance, mandated legal entitlements for existing food

[4] http://tinyurl.com/maharashtra-apmc-reform

[5] Data based on interviews with Karnataka state government officials by authors.

security programmes at a fixed price for specific foodgrains. Inevitably this sets certain structural incentives for states' own procurement efforts and thereby farmers' crop choices, with cascading effects on ecologically sustainable agriculture practices. A second reason might stem from certain common features of agriculture markets across rural India, namely the layer of intermediaries constituting the trading-cum-moneylending classes. The persistence of interlinked markets in credit and outputs enhances the bargaining power of these intermediaries vis-à-vis farmers, as well as gives them more influence in local politics, thereby making it easier to undermine reform efforts.

5. The Trade Puzzle

One of India's scarcest natural resources is water. Figure 6 provides an international comparison of availability of fresh water resources. The scarcity of fresh water in India is much worse than what is depicted in the picture since Brazil and China use only 60 per cent of their stock of fresh water availability, while India uses a little over 90 per cent. In an era of globalization, as the Hecksher-Ohlin trade model would also predict, India should produce relatively more of the commodities that use its scarce natural resources less intensively and export them. And it should produce relatively less and import commodities whose production requires intense use of its scarce resources.

[INSERT FIGURE 6 HERE: Per Capita Availability of Renewable Freshwater Resources]

In aggregate, India's production patterns are the converse. Hoekstra and Mekonnen (2012) compute the water footprint (amount of water used for production) of crop production around the world from 1996–2005. Not only is India's water footprint the highest (followed by China and Brazil), but also, at 1047 cu Gm per year, it is thrice that of Brazil (329 cu Gm per year), despite India having fewer water resources than other countries to begin with. Furthermore, India's production technology and crop choice amplifies the amount of water it uses for production. This can also be seen in Figure 7. Further, among all global provinces or states, the water footprint is highest for U.P., Maharashtra, Karnataka, Andhra Pradesh and Madhya Pradesh. This to some extent reflects the large size of these provinces. Within India, per 5 arc minute by 5 arc minute grid cell, the water footprint is the highest in the Punjab-Haryana region, as can been seen in Figure 8.

[INSERT FIGURE 7 HERE: Water Footprint of Agricultural Production]

[INSERT FIGURE 8 HERE: Water Footprint of Agricultural Production in India]

To understand the trade patterns of water, Goswami and Nishad (2015) estimate water content embedded in crops at the time of trade. This is different from water used in production, which is much higher and actually partially recoverable. Water "embedded" in crops, on the other hand, is the water content of each crop which, once the crop is exported, cannot be recovered. In 2010, India exported about 25 cu km of water embedded in its agricultural exports. This is equivalent to the demand of nearly 13 million people. India was a net importer of water until the 1980s. With increasing food grain exports, India has now become a net exporter of water—exporting about 1 per cent of its total available water every year. The ratio of export to import of virtual water is about 4 for India and 0.1 for China. Thus, China remains a net importer of water.

What might have led to this trading pattern? India's major agriculture exports (by weight or value) are rice and wheat. India exported 11.9 million tons of paddy and 2.9 million tons of wheat in the year 2014–15. In the same year, India's major agriculture import was 4.6 million tons of pulses and 11.5 million tons of edible oils. This pattern has been consistent in the last two decades, ever since the country became self-sufficient in rice and wheat. Since the water content by weight of paddy and wheat is 15 per cent whereas that of pulses is 10.5 per cent, India's agriculture trade has become a net exporter of water, even as domestic water supplies dwindle.[6]

Thus, India's trade pattern reveals that it is massively over-producing rice and under-producing pulses. The root cause is the distorted relative prices of paddy and pulses—which in this case operates through the MSP. Free (or underpriced) water for irrigation, coupled with a guaranteed MSP for paddy and wheat, incentivizes farmers to overproduce these crops. India's water exports rapidly increased around 1990, coinciding with sharp increases in the MSPs for paddy and wheat (Goswami & Nishad, 2015). If prices were to reflect market demand and incorporate the social externalities of water, India's trade pattern in food commodities would reflect the relative scarcities of its natural endowments. If we look at China for example, which is also a water-scarce country, major imports are soybeans, cotton, meat and cereal grains[7] and exports are vegetables, fruits and processed food.

The pernicious consequences of India's MSP policy for water sustainability and availability have been evident for a while, as water tables decline across the country. Policies meant to help farmers in the short-run, such as the MSP for wheat and rice, are having deeply negative long-term consequences for the same farmers, due to the shrinking availability of water. One can argue that both farmers and politicians have high discount rates and are myopic. Hence they cannot internalize the devastating effects in the long-run and consequently persist with the current MSP policy. Furthermore, even if this were not the case, high switching costs (from more water-intensive crops to less water-intensive crops) may make them loath to advocate a change in MSP policies. But such an equilibrium persisted for many years in the case of fuel subsidies, and it was eventually addressed by incremental increases in price over a protracted period of time. It is unclear why something similar has not happened in the case

[6] The water footprint (water required for production) is much higher for pulses (5354 m^3 per ton) than paddy (~3000 m^3 per ton). But much of this water is recoverable. In addition, water used for the production of pulses does not use flood irrigation (unlike rice) and comes from closer to the top soil, thereby protecting the water table. The production of pulses also helps fix nitrogen (thereby reducing the consumption of urea). More importantly, the water content in the final grain is 10.5 per cent of the weight in pulses, compared to 15 per cent in paddy and wheat.

[7] http://www.ers.usda.gov/media/1784488/eib136.pdf and http://www.fao.org/fileadmin/templates/est/meetings/wto_comm/Trade_policy_brief_China_final.pdf

of MSP policies, with annual increases in MSP inversely proportional to the water intensity of the crop, e.g., modest increases in MSP for paddy and sugarcane and more rapid increases in MSP for pulses and oilseeds.

6. The Productivity Gap Puzzle

Geography, availability of natural resources and endowment of fertile soil make Punjab, Haryana and the flood plains of the Indo-Gangetic plain one of the most fertile lands in the world. This can be easily seen in Figures 9 and 10. However, comparing the actual productivity of land in this belt to its own potential raises several interesting questions.

[INSERT FIGURE 9 HERE: Paddy Yields]

[INSERT FIGURE 10 HERE: Wheat Yields]

The Food and Agriculture Organization's Global Agro-Ecological Zones (GAEZ) dataset provides data on actual agricultural productivity on any piece of land as well as the potential productivity that could be realized if inputs were used optimally, conditional on the crop that is being currently grown there. The data is available for every 5 arc minute by 5 arc minute grid cell of the earth, roughly equal to 10 km by 10km blocks.

Therefore, if a district in Punjab and another in Eastern U.P. grow paddy, we can estimate their current and potential productivity. Since the potential productivity takes into account the crop choice and local agro-environmental conditions, the gap between actual and potential productivity should only be due to spatially specific distortions. In other words, in absence of local distortions, all districts should produce at their true potential and there should be no difference between the actual realized and potential productivity.

The data tells us that this is not the case. Table 8 notes the fraction of all districts (in %) whose productivity gap is less than 10 per cent, 25 per cent, 50 per cent and more than 80 per cent. Productivity gap is calculated as (1-actual/potential) x 100. Greater fraction of districts in the $< 10\%$ column implies that greater fractions are close to their true potential.

[INSERT TABLE 8 HERE]

There are about 27 per cent paddy-producing districts and 39 per cent wheat-producing districts whose productivity gap is less than 25 percent. Similarly, there are about 5 per cent paddy-producing districts and 6 per cent wheat-producing districts which have a productivity gap of more than 80 per cent. These are districts with potential for huge gains. Comparing across crops, whereas in paddy and wheat about 18 per cent and 32 per cent, respectively, of all districts operate within 10 per cent of their potential, this number is starkly low for sorghum (4.2 per cent), a dryland crop.

Essentially Punjab, Haryana and parts of U.P. are operating close to their potential. These are also the regions which predominate in paddy and wheat production. In other parts of country, farms are operating far from their own potential and there is substantial scope for improvement by better resource allocation alone.

The evidence also strongly suggests that the use of inputs is distorted. Table 9 provide evidence on inter-state variation in the use of nitrogen, phosphorous and potash per hectare. The proportions in which the fertilizers are used are also skewed. A lower absolute consumption does not necessarily imply that fertilizer use is sub-optimal. The proportions also need to be balanced. While the correct proportions are context-specific, measuring deviations from the accepted rule of thumb of N:P:K in the ratio of 4:2:1 is revealing.

Table 9 also presents deviations from the optimal N:P and N:K ratios (with respect to N). It is clear that fertilizer use is disproportionately tilted toward use of urea (principal source of N) as compared to other fertilizers. These distortions—more in N:K than N:P, indicating extremely low application of potash—are significantly higher as compared to China, Bangladesh, Vietnam and Thailand.

Most states use almost twice more nitrogen as compared to phosphorous than they should. These include the most productive states like Punjab, Haryana, U.P. and Gujarat. The distortions are less in Maharashtra, Karnataka and Kerala, which consume close to the optimal ratio, although this could simply be the result of different crop mixes. The overuse of urea as compared to potash is even more perverse. While Bangladesh uses only 4 per cent more urea than potash, Indian states like Punjab and Haryana use over 1300 per cent urea as compared to potash.

Understanding the reason for such large distortions in fertilizer use is important, not only because of its impact on variations in current productivity but also on future productivity due to the long-term effects on soil quality.

[INSERT TABLE 9 HERE]

7. The Exit Puzzle

Adamopoulos and Restuccia (2014) document that the typical farm size in the 20 richest countries is 34 times greater than that in the 20 poorest countries. In hectares, the average farm size in rich countries in 54 hectares and in poor countries only 1.6 hectares. The median farm size in India is 1.5 hectares, while the mean is much lower. Diego Restuccia, in a series of papers with different coauthors, has estimated gains of approximately 3 to 4 times in productivity if land is reallocated to the most productive farmers in developing counties like Malawi, Ethiopia and China.[8]

A critical reason for the underlying misallocation of land is distortions in land markets. Agricultural land in India is a peculiar asset. Its rental value for farming purposes (a proxy for farming income that may be derived from it) is a fraction of a risk-free stream of income that would accrue from its sale (i.e., its capital value), which in turn is a fraction of the price if it is converted to non-agricultural land (for commercial use) if in proximity to an urban area. Yet farmers are reluctant to sell their land. Understanding the effects of these distortions in land markets on agriculture productivity and the reasons why farmers seem reluctant to follow economic logic are two fruitful areas for further research.

There are several potential reasons why agriculturalists may not be exiting farming. One, there might be high opportunity costs of exiting. Figure 11 shows that this is not likely to be the case. Our analysis of NSS data finds that the average annual income from cultivation of the median farmer (net of production costs) is less that Rs. 20,000 in 17 states. This includes produce that farmers did not sell valued at local market prices. Given high wedges between retail and farm gate price, this might underestimate income, but it is still very low. Some farmers who own cattle, for example, might substitute this income with allied-agriculture income. Even then, a vast majority of farmers live very close to the poverty line.

[INSERT FIGURE 11 HERE: Net Annual Income of Indian Farmers]

A second—and perhaps key—factor may be the paucity of other livelihood options. India's failure to industrialize has meant that the classic ladder of occupational mobility—from farms to factories, as has been the case with China—has been foreclosed, leaving low-end service jobs in severe urban environments or modest self-employment opportunities as the only options facing someone who were to

[8] For a comprehensive survey, see Restuccia (2016).

exit farming. With 72 per cent of India's farms below 1 hectare, the investments required to increase productivity in these tiny farms are unlikely to be more forthcoming. Exit would allow for land consolidation, and increases in farm size would in turn allow for more investments and productivity. But that requires the sort of labor-intensive manufacturing growth that has simply not been taking place. Research on rural-urban linkages in factor and product markets is needed to improve our understanding of its effects on farm productivity.

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Table 1: Percentage of cereal output by farm size sold to various actors

Paddy

Farm Size	Local Private	Mandi	Government	Input Dealers	Processors
0-2ha	55.44	20.19	11.17	8.72	1.62
2-5ha	41.89	28.92	5.54	19.44	2.44
5-10ha	29.58	34.77	6.52	27.46	0.51
>10ha	14.15	50.43	3.76	15.38	0.65

Wheat

Farm Size	Local Private	Mandi	Government	Input Dealers	Processors
0-2ha	41.40	38.71	11.01	8.1	0.14
2-5ha	25.23	49.97	5.02	19.42	0.24
5-10ha	16.68	45.68	7.36	29.8	0.3
>10ha	6.07	40.45	1.67	51.77	0.08

Source: NSS Situation Assessment Survey of Agricultural Households (2012)

Table 2: Price Variation between Mandis in commodities

		Monthly avg std dev
Full Sample	All commodities	0.17
	Paddy	0.22
	No Basmati/Superfine	0.21
	Wheat	0.13
	All other	0.17
Trimmed Sample	All commodities	0.16
	Paddy	0.21
	Wheat	0.13
	Soyabean	0.07
	Sorgham	0.28
	All other	0.16

Note: The trimmed sample drops the top 5th percentile of the sample in terms of prices.
Source: Authors' Calculations from Agmarket Data.

Table 3: Spatial price variation in commodities over time.

	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Barley	0.11	0.14	0.11	0.12	0.16	0.16	0.16	0.11	0.11	0.11
Millets	0.19	0.16	0.17	0.18	0.20	0.17	0.17	0.16	0.18	0.20
Maize	0.17	0.17	0.15	0.14	0.16	0.13	0.14	0.15	0.16	0.16
Paddy	0.18	0.19	0.22	0.23	0.23	0.22	0.19	0.20	0.24	0.21
Soyabean	0.06	0.06	0.06	0.06	0.09	0.05	0.06	0.09	0.06	0.09
Sorgham	0.25	0.25	0.27	0.25	0.27	0.31	0.38	0.29	0.24	0.32
Wheat	0.14	0.15	0.14	0.11	0.12	0.13	0.14	0.12	0.13	0.12

Source: Authors' Calculations from Agmarket Data.

Table 4: Variation in Real Prices within States in 2014

State	Standard Deviation
Andhra Pradesh	0.15
Chattisgarh	0.13
Gujarat	0.14
Haryana	0.13
Jharkhand	0.14
Karnataka	0.18
Kerala	0.17
Madhya Pradesh	0.21
Maharashtra	0.16
Odisha	0.70
Punjab	0.26
Rajasthan	0.14
Tamil Nadu	0.21
Uttar Pradesh	0.11

Source: Authors' Calculations from Agmarket Data.

Table 5: Production and Procurement of Rice

State	Production (in million tonnes)		Procurement by FCI and State Agencies (in million tonnes)		% of all India procurement	Procurement as a % of total production
	2013-14	2014-15	2013-14	2014-15		
A.P.	6.97	7.23	3.737	3.596	11.65	51.63
Bihar	5.51	6.36	0.942	1.614	4.06	21.55
Chattisgarh	6.72	6.32	4.29	3.423	12.26	59.16
Gujarat	1.64	1.83	0	0	0.00	0.00
Haryana	4.00	4.01	2.406	2.015	7.03	55.23
Jharkhand	2.81	3.36	0	0.006	0.01	0.10
Karnataka	3.57	3.54	0	0.088	0.14	1.24
Kerala	0.51	0.56	0.359	0.374	1.16	68.42
M.P.	2.84	3.63	1.045	0.807	2.94	28.62
Maharashtra	3.12	2.95	0.161	0.1988	0.57	5.93
Odisha	7.61	8.30	2.801	3.357	9.79	38.70
Punjab	11.27	11.11	8.106	7.786	25.26	71.03
Rajasthan	0.31	0.37	0	0	0.00	0.00
Tamil Nadu	5.35	5.73	0.684	1.051	2.76	15.66
Telangana	5.75	4.44	4.353	3.504	12.49	77.06
U.P.	14.64	12.17	1.127	1.698	4.49	10.54
West Bengal	15.37	14.68	1.359	2.032	5.39	11.29

Source: Ministry of Agriculture and Farmer Welfare, Government of India.

Table 6: Production and Procurement of Wheat

State	Production (in lakh tonnes)		Procurement by FCI and State Agencies (in lakh tonnes)		% of All India Procurement	Procurement as a percentage of Total Production
	2013-14	2014-15	2013-14	2014-15		
Andhra Pradesh	0.04	0	0	0	0.00	0.00
Bihar	47.38	39.87	0	0	0.00	0.00
Chattisgarh	1.34	1.35	0	0	0.00	0.00
Gujarat	46.94	30.59	0	0	0.00	0.00
Haryana	118.00	103.54	58.73	6.50	23.29	55.8
Jharkhand	3.70	3.30	0	0	0.00	0.00
Karnataka	2.10	2.61	0	0	0.00	0.00
Madhya Pradesh	129.37	171.04	63.55	70.94	25.33	44.8
Maharashtra	16.02	13.08	0	0	0.00	0.00
Odisha	0.01	0.006	0	0	0.00	0.00
Punjab	176.20	150.50	108.97	116.41	42.45	69.0
Rajasthan	86.63	98.24	12.70	21.59	6.46	18.5
Telangana	0	0.07	0	0	0.00	0.00
Uttar Pradesh	298.91	224.17	6.82	6.28	2.47	2.5

Source: Ministry of Agriculture and Farmer Welfare, Government of India.

Table 7: Regression Table

	Dep var: fraction of output procured	
Log yield	28.40	32.22
	(2.68)***	(5.58)***
Log population	-16.69	-20.78
	(1.40)***	(2.76)***
N	445	188
R2	0.32	0.35
Crop	Rice	Wheat

Notes: all observations are district averages between 2011-2014. District population is from 2011 census of India. Crops include paddy and wheat. * $p<0.1$, ** $p<0.05$, *** $p<0.01$.

Table 8: Distribution of productivity gap of Indian districts

	<10%	<25%	<50%	>90%
Rice	18.5%	27.3%	62.6%	5.1%
Wheat	31.9%	38.6%	80.9%	5.7%
Sorghum	4.2%	5.0%	6.7%	79.5%
Millet	30.5%	31.5%	34.4%	2.9%

% of districts within x% of their potential.

Source: FAO Global Agro-Ecological Zones Database.

Table 9: Fertilizer Consumption and Distortion, 2014

	N (kg/ha)	P (kg/ha)	K (kg/ha)	Total	NP distortion	NK distortion
Delhi	93.33	0	0	93.33		
Nagaland	2.26	1.48	0.72	4.45	-47%	-22%
Mizoram	30.31	2.37	2.99	35.67	1079%	153%
Meghalaya	10.35	3.07	0.8	14.22	137%	223%
Manipur	22.66	3.75	3.18	29.59	404%	78%
Himachal P.	35.03	8.69	9.03	52.74	203%	-3%
Assam	36.24	9.99	19.19	65.41	163%	-53%
Rajasthan	37.97	11.51	0.21	49.69	130%	4420%
Jharkhand	65.72	13.79	2.94	82.45	277%	459%
Thailand	68.4	19.2	22.5	110.2	156%	-24%
Uttarakhand	118.89	19.24	5.67	143.8	418%	424%
Tripura	28.73	21.27	11.73	61.73	-65%	-39%
J&K	57.83	21.87	9.37	89.07	64%	54%
Odisha	63.05	23.71	11.37	98.13	66%	39%
Gujarat	88.52	24.09	6.92	119.52	167%	220%
US	74.1	24.8	26.7	125.6	99%	-31%
World	69.5	26.3	17.9	113.7	64%	-3%
Kerala	51.06	26.42	43.55	121.03	-7%	-71%
Bihar	124.88	27.44	12.55	164.87	255%	149%
West Bengal	74.09	28.11	28.97	131.17	64%	-36%
Madhya Pradesh	53.76	28.17	2.5	84.43	-9%	438%
Chhattisgarh	63.08	28.72	8.43	100.22	20%	87%
India	85.79	28.85	10.75	125.39	97%	100%
Uttar Pradesh	115.18	29.63	4.06	148.86	189%	609%
Haryana	146.49	30.58	2.41	179.48	279%	1420%
Tamil Nadu	93.27	33.47	27.03	153.76	79%	-14%
Maharashtra	72.41	35.29	19.37	127.07	5%	-7%
Karnataka	78.37	36.67	21.01	136.06	14%	-7%
Punjab	172.55	41.14	3.04	216.73	219%	1319%
Brazil	42.6	48.8	56.1	147.5	-113%	-81%
Bangladesh	140.7	53.9	33.9	228.5	61%	4%
Andhra Pradesh	153.55	54.32	18.85	226.72	83%	104%
Vietnam	127.5	66.7	43.1	237.3	-9%	-26%
China	267.6	91	41.2	399.8	94%	62%

Source: Agricultural Statistics at a Glance, 2014, Ministry of Agriculture, Govt. of India.

Figure 1: Spatial Variation in Mandi prices

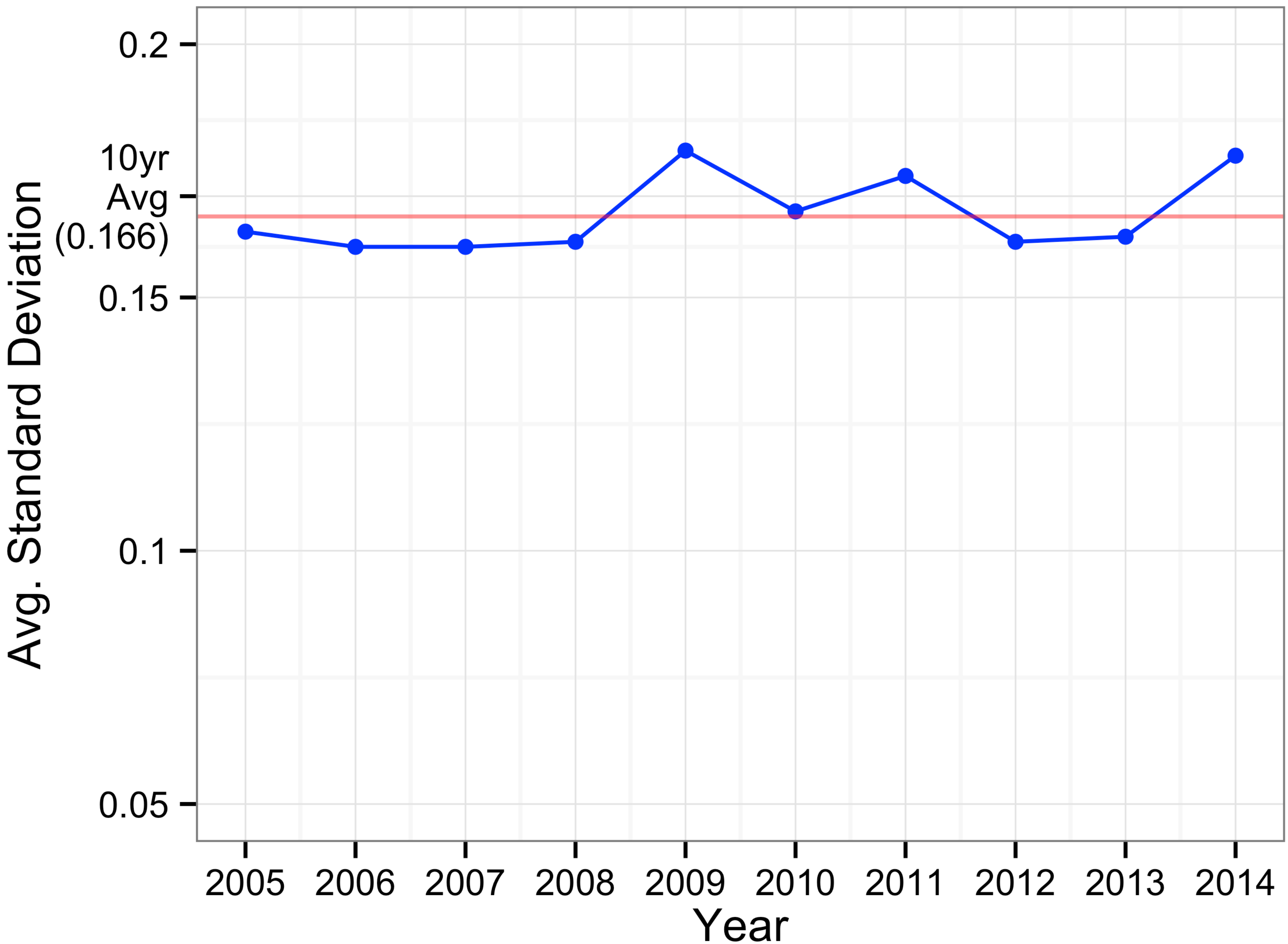
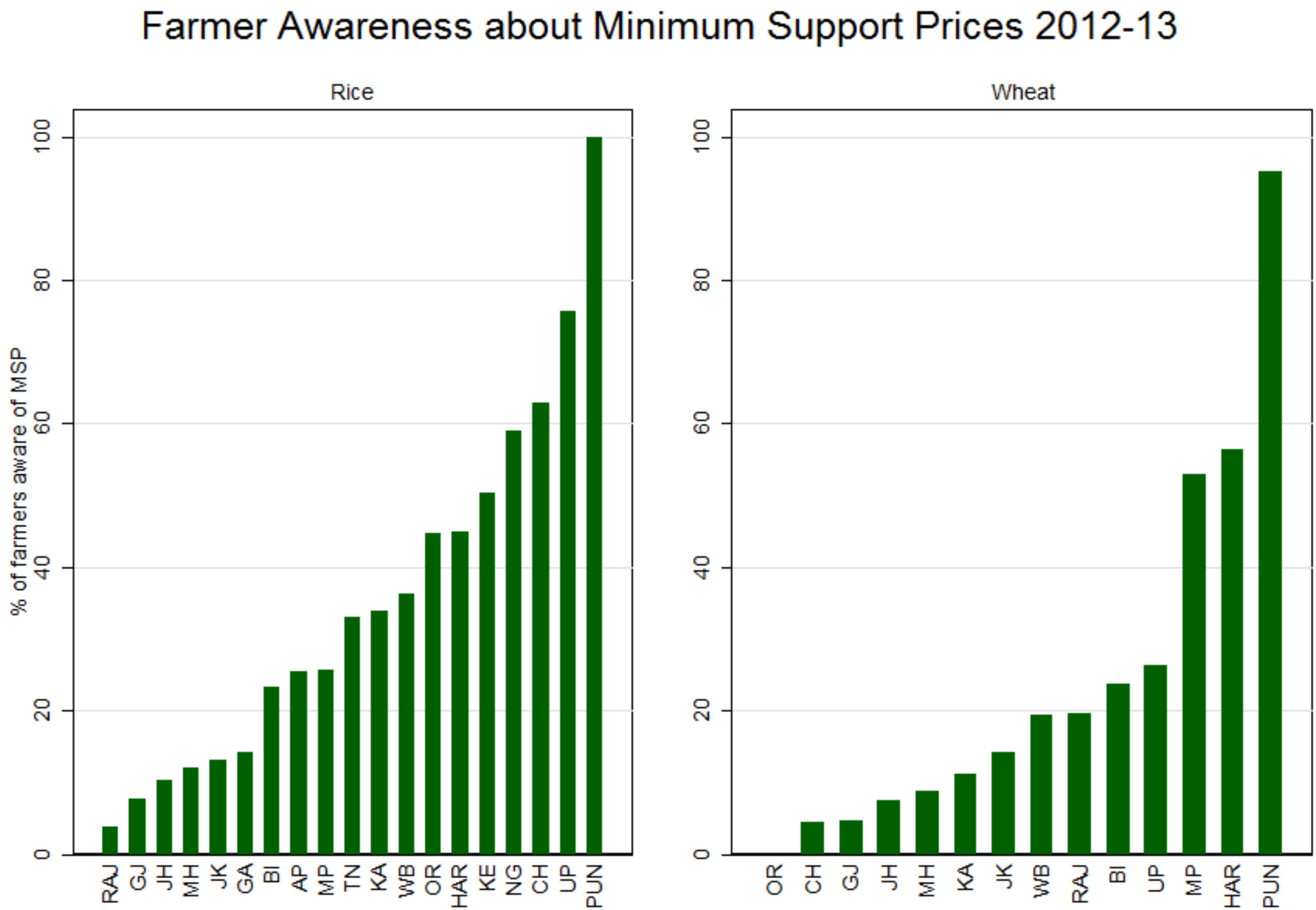
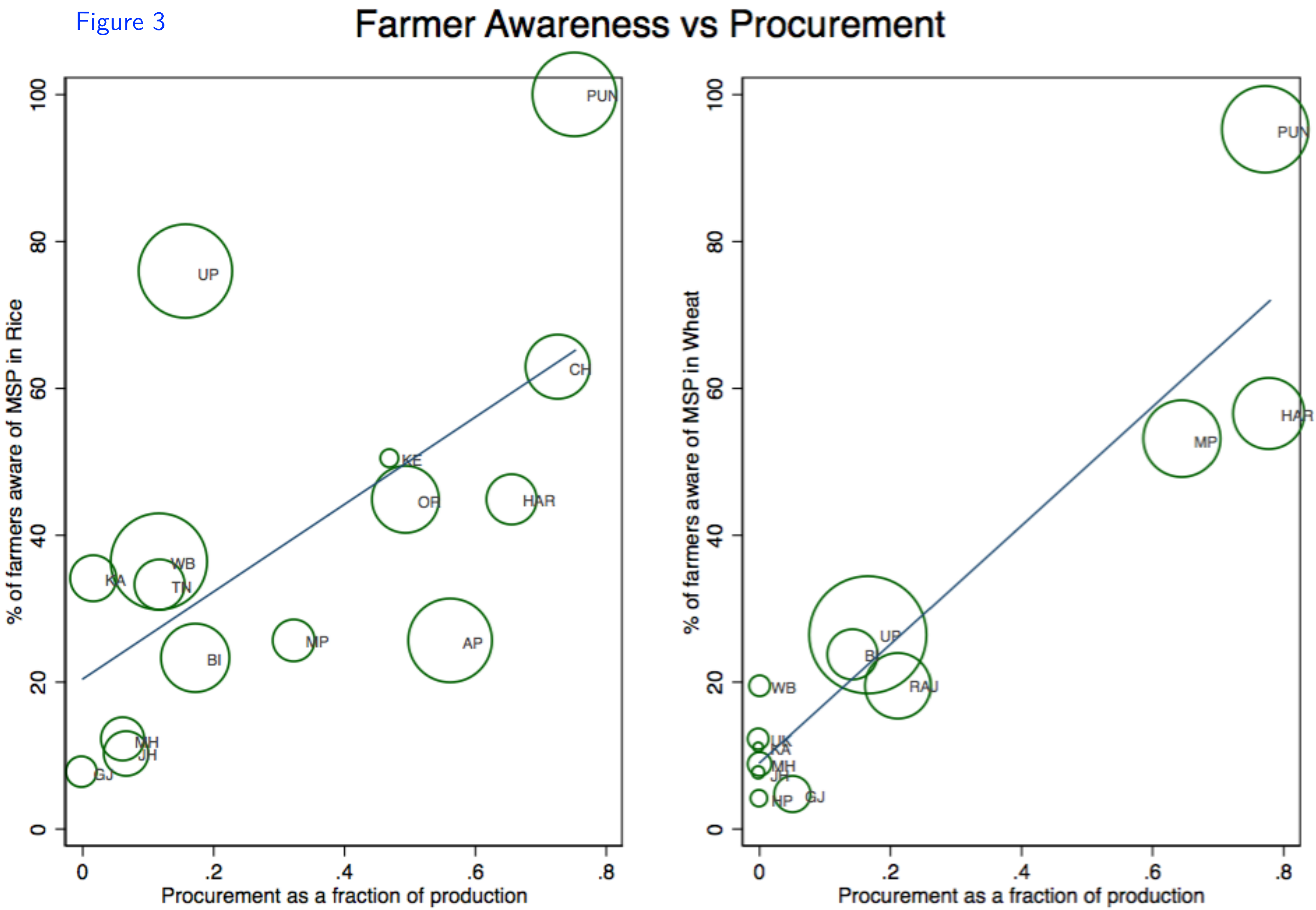


Figure 2



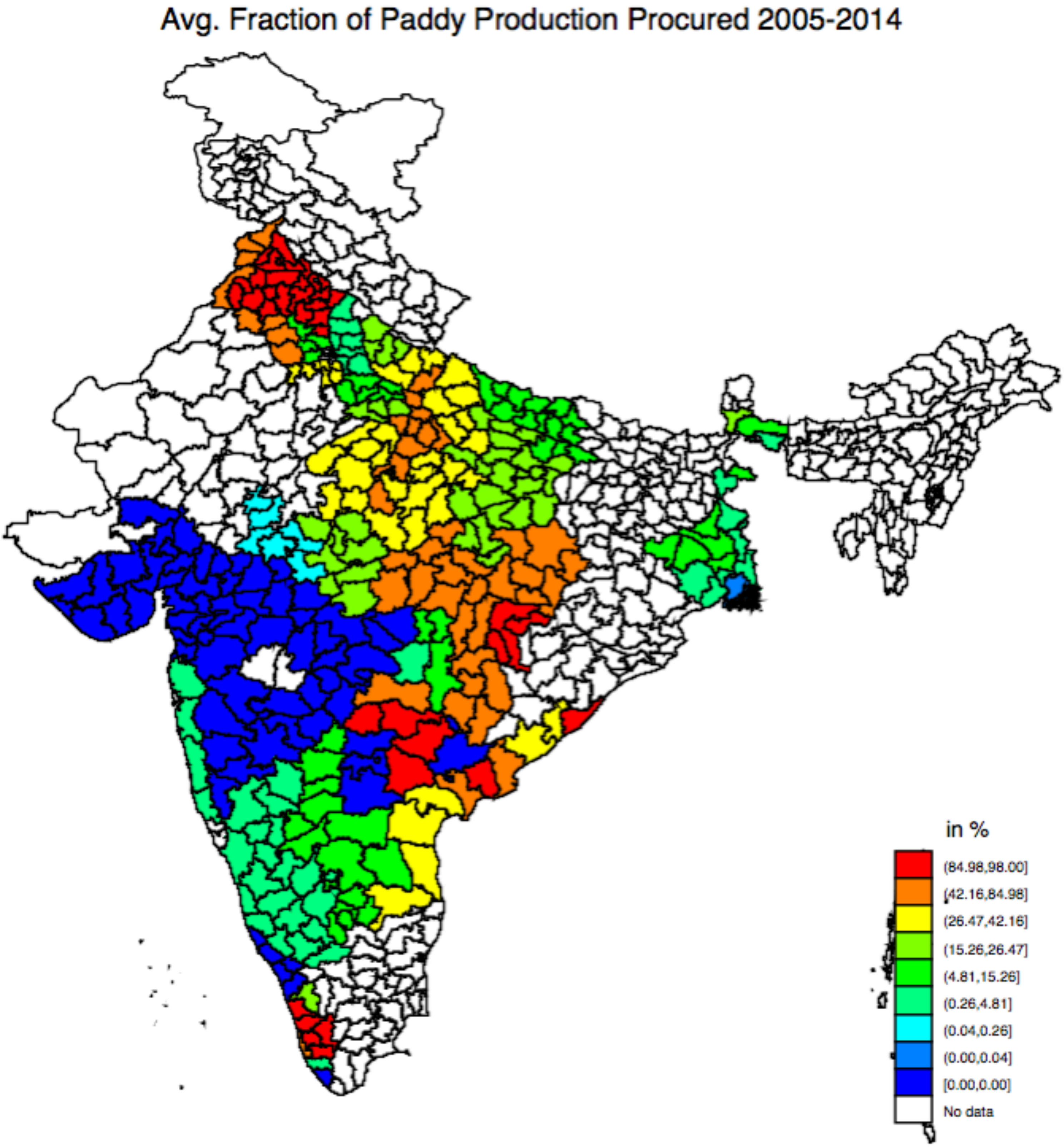
Source: NSS Situation Assessment Survey of Agricultural Households Round 70

Figure 3



Source: NSS-SAS(2012). Size of bubble represent shares in national output.

Figure 4



Avg. Fraction of Paddy Production Procured 2005-2014
in %
(84.98,98.00]
(42.16,84.98]
(26.47,42.16]
(15.26,26.47]
(4.81,15.26]
(0.26,4.81]
(0.04,0.26]
(0.00,0.04]
[0.00,0.00]
No data

Figure 5: Avg Fraction of Wheat Production Procured

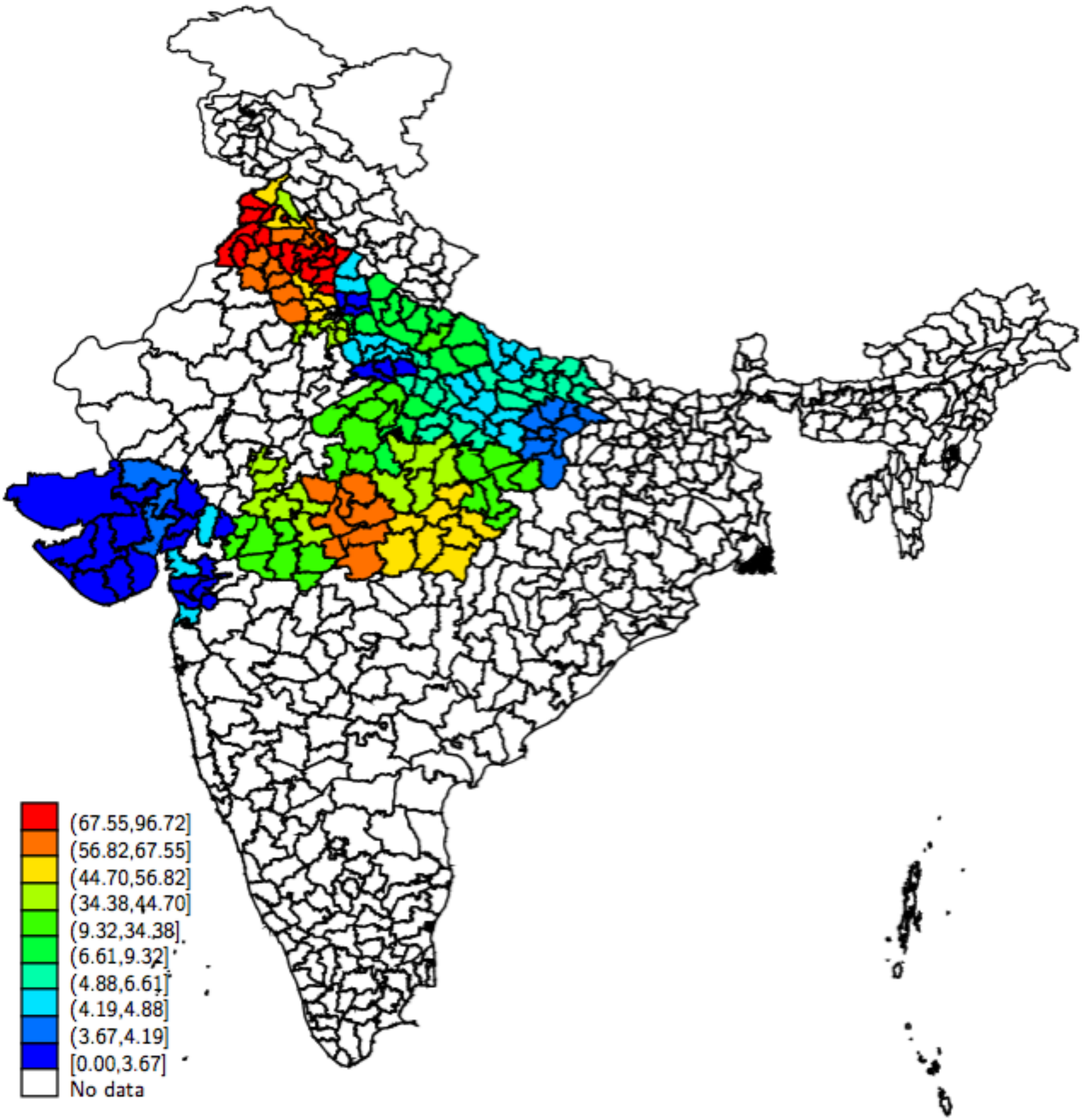
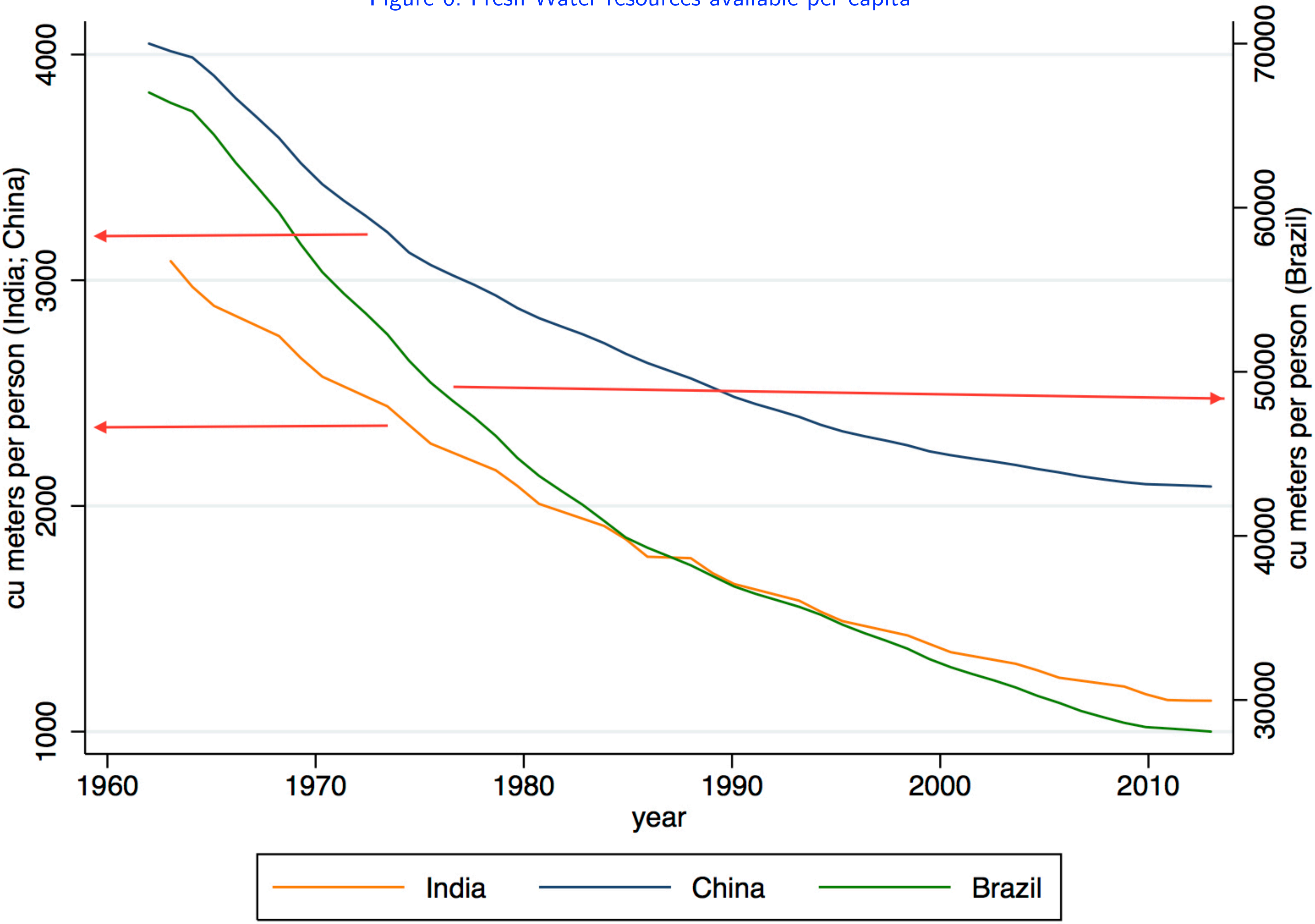


Figure 6: Fresh Water resources available per capita



Note: Read India, China off left y–axis and Brazil off right y–axis. Source:FAOSTAT, http://faostat3.fao.org/

Figure 7: Water Footprint of Agricultural Production

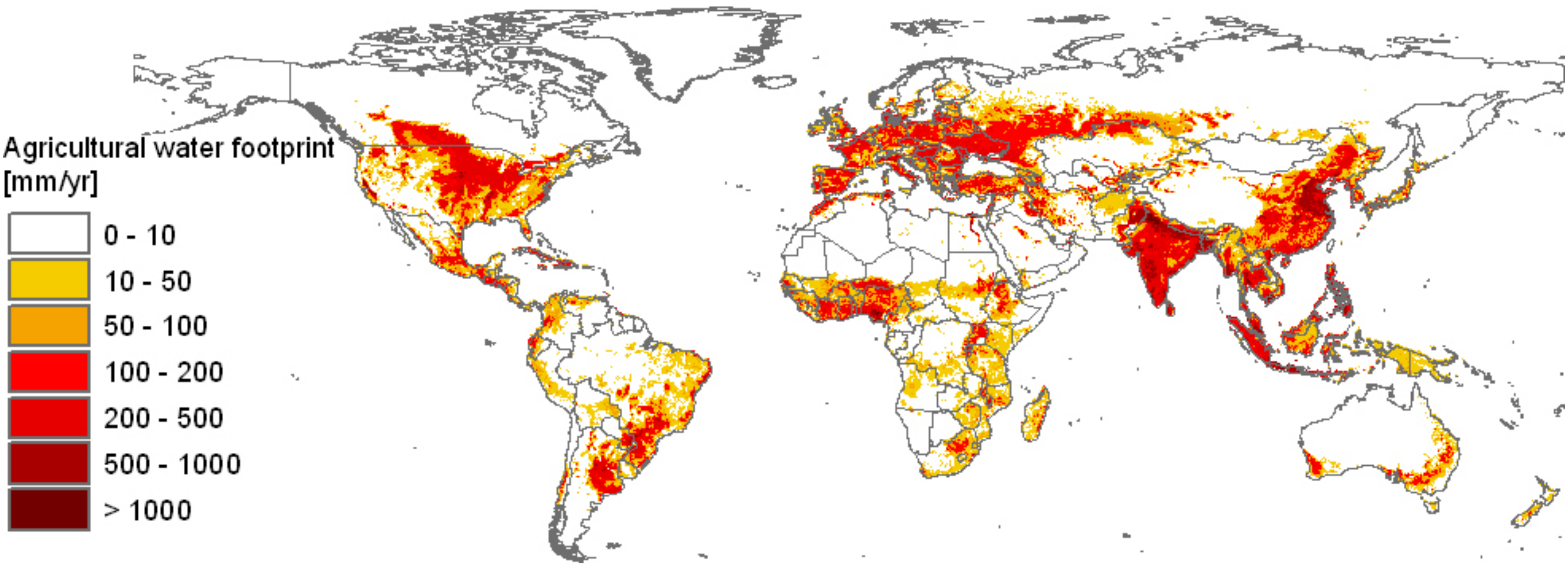
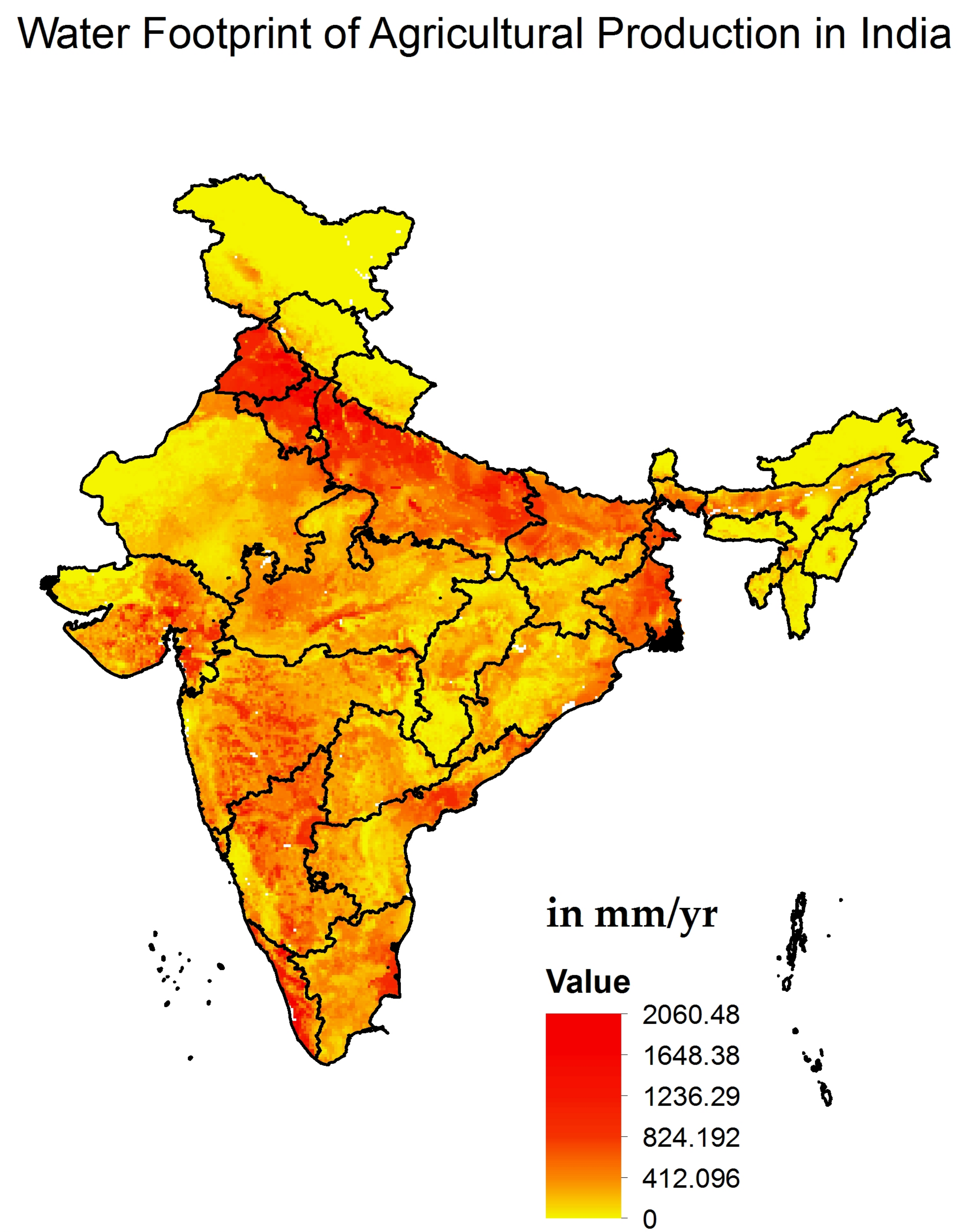
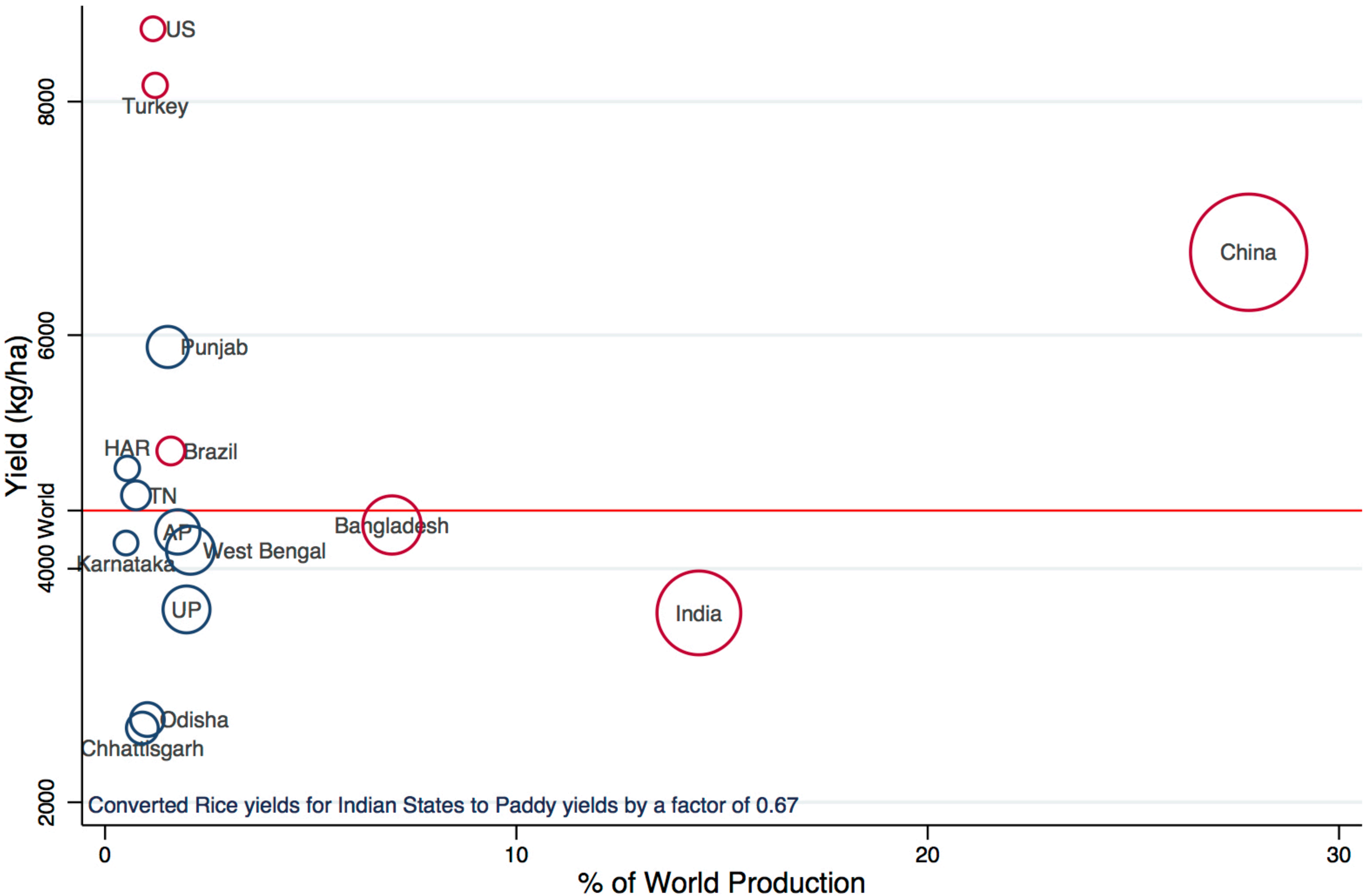


Figure 8



The map reflects water footprint for every 5 arc minute by 5 arc minute surface of the earth.
This is roungly a cell of 100 sq km area.
Source: Hoekstra, A.Y. and Mekonnen, M.M. (2012) 'The water footprint of humanity', PNAS

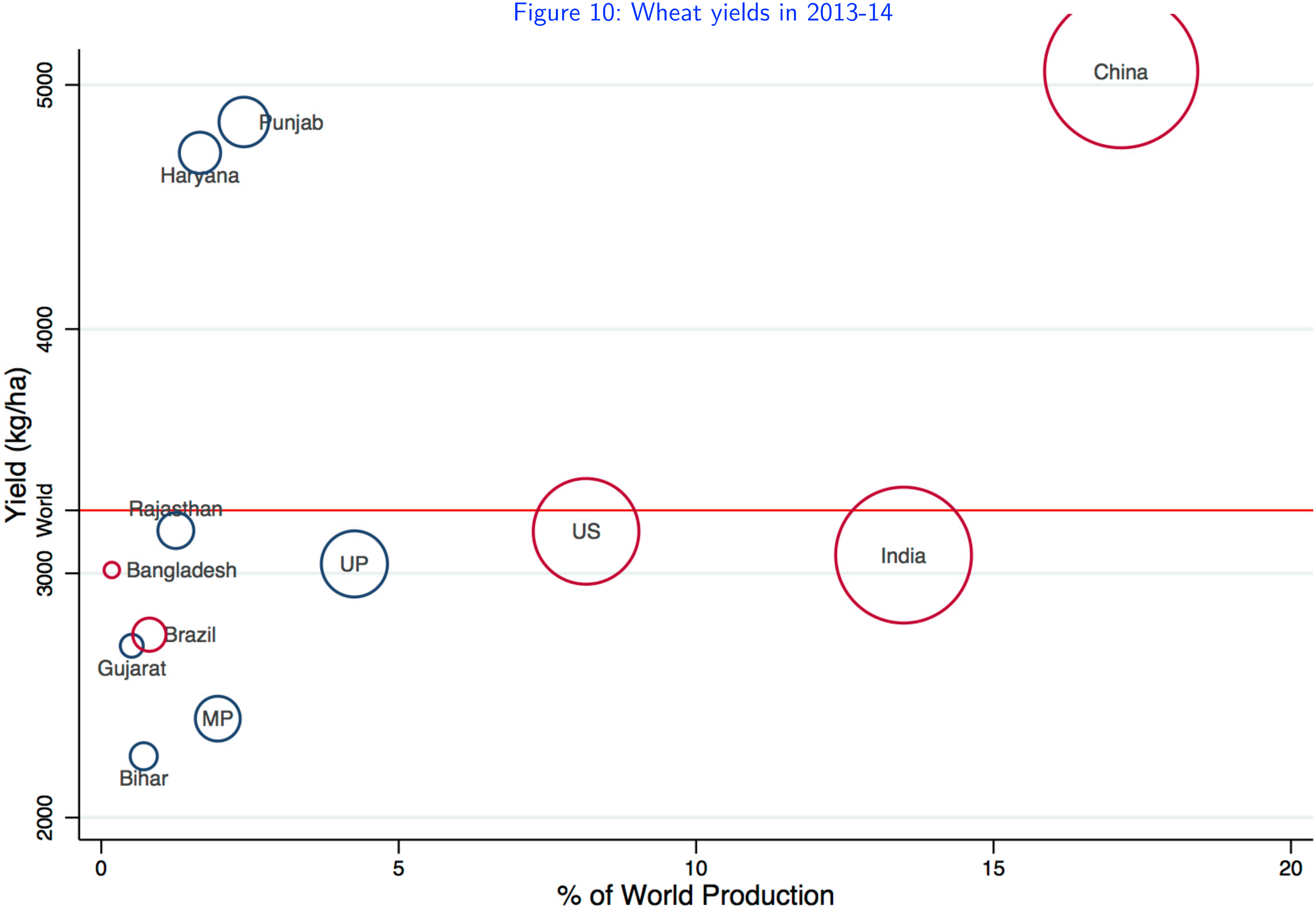
Figure 9: Paddy Yields in 2013-14



Size of the bubbles are proportional to the quantity of total production in the state/country.

Source: FAO stat for the world and Agriculture Statistics at a Glance 2014, GOI for India. All estimates for year 2013–14.

Figure 10: Wheat yields in 2013-14



Size of the bubbles are proportional to the quantity of total production in the state/country.

Source: FAO stat for the world and Agriculture Statistics at a Glance 2014, GOI for India. All estimates for year 2013–14.

Figure 11: Net Annual Farm Income in India.