



Sustainable Approaches to Reducing Food Waste in India

MIT Independent Activities Period Research Project

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February 10, 2012

Introduction

Our team, consisting of Paul Artiuch (MBA '12) and Sam Kornstein (MBA '12), spent five months researching sustainable approaches to reducing agricultural food waste in India. We chose to tackle this issue as we both have an interest in waste reduction and prevention, and saw a significant opportunity in India: reports indicate that as much as 20-40% of the food grown spoils before reaching consumers.

This problem is not unique to India. Many developing countries struggle to modernize and upgrade their agricultural supply chains to match the efficiency of those found in more advanced economies. Poor road quality, unreliable and expensive electricity, insufficient storage capacity, and uncoordinated logistics make it difficult for many countries to avoid food losses between farms and markets. However, we found India's challenges to be particularly interesting for two reasons.

First, with one of the largest agricultural sectors in the world and a population exceeding 1.2 billion people, India's farming output has a meaningful impact on global food-security. While data is difficult to obtain or verify, independent reports suggest that about 7%, or roughly 16-17 million tons of grain go to waste each year.¹ High end estimates reach nearly 55 million tons of waste for food grains alone, although official reports are significantly lower.²³ The truth is somewhere in the middle and even a small improvement could save lives and stabilize food prices in a country that battles chronic mal-nourishment and double-digit food inflation. Many Indian agricultural experts agree that most of the data on agricultural waste is anecdotal, and more comprehensive assessments need to be completed to identify prospective solutions to this enormous challenge.⁵ This trend appears to be changing, as a comprehensive food-waste study, to be completed by the Ministry of Food Processing and McKinsey & Co, was recently launched.⁶

Second, as a result of numerous factors including demographics and legislation that limits farm size to less than 50 acres, India's agricultural sector is surprisingly fragmented when compared to that of other countries.⁷ The average farmer works with just 2-4 acres, and 70% of farmers have less than 1 hectare, or 2.5 acres.⁸ Other supply chain stakeholders including transportation companies, traders, and wholesalers are also highly fragmented. This means that while efficiency improvements could benefit farming communities and small business owners rather than large agricultural and logistics corporations; typical farmers and supply chain stakeholders

¹Based on 240m grain production in 2010-2011. See: http://www.atimes.com/atimes/South_Asia/LG21Df01.html

²Estimate by Colin Gonsalves: http://www.atimes.com/atimes/South_Asia/LI11Df02.html

³ Official figures for FCI facilities: http://articles.economictimes.indiatimes.com/2011-12-19/news/30534273_1_fci-godowns-storage-losses-food-corporation

⁵ Confederation of Indian Industries, 1/5/12

⁶ Confederation of Indian Industries, 1/5/12

⁷ GlobalAgri, 1/6/12; International Development Enterprises, 1/9/12

⁸ MS Sidhu, Punjab Agricultural University, 1/12/12. GlobalAgri, 1/6/12

do not have the scale or capital to make necessary technology and infrastructure investments that could bring about these efficiencies.

These two factors inspired us to learn more about India's agricultural sector, and to research how new business models, policies, or technologies could help address the significant inefficiencies that result in waste. During the course of our research we spent time interviewing farmers, traders, commission agents, market operators, consultants, shipping and storage companies, policy-makers, and researchers. We have also conducted significant secondary research to understand the market environment.

The following report summarizes our findings. Section I outlines the underlying structure of, and incentives within, India's agricultural supply chains. The unique structure of this market means that it is particularly important to understand the sector's dynamics before considering potential food waste solutions. Section II contains an assessment of major issues and problem areas that we have identified as contributing to food waste in India. These findings are non-exhaustive and sometimes anecdotal; however, they are synthesized from information obtained through the completion of over 25 interviews and site visits covering a wide range of agricultural sector stakeholders in India. Finally, in Section III, we provide a number of recommendations and potential solutions focused on reducing food waste and improving sector efficiency. It is important to note that we have taken Indian diets as given and do not suggest that food habits should change. Our objective is to reduce waste that occurs due to inefficiencies and supply chain breakdowns in the existing system.

Section I: Agricultural Supply Chain Structure

The agricultural sector in India is highly fragmented making any changes to the system challenging. The complex politics around food and agriculture in the country have compelled the government to intervene through a variety of subsidies and regulations. Sometimes this is beneficial – government programs provide food for millions of low-income families – however, these programs can also be extraordinarily inefficient and wasteful.

As a result of the scale of government intervention in agriculture, we have grouped Indian agricultural supply chains into two categories: private sector and government managed. Both categories begin with farmers, commission agents, and traders. However, the distribution mechanism, either government or private sector, has a significant impact on (1) how the food is handled along the supply chain, (2) the prices that are paid to farmers and middle men, (3) where and how the food is distributed to consumers, and (4) the price paid by consumers. For this reason, we will first discuss the role of farmers, traders, and commission agents in the sector, and then separately map how these two distinct supply chains function before considering potential food waste solutions.

1. The Start of the Agricultural Supply Chain

Regardless of whether produce will ultimately be distributed by the private sector or the government, the beginning of the supply chain – the initial transaction between a farmer and middle man – is the same. We will initially describe this process, before discussing the difference between government distribution and that of the private sector.

1.1: Farmers. Agriculture in India contributes to just over 20% of the country's GDP, but provides employment to over 50% of the population.⁹ Further, most land holdings are very small – averaging around just a couple of acres – and are shrinking as properties are passed down and divided among children in subsequent generations. As a comparison, an average U.S. farm is over 400 acres.¹⁰ This lack of scale creates a number of challenges including inadequate investment capital, difficulty in disseminating best practices and lack of bargaining power.

Despite their weak economic positioning, in aggregate farmers do have significant political power in the world's largest democracy. They represent the largest constituency across many Indian states, and the government works to garner their support through subsidies.¹⁴ While many of these subsidies have contributed towards improved infrastructure and output, the value is rarely realized by the farmers due to their limited bargaining power.

Some farming groups fare better than others, depending on where they are and what crop they grow. The most notable group includes wheat farmers in India's Punjab region as the Indian government has invested significantly in the region's infrastructure – including irrigation, roads,

⁹ See: <http://blogs.reuters.com/breakingviews/2012/01/18/unravelling-india-part-1/>

¹⁰ See: <http://www.ers.usda.gov/statefacts/us.htm>

¹⁴ See: <http://farm.ewg.org/region.php?fips=18000>

and electricity – to secure the wheat crop. As a result, the Punjab region is among the most developed agricultural zones in India, and farm land has risen in value. Accordingly, many farmers in this region do not struggle with the same challenges as those faced by farmers in other parts of the country.

1.2: Traders & Commission Agents. Traders and commission agents are middlemen that generally purchase produce directly from farmers. This initial transaction between a farmer and middleman is the first step in the supply chain.

In regions with a concentrated agricultural sector, commission agents will typically negotiate prices with the farmers. Approximately 70% of grain transactions and as much as 90% of horticulture transactions are brokered by these agents.¹⁵ The commission agents don't own the produce at any point, but rather identify a buyer, usually the government or a produce trader, and then charge a percentage commission which generally ranges from 2.5-6% of the transaction value, depending upon the crop.¹⁶ As a result, their interests are not well aligned with those of farmers: commission agents have an incentive to complete as many transactions as possible rather than invest time negotiating higher prices for farmers.

The commission agents also often provide financing for the farmer throughout the growing period. This financing structure is particularly important because most farmers cannot get credit in excess of the value of their next harvest. Since most farmers have little land, this means they can rarely afford to make investments that will increase efficiency and reduce waste. In most regions, banks are not willing to loan money to the typical farmer. As such, most farmers do not have an alternative to using their commission agent.

In more remote agricultural regions, farmers may sell produce directly to traders, who provide payment and take custody of the produce. In these instances, the farmers usually have fewer potential buyers – often only one – and have limited bargaining power.

After the initial transaction between a farmer and commission agent or trader, the produce is distributed in either a private sector or government-run supply chain.

2. Private Sector Supply Chains

The majority of fruits and vegetables are distributed in private sector supply chains, meaning that the government never sets prices for, or takes custody of, the produce. Additionally, while the majority of grain is purchased by the government, a portion – usually of the highest quality – is also distributed by the private sector. Section 3 discusses the government's role in regulating as well as purchasing certain crops for distribution and processing.

2.1: Private Sector Middlemen. After the initial commission agent or trader purchases produce from a farmer, it is common for the produce to be exchanged among as many as five additional

¹⁵ GlobalAgri, 1/6/12

¹⁶ GlobalAgri, 1/6/12. Vinod Kumar & Ranjit Singh (Commission Agents), 1/10/12

private sector middlemen before ultimately reaching the end consumer. These middlemen are generally additional traders, and sometimes commission agents, who arrange shipping logistics or points of sale in local markets. Numerous sources indicated that a typical shipment of produce will be exchanged 3-4 times, with the price being marked up each time. The abundance of middlemen puts downward pressure on the prices farmers ultimately receive. Additionally, due to the lack of proper handling facilities and cold storage infrastructure the time lags resulting from these numerous transactions can result in tons of food spoiling.

2.2: Mandis (Markets). Nearly all private sector produce is sold in one or more government controlled markets. In many cases, the initial market is just a few kilometers from the farms. At this point, traders will exchange the produce for both local distribution, and for shipping to much larger markets near large urban areas such as the greater Delhi region. The markets are built and maintained by government agencies and are typically in poor condition due to the lack of investment capital. Transactions happen in the open on large lots or underneath rudimentary roofs where grains, fruits and vegetables are offloaded and loaded on to trucks, buggies and carts. Little modern storage is available and almost no provisions are made for hygiene and sanitation.

The Mandis provide a venue for a number of critical functions. First, this is often where prices paid to the farmers are negotiated and set. The prices depend on supply and demand as well as the quality. The product is laid out on the ground for inspection and then sorted – highest quality goods often go for processing or export while lower grade items sell at reduced prices. Agricultural products may see a few Mandis before they end up in the consumer's hands. Generally, once produce reaches a larger city wholesale market, it is sold to local retailers and restaurants, who then sell the produce to consumers.

We visited wholesale Mandis in Delhi, Shahabad (Haryana), and Udaipur (Rajasthan), including Azadpur, Asia's largest vegetable market located in North Delhi. While the storage infrastructure was generally poor, and the markets were often operating over capacity, produce trading was still remarkably efficient with minimal food waste. This is because produce that is damaged or of low quality is typically sorted and sold to discount retailers. While it is common for there to be value loss as the quality of produce decreases, this rarely translates into waste.

2.3: Private Sector Food Processing. India has a number of domestic food processors such as Haldiram's and Heritage Foods which buy inputs from traders and more recently directly from farmers. While the processed foods industry is growing in India, both domestically and for export, it still plays a minor role compared to the fresh food industry. While as much as 70-80% of food in developed countries is processed in some way, India currently processes only about 2%.¹⁷ Since food processing serves as a means of extending the shelf life of produce, this lack of food processing capacity contributes significantly toward food waste. The government is aware

¹⁷ See: http://www.cci.in/pdf/surveys_reports/food-processing-india.pdf Some estimates are higher at 10%. See: <http://www.embajadaindia.com.pe/MOFPI%20Newsletter%201st%2031st%20May.pdf>

of this, and India's Ministry of Food Processing has a stated goal of increasing the country's food processing capacity by 10% in the coming years.¹⁸

2.4: Exporters. Exporters, of both fresh and processed food are beginning to build sophisticated supply chains. FieldFresh Foods, for instance, is contracting directly with farmers to export a range of fresh produce to Western supermarkets. Similarly, Tasty Bite is exporting prepared Indian dishes to markets in North America from a plant outside of Pune. These exporters often work to educate their farmers to ensure consistency and quality.¹⁹ Additionally, exported items often yield prices that are as much as ten times those of local prices – this changes the economics of production and distribution, which makes cold storage and other infrastructure a viable investment.

3. Government-Run Supply Chains

The Indian government plays two key roles in agricultural supply chains: (1) the storage and public distribution of regulated crops, and (2) construction and operation of markets and food processing for distribution in government-run retail shops.

3.1: Regulated Crops for Public Distribution. In the 1960s, due to concerns over food security, the Indian government created special rules for five key agricultural products – wheat, rice, pulses, sugar and edible oils.²⁰ Wheat is managed particularly closely as it makes up the majority of the government's safety stock of food, which at times can amount to over 60m tons of food grains.²¹ Other products, such as fruits and vegetables, are generally unregulated and are distributed entirely by the private sector, unless they are purchased by a government run market chain or processing facility.

If the government is buying a regulated crop, the Food Corporation of India will transact with a commission agent, or in less common circumstances a trader, at a regulated minimum support price. The Food Corporation of India, a government body, is by far the largest purchaser of wheat, as well as many of the other key agricultural products, which it stores and distributes to impoverished populations through the Public Distribution System.²² Since the government doesn't purchase the grain on the basis of quality, or offer tiered pricing, this program limits farmers' incentives to invest in techniques that improve quality characteristics.²³

Much of the regulated produce is grown in Punjab and Haryana and moved by truck or train to the rest of the country. The Public Distribution System operates nearly half a million retail markets where government ration cards must be presented to receive subsidized food. Prior to distribution, the government stores as much as a few years of wheat supply in storage facilities

¹⁸ Confederation of Indian Industries, 1/5/12

¹⁹ FieldFresh Foods, 1/13/12

²⁰ MS Sidhu, Punjab Agricultural University, 1/12/12

²¹ See: http://articles.economictimes.indiatimes.com/2011-08-10/news/29872158_1_foodgrain-stocks-mt-buffer-stock

²² See: http://en.wikipedia.org/wiki/Public_Distribution_System

²³ Agni Energy, 1/11/12

throughout the country.²⁴ These facilities lack modern infrastructure, and are often simply a pile of jute bags containing wheat covered with tarps.²⁵ Unexpected rainstorms have caused facilities to lose a significant portion of wheat due to spoilage. Additionally, these facilities generally have no protection against rodents or pests.

3.2: Government Markets and Processing. The government also owns a number of food processing and retailing companies, such as Mother Dairy, which manufacture and distribute food products through a range of brand names. These facilities provide a low-cost alternative to privately run markets in many cities, and generally offer a smaller selection of items. An Indian agricultural supply chain consulting firm indicated that 30% of the typical Indian household income is spent on staple vegetables – onions, tomatoes, and potatoes – with government-run markets helping supply these items for many families at more affordable prices.²⁶

To manage the supply chain leading to these distribution outlets, government agencies contract directly with traders to purchase produce outside the auspices of the wholesale markets used for private distribution. One such example is Mangol Mandi in Northern Delhi, which sources produce for the Mother Dairy retail outlets in greater Delhi. Traders send truckloads of produce to these closed markets, and the produce is either sorted for distribution to local retail outlets, or processed in a nearby government run processing facility. The processed food – which includes canned and dried goods, juices, and sauces – is then branded and sold in government run retail shops.

Based on interviews and observations of government markets and processing operations, the facilities appear to be modern with high output capacity. However, their overall economic efficiency is difficult to judge. Government programs in India across most sectors have a reputation for being inefficient and corrupt, and the government run markets and companies are not transparent in releasing revenue and cost structure data.

²⁴ MS Sidhu, Punjab Agricultural University, 1/12/12

²⁵ See: <http://www.hindustantimes.com/News-Feed/India/India-lets-grain-rot-instead-of-feeding-poor/Article1-577688.aspx>

²⁶ GlobalAgri, 1/6/12

Section II: Problems and Breakdowns

The fragmentation and political significance of agricultural supply chains in India has a direct impact on their functioning. Through the evaluation of the supply chain systems described in Section II, a number of problem areas were uncovered – both in the public and private sectors – that contribute to food waste and value loss throughout the country.

1. Infrastructure

Infrastructure in India requires significant investment. A 2011 study shows that India ranks 89 of 142 countries for infrastructure reliability and adequacy.²⁸ Since agricultural production and distribution relies on the country's infrastructure to move and store million of tons of food each year, India's infrastructure deficiencies have a particularly adverse impact on the agricultural sector. The infrastructure challenges look different depending on both the region and crop grown.

1.1: Storage. In Punjab and Haryana, where much of the country's grain is grown, the roads and rail links are in reasonably good condition. The close proximity to a major market, greater Delhi, also makes transportation logistics relatively simple. However, storage is a serious issue in the northwestern states as the government purchases a large proportion of each year's grain crops to be distributed later as part of public redistribution programs. Since the country lacks modern storage infrastructure such as silos, grain is often stored outside under plastic tarps, which provide little protection from humidity and pests. As a result, crops often spoil before they can be moved to other parts of the country. In 2011 alone, 10 million tons of grain in the public storage system was at risk of rotting due to improper storage. Enough to feed 140 million people for 1 month.³⁰

While the government has identified modern storage as a priority area for investment, new projects, both public and private, have been slow to get underway. Issues of land acquisition, pricing and fee structures and uncertainty over investment returns have hampered many efforts.

In addition to grain storage, insufficient cold storage and cold chain transportation systems – which are able to extend the shelf life of produce from as little as a few days to weeks or more – are often cited as one of the key reasons for Indian food waste. However progress is being made with industry groups such as the Confederation of Indian Industries which has launched a cold chain task force focused on uniting investors, manufacturers, market operators, and shipping companies to develop best practices and overcome these infrastructure shortcomings.³¹ Additionally, many state governments are providing subsidies, including one program to give farmers in certain regions two free days of cold storage each month.³²

²⁸ World Economic Forum. See: <http://reports.weforum.org/global-competitiveness-2011-2012/>

³⁰ See: <http://www.livemint.com/2010/07/25234149/Instead-of-feeding-the-poor-I.html>

³¹ Confederation of Indian Industries, 1/5/12

³² International Development Enterprises, 1/9/12

However, for the vast majority of Indian crops consumed within India, cold storage does not seem to be a viable or sustainable method to reducing food waste in the short to medium term. In particular, creating ROI positive projects has been a challenge as the value of basic foodstuffs is low compared to the upfront costs of cold storage infrastructure. In many cases, the cold storage costs may exceed the value of the food. As a result, many of the existing cold storage companies deal almost exclusively with high value imported or exported products as opposed to staples such as onions or tomato which are traded in higher quantity and are more likely to go to waste. Cold storage will not become economically viable for most crops until the cost of maintaining such facilities falls below the value of the goods themselves.

1.2: Roads and Transportation. In remote parts of India, where transportation infrastructure *is* problematic, there is often no effective means to transport crops to markets. Poor roads, a lack of tractors and trucks, and long distances to city markets collectively make it difficult for farmers to extract reasonable prices. Further, the extra cost of getting to market means that in bumper crop seasons, when prices fall, it is often uneconomical to harvest in the first place. As a result, crops are left to spoil in the field.

In general, crops are shipped via truck all over the country. For instance, Delhi's wholesale vegetable market receives daily truck shipments that arrive from as far as 72 hours away. Poor roads along any portion of the route from the origin to Delhi can cause the entire truckload to be delayed and rot. Fruits such as bananas and mangos are particularly susceptible in the hot summer months, and it is common for at least 5% of shipments to spoil even without a delay.³³ Further, interstate movement of fruits and vegetables within India is regulated, and truck drivers must stop at each state border to obtain approval to continue driving.³⁴ This is time consuming and costly compounding the challenges of the poor infrastructure.

2. Government Purchase and Distribution Schemes

Bureaucracy and corruption are well known problems in India and food supply systems are not immune. The Indian government's massive redistribution program involves a number of government agencies and intermediaries. Corrupt officials running storage depots have been known to rig weighing scales to indicate less grain coming in, siphoning off the excess to the gray or black markets.³⁵ Other reports describe officials allowing, and then over-reporting, wastage in an effort to sell the excess supply.³⁶ Similar issues arise during transport when portions of shipments have been known to go missing in train yards and transfer stations.³⁷

Experts contend that the private sector is much better at ensuring that food does not go to waste, as managers typically won't be able to gain from sustained illicit transactions. However, in reality the government programs are unlikely to be eliminated, and in fact, an upcoming

³³ Dr. Ghuman, Punjab Agricultural University, 1/12/12

³⁴ Confederation of Indian Industries, 1/5/12

³⁵ GlobalAgri, 1/6/12. Vinod Kumar & Ranjit Singh (Commission Agents), 1/10/12

³⁶ GlobalAgri, 1/6/12. Vinod Kumar & Ranjit Singh (Commission Agents), 1/10/12

³⁷ GlobalAgri, 1/6/12

“Right to Food” bill may expand them by granting 2/3 of the population access to highly subsidized grains and rice.³⁸

3. Middlemen, Bargaining Power, and Price Transparency

Before food gets from a farmer to a consumer, it’s typically exchanged through a number of intermediaries: traders buy and ship produce and commission agents arrange transactions between farmers and traders. Since the typical farmer only works a couple acres of land and is not an important supplier, the middlemen have an advantage in terms of information and bargaining power.

Farmers often will not know the price for their product before they get to the wholesale market. Once at the market, the commission agents can dictate the price as it is not economical for the farmer to take the goods back in order to wait for a better price. Commission agents have little incentive to prevent waste as they are compensated based on the total transaction value, without ever taking ownership of the product. Since they generally receive only a 2.5-6% commission on sales, it makes little sense for them to invest time to find traders offering marginally higher prices – they can earn more income by completing many deals as quickly as possible.

Farther along the supply chain, traders also have few incentives to minimize waste. It is easier for them to deal with fewer goods at a higher price than more goods at depressed prices. As such, waste often occurs when these middlemen collude to restrict supply, which results in inflated prices and lower shipment quantities.³⁹ Middlemen can especially collude in remote regions where there are only a few buyers.⁴⁰

4. Price Volatility

All of the factors above, along with weather, contribute to price volatility. When future prices are difficult to estimate, farmers cannot plan to grow the most economically efficient crops. This is problematic for two reasons.

First, farmers will often choose to grow crops that were profitable over the past few seasons. When this herding behavior occurs, subsequent prices plummet, and it becomes uneconomical to harvest. This is what happened to potato prices at the end of 2011. After previously being profitable, many farmers chose to abandon existing crops and grow potatoes. This resulted in excess supply, and the price plummeted. It became uneconomical for farmers to harvest or transport their crops, and thousands of tons were left to rot in fields and in the streets.⁴¹ This boom and bust cycle is typical for a variety of crops.

³⁸ See: <http://southasia.oneworld.net/todayshadlines/india-clears-ambitious-food-subsidy-plan>

³⁹ GlobalAgri, 1/6/12. International Development Enterprises, 1/9/12

⁴⁰ International Development Enterprises, 1/9/12

⁴¹ See: <http://deshgujarat.com/2011/12/20/farmers-dump-100-tractors-full-of-potatoes-on-road-of-deesa/>

Second, when farmers cannot estimate their income in the coming year, it becomes much more risky to make long term investments that would improve future efficiency. Mechanisms to reduce price volatility would reduce food waste and increase the income of farmers allowing for more long term investments.

5. Financing, Education & Training

As previously mentioned the farming sector is highly disaggregated which leads to challenges in accessing financing as well as education and training.

As a result of India's underdeveloped agricultural banking sector it is fairly common for farmers to borrow the capital required for each growing season from commission agents, and then to repay the loan upon harvest. Few farmers have sufficient scale to justify large purchases as it is difficult for most small farmers to invest in modern equipment and infrastructure that can improve output yields, efficiency, and quality.

Farmers also lack sufficient education in areas such as fertilizer and pesticide use, crop rotation, investment decision-making, and crop planning. Most farmers inherit family land holdings, and their expertise is obtained primarily through passed-down family knowledge and by word-of-mouth. As a result, best practices in agriculture are slow to spread across India's vast farming population.

Without proper education on how to use pesticides and fertilizers, many farmers over fertilize their crops.⁴² This has caused overproduction which has put a strain on India's water supply, and in some cases has resulted in dangerous levels of chemicals in output, damaging the export market and posing a health risk to consumers. For instance, in 2011, United States regulators identified dangerous levels of certain pesticide residue in Indian rice, imports from India were subsequently banned.⁴³

It is clear that there are unique educational challenges associated with India's fragmented farming system, and improvements in information dissemination and transparency, along with access to longer term financing would go a long way towards improving both output and farmers' incomes.

⁴² Agni Energy, 1/11/12; FieldFresh, 1/13/12

⁴³ Agni Energy, 1/11/12. See: <http://www.tribuneindia.com/2011/20111201/main3.htm>

Section III: Needs and Recommendations

The five points mentioned above are major contributors to the food waste problem in India. To address food spoilage, both innovative technological/entrepreneurial solutions as well as thoughtful policy changes are needed. With farming and food subsidies being politically sensitive issues in India, any changes or new schemes are viewed with suspicion and take a long time to enact. Technological solutions, such as low cost infrastructure, new micro entrepreneurship models and improved information transparency may have a greater impact in the short term and especially if they are disseminated through private sector initiatives.

Any proposed improvements will need to work in the context of the current system and set of stakeholders. While the ultimate solution – modern infrastructure – is still years away, much can be done in the interim to improve the current workings of both private sector and public sector supply chains. In terms of technical solutions the three key areas in need of innovation are described below.

1. Packing & Storage

As mentioned above, improper packing and storage lead to significant losses both physically and in terms of lost value. We've outlined two opportunities to reduce food waste caused by inadequate storage.

1.1: Grain Bags. With grain being stored outdoors and transported in uncovered trucks the only form of protection is the jute bag. The bags do nothing to keep out moisture (e.g., from rain) or to keep out pests such as birds and rats. There is a need for an *ultra low cost 50kg storage bag* which helps to keep out external moisture as well as pests while allowing for a limited amount of moisture to permeate from the grain itself to prevent rotting. These bags could be sold through the regular farm supply retailers and would go a long way in preventing storage and transportation losses across a variety crops including grains, rice and pulses.

1.2: Storage Investments. While modern silo storage is being planned for high producing areas such as Punjab and Haryana, it is impractical to build similar facilities in more remote parts of the country which are closer to the redistribution points. As such, there is a need for *small, multipurpose, low cost storage facilities* which can be constructed from locally available materials across India. These storage centers should provide protection from the elements, ensure at least minimal humidity and temperature control and be connected to a centralized database through mobile or internet based communications. These centers could be built and operated by the Food Corporation of India, by communities, private investors, or under a public-private partnership model.

2. Distributed Food Processing

With roughly 2% of food grown in India being processed, there is a great opportunity to extend the shelf life of products through drying, curing, juicing, packaging or other food processing

techniques. This would be especially valuable in cases where there is a bumper crop and prices for a particular item plunge to the point where it is not economical to harvest or distribute (e.g., potato crops in 2011).

Processing would allow for the crops to be stored until prices recover or to be exported to other parts of the world. This would require *low cost, small scale, mobile processing technologies* which could be applied to particular crops or groups of crops. A potentially effective means to achieve scale would be through a network of distributed franchises which would be provided as a service to farmers at the community level. As with fresh products, the preserved goods could be sold through commission agents and traders and passed down the supply chain, therefore ensuring that farmers would immediately get the much needed income.

With the relatively high density of population in the rural parts of India and the shortage of cultivatable land, there is a significant population of would be micro-entrepreneurs who could take on these enterprises.

3. Information Management & Planning

Inadequate crop planning exacerbates the natural price volatility which occurs in agriculture. In addition, an individual farmer's income varies with the daily supply and demand conditions at local markets as well as with the ability of commission agents and traders to collude in controlling prices. Both causes of volatility can, at least in some ways, be addressed with information.

On the system wide level, 4-5 year price cyclicity occurs due in part to millions of farmers making similar calculations in terms of what will be profitable to plant. This leads to too many farmers planting the same crop, and prices collapse at harvest time. What is needed is a *mobile based system which would help farmers make planting decisions based on the expected behavior of other farmers in the region as well as weather forecasts and even global supply and demand projections*. While planting decisions could never be imposed, farmers could benefit from a planning tool that would give them a sense of which crops could be most profitable and have the least volatile prices.

Such a system would sample farmers in each region before planting and use historical consumption data to develop forecasting models. Farmers who subscribe to the mobile service would then receive a green, yellow or red light for each type of crop to help them with decision making. The system would be dynamic, incorporating new data as conditions change.

To help address price volatility and middlemen collusion during harvest time a similar, *mobile based, tool would feed farmers daily price information* for several of the closest markets. Farmers would then be able to decide where and when to sell their crops. The service could also incorporate an educational component to help farmers gain higher yields from their crops. A similar service, called e-choupal, has already been rolled out by Indian conglomerate ITC which has several thousand kiosks outfitted with internet-enabled computers which display

daily price information and educational materials. A text based mobile service with forecasting mechanisms, however, would allow a service to scale much faster and help reduce price volatility.

4. Policy Recommendations

The politics of agriculture in India is highly complex and dynamic. Accordingly, making policy recommendations is challenging without an intimate understanding of the entire system. Notwithstanding, a few general suggestions may help address a number of the inefficiencies identified in this report:

- **Export Enablement.** The Indian government limits exports for many crops in order to ensure food security and keep prices down. However, for farmers, exports provide a viable way to (1) learn how to improve quality and consistency, and (2) obtain a higher price for their goods. Export oriented food companies, such as FieldFresh Foods, operate highly efficient supply chains and enter into mutually beneficial relationships with both small as well as large farmers. Through these relationships farmers receive training in pesticide and fertilizer usage, crop output maximization, and technology, as well as reliable suppliers of seeds and other agricultural products.⁴⁴ Over time, these farmers learn to grow export quality crops, increasing their economic value added. Encouraging the export of Indian foodstuffs would bring value to a number of stakeholders, and if done right, is unlikely to negatively affect India's food security.
- **Accountability & Transparency at the Food Corporation of India (FCI).** While better infrastructure will help reduce the waste in government purchasing and distribution programs, the problem of corruption will need to be addressed as well. In particular, more transparency and accountability is needed along each part of the supply chain. Low cost information technologies can help keep track of inventories, however, the political mandate is needed to help implement these at the lowest level (e.g., at individual storage depots).
- **Enablement of Larger Private Sector Players.** Current Indian labor and contract laws put larger companies at a disadvantage, leaving many industries highly fragmented. For example, Indian laws prohibit binding contract farming agreements, making it difficult for large farmers to engage in long-term relationships with farmers.⁴⁵ The fragmentation reduces efficiency as there are no stakeholders who have the incentive to eliminate waste along the entire supply chain. Making it easier for larger companies, domestic and international, to apply their significant logistics and supply chain management expertise to the whole food supply system would go a long way in reducing inherent inefficiencies.

⁴⁴ FieldFresh Foods 1/18/12

⁴⁵ GlobalAgri, 1/6/12

- **Distributed Production.** The government of India has selected several crops which have special regulation in the name of food security and affordability. In the case of wheat and rice, two of the most important products on the list, most of the production occurs in the northwest and needs to be transported to every other part of the country. Policies to encourage more distributed production of these key crops would reduce the need for transportation while providing income to less developed states. This would also reduce waste in the storage and transportation process as the food would travel a smaller distance.
- **Enabling Financial Independence.** Most farmers rely on the income from each year's crop to carry them through to the following year. There is relatively little scope for saving and for many, the only form of financing available is through commission agents. A more formalized system, perhaps involving commission agents as loan officers, would give access to financing to a larger share of the rural population and would eliminate the predatory practices that many farmers are currently subject to. Microfinance organizations and coops are viable models but are not yet prevalent in India.
- **Simplification and Reduction of Agricultural Transport Regulations.** Regulations that require shipping companies to stop at each state border to obtain permission to continue driving are time consuming and costly, and contribute to delays that can result in food waste. These regulations should be simplified to reduce duplicative regulatory burdens.

These recommendations represent only a few potential policy initiatives that would help reduce food waste in the Indian agricultural sector.

Concluding Thoughts

Looking at the entire food supply system in India, the challenges are very different than ones faced by Western nations. In India, the downstream part of the supply chains is remarkably efficient. From the wholesale market to the consumer there is very little waste as there is a market for almost any type and grade of product. While the top quality is sent to high end shops, lower quality products are sold in pushcarts or fed to livestock. As we show in this report, most of the inefficiencies take place upstream of the wholesale market. In contrast, Western supply chains are highly efficient; however, households and restaurants tend to throw out huge amounts of perfectly eatable food.

Indian eating habits also provide a contrast to those of the Western world. Due to the structure (and perhaps limitations) of the supply chains most diets consist of seasonal, locally grown food with a bias towards vegetables, grains and pulses over meat.

Fresh food, especially the staples, is also an order of magnitude cheaper in India than in Western grocery stores, a requirement for a country where many live on \$2 a day or less. The lower cost of food, however, makes investment in modern (and expensive) infrastructure and logistics more difficult as fewer projects can show a positive ROI through efficiency gains.

Due to these differences, solutions to the inefficiencies of Indian agricultural supply chains will have to be uniquely Indian. Innovation in low cost infrastructure and technology, education, enlightened policy, and the inevitable substitution of labor for capital will all likely be part of that solution. Fortunately, the issues of agriculture, food security and poverty reduction are firmly in the public's eye and at the forefront of national debate in India.

Appendix

1. Select Interviews

Contact	Organization	Topics
Meetu Kapur & R Vaithiyanathan	Confederation of Indian Industry (CII) – Delhi	- Discussed Indian agriculture stakeholders, development of cold chain - Received a number of industry and government contracts from RV
Veerender Thakur	GlobalAgri - Delhi	Discussed the structure and issues of the Indian agricultural industry
Jay Lurie	IFC Advisory Services – Delhi	Discussed wheat storage and public-private partnerships in addressing infrastructure development issues
Dr. Suneel Pandey	The Energy & Resources Institute (TERI) – Delhi	Discussed rural entrepreneurship models and issues in scaling low cost eco-friendly technologies
Niraj Subrat	IDE – Delhi	Post harvest crop initiatives
Colonel Reina	Farmer – rural Haryana	Toured a working farm, discussed operational issues, supply chains, pricing and government involvement
Vinod Kumar	Commission Agent – rural Haryana	- Discussed the role of commission agents and the tactics used by CAs and government agents to game the system - Toured a mid-size rural wheat market, government storage facilities and a vegetable market
Despheer & Dhananjay Ramaswamy	Agni Energy – Chandigarh & rural Punjab	- Toured the operations of an agri-waste to industrial charcoal startup - Discussed the structure of the farming sector, issues and opportunities
M.S. Sidhu, B.S. Ghuman, Jagtar Singh Dhiman, Ashok Kumar	Punjab Agricultural University (PAU) – Ludhiana	Discussed infrastructure issues, food processing, government subsidies, rural economics
Uday Gosain	FieldFresh Foods –	Toured a research farm involved in

	Ludhiana	processing and export of fresh produce to Europe Discussed export logistics, export economics and farmer relations
Dr. Pradyumna Agrahari	FieldFresh Foods - Pune	Discussed structure of agricultural supply chains, export economics and small scale farmer relationships
Sachin Sharma	ITC – E-Choupal	Discussed the ITC e-choupal model as well as relationships between farmers and middleman
Santosh Gondhalekar	Gangotree Eco Technologies - Pune	- Discussed waste to energy technologies and models for urban waste disposal - Toured a working waste to energy plant

2. Structure of Agricultural Supply Chains

