# The quiet revolution in agri-food value chains in Asia: Understanding the fast emergence of cold storages in poor districts in India

Minten, Bart and Reardon, Thomas and Singh, K.M. and Sutradhar, Rajib

IFPRI, MSU, ICAR, JNU

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# The quiet revolution in agri-food value chains in Asia: Understanding the fast emergence of cold storages in poor districts in India

Bart Minten[1]

*IFPRI, New Delhi, India*

Thomas Reardon

*MSU, East Lansing, USA*

K.M. Singh

*ICAR-RCER, Patna, India*

Rajib Sutradhar

*JNU, New Delhi, India*

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**Abstract**

*In disadvantaged districts of Bihar, one of the poorest states in India and an area where smallholders dominate, we find that there have been dramatic increases and rapid up-scaling of modern cold storages, triggered by market reform, investment subsidies, and better overall public service provision and governance. Almost all potato farmers, small and large, participate in these cold storages. The availability of cold storages has seemingly led to improved efficiency in value chains because of lower wastages and some cold storages have become heavily involved in input, output, and especially credit markets. This emergence of cold storages thus leads to important changes in traditional potato value chains, with significant implications for smallholders.*

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## 1. Introduction

Especially technology changes and innovations at the farm level have been the driver for large productivity increases, and real price decreases, in agriculture over time and most documented innovations have thus been linked to production technologies such as irrigation and improved seeds (e.g. Spielman and Pandy-Lorch, 2009; Evenson and Gollin, 2003). While innovations midstream and downstream in the value chain might also have significant impacts on agricultural performance, and might potentially benefit producers and consumers alike (Gardner, 1975), relatively little research has been done in this area.

However, the subject is receiving more attention in recent literature, e.g. Swinnen (2007), Dries et al. (2009), Reardon et al. (2009). Most of the debate on changes of value chains in the literature has focused on the rise in the consumption of high-value crops (e.g. Delgado et al., 2008; Gulati et al, 2007) but has not looked at the impact midstream or downstream. Others have shown the rapid emergence of modern retail (e.g. Reardon et al., 2009; 2010) and its impact but have not looked at traditional value chains. However, important changes are occurring in traditional agricultural value chains in several developing countries (World Bank, 2007; Reardon et al., 2012). These changes are noted upstream at the farm level, midstream with traders and processors, and downstream in retail markets (Reardon and Timmer, 2007). Given that the changes are grassroots in nature, Reardon et al. (2012) call this this a "quiet" revolution.

We present in this paper the case of innovations and investments in post-harvest management and show how it is associated with important changes in traditional agricultural value chains. More in particular, we document in this study the case of the rapid emergence and up-scaling of cold storages in Bihar, one of the poorest states in India. The number of cold storages increased in Bihar overall by 67% in the last decade. In the two disadvantaged – as defined by India's Planning Commission - districts that were studied, an area characterized by a large number of smallholders, the number of cold storages in the last decade doubled in one district and tripled in the other and rapid up-scaling of cold storages led to an even faster total capacity expansion, i.e. a triple and five-fold increase over the same period. These cold storages are almost exclusively

used for the storage of potato, the most important vegetable (in volume) in India and in Asia more general.

The emergence of such large modern players mid-stream raises important questions, which have not been studied in the literature, on its implications. We address two questions in particular in this paper. First, we study the factors that have contributed to the rise of the cold storages. Second, we look at the role of the cold storages in the value chain and how it contributes to increased efficiency of the marketing system. To document the role that cold storages play, we rely on different sources of information. First, we conducted key informant interviews with several stakeholders in the value chain. Then, we implemented a detailed structured questionnaire with the different agents in the value chain including cold storage owners, producers, local collectors, wholesalers, and retailers.

We find that the spread of the cold storages in these districts has seemingly been driven by a multitude of factors related to policy reform, the improved provision of public goods (road infrastructure and governance), by the availability and spread of new technologies within the cold storage sector, as well as by subsidies by the government. The increasing spread of these cold storages has led to a significant larger part of potato production going through it, i.e. an increase from 39% in 1999 to 62% in 2009. Cold storages are also associated with improved efficiency of the marketing system because of lower wastages in the value chain. We further find that while almost all farmers use cold storages, relatively larger farmers participate more towards storage for sale as to benefit from higher prices in the off-season and they are then able to capture a higher share of the final consumer price. Smaller farmers benefit relatively more through the cheaper and more reliable storage of seed potatoes and possibly through the higher prices during the harvest period (because more potatoes are stored, e.g. Fuglie, 1995).

The structure of the paper is as follows. In Section 2, we describe the area studies and the data collection methodology. Section 3 illustrates the expansion of the cold storages over time. In Section 4, we dwell on the triggers for the rapid diffusion of the cold storages. Section 5 then looks at the role of the cold storages, not only for storage behavior but also for the other services delivered. In Section 6, we document storage behavior of farmers, the cost of storage in the value chain, and wastages. We finish with the conclusions and implications in Section 7.

## 2. Case study area, data and methodology

### 2.1. Background

Bihar, the state where the study was done, is considered one of the lagging states in India. Its per capita income, at about 160$, is one of the lowest in India and its economic growth in the last decades has not kept pace with the rest of India (World Bank, 2005). However, its performance seems to have improved in recent years and Bihar has registered between 2005 and 2010 one of the highest economic growth rates at the Indian state level. Given its bad economic performance over a long period, poverty levels in Bihar are high and about 37 million of its 90 million people are estimated to be poor (World Bank, 2007).

Potato is an important crop in India. India is ranked third in production in the world after China and Russia. Potato is estimated to be the largest vegetable crop counting for 23% of all area planted under vegetables (Kumar, 2009). Potato consumption is widespread in India and it is estimated that 92% of the people eat it (Das Gupta et al., 2010). Annual consumption was evaluated at 18 kgs per person per year in 2007 (Faostat). Das Gupta et al. (2010) report that potato processing is limited: the share of fresh potatoes in potato consumption is about 95% and the importance of processed potatoes (for chips, French fries, etc.) is still minor (5%).

A major challenge in India is potato storage as potato production, that takes place in the cold months of October-November to February-March (about four-fifths of total production), is followed by hot summer months which makes refrigeration necessary for storage.[2] Cold storage takes place on a large scale and it is estimated that there were about 3,400 cold storage facilities in the beginning of the 2000s in India (CIP, 2006) but they had increased to 5,386 units in 2008 that could store over eighteen million tons of crops (www.Indiastat.com).[3] Most of the cold

[2] Also important is that potato is mainly grown in Indo-gangetic plains in the North so that there is no multi-season flows from different zones.

[3] Cold storage is usually referred to as a refrigerated warehouse space as to preserve food products. Storage conditions and length of time in storage influence the quality of the products and their consequent susceptibility to handling. By lowering the temperature during storage of food products, they can be stored for longer periods and can then marketed during periods of the year when no production is possible. Cold storage of table and seed potatoes is usually done at a temperature of 2-4 C. However, this temperature induces the conversion of starch to sugar,

storages in India are uses towards potato storage. CIP (2006) estimates that approximately three-fifths of potatoes in cold storages are table potatoes, intended for consumption, while the other two-fifths are used for seed. Using average storage charges from our survey and 80% of cold storage use by potatoes, it is estimated that about 0.4 billion USD is spent yearly by traders and farmers on storage for these potatoes in India, indicating the large size of this business.

Some characteristics of Bihar's potato economy differ from India's overall. Red potatoes are preferred and widely consumed by consumers in Bihar and a price premium is paid for them. It is estimated at the state level that 60% and 40% of the potato production are respectively white and red-skinned. Currently no formal potato processing sector is present in Bihar. Several varieties are being cultivated in Bihar and their adoption and dis-adoption seem related to different factors[4].

### 2.2. Data collection

Two disadvantaged[5] districts where potato production, as measured by total quantities produced, is important in Bihar, i.e. Vaishali and Samastipur, were selected to field the surveys. Different types of surveys were set up at the end of 2009 as to understand the role of cold storages, storage behavior of farmers, and the role of storage in potato marketing in Bihar. They included surveys with potato producers and a village survey, wholesale and retail trader surveys, and a cold storage survey.

The trader survey and cold storage surveys were set up as follows. First, two village trader/collectors were randomly selected from those that were active in the selected villages and

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leading to the sweetening of potatoes that are less desired in the market place. Customers are thus usually willing to pay a premium for 'fresh' potatoes, potatoes that have not gone through cold storage.

[4] First, the lack of resistance against the *late blight* disease is leading to the increasing disadoption of the *Kufri Senduri* variety. Second, varieties that grow for shorter periods (90 days instead of 120 days) can be better intercropped with maize, which matures after the potato crop, after 6 months on average, and thus the land can be more intensively used. Shorter-duration varieties can also be sold earlier on the market and might thus fetch a premium because of that. On the other hand, shorter-duration varieties contain less dry matter, making it more prone to rotting. Third, there is a trade-off between yields and dry matter for the choice of varieties. Lower yield varieties are often associated with higher dry matter, making it better suited for storage. The higher the dry matter, the lower the likelihood of rotting becomes (Personal communications with Dr. R.P. Rai, Central Potato Research Station ).

[5] Based on several indicators (agricultural productivity per worker, agricultural wage rates, and share of the scheduled caste/tribe in total population), 150 districts were thus assigned to the 'disadvantaged district' status by the Planning Commission of India.

were then interviewed. Second, 30 traders were interviewed from the local wholesale market in the district. Third, 20 urban wholesale traders and 164 retailers in Patna were randomly selected and interviewed.[6] To implement the cold storage survey, a list of all the cold storages in the district of Samastipur/Vaishali was obtained from the Horticulture Department (all cold storages have to be registered). A random selection of 27 was done and detailed surveys were conducted. For all cold storages that were not visited for a detailed survey, the date of establishment was collected through key informant interviews. We also collected data on cold storages that ceased operations. This information allows us to analyze their net growth over time.

The village and household survey was set up as follows. For potato farm households, the most important potato producing *tehsil* - in terms of quantities produced - in each of Vaishali and Samastipur was selected. Given that Samastipur is a bigger potato producing area than Vaishali, more villages were selected in the former.[7] In each selected village, a village questionnaire was implemented. In each selected village, a census of households was conducted to enumerate the potato producers. Using the census questionnaire, a list of all the potato producing households in the village was made. Each household was asked questions on their total land cultivation and potato cultivation in particular and if they were a seller of potato. 18 potato producing households in 14 villages were then randomly selected in the village, half from the largest farm group and half of them from the smallest farm group as to reflect their importance in the potato value chain. 254 potato farm households were thus interviewed in total.

### 2.3. Descriptive statistics

We first present some descriptive statistics on the different surveys implemented (Tables 1 and 2). The potato farmers in the survey are on average 55 years old (Table 1). They have a household of about 7.4 family members and 98% of the heads of households are reported to be

[6] 10 retailers were interviewed additionally on pricing specifically in May 2009.
[7] The sample in Samastipur was done as follows. In a *tehsil,* Gram Panchyats (GPs) were ranked from big, medium to low producing GPs (three terciles). 3 GPs was randomly selected from the big producing GPs, 1 GP will be selected from the medium producing GP, and 1 GP will be selected from the low producing GPs. In each selected GP, two villages will be selected at random. For the GP of the lowest producing tercile, only 1 village was selected. In Vaishali, the following strategy was used. Gram Panchyats (GPs) were ranked from big, medium to low producing GPs (three terciles). 1 GPs was randomly selected from the big producing GPs, 1 GP was randomly selected from the medium producing GP, and 1 GP was selected from the low producing GPs. In each selected GP, two villages were selected at random. For the GP of the lowest producing tercile, only 1 village was selected.

male. 10% of the potato farming households are illiterate, significantly lower than the average at the state level as 53% of the population was estimated to be illiterate in the national census of 2001. This indicates that these farmers are relatively better endowed than other farmers in Bihar. The value of the land of these farmers – their most important asset – is estimated at 2.6 million Rs or 59,000 USD. The value of land assets owned by larger farmers is almost three times as high for the larger farmers than for the smaller ones.

Potato farmers that were selected in these two districts are in general small, as they only cultivated 2.23 acres in total, of which 0.95 acres are allocated to potatoes. An average potato farmer cultivates 3.2 potato plots. 90% of the cultivated potato land is owned by the farmer and 10% of the land is rented in. A farmer sold 5.3 tons of potato in the year prior to the survey. Most of the produced potatoes are used towards sales, indicating the importance of potatoes as a cash crop for these households. About two-thirds of the potato production is estimated to be sold while 30% is kept towards seed use and own consumption. It is estimated by the households that 5% of the production is wasted before, during, or after storage.

Table 1: Characteristics of potato farmers

Table 2 shows some statistics of the other value chain agents that were interviewed. 27 cold storage owners, 65 wholesalers, and 164 retailers were interviewed in total. The results show the significantly larger capital that cold storages have at their disposal. The value of a cold storage in the surveyed region amounts to about 1 million USD. This compares to a value of assets (and working capital) of 1,250 USD (3,390 USD) for wholesalers and 190 USD (430 USD) for retailers. Of all agents in the value chain, the retailers have least capital at their disposal for their business. The turnover of wholesalers is estimated to be almost five times as much as that of retailers, i.e. 635 and 130 kgs per day respectively.

Table 2: Descriptive statistics agents value chain surveys

Data from the village surveys show to what extent the value chain of potatoes has changed in the last ten years. Village leaders were asked to evaluate different indicators related to potato production and marketing (Table 3). The number of households that are involved in potato production has increased significantly over the last year. The percentage of producers increased

from 71 ten years ago to 83 in 2009. We also see a switch from red potato (55% and 38% of the total production ten years ago and now respectively) to white potato. The number of village traders also increased significantly over that period. While the median number of village traders was 2 in 1999, it increased to more than 5 in 2009. Finally and most importantly, the estimated percentage of potato production going through cold storages increased from 39% in 1999 to 62% in 2009, illustrating their rapidly increasing importance in these districts. In the next section, we look in more detail at this rapid change at the district level and at the factors that triggered their rise.

Table 3: Evolution of potato production and marketing, as reported by village leaders

## 3. The emergence of cold storages

A major challenge in India is potato storage as potato production, that takes place in the cold months of October-November to February-March (about four-fifths of total production), is followed by hot summer months which makes refrigeration necessary for storage.[8] Cold storage takes place on a large scale and it is estimated that there were about 3,400 cold storage facilities in the beginning of the 2000s in India (CIP, 2006) but they had increased to 5,386 units in 2008 that could store over eighteen million tons of crops (www.Indiastat.com).[9] Most of the cold storages in India are uses towards potato storage. CIP (2006) estimates that approximately three-fifths of potatoes in cold storages are table potatoes, intended for consumption, while the other two-fifths are used for seed. Using average storage charges from our survey and 80% of cold storage use by potatoes, it is estimated that about 0.4 billion USD is spent yearly by traders and farmers on storage for these potatoes in India, indicating the large size of this business.

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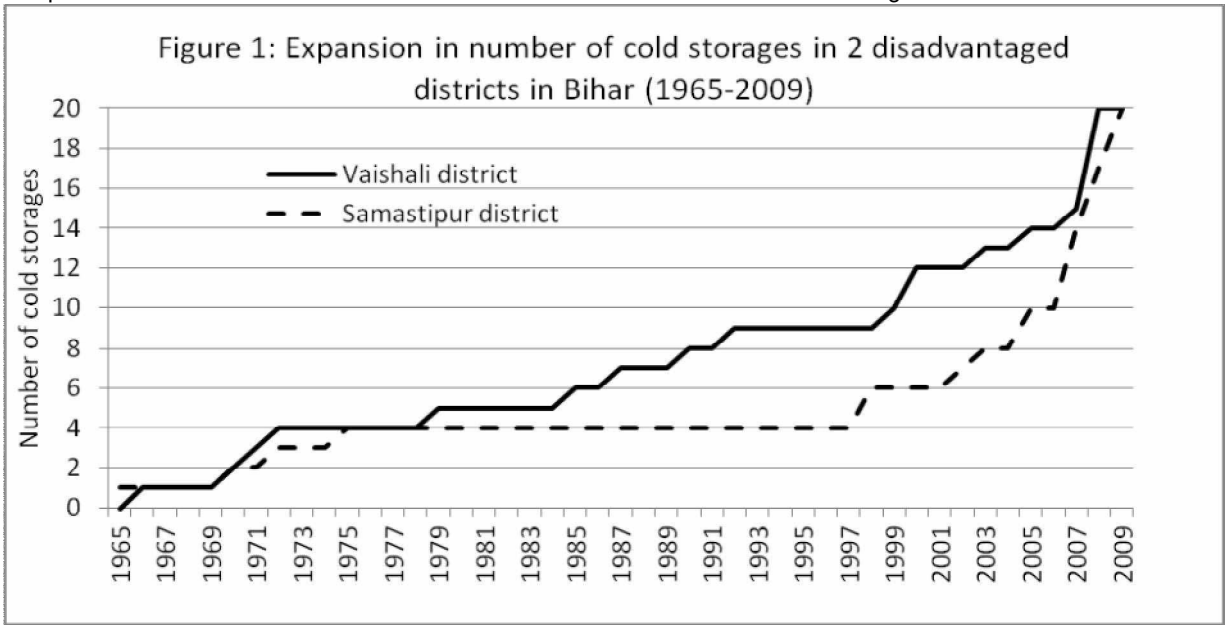
[9] Cold storage is usually referred to as a refrigerated warehouse space as to preserve food products. Storage conditions and length of time in storage influence the quality of the products and their consequent susceptibility to handling. By lowering the temperature during storage of food products, they can be stored for longer periods and can then marketed during periods of the year when no production is possible. Cold storage of table and seed potatoes is usually done at a temperature of 2-4 C. However, this temperature induces the conversion of starch to sugar, leading to the sweetening of potatoes that are less desired in the market place. Customers are thus usually willing to pay a premium for 'fresh' potatoes, potatoes that have not gone through cold storage.

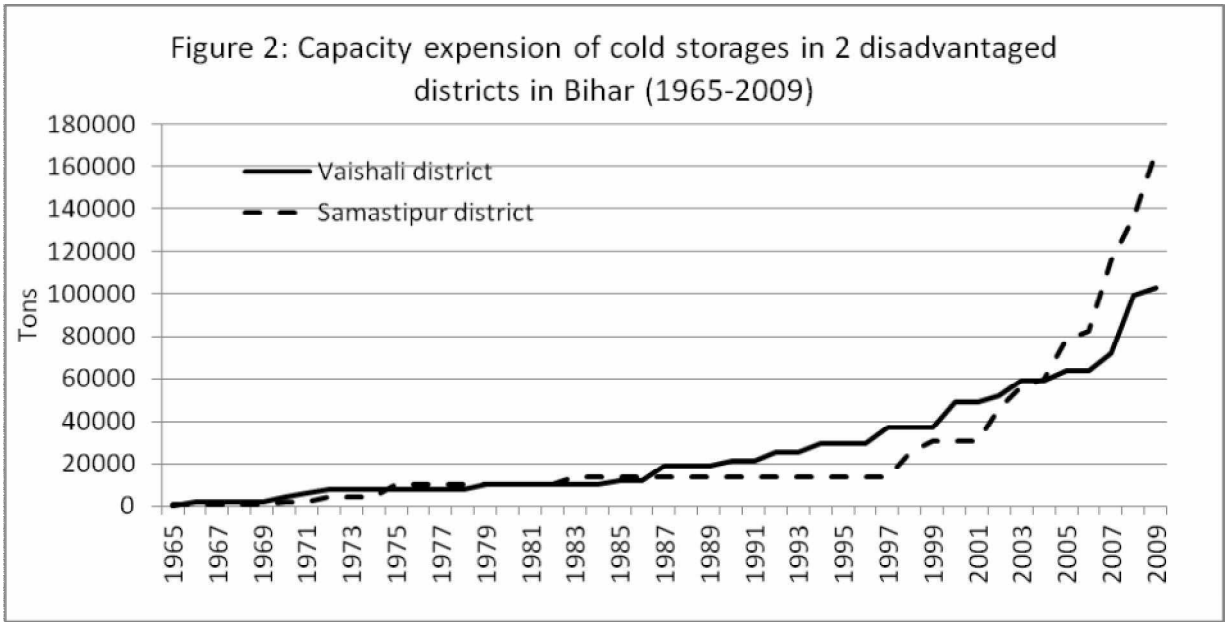
Building on a list of cold storages distributed by the National Horticultural Board, we evaluated through key informant interviews, as well as formal surveys, the evolution in the number and the capacity of cold storages. It is estimated that the number of cold storages in Bihar overall increased between 2000 and 2009 from 195 to 320, an increase of 64%.[10] Figure 1 shows the expansion of such cold storages in the two districts in particular. It shows that there were 20 cold storages in each of the districts at the time of the survey. The graph shows how the growth of the cold storages has mostly happened in the last decade, or even more recently. The district of Samastipur only had 10 cold storages in 2005 but this doubled since then. Before 1998, there were only 4 cold storages in the district as a whole. The growth in Vaishali was much smoother as cold storages 'only' doubled in the last decade.

While the number of cold storages increased dramatically, these graphs do not take into consideration the increase in expansion of the existing cold storages. As we implemented a survey with the cold storages and questions were asked on their capacity expansion over time, this allows us to calculate complete capacity expansion in these two districts. The average capacity per cold storage was between 1,000 and 2,000 tons in the beginning of the seventies but at the time of the survey, this was as high as 5,142 tons in the district of Vaishali and 8,350 tons in the district of Samastipur. Combining the growth of capacity per cold storage with the total number of cold storages gives the total cold storage capacity expansion in the two districts. As expected, the results (Figure 2) show an even more dramatic increase as in the previous graph. In the last decade, total cold storage capacity expanded almost three-fold in the case of Vaishali while it expanded more than five times in the case of Samastipur. Total cold storage capacity in 2009 was just over 100,000 tons in Vaishali and about 170,000 tons in Samastipur. When all capacity of the cold storages would be used, this involves an approximate yearly business or revenue of just below 10 million $ in the two districts combined.[11]

[10] Indiastat and personal communication, Bihar Horticultural Department
[11] A average cost in these two districts of 33.2 USD/ton, i.e. 75 Rs per bag of 50 kgs, would amount to 8.9 million tons of storage costs.




*Source: Authors' calculations*




*Source: Authors' calculations*

Based on in-depth discussions with cold store owners, several factors were identified that contributed to the boom of cold storages in these two disadvantaged districts. The triggers relate to the provision of public goods by the state government, policy reform, subsidies towards cold

storage investments by the national and state governments, and the availability and spread of new technologies.

The first trigger was a series of improvements in Bihar in the last decade in public good provision and in policy reform that created a better business environment which allowed the boom to happen. Three factors were crucial. First, deregulation of the sector seems to have given an important impetus. Key informants indicated that there were a few cold storages in both the districts in the period of 1960s through 1980s but they were hardly sufficient to meet the demand, which often led to a scramble among the farmers for space in the cold storages.[12] During the regulatory period, cold storages were supposed to be used only for seed potatoes. Each cold storage was assigned a certain number of blocks by the district horticulture department, with the number of blocks assigned to be determined by the capacity of the cold storage. Getting quota in the cold storage was an onerous task for a farmer in those days as he had to submit his land documents to the block officer who would verify his area of potato cultivation and then assign a certain quota, based on the seed requirement of the farmer.[13]

Second, Bihar has suffered from the lack of public infrastructure provision and has been ranked poorly with the rest of India on this. However, the government that came to power at the end of 2005 in Bihar has made - and is further planning - significant investments in road infrastructure, improving the marketing of agricultural products from the more remote and disadvantaged districts. Making improved road infrastructure as one of its key priorities, it was planned that the state government would spend more than 3 billion USD on road construction in three years

[12] Though Bihar was not regulated by the Cold Storage order 1964 promulgated by the Ministry of Agriculture under section 3 of the Essential Commodities Act (1955) the state had its own regulation with which it has persisted even after the Cold Storage Order was repealed by the Central Government in 1997.

[13] Before the deregulation period, Bihar had a separate Cold Storage Order, which was not governed by Central Cold Storage Order. However, one of the requirements to benefit from the national subsidy scheme provided by the National Horticulture Board (NHB) was to abolish this state Cold Storage Order. The state issued a new Cold Storage Act in the year 2003, though it had several flawed regulations including the fixing of the cold storage fees by the state government. The government of Mr. Nitish Kumar removed that clause from the Act in the year 2007 and left it to the cold storage association of each district to fix the storage fees before the beginning of each harvesting season.

(Government of Bihar, 2006). It has been estimated that between 2005 and 2009, 6,800 kilometers of roads and 1,600 bridges have been constructed (ToI, 2010).

Third, Bihar has been known for important governance issues and for a lack of law and order in the state, discouraging businesses from locating in Bihar, especially so in rural areas (World Bank, 2005). This seemed to have changed in recent years. For example, only 317 kidnappings for ransom were reported between 2006 and 2009. This compares to 1,393 in the previous four (ToI, 2010).

The second trigger was the doling out of subsidies by the Indian government in an effort to stimulate innovation in the horticultural sector. In its 1999-2000 budget, the Central Government proposed a subsidy scheme for the construction of cold storages. It is estimated that between 1999/00 and January 2005 the National Horticultural Board (NHB) provided financial support amounting to Rs 3.1 billion for the establishment of 1,242 cold storages in the country, covering 23 states (Patnaik, 2005). This expanded cold storage capacity by 4.9 million mt nationally. Uttar Pradesh accounted for the largest share in terms of additional capacity created (2.2 million mt), number of facilities (464 cold storages), and subsidies (Rs1.4 billion). Maharashtra (216,000 mt) came second and Bihar (225,000 mt) third in additional capacity created. The cold storages in Bihar started receiving the subsidies only late compared to the rest of the country, due to the reluctance of the state government to change its Cold Storage Order. On top the subsidies of the center, the new state Government gave additional incentives that seemingly stimulated the rapid diffusion of cold storages. In addition to the 25 % subsidies given by the NHB, the state government reportedly gave another 15 % subsidies, including 10% by the State Industrial Promotion Board.

The third trigger was the availability and spread of new technologies. First, the introduction of high speed compressors in the cold storage operations in the beginning of the years 2000 meant that less time was required to bring down the temperature and that electricity consumption was significantly reduced, which according to some of the interviewed owners, led to a reduction of cost of operation by almost 20 to 30 %. Second, investments were done by the research and extension system as to improve the spread of potato varieties that were apt for storage given that

the traditional red potato that was commonly grown in Bihar was much more difficult to store for longer periods than most varieties of white potato.

## 4. Role of the cold storages

### 4.1. Storage behavior

Cold storage owners were asked questions on the type of people that store potatoes in the cold storage (Table 4). About 2,245 people store potatoes in an average cold storage. Interestingly, 91% of the users of cold storages are farmers. An average cold storage contained in the last year almost 100,000 50 kg bags. Two-thirds of the stored bags belonged to farmers. 31% of the bags belonged to traders, indicating that the average quantity stored by traders is significantly higher than those stored by farmers: an average farmer would store 33 bags; this compares to 144 bags on average per trader. The number of bags stored by the cold storage owner himself is estimated to be significantly less important in total (0.3% of all the bags stored).[14]

Table 4: Characteristics of cold storages

Storage behavior is changing quickly over time. First, we see an important process of up-scaling of these cold storages (Table 4). While a cold storage was holding 4,200 tons at start-up (on average in 1996), this had increased to 6,300 tons at the time of the survey. If a cold storage was started up before 2000, its storage capacity was on average only 3,600 tons. If started up after 2000, this was as high as 5,100 tons. Second, the type of potatoes that are stored has changed. While more than two-thirds of all potato storage 10 years ago was towards seed potatoes, this has now been reduced to about half of the potatoes in storage (Table 5). The other half of the potatoes are now stored towards sales as table varieties, indicating the increasing commercialization of potato in these districts. This increase seems to lead to an increasing importance of the role of traders and cold storage owners over time in potato storage, e.g. while traders owned 8% of all stored potatoes in 1999, this share had increased to 16% in 2009.

Table 5: Evolution in storage behavior over the last decade

[14] However, he would still be considered a big trader himself as he sells double the quantity of an average trader.

## 5. Cold storages and the potato value chain

### 5.1. Farmers' participation in cold storages

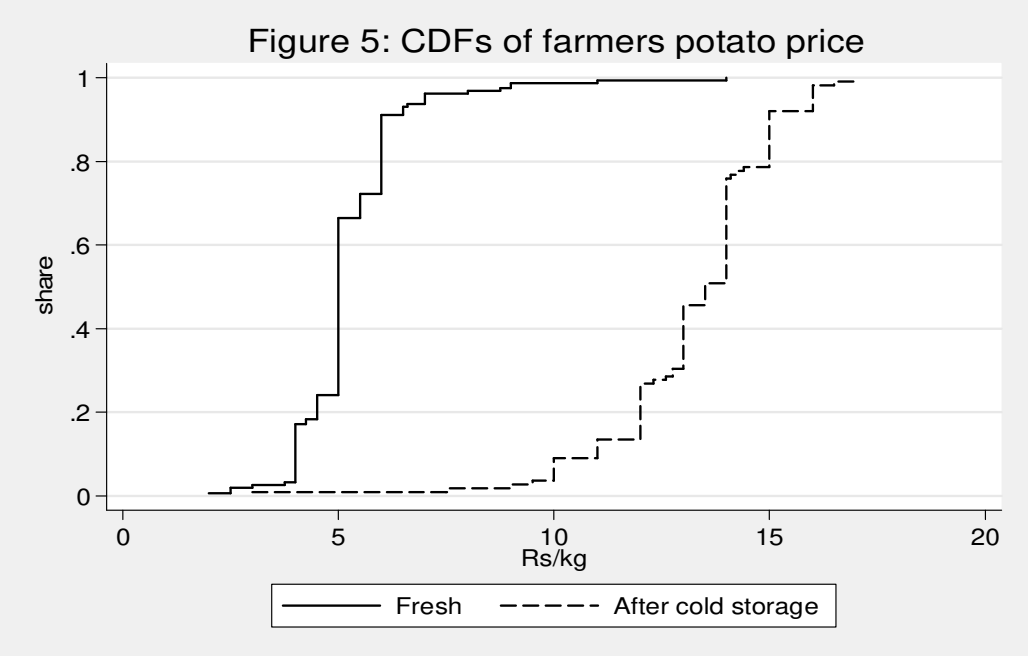
Detailed information was asked on farmers' storage behavior in the year prior to the survey (Table 6). 92% of the farmers reported that they had stored potatoes in 2009. For those who did not store potatoes, they mostly reported that they could not store because they needed money urgently after the harvest. For those that stored, they reported to have done so because they expected the price of potatoes to rise (35%) or because they were storing for seed potatoes (62%). All the farmers that stored potatoes in 2009, used cold storages to do so and it thus seems that traditional storage schemes have disappeared over time.

To understand the role of cold storages for farmers, questions were asked on the importance of reasons for choosing a cold storage. The most important reason why farmers choose a particular cold storage is linked to the distance to the cold storage as well as the quality of the cold storage. Access to input markets and financial services are judged to be less important. In the bottom of the Table, statistics are presented on the storage transactions in the year 2009. An average farmer would store 111 bags in cold storage. This would mostly be done in the month of March while the majority of the stored crop would be taken out in the month of October. Only a small minority of the farmers reported that they received inputs from the cold storage or that the cold storage owner put them in contact with a buyer. Most of the farmers stored for a combined reason of having access to seeds for the next harvest as well as sales in the off-season.

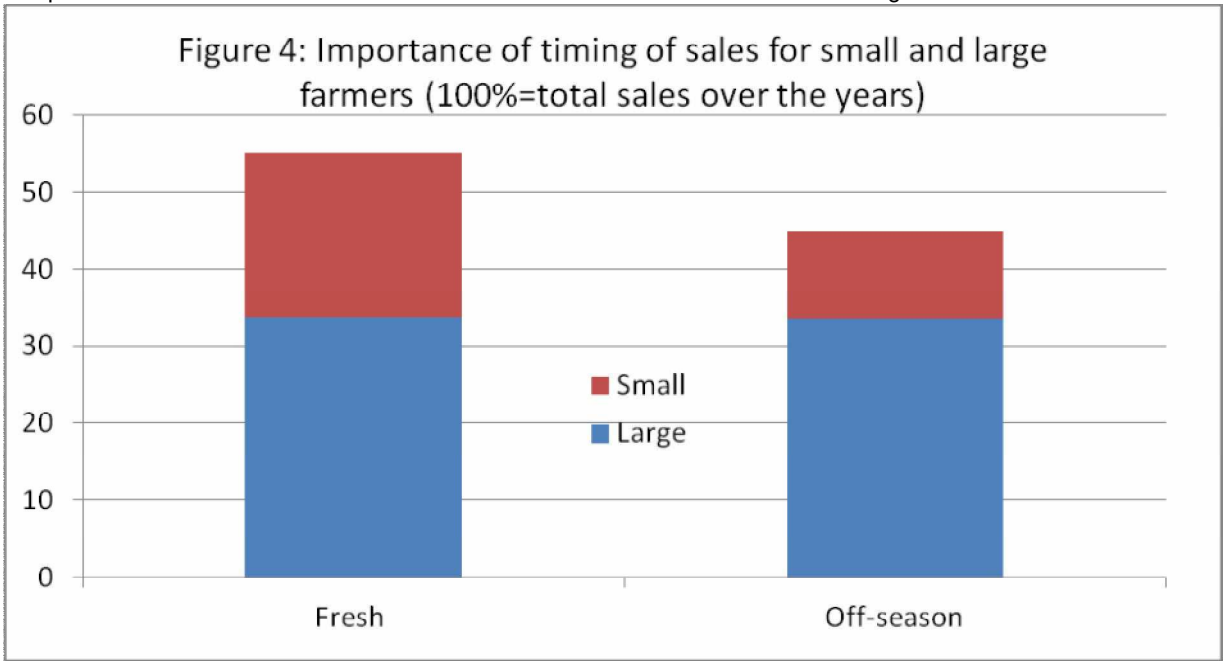
Table 6: Storage of potato farmers

We further discuss the different timings of sales and their relationship with prices obtained. Figure 3 shows cumulative density functions for sales prices in the harvest period and after cold storage. They show that the prices after cold storage dominate the harvest period prices by a significant margin over the whole domain. 96% of the reported prices at the harvest period were below 7 Rs/kg while 99% of the sales prices after cold storage were above that level in the off-season period. This shows the extent those farmers that were able to postpone sales benefited

from doing so, as the benefits of doing so seemingly far outweighs the costs (the monetary cost of cold storage is about 1.5 Rs/kg).




To illustrate how farmers spread their sales over time and who benefits from these higher prices in the off-season, we present a graph on the importance of sales for small and large farmers over the course of the year, simply aggregating sales over the (un-weighted) sample (Figure 4). About 55% of the potatoes are sold fresh (defined as the period from February until June) and 45% of the sold potatoes have gone through cold storage (from July until November). Small as well as large farmers sell a significant portion of their potatoes fresh as well as after cold storage. However, the importance of the sales in off-season is relatively more important for the larger farmers. While the quantities sold in fresh and cold period are the same for the large households, small farmers sell half of quantity of the fresh period in the off-season.



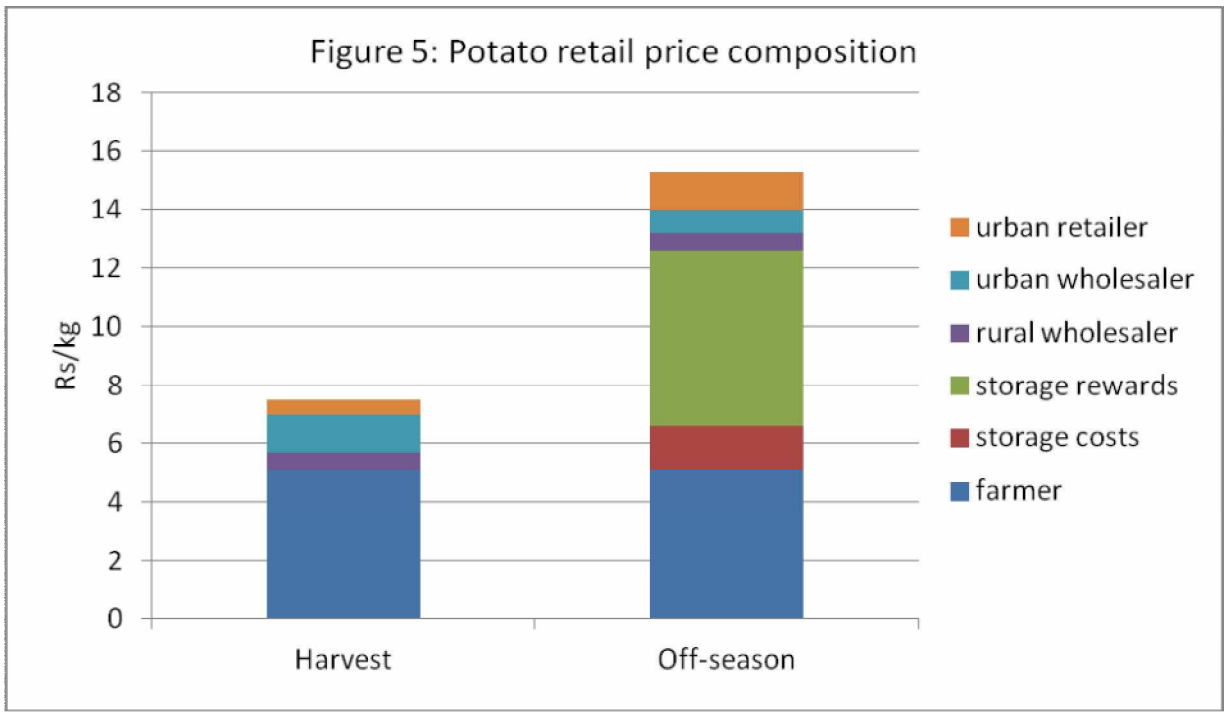

### 5.2. Cost of storage in the value chain

Questions were asked on the price evolution over the last year at different points in the value chain (producers, cold storage owners, wholesalers in urban and rural areas, and urban retailers in Patna). This information allows us to de-compose the final retail price and to evaluate the size of the margins in the value chain. Figure 5 shows the (red) potato price evolution in the 12 months prior to the survey at each level of the value chain as calculated from recall questions from a representative number of interviews at each level. As commonly is the case, prices rise after the harvest period due to storage costs and the opportunity costs of money. In the 2008-2009 season, potato retail prices in Patna rose from a low of 7.5 Rs/kg during the month of March to a high of 15.3 Rs/kg during the period of September.

It is estimated that during the harvest period, the share of the producer in the two districts interviewed in the final consumer price in Patna was 68%. The cost of marketing a kg of potatoes from producers to urban consumers was about 2.4 Rs/kg during that period. The share of producers that were willing and able to store potatoes for sales increased to 82% of the final price by the month of September when most of the potatoes that were held in cold storages are taken out. This share is significantly higher than those conventionally found in horticultural

value chains in India. This might reflect the better options that potato producers have as they are not obliged to sell immediately and this in contrast with other more perishable crops. Potatoes are also less perishable than most other fruits and vegetables.

The results further show that the storage costs are only a minor cost in the potato value chain. The costs accounted for less than 10% of the final retail price that the consumer in Patna paid for the potatoes in the off-season. A big share in the final retail is explained by the rewards to storage, accounting for 40% of the final retail price. However, it is important to note that 2009 was an exceptional year where potato prices were significantly higher than normal and thus the rewards are significantly inflated compared to a regular year.[15]




### 5.3. Wastage in the value chain

The conventional wisdom is that the traditional supply chain for staples in India is necessarily mired in high rates of wastage. For example, Mattoo et al. (2007) find that the average losses in horticulture overall and potato value chains are as high as 12% and 11% respectively. They also

[15] In a period of low prices, the high producer share in the final retail price that was observed in the survey period would also decline and the relative share of marketing costs would obviously increase.

mention that "According to one study, India wastes more fruits and vegetables than those consumed in the UK" (ibid, p. 43). Others put wastage of horticulture crops between 20% and 40% (CII/McKinsey, 1997; Mittal, 2007). In Bihar, the World Bank (2007) estimates the wastage in the potato value chain at 24%.

Several questions were included on wastage. First, farmers were asked on the responsibility on potential losses that might occur during storage. The majority of the farmers reported that they alone are responsible, even when losses during storage would exceed 10%. However, in the latter case, 31% of farmers believe that the owner of the cold storage would somehow compensate them. Compared to traditional storage schemes, there is thus in some case an insurance scheme provided by the cold storage that puts a floor under the losses that some farmers would have to bear.

Second, to get at the level of total wastages in potato value chains, we asked the different agents how much was wastage in storage, between the process of obtaining and selling potatoes, and during their last transaction when potatoes might have been transported. This gives us a reasonable approximation of the total waste in the value chain. We find that the total quantities of potatoes wasted, and not used for consumption, are equal to 8.0% in the harvest period and 9.3% in the off-season of all the quantities that enter the value chain (Table 7). Such a performance might even be better than developed countries, where quality and cosmetic criteria are more severe (Kader, 2005; Parfitt et al., 2010). While some have argued that the cuts in electricity in Bihar leads to major losses for potato cold storage, in our surveys, all cold storages have diesel generators that keep the storages cool at times of electricity cuts, at admittedly higher costs. Because of the availability of cold storages, wastage levels seem to have come down as these wastage numbers are significantly lower than those done in previous estimates (World Bank, 2007).[16]

[16] It is also important to note that transport costs of about 100 Rs/ton from producers to wholesale markets in Patna are of minor importance in the final retail price, accounting for about 1% in the final retail price. While the relatively low costs of transport is known to some, the problem that is argued to exist is that the quality of tucks and services is poor and slow, leading to high wastages (Mattoo et al., 2007). This lower importance of wastage and transport costs that we find might be due to the development of better infrastructure (cold storage and road infrastructure) but might also reflect lack of evidence in other studies on the actual situation on the ground given lack of primary data.

Table 7: Wastage in the value chain

## 6. Conclusions and policy implications

We present here the case of innovations and investments in post-harvest management and show how it is associated with important changes in traditional value chains. More in particular, we document in this study the rapid emergence of cold storages in poor disadvantaged districts in Bihar, an area characterized by a large number of smallholders. In the two disadvantaged districts that were studied, the number of cold storages in the last decade doubled in one district and tripled in the other one and rapid up-scaling of cold storages led to an even faster total capacity expansion, i.e. a triple and five-fold increase over the same period.

The spread of the cold storages in these districts has seemingly been driven by the improved provision of public goods (road infrastructure and better governance), by policy reform, by the availability and diffusion of new technologies, as well as by government subsidies. The increasing spread of these cold storages is associated with lower wastages and changes in factor markets. We thus show that market innovations, even in poor settings, can be important drivers for better agricultural performance.

The analysis illustrates how improvements in post-harvest management technologies can have large impacts on value chains. However, as there was high capacity use during a year when potato production was bad, as the prices charged were still relatively high, and as there are high profitability rates for these investments, this all points to a need for further investments in this area in Bihar as to ensure a more competitive environment that would further drive down prices. While the subsidies that were given out by the government have helped to stimulate the setting up of cold storages in Bihar, it has however not (yet) led to the lower storage costs that one would expect.

Finally, the results of our study point to several important policy implications. First, the study has shown the importance of appropriate policies as to stimulate the take-off of agricultural businesses in Bihar. These policies should focus foremost on the provision of public goods such as reliable electricity, road infrastructure, and good governance. Given the still existing large deficiencies, Bihar should make further investments in this area as to allow private business to

further flourish and to allow farmers in these disadvantaged districts to become better integrated in the market economy. Second, policy makers should further stimulate increased investments in the cold storage sector, but not necessarily through subsidies. More competition in the cold storage sector is desirable as to drive down the cost of storage. The further spread of cold storages as intermediaries in the potato value chains might also open some important opportunities towards upgrading the potato value chains as cold storages can serve as focal points for the distribution of better seed varieties, extension advice, marketing advice, etc. This could especially benefit smaller farmers who, because of liquidity constraints, are less willing to sell after storage and benefit from the higher prices off-season.

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Chapter 12 The Quite Revolution in Agri-Food Value Chainsin Asia

Table 1: Characteristics of potato farmers

| | | Statistics | |
|---|---|---|---|
| | Unit | Mean | Median |
| Number of observations | Number | 256 | |
| **Background information household** | | | |
| Age head of household | Years | 53 | 55 |
| Household size | Number | 7.4 | 7.0 |
| Gender of head of households | %male | 98 | |
| Illiterate heads of household | % | 10 | |
| **Land and assets** | | | |
| Land owned and cultivated | Acres | 2.02 | 1.29 |
| Land owned but cultivated by another household | Acres | 0.10 | 0.00 |
| Rented in land or received for free | Acres | 0.21 | 0.00 |
| Number of plots cultivated | number | 9.5 | 7.00 |
| Value of land owned | 1000 Rs | 2,660 | 1,592 |
| Value of livestock assets | 1000 Rs | 40 | 21 |
| Value of farm assets | 1000 Rs | 47 | 13 |
| **Potato activities** | | | |
| *Potato land:* | | | |
| Land owned and cultivated with potato | Acres | 0.85 | 0.55 |
| Rented in land or received for free cultivated with potato | Acres | 0.10 | 0.00 |
| Total potato land cultivated | Acres | 0.95 | 0.55 |
| Number of potato plots cultivated | number | 3.2 | 3.0 |
| Was growing potatoes ten years ago | % | 87.3 | |
| Use of potato production: | | | |
| - own consumption/seed use | % | 30 | |
| - wasted | % | 5 | |
| - sales | % | 65 | |
| - total | % | 100 | |
| Total potato sales in 2009 | ton | 5.3 | 1.7 |

Table 2: Descriptive statistics agents value chain surveys

| | Unit | Mean | Median |
|---|---|---|---|
| *Cold storage* | | | |
| Number of observations | Number | 27 | |
| Capacity of cold storage | Tons | 6,288 | 6,000 |
| Value of cold storage | 1000 USD | 1,140 | 1,064 |
| *Wholesalers* | | | |
| Number of observations | Number | 65 | |
| Quanitities procured daily | kgs/day | 635 | 170 |
| Value of assets | 1000 USD | 1.25 | 0.24 |
| Working capital | 1000 USD | 3.39 | 1.94 |
| *Traditional retailers* | | | |
| Number of observations | Number | 164 | |
| Quanitities procured daily | kgs/day | 130 | |
| Value of assets | 1000 Rs | 8.6 | 1.3 |
| Value of assets | 1000 USD | 0.19 | 0.03 |
| Working capital | 1000 Rs | 19.3 | 10.0 |
| Working capital | 1000 USD | 0.43 | 0.22 |

Table 3: Changes in the potato economy, as reported by village focus groups

| | | % of answers | |
|---|---|---|---|
| | | 1999 | 2009 |
| % of households growing potatoes | Mean | 71 | 83 |
| | Median | 70 | 90 |
| Of the potato grown in the village, | | | |
| - % white potato | Mean | 49 | 62 |
| | Median | 35 | 60 |
| - % red potato | Mean | 55 | 38 |
| | Median | 70 | 40 |
| Number of village traders that buy up potato in the village itself | Mean | 10 | 14 |
| | Median | 2 | 6 |
| % of potatoes produced in village that is stored in cold storage | Mean | 39 | 62 |
| | Median | 27 | 67 |

Table 4: Characteristics of cold storages

| | Mean | Median |
|---|---|---|
| Number of observations | 27 | |
| **Overall information** | | |
| Year of start-up | 1996 | 1998 |
| Storage capacity (in tons) | 6,288 | 6,000 |
| Storage capacity (in tons) at start-up | 4,272 | 3,500 |
| Storage capacity at start-up (in tons), if started up before 2000 | 3,672 | 3,000 |
| Storage capacity at start-up (in tons), if started up after 2000 | 5,145 | 6,000 |
| Current value of the cold storage | | |
| - millions of Rs | 54 | 50 |
| - millions of $ | 1.1 | 1.1 |
| **People that store in cold storage** | | |
| Number of farmers | 2,034 | 1,600 |
| Number of traders | 211 | 50 |
| Total number of people | 2,245 | 1,800 |
| **Quantity of potatoes stored** | | |
| Number of bags stored by farmers | 66,308 | 54,000 |
| Number of bags stored by traders | 30,368 | 19,000 |
| Number of bags stored by cold storage owner | 326 | 0 |
| Total number of bags stored | 97,003 | 93,000 |

Table 5: Evolution in storage behavior over the last decade

| | Simple average % of answers | | Weighed average* % of answers | |
|---|---|---|---|---|
| | 1999 | 2009 | 1999 | 2009 |
| **Use of potato** | | | | |
| Seed potatoes (%) | 67 | 52 | 70 | 53 |
| Table varieties for sale on market (%) | 33 | 47 | 30 | 46 |
| Processing varieties (%) | 0 | 0 | 0 | 0 |
| **Ownership of potatoes in cold storage** | | | | |
| Owned by farmers (%) | 89 | 73 | 90 | 74 |
| Owned by traders (%) | 9 | 19 | 8 | 16 |
| Owned by cold storage owners (%) | 2 | 9 | 2 | 11 |
| *: weighed by size of the cold storage | | | | |

Table 6: Storage by potato farmers

| | Unit | Small | Large | Total |
|---|---|---|---|---|
| *Storage behavior* | | | | |
| If no storage, why not? | | | | |
| - I need the money urgently after harvest | % | 88 | 82 | 87 |
| - I expected the price of potatoes to fall | % | 9 | 9 | 9 |
| - Storing is costly | % | 2 | 9 | 4 |
| - Total | % | 100 | 100 | 100 |
| If storage, why? | | | | |
| - I need the money later in the year | % | 3 | 3 | 3 |
| - I expect the price of potatoes to rise | % | 31 | 46 | 35 |
| - I store for seed potatoes | % | 66 | 51 | 62 |
| - Total | | 100 | 100 | 100 |
| % of farmers that stored and that used cold storages in 2009 | % | 99 | 100 | 99 |
| *If use of cold storage* | | | | |
| "Very important" or "A bit important" reason for choosing a cold storage | | | | |
| - Low cost storage | % | 48 | 38 | 44 |
| - Quality of storage | % | 92 | 90 | 91 |
| - Distance to cold storage | % | 92 | 90 | 91 |
| - Access to quality seeds | % | 44 | 43 | 43 |
| - Access to extension advice | % | 26 | 14 | 22 |
| - Access to chemicals | % | 20 | 18 | 19 |
| - Access to input advances before storage | % | 15 | 10 | 14 |
| - Credit given at time of storage | % | 24 | 21 | 23 |
| - Finding a buyer | % | 27 | 22 | 26 |
| *Cold storage transactions in 2009* | | | | |
| Quantity stored | Bags | 40 | 251 | 111 |
| Month of deposit (% of farmers that deposited in March) | % | 71 | 82 | 75 |
| Received input advances from cold storage | % | 1 | 4 | 2 |
| Bought potato seeds through the cold storage | % | 1 | 3 | 2 |
| Cold storage extended loan | % | 1 | 4 | 2 |
| Month taken out (% of farmers that took bags out in October) | % | 58 | 66 | 60 |
| Potatoes that were wasted during storage | % | 5.7 | 5.6 | 5.6 |
| Major use of potatoes | | | | |
| - Own seeds | % | 36 | 25 | 32 |
| - Own consumption | % | 0 | 0 | 0 |
| - Sales | % | 6 | 8 | 7 |
| - Combination | % | 58 | 67 | 61 |
| Amount paid for storage | Rs/ba | 77 | 78 | 77 |
| Cold storage put farmer in touch with buyer | % | 4 | 8 | 5 |

| Table 7: Wastages in the potato value chain | | | |
|---|---|---|---|
| | Unit | Harvest | Off-season |
| **Wastages during marketing and storage** | | | |
| Producer before storage* | % | 2.4 | 2.4 |
| Cold storage** | % | 0.0 | 1.3 |
| Producer after storage* | % | 2.1 | 2.1 |
| Rural wholesaler***# | % | 0.7 | 0.7 |
| Urban wholesaler*** | % | 0.4 | 0.4 |
| Urban retailer*** | % | 2.4 | 2.4 |
| Total wastage post-harvest | % | 8.0 | 9.3 |
| If potatoes damaged, who bears losses? If losses less than 10%? | | | |
| - Myself | % | | 97 |
| - The owner of the cold storage | % | | 2 |
| - Joint responsibility | % | | 1 |
| If potatoes damaged, who bears losses? If losses more than 10%? | | | |
| - Myself | % | | 68 |
| - The owner of the cold storage | % | | 29 |
| - Joint responsibility | % | | 3 |
| * wastage reported during marketing in last transaction | | | |
| * from farmer surveys; cold storage only; | | | |
| *** based on last transaction information | | | |
| # average of off-market and on-market rural wholesaler | | | |