Food Security in Asia and the Pacific: The Role of Smallholders

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ABSTRACT

This paper discusses the challenges and opportunities faced by small farmers in Asia and the Pacific region in raising agricultural productivity and in diversifying into high-value commodities. About 87 percent of the world's 500 million small farms (less than 2 hectares) are in this region, with China and India accounting for 193 million and 93 million of these, respectively. Small farms significantly contribute to agricultural production, food security, rural poverty reduction, and biodiversity conservation, despite their constraints with respect to access to productive resources and service delivery. More new challenges confront them: integration into high-value chains, adaptation to climate change, market volatility, and other risks and vulnerability. The small farms can benefit from high-value chains if they can receive support through intermediation (e.g., public-private cooperation to ensure food safety standards) and internalization (e.g., through producers' association to meet quality standards). New investment opportunities have emerged in agriculture, leading to large-scale investments and competition for land. Although new economies of scale (e.g., in external financing) have emerged, smallholders can enhance their competitiveness only if the biases against them (e.g., in credit) are eliminated. Governments must play an active role in coordinating the delivery of inputs, technical services, and output marketing services to small farms. They must also provide incentives to the private sector to innovate. Support is also needed to enable smallholders to adapt to climate change and market volatility.

INTRODUCTION

Small farms have been defined in a variety of ways. Many sources characterize small farms as those with less than 2 hectares (ha) of crop land. Others describe them as those depending on household members for most of the labor or those with a subsistence orientation, whose primary aim is to produce the bulk of the household's consumption of staple foods (Hazell et al. 2007). The World Bank (2003) identifies smallholders as those with a low asset base, operating less than 2 ha of cropland. An FAO study defines smallholders as farmers with limited resource endowments, relative to other farmers in the sector (Dixon, Taniguchi, and Wattenbach 2003). In this paper, small farms are those with less than 2 ha of land area and those depending on household members for most of the labor.[1] Whether inadequacy of farm income supplemented by wages necessarily implies that they are mostly net food buyers is not self-evident or generally corroborated.

About 87 percent of the world's 500 million small farms (less than 2 ha) are in Asia and the Pacific region (International Food Policy Research Institute [IFPRI] 2007), with China and India accounting for 193 million and 93 million of these, respectively. Three other Asian countries have a large number of small farms: Indonesia (17 million), Bangladesh (17 million), and Vietnam (10 million).

Usually, a sharp distinction is made between smallholders and laborers to rule out any overlap between their interests. An important point is that since smallholders earn a bare subsistence if the soil quality is poor, access to markets is limited, technology is outdated, and product mix is not remunerative, they are forced to pursue other livelihood options.

Typically, household income is supplemented by working on neighboring farms and elsewhere. The National Sample Survey (NSS) data for India in 1993–2004 support this point. For example, about 28 percent among those in the lower land interval (0–1 ha) were self-employed in agriculture in 1993 and a slightly lower proportion (over 24%) in 2004. A little under half of households in this interval (about 48%) worked as laborers in 1993 and a slightly lower proportion (about 46%) did so in 2004. Of agricultural laborers, three-fourths operated or owned land in the interval 0–2 ha in 1993 and 98 percent in 2004.

The overlap between smallholders and laborers is large, suggesting that a sharp dichotomy between them runs the risk of a false separation. Several policies designed to enhance the welfare of one would benefit the other. Higher productivity, for example, would enhance the welfare of smallholders as well as agricultural laborers.

Agriculture in Asia is characterized by smallholders cultivating small plots of land. The average size of operational holdings (actual area cultivated) is only 0.5 ha in Bangladesh, 0.8 ha in Nepal and Sri Lanka, 1.4 ha in India, and 3.0 ha in Pakistan. About 81 percent of farms in India are less than 2 ha in size, whereas their share in total cultivated area is about 44 percent (National Commission for Enterprises in the Unorganised Sector [NCEUS] 2008). In China, 95 percent of farms are also smaller than 2 ha. In Nepal, small farmers (< 2 ha) operate 93 percent of operational holdings, covering 69 percent of the cultivated area. Similarly, small farms in Bangladesh account for 96 percent of operational holdings, accounting for 69 percent of the cultivated area. Pakistan, with its relatively high concentration of large landholdings, is an

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1   With the exception of the analysis of size, marketed surplus and price in India, where land owned is measured in terms of acres instead of hectares. This was done because of a small number of observations in the size interval > 2 ha.

exception. Fifty-eight percent of its farms are less than 2 ha, but they cover only 16 percent of the total farm area; in contrast, farms of more than 10 ha occupy 37 percent of the total farm area.

Farm size in Asia has been declining over time. It decreased from 0.56 ha in 1980 to 0.4 ha in 1999 in China (Fan and Chan-Kang 2003), from 5.3 ha in 1971–1973 to 3.1 ha in 2000 in Pakistan, from 3.6 ha in 1971 to 2 ha in 1991 in the Philippines, from 2.2 ha in 1950 to 1.33 ha in 2000–2001 in India (Nagayets 2005; Government of India 2008), from 1.4 ha in 1977 to 0.6 ha in 1996 in Bangladesh, and from 3.8 ha in 1978 to 3.4 ha in 1993 in Thailand (Table 1).[2]

The Gini coefficient of land distribution is declining in India but increasing in other countries like Bangladesh, Pakistan, and Thailand. In many countries in Asia and the Pacific, unequal land access is perpetuated through social mechanisms, which leave many households belonging to indigenous peoples or ethnic minorities without access to land or with land plots too small to meet their needs.

The number of small farms and their share in total cultivated area has increased over time in some Asian countries. For example, in India, small farms accounted for almost 81 percent of operational holdings in 2002–2003 compared with about 62 percent in 1960–1961 (Table 2). Correspondingly, the area they operated also increased from about 19 percent to 44 percent during the same period (NCEUS 2008). The

Table 1. Changes in farm size and land distribution in selected Asian and Latin American countries

Country	Period	Land distribution (Gini)		Average Farm Size (ha)		Change in Total Number of Farms (%)	Change in Total Area (%)
		Start	**End**	**Start**	**End**		
Smaller farm size, more inequality							
Bangladesh	1977–1996	43.1	48.3	1.4	0.6	103	-13
Pakistan	1990–2000	53.5	54.0	3.8	3.1	31	6
Thailand	1978–1993	43.5	46.7	3.8	3.4	42	27
Smaller farm size, less inequality							
India	1990–1995	46.6	44.8	1.6	1.4	8	-5

Sources: World Bank 2007; Anriquez and Bonomi 2007

Table 2. Changes in percentage distribution of operated area by size of operational holdings in India, 1960–1961 to 2002–2003

Land class	% Distribution of Operational Holdings				% Distribution of Operated Area			
	60–61	**81–82**	**91–92**	**02–03**	**60–61**	**81–82**	**91–92**	**02–03**
Small	61.7	68.2	75.3	80.6	19.2	28.1	34.3	43.5
Medium	33.8	28.8	24.8	18.1	51.9	53.7	50.5	44.7
Large	4.5	3.1	1.9	1.3	29.0	18.2	15.2	11.8

Source: Computed from NCEUS 2008
Note: small: < 2 ha; medium: 2–10 ha; large: > 10 ha

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2   For a persuasive explanation of persistence of small farms on efficiency grounds, see Lipton (2006).

distribution of landownership in the country has become less skewed; the share of land area owned by small farms increased from 20 percent in 1961–1962 to 43.5 percent in 2003. Also, the trend toward landlessness appears to have been arrested, with the percentage of landless between 1971–1972 and 2003 remaining at approximately 10 percent. In India, the distribution of operational holdings (actual area cultivated) closely mirrors the distribution of land owned.[3]

Smallholders' contribution to the total value of agricultural output is also significant in many countries of Asia. In India, for example, contribution to total farm output exceeds 50 percent although smallholders cultivate only 44 percent of land. Many studies have also confirmed the inverse relationship between farm size and productivity. Small farmers use smaller capital but more labor and other family-owned inputs; they also generally have a higher index of cropping intensity and diversification. The inverse relationship between farm size and productivity is a powerful rationale for land reform policies, including land redistribution for both efficiency and equity gains.[4] Small farms tend to grow a wide variety of cultivars, many of which are landraces. These landraces are genetically more heterogeneous than modern varieties, offer greater resilience against vulnerability, and enhance harvest security in the midst of diseases, pests, droughts, and other stresses (Clawson 1985). More recent evidence from India confirming and elaborating the inverse size-productivity relationship in agriculture is given in the third section of this paper.

The authors' recent analyses of household data in Lao PDR and Cambodia suggest that proportions of the poor (including those below the cut-off of USD 1.25/day) are highest in the lowest size interval (< 2 ha), but regional variations exist.[5] Although there are plausible grounds for asserting that this is the most poverty-prone group (they lack access to credit, technology, and markets), firm evidence is lacking, except for a few countries in the Asia-Pacific region.

Experience shows that Asian countries that promoted small farms such as India were able to launch the Green Revolution. On the other hand, countries like China started supporting smallholder farming only after collective farms could not provide adequate incentives to increase production and productivity.

This paper discusses the challenges and opportunities faced by small farms in Asia and the Pacific region in raising agricultural productivity and in diversifying into high-value commodities. It first gives a brief account of the transformation of the agricultural sector in the region from the mid-1960s to the mid-1990s. This period was characterized by a dramatic increase in agricultural production

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3 Further investigation of this similarity requires data on leasing-in and leasing-out by size class of land owned, to which the authors did not have access.

4 Small farmers are not just more productive (per ha of land) but also exhibit higher returns per unit of investment (Lipton 2006). More interestingly, Foster and Rosenzweig (2010), based on an all-India household survey in 2006, confirm that (1) returns on investment decline rapidly with landholding size; (2) profits per acre peak at a little over 4 acres (1 ha = 2.47 acres) (the important point is that even at small landholding size the profits per acre are high, despite credit and other constraints); and (3) marginal returns to fertilizer fall as landholding size increases, further confirming efficient use of scarce inputs. Lipton (2006) also emphasizes the key role of smallholders in poverty reduction. In most areas with widespread poverty, anti-poverty paths must enhance the physical assets of the poor, their employment income, and food entitlements.

5 For details, see APR (2011), Gaiha and Annim (2010), and Gaiha and Azam (2011).

and productivity through major breakthroughs in technological innovations; the more recent transformation is characterized by significant changes in diets brought about by increases in incomes, urbanization and globalization, and the resulting changes in production of high-value commodities and major transformation in the agri-food industry. The paper then discusses the challenges faced by smallholders in addressing the problems related to sustainability of food production as well as agricultural diversification. Of particular importance in this context is responsiveness of marketed surplus of food commodities to prices. As an illustration, based on a recent household survey in India, new light is thrown on whether smallholders are constrained in marketing the outputs of these commodities. Also, two interrelated issues are examined: (1) whether large-scale investments in agriculture, especially in some of the poorest countries in Asia and the Pacific, are justified on efficiency grounds; and (2) whether complementarities between large investors and smallholders could be better exploited. Following this, the paper highlights some of the technological and institutional innovations that have been tested to address such challenges. It then discusses the policy and program support provided by selected countries in the region to small or family farms in enhancing productivity and in benefiting from emerging markets in high-value commodities. Finally, it identifies some measures that governments, the private sector, and international development partners can take to support small farmers in dealing with emerging challenges and in sharing experiences and learning from one another.

AGRICULTURAL TRANSFORMATIONS

This section briefly discusses two important transformations of the agriculture sector that have had a profound impact on the small or family farms of Asia and the Pacific region. In the first one, small farms played an important role, particularly in Asia, in raising food production and incomes based on biological, chemical, and mechanical innovations. The second transformation, which is linked to dietary transformation and high-value chains, is more recent and presents a considerable challenge as well as an opportunity for these farmers to benefit from new agriculture.

The Green Revolution

The Green Revolution in Asia, which mainly comprised a dramatic increase in the production of three important cereal crops—rice, maize, and wheat—between 1965 and 1990, was driven by rapid advances in the sciences and substantial public investments in and policy support for agriculture (Hazell 2009). This represented the first major transformation of the agriculture sector in Asia in its modern history. Cereal production more than doubled

Table 3. Changes in cereal yield and production in Asia, 1970 and 1995

	India	Other S. Asia	China	SE Asia	Developing Asia
Cereal yield (tons/hectare)					
1970	0.93	1.20	1.77	1.35	1.32
1995	1.74	1.85	4.01	2.24	2.63
% change	88.40	54.20	126.50	65.60	99.50
Cereal production (million tons)					
1970	92.80	25.40	161.10	33.80	313.20
1995	174.60	48.10	353.30	73.60	649.60
% change	88.10	89.30	119.30	117.80	107.40

Source: Hazell 2009

in Asia between 1970 and 1995, from 313 to 650 million tons (t) per year (Table 3). As a result, per capita calorie availability increased by about 30 percent and real prices of wheat and rice decreased. Higher production of all three major cereal crops was realized mainly through yield growth. Between 1965 and 1982, average annual yield of rice, maize, and wheat increased by 2.54 percent, 3.48 percent, and 4.07 percent, respectively. Meanwhile, cultivated area expanded by only 0.7 percent, 1.09 percent, and 1.3 percent, respectively.

The Green Revolution's success in raising food production and productivity, broadening economic growth, and reducing poverty had been impressive. Nevertheless, in recent years agricultural production has experienced a number of challenges that have cast doubts on the sustainability of past gains. (See next section for more details.)

Recent Agricultural Transformations

Growth in consumption and production of high-value commodities

Rapid economic and income growth, urbanization, and globalization are giving rise to a significant shift in diet in Asia and the Pacific region, away from staples and increasingly toward livestock and dairy products, fruits and vegetables, and fats and oils. Rapid income growth is a key factor in the rising demand for high-value agricultural products. In most Asian countries, urbanization is increasing rapidly and studies have shown that urban households spend more on meat, fish, and sugar and less on rice compared with rural households, even

after taking into account income and household characteristics (Minot et al. 2003).

Urbanization, rapid growth in per capita incomes, and the increase in the opportunity cost of women's time, as a result of their entry into the workforce, have led to a greater demand for non-staples, particularly perishables and processed foods in Latin American countries (Reardon, Berdegue, and Farington 2002). On the supply side, trade liberalization since the early 1980s made it easier and cheaper to import food and non-food products. It has also contributed to the growth of high-value agriculture. The reduction in import barriers in industrialized countries has favored the growth of high-value exports such as fish and seafood products. Likewise, foreign direct investment has facilitated the transformation of agricultural production in developing countries. It has helped expand food processing, animal feed production, exports, and food retailing. The entry of foreign companies into the agriculture sector has put competitive pressure on domestic agribusiness companies (Gulati et al. 2005).

Some years back, IFPRI analyzed the growth of high-value agriculture in Asia and its implications on the restructuring of the agricultural supply chain and on the role of small farmers (Gulati et al. 2006). The countries studied include the largest and most important transforming countries of Asia: Bangladesh, India, and Pakistan in South Asia; Indonesia, the Philippines, Thailand, and Vietnam in Southeast Asia; and China in East Asia.

The study documented a clear shift in food consumption from grains and other starchy staple crops such as cassava and sweet potatoes

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6 The dietary changes have significant nutritional implications. In 2000, 56 percent of all the calories consumed in developing countries were obtained from cereals and 20 percent from meats, dairy, and vegetable oils. By 2050, the contribution of cereals
is estimated to drop to 46 percent; that of meat, dairy, and fats will rise to 29 percent (*The Economist*, Special Report: Feeding the World, February 26, 2011). For discussion on a similar shift in India, see Gaiha, Jha, and Kulkarni (2010); and Kaicker, Kulkarni, and Gaiha (2011).

Table 4. Average annual percentage growth in per capita consumption of selected foods in selected Asian countries, 1990–2000

	Bangladesh	India	Pakistan	Indonesia	Philippines	Thailand	Vietnam	China
Cereals	0.2	-0.4	0.0	0.9	0.1	0.2	1.2	-1.3
Vegetables	0.2	2.1	2.2	3.3	0.0	0.5	4.9	8.5
Fruits	-1.5	2.9	0.5	1.9	0.2	0.3	1.7	10.0
Milk	0.2	1.9	3.0	5.9	1.5	5.0	13.5	5.0
Meat	1.0	0.9	0.2	0.4	4.7	1.5	4.3	6.8
Eggs	4.6	1.9	1.9	3.7	1.6	-0.4	5.8	9.7
Fish	4.7	2.0	1.6	3.2	-1.4	3.9	3.7	8.4

Source: Gulati et al. 2006 (based on FAO Food Balance Database)

to meat, milk, eggs, fish, fruits, and vegetables mainly due to income increases (Table 4). Per capita grain consumption either increased very slowly or even decreased between 1990 and 2000. In contrast, per capita demand[6] for vegetables, fruits, and animal products increased substantially in all countries.

In addition to rising domestic demand, these high-value commodities have also experienced high export demand. The share of high-value products such as fruits, vegetables, livestock products, and fish in the international trade of agricultural products is rapidly growing. The combined share of high-value exports in total agricultural exports in the studied countries increased from 47 percent to 53 percent.

Due mainly to high growth in domestic demand, and to some extent an increase in exports, the production of high-value commodities in many Asian countries has grown more rapidly than that of food grains. The annual production of food grains in the eight countries studied increased by 1.3 percent during the 1990s, slightly below the population growth rate of 1.5 percent. In contrast, the production of high-value commodities grew much more rapidly (Table 5). For example, fruit and vegetable production increased by 7.7 percent. China, in particular, achieved a very high growth rate in fruit and vegetable production. It accounted for 58 percent of the increase in global horticulture production between 1980 and 2004; 38 percent was from all other developing countries and the remaining 4 percent from developed countries (Ali 2006). India, Indonesia, Pakistan, and Vietnam also recorded an annual growth rate of more than 3 percent in fruit and vegetable production in the 1990s.

Table 5. Average annual percentage growth in production of food grains and high value commodities in selected Asian countries, 1990–2000

	Bangladesh	India	Pakistan	Indonesia	Philippines	Thailand	Vietnam	China
Grains	3.6	1.9	3.8	1.7	1.4	3.7	5.7	0.1
Fruits and vegetables	1.7	4.3	3.8	4.1	2.1	2.1	4.7	10.2
Milk	3.0	4.2	5.7	2.8	-6.5	14.8	3.5	5.8
Eggs	6.4	4.2	4.6	4.9	3.4	1.1	6.7	10.8
Meat	3.4	3.0	2.8	1.6	5.6	3.6	6.3	7.6
Fish	7.0	4.0	2.7	5.0	0.4	3.0	7.6	11.3

Source: Gulati et al. 2006 (based on FAO Agricultural and Fisheries Production Databases)

The production of livestock products also increased impressively in many Asian countries during the 1990s. Milk production grew by 4.6 percent per year in these eight countries during the period studied. Most countries also achieved high growth rates in the production of eggs, meat, and fish.

Transformation of the agri-food industry

The growth in domestic consumption and production of high-value agricultural commodities in Asia and the Pacific was accompanied by a transformation of the agri-food industry, which includes processing, wholesale, and retail. Governments contributed to this mainly through investment in municipal wholesale markets, parastatal processing firms, and state-run retail chains. However, the main new developments are private-sector investment in and consolidation of processing and retail (Reardon et al. 2009; Timmer 2009).

This transformation has three important elements. First is the restructuring of the wholesale sector, which started with the public investment phase in the 1970s–1980s in many parts of Asia and in the 1990s in China. This phase was characterized by public investment in the expansion and upgrading of wholesale markets and investment in market information systems to reduce transaction costs for small farmers to gain access to growing urban markets. In the 1990s and 2000s, more attention was paid to deregulation of wholesale markets to allow greater entry and competition.

Second is the restructuring of the processing sector. In the 1990s, private small and medium-sized processing companies grew due to liberalization in the processing sector.

This growth was facilitated by a rapid increase in the consumption of processed foods spurred by rising incomes and urbanization as well as a concomitant increase in the number of women working outside their homes.

Third is the restructuring of the retail sector, which is mainly characterized by the supermarket revolution and a rapid spread of fast-food chains in many countries of the region. The growth in supermarkets, which started in the early to mid-1990s, was driven by a massive flow of foreign direct investment and competitive domestic private investment, privatization of retail parastatals, rising incomes and urbanization, and procurement system change (Reardon et al. 2009; Timmer 2009; Gaiha and Thapa 2007b). The spread of modern retail occurred in three waves: first in East Asia outside China, then in Southeast Asia, and finally in China, India, and Vietnam. Within a given country, supermarkets first sold processed products, then semi-processed, and recently fresh produce.[7]

CHALLENGES FACED BY SMALL FARMS

Farmers face a number of challenges in producing food sustainably as well as in diversifying from cereal production to production of high-value commodities. Although some challenges affect both large and small farms, evidence shows they apply more strongly to small farms. For example, small farmers cannot take advantage of higher food prices by expanding production if they have difficulty in accessing services and credit. Similarly, when new technologies require higher capital inputs or mechanization, small farmers may be at a disadvantage unless they

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7 In a perceptive comment, Timmer (2009) points to a significant feature of the food policy agenda in this context. He observes that the food system is more consumer driven than before and that the marketing system is far more crucial as an efficient system for transmitting consumer preferences to farmers although there are fewer players in the system.

8 Subject to a caveat, as emphasized later in this section.

are helped in order to reduce their transaction costs in accessing inputs, credit, and marketing facilities.

In recent years, productivity growth of major food crops has declined quite significantly.[8] Yet, funding has shifted from public to private research, particularly in biotechnology. This change is reportedly disadvantageous to small farmers because private research companies lack incentives to address small farmers' concerns (Pingali and Traxler 2002). Also, the impacts of both environmental degradation and climate change are usually more severe for small farmers than for large farmers because the former have less access to human, social, and financial capital and information than large farmers (Hazell et al. 2007; IFAD 2011).

An important insight relates to supply response to higher food prices. The slowdown in growth rate of agricultural capital formation was in part a consequence of a long spell of unfavorable prices facing producers, resulting in capital moving out of agriculture. The incentives offered by spiraling food prices are likely to accelerate agricultural growth and dampen food price inflation.[9]

Attractive investment opportunities have opened up in agriculture, leading to large-scale investments and competition for land (e.g., rubber plantations in Cambodia, palm oil production in Indonesia, cereals in Kazakhstan)[10] New sources of economies of scale have emerged as a result of technical change (zero tillage and genetically modified organisms), new markets (contracts with supermarket chains for large, continuous, and uniform deliveries),

and institutional changes (e.g., access to international finance).[11] However, market failures (e.g., credit), institutional gaps (e.g., weak extension services), and policy distortions (e.g., minimum support prices) have frequently given advantage to large farms. Elimination of such biases against smallholders would enhance their competitiveness. State interventions and collective action by producers' organizations would make a significant difference.

A feasible option is to explore mutually beneficial complementarities between large and small farms. In cooperatives, for example, large farmers could be cast in an entrepreneurial role that enables small farmers to access technology and markets.

What follows is an analysis that throws new light on how constrained smallholders are in marketing their produce, based on a 2006 nationwide household survey in India. This analysis is essentially illustrative. Structured around a well-known and insightful model of marketed surplus, it gives new evidence on why responsiveness of marketed surplus varies by size class of land owned, own price, cross-prices of other food crops, and access to markets, among others. Although limited to India, these findings are of considerable significance, given diverse agro-climatic conditions.[12]

Size, Marketed Surplus, and Price

To serve as a backdrop to the analysis, a distillation of available evidence on market arrivals and size of holdings in India is given below. Many of the important contributions

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9 For details, see Imai et al. (2011).

10 For details, see Deininger and Byerlee (2010).

11 Many land concessions in Lao PDR and Cambodia—two of the poorest countries in Asia and the Pacific—were withdrawn either because there was the lack of transparency in granting them or because no investment was made. For details, see Gaiha and Annim (2010), Gaiha and Azam (2011), and APD (2011).

12 Ideally, similar applications to other countries would have been more helpful but data and time constraints precluded them.

were based on farm management studies and cost of cultivation surveys carried out by Krishna (1995a; 1995b; 1995c), Bardhan (2003), P. Bardhan and K. Bardhan (2003), and more recently Kanwar (2006). The insights from these studies are highly relevant in the context of rising food and oil prices and their implications for the rural poor.

One important finding relates to the price response of marketed surplus of food grains. P. Bardhan and K. Bardhan (2003) first specified a theoretical model of farmers' food grain marketing decision, positing that in the production decision the relevant prices are those of food grains relative to competing crops and agricultural inputs; whereas in the consumption decision, the relevant prices are those of food grains relative to competing consumption good(s), including manufactured consumables. They concluded that the marketed surplus of grains is higher when the relative cereal price is higher; conversely, it is lower when the relative price of commercial crops is higher. The intuition underlying these results is that when the relative cereal price is high, more is marketed as less is consumed; when the relative price of commercial crops is high, marketed surplus of grains is lower because of switching of acreage.

The analysis given here builds on the literature by using a recent all-India Rural Economic and Demographic Survey (REDS) conducted by the National Council for Applied Economic Research in the country's 17 states in 2006.[13] However, since the household and village data are being subjected to consistency checks, the results of this analysis are not to be treated as definitive. The sample consists of 5,695 households in the 17 states. The researchers worked with smaller samples because outliers had to be eliminated.

The analysis focused on marketed surplus (amount marketed divided by crop output) by size of land owned. As the entire land data are in acres, for analytical convenience the households were grouped into cultivating < 2 acres (small), 2–5 acres (medium), and > 5 acres (large).[14] Since the groupings vary in terms of soil condition and whether irrigation is used, they are essentially a first order of approximation. Although recent cross-country evidence confirms robustly a positive supply response of food commodities to prices, the present analysis seeks to extend it by analyzing the responsiveness of market surplus of various commodities to their own prices by size of land owned.[15]

Another contribution of this analysis is that it disaggregates food commodities into four groups: cereals, pulses, oil seeds, and vegetables. As the consumption basket has changed in recent years, as illustrated earlier, it is worthwhile to examine whether smallholders are responding to the high-value chains (e.g., by producing and marketing more high-value commodities such as oil seeds and vegetables in response to market prices).[16]

In a broad brush treatment, farming households are distributed as (1) small, medium and large; (2) shares of land irrigated; (3) proportions using fertilizers; and (4) access of sample villages to rural infrastructure. About

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13 The states include Tamil Nadu, Kerala, Karnataka, Maharashtra, Gujarat, Rajasthan, Punjab, Haryana, Uttar Pradesh, Bihar, Jharkhand, West Bengal, Orissa, Chhattisgarh, Madhya Pradesh, Himachal Pradesh, and Andhra Pradesh.

14 With the observations on large farms, it was not feasible to use a classification in hectares.

15 For details of the cross-country evidence, see Imai et al. (2011).

16 In fact, evidence has accumulated pointing to a dietary transition in India. For details, see Kulkarni and Gaiha (2010) and Gaiha, Jha, and Kulkarni (2010).

three-fourths of the sample households are small landholders, about 15 percent are medium, and just under 10 percent are large. About 57 percent of smallholders' land is irrigated; the figures for medium and large landholders are slightly lower. However, more than half of the total irrigated land belongs to large landholders; smallholders account for less than one-fifth of the area.

Given the cost of fertilizer, it is not surprising that the fraction of farmers *not* using fertilizers is highest among smallholders— in fact, it is nearly three times higher among smallholders than large landholders.[17] Two striking features with respect to the educational attainment of household heads are that (1) the proportion of illiterate household heads is highest among smallholders and lowest among large landholders, and (2) the proportion with more than 10 years of schooling is lowest among smallholders and highest among large landholders. As access to new technology and markets with more remunerative prices are positively linked to educational attainment— admittedly, these links have weakened somewhat with advances in information and communication technology (ICT), smallholders are at a disadvantage.[18]

Annex Table 1 describes access to different forms of rural infrastructure. Unfortunately, the context is the village, not household. Hence, the analysis was unable to capture inequity in access by size of holding. Subject to this caveat, it is noted that village access varies enormously depending on the type of infrastructure. About 72 percent of the villages had a *pacca* road and about 70 percent had a telephone facility. On the other hand, more than half of the villages had access to a wholesale agricultural product market at a distance of more than 10 kilometers (km); about 48 percent of them had access to an input store at a distance exceeding 5 km, whereas about 35 percent had access within < 5 km, about 41 percent of the villages had access to banks within < 5 km whereas about 33 percent had access within 5–10 km. As access to the nearest town makes a difference to marketing of output and purchase of input options, it is of some concern that the nearest town for over 43 percent of the villages was at a distance of >10 km.

Investment in rural transportation and other facilities (e.g., banking, communication, storage) is likely to make agricultural markets more efficient and more beneficial to the poor. Evidence for other Asia and Pacific countries points in the same direction (Gaiha et al. 2009).

Crop Yields by Size

As a *descriptive* technique, distributions of crop yields by size were approximated using kernel density functions. Relative to histograms, these are smoother and not influenced by the end points of bins.[19]

Kernel densities of cereal yields among smallholders are unimodal, with a cluster around moderately high values; the densities among medium landholders are unimodal, too, with the cluster at slightly lower yields than among smallholders (Annex Figure 1.1). On the other hand, the densities among large landholders are bimodal, with clusters at low and moderately high yields.

For pulses, kernel densities are bimodal among both large and smallholders, with

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17 This should not be taken to imply that fertilizer use does not vary by crop.

18 See, for example, Byerlee, de Janvry, and Sadoulet (2010).

19 The underlying distribution is Gaussian. For a lucid exposition of why kernel densities are to be preferred to histograms, see Deaton (1997).

very different clusters of yields; among the latter yields cluster around very low and large values, while among the former the clusters are around very low and slightly larger values (Annex Figure 1.2). In striking contrast are the unimodal densities among medium landholders, with a cluster around low yields, but skewed to the right, implying that many obtain low yields while others obtain moderate to high yields.

For vegetables, kernel densities are bimodal among all three size groups (Annex Figure 1.3). Yield clusters among smallholders occur at moderate or high values, with a few obtaining very high yields; among medium landholders they occur at moderate or high values. Large landholders, on the other hand, have yield densities with clusters at low and moderately high values.

For oilseeds, the kernel densities are unimodal among large landholders, with a cluster of yields at low values (Annex Figure 1.4). Those among medium landholders, by contrast, are bimodal, with clusters at low and moderately high yields. While the kernel densities are bimodal also among smallholders, the clusters occur at low and very high values.

In short, the analysis confirms the generalization that has dominated the size-productivity debate: smallholders are more productive. The descriptive analysis suggests, however, that this relation varies with food commodity group (not so strong, for example, in cereals). Moreover, while much lower fractions of smallholders are concentrated in lower yield ranges compared with medium and large landholders, segments of smallholders also obtain very low yields (for example, in oilseeds).

Determinants of Marketed Supply

The specification used and the results are given in Annexes 2A and 2B.

Cereals[20]

The Tobit results on the marketed surplus of cereals are given in Annex Table 2B.1. The main findings are the following:[21]

1. The higher the household head's schooling, the higher is the marketed surplus of cereals.
2. Lower caste households—the Scheduled Castes (SCs) and Other Backward Castes (OBCs)—market lower fractions relative to Others (the omitted group), presumably because of discriminatory practices in output and credit markets.
3. Controlling for these and other effects, small landholders marked significantly lower proportions than large landholders (the omitted group), and these proportions are substantially lower.
4. The higher the price of cereals, the larger is the marketed surplus. The elasticity of marketed surplus of cereals to its own village price is about 0.39, implying that a 1 percent price increase is likely to induce a 0.39 percent increase in marketed surplus.
5. The cross-price effects are statistically but not economically significant. The higher the price of oilseeds, the higher is the marketed surplus of cereals. However, the elasticity is low (0.02). The interaction effect of prices of oilseeds and vegetables is negative but with a low elasticity (-0.01).

20 Out of 5,694 observations in the sample, the uncensored were 2,791. The use of a Tobit is thus justified taking the size of land owned as predetermined.

21 As the log of a variable has a monotonic relation to the values of the variable, use of log was avoided for expositional convenience.

Annex Figure 2B.1 points to a quadratic relationship between predicted marketed surplus and land size.

Pulses[22]

The regression results for pulses are given in Annex Table 2B.2. The main findings are the following:

1. The household head's schooling does not have a significant positive effect on marketed surplus of pulses.
2. The caste affiliations matter, as both SCs and Scheduled Tribes (STs) market lower proportions of pulses produced.
3. Smallholders and medium landholders market significantly lower proportions than large landholders.
4. Controlling for these effects, the price of pulses and marketed surplus are positively related, with elasticity of 0.35 (slightly lower than that of cereals). This implies that if cereal price rises by 1 percent, the marketed surplus rises by 0.35 percent.
5. The cross-price effects of cereals and oilseeds are negative, with a larger (absolute) elasticity of cereals (-0.16) relative to that of oilseeds (-0.05). These results imply that there are significant production substitutions and lower marketed surplus of pulses in response to changes in relative prices.

Annex Figure 2B.2 points to a quadratic relationship between predicted market surplus and land size.

Vegetables

The sample of households that grew vegetables was small (283). The main findings from Annex Table 2B.3 are:

1. The household head's schooling and marketed surplus of vegetables are positively related.
2. ST households market significantly lower fractions than Others.
3. Smallholders market a significantly lower proportion of vegetables than large landholders.
4. Controlling for these effects, the price has a robust effect on marketed surplus. The elasticity is 0.14, implying that a 1 percent price increase induces a 0.14 percent increase in marketed surplus.
5. The higher price of pulses, however, induces a lower marketed surplus but the (absolute) value of the elasticity is low (-0.016).
6. In another specification without price of cereals, the longer the distance to a wholesale market, the lower is the marketed surplus. This is highly plausible as, given the lack of cold storage facilities, vegetables cannot be marketed over long distances. The elasticity is 0.09, implying that a 1 percent increase in distance to the nearest market results in a 0.09 percent decrease in marketed surplus.

Annex Figure 2B.3 suggests an almost flat linear relation between predicted marketed surplus of vegetables and land owned.

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22 The uncensored observations were 634.

Oilseeds

The Tobit results for oilseeds (the household sample was only 601) are given in Annex Table 2B.4. The main findings are:

1. Somewhat surprisingly, the household head's education is not linked to marketed surplus of oilseeds.
2. SCs market lower fractions but STs market higher fractions (relative to Others).
3. Both small and medium landholders market lower fractions of their output than large landholders, especially the former.
4. Controlling for these effects, there is a significant positive price effect on marketed surplus of oilseeds. The elasticity is 0.28, implying that a 1 percent price increase induces a 0.28 percent increase in marketed surplus.
5. The cross-price effect of cereals is significant with a negative sign and a moderately large (absolute) elasticity (-0.14). This further corroborates production substitution and lower marketed surplus.

Annex Figure 2B.4 suggests that a quadratic equation fits the relationship between marketed surplus and land owned.

In short, the analysis confirms the important own price effects on marketed surplus of each of the four food commodity groups: cereals, pulses, vegetables, and oilseeds However, elasticities with respect to own price vary, with the highest for cereals, followed by pulses and then oilseeds. For vegetables, easier access to markets matters, given the lack of cold storage facilities. There is also evidence of cross-price effects, implying production substitutions and changes in marketed surplus. Education of household head matters also in two commodity groups. To the extent that education enables access to new technology and market prices, it is also positively related to marketed surplus. In all four cases, smallholders are associated with lower marketed surplus. The analysis, however, could not throw light on whether smallholders market lower fractions because they receive lower farm gate prices and/or because their access to markets is more constrained.

Declining Productivity Growth

A number of studies have confirmed a slowdown in productivity growth in cereal crops such as rice and wheat in major irrigated areas of Asia such as the Indo-Gangetic plain and East Asia (Bhandari et al. 2003; Pingali, Hossain, and Gerpacio 1997). For example, rice yield growth in irrigated areas of Asia declined from 2.31 percent per annum in 1970–1990 to 0.79 percent in 1990–2000 (Hossain 2006). The major reasons for this decline include the displacement of cereals on better lands by more profitable crops, diminishing returns on modern varieties when irrigation and fertilizer use are already at high levels, and the recent low price of cereals relative to input costs, making additional intensification less profitable (Hazell 2009). In intensive monocrop systems such as the rice-wheat system of the Indo-Gangetic plains, deteriorating soil and water quality is an important problem; degradation of

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23 This is not as worrying as it may seem, as population growth is slowing and yields of some crops, notably maize, are still rising at a modest pace. More importantly, as a recent study (Fuglie 2010) demonstrates, growth in yields has slowed as farmers are cutting inputs for environmental reasons or simply because they are more concerned about quality than quantity. Farmers' productivity is still rising at a healthy 1.4 percent per annum but it needs to rise to 1.75 percent per annum (*The Economist,* February 26, 2011).

soils and buildup of toxins have been reported in intensive paddy systems in several Asian countries (Pingali, Hossain, and Gerpacio 1997; Ali and Byerlee 2002).

Researchers have documented stagnating or even declining levels of total factor productivity (TFP) in some of these production conditions (Janaiah, Otsuka, and Hossain 2005). An analysis of data from long-term yield trials in several countries in South Asia found stagnating or declining yield trends in rice and wheat when input use was held constant (Ladha et al. 2003). One reason for slow yield growth has been reported to be pest and disease resistance of modern varieties to chemical pesticides.[23]

Although these findings are informative, an important recent contribution offers a new perspective, based on careful calculation of TFP growth for a large sample of countries and over a very long period (Fuglie 2010). Briefly, in developing regions, productivity growth accelerated in the 1980s and in the subsequent decades. Input growth slowed but remained positive. China has sustained exceptionally high TFP growth rates since the 1980s. A few other countries and sub-regions in Asia and the Pacific have performed well also. TFP performance is strongly correlated with national investments in "technology capita"—a measure of a country's ability to develop and extend improved technology to farmers.[24]

Environmental Problems

Poor water management in many Asian countries has resulted in land degradation in irrigated areas through salinization and waterlogging. Almost 40 percent of irrigated land in dry areas of Asia is estimated to be affected by salinization (Millennium Ecosystem Assessment 2005).

Inappropriate use of fertilizers and pesticides has led to water pollution and damage to larger ecosystems, where excess nitrates from agriculture enter water systems. Fertilizer nutrient runoff from agriculture has become a major problem in intensive systems of Asia, causing algal bloom and destroying wetlands and wildlife habitats.

Serious soil and water degradation has taken place in the rice-wheat system of India and Pakistan due to intensive and continuous monoculture of rice in summer and wheat in winter (Ali and Byerlee 2002; WDR 2008). The effects of soil nutrient mining, salinization, and declining organic matter have been exacerbated by the depletion of groundwater aquifers, buildup of pest and weed populations, and resistance to pesticides.

Land and Tenure Security

In many countries of the region, marginalization is linked to lack of access to land and land-use rights. Improving poor people's access to land is important to improve equity as well as production, as small farms tend to be more productive than large farms (Lipton 1993, 2006). The political prospects for redistributive land reform are not bright for many developing countries. Also, land has become scarce as rapid urbanization is reducing the area available for agriculture (Cassman et al. 2003). Crop land per capita of agricultural population is only 0.23 ha in East Asia and the Pacific and 0.27 ha in South Asia, compared with 0.48 ha in Sub-Saharan Africa, 0.74 ha in the Middle East and North Africa, 1.55 ha in Latin America and the Caribbean, and 3.53 ha in Europe and Central Asia.

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24 For further details, see APD (2011) and Fuglie (2010).

Some aspects of land reform, such as the extension of tenurial security, may be less difficult to implement than other aspects, such as land ceilings. Tribal development projects in India supported by the International Fund for Agricultural Development (IFAD) illustrate the importance of security of tenure. For example, the Orissa Tribal Development Project provided tribal groups titles to land above 10 degrees in slope. Land occupied by tribal groups became transferable to women in the form of inheritable land titles in perpetuity. Such land titling provided incentives due to clear property rights and led to major improvements in natural resource management.

In socialist countries like China and Vietnam, land tenure reform has led to significant increases in agricultural production and rural poverty reduction. In accordance with the *Doi Moi* reform policy, Vietnam converted its agricultural collectives in 1988 to contract land to households for 15 years for annual crops and 40 years for perennial crops (Kirk and Nguyen 2009). This reform, together with the relaxation of price controls and the opening up of domestic and international trade, promoted entrepreneurship and productivity. Vietnam passed a Land Law in 1993, which extended land tenure to 20 years for annual crops and 50 years for perennial crops. These reforms generated strong incentives to invest in agriculture, which led to greater food security and better nutrition. Land transactions increased greatly as a result of tenure reforms. The country has an active land market, with the number of households participating in land transactions increasing from 3.8 percent in 1993 to 15.5 percent in 1998. Land sales are not allowed, but with more

secure land rights many farmers have diversified their production into aquaculture, livestock, and perennial crops such as coffee and cashew. In China, land rentals have contributed to rural diversification and income growth. Similarly, in Cambodia, land titles raised rice productivity and reduced rural poverty (Gaiha and Azam 2011).

An analysis of land reforms in India by Deininger, Jin, and Nagarajan (2009) using a 20-year panel (1981–1999) of household data for rural India yields useful insights into their effects. First, by allowing households to increase investment, land reforms had a positive impact on accumulation of both human and physical assets. Partly through this channel, land reforms promoted growth.[25] Second, the benefits to the poor were disproportionately large, implying a positive impact on equity. Third, the impact of reforms declined with time: land transfers have come to a virtual standstill in recent years, emphasizing the need for more imaginative approaches that take note of existing opportunities to access land, the obstacles preventing such access, and the potential economic returns from land compared with the alternatives.

Water Shortages

In much of Asia, the demand for water for both agricultural and non-agricultural uses is rising while water is becoming acutely scarce, thus limiting the future expansion of irrigation.[26] Irrigated food production in large areas of China and South Asia is being maintained through unsustainable extraction of water from rivers or the ground (UNDP

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25 Tenancy reforms and ceilings have significant and positive (reduced form) effects on income, consumption, and assets, with the former yielding stronger effects (Deininger, Jin, and Nagarajan 2009).

26 Water shortage may be aggravated by dietary shift toward meat. It takes 1,150–2,000 L of water to produce 1 kg of wheat but about 16,000 L of water for 1 kg of beef. As more people eat more meat, rising demand by farmers will be pitted against contracting water supplies (*The Economist*, February 26, 2011).

2006). The expansion of tube well irrigation in South Asia has resulted in serious overdrawing of groundwater and falling water tables. In the agriculturally advanced states of India (Haryana, Punjab, Rajasthan, and Tamil Nadu), more than one-fifth of groundwater aquifers are overexploited (World Bank 2007). As a result, water pumping has become difficult and too costly.[27] The most affected are small farmers, who have little access to expensive pumps and often have insecure water rights.

In Asia, particularly in South Asia, the area of land irrigated by large-scale surface schemes has been declining since the early 1990s. For example, between 1994 and 2001, India and Pakistan together lost more than 5.5 million ha of canal-irrigated areas, despite very large investments in rehabilitation and new projects (Mukherji et al. 2009), partly due to irrigation-induced soil salinity and waterlogging.

Diversification

Small farmers have the potential to raise their incomes by switching from grain-based production systems to high-value agriculture. The production of high-value agriculture is labor-intensive and thus more suitable for smallholders, however, they face a number of constraints. Since high-value agricultural commodities are perishable and their markets are fragmented, their prices are highly volatile, posing high market risk. In addition, small farmers have low volumes of marketable surplus and their farms are mostly located in remote areas with poorly developed infrastructure. Thus, they face high transaction costs and risks

in producing and marketing such commodities, especially with the stringent food safety and quality standards. They also have poor access to credit.[28]

Although growth of urbanization and rising incomes fueled the growth of a diversified agricultural sector and integration into high-value chains linked to supermarkets in some parts of Asia and the Pacific region, following the food crisis, there is evidence of eroding trust in markets allocating food supplies in countries worst affected and heightened concerns for self-sufficiency in food staples. Manifestation of such concerns (reflected in protectionist policies toward rice in particular) runs the risk of slowing down diversification of agriculture.

Impact of Climate Change

Researchers predict that climate change will have serious consequences to agriculture, particularly to smallholders in poor developing countries. In tropical countries, even moderate warming (1°C for wheat and maize and 2°C for rice) can significantly reduce yields because many crops are already at the limit of their heat tolerance (World Bank 2007). In parts of Asia and Central America, wheat and maize yields could decrease by 20–40 percent as the temperature rises by 3–4°C, even if farm-level adjustments are made to accommodate higher average temperatures, such as changing the seeding date or planting drought-resistant varieties (Long et al. 2007). Rice yields would also decline, although less than wheat and maize yields.[29]

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27 In Punjab (an Indian state), the water table has plummeted from a couple of meters below the surface to, in parts, hundreds of meters down (*The Economist*, February 26, 2011).

28 As noted, although yields of food crops are higher among smallholders, the fact that they market substantially lower fractions of their outputs suggests that lack of easy access to credit and markets are major impediments.

29 Some researchers point to the fact that the projections of crop yield losses made by different climate change models may be overestimated, as they tend to be based on cereal monocrops with high rates of chemical fertilizer use.

Agriculture in low-lying areas will be adversely affected by flooding and salinization due to sea level rise and salt water intrusion in groundwater aquifers. Due to decreasing snow cover over time, water scarcity will increase in areas such as Nepal and parts of China and India, where glacial melt is an important source of irrigation water.

In an unpleasant taste of what climate change may do, during the 2010 summer the jet stream (air currents of 7,000–12,000 meters above sea level which affect the winds and weather) changed its course. This phenomenon was linked to catastrophic floods in Pakistan and forest fires in Russia, resulting in spiraling food prices later in 2010 (*The Economist*, February 26, 2011).

Both mitigation and adaptation measures are necessary, with greater emphasis on the latter. As the "world's appetite for emissions reduction has been revealed to be chronically weak," it is imperative "to find ways of adapting to many possible future climates" (*The Economist*, November 25, 2010).

Adaptation calls for not just expanded research into improved crop yields and tolerance of temperature and water scarcity, but also research into management of pests, soil conservation, and cropping patterns that enhance their resilience.[30] There is also a case for weather insurance that will pay not when crops fail but when specific climatic events occur (e.g., rainfall below a set level).[31]

Strategies of adaptation by smallholders raise specific concerns because these farmers are likely to suffer impacts of climate change that are locally specific and hard to predict. As such, the variety of crop and livestock species they produce and the importance of non-market relations will increase the complexity of both the impacts and the subsequent adaptations relative to commercial farms with more restricted ranges of crops. Although small farm sizes, low technology, low capitalization, and diverse non-climate stressors (e.g., population driven land fragmentation, limited access to markets) add to their vulnerability, their existing patterns of diversification away from agriculture and store of indigenous knowledge impart greater resilience (Morton 2007).

Risk and Vulnerability

Smallholders face a number of individual risks (e.g., disease, injury, and death of animals) and common or aggregate risks (e.g., drought, epidemic, and economy-wide shocks), affecting everyone in the locality. These risks can have extremely severe consequences, potentially leading to malnutrition, disease, starvation, or even death. As a result, managing and coping with risks are an integral part of the daily lives of poor rural people.

In addition, there has been a concern that the recent successes of market-oriented policy reforms (e.g., in India and China) or the advance of globalization may have further increased the degree of potential income fluctuations, thereby exacerbating the already precarious position of poor rural people, comprising principally of landless and small farmers (Dercon 2005). Evidence points to high vulnerability of small farmers in the semi-arid region of south India to crop shocks. Worse, they are occasionally subject to a series of such shocks, making it harder for them to escape persistent poverty

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30 For details, see Gaiha and Mathur (2010).

31 For a review of weather-based insurance, see Gaiha and Thapa (2006).

(Gaiha and Imai 2004). Other evidence from the Philippines, Bangladesh, and Cambodia confirm the significant effects of natural hazards (e.g., El Niño in the Philippines, floods in Bangladesh; droughts, floods, and windstorms in Cambodia) on various indices of poverty and anthropometric measures of undernutrition.[32] Disasters often disrupt food production, resulting in loss of livelihoods and in higher food prices. Finally, poor rural people not only lose assets, they also lack access to risk-sharing mechanisms, such as insurance. It is therefore not surprising that disasters substantially increase poverty levels (e.g., 50 percent of the increase in the incidence of poverty in the Philippines during the 1998 crisis was due to El Niño). Although the devastation is seldom confined to the poorer segments (including small farmers), in the absence of easy access to credit and insurance, they find it harder to recover their previous standard of living (Jalan and Ravallion 2001).

Although there is an overlap between poverty and vulnerability to poverty, with a diverse pattern both *within* and *between* countries where evidence exists, a useful insight is that poverty and vulnerability are *distinct*. Thus, interventions designed to target the latter must differ from those designed for the former. Specifically, more careful attention must be given to risk mitigation and coping in dealing with vulnerability to poverty, especially in rural areas.

OPPORTUNITIES FOR HIGHER PRODUCTIVITY, HIGHER INCOMES, AND SUSTAINABILITY

This section discusses technological as well as institutional innovations that enable small or family farms to raise agricultural productivity

sustainably and to increase incomes by accessing emerging markets for high-value commodities.

Technological Innovations to Address Environmental Problems and Yield Growth

To address concerns about the sustainability of Green Revolution technologies and their ability to benefit poor farmers, particularly in less-favored areas, many are advocating new technological approaches (e.g., Pender 2008). These include low external input and sustainable agriculture approaches based on ecological principles of farming; organic agriculture based on a similar set of agro-ecological principles but without the use of artificial chemical fertilizers, pesticides, or genetically modified organisms; and biotechnology. Although biotechnology and agro-ecological approaches seem to be in opposition to one another, both approaches focus on biologically-based rather than chemically-based technologies, and there may be potential for realizing complementarities between these approaches. In fact, it has been argued that a combination of ecological and biotechnology approaches is needed to bring about a "Doubly Green Revolution" (Conway 1997). Others have argued that integrated agricultural and natural resource management innovations that combine improved germplasm (using both conventional methods and biotechnology) and improved and integrated management of soils, water, biodiversity, and other natural resources are needed (CGIAR 2005).

Conservation agriculture/zero tillage

Zero tillage is seen as a technology that can address the declining productivity growth of the

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32 See, for example, Gaiha and Azam (2011) for a robust confirmation of how natural hazards aggravate rural poverty in Cambodia.

rice-wheat system in the Indo-Gangetic plain. It is promoted by the Rice-Wheat Consortium, a partnership of the Consultative Group on International Agricultural Research (CGIAR) centers and national agricultural research and extension system and with the support of IFAD and other development partners. It involves planting wheat immediately after rice, without tillage, so that wheat seedlings germinate using the residual soil moisture from the previous rice crop. Zero tillage has been reported to have many advantages over conventional tillage in the rice-wheat system. It saves on labor, fertilizer, and energy; minimizes planting delays between crops; conserves soil; reduces irrigation water needs; increases tolerance to drought; and reduces greenhouse gas emissions (Erenstein et al. 2007).

Organic agriculture

Organic agriculture is a specific type of low external input whose requirements are more restrictive—no use of chemicals or genetically modified organisms. Based on certification, price premiums of 10–50 percent are common for developing country exports of organic products (IFAD 2005). Organic farming has increased rapidly in many Asian countries in the past few years. In 2000–2002, about 60,000 farms were producing certified organic products on about 600,000 ha. This increased to more than 90,000 farms on more than 3.8 million ha in 2005–2006 (Pender 2008). China, India, and Indonesia are the major organic producers in Asia.

Several studies have shown favorable impacts of organic agriculture on the costs of production and yields (IFAD 2005; Reunglertpanyakul 2001). However, adoption of organic farming has several constraints. Profit margins usually diminish due to increased competition, and organic producers may face greater market risks as the sector grows.

Perhaps the most important concern among small farmers relates to the costs of certification and assuring compliance with organic standards. These problems can be addressed by developing farmer organizations at the local level and through efforts by outside agencies to develop local capacities and facilitate linkages to markets.

Biotechnology

Broadly defined, biotechnology includes a wide variety of techniques, from traditional methods such as conventional plant and animal breeding to more modern techniques such as tissue culture, embryo transfer, cloning, breeding using marker-assisted selection, genetic engineering of plants or animals, and genomics (ADB 2001). In current literature, the term "biotechnology" is used to refer to modern agricultural biotechnology; it is used synonymously with "genetic engineering." Biotechnology is reported to have the potential of incorporating many traits in crop varieties that can address problems faced by smallholders, such as drought resistance, disease and pest resistance, yield improvement, and quality improvement.

Since 1996, there has been a rapid adoption globally of a few genetically modified (GM) crops. Among Asian countries, an estimated 6.4 million small farmers in China (on an average area of 0.5 ha) and 1 million small farmers in India (on an average area of 1.3 ha) were growing Bt cotton by 2005, whereas more than 50,000 farmers in the Philippines (on an average area of 2 ha) were growing Bt maize (Pender 2008). Studies have shown that Bt cotton has contributed to increasing yields, reducing costs of production, increasing farmer incomes, and reducing negative health and environmental effects of high pesticide use, particularly in China (Smale et al. 2006; Huang et al. 2002).

Other studies conducted in India have also reported reduced pesticide use and increased yields (Bennett et al. 2006; Qaim et al. 2006).

Genetically modified cotton has been adopted by large numbers of smallholders in China and India, indicating that the technology can be adopted equally by large and small farmers. Its adoption confirms the ability of smallholders to adopt new technologies, although there may be lags due to considerations of costs and risks. The dissemination of biotechnology to developing countries is inhibited by intellectual property rights issues, the lack of interest of multinational corporations in investing in the development of genetically modified crops in poor countries and less-favorable areas, difficulties in establishing public-private partnerships, and the lack of investment and leadership in biotechnology by international agricultural research centers (Pender 2008).

Institutional Innovations for Productivity Enhancement and Diversification

Although smallholders face formidable challenges, a number of innovative institutional models are emerging that can help them benefit from the 'new agriculture' dominated by value chains. These include the development of farmer/producer organizations for marketing, the promotion of contract farming, the development of supply chains for high-value exports through an appropriate mix of private- and public-sector initiatives, facilitating private-sector provision of market information through telecommunication, and directing fiscal stimulus to rural areas.

Farmer/producer organizations

To overcome challenges related to high transaction costs, small farmers in many countries have formed producer organizations.

These organizations are of various kinds, including cooperatives, associations, and societies. They support their members in gaining access to markets and public services, and for advocacy. One of the most well-known producer organizations in Asia is the Indian dairy cooperative, which in 2005 had a network of more than 100,000 village-level dairy cooperatives with 12.3 million members; it accounts for 22 percent of milk produced in the country (National Dairy Development Board 2006). Sixty percent of the members are landless or smallholders; women make up 25 percent of the membership. This cooperative model was replicated with the brand name "Safal" for fruits and vegetables to meet the growing demand in Delhi, India's capital.

Contract farming

Contract farming has been promoted in many Asian countries as a potential means to incorporate small farmers into growing markets for high-value commodities. Since contracts often include the provision of seed, fertilizer, and technical assistance for accessing credit as well as a guaranteed price at harvest, this form of 'vertical coordination' has the potential to address many constraints to small-farm productivity. In this sense, it has been viewed as an institutional solution to the problems of market failure for credit, insurance, and information.

Several studies that assessed the degree of small farmers' participation in contract farming in Asia report mixed findings. A recent study of contract and non-contract growers of apples and green onions in Shandong province of China found no bias toward large farmers in contract farming schemes (Miyata et al. 2009). In contrast, another study found that small farmers were less likely to participate in contract farming than larger farmers (Guo et al. 2005). Singh (2002) identifies several problems

associated with contract vegetable production in Punjab: power imbalance between farmers and companies, violation of the terms of the agreements, social differentiation, and environmental unsustainability.

Most studies indicate positive impacts of contract farming on incomes. Birthal et al. (2005) found that the gross margins for contract dairy farmers in India were almost double those of independent dairy farmers, largely because contract farmers had lower production and marketing costs. Miyata et al. (2009) also found that contract farmers earned more than non-contract farmers even after controlling for household labor availability, education, farm size, share of land irrigated, and proximity to the village leader. The major factors for this difference include higher yields obtained by contract growers due to the technical assistance and specialized inputs provided by the packers and higher prices received.

Two challenges regarding contract farming are to (1) achieve discipline in collective action for the producer organization to meet the terms of the contract and at the same time ensure that members resist the temptation of side-sales, particularly when prices are rising and local markets exist for the contracted product; and (2) ensure that the commercial partner, often with monopsonistic power, does not renege on the contractual arrangement when the crop is ready, by offering lower prices or imposing higher quality standard (Byerlee et al. 2010).

Supply chains and supermarkets

Several researchers have argued that smallholders enjoy several advantages over large commercial farmers in supplying to supermarkets. The first advantage is linked to production technologies and the associated labor requirements. Thai Fresh United, for example, has a portfolio of 140 herbs, spices, vegetables, and fruits, each of which has stringent quality requirements (Gaiha and Thapa 2007b). Smallholders, especially women, are able to give the careful attention such crops require. As such, small producers supplying Hortico, for example, have lower rejection rates for certain non-traditional vegetables relative to large farmers. Second, the traditional agro-economic and production practices of smallholders are more amenable to the requirements of supermarkets. In Thailand, Tops has found that smallholders adapt more easily to organic production through crop rotation and selection among resistant varieties.

However, smallholders need support for intermediation and internalization to be able to integrate into the supply chains (Gaiha and Thapa 2007; Lipton 2006; Swinnen 2006). Intermediation can take different forms involving the cooperation of public and private agencies. For example, food safety standards might be laid down by national governments, and private agencies might help smallholders implement them; rural infrastructure might be strengthened by the public sector through private financing; and suppliers might help finance the provision of inputs and provide extension. Internalization involves organizations of producers, especially small producers, that will negotiate production and marketing arrangements with supermarkets or their suppliers.

A study sponsored by IFAD found the prospects for expansion of supermarkets to be promising in most Asian countries (Gaiha and Thapa 2007). It also saw a good potential for the integration of smallholders in a rapidly transforming food and agricultural sector, provided they receive adequate support from the public and private sectors.

Information and communication technology

Information and communication technologies can reduce information asymmetries by providing information to smallholders on

weather, input and output prices, and production technologies. Many successful examples of smallholders benefiting from ICT are emerging.

Fiscal stimulus

The contagion of the financial crisis did not dampen growth in Asia and the Pacific region as much as initially feared. As such, the projected reductions in growth rates were only 2 percent or more in 2009. This was largely due to the resilience of China and, to a lesser extent, India (ADB 2009a). In anticipation of such losses and to minimize them, fiscal stimulus was undertaken by many countries in the region, ranging from 0.5 percent of gross domestic product to more than 5 percent (ADB 2009b). A study undertaken by IFAD's Asia and the Pacific Division (Gaiha et al. 2009) demonstrates the potential of fiscal stimulus in accelerating overall growth through agricultural growth. If mechanisms are put in place to direct the fiscal stimulus to rural areas where both physical and social infrastructure are inadequate to sustain the growth impulse, substantial increases in yields and revenues from agriculture are likely. Various studies have confirmed the vital role of rural roads, transportation, and market access in enabling small farmers and others to reap greater benefits from higher prices (Fan and Rao 2008; Gaiha et al. 2009). Of particular significance are the findings by Shilpi and Umali-Deininger (2008), focusing not only on distance to a market in the Indian state of Tamil Nadu, but also on the facilities available in that market. Their analysis shows that additional investments in market facilities are indeed pro-poor, since sales by poorer farmers increase more than those by wealthy farmers. In other words, although the wealthier farmers capture the benefits of existing facilities better than the poorer farmers, the marginal benefit from an improvement of market facilities is substantially greater for small (poorer) farmers.

Sustainability of the fiscal stimulus, however, seems doubtful amidst fears of inflation in emerging Asian countries (notably China and India).

ENABLING POLICY AND PROGRAMME SUPPORT TO SMALL OR FAMILY FARMS: AN EXAMPLE FROM ASIA AND THE PACIFIC

There are powerful efficiency and equity reasons to support small farms in Asia and the Pacific. They are economically more efficient relative to large farms, can create large amounts of productive employment, reduce rural poverty and food insecurity, support a more vibrant rural nonfarm economy, and help to contain rural-urban migration (Hazell 2003). The Green Revolution experience showed the strong commitment of Asian governments to agriculture, which led to significant investments in technologies and rural infrastructure as well as major policy and institutional reforms in support of agriculture. However, there was one major difference between the two regions. In countries such as China and India, public interventions such as land policies, agricultural marketing and support services, and agricultural research and extension benefited commercially oriented small farms. In China, small farms were supported after collective farms could no longer provide adequate incentives to increase production and productivity. The reform of the rural economic system in China in 1978 laid an institutional foundation for rural development and poverty reduction. Its main element was the change in the agricultural production model from centralized planning to household contract farming. This reform significantly boosted farmers' incentives to produce more, thus, promoting agricultural development.

Vietnam is an excellent example of how conducive policy changes can help spur agricultural productivity growth, improved food security, and poverty reduction (Gaiha

and Thapa 2007a; Kirk and Nguyen 2009). Vietnam had been experiencing slow economic growth, declining agricultural production and high inflation until 1986, when the government introduced *Doi Moi*—a comprehensive reform program. This marked the beginning of the country's transition from a planned to a market economy. The policy reforms had broadly two phases: the first phase was the dismantling of central planning (1986–1989), and the second was the building and strengthening of a market-oriented policy regime (1990 to present). Under these reforms, the government abolished the collective agricultural system, assigned land-use rights to farmers, and implemented other wider economic reforms. In 1988, under Resolution 10, the government directed agricultural cooperatives to contract land to households for 15 years for annual crops and 40 years for perennial crops. Although households still had to meet production quotas, the production volumes and prices were fixed for five years, giving them a great deal of certainty. The private sector was allowed to get involved in food marketing and farmers were allowed to buy and sell animals, machinery, and equipment.

The government implemented additional reform measures between 1987 and 1991, such as opening up of domestic and international markets and relaxation of government control over prices. These provided the impetus for farmers to increase their production and marketable surplus. As a result, the agriculture sector grew by almost 4 percent per year between 1989 and 1992. The sharp devaluation of the local currency in 1989 made Vietnam's exports more competitive internationally. The country implemented a Land Law in 1993, which extended land tenure to 20 years for annual crops and 50 years for perennial crops.

Indeed, the policy reforms in the agriculture sector have had dramatic impact on agricultural production, food security and nutrition, and poverty reduction. Rice yields increased from

3.2 to 4.9 tons per hectare between 1990 and 2006. Higher incomes led to diversification of diets, which contributed to better nutrition. The rates of stunting in children declined dramatically from 53 to 33 percent between 1993 and 1998. The incidence of poverty dropped from 58 percent in 1993 to 29 percent in 2002.

The land tenure reforms have contributed to an active market in land transactions in the country. Participation of households in land rental markets increased from 3.8 percent in 1993 to 15.5 percent in 1998. Because of more secure land rights, Vietnamese farmers have diversified into non-cereal production such as aquaculture, livestock, and perennial crops like coffee and cashew. In 2004, the Land Law was amended requiring land-use certificates to include the names of both husband and wife. This has contributed to gender balance and has provided incentives for women to invest in land.

CONCLUDING REMARKS

Small farms have proved resilient over time and have been contributing significantly to agricultural production, food security, rural poverty reduction, and biodiversity conservation in Asia and the Pacific region, despite their constraints with respect to access to productive resources and service delivery. These days, they face more new challenges: integration into new agriculture dominated by value chains, adaptation to climate change, and management of market volatility and other risks and vulnerability. Being resilient, they have shown ability to integrate into the emerging value chains, provided they have support through intermediation and internalization. Intermediation may take a variety of forms whereby public and private agencies cooperate (e.g., food safety standards might be laid down by governments and private agencies might help smallholders implement them;

rural infrastructure might be strengthened by the public sector through private financing; suppliers might help finance the provision of inputs and provide extension). Internalization involves organizations of producers, especially small producers, that negotiate production and marketing arrangements with supermarkets or their suppliers.

In the wake of the food price crisis, attractive investment opportunities have opened up in agriculture, leading to large-scale investments and competition for land. However, frequently large farms are in the advantage due to market failures (e.g., credit), institutional gaps (e.g., weak extension services), and policy distortions (e.g., minimum support prices). Elimination of such biases against smallholders would enhance their competitiveness.

Institutional innovations can play an important role in the provision of inputs and services to small or family farmers when there are market failures. In some cases, the private sector has adequate incentives to innovate (as discussed in the sections on contract farming and supermarkets). However, governments should play an active role in coordinating the delivery of input, financial, technical, and output marketing services to small farms. Support should also be provided to enable small farmers to face emerging challenges related to climate change impact and market volatility.

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ANNEX 1: CROSS-TABULATIONS

Annex Table 1. Distribution (%) of villages by access to infrastructure and markets

Distance range	Nearest wholesale agriculture product market	Nearest *pacca* road	Nearest agricultural input store	Nearest bank	Nearest district headquarters	Nearest town	Nearest telephone facility
0 km	3.42	72.27	16.17	14.49	0.00	2.54	69.66
0–5 km	18.80	22.27	34.89	41.12	0.84	21.61	22.65
5–10 km	27.35	2.52	25.11	32.71	5.88	32.63	5.13
above 10 km	50.43	2.94	23.83	11.68	93.28	43.22	2.56
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00

Annex Figure 1.1. Kernel density function for log of cereals quantity (in quintal) produced per acre for small, medium, and large land holders
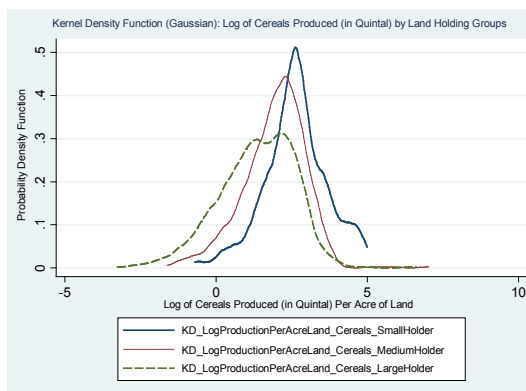
Annex Figure1.2. Kernel density function for log of pulses quantity (in quintal) produced per acre for small, medium, and large land holders
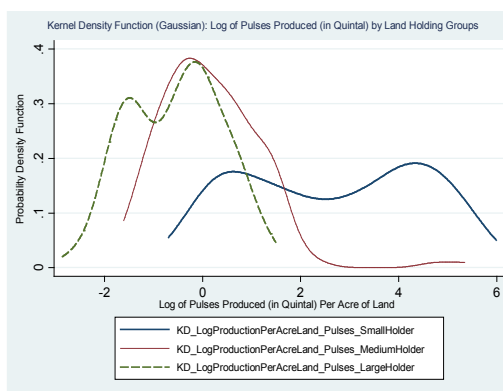
Annex Figure1.3. Kernel density function for log of vegetables quantity (in quintal) per acre of land for small, medium, and large land holders
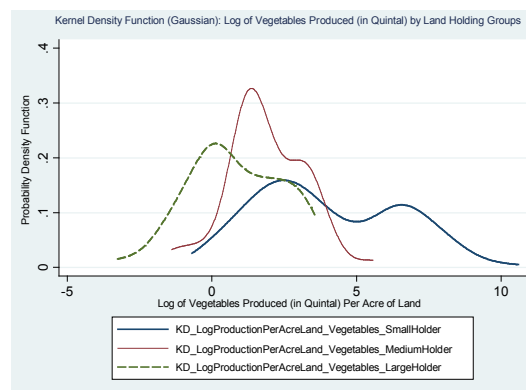
Annex Figure1.4. Kernel density function for log of oilseeds quantity (in quintal) produced per acre for small, medium, and large land holders
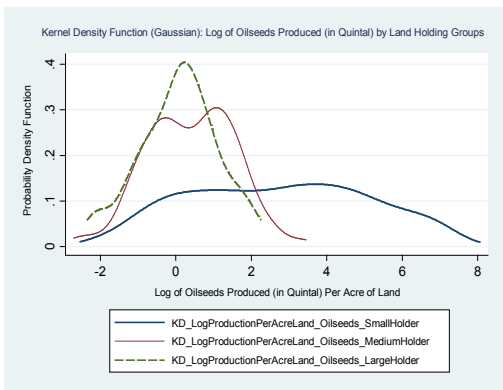
ANNEX 2A: THE TOBIT MODEL

A Tobit specification was used in which (positive) values of marketed surplus of a food commodity are transformed logarithmically and zeros are treated as 1 (so that the natural log is 0). The Tobit specification is appropriate when there is a large number of zeros for a variable of interest and it is continuously distributed over positive values.[a] The censored normal regression model, or Tobit model, is one with censoring from below at 0 where the latent variable is linear in regressors. Thus,

$$y^* = \beta_0 + x_\beta + \mu, \ \mu | x \sim \text{Normal } (0, \sigma^2) \qquad (1)$$
$$\mathbf{y} = max \ (0, \text{y}^*) \qquad\qquad (2)$$

The latent variable y^* satisfies the classical linear model assumptions: in particular, it has a normal, homoscedastic distribution with a linear conditional mean. Equation (2) implies that the observed variable $\mathbf{y}$ equals y^* when $y^* \geq 0$, but $\mathbf{y} = 0$ when $y^* < 0$. Since y^* is normally distributed, $\mathbf{y}$ has a continuous distribution over strictly positive values.

In the estimating equation, the dependent variable $\mathbf{y}$ represents marketed surplus of food, x is a vector of independent variables, β is a vector of unknown coefficients, and μ is an independently distributed error term assumed to be normally distributed with 0 mean and variance σ^2.

In the Tobit, two expectations are of particular interest: $E(y \mid y > 0, \mathbf{x})$, which is sometimes called the "conditional expectation" because it is conditional on y > 0, and $E(y|\mathbf{x})$, which is unfortunately called the "unconditional expectation". (Both expectations are conditional on the explanatory variables).[b] We have used the former.

ANNEX 2B: TOBIT RESULTS

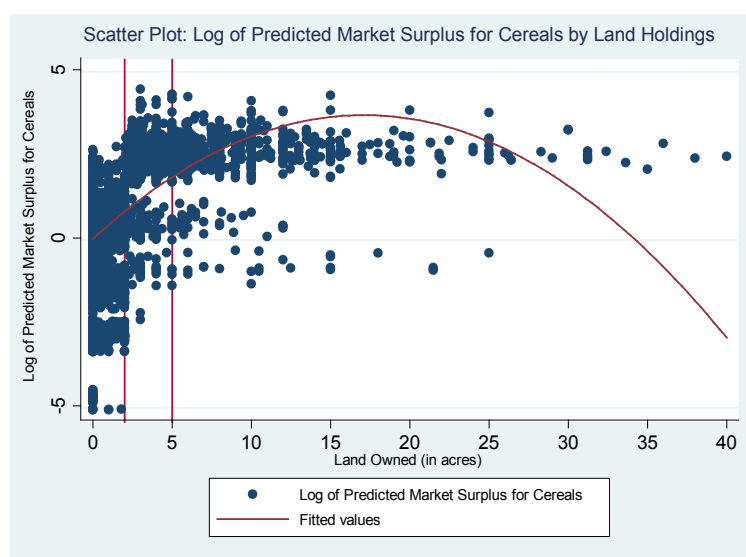### Annex Table 2B.1 Factors affecting marketed surplus of cereals: Tobit estimates

Explanatory Variable	Coefficient (t-statistic)	Elasticity (z-statistic)
Log of household head's years of schooling	0.2000***(3.65)	0.0329***(3.65)
Caste dummy: SC	-2.1252***(-11.59)	-0.0403***(-11.63)
Caste dummy: ST	0.3121(1.42)	0.0029(1.42)
Caste dummy: OBC	-0.3916***(-3.18)	-0.0236***(-3.18)
Land owned dummy: small	-2.0155***(-11.39)	-0.1956***(-11.40)
Land owned dummy: medium	-0.0478(-0.23)	-0.0009(-0.23)
Log of village level trader's price for cereals	0.4909***(13.13)	0.3942***(13.23)
Log of village level trader's price for oilseeds	0.0557***(3.24)	0.0266***(3.24)
Log of village level trader's price for vegetables	0.0223(0.85)	0.0061(0.85)
Interaction of log of village level trader's price for oilseeds and vegetables	-0.0103**(-2.45)	-0.0148**(-2.45)
Constant	-0.9213***(-2.86)	
/sigma	3.6312	
Number of observations	5694	
Left-censored observations at dep. variable = 0	2903	
Uncensored observations	2791	
LR chi-square(10)	726.11***	
Pseudo R-square	0.0365	
Log likelihood	-9588.2501	

Note: Log of market surplus of cereals is the dependent variable.
*** refers to significance at 1% level. The elasticities are based on the uncensored observations. After controlling for interaction terms, the marginal effects of log of village level trader's price for oilseeds and log of village level trader's price for vegetables at the means were -0.0049 and -0.0550, respectively.

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a An assumption here is that size distribution of land is predetermined.

b For further details, see Wooldridge (2006).

**Annex Figure 2B.1. Log of predicted market surplus for cereals by land holdings**

Scatter Plot: Log of Predicted Market Surplus for Cereals by Land Holdings

Note: Vertical lines are drawn at 2 acres and 5 acres, respectively. The lines separate small, medium, and large land holders.

Annex Table 2B.2 Factors affecting marketed surplus of pulses: Tobit estimates

Explanatory Variable	Coefficient (*t*-statistic)	Elasticity (*z*-statistics)
Log of household head's years of schooling	-0.1068(0.70)	-0.0072(0.70)
Caste dummy: SC	-2.3784***(4.14)	-0.0184***(4.18)
Caste dummy: ST	-2.3306***(2.96)	-0.0089***(2.98)
Caste dummy: OBC	-0.0724(0.20)	-0.0018(0.20)
Land owned dummy: small	-3.1143***(6.92)	-0.1234***(7.05)
Land owned dummy: medium	-1.8783***(3.51)	-0.0145***(3.53)
Log of village level trader's price for pulses	1.8177***(15.85)	0.3466***(23.64)
Log of village level trader's price for cereals	-0.4854***(5.78)	-0.1591***(5.88)
Log of village level trader's price for oilseeds	-0.2783***(6.65)	-0.0542***(6.79)
Constant	-10.6709***(9.77)	
/sigma	5.9603	
Number of observations	5694	
Left-censored observations at dep. variable = 0	5060	
Uncensored observations	634	
LR chi-square(9)	1199.87***	
Pseudo R-square	0.1716	
Log likelihood	-2896.5451	

Note: Log of market surplus of pulses is the dependent variable.
*** refers to significance at 1% level. The elasticities are based on the uncensored observations.

**Annex Figure 2B.2. Log of predicted market surplus for vegetables by land holdings**
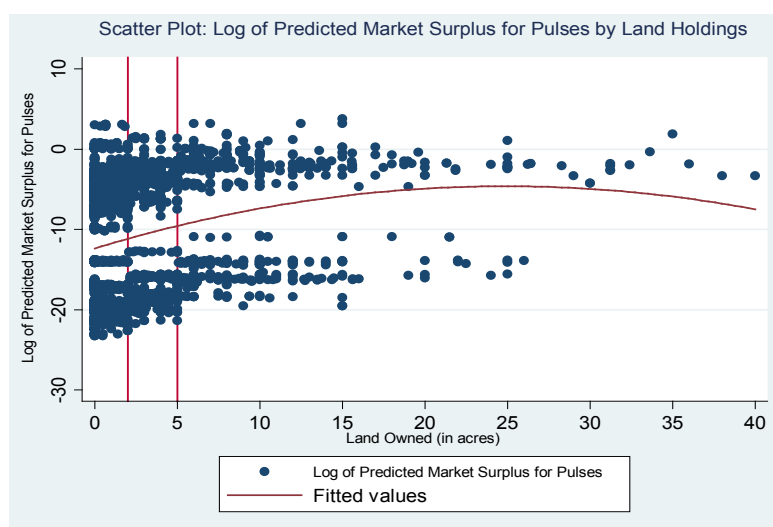
Scatter Plot: Log of Predicted Market Surplus for Pulses by Land Holdings

Note: Vertical lines are drawn at 2 acres and 5 acres, respectively. The lines separate small, medium, and large land holders.

Annex Table 2B.3. Factors affecting market surplus of vegetables: Tobit estimates

Explanatory Variable	Coefficient (*t*-statistic)	Elasticity (*z*-statistics)
Log of household head's years of schooling	0.8826***(3.58)	0.0466***(3.64)
Caste dummy: SC	-0.6093(-0.82)	-0.0037(-0.83)
Caste dummy: ST	-6.2826***(-3.03)	-0.0188***(-3.09)
Caste dummy: OBC	-0.7312(-1.36)	-0.0142(-1.36)
Land owned dummy: small	-2.2901***(-3.23)	-0.0715***(-3.27)
Land owned dummy: medium	-0.8137(-0.96)	-0.0049(-0.96)
Log of village level trader's price for pulses	-0.1050*(-1.66)	-0.0158*(-1.67)
Log of village level trader's price for cereals	-0.1316(-0.71)	-0.0340(-0.71)
Log of village level trader's price for vegetables	1.5609***(14.48)	0.1381***(22.84)
Constant	-15.7938***(-9.23)	
/sigma	7.2989	
Number of observations	5694	
Left-censored observations at dep. variable=0	5393	
Uncensored observations	301	
LR chi-square(9)	644.43***	
Pseudo R-square	0.1692	
Log likelihood	-1582.4242	

Note: Log of market surplus of vegetables is the dependent variable.
*** and * refer to significance at 1% and 10% levels, respectively. The elasticities are based on the uncensored observations.

Annex Figure 2B.3. Log of predicted market surplus for vegetables by land holdings
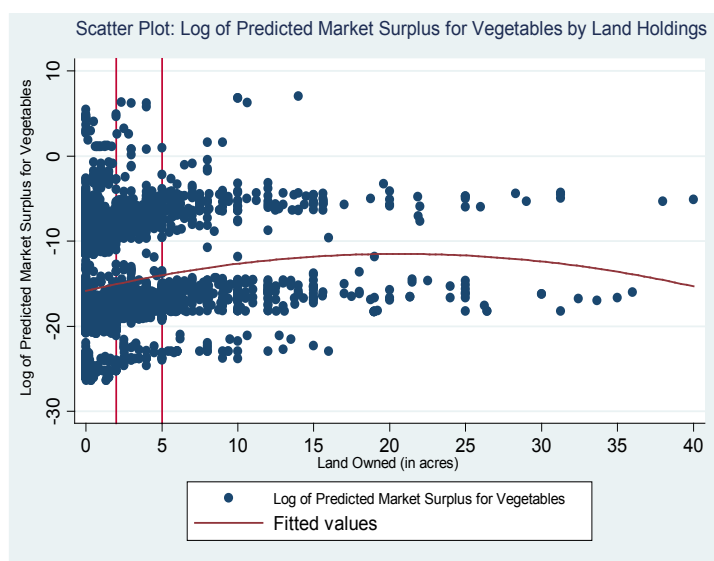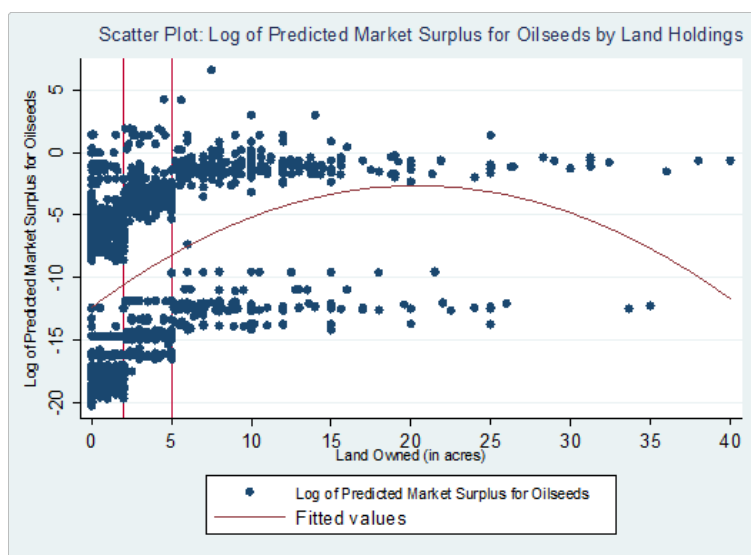

Note: Vertical lines are drawn at 2 acres and 5 acres, respectively. The lines separate small, medium, and large land holders.

Annex Table 2B.4. Factors affecting market surplus of oilseeds: Tobit estimates

Explanatory variable	Coefficient (*t*-statistic)	Elasticity (*z*-statistics)
Log of household head's years of schooling	-0.0101(-0.06)	-0.0007(-0.06)
Caste dummy: SC	-1.4538***(-2.62)	-0.0111***(-2.63)
Caste dummy: ST	1.4485**(2.13)	0.0054**(2.13)
Caste dummy: OBC	0.0369(0.10)	0.0009(0.10)
Land owned dummy: small	-5.1216***(-11.23)	-0.1993***(-11.95)
Land owned dummy: medium	-2.3031***(-4.45)	-0.0175***(-4.49)
Log of village level trader's price for cereals	-0.4379***(-3.52)	-0.1410***(-3.56)
Log of village level trader's price for oilseeds	1.4809***(16.73)	0.2834***(23.36)
Log of village level trader's price for vegetables	0.0493(1.09)	0.0054(1.09)
Constant	-9.5779***(-9.03)	
/sigma	6.2926	
Number of observations	5694	
Left-censored observations at dep. variable=0	5093	
Uncensored observations	601	
LR chi-square(9)	1041.03***	
Pseudo R-square	0.1550	
Log likelihood	-2838.4201	

Note: Log of market surplus of oilseeds is the dependent variable.
*** and ** refer to significance at 1% and 5% level, respectively. The elasticites are based on the uncensored observations.

Annex Figure 2B.4. Log of predicted market surplus for oilseeds by land holdings

Note: Vertical lines are drawn at 2 acres and 5 acres, respectively. The lines separate small, medium, and large land holders.

Annex Table 2B.5. Crops included under cereals, pulses, and vegetables

Commodity	Crops included
Cereals	Paddy, wheat, barley, maize, *jawar*, *bajra*, *ragi*, other cereals, and millets
Pulses	Black gram (*urd*), green gram (*moong*), pigeon pea (*arhar,tur*), horse gram (*kulthi*), cowpea (*lobia*), kidney bean (*moth*), lentil (*masoor*), field pea (*matar*), bengal gram (*chana*), and other pulses
Vegetables	Ash gourd (*kohla*), beet root (*chukandar*), bitter gourd (*kerela*), bottle gourd (*louki*), brinjal, eggplant (*baingan*), broad bean (*baakla*), cabbage (*pattagobby*), carrot (*gajat*), cauliflower (*phool gobby*), cluster bean (*guvar ki fali*), cowpea (*lobia*), cress, garden cress (*pani dhleem*), cucumber (*khera*), double bean, drum stick (*sejana*), elephant ear, edible arum (*akhi*, *arvi*), elephant foot (*gimmy kand*), french bean (*jungli sem*, frans bean), garden pea, pea, (*matar*), goose foot (*bathua*), indian bean (*sem*), knolknol (*gaath gobhi*), lady's finger (*bhindi*), lettuce (salad), lima bean, little gourd (*kundroo, tindora*), mountain spinach (*pahari palak*), musk melon (*kharbooja*), onion (*piaz*), pointed gourd (*parwal*), potato (*aaloo*), pumpkin (*petha*), radish (*mooli*), red pumpkin (*sitaphal, kaddu*), ridge gourd (*tori*), round gourd (*tinda*), smooth gourd (*kali tori*), snake guard (*chachera, chachinda*), spinach (*palak*), sword bean, sweet potato (*sakar kandi*), tomato (*tamattar*), turnip (*saljam*), velvet bean (*khamch, tohar sem*), water melon (*tarbooj*), yam (*tataaloo*), and other vegetables
Oilseeds	Sesame (*til*), groundnut, castor, sunflower, niger (*ramtil*), soybean, safflower (*kusum, kardi*), rapeseed/mustard (*sarsoan*), indian mustard (*rai*), linseed (*alsi*), other oilseeds

Annex Table 2B.6. Definitions of variables used in regression analysis

Variable	Definition
Dependent variable	
Log of market surplus for commodity i	Log of market surplus for commodity i = log (total sale quantity of commodity i multiplied by 100 and divided by total production quantity of that commodity). i = cereals or pulses or vegetables or oilseeds
Log of production for commodity i	Log of total quantity produced (in quintals) for commodity i. i = cereals
Explanatory variable	
Log of household head's years of schooling	Log of household head's years of schooling
Caste dummy: SC	= 1 if household is Scheduled Caste; 0 otherwise
Caste dummy: ST	= 1 if household is Scheduled Tribes; 0 otherwise
Caste dummy: OBC	= 1 if household is Other Backward Caste; 0 otherwise
Caste dummy: Others	Reference group
Land owned dummy: small	= 1 if land owned by household is less than 2 acres; 0 otherwise
Land owned dummy: medium	= 1 if land owned by household is greater than 2 acres but less than or equal to 5 acres; 0 otherwise
Land owned dummy: large	Reference group
Log of village level trader's price for cereals	Log of village level price (in INR/quintal) on which produced cereals were sold to traders
Log of village level trader's price for pulses	Log of village level price (in INR/quintal) on which produced pulses were sold to traders
Square of log of village level trader's price for pulses	Square of log of village level trader's price for pulses
Log of village level trader's price for vegetables	Log of village level price (in INR/quintal) on which produced vegetables were sold to traders
Log of village level trader's price for oilseeds	Log of village level price (in INR/quintal) on which produced oilseeds were sold to traders
Log of village level price of chemical fertilizer	Log of village level price (in INR/Kg) of chemical fertilizer
Log of distance of whole sale agricultural market from the village	Log of distance of whole sale agricultural market from the village
Distance of *pacca* road from village	Distance of *pacca* road from village
Square of distance of *pacca* road from village	Square of distance of *pacca* road from village