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Abstract

Our analysis illustrates one pathway between agriculture and nutrition through production of nutrients by crop and size as well as through livestock. As this pathway is subsumed in agriculture and nutrition studies focusing on anthropometric outcomes, and hardly any light is thrown on the contribution of smallholders, it is emphasised that they play an important role as producers of nutrients. Specifically, despite various disadvantages (e.g. inadequate access to extension, technology, credit and markets), they contribute largest shares of calories, protein and fats. However, profits earned (using an approximate measure) are considerably lower among them than among medium and large landholders. At least two reasons are identified in our analysis: one is limited access to markets and another is lower crop prices. A much greater emphasis on enabling higher investment, access to technology and markets through better rural infrastructure would help increase profitability of crop production. Equally important are market imperfections that manifest in lower crop prices for smallholders. How economies of scale could be exploited through farmers' groups needs careful scrutiny.

Key words: agriculture, food crops, livestock, smallholders, calorie, protein and fat

JEL Codes: I15, Q18, N35.

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Agriculture-Nutrition Pathway in India

1. Introduction

Economic growth has played a key role in reducing undernutrition; the rate of child underweight prevalence is usually about half the rate of growth of per capita GDP. Using this benchmark for India, given a GDP growth rate of 4.2 per cent per year from 1990-2005, the underweight prevalence was expected to decline by 2.1 per cent per year, or by about 27 per cent during this period. The actual decline, however, was 10 per cent, based on National family health Survey data (Gillespie and Kadiyala (2011)².

There are many parts of this puzzle. Nutrition outcomes are a result of interplay of several factors: individual dietary intake and health status, household food security, caring capacity and practices, access to adequate health services, and a healthy environment. But an important part of the puzzle is the role of the agriculture sector. Although its share in GDP has declined (16 per cent in 2007), and it employs 52 per cent of the work force, it continues to play a major role in India's socio-economic development. Indeed, its potential for poverty reduction remains substantial (Imai et al. 2011). Besides, it has the potential to improve the availability of and access to diverse foods and, thereby, improve nutrition (Gillespie and Kadiyala, 2011, and Fan and Brzeska, 2011).

Several pathways between agriculture and nutrition have been identified. These include: increased household production leading directly to higher and more diversified food consumption; increased agricultural production for markets resulting in higher incomes, and thus enabling food purchase and access to health and education services; lower and less volatile food prices from rising agricultural productivity benefiting urban poor and rural food buyers, while freeing resources for other expenditures; and, finally, increased government revenue financing health care, education and nutrition interventions (Fan and Brzeska, 2011).

² In a recent study, Ecker et al. (2011) demonstrate with cross-country regressions that undernutrition declines rapidly in response to additional income during the early stages of a country's growth, when levels of GDP per capita are low. As a country moves up the income ladder, the relationship between growth and nutritional status becomes much weaker. A similar pattern is reported for agricultural growth. The relationship between growth and child malnutrition is more modest, with the latter less responsive to growth even during the early stages of a country's economic development. Heady (2010), in another interesting contribution, points out that the impact of growth-both overall and agricultural-on undernutrition varies across several factors. Specifically, agricultural growth is associated with reductions in both underweight and stunting in more food-insecure countries, with the exception of India.

Different agricultural sub-sectors, for example, staple crops and livestock, have different impacts on growth and undernutrition. Their impacts vary with (i) their linkages with the rest of the economy; (ii) initial size and its geographic location; (iii) its growth potential; and (iv) market opportunities. These impacts are often calculated using computable general equilibrium models (CGE), transmitted through economy-wide channels such as income, prices, employment and wages. A limitation, of course, is inaccuracy of parameters and inability to validate the model with empirical data (Fan and Brzeska, 2011).

Although there is enormous literature on agricultural development in India, the links between agriculture and nutrition are woefully thin. This gap needs to be filled so that the ‘disconnect’ between them is better understood and addressed.

The objective of the present study is modest. It seeks to examine production of different crops by farm size, fractions marketed, prices received, and above all nutrients (calories, protein and fats) produced. While the studies reviewed here point to nutrition outcomes of agricultural growth, there is little separation of availability or production of these nutrients and demand. As the demand side is explored in two companion studies (Gaiha et al. 2012 a, b), the present study focuses on the production of nutrients. Specific hypotheses relate to differences in cropping patterns and associated differences in production of nutrients. The present analysis is based on the 59th round of the NSS (*Situation Assessment Survey of Farmers*) for 2002-2003. A sample of 51770 households was surveyed. Crop seasons between July 2002-June 2003 were covered. Dairy and other livestock products, however, were covered for 30 days preceding each of the two visits. Hence we have separated the livestock results from crop results.

2. Review of Agriculture-Nutrition Pathways

Although the evidence summarised below is far from robust-a limitation being absence of unit record data on crops produced and nutrient intake- it illustrates the variation between agricultural growth and anthropometric outcomes of children and women³.

Between 1992-2005, Andhra Pradesh, Maharashtra, Himachal Pradesh, Tamil Nadu, Kerala, Bihar, and Assam recorded fairly rapid agricultural growth and significant improvements in at least one anthropometric indicator, but improvements were uneven.

³ This draws upon Gillespie and Kadiyala (2011).

Andhra Pradesh made no improvement in child stunting, Kerala in underweight prevalence, and Assam and Bihar recorded a sharp increase in the prevalence of low BMI in women. Madhya Pradesh and Gujarat witnessed fairly strong agricultural growth but poor anthropometric outcomes. However, evidence on the specific pathways is limited.

There is confirmation of the importance of agriculture as a source of food. Given fluctuations in the agricultural sector (due, for example, to market volatility and seasonality), diversification of food sources makes a difference. Diversification of foods grown by a household enhances food diversity and nutrition outcomes. However, without further investments in public health and nutrition education, production of foods with high nutrition value does not necessarily convert into increased intake by producer households. Further, any negative shocks exacerbate intrahousehold bias against women.

On the demand side, income matters but its effect has weakened over time for all three nutrients: calories, protein and fats. Food price effects matter as well but their effects have weakened too. These effects of course vary between rural and urban areas. A somewhat surprising finding is the slowing down of reduction in calorie intake in 2004-09 – especially in rural areas. A similar result is obtained for protein—a slowing down of reduction over this period. Mean fat intakes, by contrast, continued to rise but at a slower rate (Gaiha et al. 2012 a).

An interesting observation relating to food prices inducing changes in consumption patterns is the policy bias (Gillespie and Kadiyala, 2011). Lack of investment and the policy bias towards wheat and rice (reflected in the large allocation of R&D funds, fertiliser and water subsidies and the inclusion of wheat and rice in the Public Distribution System) has tended to neglect pulse production.

As noted above, hardly any new light is thrown on the supply or, more specifically, production of nutrients—especially by smallholders.

3. Crop Production

All our analysis is disaggregated by size of farm. Three categories are distinguished: small (<2 ha), medium (2-5 ha), and large (>5 ha)⁴.

(a) Area Sown

Let us first consider differences in area sown under 9 crops. Table 1 gives the distribution.

A large share of area sown under these crops was by smallholders (about 73 %), followed by medium (16%) and large landholders (11%).

Table 1: Area Sown (Million Hectares) under Various Crops, by Size of Landholding, Rural India (2002-03)

	Small Farms (<2 ha)	Medium Farms (2-5 ha)	Large Farms (>5 ha)
Foodgrains	145.299	24.361	15.018
Pulses	3.271	2.140	2.542
Sugarcane and other crops	1.838	1.370	0.661
Condiments and spices	0.685	0.484	0.289
Fruits, Nuts and Vegetables	3.156	1.209	0.543
Oilseeds	5.126	4.879	4.221
Cotton and other fibres	6.021	2.230	1.798
Tobacco and narcotics	0.119	0.063	0.023
Tea Coffee and other plantation crops	0.561	0.186	0.135

Source: 59th Round of NSS

Among smallholders, the largest share of area sown was under foodgrains (87%), the next highest was oilseeds (over 3 %), pulses (1.96%) and then fruits, nuts and vegetables (1.9%). Among medium size farmers, area under foodgrains was considerably smaller (66 %), followed by oilseeds (13 %), pulses (5.8 %), sugarcane (3.7 per cent), and fruits, nuts and vegetables (3.3 %). Thus medium landholders concentrated less on production of foodgrains and more on other crops (e.g. oilseeds, and pulses). Large landholders devoted about the same share as medium landholders to foodgrains (over 59 per cent) but larger shares to oilseeds (under 17%) and pulses (about 10 %). Shares under sugarcane and vegetables, however, were lower.

⁴ We use small, medium and large farmers synonymously with smallholders, medium landholders and large landholders, respectively.

(b) Production and Marketing of Crops

Differences in amounts of these crops per ha by land size are given in Table 2. These differences vary considerably by crop and size. Foodgrains per ha are highest among medium landholders, followed by large landholders. Production per ha among smallholders is barely 40 % of that among medium landholders. Pulses present a different contrast but with medium landholders producing highest amount per ha. Smallholders produced under 71 % of this amount but 86 % more than that by large landholders. Smallholders produced slightly higher amount of sugarcane than medium landholders and both were considerably higher than the amounts produced by large landholders.

Table 2: Production (kg) Per Hectare with Proportion of Produce Marketed, Rural India (2002-03)

	Small Farms (<2 ha)	Medium Farms (2-5 ha)	Large Farms (>5 ha)
Foodgrains	816.1 (0.35)	2051.9 (0.53)	1806.8 (0.64)
Pulses	595.7 (0.55)	843.8 (0.41)	318.9 (0.73)
Sugarcane and other crops	44881.8 (0.78)	43382.1 (0.76)	35061.4 (0.87)
Condiments and spices	2278.1 (0.85)	2448.3 (0.64)	1043.9 (0.68)
Fruits, Nuts and Vegetables	9228.1 (0.73)	7525 (0.8)	6583.9 (0.76)
Oilseeds	1218 (0.74)	985.2 (0.84)	901.3 (0.81)
Cotton and other fibres	491.2 (0.9)	1030.4 (0.87)	715.5 (0.96)
Tobacco and narcotics	1701.5 (0.88)	1111.7 (0.99)	1889.6 (1)
Tea Coffee and other plantation crops	2837.4 (0.95)	995.1 (0.91)	682.5 (0.89)

Source: 59th Round of NSS

Medium landholders produced highest amount of condiments and spices, followed by smallholders. Large landholders produced barely 46 % of the amount by smallholders. Smallholders produced highest amount of fruits, nuts and vegetables, followed by medium landholders and large landholders. However, the range was relatively narrow (e.g. large landholders produced about 71 % of the amount smallholders did). Smallholders also produced highest amount of oilseeds, followed by medium landholders and large landholders. The amount produced by smallholders was 35 % higher than that by large landholders. Highest amount of tea, coffee and other plantation crops was recorded by smallholders, followed by medium landholders and large landholders.

As revenues earned and market prices depend on amounts marketed, shares marketed are also given in Table 2. Differences in amounts marketed vary with the crop and by size of farm.

There is a clear progression in the share of foodgrains marketed by size, with the smallest share among smallholders. A large share (65%) is not marketed and presumably consumed. By contrast, under 2/3rds is marketed by large landholders. Highest share of pulses is marketed by large landholders, followed by smallholder and medium landholders. In fact, 3/4ths of the amount produced is marketed by large landholders. More than 3/4ths of the amounts produced of sugarcane are marketed by each group, with the highest share by large landholders. 85 % of condiments are marketed by smallholders and the smallest share by medium landholders (64%). Shares of fruits, nuts and vegetables marketed are high among all groups, with the highest share among medium holders, and about 3/4ths among both small and large landholders. So also is the case with oilseeds, with the highest share marketed by medium holders (84 %). Most of the production of tea, coffee and other plantation crops is marketed, with the highest share among smallholders.

(c) Crop Sales and Prices

Values of crops sold and prices per kg are given in Table 3.

Table 3: Value of Sale (Rs. Million), and Price Per Kg of Sale

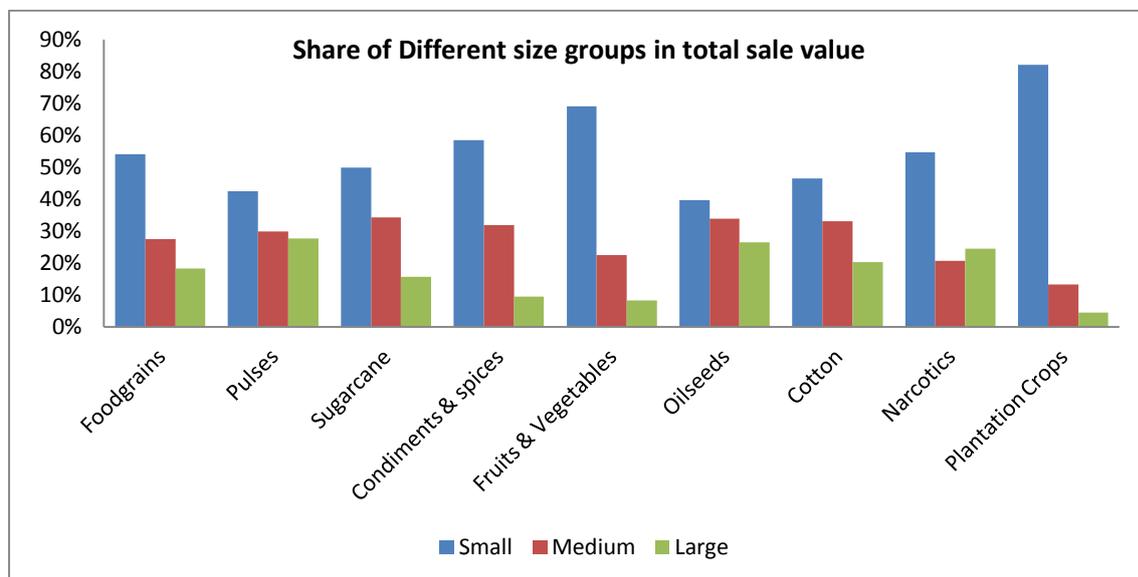
	Small Farms (<2 ha)	Medium Farms (2-5 ha)	Large Farms (>5 ha)
Foodgrains	55859 (4.2)	28376 (5.5)	18791 (5.6)
Pulses	1115 (10.4)	782 (9.3)	724 (10.7)
Sugarcane and other crops	68265 (0.8)	46877 (0.9)	21509 (0.9)
Condiments and spices	1454 (13.5)	792 (16.5)	234 (21.9)
Fruits, Nuts and Vegetables	23129 (3.5)	7492 (3.9)	2796 (4.2)
Oilseeds	4787 (10.6)	4101 (10.9)	3194 (12)
Cotton and other fibres	2840 (9.6)	2022 (14.1)	1244 (16.7)
Tobacco and narcotics	183 (20.8)	69 (26.9)	82 (9.7)
Tea Coffee and other plantation crops	1513 (11)	245 (16.6)	82 (19.8)

Source: 59th Round of NSS

Clearly, the smallholders account for a majority of sales for each of the crops. For foodgrains, the share of smallholders in total sales is 54%, with varying shares for other

crops, ranging from 40% for oilseeds to 82% for plantation crops. Fig: 1 shows the shares of various sizes of farms in the total sales.

Among the smallholders, the largest share in total crop value was that of sugarcane (about 43 %), followed by that of foodgrains (over 35 %), fruits and vegetables (about 14.53 %), and oilseeds (3 %). Thus the bulk of the revenue is from foodgrains and sugarcane (78%). Among medium landholders, these two crops account for a slightly higher share (over 83 %). While fruits and vegetables accounted for a much lower share (a little over 8 %), that of oilseeds was slightly higher (4.5 %). Among large landholders, the share of foodgrains and sugarcane was about the same as among medium landholders (a little under 83 %), that of fruits and vegetables was lower (about 5.7 %) and that of oilseeds was higher (about 6.6 %).



Source: 59th Round of NSS

Fig: 1 Shares of Different Size Groups in Total Sales, Rural India, 2002-2003

The figures in parentheses show price per kg of crops sold. As expected, prices received by the smallholders were lower in some cases (foodgrains, pulses, condiments and spices, fruits and vegetables, oilseeds, and plantation crops), and about the same for sugarcane. Other things being equal, the supply response is likely to be weaker as prices are not as remunerative for them as others (Imai et al. 2012).

(c) Profitability of Crops by Size of Farm

There has been a continuing debate on an inverse relationship between size and productivity. Explanations include higher labour intensity per ha and better soil quality among smallholders⁵. Here our focus is on profitability of different crops by size, based on paid out costs and prices received. This is at best a partial picture as imputed costs of family labour, farm produce for self-consumption and some of the transaction costs (e.g. difficulties in obtaining credit, lack of easy access to markets) are not fully accounted for. So subject to these caveats, let us consider the estimates in Table 4.

As may be noted, in all cases (including commercial crops), profitability was lowest among smallholders and in some highest among medium landholders (e.g. foodgrains, pulses, sugar cane) and in others among large land holders (condiments and spices, fruits and vegetables, and oilseeds).

These result from difficult market access for smallholders, small quantities offered for sale, and timing of sales. Policies are called for that improve market access, quality of crops produced through better extension services, and economies of scale in marketing (through farmers' groups).

Table 4: Profitability: Sale Price – Expenses Per Kg of Production¹

	Small Farms (<2 ha)	Medium Farms (2-5 ha)	Large Farms (>5 ha)
Foodgrains	1.711	3.137	3.011
Pulses	5.417	6.542	4.401
Sugarcane and other crops	0.432	0.547	0.438
Condiments and spices	7.612	10.097	11.882
Fruits, Nuts and Vegetables	1.789	2.176	2.556
Oilseeds	5.867	5.941	6.757
Cotton and other fibres	3.906	7.060	7.226
Tobacco and narcotics	9.778	15.071	-0.560
Tea Coffee and other plantation crops	7.711	10.714	14.330

Source: 59th Round of NSS

1. Profits are calculated as: Profit per kg = (Total Sale Value in million Rs. / Total Quantity Sold in million kgs) – (Total Expenses in million Rs. / Total Quantity Produced in million kgs). In principle, total costs should relate to output marketed. This was not feasible without making ad hoc assumption.

⁵ For a comprehensive review of recent literature, see Thapa and Gaiha (2012).

4. Production of Nutrients

Here we analyse the nutrients (calories, protein and fats) produced by size of farm. Table 5 gives the shares of calories produced from different crops.

(a) Calories

If we compare across size groups, largest share of total calories from foodgrains are produced by smallholders. This is equally true of other food items as well. Of particular significance is the large gap in calories from fruits and vegetables produced by smallholders. Calorie share of oilseeds is also highest among smallholders. An

Table 5: Shares of Different Size Groups in Total Calories Produced, Rural India, 2002-03

	Small Farms (0-2 ha)	Medium Farms (2-5 ha)	Large Farms (>5 Ha)
Foodgrains	60%	26%	15%
Pulses	43%	39%	18%
Sugarcane	50%	36%	14%
Condiments & spices	49%	40%	11%
Fruits, Nuts and Vegetables	70%	22%	8%
Oilseeds	38%	34%	28%

Source: 59th Round of NSS

implication is that with dietary diversification, sugar, fruits and vegetables and oil are likely to become more important in diets. Given the cropping patterns, a policy focus on smallholders is thus desirable from the point of view of changing diets. The channels through which higher contribution of supply of calories will lead to higher intake of calories include better technology comprising fertiliser and irrigation, access to markets, and more remunerative prices. There is also an important issue of changing relative prices for smallholders and others to switch to crops that are likely to be in greater demand (oil, pulses, sugar, fruits and vegetables, among others).

(b) Protein

The results for protein in Table 6 are similar to those for calories produced. In the production of protein, smallholders dominate in all food crops. What is indeed striking is the large gaps between smallholders and medium landholders and between medium

holders and large landholders. This further reinforces the case for smallholders as producers of nutrients.

Table 6: Shares of Different Size Groups in Total Protein Intake, Rural India, 2002-03

	Small Farms (0-2 ha)	Medium Farms (2-5 ha)	Large Farms (>5 Ha)
Foodgrains	58%	26%	16%
Pulses	43%	38%	19%
Sugarcane	51%	35%	14%
Condiments & spices	51%	38%	11%
Fruits, Nuts and Vegetables	71%	20%	9%
Oilseeds	34%	33%	32%

Source: 59th Round of NSS.

(c) Fats

Table 7 further confirms the largest contribution of smallholders to fat production through different crops. The gaps between smallholders and large landholders are very large, ranging from 3 times higher among the former in respect of, say, foodgrains and pulses to 7 times higher in respect of vegetables. As fat deficiency continues to be high (Gaiha et al. 2012 a), strengthening of rural infrastructure, easier access to extension and improved technology, and to markets, under certain conditions, is likely to contribute to alleviate fat deficiency.

Table 7: Shares of Different Size Groups in Total Fat Production, Rural India, 2002-03

	Small Farms (0-2 ha)	Medium Farms (2-5 ha)	Large Farms (>5 Ha)
Foodgrains	55%	27%	17%
Pulses	43%	40%	17%
Sugarcane	Negligible	Negligible	Negligible
Condiments & spices	59%	31%	10%
Fruits, Nuts and Vegetables	71%	19%	11%
Oilseeds	39%	35%	27%

Source: 59th Round of NSS

5. Livestock

As livestock data are collected for preceding 30 days, and the crop data over crop seasons between July 2002 and June 2003, we decided against merging the data. Also, the livestock data are not as detailed as crop data. In particular, fractions of amounts sold are not reported. We, however, computed prices for milk, and meat and poultry by dividing

total value of output by quantity produced. Another difficulty is that any byproducts of milk are not reported. Hence shares of milk produced across different farm sizes are also identical to shares of nutrients produced. Subject to these caveats let us consider the results given below.

Table 8: Shares of Milk and Other Livestock Products by Size of Farm, Rural India 2002-03

Farm Size	Milk	Meat
	% Share	% Share
	in production	in production
Small Farmers(0-2ha)	72.5%	86.2%
Medium Farmers (>2-5ha)	19.3%	12.0%
Large Farmers>5ha	8.2%	1.8%

Source: 59th Round of NSS

Given the large share of smallholders among total farmers, it is not surprising that they contribute the highest shares of milk, and meat and poultry products. In fact, the share of the latter is much higher. Somewhat surprisingly, the share of large landholders in the latter is under 2 %. If we compare the prices received, there is hardly any variation in milk price. But meat and poultry prices are considerably higher among large landholders relative to both small and medium landholders, as given below in Table 9.

In Table 10, we give shares of nutrients from livestock produced by size of farm.

As noted earlier, given that milk is a single product, nutrient shares correspond exactly to the shares produced by different groups of farmers. The largest shares of calories, protein and fats are produced by smallholders, followed by medium and large holders. Similar results are obtained for meat and poultry except that the contributions of smallholders are far greater.

Table 9: Milk and Meat Prices by Size of Farm, Rural India 2002-03

Farm Size	Milk	Meat
	Price Rs Per Litre	Price Rs Per KG
Small Farmers(0-2ha)	10.03	36.50
Medium Farmers (>2-5ha)	9.87	34.67
Large Farmers>5ha	10.12	48.74

Source: 59th Round of NSS

Table 10: Shares of Nutrients Produced by Milk, Meat and Poultry by Size of Farm, Rural India, 2002-2003

Farm Size	Milk			Meat and Poultry		
	% Share	% Share	% Share	% Share	% Share	% Share
	in calories	in Protein	in fat	in calories	in Protein	in fat
Small Farmers(0-2ha)	72.5%	72.5%	72.5%	84.7%	87.5%	79.2%
Medium Farmers (>2-5ha)	19.3%	19.3%	19.3%	13.7%	10.5%	19.7%
Large Farmers>5ha	8.2%	8.2%	8.2%	1.7%	1.9%	1.1%

Source: 59th Round of NSS

As diets shift towards dairy and other livestock products, constraints under which smallholders operate (technological, storage and market) deserve higher priority than generally given.

While a strong case is made for support to smallholders on grounds of productivity and equity, our analysis highlights their potential contribution to alleviating nutritional deprivation.

6. Concluding Observations

Our analysis illustrated one pathway between agriculture and nutrition through production of nutrients by crop and size as well as through livestock. As this pathway is subsumed in

agriculture and nutrition studies focusing on anthropometric outcomes, and hardly any light is thrown on the contribution of smallholders, it is emphasised that they play an important role as producers of nutrients. Specifically, despite various disadvantages (e.g. inadequate access to extension, technology, credit and markets), they contribute largest shares of calories, protein and fats. However, profits earned (using an approximate measure) are considerably lower among them than among medium and large landholders. At least two reasons are identified in our analysis: one is limited access to markets and another is lower crop prices. A much greater emphasis on enabling higher investment, access to technology and markets through better rural infrastructure would help increase profitability of crop production. Equally important are market imperfections that manifest in lower crop prices for smallholders. How economies of scale could be exploited through farmers' groups needs careful scrutiny.

From a policy perspective, rural transportation network has a key role in determining the efficiency of agricultural marketing system. In a recent contribution, Shilpi and Umali-Deininger (2008) offer a broader perspective that takes into account not just distance but also facilities available at the market. Their findings based on village survey data in Tamil Nadu in India show that (i) an improvement in market facilities implied by a higher value of the market access index⁶ is associated with an increase in the farmers' propensity to sell; and (ii) the impact of the market access index also depends on the wealth of a farmer, as reflected in a negative coefficient of the interaction of these variables. So, although wealthy farmers are able to take greater advantage of cheaper modes of transportation to reduce waiting time, this advantage reduces with higher land owned groups. Simulations with a 20 per cent improvement in market facilities show that additional investments in market facilities are pro-poor as sales of the poorer farmers increase more than proportionately to those of wealthy farmers. In other words, while the latter capture the benefits of existing facilities better than the former, the marginal benefit from an improvement of market facilities is substantially greater for smallholders.

Government's efforts (through Ministry of Agriculture, GOI) in operating AgMark Net are a good example of the State's proactiveness. AgMark Net collects price information from wholesale markets all over the country and disseminates it through the internet. Now the private sector is also developing its own network.

⁶ See Shilpi and Umali-Deininger (2008) for the definition of market access index

In sum, while the objective of diversifying smallholder agricultural production and ensuring better access to market opportunities is daunting, recent evidence favours an optimistic view.

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