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IFPRI Discussion Paper 00727

November 2007

Diversification in Indian Agriculture towards High-Value Crops

The Role of Smallholders

P. S. Birthal, National Centre for Agricultural Economics and Policy Research
P. K. Joshi, National Centre for Agricultural Economics and Policy Research
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Markets, Trade and Institutions Division

INTERNATIONAL FOOD POLICY RESEARCH INSTITUTE.

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ABSTRACT

Agricultural diversification towards high-value crops can potentially increase farm incomes, especially in a country like India where demand for high-value food products has been increasing more quickly than that for staple crops. Indian agriculture is overwhelmingly dominated by smallholders, and researchers have long debated the ability of a smallholder-dominated subsistence farm economy to diversify into riskier high-value crops. Here, we present evidence that the gradual diversification of Indian agriculture towards high-value crops exhibits a pro-smallholder bias, with smallholders playing a proportionally larger role in the cultivation of vegetables versus fruits. The observed patterns are consistent with simple comparative advantage-based production choices. The comparatively high labor endowments of the small farmers, as reflected in their greater family sizes, induce them to diversify towards vegetables. Although fruit cultivation is also labor intensive (as compared to cultivation of staples), fruits are relatively capital intensive, making them a less advantageous choice for smallholders who tend to have low capital endowments. Furthermore, both the probability of participation in fruit and vegetable cultivation as well as land allocation to horticulture decreases with the size of landholdings in India. Small or medium holders do not appear to allocate a greater share of land to fruits or vegetables. However, the share allocated to vegetables is significantly higher if the family size is bigger, while the reverse is true in the case of fruits.

Keywords: Diversification, smallholders, high-value agriculture

1. INTRODUCTION

Although agriculture occupies a shrinking share of India's national economy, achieving rapid growth in agriculture remains a major policy concern nationwide. The contribution of agriculture to India's gross domestic product (GDP) fell from 40% in 1980/81 to 21% in 2004/05. However, 72% of India's population lives in rural areas, and three-fourths of the people making up these rural populations depend on agriculture and allied activities for their livelihoods. Furthermore, the agricultural sector is the main source of employment in India, comprising 57% of the country's labor force in 1999/2000.

Between 1980/81 and 1995/96, the agricultural sector in India grew at a rate of 3.3% per year, and this growth had a significant impact on poverty reduction. This is consistent with the findings of Ravallion and Datt (1996) and Warr (2003), who showed that growth in the agricultural sector is more poverty-reducing than growth in other economic sectors. However, despite the past growth in this sector, agriculture in India is now beset with problems. Most importantly, agricultural growth decelerated to 2.1% between 1996/97 and 2002/03, largely due to a decline in the food grain segment that grew at merely 0.6%. Given the high dependence of the poor on agriculture, the stagnation in this sector is currently threatening to stall poverty reduction in India.

Under such a scenario, the fundamental question is: how can agricultural growth be accelerated? The potential to increase growth through staples appears limited, mainly because the demand for staples has stagnated. The consumption patterns have diversified towards high-value agricultural commodities (HVA) such as fruits, vegetables, dairy, poultry, fish, and processed food (Ravi and Roy 2006). This demand shift is underpinned by sustained income growth and urbanization; Ravi and Roy (2006) project demand in India through 2020, and show that the diversification in consumption patterns towards high-value agricultural products will become more pronounced with income growth and changes in other determinants such as urbanization. Moreover, globalization has created new opportunities for the export of high-value products. Diaz-Bonilla and Recca (2000) observed an accelerated flow of exports of high-value food commodities from developing to developed countries.

From the perspective of poverty reduction, diversification is particularly appealing. Most high-value food commodities are labor-intensive, have low gestation periods and generate quick returns. Hence, they offer a perfect opportunity for smallholders to utilize surplus labor and augment their incomes (Joshi et al. 2002; Barghouti et al. 2005; Weinberger and Lumpkin, 2005). Previous studies in South and Southeast Asia have indicated that diversification towards high-value food commodities supports the development of innovative supply chains and opens new vistas for augmenting income, generating employment and promoting exports (Barghouti et al. 2004; Pingali 2004; Deshingkar et al. 2003; Pokharel 2003; Wickramasinghe et al. 2003; Goletti 1999). Moreover, food and income security

have been shown to increase in regions where agricultural diversification takes place, particularly favoring horticulture, animal husbandry, and aquaculture (Barghouti et al. 2005; Dorjee et al. 2002).

However, the transition towards high-value agriculture is not without constraints, especially for smallholders. If the high-value commodities are products that the farmers have not grown before, the farmers may lack necessary information on production methods, marketing opportunities, and the probable distribution of net returns. This problem is particularly acute when the target consumers have very specific quality requirements and/or strict food safety requirements. Of course, the farmers can attempt to gather information, but this often involves a fixed cost (one not related to the level of output), thus giving an advantage to larger-scale farmers (Minot and Roy, 2006). Larger farmers are often better able to bear the risks associated with producing and marketing high-value commodities.

Furthermore, a small farmer who allocates land to a commercial crop often has to depend on market purchases to meet food requirements, resulting in an additional source of risk. Some high-value agricultural commodities also require significant investments, including the use of specific inputs. For example, fruit production typically means that the farmer must plant trees and wait 3-5 years for them to begin producing. Finally, the production and marketing of highly perishable high-value commodities benefit from the producing farm being located near markets and good marketing infrastructure (Torero and Gulati, 2004).

Farmers in developing countries such as India, particularly poor farmers, often do not have the savings or credit access needed to make these investments and purchase the necessary inputs. However, high-value commodities like fruits and vegetables may become viable prospects when these constraints are relieved through intervention. Furthermore, smallholders tend to have greater labor endowments (i.e. larger families), meaning that they may be better suited in cultivating labor intensive high-value crops.

The competitiveness of small farmers relative to large farmers is not fixed and can change over time, usually as a result of changes in physical, human, or social capital. Farmers may acquire new equipment or build irrigation works (physical capital) that reduce the cost of production. Farmer skills (human capital) can also change over time as a result of learning-by-doing and/or through outside technical assistance (Minot and Roy, 2006).

There has been some debate as to whether a smallholder-dominated economy can actually diversify, and whether smallholders participate significantly in production diversification towards high-value products. Here, we use both aggregate and household-level data to address this question in the context of crop diversification towards fruits and vegetables in India. The time period for the state-level analysis spans more than two decades, from 1980/81 to 2002/03.

During this period, India became self-sufficient in grain production (during the 1990s), which might have triggered diversification out of staples. Also, the food basket of consumers underwent a

significant change during the 1990s; the per capita consumption of cereals declined, while that of high-value commodities increased considerably. Moreover, India initiated economic reforms in 1991. Since then, a number of policy initiatives have been undertaken to liberalize markets and improve agriculture-industry linkages. A priori, it is expected that these developments played a role in inducing diversification.

Using state-level information on the percentage of landholdings belonging to smallholders, along with various indicators of diversification in agriculture, we show that diversification away from cereals into fruits and vegetables is significantly higher in states with a greater share of smallholders. Our fixed effects specification suggests that these results are robust after controlling for observed and unobserved state level factors.

Further, using household-level data for a single time period, we assess crop choices across the various farm sizes and show that the probability of a given household diversifying into vegetable cultivation is higher for smaller farmers, but that no such bias exists in the case of fruits. This can likely be explained by the relatively lower labor requirements and greater capital intensity (in terms of both start-up and working capital) required for cultivation of fruits, both of which work against small farmers. Larger families show a higher tendency to diversify mainly into vegetables, whereas family size does not significantly impact diversification into fruits. Finally, in both fruits and vegetables, the probability of diversifying into the respective commodity (fruit or vegetable) declines with increasing land size.

The paper is organized as follows: section 2 briefly describes the data and measurement of variables used herein, section 3 examines the contribution and growth of high-value food production at the national and state levels, section 4 discusses smallholder participation in high-value food production, based on secondary household level data, and conclusions are presented in section 5.

2. DATA AND MEASUREMENT OF VARIABLES

We herein use secondary data from several published sources. The values for various agricultural commodities come from the National Accounts Statistics prepared by the Central Statistical Organization (CSO), Ministry of Statistics and Program Implementation, Government of India. The data on crop areas and production are from the publications of the Directorate of Economics and Statistics, Ministry of Agriculture, Government of India. The data on infrastructure, technology, etc. are from statistical yearbooks published by the various state governments.

In this paper, the smallholder is defined as a farmer with less than or equal to 2 hectares of land. For analysis of smallholder participation in HVA, the household-level data come from the National Sample Survey Organization (NSSO) [54th round in 1998, dealing with cultivation practices (GOI, 1999)]. The sample comprises approximately 50,000 households.

We employ three measures of diversification towards fruits and vegetables. The first measure is the gross value of horticultural output at constant prices at the state level. The second measure is the share of fruits and vegetables in the overall value of agricultural output at constant 1993-94 prices. The total value of agricultural output contains other farm and non-farm high-value products, such as high-quality rice and livestock products, and fish. The last measure is the share of agrarian land devoted to fruits and vegetables in each state, and can be considered a true indicator of crop diversification.

3. DIVERSIFICATION TOWARDS FRUITS AND VEGETABLES AT THE MACRO LEVEL

The share of high-value food commodities making up the total value of agricultural output in India increased from 32.5% in triennium (TE) 1982/83 to 44.4% in TE2002/03 (Table 1). Table 2 presents these figures at the state level, which is the unit of analysis at the macro level. Over the course of the examined period, the share of fruits and vegetables in the gross value of agricultural output increased from 14% to 17.9%.

During the 1980s, there were relatively few changes in the production portfolio. The shares of cereals, pulses, sugar, fibers and spices in gross value of agricultural output remained nearly constant during this decade, with the share of fruits and vegetables remaining around 14%. There were three exceptions to this pattern, namely oilseeds, which showed an increase in share from 6.6% in TE1982/83 to 8.5% in TE1992/93, and pulses and coarse cereals, which declined in share. In contrast to the 1980s, the 1990s were marked by significant changes in the production portfolio. The share of food grains decreased from 33% in TE1992/93 to 23.5% in TE2002/03, and rapid declines were seen in rice, coarse cereals, pulses and oilseeds.

The robust growth in HVA production during 1990s may be associated with a number of forces. First, India achieved self-sufficiency in food grain production in the mid-1990s, thereby mitigating the prevalent food security concerns. Food grain production increased from 176 million tons in 1990/91 to 213 million tons in 2003/04. During this period, the Indian economy also witnessed consistently robust growth of about 6% a year. The urban population grew faster than the rural population between 1991 and 2001, when the compound annual growth in the urban population was 2.8% compared to 1.7% in the rural population. These factors could be seen as collectively propelling rapid changes in the food baskets of Indian consumers (Ravi and Roy 2006).

Table 1. Composition and growth of agricultural sector in India (in constant 1993-94 prices)

Commodity	Share in gross value of agricultural output (%)			Compound annual growth (%)	
	TE1982/83	TE1992/93	TE2002/03	1980/81 to 1991/92	1992/93 to 2002/03
Crops	77.3	74.3	70.9	2.8	2.5
Rice	14.6	15.1	12.9	4.0	1.5
Wheat	7.9	8.2	7.7	3.2	2.6
Coarse cereals	4.9	3.9	2.8	0.4	-0.1
Pulses	5.6	4.6	3.3	1.2	-.0.1
Food grains	33.0	31.8	26.8	2.8	1.4
Oilseeds	6.6	8.5	6.7	6.0	0.3
Sugar	6.0	5.9	6.4	3.5	4.4
Fiber	3.4	3.3	2.5	2.9	-0.03
Drugs and narcotics	1.6	1.4	1.7	1.9	4.5
Spices	2.1	2.2	2.6	4.3	4.4
Fruits and vegetables	14.0	13.5	17.9	2.5	6.0
Total agriculture	100.0	100.0	100.0	3.2	2.9
High-value (including livestock)	32.5	35.9	44.4	4.1	5.0
Rest	67.5	64.1	55.6	2.7	1.5

Source: GOI (various years), National Accounts Statistics.

Table 2. Compound annual growth rate in agriculture and horticulture across major states

State	Agriculture		Horticulture	
	1980/81 to 1991/92	1992/93 to 2002/03	1980/81 to 1991/92	1992/93 to 2002/03
Haryana	3.1	3.0	0.3	15.8
Himachal Pradesh	3.2	3.1	4.9	6.3
Jammu & Kashmir	3.5	3.3	4.2	5.4
Punjab	3.8	2.0	7.5	4.1
Uttar Pradesh	2.8	2.6	1.5	9.9
Bihar	3.5	3.9	0.5	10.8
Orissa	2.6	0.8	2.6	5.5
West Bengal	5.8	3.6	4.5	6.7
Assam	2.5	2.2	3.9	4.4
Andhra Pradesh	2.9	4.0	-0.04	4.4
Karnataka	4.0	4.0	9.0	4.5
Kerala	2.9	2.9	0.3	3.0
Tamilnadu	3.4	2.6	3.5	5.9
Gujarat	-0.2	2.0	1.1	4.3
Madhya Pradesh	4.3	1.3	4.2	6.6
Maharashtra	2.3	3.2	5.4	5.3
Rajasthan	3.1	2.5	10.5	11.4

Source: GOI (various years), National Accounts Statistic.

Moreover, the green revolution technologies that were instrumental in boosting cereal production started showing signs of fatigue in the late 1980s, leading to depression in farm incomes. This, together with increasing demand for high-value food commodities, prompted farmers to diversify into higher value

food commodities. To a limited extent, diversification was also supported by the fact that various policies shifted from cereals towards high-value food commodities, especially horticulture (during the 1990s). The National Horticulture Board was established in 1984 to boost production, disseminate information, provide technical know-how and services and strengthen backward and forward linkages. This emphasis on horticulture continued in subsequent years with the 2005 launch of the National Horticulture Mission, which was aimed at increasing production, processing and exports of horticultural products.

Furthermore, a number of regulations were amended to facilitate private sector participation in the food sector. The Agricultural Produce Market Committee Act, which previously restricted transactions outside state-designated markets, was amended in several states to allow direct sale/purchase of agricultural commodities between producers and processors through institutional mechanisms like contract farming, producers' associations and formal/informal cooperatives. Moreover, the institutional lending agencies were allowed to finance such schemes. Until recently, the processing of a number of agricultural products was reserved for small-scale industries; now, many items have been de-reserved. In addition, a number of fiscal incentives are now offered to the processing industry, including reduction in excise and corporate taxes, as well as reduced import duties on imported machines and equipment.

Crop Diversification and the Role of Smallholders

Though smallholders dominate Indian agriculture, there are substantial inter-state differences in the share of smallholders in agricultural holdings, as well as in the share of smallholders in total land holdings over time. Table 3 presents the share of smallholders in landholdings for the major states in India for the year 1998.

Figure 1 shows the percentage distribution of smallholder shares with regard to total state land holdings over time. The share of smallholders changes over time in every state examined. All states exhibit a trend towards fragmentation of landholdings as the population pressure increases, likely because the need for land is not offset by generation of non-farm opportunities, resulting in sequential decreases in holding size.

Moreover, there is sizeable time-dependent variation in the state-level diversification towards fruits and vegetables. Figure 2 (below) shows the percentage area allocated to fruits and vegetables in the various states over time. For most states, a greater proportion of land area is allocated to the cultivation of fruits and vegetables over time. [1]

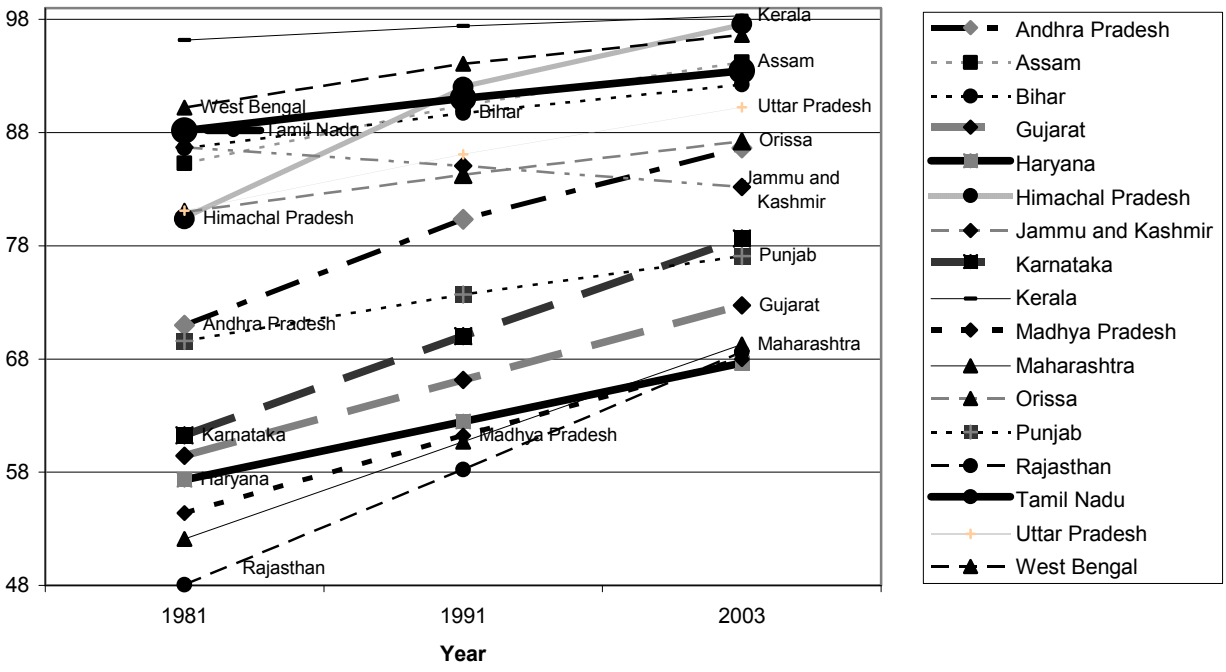
[1] The sharp reduction in share of land allocated to fruits and vegetables seen in the mountainous states of Jammu and Kashmir, is due to a militant insurgency that started in the early 1990s.

Table 3. Share of landholders by size (1998)

State	Small	Medium	Large
Andhra Pradesh	78.6	14.0	7.4
Assam	87.1	10.8	2.1
Bihar	89.5	7.8	2.7
Gujarat	68.9	17.4	13.7
Haryana	59.6	23.6	16.8
Himachal Pradesh	92.6	5.8	1.6
Jammu & Kashmir	94.2	4.9	0.9
Karnataka	72.7	16.1	11.2
Kerala	98.0	1.5	0.5
Madhya Pradesh	63.5	24.4	12.1
Maharashtra	68.4	19.4	12.2
Orissa	90.7	7.4	1.9
Punjab	57.3	22.9	19.8
Rajasthan	59.2	20.4	20.4
Tamilnadu	88.9	7.8	3.3
Uttar Pradesh	87.3	9.2	3.5
West Bengal	95.7	3.9	0.4

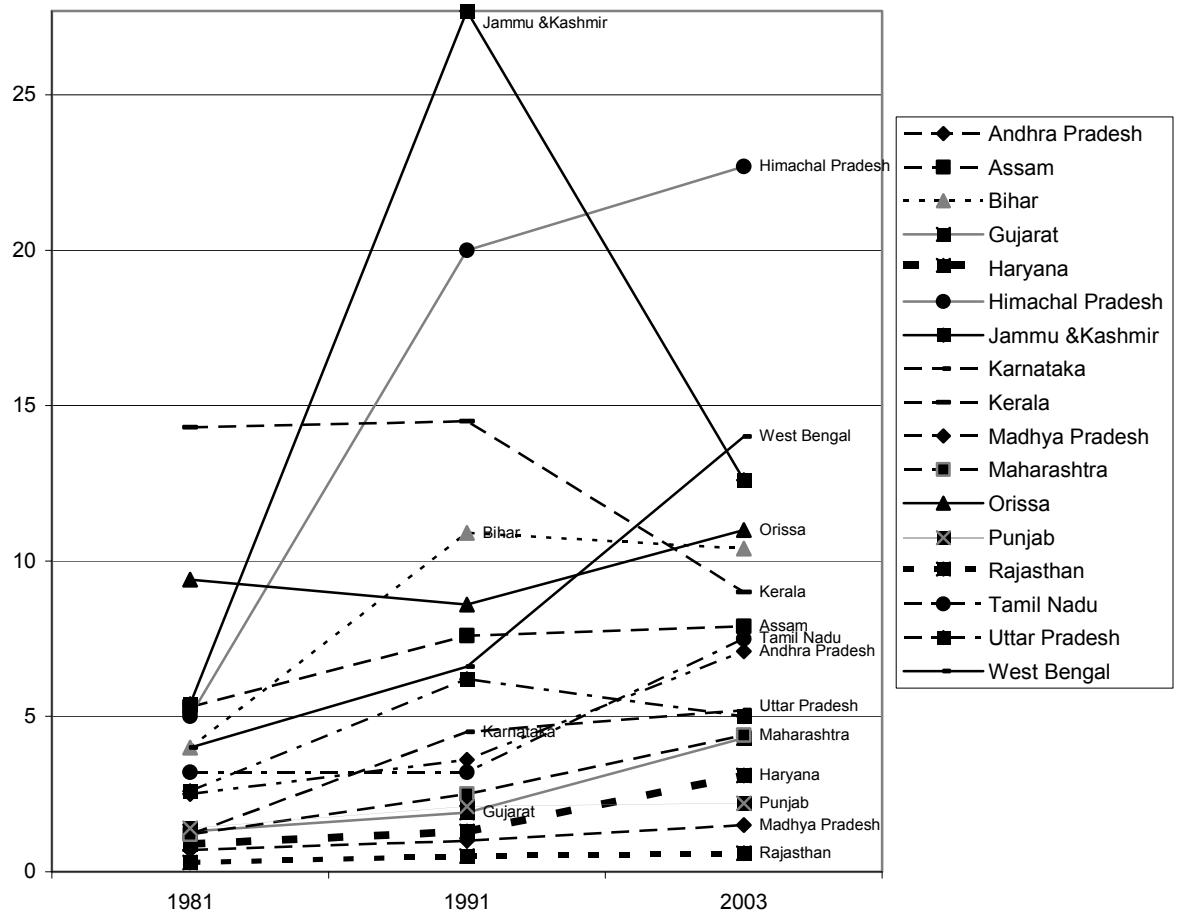
Source: Agricultural Census.

Figure 1. Percentage of smallholders in total landholdings in various states over time (1981, 1991 and 2003)



Source: National Accounts Statistics, various years.

Figure 2. Share of land allocated to fruits and vegetables in the various states over time (1980, 1991, 2003)



Source: National Accounts Statistics, various years.

To assess the relationship between diversification at the state level and the share of landholdings with the smallholders, the fixed effects regression for our analysis is specified as:

$$I_{it} = \alpha_i + \beta_t + \delta * d + \gamma * X + \theta Sm_{it} + \varepsilon_{it} \qquad (1)$$

I_{it} is one of the three dependent variables, value of horticultural output at the state level (at constant 1980-81 prices), share of horticulture in the value of agricultural output at the state level (in constant prices) and share of agricultural land devoted to horticultural production respectively. The last two dependent variables measure diversification relative to other crops (in terms of share in value and in land area respectively).

In equation (1), the coefficient of interest is θ, which captures the state-level share of smallholders in total landholdings (the variable sm_{it}) . In the regression, we control for several time- and

state-dependent variations in demand (d)- and supply-side factors (X) .The dummy variables α_i and β_t denote the state-level and time-fixed effects, respectively. All dependent and explanatory variables are transformed to their natural logarithms, in order to smooth out the resulting series. The identification of the coefficients comes from within-state changes over time.

Since the panel data results could suffer from spurious regression due to non-stationarity of the time series variables, we tested for the stationarity of the variables using the Im-Pesaran-Shin (IPS) test for the three panels. The IPS test assumes that under the null hypothesis, all series in the panel are non-stationary processes. Under the alternative hypothesis, a fraction of the series in the panel are assumed to be stationary.

The methodology is an extension of the Augmented Dickey Fuller (ADF) test. In the IPS test, ADF regressions are computed for each unit, and a standardized statistic is computed as the average of the Lagrange Multiplier (LM) tests for each equation. Adjustment factors are used to derive a test statistic that is distributed as a standard normal under the null hypothesis. IPS also propose the use of a group–mean t bar statistic, where the statistics from each ADF test are averaged across the panel; again, adjustment factors are needed to translate the distribution of the t bar into a standard normal variate under the null hypothesis. Table A.1 in the appendix give the IPS t bar statistics (with 2 lags) for the three panels used in the regressions. Based on the IPS test, the variables included in the three regressions are stationary.

In the fixed effect regressions, demand-side factors such as population density, urbanization and per capita income in each state are included as controls. [2] On the supply side, water availability (irrigation and rainfall), production technology, resource endowment (land and labor), and infrastructure (roads and markets) facilitate diversification towards fruits and vegetables. Thus, the regression further controls for irrigation, annual rainfall, land holding size and roads. HVA is labor intensive; thus, in order to capture the economic availability of labor, we use the real wage rate of agricultural labor as one of the control variables on the supply side. To capture the effect of the relative profitability of fruits and vegetables, we further include the relative price of fruits and vegetables with respect to cereals in each state.

Furthermore, crop diversification towards fruits and vegetables often requires greater start-up capital, making credit an important variable. Non-institutional credit is largely sought for non-productive activities, while institutions mainly provide credit for production related activities. Thus, the availability of institutional credit is also included as an explanatory variable.

[2] In terms of demand-side controls, the factors affecting demand could well be beyond the state level (e.g. per capita income in neighboring states). Since the variable of interest is the share of smallholders in states, we let these omitted variables be subsumed in the error term. However, in states with low levels of infrastructure, such as roads and post-harvest technology, the role of local demand is amplified.

The coefficient reflecting the smallholders' share in landholdings is highly significant in all three regressions. The fixed effect specification controls for several unobserved state-level variables that do not change over time (e.g. agro-climactic conditions). Similarly, time-fixed effects capture various state level changes relevant for inducing diversification (e.g. tastes and preferences). Technological changes that could be important drivers of diversification are controlled by time fixed effects. The results are presented in Table 4.

Does this aggregate evidence thus indicate that small farmers are more likely to adopt horticulture? In order to answer this question, we next analyze household-level information from a national sample survey on cultivation practices. As discussed above, there are both pros and cons for participation of small farmers in high-value agriculture compared to the large farmers. We show in the next section that smallholders in India appear biased toward diversifying into the cultivation of vegetables but not fruits.

Table 4. Determinants of growth in high-value food production: fixed effects regressions for fruits and vegetables

Explanatory variables	Fixed effects regression (dependent variable – Value of horticultural output at constant 1980-81 prices	Fixed effects regression (dependent variable – share of fruits and vegetables in agricultural output at constant 1993-94 prices)	Fixed effects regression (dependent variable – share of fruits and vegetables in agricultural land area in state)
Percentage of landholdings belonging to smallholders (< 2 hectares)	2.80(6.55)***	2.40(6.66)***	2.35(5.69)***
Average size of landholding in state	0.26 (1.71)**	0.19(1.75)*	0.01(0.11)
Per capita income in state	0.23(1.82)*	-0.17 (1.60)	0.20(1.54)
Urbanization in state	-1.01 (-2.44)	-0.54(-1.56)	-0.78(-1.88)*
Irrigation (% of land area irrigated)	-0.02(-0.34)	-0.01(-0.29)	-0.01(-0.16)
Rainfall (annual in mm)	0.01(0.31)	-0.06(-1.85)**	0.005(0.11)
Agricultural wage (in Rs per day)	-0.20(-2.33)**	-0.18(-2.53)**	-0.32(-4.06)***
Agricultural credit (total agricultural credit/total cultivated land area)	-0.002 (-0.11)	0.002 (0.16)	0.01(1.17)
Roads (paved roads per 100 square km)	-0.08(-2.21)**	-0.005 (-0.07)	-0.28 (-3.26)***
Markets per 100 square km in the state)	0.10(1.78)*	0.01 (0.26)	0.11(2.19)**
Population density	-0.13(-0.71)	0.48 (2.87)***	1.06(5.21)***
Relative prices of fruits and vegetables	0.78(7.01)***	0.74(7.80)***	-0.34(-4.69)***
Year fixed effects	Yes	Yes	Yes
State fixed effects	Yes	Yes	Yes
R-squared	0.86	0.97	0.97
No. of observations	341	341	341

Notes: *denotes 10% level of significance, ** denotes 5% level of significance and *** denotes 1% level of significance. Terms in parentheses are the t statistics.

4. HOUSEHOLD PARTICIPATION IN CULTIVATION OF FRUITS AND VEGETABLES BY FARM SIZE

Regional Heterogeneity and the Role of Smallholders in the Cultivation of Fruits and Vegetables

India is characterized by considerable heterogeneity in soils, topography, rainfall, temperature, irrigation, infrastructure and socio-economic conditions. This has both demand- and supply-side implications for the relative profitability of different crops, and therefore affects the participation of smallholders in cultivation of fruits and vegetables. India includes 29 states that are broadly divided into five regions: the north (Haryana, Himachal Pradesh, Jammu & Kashmir, Punjab and Uttaranchal, Uttar Pradesh), east (Bihar, Jharkhand, Orissa and West Bengal), northeast (Assam, Arunachal Pradesh, Meghalaya, Manipur, Nagaland, Sikkim and Tripura), west (Chattishgarh, Gujarat, Goa, Madhya Pradesh, Maharashtra and Rajasthan), and south (Andhra Pradesh, Karnataka, Kerala and Tamil Nadu). Although this classification does not fully capture within-region variations in agro-climatic attributes, the states in a particular region tend to be homogeneous to a certain degree of approximation. Because of the acknowledged between-region variations, we felt that it was important to control for a given farmer's agro-economic zone and geographical location in our household-level analysis.

The major states in the northern region have alluvial soils and good irrigation facilities (72-96% of the gross cropped area is irrigated). The eastern states are broadly similar in agro-climatic conditions, with a generally humid climate, normal rainfall over 1200 mm per year, and the amount of irrigated area as percentage of gross cropped area ranging between 28% in Orissa to 48% in Bihar. Likewise, the northeastern states also are homogenous with respect to soils, topography and rainfall. The western and southern states largely represent semi-arid climates (with the exception of some arid parts of Rajasthan in the western region) with less than 40% of the areas currently under irrigation.

In terms of food crops, the northern region has been called the cradle of the green revolution, and is highly specialized in the production of rice and wheat. Food grains accounted for 38.5% of the gross value of agricultural output in TE2002/03, with similar values seen consistently over the previous two decades. Sugarcane and oilseeds are other important crops in this region, although the importance of oilseeds in this region has declined over time, while the share of fruits and vegetables has increased considerably since the early 1990s. Some states in the northern region suffer from acute labor shortages, resulting in higher wage rates and discouraging the production of labor-intensive HVA crops.

The eastern region is most backward in terms of agricultural development. In the northeast, the agro-climatic conditions are favorable for horticulture, and for spices and aromatic and medicinal plants. This region includes some of the most remote areas in India, and lack of infrastructure and subsequent market underdevelopment is acute, even more so than in the eastern region. In the south, rice is the main

staple crop. Its share, however, has declined considerably since the early 1990s. Fruits and vegetables are important everywhere in the region, except in Andhra Pradesh, where fruits and vegetables accounted for less than 10% of the agricultural output in TE2002/03.

Agriculture in the western region is largely rain fed and is highly diversified. Recent years have seen rapid increases in HVA production in this region, largely due to various technological and institutional interventions. The robust growth in fruit and vegetables in Maharashtra can be attributed to a strong network of cooperatives and producers' associations. Given the scarcity of water in Maharashtra, the government made substantial investment in watersheds and technologies in an effort to enhance the efficiency of water use (e.g. drip-fed irrigation and sprinklers). The area under drip irrigation in Maharashtra increased from a mere 500 hectares (ha) during the 1980s to about 1.0 million ha in 2002. Moreover, in 1990 the state government in Maharashtra linked horticultural production with the Employment Guarantee Scheme (EGS), which mandated that every beneficiary was supposed to put at least 0.2 ha of land to horticultural crops, and provided government-subsidized inputs (e.g. planting materials). This had a strong effect on horticultural production in this region.

At the national level in India, land holdings of less than 2 hectares comprise nearly 81% of the holdings and account for 41.4% of the land area based on 1996 agricultural census (see Table 3). The proportion of smallholders is highest in the eastern region (91.7% of holdings accounting for 65.3% of the land area) and is lowest in the western region (64.5% of holdings accounting for 26.8% of the land area). In the north and northeast, about 86% of the farm households are smallholders. Inter-state differences in the proportions of small landholdings are given in Table 3.

In terms of national crop distributions, 15.3% of farm households grow vegetables and 4.6% grow fruits (Table 5). Nearly 16% of households with less than 2 hectares grow vegetables. The corresponding figures for medium and large farm households are 14.8 and 10.4%, respectively. The proportion of households growing fruits is also higher among smallholders.

Smallholder participation in vegetable cultivation is highest in the northeastern region (65.5%), while the participation rate in the north is similar to the national average and those in the western and southern regions are below the national average. Participation rates also vary across farm categories in the different regions. In the north, large farms participate in vegetable cultivation less than small and medium-sized farms. In the east, the proportion of vegetable-growing households is the least among marginal farmers followed by large farmers. In the south, the participation rate is higher among the large farmers followed by marginal, medium and small farmers.

Table 5. Participation of categories of farm households in cultivation of fruits and vegetables

	North	East	Northeast	South	West	National
			% Households			
Vegetables						
Small	15.8	21.1	65.5	8.1	5.6	*15.8*
Medium	15.3	29.0	75.9	8.0	8.3	*14.8*
Large	12.7	22.3	74.5	8.7	6.9	*10.4*
All	15.6	21.6	66.9	8.1	6.4	*15.3*
Fruits						
Small	2.2	1.1	4.5	17.6	1.5	*5.0*
Medium	2.0	1.9	6.1	6.7	1.3	*2.7*
Large	2.9	0.0	4.9	6.4	2.2	*3.0*
All	2.3	1.1	4.7	15.7	1.5	*4.6*
			% Of gross cropped area			
Vegetables						
Small	2.32	4.02	14.20	2.36	1.36	*2.97*
Medium	1.67	2.78	10.28	1.63	1.05	*1.80*
Large	1.31	2.31	10.59	1.23	0.82	*1.20*
All	1.91	3.52	12.73	1.83	1.04	*2.12*
Fruits						
Small	0.65	0.23	0.83	3.93	0.44	*1.02*
Medium	0.39	0.37	1.03	2.56	0.29	*0.67*
Large	0.47	0.00	1.13	2.25	0.57	*0.78*
All	*0.54*	*0.22*	*0.92*	*3.08*	*0.46*	*0.86*

Source: GOI (1999): Cultivation practices in India.

A comparatively high proportion of farmers in the southern region (15.7%) grow fruits, and there is a distinct negative relationship between participation rate and farm size. The medium farmers dominate fruit cultivation in the northeast, while in other regions, the proportion of fruit-growing households is highest among large farmers.

Table 5 presents the area allocation to fruits and vegetables by farm size. In general, farmers allocate a relatively small proportion of their land to vegetables and fruits. Across the farm categories, the percentages of area under vegetables tend to decline with farm size. A similar relationship holds for fruits, except that large farmers allocate more area to fruits compared to small and medium farmers. The pattern of area allocation to vegetables differs by region, with the northeast having the highest area under vegetables (12.7%), followed by the east (3.5%), north (1.9%) and west (1%).

Assuming identical productivity among different farm sizes, smallholders contribute 61% to vegetable and 52% to fruit production, which is a much higher share than their share in arable land (41%). Furthermore, these shares could well be an underestimation if the productivity on small farms is higher which is likely because of higher labor endowments of the smallholders. In contrast, large farmers, who constitute 6.8% of the farm households and occupy 34.3% of the arable land, contribute only 18.1% to vegetable production and 28.8% to fruit production.

The regional pattern of area allocated to fruits corresponds with the various participation rates. Except in the south and northeast, the proportion of area under fruits shows a U-shaped relationship with farm size. In the northeast it increases with farm size, while in the south the proportion is higher among the marginal farmers, but relatively little difference is seen in the allocation of land among the other farmer categories.

To summarize, small and large landholders appear to participate in HVA at similar levels, while smallholders participate significantly more in vegetables. Most vegetables have a short production cycle, generate quick returns, require less capital and are relatively labor-intensive, making them ideal for the cropping schemes of smallholders.

Table 6. Share of different farm categories in area under vegetables and fruits (%)

	North	East	Northeast	South	West	National
Vegetable growing households						
Small	86.7	89.4	84.7	82.7	57.2	83.5
Medium	9.5	8.7	12.2	10.6	27.4	11.9
Large	3.8	1.9	3.1	6.7	15.4	4.6
Vegetable area						
Small	61.9	74.4	68.6	58.1	37.4	61
Medium	20.6	16.2	21.0	20.5	27.5	20.9
Large	17.5	9.4	10.4	21.4	35.1	18.1
Fruit growing households						
Small	85.3	88.8	83.1	92.9	61.4	88.4
Medium	8.7	11.2	14.0	4.6	17.8	7.1
Large	6.0	0.0	2.9	2.5	20.8	4.5
Fruit area						
Small	62.1	65.8	55.4	57.5	27.5	51.9
Medium	16.7	34.2	29.3	19.2	17.4	19.3
Large	22.2	0.0	15.4	23.3	55.1	28.8

Source: GOI (1999): Cultivation practices in India.

Indeed, Table 7 shows little convergence in crop choices between fruits and vegetables. Growers of fruits and vegetables are distinctly different in the sense that they rarely combine cultivation of fruits and vegetables. Nearly 93% vegetable growers never cultivate both fruits and vegetables simultaneously. Similarly 76% of the fruit growers do not cultivate vegetables.

Table 7. Distribution of households growing either vegetables or fruits or both in India (%)

Farm category	Vegetable growers		Fruit growers	
	Vegetables but no fruits	Both vegetables and fruits	Fruits but no vegetables	Both fruits and vegetables
Small	92.3	7.7	75.7	24.3
Medium	95.9	4.1	77.1	22.9
Large	95.2	4.8	83.6	16.4
All	92.8	7.2	76.1	23.9

Source: GOI (1999): Cultivation practices in India.

Table 8 shows the share of fruits and vegetables in the cropped area of the households growing them. On an average, vegetable growers allocate nearly 15% of their cropped area to vegetables, while fruit growers put 31% of their cropped area to fruits. The relationship between farm size and area allocated to these crops is generally negative (except for fruits in the South and northeast and vegetables in the west). On small and large farms growing these crops, vegetables occupy 18 and 11.3%, respectively, of the cropped area, while fruits occupy 35 and 25.6%, respectively. Although there are significant between-region differences in the areas allocated to these crops, there is a consistently negative relationship with farm size, especially for vegetables.

Table 8. Share of vegetables and fruits in total cropped area of the growing households (%)

	North	East	Northeast	South	West	National
			Vegetables			
Small	13.5	15.9	22.1	32.5	20.3	17.8
Medium	11.1	9.8	13.4	23.0	11.9	12.5
Large	11.0	8.0	12.9	14.4	14.6	11.3
All	12.5	13.3	18.3	24.0	19.2	14.9
			Fruits			
Small	28.3	19.2	16.7	43.6	35.4	34.9
Medium	19.6	20.4	20.5	6.7	29.8	30.9
Large	18.0	0.0	34.6	11.3	22.8	25.6
All	23.6	19.6	19.3	12.1	26.5	30.9

Source: GOI (1999): Cultivation practices in India.

Though smallholders allocate proportionately more area to vegetables and fruits, their scales of production are small. There is a strong positive relationship between scale of production and farm size for both fruits and vegetables (Table 9). For instance, the area under vegetables on large farms (0.94 ha) is more than seven times than on the marginal farms (0.13 ha). The difference is even higher in case of fruits. A similar pattern exists at the regional level, except in the west where the difference between small and large farms is more moderate. The scale of vegetable production within each farm category is not significantly different across regions, while the scale of fruit production varies widely within the different farm categories.

Table 9. Scale of production (area put under cultivation) of vegetables and production of the growing households (ha)

	North	East	Northeast	South	West	National
			Vegetables			
Small	0.15	0.16	0.18	0.21	0.28	0.17
Medium	0.45	0.35	0.38	0.58	0.43	0.42
Large	0.97	0.95	0.74	0.96	0.97	0.94
All	0.21	0.19	0.22	0.30	0.43	0.24
			Fruits			
Small	0.30	0.17	0.15	0.16	0.35	0.19
Medium	0.79	0.71	0.48	1.09	0.76	0.88
Large	1.54	0.00	1.21	2.40	2.07	2.08
All	0.41	0.23	0.23	0.26	0.78	0.32

Source: GOI (1999): Cultivation practices in India.

Determinants of a Household's Diversification towards Fruits and Vegetables

The comparisons above show that smallholders have a greater participation in vegetables and comparable contribution in fruits relative to large farmers. Table 10 summarizes the characteristics of fruit and vegetable growers compared to non-growers. Overall, the non-growers of fruits and vegetables are marginally younger. The proportion of female-headed households is lowest among vegetable growers (5.3%) and highest among the fruit growers (14.1%). Vegetable growers have larger families compared to fruit growers or non-growers, who have similar family sizes. This observation is consistent with the notion that vegetable production, which is a more labor-intensive is more often undertaken by households with greater labor endowments.

Agriculture is the main occupation of two-thirds of the vegetable growers, 49.2% of the fruit growers and 56.5% of the non-growers. Agricultural labor is the second most important occupation for non-growers (24.1%) and vegetable growers (14.7%). Non-farm employment (self-employment in non-agricultural activities, non-agricultural wage employment and employment in public and private sector) is higher for fruit growers than for the other categories.

Notably, the fruit and vegetables growers have smaller land holdings compared to the non-growers, and have better access to their own sources of irrigation compared to non-growers. Overall, nearly 48% of vegetable growers and 62% of fruit growers have access to some source of irrigation, compared to only 39% of non-growers.

Fruits require more capital compared to vegetables and staple crops, meaning that farmers seeking to cultivate fruit must often supplement their own resources by borrowing from institutional and non-institutional sources. Twenty-four percent of fruit growers, compared to only 10.4% of vegetable growers and 11.4% of non-growers availed themselves of institutional credit. Since high-value food production is also information-intensive, more HVA farmers had access to sources of information, such as radio, television and newspapers.

Based on the summary discussion above, we next examine whether smallholders in India have a significantly higher participation in undertaking fruit/vegetable cultivation after we control for various characteristics.

Table 10. Characteristics of growers versus non-growers of fruits and vegetables

	Vegetable Growers				Fruit Growers				Non-growers			
	Small	**Medium**	**Large**	**All**	**Small**	**Medium**	**Large**	**All**	**Small**	**Medium**	**Large**	**All**
Personal characteristics												
Age of the household head (years)	45.7	48.9	50.6	46.3	48.3	52.0	53.8	48.8	44.8	47.8	49.9	45.6
% Female headed households	5.6	4.0	3.1	5.3	14.9	8.6	7.4	14.1	7.4	4.4	3.9	6.8
Main occupation of the households (%)												
Self-employed in agriculture	60.8	91.5	90.8	65.8	44.3	90.6	82.2	49.2	48.6	86.6	91.7	56.5
Agricultural labor	17.3	1.7	0.2	14.7	19.3	1.0	0.2	17.2	29.2	5.0	1.2	24.1
Non-agricultural labor	5.9	0.6	0.5	5.0	15.3	0.9	0.0	13.6	5.9	1.2	0.7	4.9
Self-employed in non-agriculture	7.8	1.9	2.8	6.9	10.3	1.9	7.1	9.6	8.5	2.4	2.2	7.2
Other occupations	8.2	4.4	5.7	7.6	10.8	5.6	10.5	10.4	7.9	4.8	4.2	7.3
Land and labor endowment												
Size of land holding (ha)	0.7	2.7	7.4	1.2	0.5	2.7	8.4	1.0	0.7	2.7	6.9	1.4
Household size (No.)	5.6	6.6	8.0	5.8	4.8	6.1	7.4	5.0	5.2	6.1	6.9	5.4
% Households having access to irrigation												
Tubewell	28.7	53.6	68.4	33.5	50.7	63.3	68.9	52.4	22.6	44.5	54.2	27.6
Surface irrigation	15.8	15.6	15.9	15.8	12.0	23.7	19.8	13.2	12.2	11.2	12.2	12.1
% Having access to institutional credit	9.0	16.5	20.9	10.4	22.1	38.0	39.6	24.1	9.2	17.7	25.0	11.4
Access to information (%)												
Possesses a telephone	1.3	2.4	3.9	1.6	7.3	11.0	30.0	8.5	1.0	2.2	4.7	1.4
Possesses a television	18.9	30.1	38.8	21.1	34.9	42.2	64.2	36.7	15.2	26.4	36.8	18.2
Possesses a radio	43.5	48.8	51.4	44.5	61.7	63.0	50.6	61.3	28.9	34.9	39.5	30.4
Regularly reads a newspaper	18.5	26.4	26.0	19.7	45.4	39.0	43.9	44.9	14.9	17.4	22.2	15.7

Source: GOI (1999): Cultivation practices in India.

Regression Analysis for a Household's Participation in Fruit/Vegetable Cultivation

We estimate a logit model separately for vegetable and fruit growers, with participation as a binary dependent variable. The explanatory variables include household characteristics and their access to inputs (e.g. credit and infrastructure). In addition, we control for each farmer's location by including dummies for the agro-climatic region and state of each farming household. Furthermore, we investigate the participation of the farmers by size in terms of the area of the agrarian land allocated to fruits and vegetables (i.e. as a continuous measure of participation). Since there are several corner solution responses (zeros), we estimate a Tobit model separately for the share of land allocated to fruits or vegetables, respectively. In the sample comprising 50,000 households, approximately 20% of the households cultivated either fruits or vegetables, and little intersection was observed between the two.

The farmer characteristics included in the regressions are experience and managerial skills, where age of the head of household proxies for experience and managerial skill. To capture diminishing returns to experience, we also include age squared as a control variable. Indeed, to the extent that HVA involves more risk, and younger people are likely to be less risk averse, age could have the opposite effect. As reported by von Braun (1994), female managers are less likely to participate in cash crop production. Thus, the gender of the head of the household is included in the analysis. Female-headed households are less likely to participate in labor-intensive HVA activities due to greater opportunity cost of labor and possibly due to greater risk aversion.

Vegetable and fruit cultivation is labor-intensive and thus favors households with greater stocks of family labor. In our participation regressions (logit and tobit), we take the household size as a proxy for labor availability. Apart from labor, the most important resource is land. The size of landholdings, however, may have both a positive and negative influence on cultivation of vegetables and fruits. Large holders may allocate a higher proportion of land to vegetables and fruits simply because more land is available, whereas land availability may be an important constraint for smallholders who also need to meet their own subsistence requirements with grain. Since fruit and vegetable production is labor-intensive, sufficient availability of labor in a smallholder household may enable small farmers to undertake cultivation of these crops more easily, compared to the relatively labor-constrained large landholders. Here, we run two specifications in the participation regressions, one with a categorical dummy (smallholder and medium holder with large holder as the excluded category), and the other with land size as a continuous variable.

Ceteris paribus, a household's occupation is an important determinant of its crop choices. Households engaged in non-farm activities are expected to indulge less in labor-intensive crops because

of competing uses of labor and a relative lack of skill, especially with regards to skill-intensive farm activities. The NSSO dataset classifies households based on their main income sources, namely self-employment in agricultural activities, self-employment in non-agricultural activities, agricultural labor, non-agricultural labor and others (employment in public and private sector). We include dummies for these employment categories as control variables.

We also include farmer's access to irrigation as an explanatory variable. High-value crops are capital-intensive, and farmers (especially smallholders) are often capital constrained. Credit markets in India are dominated by informal moneylenders, and a farmer's access to institutional credit may be limited. To capture the effect of borrowing on the decision to grow fruits and vegetables, a dummy for access to institutional credit is included in the set of explanatory variables.

The information requirements of HVA tend to be high compared to those for staple crops. Thus, the search costs for information are higher for HVA. Farmers typically obtain information through different channels, including extension agents, newspapers, radio, television and the telephone. In recent years, the public extension system in India has reportedly become increasingly inefficient (NSSO 2005), and farmers have been forced to rely on alternative private sources of information. In order to capture the effect of information, dummy variables for a household's possession of a radio, television and/or telephone, as well as newspaper readership, are included in the model. Well-informed households are expected to participate more in fruit and vegetable production.

The cropping choice of a household is ultimately determined by relative prices and off-farm supply-side factors such as local infrastructure. Urbanization and infrastructure are expected to have a positive effect on a farmer's decision to grow fruits and vegetables. The share of urban population and road density in the relevant district are included as explanatory variables from outside the NSSO dataset. As in our state-level analysis, the caveat for these demand-side factors is that, conditional on infrastructure availability, the demand factors could have non-localized influences.

Agro-ecological factors, such as rainfall, temperature, length of growing period, and soil type are important determinants of crop composition. To examine their effects on diversification, dummy variables for the agro-ecological environment in which the farmer resides (arid, rainfed, irrigated, hills and mountains, or coastal) were created and included in the explanatory variables. Agriculture in India is a state subject, and agricultural policies vary from state to state. In order to capture the effects of state policies, state dummies were introduced in the model as explanatory variables.

The results from the regression are shown in Tables 11 and 12. Our variables of interest are the farm and household sizes. As expected, the dummies for marginal and small farms are significant for vegetables in the logit specification (without controlling for land size). Importantly, when the land size variable is included, it is negative and significant for both fruits and vegetables, indicating that the

probability of diversification towards fruits and vegetables decreases with farm size. The effect of household size is positive and significant for vegetables, which is consistent with the greater labor requirements for vegetable production. The coefficient of household size is negative and significant in case of fruits. In general, fruits require more labor in the initial years of their life cycle, but their labor requirements decrease substantially once the plants have attained maturity.

The tobit results shown in Table 12 present a continuous variant of household participation in fruits and vegetables. The dependent variables are the shares of land allocated to fruits and vegetables, respectively. There did not appear to be a statistically significant effect of smallholding on the share of land allocated to fruits or vegetables (though it is positive for vegetables). As in case of the dichotomous participation variable, the greater the land size, the smaller the share of land allocated to fruit and vegetable production. The importance of household size as a determinant of family labor supply is borne out by the continuous measure of participation. Household size has a positive and significant impact on the land allocated to vegetables, and a negative and significant impact on the allocation to fruits.

Table 11. Results of logit regression for participation in fruit and vegetable cultivation

Logit	Vegetables	Marginal effects (logit regression for vegetables)	Fruits	Marginal effects (logit regression for fruits)	Vegetables	Marginal effects (logit regression for vegetables)	Fruits	Marginal effects (logit regression for fruits)
Explanatory variables	Dependent variable: Growers =1, otherwise=0 Coefficient (z-statistic)		Dependent variable: Growers =1, otherwise=0 Coefficient (z-statistic)		Dependent variable: Growers =1, otherwise=0 Coefficient (z-statistic)		Dependent variable: Growers =1, otherwise=0 Coefficient (z-statistic)	
Age of the household head	0.03(6.70)***	0.005(6.27)***	0.02(2.68)***	0.0007(2.67)**	0.03(6.78)***	0.004(5.39)***	0.02(2.81)***	0.0007(2.76)***
Age squared of the household	-0.0004 (-7.61)***	-0.00005 (-6.81)***	-0.0002(-2.36)**	-0.00006 (-2.37)**	-0.0004(-7.64)***	-0.00005 (-6.26)***	-0.0002(-2.45)**	-0.00006 (-2.40)**
Sex of the household head, male =1 otherwise =0	-0.27(-5.50)**	-0.03 (-4.14)***	0.12(1.81)*	0.003(1.7)*	-0.27(-5.62)***	-0.02(-3.14)***	0.10(1.59)	0.002(1.49)
Self-employed in agriculture	0.31(5.82)***	0.04(5.99)***	-0.23(-3.20)**	-0.006(-3.20)***	0.34(6.42)***	0.05(6.93)***	-0.15(-2.03)**	-0.002(-2.43)**
Agricultural labor	-0.14(-2.44)**	-0.07 (-10.64)***	-0.35(-3.94)***	-0.008 (-4.29)***	-0.15(-2.47)**	-0.07(-10.35)***	-0.34(-3.91)***	-0.008 (-4.24)***
Self-employed in non-agriculture	0.04(0.70)	0.006(0.69)	-0.34(-3.34)***	-0.007 (-3.57)***	0.04(0.71)	0.005(0.48)	-0.33(-3.23)***	-0.007 (-3.42)***
Other occupations	0.21(3.76)	0.03(3.58)***	-0.42(-4.75)***	-0.009 (-5.39)***	0.10(1.61)*	0.04(3.98)***	-0.39(-4.42)***	-0.009 (-5.41)***
Small farm	0.32(1.68)*	0.04(1.81)*	-0.05(-0.17)	-0.001(-0.12)				
Medium farm	-0.07(-0.36)	-0.001(-0.71)	-0.71(-1.97)**	-0.01 (-2.79)***				

Table 11. Continued

Logit	Vegetables	Marginal effects (logit regression for vegetables)	Fruits	Marginal effects (logit regression for fruits)	Vegetables	Marginal effects (logit regression for vegetables)	Fruits	Marginal effects (logit regression for fruits)
Landholding size					-0.03 (-6.32)***	-0.008(-6.86)***	-0.07 (-5.76)***	-0.002 (-4.50)***
Household size (No.)	0.03(6.99)***	0.005(8.04)***	-0.02(-2.80)***	-0.0008(-3.02)***	0.03(7.51)***	0.006(8.58)***	-0.01(-2.00)**	-0.006(-2.42)**
Access to irrigation (tubewell =1, otherwise =0)	0.26(8.95)***	0.05(9.08)***	0.73(14.57)***	0.02(12.49)***	0.28(9.49)***	0.03(8.59)***	0.75(14.92)***	0.02(12.22)***
Access to information variables	Yes		Yes		Yes		Yes	
Zone and state dummies	Yes		Yes		Yes		Yes	
Urbanization	-0.01 (-11.38)***	-0.002(-14.71)***	0.01(8.32)***	0.0003(8.22)***	-0.01 (-11.12)***	-0.002 (-14.82)***	0.01(8.44)***	0.0003(8.29)***
Road density	0.0007(2.42)**	0.0006(11.71)***	-0.001(-1.88)	-0.00004(-2.78)***	0.0007(2.32)**	0.0006(12.72)***	-0.001(-1.86)*	-0.00004 (-2.81)**
Log-likelihood	-21580.74		-8163.03		-21576.13		-8152.74	
Pseudo R-squared	0.14		0.21		0.14		0.21	
No. of observations	47599		46501		47599		46501	

Notes: *-denotes significance at 10% level, **-denotes significance at 5% level, ***-denotes significance at 1% level.

Table 12. Tobit regression on share of land devoted to fruit and vegetable cultivation by households

Tobit	Share of land area under vegetables	Share of land area under fruits	Share of land area under vegetables	Share of land area under fruits
Explanatory variables	Coefficient (t-statistic)	Coefficient (t-statistic)	Coefficient (t-statistic)	Coefficient (t-statistic)
Age of the household head	0.006(5.66)***	0.008(2.26)**	0.007(5.26)***	0.009(2.41)**
Age squared of the household	-0.0008(-6.62)***	-0.00006(-1.86)**	-0.00008(-6.76)***	-0.00007(-1.97)
Sex of the household head, male =1 otherwise =0	-0.04(-3.76)***	0.07(2.73)***	-0.04(-3.97)	0.06(2.54)**
Self-employed in agriculture	-0.04(-4.25)***	-0.16(-5.44)***	-0.03(-3.12)***	-0.12(-4.16)***
Agricultural labor	-0.06(-5.05)***	-0.15(-4.55)***	-0.06(-5.05)***	-0.15(-4.50)***
Self-employed in non-agriculture	-0.006(-0.42)	-0.14(-3.58)***	-0.005(-0.37)	-0.13(-3.50)***
Other occupations	-0.01(1.29)	-0.18(-5.33)***	-0.01(-1.01)	-0.17(-5.70)***
Small farm	**0.06(1.44)**	-0.02(-0.21)		
Medium farm	-0.04(-0.93)	-0.26(-1.99)**		
Household size (No.)	**0.004(4.17)*** **	-0.01(-3.55)***	0.005(5.12)***	-0.009(-2.68)**
Land size			-0.01(-10.04)***	-0.03(-6.95)***
Access to irrigation (tubewell =1, otherwise =0)	0.06(9.45)***	0.26(13.66)***	0.07(10.43)***	0.27(14.16)***
Access to irrigation (surface water =1, otherwise =0)	0.04(5.36)***	-0.10(-4.37)***	0.04(5.37)***	-0.09(-4.16)***
Access to institutional credit	-0.05(-5.40)***	0.16(7.12)***	-0.04(-4.96)***	0.17(7.52)***
Possess telephone	-0.04(-6.24)***	0.10(5.54)***	-0.03(-5.57)***	0.11(6.06)***
Possess radio	0.08(14.81)***	0.25(14.48)***	0.08(14.92)***	0.24(14.27)***
Zone and state dummies	Yes	Yes	Yes	
Urbanization	-0.001(-7.99)***	0.005(9.94)***	-0.001(-7.62)***	0.005(10.10)***
Road density	0.0002(4.15)***	-0.0001(-0.91)	0.0002(3.90)***	-0.002(-1.01)
N	47599	47599	47599	47599

Notes: *-denotes significance at 10% level, **-denotes significance at 5% level, ***-denotes significance at 1% level.

5. CONCLUSIONS

One of the main channels through which diversification towards high-value crops can reduce poverty is via the participation of small farmers. However, although smallholders have the benefits of proportionally larger labor pools, this may be offset by constraints such as lack of access to credit. Thus, there is continued debate as to whether smallholders can successfully diversify into the high-value sector.

Using state level data from India, we herein show that smallholders show more participation in high-value fruit and vegetable production compared to larger farms. The household-level analysis, however, points to differences within the category of fruits and vegetables. The high capital intensity and greater gestation lags in fruits seem to be deterrents for small farmers having a minimal capital base (physical and human) and a low appetite for the riskier fruit market.

This is not to say, of course, that the observed level of diversification is necessarily the optimal level. Given the high labor endowments in India and the preponderance of smallholders, the share of resources allocated to high-value agriculture continues to be relatively small, although it is increasing over time. Conditional on supporting infrastructure and institutions, smallholders have an advantage when adopting labor-intensive crops such as vegetables. The bias towards vegetables rather than fruits clearly points to the role of enabling factors in transforming the potential advantages of the smallholders (such as larger families) into realized crop choices that favor high-value products.

APPENDIX

Table A.1. Panel unit root test

Variables	IPS (t-bar)
ifv	-1.92**
fv	-1.77**
areafv	-1.71**

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