INTERNATIONAL FOOD POLICY RESEARCH INSTITUTE
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MICHIGAN STATE UNIVERSITY

RIMISP
Centro Latinoamericano para el Desarrollo Rural

INCATA PROJECT NOTE 5 JANUARY 2026

Does commercial small-scale vegetable farming production enhance farmer welfare?

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Key Findings

This project note analyzes links between agricultural commercialization and producer welfare by comparing vegetable farmers with non-vegetable farmers, who mainly grow rice. The following key findings stand out.

- **Vegetable farming is an engine of smallholder commercialization in Odisha.** Vegetable producers sell 74 percent of the vegetables they produce, about double the market surplus for rice.

- **Vegetable farming households are of modestly higher average socioeconomic status than non-vegetable farmers.** They are significantly better educated, more likely to belong to a general caste and less likely to belong to a scheduled tribe, but the size of differences in the characteristics of the two groups is not large.

- **Access to land, irrigation, and midland plots are strongly associated with the adoption of commercial vegetable farming**. Vegetable farmers operate slightly more land, lease in land more frequently, cultivate more midland plots, and are nearly twice as likely to have irrigated land.

- **Vegetable farming is associated with higher agricultural income, but not total household income.** Vegetable farmers earn 24 percent higher agricultural incomes on average, but total household incomes do not differ significantly from those of non-vegetable farmers, likely due to lower participation in non-farm employment.

- **Vegetable commercialization is associated with better diet quality.** Vegetable farming households consume a greater diversity of vegetables more frequently and have significantly higher household diet diversity scores than non-vegetable farmers.

- **Income inequality is not higher among vegetable adopters.** Gini coefficients for agricultural and household income are similar between vegetable and non-vegetable farmers, and similar across blocks with higher an lower concentrations of commercial vegetable cultivation, suggesting that smallholder commercialization has not exacerbated inequality.

- **Spatial clustering of vegetable production is associated with higher agricultural incomes.** Vegetable and non-vegetable farmers in blocks with high concentrations of vegetable farms have higher average agricultural incomes than those in blocks with less vegetable farming. This pattern suggests that links exist between initial conditions such as infrastructure, irrigation, and market access that foster the formation of spontaneous clusters, while intra-cluster features such as MSME density and knowledge spillovers may play a role in deepening agricultural commercialization and raising farm productivity.

Introduction

A key hypothesis of the INCATA project is that agricultural commercialization may improve small-scale agricultural producer welfare by, for instance, raising farm incomes or improving diets.

To explore the relationship between commercial small-scale vegetable cultivation and household welfare we surveyed farm households who produce vegetables and sell their crop (*"vegetable farmers"*) and farm households who grow rice but do not produce vegetables for sale (*"non-vegetable farmers"*).

Most vegetable farmers (90 percent) grow rice, reflecting its status as the main staple crop in Odisha. Almost all rice growing households produce monsoon rice, but only 6 percent grow an irrigated dry season rice crop. Twenty-one percent of households selected into the non-vegetable farmer sample were found to have produced some vegetables during the preceding year, but planted an extremely low average area of vegetables (0.04 ha) and generated a limited marketed surplus (17 percent), indicating that they operated kitchen gardens primarily for subsistence use.

Vegetable production in Odisha is strongly commercially oriented. The vegetable farmers in our sample sold an average of 74 percent of their production. That is a much higher rate of commercialization than found in rice cultivation: non-vegetable farmers sold 47 percent of their rice crop, vegetable farmers sold 35 percent, and 34 percent of households sold no rice at all. Thus, comparing these two groups provides an entry point for exploring the relationship between smallholder commercialization and welfare.

In the remainder of this note we compare the household, landownership, and asset ownership characteristics of vegetable and non-vegetable farming households. We then compare indicators of household welfare and use regression analysis to further parse out the associations between household characteristics, agricultural commercialization through vegetable cultivation, and key welfare outcomes (income and diet diversity).

Household characteristics

The household characteristics of vegetable and non-vegetable farmers are broadly similar, but the overall socioeconomic status of vegetable farmers is slightly higher than that of non-vegetable farmers. Ninety-nine percent of vegetable farmers are Hindu, compared to 96 percent of non-vegetable farmers. The share of scheduled caste households is very similar for both types of farmers (19 percent), but the share of scheduled tribe households engaged in vegetable farming is lower than that in non-vegetable farming (24 percent vs 33 percent). Conversely, a larger share of vegetable farmers (57 percent) belong to non-scheduled castes than non-vegetable farmers (47 percent).

Vegetable farmers are better educated on average than non-vegetable farmers: 48 percent and 43 percent, respectively, have some secondary education. Vegetable farmers are also more likely than non-vegetable farmers to report that agriculture is their main occupation (74 percent vs 63 percent) and, conversely, less likely to report that their main source of income is casual labor (16 percent vs 25 percent). This suggests that vegetable farmers may have greater agricultural assets and earnings than non-vegetable farmers, making them less dependent on casual non-farm employment to supplement farm income. Similar shares of households of both types (around 17 percent) have a current migrant.

Table 1: Household characteristics of vegetable producing and non-vegetable producing farm households.

Characteristic	Non-vegetable farmers	Vegetable farmers	P-value & significance
Hindu	95.5	99.2	<0.000***
Scheduled tribe	32.7	23.8	<0.000***
Scheduled caste	19.7	19.1	<0.715
Other castes	47.3	56.9	<0.000***
Household head has no primary education	12.7	9.6	<0.010***
Household head started or completed secondary education (%)	42.7	47.7	<0.008***
Household's main occupation is agriculture	63.1	73.8	<0.000***
Household's main income source is casual labor	25.3	15.9	<0.000***
Household currently has a migrant	17.8	17.1	<0.635

Source: INCATA Odisha Farmer Survey, 2025

Landholdings

Table 2 presents the landholding characteristics of both sets of farmers. We define landowning households in the strict sense, as those where one or more household members possess a land title in their name. Many farmers in Odisha work land belonging to parents or siblings, that has not been formally divided or inherited. We include this in the category 'operated land', along with land leased, borrowed, shared, or mortgaged in.

Agricultural landholdings in Odisha are highly fragmented, making it time consuming to collect detailed information on the individual plots operated by a household. To facilitate respondent recall, we recorded detailed information about landholdings at 'segment' level. A segment is a piece of land with a distinct

identity (e.g. a name), often originally a single large holding that has been subdivided into smaller plots over time. The plots of land in a segment usually have common characteristics (e.g. the same elevation and soil type). A household can operate more than one plot of land on a given segment.

Table 2: Land ownership and operation characteristics of vegetable producing and non-vegetable producing farm households

Characteristic	Non-vegetable farmers	Vegetable farmers	P-value & significance
Household owns land (%)	80.1	76.0	<0.010***
Household leases in land (%)	23.4	29.1	<0.001***
Area of land operated (ha)	0.69	0.89	<0.000***
Number of segments of land operated by household	2.2	2.6	<0.000***
Number of individual plots of land operated by household	7	8	<0.000***
Number of operated segments under vegetables	0.2	1.2	<0.000***
Number of operated segments under rice	1.8	1.7	<0.016**
Number of operated segments under other crops	0.4	0.5	<0.090*
Number of lowland segments of land per household	0.6	0.6	<0.909
Number of midland segments of land per household	0.9	1.2	<0.000***
Number of upland segments of land per household	0.6	0.7	<0.077*
Household has irrigated land (%)	41.6	78.8	<0.000***
Number of irrigated segments operated by household	0.7	1.3	<0.000***
Share of segments operated by household that are irrigated (%)	30.0	54.5	<0.087*
Simpson index of agricultural production	0.20	0.46	<0.001***

Source: INCATA Odisha Farmer Survey, 2025

Vegetable farmers are slightly less likely to own land than non-vegetable farmers. Seventy-six percent and 80 percent respectively possess land to which they have title. This could imply that vegetable farmers are more likely to be part of extended households where multiple siblings work land with a shared title deed. Conversely, slightly more vegetable farmers (29 percent) lease in land than non-vegetable farmers (23 percent). This could imply that commercial vegetable cultivation is associated with thickening land markets, as households lease in land to initiate or expand a potentially lucrative form of cultivation, but may also be related to the lower share of vegetable farmers reporting that they own land.

The average area of land operated by vegetable farmers (0.9 ha) is 29 percent larger than that operated by non-vegetable farmers (0.7 ha), but small in relative terms: the average area of land operated by vegetable farms in land tercile 3 (i.e. the largest third) is 1.8 ha: less than 2 ha, the international definition of a smallholder. Vegetable farming households operate slightly more segments of land than non-vegetable farming households (2.6 vs 2.2) and slightly more plots within those segments (8 vs 7).

Vegetable farmers devote one more segment of land to vegetable cultivation than non-vegetable farmers (1.2 vs 0.2) but operate similar numbers of segments under rice (1.7 vs 1.8) and other crops - pulses, oilseeds, maize, millet, fibers, flowers, and tree crops - (0.5 vs 0.4). This pattern suggests that

vegetable farmers use their land more intensively than non-vegetable farmers by devoting some plots to vegetable cultivation outside the main monsoon rice cultivation period.

Lowland (flat, low-lying land that accumulates water) is well suited to rice cultivation, while midland and upland (elevated, sloping, well-drained land) is usually better suited to vegetable cultivation, pulses and oilseeds, and cereals such as maize or millet. Vegetable and non-vegetable farming households operate similar numbers of lowland segments (0.6) and upland segments (0.6), but vegetable farmers operate significantly more midland segments than non-vegetable farmers (1.2 vs 0.9). This seems to imply that having access to midland increases the likelihood of households entering vegetable cultivation, but could also suggest that some vegetable growing households deliberately expand their midland holdings to enable expanded vegetable cultivation.

Irrigation is an important factor for enabling vegetable cultivation, particularly during the cooler post-monsoon months which are the peak season for vegetable production. Vegetable farming households are much more likely than non-vegetable farming households to have irrigated land (79 percent vs 42 percent). They also have more irrigated segments per household (1.3 vs 0.7) and a higher share of segments that are irrigated (55 percent vs 30 percent). These numbers underline the importance of irrigation access as a catalyst for vegetable cultivation and may also suggest that vegetable cultivators invest in irrigation to facilitate production.

The above factors result in a much higher level of agricultural diversification by vegetable farmers than non-vegetable farmers. The value of the Simpson index (a measure of diversity) of agricultural production based on the number of crops grown and area allocated to each, is more than double for vegetable farmers (0.46) than non-vegetable farmers (0.2).

Assets

Table 3 compares the credit use and asset ownership characteristics of vegetable and non-vegetable farming households and their receipt of government transfers, to explore whether these differ among the two categories of household. Vegetable farmers were slightly more likely to have borrowed for use in agriculture in the past year than non-vegetable farmers, and among households that had not borrowed, were slightly less likely to report difficulties accessing agricultural credit. The first point could suggest that the operating costs associated with vegetable farming create more demand for agricultural credit than rice cultivation alone, while together these points may suggest that vegetable farming households have slightly better access to agricultural credit.

The Government of Odisha's KALIA (Krushak Assistance for Livelihood and Income Augmentation) Scheme provides financial transfers to farmers and vulnerable households to support their agricultural activities. The share of households receiving funds from KALIA within the past 12 months is similar among groups of farmers (around 58 percent), suggesting that neither group has privileged access to public resources, but perhaps also that receiving KALIA payments is not sufficient to stimulate adoption of vegetable cultivation.

Vegetable cultivation appears to offer a pathway to expanded reproduction or accumulation for some farm households. More vegetable farmers report having ever leased in or purchased land than non-vegetable farmers (28 vs 21 percent and 9 vs 4 percent, respectively. Although we did not collect information on the timing of land leases and purchases, it seems plausible that vegetable farmers expanded

their holdings by leasing, or accumulated land by purchasing, at a higher rate than non-vegetable farmers, either to enable initiation or expansion of vegetable cultivation, or through reinvestment of profits earned from vegetable farming activities.

Table 3: Borrowing, transfers, and asset characteristics of vegetable producing and non-vegetable producing farm households.

Characteristic	Non-vegetable farmers	Vegetable farmers	P-value & significance
Borrowed to fund agriculture in 2024 (%)	46.1	50.4	0.025**
Unable to access agricultural loan in past year (conditional on not borrowing) (%)	7.6	4.6	0.025**
Received Kalia transfer in past 12 months (%)	57.4	60.6	0.252
Ever leased in land (%)	20.5	28.2	<0.000***
Ever purchased land (%)	4.1	8.7	<0.000***
Owns irrigation equipment (%)	20.2	46.4	<0.000***
Owns agricultural machinery (%)	2.7	5.8	<0.000***
Owns motorbike (%)	58.8	63.2	0.016**
Owns mobile phone (%)	97.0	96.8	0.836
Number of types of asset owned by household	4.1	4.7	<0.000***

Source: INCATA Odisha Farmer Survey, 2025

Vegetable farming households own more agricultural assets than non-vegetable farmers on average. The shares of vegetable farmers owning irrigation equipment (e.g. pumps) and agricultural machinery are more than double those of non-vegetable farmers (46 vs 20 percent and 5.8 vs 2.7 percent, respectively). This reflects in part the higher irrigated area operated by vegetable producers and suggests that irrigation equipment may be a threshold investment for entry into vegetable production. Higher rates of agricultural machinery ownership among vegetable farmers could be related to the labor demands of vegetable farming, or to high returns relative to non-vegetable farming which may be reinvested in productive assets.

Motorbike ownership is slightly higher among vegetable farming households than among non-vegetable farmers (63 vs 59 percent), but rates of mobile phone ownership are identical. Vegetable farming households own a greater number of types of asset on average than non-vegetable farmers (4.7 vs 4.1), but the difference, though significant, is not large and is accounted for mainly by differences in agricultural asset ownership.

Welfare

Table 4 presents variables for vegetable and non-vegetable farming households that are indicators of several dimensions of welfare.

Vegetable farmers consume significantly more vegetables of all types more frequently than non-vegetable farmers and have significantly more diverse diets overall, suggesting positive nutrition benefits. Between 8 and 19 percent more vegetable farmers consumed vitamin A-rich vegetables, dark green leafy

vegetables, and other types of vegetable within the past 24 hours than non-vegetable farmers. Vegetable farmers average household diet diversity score, based on a total 16 food groups, is 8.8, compared to 8.2 for non-vegetable farmers.

Table 4: Welfare characteristics of vegetable producing and non-vegetable producing farm households.

Characteristic	Non-vegetable farmers	Vegetable farmers	P-value & significance
Household consumed vitamin A-rich vegetables within past 24 hours (%)	40.8	48.5	0.007***
Household consumed dark green leafy vegetables within past 24 hours (%)	67.5	73.2	0.027**
Household consumed other vegetables within past 24 hours (%)	86.7	95.8	<0.000***
Household Diet Diversity Score	8.2	8.8	<0.000***
Annual agricultural income (INR)	37,282	46,188	0.011**
Annual household income (excluding government transfers) (INR)	90,817	90,415	0.953
Gini co-efficient of agricultural income	0.52	0.52	n/a
Gini co-efficient of household income	0.43	0.45	n/a

Source: INCATA Odisha Farmer Survey, 2025

Vegetable farmers have significantly higher agricultural incomes than non-vegetable farmers. The average annual agricultural income earned by vegetable farming households is ₹46,188 ($530) - 24 percent higher than that earned by non-vegetable farmers. This result suggests that vegetable cultivation has an important role to play in contributing of the Government of India's policy objective of doubling farmers' income. However, the average household incomes of rice and vegetable farmers, excluding income from government transfers, are not significantly different, suggesting that non-vegetable farming households may specialize more in non-farm employment, while the labor-intensive nature of vegetable cultivation may limit opportunities to engage in such kinds of work.

The Gini coefficient is a measure of inequality within a population. A value of 0 signifies total equality and 1 signifies total inequality. We calculated the Gini coefficient of agricultural income for vegetable farming and non-vegetable farming households. If vegetable farming results in some vegetable growing households increasing their agricultural earnings at a faster rate than others, we might expect to see higher income inequality among this group than among non-vegetable farmers, but the Gini coefficient of agricultural and household income is very similar (0.52) for both vegetable farming and non-vegetable farming households, suggesting that vegetable farming does raise income inequality among adopters.

However, it is possible that within-group inequality does not widen while inequality across the whole population of agricultural households rises. To test this, we compare the Gini coefficient of agricultural income across all surveyed households in blocks with low, medium and high concentrations of vegetable farms. Inequality is highest in high vegetable cultivation concentration blocks (0.53), lowest in medium concentration blocks (0.50) and intermediate in low concentration blocks (0.51). However, these differences are small, and caution must be exercised in interpreting them as our sampling strategy is not designed to statistically represent the population of each block.

Regression analysis

In this section we analyze associations between key descriptive variables reviewed in preceding sections and five outcome variables indicative of household welfare, namely annual income per capita (gross revenue minus paid out costs, divided by number of household members) from: (1) vegetables, (2) rice, (3) total crops; (4) total household income (including farm and non-farm sources); (5) the household diet diversity score (HHDDS), based on 16 food groups). The following results stand out.

First, we compare the association between caste and welfare indicators for (1) scheduled tribe, (2) scheduled caste, and (3) general caste households, in relation to other backwards caste (OBC) households. There is no significant difference between OBC, scheduled tribe, and scheduled caste households for each category of income. General caste households have significantly higher vegetable income, overall crop income and HHDDS) relative to OBC households. This result suggests that general caste households derive a higher relative level of benefit from vegetable cultivation than other groups, possibly reflecting unobserved factors such as social capital embedded in caste networks.

Second, we compare the association between education and welfare for households where the household head's level of education is (1) below primary level, (2) secondary level or above, taking completion of primary education as the reference value. The association between primary level education and household income is negative ($p<0.05$), while the association with secondary level education is positively associated ($p<0.05$), but there is no significant association between education level and vegetable, rice, or all total crop income, suggesting that education is an important factor in determining off-farm income, but not agricultural income. Secondary level education and above is weakly positively correlated with HHDDS, suggesting an income effect of education on diet quality.

Third, having a migrant is strongly negatively correlated ($p<0.01$) with income derived from vegetables, rice, and all crops, and positive but insignificant for total household income. Migration is not associated with any significant change in HHDDS. These results suggest that reduced household labor supply associated with migration may negatively impact agricultural production, but may be offset financially by remittance earnings, and/or that receipt of remittance earnings may incentivize households to devote less effort to farming.

Fourth, household size (the number of members present in the household) is strongly negatively correlated with all 4 per capita income variables but not significantly correlated with HHDDS. We interpret this to mean that in larger households, earnings are split between more members resulting in lower incomes per capita.

Fifth, the area of agricultural land operated by the household is positively associated with all 4 types of per capita income, but the effect is slightly weaker for vegetable income ($p<0.05$) than rice income ($p<0.01$). This result implies that, as expected, the more land households have at their disposal for agriculture the higher their agricultural incomes, but that the relationship is stronger for rice than for vegetables, which can produce high yields from small cropped areas.

Table 4: Ordinary least square regressions on associations between characteristics of vegetable producing and non-vegetable producing farm households, incomes and diet diversity.

Variables	(1) Annual vegetable income/capita from (INR)	(2) Annual rice income/capita (INR)	(3) Annual crop income/capita (INR)	(4) Annual household Income/ capita (INR)[≠]	(5) Household diet diversity score (0-16 scale)
Scheduled Tribe (Ref: OBC)	1412.822	-1344.172	479.442	-4083.902	0.251
	(959.26)	(1328.14)	(1730.07)	(2572.03)	(0.20)
Scheduled caste (Ref: OBC)	869.017	-1736.563	-567.086	-1720.573	0.229
	(811.46)	(1094.66)	(1577.34)	(2887.60)	(0.20)
General caste (Ref: OBC)	3390.265***	191.016	3490.356**	129.059	0.368**
	(1177.16)	(1006.56)	(1552.08)	(2782.71)	(0.18)
Below primary (Ref: Completed primary)	83.628	-348.936	-702.210	-4628.408**	0.266
	(1524.09)	(1573.97)	(2249.47)	(2158.87)	(0.22)
Secondary or Tertiary (Ref: Completed primary)	-611.850	686.271	461.080	3403.514**	0.255*
	(844.57)	(854.71)	(1378.40)	(1690.88)	(0.14)
Household has a current migrant (0/1)	-2718.747***	-1632.518**	-4838.953***	3303.926	-0.095
	(806.39)	(720.18)	(1169.53)	(2128.71)	(0.17)
Number of HH members	-952.506***	-1761.201***	-3166.448***	-3490.923***	0.040
	(208.70)	(236.38)	(413.92)	(519.66)	(0.03)
Area of land operated by the household (ha)	1891.563**	11047.183***	16050.890***	8234.431***	0.001
	(735.43)	(1457.55)	(2846.60)	(2005.57)	(0.08)
HH ever leased in or purchased land (0/1)	3772.617**	-217.609	3532.575*	4100.085*	-0.046
	(1662.07)	(964.19)	(2104.56)	(2443.84)	(0.15)
Share of operated segments that are upland (%)	20.115**	0.388	21.384	32.613*	0.004**
	(9.40)	(10.48)	(15.33)	(19.47)	(0.00)
Share of operated segments that are lowland (%)	1.131	41.049**	45.207**	84.753**	-0.003
	(10.03)	(17.03)	(21.19)	(33.03)	(0.00)
Borrowed for farming in past 12 months (0/1)	-406.834	-1241.441	-2316.504*	-8095.072***	-0.258*
	(715.61)	(925.02)	(1384.16)	(1696.84)	(0.13)
Household owns irrigation equipment (0/1)	2015.291**	789.417	1912.269	1531.793	0.629***
	(831.12)	(944.72)	(1664.43)	(1888.51)	(0.14)
Simpson index of area of agricultural production	12869.228***	-5712.263***	13389.795***	2876.359	0.339
	(1338.50)	(1428.44)	(2861.80)	(3393.09)	(0.24)
Household received KALIA transfer in past year (0/1)	665.333	-755.999	380.116	-1373.583	-0.304**

Variables	(1) Annual vegetable income/capita from (INR)	(2) Annual rice income/capita (INR)	(3) Annual crop income/capita (INR)	(4) Annual household Income/ capita (INR)≠	(5) Household diet diversity score (0-16 scale)
	(1246.38)	(881.99)	(1591.66)	(1866.12)	(0.13)
Household received cash transfer from other government scheme in past year (0/1)	51.645	-3559.844*	-3108.550	-3167.833	-0.479**
	(1324.48)	(1954.87)	(2392.56)	(3842.80)	(0.24)
Household received transfer from public distribution system in past year (0/1)	-1679.930	136.460	-1037.077	920.632	0.289*
	(1649.14)	(1089.26)	(2099.63)	(3001.02)	(0.17)
Medium vegetable farming concentration block (Ref: High concentration)	-1315.243	-2805.821**	-3336.904*	-228.145	-0.199
	(1125.31)	(1192.36)	(1943.45)	(1926.57)	(0.16)
Low vegetable farming concentration block (Ref: High concentration)	-2141.577***	-546.832	-2897.951**	202.199	-0.091
	(800.56)	(1176.12)	(1427.02)	(1976.12)	(0.16)
Constant	978.635	16649.353***	16608.557***	33711.243***	9.326***
	(1957.26)	(2534.53)	(3773.72)	(5863.47)	(0.39)
District level fixed effect	YES	YES	YES	YES	YES
Observations	1205	1205	1205	1205	1205
R-squared	0.133	0.306	0.277	0.178	0.189

Source: INCATA Odisha Farmer Survey, 2025Note: ≠Annual household income excludes government transfers. Standard errors in parentheses. Significance: * p<0.1, ** p<0.05, *** p<0.01.

Sixth, having purchased or leased in land is positively associated with vegetable income (p<0.05) and weakly associated with total crop income and household income, but not significantly associated with rice income. This finding suggests that some households are able to increase their earnings from vegetable cultivation by expanding their landholdings, with leasing being the most common means of doing so (see Table 3). For rice farmers, leasing in land may be associated with having inadequate holdings to support subsistence needs, and hence less likely to result in improvements in income than acquiring land for higher value vegetable cultivation.

Seventh, the share of upland segments of land operated per household is positively associated with vegetable income (p<0.05), household income (p<0.01) and HHDDS (p<0.05), whereas the share of lowland segments operated per household is positively associated with rice income, crop income and household income, but uncorrelated with HHDDS. These results underline how the portfolio of types of land that a household possesses influences its ability to engage in production of crops of different types and further illustrates the positive link between vegetable production and HHDDS.

Eight, borrowing to support agricultural production is negatively associated with total crop income (p<0.1), household income (p<0.01) and HHDDS (p<0.1), but is not significantly associated with vegetable or rice income. This suggests that households with fewer financial resources are more likely to borrow to fund agriculture.

Ninth, ownership of irrigation equipment is positively associated with vegetable income ($p<0.05$) and HHDDS ($p<0.01$), but is not significantly associated with rice income, total crop income, and total household income. This demonstrates the importance of private irrigation for vegetable cultivation, possibly constituting a threshold investment in some cases, and underlines again the positive relationship between vegetable cultivation and HHDDS. This result might also suggest that rice cultivators are better served than vegetable farmers by public irrigation works such as canals.

Tenth, the Simpson index of agricultural production is strongly positively associated with vegetable income, total crop income and HHDDS ($p<0.01$) and positively but insignificantly associated with total household income and HHDDS. Although endogenous, this result confirms the link between vegetable cultivation and agricultural diversification, and agricultural diversification and diet diversity.

Eleventh, receipt of a KALIA transfer, a welfare payment for farmers designed to support agricultural production, is not significantly correlated with any of the 4 income variables, but is negatively associated with HHDDS ($p<0.05$). A similar set of relationships holds for receipt of other government cash transfers. Receipt of rice and other foods from the public distribution system (PDS) is also uncorrelated with any income variables, but is positively associated with HHDDS ($p<0.1$).

We interpret these results to suggest that KALIA and other government transfers are targeted toward lower income households. Positive effects of the KALIA transfer on agricultural incomes may be obscured by the lower base agricultural income of the recipients. It is also possible that some KALIA payments are utilized in whole or in part for consumption rather than agricultural investments. Receipt of PDS food does not appear to be a disincentive to agricultural production. Nor do PDS food transfers appear associated with substitution of rice cultivation for vegetable production, as might be anticipated receipt of PDS grains were to substantially relax the imperative to produce rice for subsistence. The positive association between receipt of PDS transfers and HHDDS may suggest that by relieving the burden of household expenditure on staple foods, PDS transfers allow households to increase their purchases of non-staples.

Twelfth, we address associations between the clustering of vegetable production at the block level (predefined as part of our sampling strategy, which categorized all blocks in surveyed districts as having a high, medium, or low concentration of vegetable farms) and the 5 welfare variables, using high concentration blocks as the reference category. Being located in a medium vegetable farming concentration block is negatively associated with vegetable income, relative to high concentration blocks, but the coefficient is insignificant. However, being in a low vegetable concentration block is strongly negatively associated ($p<0.01$) with vegetable income. Being in a medium concentration block is negatively associated with rice income ($p<0.05$). In low concentration blocks the association with rice income is negative but not significant. The coefficient of all crop income is negative and significant in medium and low concentration blocks, but stronger in low (<0.01 vs 0.05). Finally, there is no significant association between vegetable farm concentration at the block level and household income or HHDDS.

In sum, the general tendency apparent in this pair of results is for agricultural incomes from all sources to be higher in blocks with high concentrations of vegetable cultivation activities. We hypothesize that this reflects a confluence of factors that could include irrigation access, infrastructure provision, market access, the density of micro, small and medium enterprises (MSMEs) in off-farm segments of the agricultural value chain, and access to information (e.g., knowledge spillovers among farmers and from MSMEs). These results may be cautiously interpreted as supporting the inference that spontaneous clusters of vegetable farms form in areas with suitable initial conditions, and that the densification of

commercializing farms and supporting MSMEs in these areas creates conditions that can raise agricultural incomes in these locales, with complementarities between vegetable cultivation and other types of farming, including rice.

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ACKNOWLEDGMENTS

The INCATA project was implemented under a Memorandum of Understanding between the International Food Policy Research Institute and the Government of Odisha. We gratefully acknowledge the guidance and strategic direction provided by Dr. Arabinda Kumar Padhee (IAS), Additional Chief Secretary to the Government, Department of Agriculture & Farmers' Empowerment (DA&FE), Government of Odisha. We also extend our sincere appreciation to Sri. Pawan Kalyan (IAS), Director of Horticulture, Government of Odisha, Smt. Dharitree Mishra, Managing Director, Odisha State Agricultural Marketing Board (OSAMB), Sri Shubhranshu Mishra (OAS), Additional Secretary to the Government, DA&FE, Government of Odisha, Dr. Sangram Kesari Pattanaik, Joint Director of Agriculture, DA&FE, Sri Nagendra Kumar Mallik, Dy. Director of Agriculture, DA&FE and other officials and staff of the Government of Odisha for their valuable advice, inputs, and support in facilitating field-level activities.

This work was supported by the Gates Foundation GRANT INV-066950, awarded to RIMISP and has not been independently peer-reviewed. Any opinions expressed here belong to the authors and are not necessarily representative of or endorsed by IFPRI or CGIAR. The conclusions and opinions expressed in this work are those of the authors alone and shall not be attributed to the Foundation. This work is a contribution to the CGAIR Science Program on Policy Innovations.

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