

Chapter 6

MORE LAND, MORE DIVERSE DIETS?

Exploring Production and Consumption Trade-Offs in the Eastern Indo-Gangetic Plains

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KEY MESSAGES

- Persistent land inequality and gender disparities in land ownership across the Eastern Indo-Gangetic Plains of Bangladesh, India, and Nepal reinforces structural constraints that limit productivity and worsens nutrition outcomes for land-poor households.
- Cereal and tuber yields increase with greater land access – particularly on leased-in land – while leased-out land reduces productivity, indicating that well-functioning rental markets are central to improving staple crop performance.
- Production allocation patterns vary across landholding groups: land-poor households retain more for subsistence, while larger landholders commercialize a greater share, often selling nutrient-dense foods and retaining cereals and milk for home consumption.
- Higher production diversity is associated with improved diet quality, but land-poor households remain at elevated diet-related health risk, indicating that diversification must be complemented by improved land access, market integration, and nutrition support.

The Eastern Indo-Gangetic Plains (EIGP), which cover eastern India, Nepal's Terai, and northwestern Bangladesh, are densely populated and agriculturally important, yet the region is marked by high rates of rural poverty, malnutrition, and fragmented landholdings (Aravindakshan et al. 2018; Pingali 2019; Pyne et al. 2023). Despite the EIGP's fertile soils, the region has experienced sluggish gains in productivity and enduring food and nutrition insecurity. National and provincial production statistics reveal trends in crop yields and production but mask household-level variations in crop–livestock portfolios and allocation of outputs. With the vast majority¹ of farms in the region classified as small or marginal (<2 hectares) (India MoAFW 2023; Bangladesh, BBS 2022; Nepal, NSO 2023), it is vital to understand how landholding shapes production and dietary outcomes.

Although land size is linked to cropping intensity and mechanization (Lowder et al. 2016), limited empirical evidence exists on how households allocate what they produce and whether this influences diet quality or health risks. This chapter uses household-level data to explore the connection between landholding groups and agricultural production, use, and diet quality across five districts: Banke and Surkhet (Nepal), Nalanda (India), and Rajshahi and Rangpur (Bangladesh). It examines (1) landholding structure, (2) productivity patterns, (3) crop use across classes, and (4) production diversity–diet quality relationships. The chapter aims to generate granular insights into agrifood system dynamics and inform inclusive, sustainable development pathways in the EIGP.

METHODS

This chapter uses harmonized agrifood systems survey data from 4,000 farm households in Bangladesh (2,000), India (1,000), and Nepal (1,000), collected under the CGIAR Research Initiative

on Transforming Agrifood Systems in South Asia (TAFSSA). The dataset includes detailed information on landholding, input use, production allocation, and diet quality. Households were grouped as landless, small, or large based on their land size and tenure. Differences among these groups were analyzed using descriptive statistics and one-way analysis of variance.

Productivity analysis focused on cereal- and tuber-producing households, with yield (tons per hectare [ha]) as the dependent variable. Predictors included landholding size, women's land ownership, leasing, mechanization, labor constraints, and irrigation type. Ordinary least squares (OLS) and mixed-effects models (with district-level random intercepts) were compared.

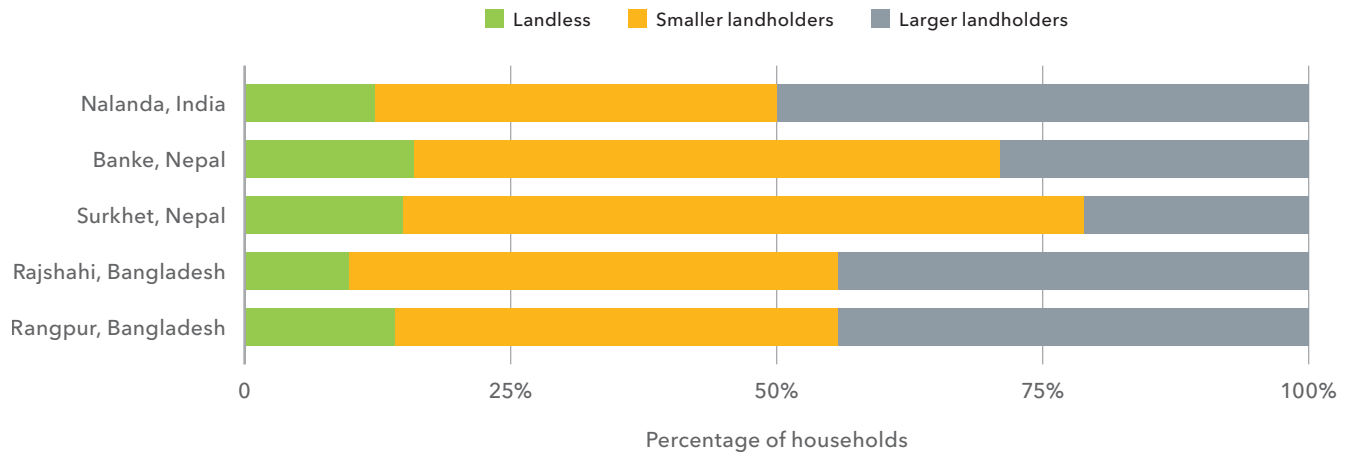
Production Diversity Score and Global Diet Quality Score (GDQS) scatterplots were used to examine associations between production and diet quality, with GDQS classified by risk thresholds. Analyses were stratified by landholding class, and stacked bar plots were used to visualize output allocation (consumption, sale, mixed use, or other). The analysis is descriptive and inferential, rather than causal.

RESULTS

Access to agricultural land and land rental dynamics

High levels of landlessness and near-landlessness remain a defining feature of rural South Asia. At the same time, landholdings are highly fragmented, with most farms operating on very small parcels. In this context, land rental markets can play a dual role by providing access to cultivable land for landless and marginal households and enabling the consolidation of operational holdings despite highly unequal ownership patterns. To examine how households gain access to agricultural land, we categorized them into three groups based on land ownership and operation: landless, small landholders, and large landholders. We then compared their average land ownership, leasing activity, operational holdings, and land held by women.

1 More than 86 percent of Indian farms, with similar rates in Bangladesh and Nepal.

FIGURE 6.1 Landholding status by district in the EIGP, share of households

Source: Data from TAFSSA district agrifood systems assessment.

Figure 6.1 illustrates the distribution of landholding across the study districts in Bangladesh, Nepal, and India. Landlessness was particularly widespread in Bangladesh's Rajshahi and Rangpur districts and in India's Nalanda district, where more than 60 percent of households reported owning no land. In contrast, Nepal's districts (especially Surkhet and Banke) had higher shares of small landholders and relatively fewer landless households. Large landholders were a minority across all districts, with the highest representation – just 24 percent – observed in Surkhet.

Table 6.1 presents the pooled average of land owned and operated by households in each category. Large landholders owned nearly 1 ha on average, compared to 0.18 ha among small landholder households and none among landless households. While small and landless households rented-in modest amounts of land (0.14–0.19 ha), large landholders participated more actively in land rental markets – leasing-in 0.37 ha and leasing-out 0.30 ha on average. These patterns suggest the presence of *reverse tenancy*, where wealthier farmers consolidate land through rentals.

TABLE 6.1 Land ownership and use by landholding category in EIGP, mean \pm SD (pooled data)

Variable	Landless	Smaller	Larger
Total land owned (ha)	0.00 \pm 0.00 ^c	0.18 \pm 0.12 ^b	0.98 \pm 0.67 ^a
Leased-in land (ha)	0.14 \pm 0.27 ^b	0.19 \pm 0.37 ^b	0.37 \pm 1.80 ^a
Leased-out land (ha)	0.00 \pm 0.02 ^c	0.04 \pm 0.09 ^b	0.30 \pm 0.50 ^a
Operated land (ha)	0.18 \pm 1.15 ^c	0.30 \pm 0.37 ^b	0.99 \pm 1.52 ^a
Women-owned land (ha)	0.03 \pm 0.06 ^c	0.10 \pm 0.10 ^b	0.30 \pm 0.36 ^a

Source: Data from TAFSSA district agrifood systems assessment.

Note: Superscript letters (a, b, c) indicate statistical groupings based on Tukey's HSD post-hoc tests. Groups with different letters differ significantly at $p < 0.05$. Groups with the same letter are not statistically different.

Total operational holdings followed a clear pattern: 0.18 ha for landless households, 0.30 ha for small ones, and nearly 1 ha for large landholders. Gender disparities in land access were also apparent. Women's land ownership rose steadily with household landholding status, from just 0.03 ha among landless households to 0.30 ha among large ones. This gradient reinforces structural inequalities, not only by land class but also by gender.

Average patterns are consistent across the region, although notable geographic differences exist. For example, leasing-in by landless and small landholders was more common in Banke and Nalanda, while leasing-out was significant among large landholders in Rajshahi and Rangpur. Women's land ownership was highest in Banke and Nalanda, further underlining the intersection between gender and local context in shaping land access.

Seasonality of crop production

Agricultural activity in the EIGP spans three main seasons – monsoon, winter, and spring – but the extent of crop diversity within each season varies sharply by landholding class. Large landholders are more likely to diversify crops within a season, growing multiple crops on owned or rented land. In contrast, landless households tend to specialize, typically cultivating only one crop per season – usually rainfed rice during the monsoon – due to limited access to land and irrigation. This inequality is particularly visible in winter, the region's most productive season. For instance, in Nalanda (India) and Banke (Nepal), more than half of large landholding households grow three or more winter crops, while less than 15 percent of landless households do so. The most common combinations of winter crops include wheat, maize, potato, mustard, and legumes. In the monsoon season, most households focus on a single rice crop. Again, however, large landholders are more likely to diversify by growing maize, legumes, or other cereals, especially in Surkhet and Rajshahi.

Spring cropping remains limited across the region, engaging less than 13 percent of households, but where it occurs (notably in Surkhet and Nalanda),

it is concentrated among larger landholders growing maize and pulses. Figure 6.2 shows the association between seasonal crop diversity and landholding, underlining the importance of land access, irrigation, and other resources in enabling diversified farming strategies. For landless and smaller farmers, limited land access constrains both seasonal participation and the ability to mitigate risks or improve diets through diversified production.

Uneven yields and unseen variability

Farmer-reported yields in the EIGP vary widely by region and crop, often diverging from national averages. In Bangladesh (Rajshahi and Rangpur), yields were consistently higher than national benchmarks. Cereal yields averaged 5.8 metric tons/ha (vs. 4.5 tons/ha nationally), and vegetable yields reached nearly 20 tons/ha (vs. 6.2 tons/ha nationally), likely reflecting high-yield crops such as gourds or tomatoes. Legume yields were exceptionally high at 5.4 tons/ha (vs. 1.0 tons/ha), possibly due to outliers or specific crop types. In Nepal (Banke and Surkhet), cereal yields (4.3 tons/ha) outpaced the national average (3.4 tons/ha), but compared to the national averages, yields were lower for oilseed (0.5 tons/ha) and vegetables (5 tons/ha). Legume yields were modest and below national levels. In India (Nalanda), yields were generally lower than national averages. Cereals averaged 3.3 tons/ha (vs. 3.9 tons/ha nationally), likely due to the lower-performing rice-wheat system. Oilseed and vegetable yields were also below national yields, while legume yields were roughly the same as national yields.

Sources of staple crops productivity in the Eastern Indo-Gangetic Plains

Regression results (Figure 6.3) indicate that access to land – both owned and leased-in – was most consistently associated with cereal and tuber yields across the EIGP. In the mixed-effects model, total landholding (coefficient: 3.97, $p < 0.001$) and leased-in land (coefficient: 2.95, $p < 0.001$) showed strong positive associations with productivity, while leased-out land was negatively associated (coefficient: -3.85,

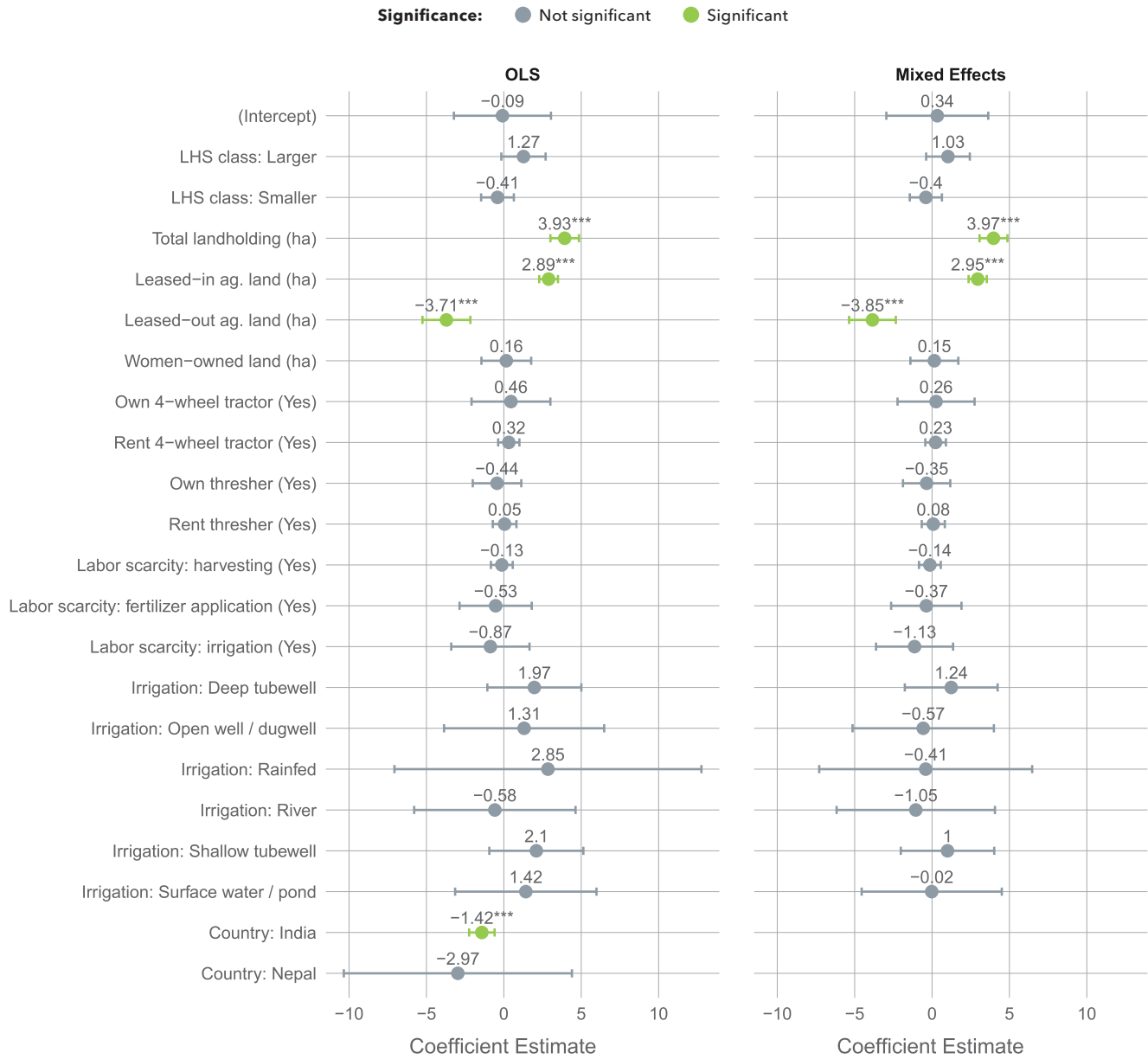
FIGURE 6.2 Seasonal crop diversity by landholding class in the EIGP, share of farmers cultivating 1, 2, and 3 crops



Source: Data from TAFSSA district agrifood systems assessment.

Note: The graph shows the percentage of landless, small, and large landholding households cultivating one, two, or three or more crops during the monsoon, winter, and spring seasons.

FIGURE 6.3 Coefficient estimates of cereal and tuber productivity across the EIGP



Source: Data from TAFSSA district agrifood systems assessment.

Note: Estimates with 95% confidence intervals from OLS and mixed effects models. Productivity = tons/ha. n = 338. *p < 0.1, **p < 0.05, ***p < 0.01, · = marginally significant at p < 0.10. Surkhet (Nepal) excluded due to incomplete data.

$p < 0.001$). Large landholders also had somewhat higher productivity than landless households (1.03, $p \approx 0.12$). This pattern differs from the commonly observed inverse relationship between farm size and productivity in many smallholder systems. However, studies by Larson et al. (2016) and Deininger and Ali (2024) suggest that this inverse association may weaken in areas with better market access, higher input use, and greater mechanization – conditions that are likely present in parts of the EIGP.

Mechanization (ownership or rental of tractors and threshers), labor constraints, and irrigation type were not significantly associated with productivity in the mixed-effects model, possibly reflecting unmeasured variation in quality or timing. Women's land ownership also showed no measurable association.

The OLS model revealed regional differences: households in Nalanda (India) had lower yields than those in Rajshahi and Rangpur (Bangladesh) (-1.42, $p < 0.001$), while yields in Bangladesh and Nepal did not differ significantly. Incorporating district-level random effects improved model fit (Akaike Information Criterion, AIC: 1721.9 vs. 1730.5), where a lower AIC value indicates a better balance between goodness of fit and model simplicity, suggesting spatial heterogeneity not captured by the observed variables. Overall, land access – not mechanization or irrigation – was most closely linked with higher staple crop productivity across the EIGP. This finding underscores the importance of policies that enhance secure tenure and support efficient rental markets to enable more equitable and productive land use in the region.

Patterns of farm produce allocation by landholding class

Household decisions on whether to consume, sell, or share farm outputs vary significantly by landholding status and country, reflecting different levels of market integration, subsistence needs, and production capacity.

Among landless households, output allocation differs notably across countries. In Bangladesh and

India, landless farmers are highly integrated into markets, particularly for cereals, legumes, vegetables, and livestock. These products are mostly sold or used for both consumption and sale. For instance, more than 80 percent of landless households in Nalanda, India, sell cereals and vegetables, while eggs are typically consumed at home. In contrast, landless households in Nepal follow a more subsistence-oriented pattern, especially for cereals, vegetables, and milk, which likely reflects more limited access to markets and infrastructure. However, these households still sell a substantial share of legumes, fruits, and livestock.

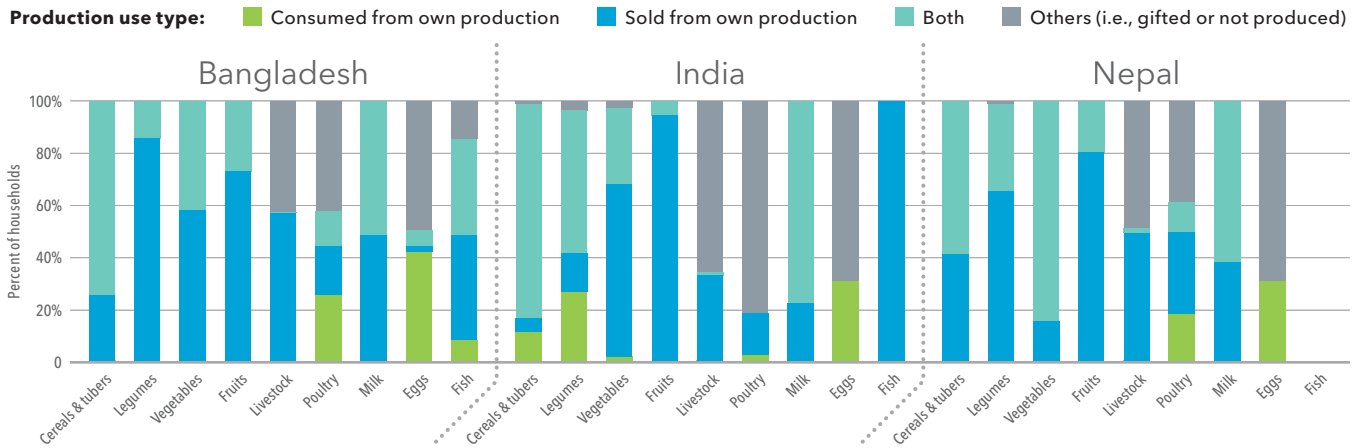
Small landholders display mixed strategies. Across all three countries, most small landholders both consume and sell cereals, with varying degrees of commercialization for other crops. Nepali smallholders are more subsistence oriented, integrating cereals, legumes, and vegetables into household diets. In India, sales are more prominent, especially for livestock and poultry. Bangladeshi smallholders appear to employ both strategies, with dual use of cereals and vegetables but greater commercialization of fruits and legumes.

Large landholders exhibit more commercialization overall, yet they still retain strong household use of staples such as cereals and milk. In Bangladesh and India, fruits, legumes, and livestock are predominantly sold, while cereals and milk are mostly split between consumption and sale. Large landholders in Nepal follow a similar pattern but are slightly less market oriented for livestock products, particularly milk and eggs.

These patterns (Figures 6.4, 6.5, and 6.6) underscore that:

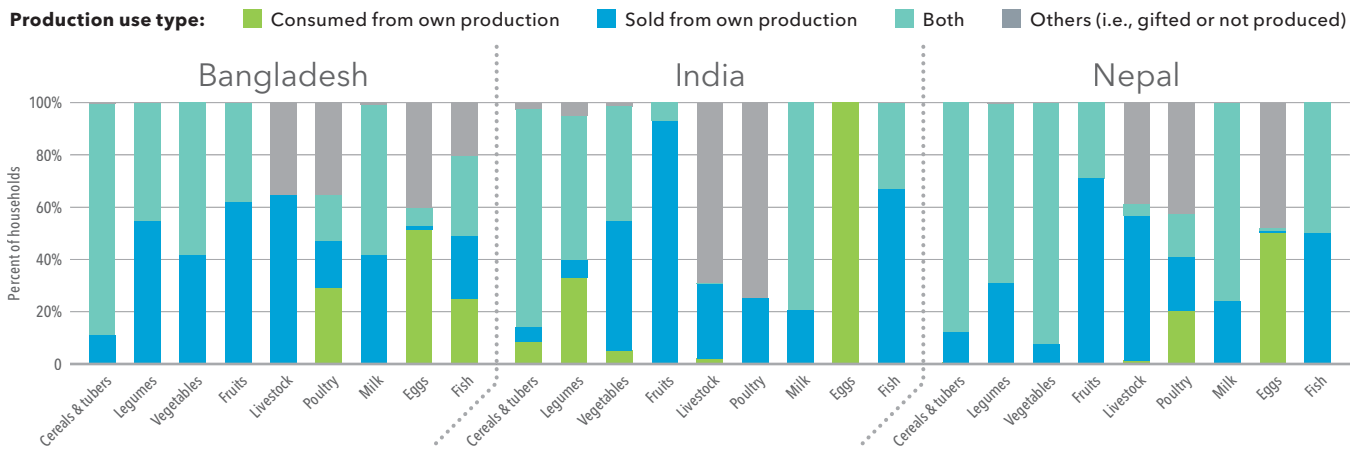
- Staples such as cereals and milk remain central to household consumption, regardless of landholding size.
- Higher-value outputs – such as legumes, fruits, and livestock – are more commonly sold, especially by larger and more land-secure households.

FIGURE 6.4 Use of crops, livestock, and fish products by landless households in EIGP (%)



Source: Data from TAFSSA district agrifood systems assessment..

FIGURE 6.5. Use of crops, livestock, and fish products by small landholding households in EIGP (%)



Source: Data from TAFSSA district agrifood systems assessment.

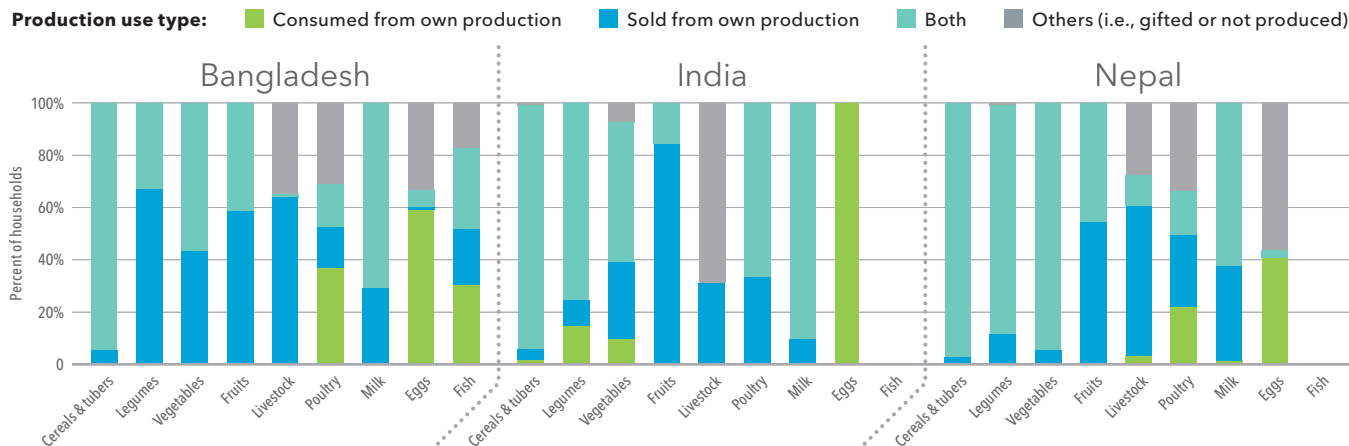
- Country context matters, with Nepal showing more subsistence orientation, especially among landless and small landholding households, while India and Bangladesh display greater market engagement, even among the land-poor.

These data highlight the importance of designing context-specific policies that reflect household production goals, not just yield potential. For

instance, interventions aimed at improving nutrition outcomes must account for the limited on-farm retention of high-protein and nutrient-dense foods among commercialized households.

PRODUCTION DIVERSITY, DIET QUALITY, AND HEALTH RISKS

Figure 6.7 illustrates the relationship between household production diversity and diet quality

FIGURE 6.6 Use of crops, livestock, and fish products by large landholding households in EIGP (%)

Source: Data from TAFSSA district agrifood systems assessment.

across landholding groups. Diet quality is measured using the GDQS, a food-based metric that classifies diets into high, moderate, or low risk of nutrient inadequacy and noncommunicable disease. A GDQS below 15 indicates high risk, 15.0–22.9 suggests moderate risk, and scores of 23 or higher reflect low dietary risk (Bromage et al. 2021). Production diversity, calculated using the Shannon Diversity Index, captures crop–livestock agrodiversity on farm (excluding aquaculture).

Large landholders tend to have both higher production diversity (>1.0) and better diet quality (GDQS scores of 16–22). In Rangpur and Rajshahi, for example, households with production diversity scores between 1.2 and 1.4 also report GDQS values around 20, with very few falling into the high-risk category. These patterns suggest a positive relationship between diversified production and improved diets.

By contrast, landless households consistently show low production diversity and higher dietary risk. In Nalanda, most landless households have nearly zero production diversity and GDQS scores between 12 and 15, indicating elevated health risks. In Rangpur, Rajshahi, Surkhet, and Banke, landless households with diversity scores up to 0.75 often remain below the 15-point GDQS threshold.

Small landholders hold an intermediate position. In Bangladesh, their production diversity ranges from 0 to 1.5, with GDQS scores varying from 12 to 22. Those with diversity scores below 0.5 are more likely to face high dietary risk. In Nalanda, Surkhet, and Banke, few exceed a diversity score of 1.0, and many remain within the moderate-risk GDQS range of 14–20.

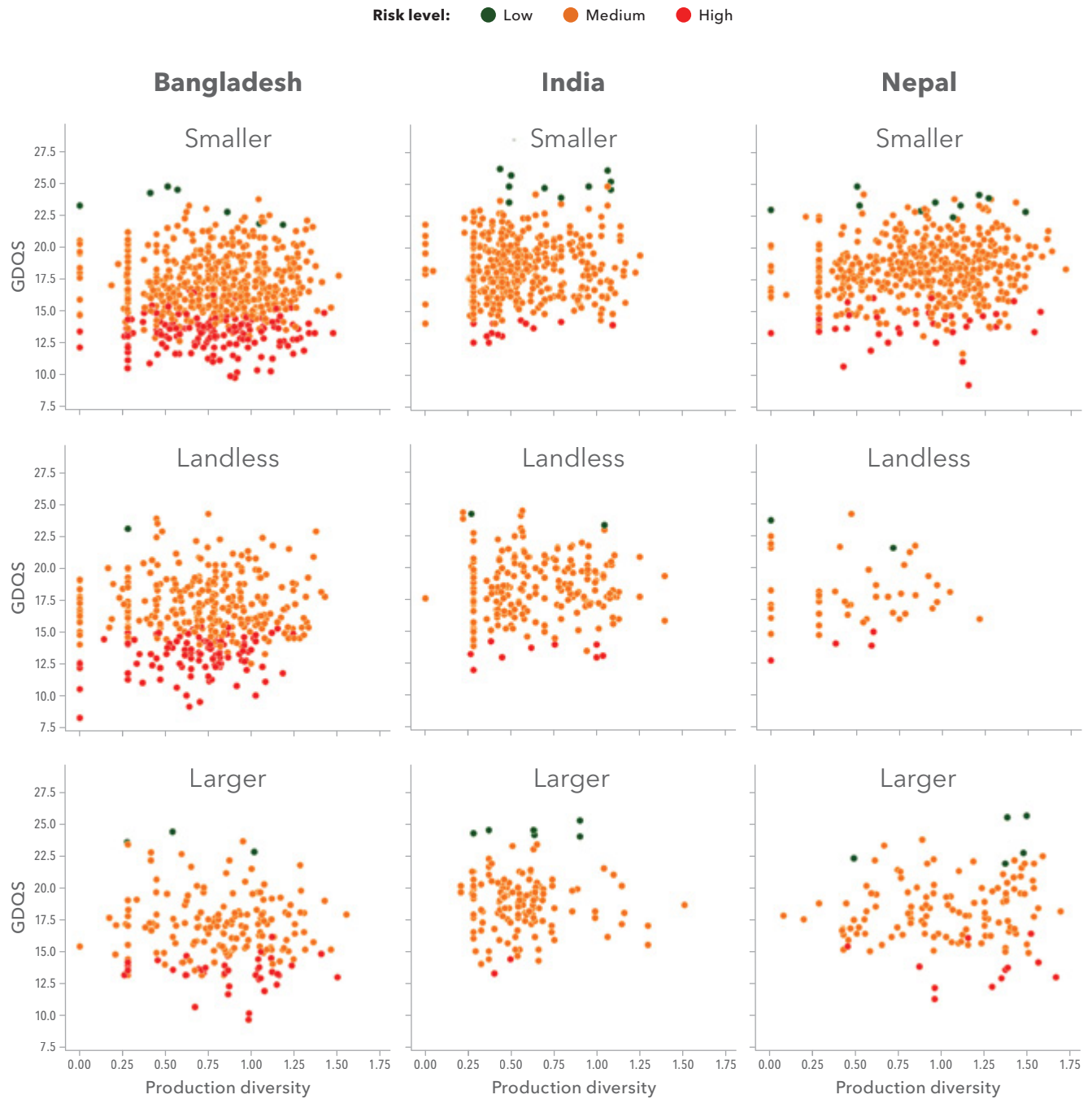
Although greater production diversity tends to support better diet quality, the strength of this association varies by landholding and local context. Higher GDQS scores among larger landholders may also reflect wealth effects, not just on-farm diversity.

Overall, these findings underscore the vulnerability of landless and small landholder households to poor diet quality. These households face elevated dietary risks due to low production diversity and limited access to diverse foods, highlighting the importance of integrating market access and nutrition-sensitive interventions alongside diversification strategies.

DISCUSSION AND POLICY IMPLICATIONS

This chapter explores how landholding patterns and production decisions shape agricultural

FIGURE 6.7 Relationship between production diversity and diet quality across landholding classes in EIGP, with color-coded health risk levels



Source: Data from TAFSSA district agrifood systems assessment.

Note: Diet quality is measured by the Global Diet Quality Score (GDQS). Production diversity is measured using the Shannon Diversity Index. Study areas include Rangpur and Rajshahi in Bangladesh, Nalanda in India, and Surkhet and Banke in Nepal.

productivity and diet quality across five districts in Bangladesh, India, and Nepal. Consistent with earlier studies on agrarian inequality (Li et al. 2024; Matita et al. 2022), findings from the TAFSSA survey confirm that disparities in land access remain central to explaining rural livelihood and nutrition outcomes in the EIGP. Larger landholders report higher yields and are more likely to both consume and sell their produce, while landless households are more dependent on external food sources. Total and leased-in landholdings emerged as strong positive predictors of cereal and tuber productivity, whereas leased-out land significantly reduced yields. The mixed-effects model further underscores that household-level productivity is shaped by structural land access constraints and moderated by district-level heterogeneity (Kakkar 2021). Policy environments across countries have influenced these dynamics: India's fertilizer and electricity subsidies (PPVFRA 2023), Bangladesh's investment in input delivery and machinery access (Bangladesh, General Economics Division 2020), and Nepal's Agriculture Development Strategy reforms (Nepal, Ministry of Agricultural Development 2015) have expanded input access, albeit with varying degrees of implementation and sustainability.

Beyond productivity, the analysis highlights how production diversity is linked to dietary outcomes. Landless and small landholding households in Bangladesh and India are more likely to experience high dietary health risks, while larger landholders in Surkhet, Banke, and Nalanda show better diet quality. However, production diversity alone does not ensure improved diets, reinforcing evidence that market access, nutrition knowledge, and food availability are critical enablers (Herforth et al. 2024; Pyne et al. 2023). Larger landholders are better positioned to allocate produce for both consumption and sale, whereas landless and marginal farmers face constraints in both quantity and use (Quisumbing et al. 2015; von Braun and Torero 2008). Although all three countries have adopted nutrition-sensitive agricultural strategies,

sectoral coordination remains weak (NITI Aayog 2017; Nepal, National Planning Commission 2017; Bangladesh, Food Planning and Monitoring Unit 2022). Strengthening decentralized governance, integrating agriculture and nutrition programming, and targeting support to landless and small landholding households will be essential to improving productivity and dietary outcomes across the EIGP.

Acknowledgments

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