

Food Sourcing and Diets: Evidence from 45 Low- and Middle-Income Countries

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1 **Abstract**

2 Globally, 2.4 billion people are food insecure, and 3.1 billion lack access to nutritious diets, with no
3 substantial improvement anticipated soon. While over 1.1 billion people engage in agriculture, recent
4 evidence suggests that even agricultural households may purchase most of their food. However, there
5 is a lack of evidence beyond case studies on the relationship between dietary diversity and food
6 sources in low- and middle-income countries (LMICs). Using a sample of 1,105,681 households
7 representing 2.8 billion people in 45 LMICs, we examine how different food sources contribute to
8 household diets across regions, socioeconomic characteristics, and time. Our findings reveal that
9 markets are the principal food source in LMICs, even for rural subsistence-oriented and extremely
10 poor households—those most affected by food insecurity and malnutrition—challenging the
11 assumption that these groups rely primarily on their own production. Dietary diversity is primarily
12 driven by purchased foods, including nutritionally important foods like eggs and meat, which are
13 almost exclusively sourced from markets. This leads to pronounced differences in the consumption
14 of these foods between household income groups, with poorer households consuming less fruits and
15 animal-source foods. In some settings, foods from gifts and in-kind contributions are also significant
16 sources of diet diversity. Improving affordability and market access, not just agricultural production,
17 is critical for improving dietary diversity for the most vulnerable in LMICs.

18 **Main**

19 Food insecurity and malnutrition remain major global challenges, disproportionately affecting millions
20 of people in low- and middle-income countries (LMICs). In 2023, 2.4 billion people—nearly a third
21 of the global population—were food insecure and 3.1 billion lacked access to nutritious diets, and
22 these figures are on an upward trajectory¹. Limited physical and economic access to diverse and
23 nutritious foods forces individuals to rely on nutrient-poor starchy staples for most of their caloric
24 intake, resulting in micronutrient deficiencies², and in many cases, increased reliance on cheap ultra-
25 processed foods, which are linked to chronic diseases^{3–5}.

26 Addressing food insecurity and malnutrition requires not only increasing access to food but also
27 enhancing the quality and diversity of diets. A more varied diet is linked to better physical and
28 cognitive development, nutrient adequacy, and overall well-being^{6–9}. However, effective strategies to
29 increase dietary diversity in LMICs remain elusive. Some proposals emphasize the diversification of
30 foods produced on household farms for subsistence, while others advocate for improving household
31 access to markets^{10,11}. Given that agriculture employs around a third of the workforce in LMICs¹² and
32 over 80% of farms are small farms with less than two hectares¹³, who consume part of what they
33 produce, increasing on-farm production diversity by introducing additional crop and livestock
34 species has been proposed as a means of improving dietary diversity^{11,14–17}. However, evidence
35 suggests that smallholder farmers in many regions, particularly in sub-Saharan Africa, already
36 produce a variety of crops and livestock species, and that further diversification could reduce cash
37 income because of the inability to realize specialization gains^{11,18}. This trade-off is crucial because
38 even households primarily engaged in subsistence farming are increasingly dependent on foods
39 purchased from markets, necessitating cash income^{11,18–24}. This phenomenon can be attributed to

40 improved market access and diversified income that come with a rapid urbanization process, reducing
41 the need for households to produce all of their own food²¹.

42 Thus, the most effective strategy for diversifying diets in LMICs requires careful consideration of the
43 balance of food obtained through own production versus market purchases. However, there is a lack
44 of empirical evidence on the contribution of own production versus purchases to the diversity of diets
45 in LMICs. Most studies have used cross-sectional surveys restricted to farming households of single
46 countries^{11,22,23} or limited to few countries^{18,21,24,25}, offering fragmentary understanding of food-
47 sourcing patterns across regions and socioeconomic groups. To address this gap, we developed a
48 harmonized dataset of nationally representative household consumption and expenditure surveys
49 conducted between 2008 and 2022 and covering 1,105,681 farming and non-farming households
50 across 45 LMICs, representing 2.8 billion people. To measure household dietary diversity, we use
51 nine food groups based on the household dietary diversity score (HDDS) which are important for a
52 healthy and nutritious diet (see Methods, herein ‘healthy HDDS’): (i) cereals, (ii)
53 roots/tubers/plantains, (iii) pulses/nuts/seeds, (iv) vegetables, (v) fruits, (vi) meat, (vii) fish/seafood,
54 (viii) milk/dairy products, and (ix) eggs. For each food group, we determine whether it is sourced
55 from own production, market purchases, or other sources such as gifts or in-kind payments from other
56 households or institutional sources like churches, governments, NGOs, or humanitarian aid.

57 Our study aims to inform policies and interventions to improve dietary and nutritional outcomes in
58 LMICs by providing robust, generalizable insights into the dynamics of food sourcing and dietary
59 diversity. We pursue four specific objectives. First, we assess where households in LMICs source
60 their food from, overall and by food group, and how this differs by region and household-level
61 demographics. Second, we determine the contribution of own-production, market purchases, and
62 other sources to healthy HDDS and how this differs by region, household-level demographics, and

over time (i.e. years) and months (i.e. seasonality). Third, we examine physical and economic barriers to food access across different regions and countries. Lastly, we determine the relevance of various socioeconomic and demographic factors for healthy HDDS derived from different food sources.

Sources of foods

Three out of four households in Latin America and the Caribbean and the Middle East and North Africa rely solely on market purchases for their food, with Argentina leading at 95% of households obtaining all of their food from markets (Table 1 and SI Figure 1). In these regions, own production plays a minimal role, with less than 8% of all households consuming own produced foods in each food group. For instance, only 2% of households in Latin America and the Caribbean and 3% in the Middle East and North Africa consumed any vegetables from their own production within the past 7 days (Figure 1).

In contrast, in Sub-Saharan Africa only 24% of households purchase all their food from markets, implying a greater reliance on own production for at least some food items. For example, 75% of households in Malawi produce some of the food they consume.

Region	Only purchases	Any consumption from own production
	Mean (SE)	Mean (SE)
East Asia and Pacific	29.16% (0.29)	67.44% (0.33)
Central Asia	46.07% (5.59)	44.56% (5.31)
Latin America and Caribbean	75.14% (3.52)	10.20% (1.49)
Middle East and North Africa	75.67% (5.10)	14.03% (4.49)
South Asia	34.14% (0.31)	37.88% (0.30)
Sub-Saharan Africa	24.27% (0.45)	60.59% (0.47)
Sample size	1,104,938	1,105,681

Table 1: Consumption of foods from purchases and own production by region. Means are population-weighted regional means of households that sourced their food entirely from purchases during the past 7 days and households that sourced any food from their own production. Standard errors (SE) are shown in parentheses.

82 Across regions, a majority of animal-source foods are purchased from markets (SI Figures 2 and 3).
83 Central Asia has the highest proportion of households sourcing these foods from their own
84 production, with 22% for milk and dairy products and 14% for eggs (Figure 1). Nonetheless, even in
85 these cases, market purchases remain the primary source of animal-source foods.

86 There was more variability in sourcing of plant-based food, especially in Sub-Saharan Africa and, to
87 a lesser extent, in Asia. For example, while 35% of households in Sub-Saharan Africa consumed
88 own-produced vegetables, 89% purchased vegetables within the past 7 days. Similarly, in East Asia
89 and the Pacific, significant proportions of households consume own-produced cereals (42%),
90 vegetables (37%), and fruits (31%). Despite this, 97%, 96%, and 68% of households purchased
91 cereals, vegetables, and fruits, respectively, suggesting that households frequently supplement their
92 own production with market purchases. This trend is also observed among plant-based foods in Sub-
93 Saharan Africa. Roots, tubers, and plantains and pulses, nuts, and seeds are almost exclusively
94 obtained from purchases. In Sub-Saharan Africa, for instance, 54% and 61% of consumer households
95 rely exclusively on market purchases for these food groups. In all other regions, these figures exceed
96 70%.

97 Gifts and in-kind payments also contribute to household diets. Across regions, one in three
98 households that consume cereals receive them as gifts or in-kind (SI Figure 2). This number is largely
99 driven by South Asia, where this food source exceeds consumption from own production of cereals
100 by far (Figure 1). Consumption of other plant-based foods from gifts/in-kind is particularly common
101 in Sub-Saharan Africa and East Asia and the Pacific (Figure 1). In Latin America and the Caribbean
102 and North Africa and the Middle East, this food source is roughly as (less) important as own
103 production.

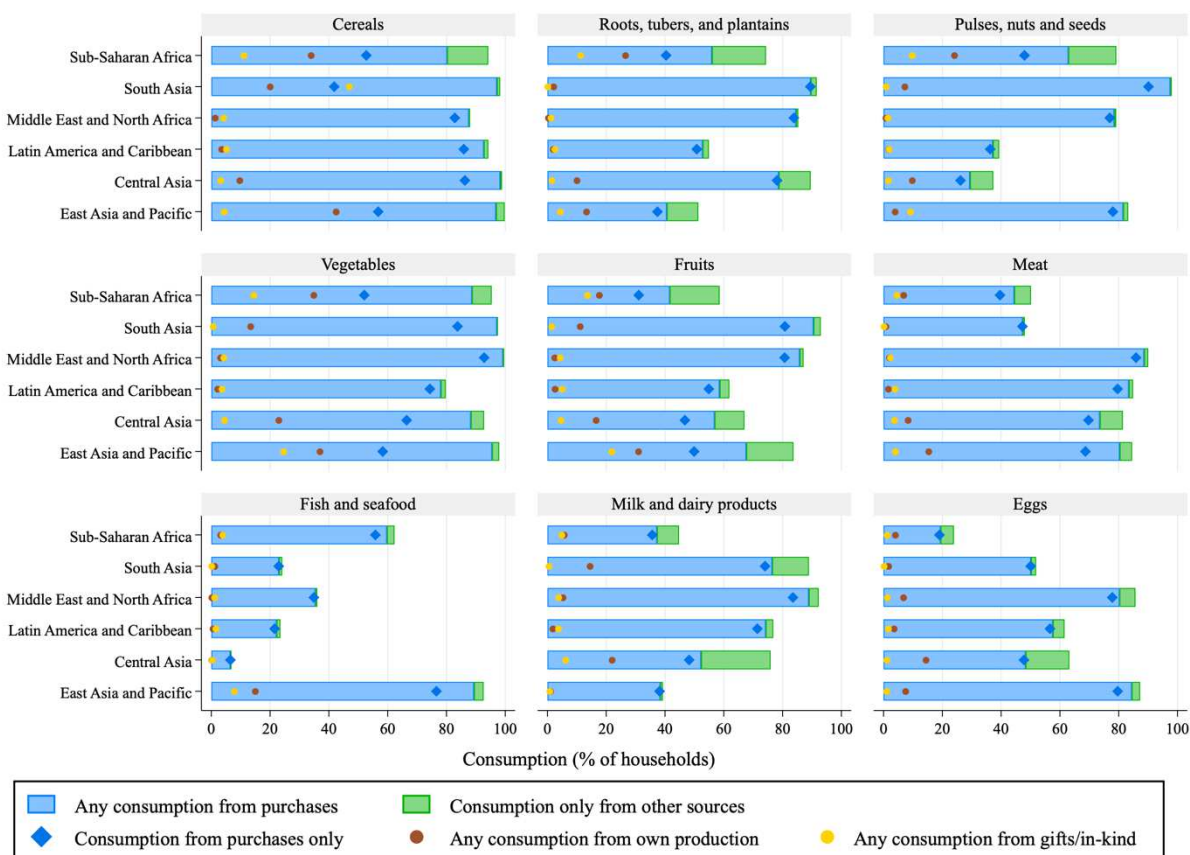


Figure 1: Share of households representative of 2.8 billion people who consume each of the 9 food groups and where they source them, by region. The total bar length represents the average consumption of that food group within that region (in % of all households). The length of the blue bar represents the proportion of households that consume this food group from purchases, independently of whether they also consume it from other sources. The blue diamonds depict the share of households that consume a food group exclusively from purchases. The brown dots show the proportion from own production, while the yellow dots show the share of households that consume a food group from gifts or in-kind. We weighted each country based on its population size. Sample size: N = 1,105,616 households for any consumption, N = 1,105,616 households for purchases, N = 1,105,681 households for own consumption, N = 772,291 households for gifts/in-kind.

Data from selected countries with more disaggregated food source categories shows that gifts/in-kind primarily consist of gifts from other households, with minimal contribution from institutional sources like churches, governments, NGOs, or humanitarian aid (SI Figure 4). In India, nearly half of households benefit from the Public Distribution System (PDS), a social security initiative designed to enhance food security and alleviate poverty (SI Figure 4). However, the food distributed through the PDS primarily consists of rice and wheat, which, while addressing calorie needs, contributes little

121 to dietary diversity. In fact, home-grown food generally contributes on average more to a varied diet
122 than food sourced for free from the PDS.

123 Consumption patterns of cereals, roots, tubers, plantains, pulses, nuts and seeds, and vegetables show
124 little variation across household income groups (Figure 2). However, poorer households are more
125 likely to consume these foods from their own production, while richer households rely heavily on
126 market purchases. For vegetables, the proportion of households purchasing them does not vary
127 notably across income groups, but poorer households are less likely to consume vegetables
128 exclusively from purchases and instead supplement them with their own production.

129 Consumption of fruits and animal-source foods is substantially higher in richer households who are
130 two to four times more likely to consume these food groups than extremely poor households. This
131 disparity is driven by an increase in consumption from purchases, as own consumption of these food
132 groups does not change notably with income (Figure 2 and SI Figure 5). Consumption of fish and
133 seafood is slightly higher among poor households, entirely driven by increased purchases (Figure 2).
134 While purchases of fruits, meat, and milk and dairy products consistently increase with income, there
135 is an inverse U-shaped relationship between income and purchases of roots, tubers, and plantains,
136 pulses, nuts and seeds, vegetables, and eggs (SI Figure 5). Thereby, the decline in egg consumption
137 is driven by Latin America and the Caribbean, where higher-income households are also less likely
138 to consume roots, tubers, and plantains and pulses, nuts and seeds (SI Figure 6). Conversely, as
139 income rises, consumption of fruits, meat, fish and seafood, and milk and dairy products, increases
140 suggesting a gradual replacement of the aforementioned food groups.

141

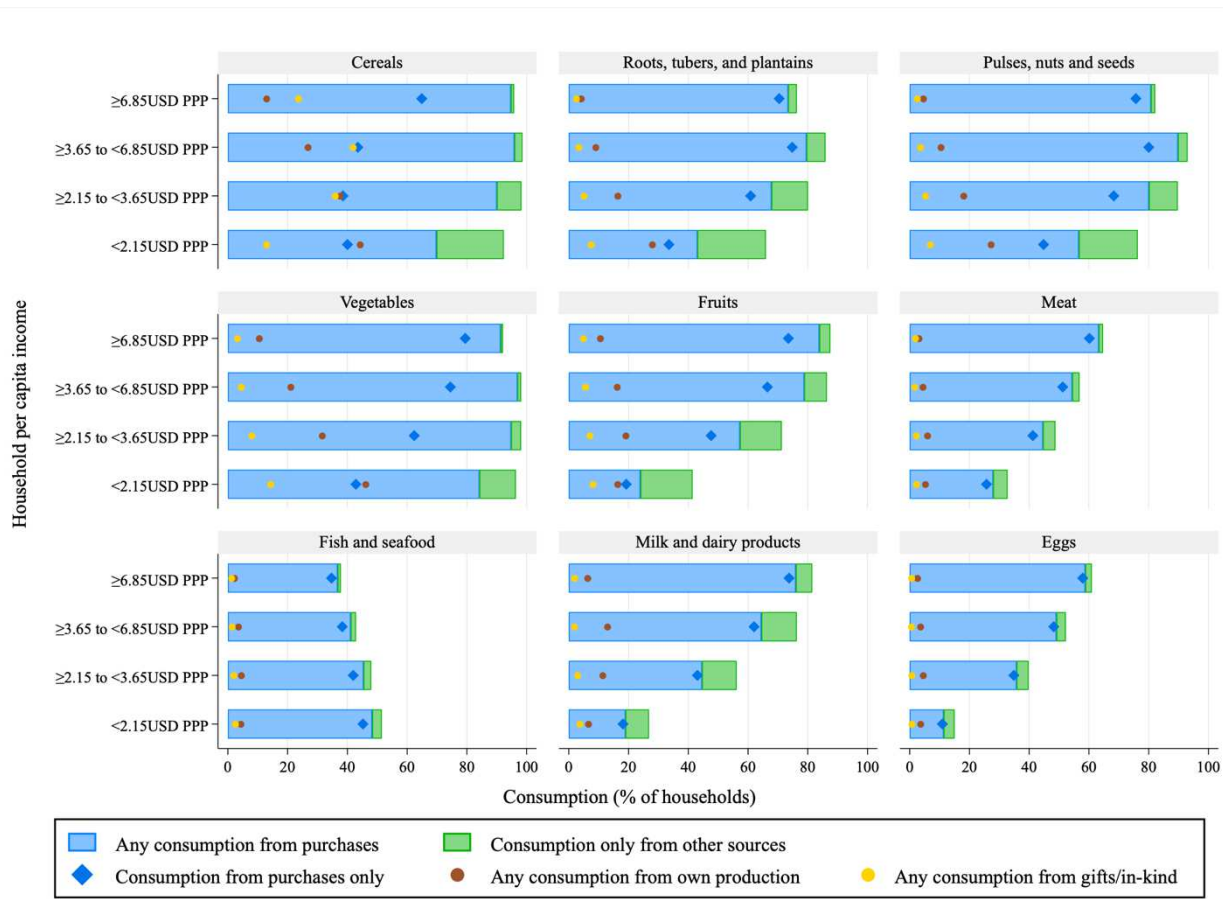


Figure 2: Share of households representative of 2.8 billion people who consume each of the 9 food groups and where they acquire them, by poverty category. The total bar length represents the average consumption of that food group within that category (in % of all households). The length of the blue bar represents the proportion of households that consume this food group from purchases, independently of whether they also consume it from other sources. The blue diamonds depict the share of households that consume a food group exclusively from purchases. The brown dots show the proportion from own production, while the yellow dots show the share of households that consume a food group from gifts or in-kind. We weighted each country based on its population size. Sample size: N = 1,017,628 households for consumption, N = 1,017,628 for purchases, N = 1,017,693 for own consumption, N = 684,304 for gifts/in-kind.

Food sources and household dietary diversity

Markets emerge as the dominant source of dietary diversity in all regions, although the degree of reliance varies. In Latin America and the Caribbean and the Middle East and North Africa, purchased foods contribute to over 90% of healthy HDDS (Figure 3). Indeed, across all countries over half of healthy HDDS is derived from purchased foods. Countries with a higher healthy HDDS are not

158 necessarily more likely to have a higher proportion from purchases (SI Figure 10). Island and Sub-
159 Saharan African countries have the largest contributions from own production to healthy HDDS. For
160 example, in Timor-Leste, on average, 3.6 of the 5.6 food groups consumed (64%) are from own
161 production; and in Uganda 2.1 out of 5.7 food groups consumed (37%). These trends are also robust
162 to other measures of dietary diversity such as the Minimum Dietary Diversity Score for Women
163 (MDDW) (SI Figure 11) or food item variety (SI Figure 12). Countries in Latin America and the
164 Caribbean consume less than 10% of their food items from their own production and, in multiple
165 countries, more from gifts/in-kind. In Timor-Leste and Uganda, households source 56% and 28% of
166 their food items from own production, respectively, while in Liberia households source a greater
167 variety of their products from gifts/in-kind compared to their own production (SI Figure 12).

168 Longitudinal data from seven countries indicate that the reliance on market purchases for dietary
169 diversity is not a recent phenomenon (SI Figure 13). For example, in Malawi, the proportion of
170 healthy HDDS derived from purchased foods was already high at 67% in 2004 and increased to 77%
171 by 2019. In Armenia, it increased from 85% to 91% over a similar time period (2004-2018).
172 Conversely, the contribution of own production to dietary diversity has declined in all countries
173 except Nigeria.

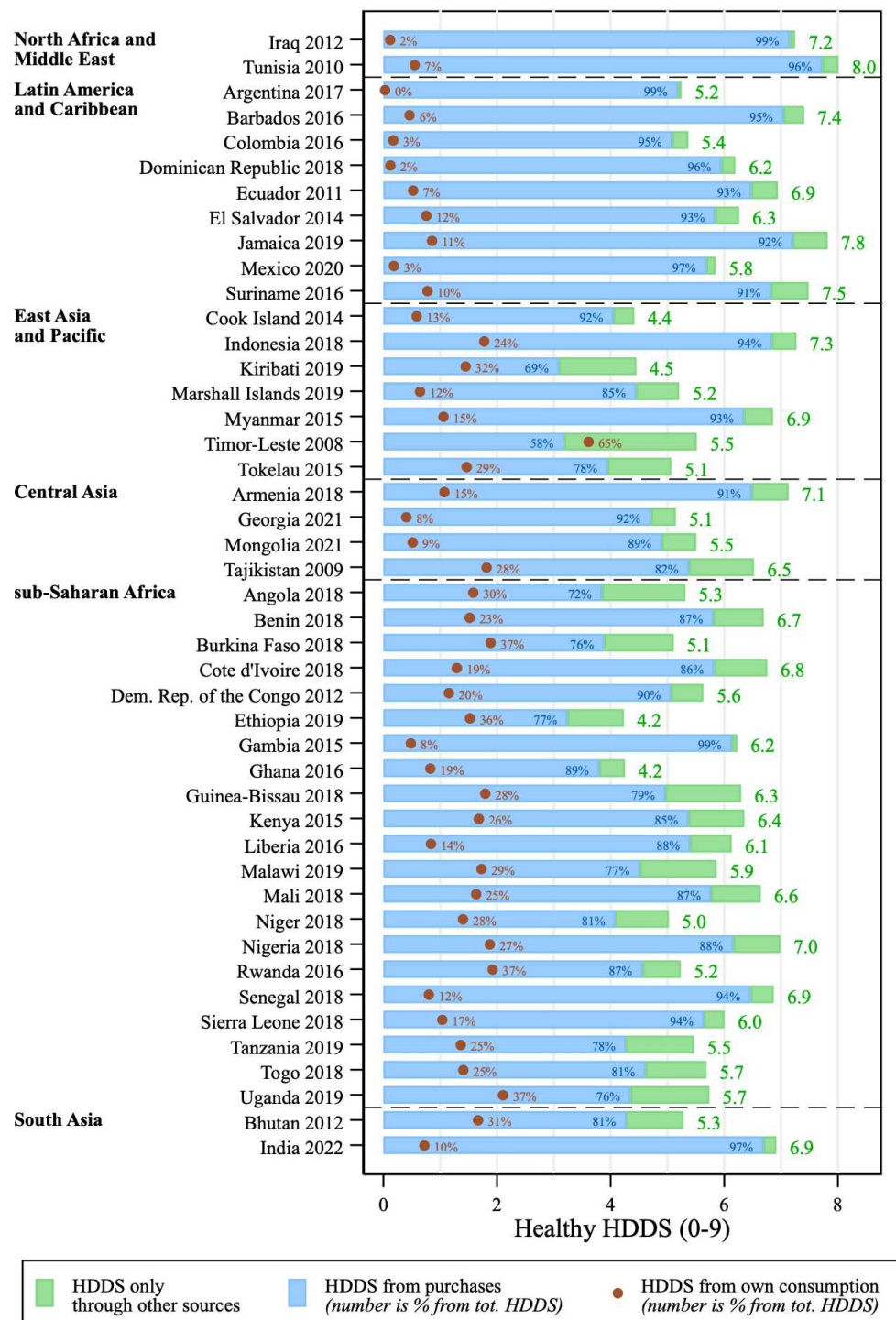


Figure 3: Healthy household dietary diversity (9 food groups) by country. The blue bars represent dietary diversity originating from purchases with numbers indicating their proportion from the total dietary diversity, while the green bar represents diversity augmented by alternative sources, including consumption from own production or contributions in the form of gifts or in-kind provisions. Thus, the green bar represents the proportion of dietary diversity that remains unmet by purchases, and not the total diversity provided by other sources. The dietary diversity attributed to these alternative sources could be greater than that of the green bars. Brown dots indicate their dietary diversity from own consumption, whereas numbers display their share from total dietary diversity. Years on the y-axis indicate the survey start year. Sample size: N = 1,105,616 households for any consumption, purchases, and own consumption.

183

184 Monthly data from ten countries reveals only minimal seasonal variation in food consumption
185 diversity from purchases versus own production (SI Figure 14). Liberia exhibits the highest
186 variability, with the proportion of healthy HDDS derived from purchases being lowest in November
187 at 83% and highest in December at 91%. Similarly, the proportion of consumed items from purchases
188 fluctuates between 72% and 83% in these months in Liberia (SI Figure 15). The greatest variability
189 in the proportion of healthy HDDS derived from own consumption is observed in Georgia, with the
190 lowest in January at 4% and the highest in August at 13%. Seasonal variability is more pronounced
191 for specific food groups, particularly fruits and vegetables, where purchases do not compensate for
192 reduced own consumption but rather mirror similar seasonal patterns (SI Figure 15). For example, in
193 Georgia, the percentage of households purchasing vegetables drops to 49% in January but rises to
194 88% in June (SI Figure 16). Similarly, in Nigeria, fruit purchases correspond with monthly
195 temperature and rainfall patterns, peaking in May and November, and diminishing in January and
196 August.

197

198 **Market foods are the most important source even among agricultural households**

199 Agricultural and rural households get a larger proportion of their foods from their own production,
200 particularly plant-based foods, though the amount of these foods consumed is largely similar between
201 agricultural and non-agricultural households and rural and urban households (SI Figure 7 and SI
202 Figure 8). Nonetheless, even amongst agricultural households, a majority of nutrient-rich foods
203 including pulses, nuts, and seeds, vegetables, and fruits were purchased from markets (77%, 92% and
204 62% of consumer households, respectively). In terms of food group variety, even agricultural

households source 79% or more of their food items from purchases, only for roots/tubers/plantains and fruits did these households source 19% and 22% from their own production (SI Figure 9).

In East Asia and the Pacific, South Asia, and Sub-Saharan Africa, non-agricultural households exhibit a significantly higher healthy HDDS than agricultural households, whereas in other regions, there is no significant difference (Figure 4). There is not a single country where agricultural households are better off than non-agricultural households in terms of dietary diversity (SI Figure 17). Non-agricultural households meet over two-thirds of their healthy HDDS through purchased foods, in most cases exceeding 85%. Conversely, agricultural households rely more on their own production for dietary diversity and have a lower healthy HDDS from purchases compared to their non-agricultural counterparts. Even in Sub-Saharan Africa and Central Asia, where smallholder farmers predominate²⁶, agricultural households obtain about three-quarters of their healthy HDDS from purchases. In Angola (62% own production vs. 46% market purchases) and Timor-Leste (77% own production vs. 50% market purchases) agricultural households obtain a greater proportion of their dietary diversity through own production than through purchases, in all other countries purchased foods are more relevant for healthy HDDS than own-produced foods, even among agricultural households (SI Figure 17).

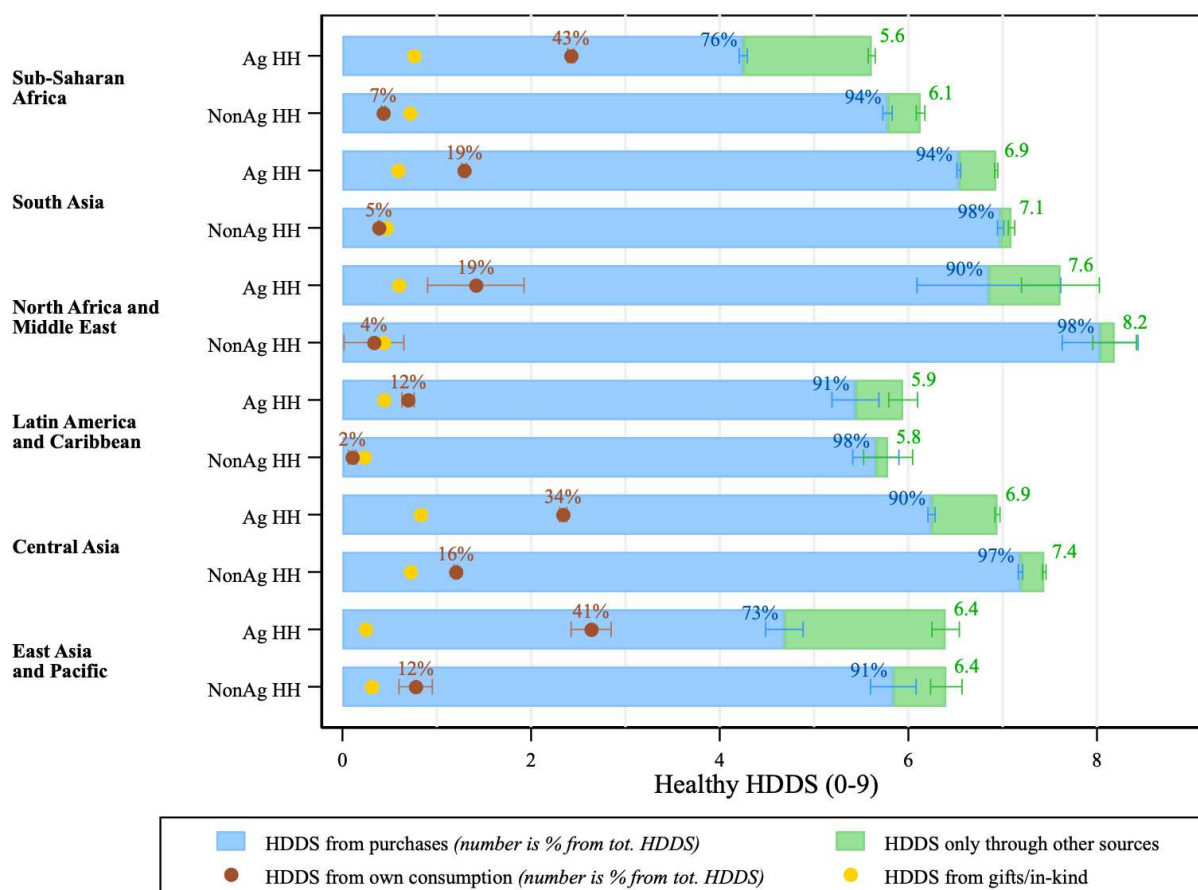


Figure 4: Healthy household dietary diversity scores, by world region and agricultural ('Ag HH') versus non-agricultural ('NonAg HH') households. An agricultural household is defined as one in which the primary activity of any household member involves engaging in agricultural activities. This can be wage employment in agricultural occupations or the agricultural sector or informal self-employment performing agricultural activities in their own gardens. We weighted each country based on its population size. Sample size: N = 1,001,311 households for any consumption, purchases, and own consumption, N = 682,746 for gifts/in-kind.

232 **Physical and economic constraints of food sources**

233 In addition to comparing agricultural and non-agricultural households, we analyze dietary diversity
234 patterns across regions, rural versus urban settings, and household expenditure groups. We take
235 differences in dietary diversity between rural and urban households of comparable expenditure groups
236 to reflect physical access constraints. Whereas, differences between consumption expenditure groups
237 within the same area we take to reflect economic barriers.

238 Among richer urban households, purchases cover more than 95% of healthy HDDS in almost all
239 countries (Figure 5 and SI Table 1). Even poorer urban households typically achieve more than 90%
240 of their healthy HDDS through purchases. An exception is Timor-Leste, where urban poor households
241 source their healthy HDDS almost equally through own production and purchases. For urban
242 households of the highest expenditure tercile, own consumption is marginal, contributing to less than
243 5% of healthy HDDS, exceptions include Timor-Leste (20%), Kiribati (18%), and Uganda (14%) (SI
244 Table 1).

245 Rural households cover a substantially lower proportion of their dietary diversity with foods from
246 purchases. However, even poor rural households meet between 69% (sub-Saharan Africa) to 93%
247 (South Asia) of their healthy HDDS through purchases (Figure 5). Results from individual countries
248 show that rural households in the lowest expenditure tercile still acquire about three-quarters of their
249 dietary diversity from purchases and only one-third through own consumption (SI Table 1). Albeit
250 foods from purchases play the most significant role for healthy HDDS, this is not universally true. In
251 certain rural contexts, such as among the poorest tercile in Angola (71% from own consumption and
252 33% from purchases), Burkina Faso (58% and 57%, respectively), and Timor-Leste (83% and 44%,
253 respectively), own production is more important for dietary diversity than market purchases (SI Table
254 1).

255 **Physical access constraints:** Healthy HDDS among rural households is only slightly lower than
256 those of urban households within the same income group, with a maximum difference of 0.8 food
257 groups (Figure 5). More pronounced are the differences in food sources, as rural households exhibit
258 a higher healthy HDDS from own production, especially in Central Asia and sub-Saharan Africa,
259 where 35% and 41%, respectively, of healthy HDDS is attained through own production. This
260 translates into a considerable difference of 31 and 33 percentage points (p.p.) more than their urban
261 counterparts, respectively (Figure 5). Comparing households within the same income groups in a
262 given country, the significance of own consumption for dietary diversity consistently increases in
263 rural areas, while the importance of purchases diminishes (SI Table 1). This trade-off is less
264 pronounced in Latin American and Caribbean countries, but amounts to a change of around ± 50 p.p.
265 among poorer households in Angola and ± 39 p.p. in the Marshall Islands.

266 The difference in healthy HDDS between rural and urban households of the same expenditure tercile
267 (physical barrier) is one or lower across all countries and income groups, with the exceptions being
268 poorer households in Ecuador (-1.2) and Georgia (-1.1) and the richest tercile in Timor-Leste (-1.2)
269 and the Marshall Islands (-1.2) (SI Table 2). In these countries, the reduction in healthy HDDS
270 through purchases cannot be adequately replaced by an increase in healthy HDDS through own
271 consumption. In some contexts, the increase in healthy HDDS derived from own consumption
272 considerably exceeds the reduction in healthy HDDS from purchases and results in a higher diversity
273 in rural areas, for instance, +2.5 food groups from own consumption versus -1.0 in purchases among
274 richer Armenian households, +2.3 versus -1.1 in richer Kenya, or +1.3 versus -0.2 in richer Tanzania
275 (SI Table 2).

276

277 **Economic access constraints:** Comparing income groups within the same rural-urban location
278 reveals a distinct gradient: richer households have a higher healthy HDDS compared to poorer
279 households (Figure 5). Notably, the diversity derived from own consumption remains similar across
280 income groups, thus, gaining relatively more importance for extremely poor households, where up to
281 39% (East Asia and Pacific) and 47% (sub-Saharan Africa) of healthy HDDS can be achieved through
282 own consumption. Thus, economic access constraints are entirely driven by lower diversity from
283 purchases.

284 The difference between the poorest and richest terciles within the same rural-urban location of a
285 country (economic barrier) varies between 0 and 2 for most countries and is highest for urban
286 households in Malawi (-2.4), where the reduction in diversity from purchases by 2.5 food groups is
287 not mitigated by more own consumption (SI Table 2). In general, income-related differences in
288 healthy HDDS are driven by market purchases rather than own consumption. Only in a few cases,
289 poor households manage to partially offset some of the diversity they cannot afford through higher
290 own consumption, for instance, in urban Benin (+1.1), Burkina Faso (+1.0) or Timor-Leste (+1.7).

291 In a few cases, poorer households exhibit a higher healthy HDDS such as Colombia (+0.2 for rural
292 and +0.8 for urban) or urban Ecuador (+1.3). This is driven by an increase in purchases rather than
293 own consumption (SI Table 2) and occurs in situations where dietary diversity peaks at lower income
294 levels and decreases thereafter (SI Figure 18). In most countries, however, healthy HDDS and healthy
295 HDDS from purchases reach saturation at higher income levels. In extremely low-income countries
296 such as Malawi, Niger, or Angola, dietary diversity consistently increases with income even at higher
297 levels, indicating no saturation point (SI Figure 18). These trends are not only prevalent when using
298 food group diversity, also sourcing of single food items behaves similarly with income in each
299 country (SI Figure 19).

300 **Total deprivation:** The difference in healthy HDDS between rural households of the poorest tercile
301 and urban households of the richest tercile represents a measure of the total diet diversity inequality
302 with a country. This gradient is greatest in Malawi (-3.1), Timor-Leste (-2.2), Niger (-2.2), and
303 Angola (-2.1), where diversity from purchases is reduced by 4.3, 4.1, 3.2, and 4.5 food groups,
304 respectively (SI Table 2).

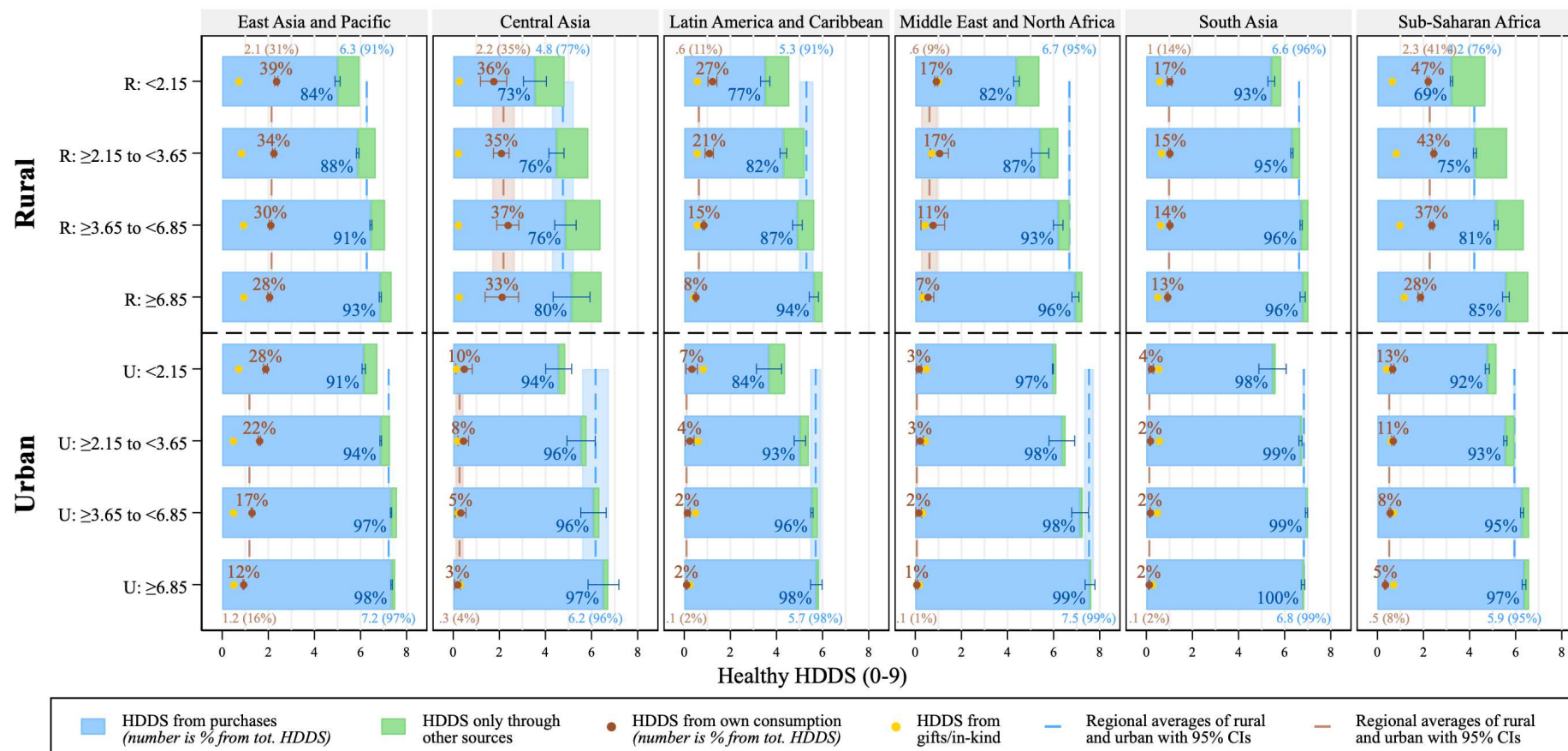


Figure 5. Healthy household dietary diversity score (HDDS) by world region, rural-urban location, and household income group. The y-axis indicates the income group and rural (R) versus urban (U) location. Blue and green represent the healthy HDDS from purchases and diversity augmentation from other sources, respectively. Brown and yellow dots show the healthy HDDS from own consumption and gifts/in-kind, respectively. Green figures depict the total healthy HDDS, blue figures the proportion that is met by purchased foods, and brown figures the proportion covered by own consumption. The gray dashed lines show regional averages among rural and urban households with 95% confidence intervals (CIs). We weighted each country based on its population size. Sample size: N = 1,035,854 households for any consumption, purchases, and own consumption representative of 2.76 billion people, and N = 702,530 for gifts/in-kind representative of 2.45 billion people.

312 **Other factors associated with household dietary diversity**

313 The results presented previously do not account for potential confounding factors. Accounting for
314 various demographic and socioeconomic characteristics (see Methods) highlights that household
315 consumption expenditure has by far the strongest association with healthy HDDS from all sources,
316 purchases in particular. A one-standard-deviation increase in per adult-equivalent expenditure
317 correlates with a 2.50-2.62 standard deviation increase in dietary diversity from purchases and overall
318 healthy HDDS and a 0.96 standard deviation increase from gifts or in-kind sources (Table 2). Hence,
319 a 0.69% (10%) increase in household expenditures is associated with a 0.05 (0.71) increase in dietary
320 diversity from purchases and a 0.04 (0.62) increase in overall healthy HDDS. Dietary diversity from
321 own consumption is positively associated with consumption expenditure in most regions, particularly
322 Central Asia and sub-Saharan Africa, but negatively in Latin America and the Caribbean (SI Table
323 3). The positive relationship between dietary diversity from gifts/in-kind and consumption
324 expenditure is largely driven by South Asia and sub-Saharan Africa (SI Table 3). The negative
325 association between squared income and dietary diversity suggests a non-linear relationship (Table
326 2, SI Figure 18). Beyond consumption expenditure, healthy HDDS from gifts/in-kind is associated
327 with a smaller household size, an older or female household head, and rural residency.

328 Household involvement in agricultural activities is associated with a 0.88-unit increase in dietary
329 diversity from home-produced foods, alongside a 0.06-unit decrease in overall healthy HDDS. This
330 association is strongest in sub-Saharan Africa, where one standard deviation increase in household
331 engagement in agriculture corresponds to a 0.43 standard deviation increase in dietary diversity from
332 own production—roughly twice the effect observed in other regions. Notably, in sub-Saharan Africa
333 and Central Asia, agricultural households tend to show higher overall healthy HDDS scores. By
334 contrast, the negative association is driven by South and East Asia and the Pacific (SI Table 3).

Table 2: Association between healthy household dietary diversity score (HDDS) and household demographic and socioeconomic characteristics.

	(1) HDDS (1.628)	(2) HDDS from purchases (1.958)	(3) HDDS from own consumption (1.475)	(4) HDDS from gifts/in-kind (0.823)
Cons. exp. per AE, log	2.621*** (0.687)	2.499*** (0.687)	0.161** (0.687)	0.958*** (0.687)
Cons. exp. per AE, log, squared	-2.343*** (10.709)	-2.235*** (10.709)	-0.134* (10.708)	-0.989*** (10.673)
Highest education in HH				
Less than basic	-0.056*** (0.398)	-0.060*** (0.398)	-0.018*** (0.398)	0.004 (0.408)
Basic	ref. cat.	ref. cat.	ref. cat.	ref. cat.
Intermediate	0.009*** (0.416)	0.016*** (0.416)	-0.012*** (0.416)	-0.021*** (0.406)
Advanced	-0.021*** (0.421)	-0.011** (0.421)	-0.009*** (0.421)	-0.052*** (0.425)
Household size	0.173*** (2.404)	0.139*** (2.404)	0.089*** (2.404)	-0.051*** (2.465)
Age of household head	-0.001 (14.116)	-0.026*** (14.116)	0.055*** (14.116)	0.057*** (14.190)
HH engaged in agricultural activities (1=Yes)	-0.020*** (0.497)	-0.095*** (0.497)	0.297*** (0.497)	-0.011** (0.498)
Sex HHH (1=Female)	0.003 (0.366)	0.007 (0.363)	-0.022*** (0.363)	0.054*** (0.363)
Location (1=Urban)	0.007 (0.482)	0.083*** (0.482)	-0.239*** (0.482)	-0.108*** (0.475)
Observations	854,208	854,208	854,260	536,208

Notes: This table depicts OLS regression coefficients of standardized healthy household dietary diversity from different sources on various standardized socioeconomic characteristics. We employ country-fixed effects, survey weights and clustered standard errors. The most restrictive sample in column (4) includes 28 countries. Columns (1), (2) and (3) add Bhutan, Ghana, Indonesia, and Rwanda for which foods from gifts/in-kind are not available. The value of one standard deviation is displayed in brackets.

Limitations

While these findings collectively yield a compelling narrative of the importance of purchases for dietary diversity and food consumption in general, there are several limitations to our analysis.

First, we use rural-urban location as a proxy for physical access, recognizing that within rural areas, significant variations in the physical accessibility of foods exist, ranging from smaller towns to very remote villages. However, physical accessibility is not solely determined by distance to markets; it also depends on factors like market frequency and operating hours. Yet, there is no consensus on how

350 to measure physical access to markets, leading to a lack of comparable measures across countries.
351 Ongoing debates center around which types of markets to include, whether to use distance or time to
352 reach the market and to what extent operating hours should be factored in^{27–31}. Each option has its
353 strengths and weaknesses, making it challenging to reach a consensus.

354 Second, the surveys used for our analysis differ in their methodologies for measuring food
355 consumption. For instance, while the 7-day recall method is the most commonly used, some surveys
356 use a diary to report food consumption. An extensive literature discusses the impact of measurement
357 differences on food consumption estimates^{32–36}. However, since our paper primarily focuses on the
358 proportions of diversity derived from each source, and we anticipate minimal variations in the effects
359 on consumption from different sources. This minimal effect was confirmed when we incorporated
360 country/survey-fixed effects (Table 2), yielding results that largely consistent with our earlier
361 findings.

362 Third, the healthy HDDS provides valuable insights into household-level food consumption but does
363 not capture the intra-household allocation of foods. Due to the unavailability of nationally
364 representative individual-level food consumption data, household-level information is the best proxy
365 currently accessible. Recent research has shown that macro- and micronutrient intake from 7-day
366 household recall modules are a comparatively good proxy for ‘true’ intake from the benchmark highly
367 supervised individual-level diaries^{32,37}. Nevertheless, given the limitations of the available data,
368 interpretations of our results should center on food sources at the household level rather than
369 individual-level nutrient intake.

370 Fourth, although dietary diversity offers valuable insights into the variety of food groups consumed,
371 it does not account for unhealthy foods such as ultra-processed products. Because these items are
372 almost exclusively purchased, higher incomes may also correlate with higher consumption of

373 unhealthy foods. While some tools, such as the Global Diet Quality Score³⁸, consider both healthy
374 and unhealthy foods, they are not applicable to our dataset and would impair cross-country
375 comparability.

376

377 **Discussion**

378 Improving the diversity, and thus the quality, of household diets in LMICs in the face of a changing
379 climate is one of the greatest challenges of the next decade. In the largest global analysis to date, we
380 show that households in LMICs, even agricultural households, primarily depend on market purchases
381 to achieve dietary diversity. Albeit there is an increase in the importance of purchased foods compared
382 to own production for household's diets, markets have been the predominant source even 20 years
383 ago. While income is linked to greater diversity from own production at lower income levels,
384 variations in healthy HDDS with income are mainly due to differences in the diversity from purchased
385 foods. This is especially true for animal-source foods, which are almost entirely obtained from
386 markets. Furthermore, our findings highlight the often-overlooked importance of alternative food
387 sources—gifts and in-kind payments—in promoting household dietary diversity in LMICs.

388 Higher dietary diversity is strongly associated with a lower risk of deficiencies in various nutrients
389 essential for optimal human health and functioning³⁹. Diet diversity and diet quality can improve
390 nutrition outcomes, such as undernutrition and iron deficiency anemia^{39,40}, but also cognitive and
391 physical development and overall well-being^{6–9}. Identifying effective strategies to enhance dietary
392 diversity in LMICs remains a complex challenge. The academic debate often centers around whether
393 improving market access or increasing on-farm production diversity is more effective in enhancing
394 dietary diversity^{10,11,15–17}.

395 In addition to enhancing dietary diversity, understanding who accesses which foods from which
396 sources is crucial for building resilience to shocks. Recent events, such as COVID–19 and
397 skyrocketing food prices in 2022 highlighted the fragility of global food systems and underscored the
398 repercussions high reliance on market-sourced foods can have on physical and economic access to
399 food. The increased frequency of extreme weather events poses additional risks, potentially leading
400 to significant harvest losses, and affecting both market supply chains and local production. In such
401 scenarios, access to food markets can be a crucial lifeline for households striving to maintain food
402 security.

403 A growing body of literature has investigated the relative importance of market purchases versus own
404 production for food security, particularly among farmers^{11,18–25}. We add to these case studies
405 empirical evidence from 45 LMICs that market purchases are the largest contributor to households’
406 dietary diversity, even for agricultural households. Contrary to the common perception that
407 agricultural households in Sub-Saharan Africa are predominantly subsistence-based, we show that
408 approximately three-quarters of their dietary diversity comes from markets. Notably, 71% and 93%
409 of households in Sub-Saharan Africa that consume fruits and vegetables, respectively, source them
410 through purchases. Our longitudinal analysis demonstrated that the reliance on market-sourced foods
411 is not a recent phenomenon, suggesting that it may not be entirely driven by rapid global urbanization.
412 Indeed, even in low-income countries, such as Malawi, market purchases have been the primary
413 means of food consumption and dietary diversity for at least the past two decades.

414 Furthermore, while we have found little seasonal variation in food sources and overall household
415 dietary diversity, consumption of healthy foods such as fruits and vegetables can be subject to
416 considerable seasonal fluctuations – from both own production and market purchases. When fruits
417 and vegetables available in markets are locally produced, their availability and prices fluctuate in

418 accordance with seasonal production patterns, thereby restricting accessibility. This is in contrast to
419 other research that has shown an enhanced importance of own consumption of plant-based foods
420 during the harvest season³¹. While seasonal fluctuations in food production are well documented,
421 there is little research on the seasonality of food consumption and the role of various food sources in
422 this context, underscoring the need for further investigation in this area.

423 Most of the research on food sources focuses only on purchases and own production^{11,22,23}. However,
424 this study shows that foods received as gifts or in-kind represent a source of dietary diversity that
425 should not be neglected considering that one in five households that consume fruits obtain them as
426 gifts or in-kind. This food source is particularly common in Sub-Saharan Africa and East Asia and
427 the Pacific, where malnutrition and food insecurity are the highest globally. In urban settings, and
428 specifically for fruits and animal-source foods, this food source is just as important as own-
429 production. Foods received in-kind can play an important role in mitigating adverse effects of food
430 price spikes and, thus, food security⁴¹.

431 We have shown that household dietary diversity increases strongly with income in most countries,
432 which is almost entirely driven by an increased diversity from purchased foods, not own production.
433 For many plant-based foods, poorer households may compensate for their lack of financial resources
434 to buy these foods by sourcing them from their own production. This is not true for fruits and animal-
435 source foods, where consumption is considerably lower among poorer households. Among extremely
436 poor households, only 42% have consumed fruits within the past 7 days, 33% meat, 27% milk and
437 dairy products, and 15% eggs, which may have severe health consequences, particularly for
438 children⁴².

439 We have demonstrated that animal-source foods are almost exclusively acquired from markets
440 regardless of households' location, occupation, or income. A high reliance on purchases for animal-

441 source foods sparks the question of whether there is room for improvement for more diverse diets,
442 especially through own consumption of animal-source foods to achieve levels seen in Central Asia.
443 Studies have shown that provision or ownership of livestock can improve own consumption of milk
444 and meat and nutrition outcomes, particularly when market access is low and during lean
445 seasons^{10,31,43,44}. In contexts without functioning cold-chain infrastructure (and low market access),
446 increasing consumption of animal-source foods through own production may be a viable strategy to
447 improve dietary diversity in the short term.

448 One-fifth of all households have consumed vegetables from their own production in the past 7 days.
449 While own consumption of vegetables is common, particularly among low-income households, it
450 appears that there is either an insufficient quantity of own production or a lack of variety in food
451 items. Even households engaging in own production often supplement their vegetable intake with
452 vegetables from markets or vice versa.

453 Cultural factors also shape food consumption patterns, determining which foods or food groups are
454 included in household diets⁴⁵. The ideal dietary diversity, therefore, should reflect what households
455 would consume with unrestricted access to their desired foods, free from physical and economic
456 access constraints. Assuming that supermarkets in urban areas have sufficient variety and at least the
457 wealthiest people in a country can afford their desired foods, we assumed that the desired diversity is
458 reached by the richer urban households in a country or region (our analysis shows that in some poorer
459 countries, this is not the case as there is no saturation with increasing income even among the
460 wealthiest households). In nine countries, poor rural households consume on average two to three
461 food groups less than their richer urban counterparts, where an increase of dietary diversity from own
462 consumption by two to three food groups is exceeded by a reduction in purchased diversity of three
463 to five food groups.

464 Our analysis shows that improving market access is important to improve diets in LMICs where both
465 physical and economic constraints play a role in accessing diverse diets, the latter being the more
466 limiting factor. While differences in purchased dietary diversity between rural and urban households
467 are often mitigated by an increase in own consumption among rural households, variations in
468 purchased dietary diversity between income groups translate almost entirely to reduced consumption
469 among poorer households. Around 3 billion people globally cannot afford healthy diets, a finding that
470 aligns with our results, emphasizing the central role of income in shaping diverse diets¹. These
471 findings have important implications for both food price and poverty policies. To achieve food
472 security, diverse and nutritious diets must be made affordable for everyone, enabling people to live
473 active and healthy lives. High reliance on foods from markets for dietary diversity necessitates cash
474 income. Tackling poverty may therefore be the most effective strategy to enhance diets and nutrition
475 in LMICs.

476

477

478 **Methods**

479 **Data**

480 This study uses data from nationally representative household surveys conducted in 45 LMICs. We
481 collate survey data from Household Consumption and Expenditure Surveys (HCES) conducted
482 between 2008 and 2022 (SI Table 4). HCES were originally designed to construct consumer price
483 indices and calculate poverty rates. They collect detailed information on a wide range of topics
484 surrounding food and non-food consumption and expenditure, including income, housing, health,
485 education, and various other household and individual characteristics. These surveys are typically
486 conducted by national statistics offices, often with assistance from the World Bank. The harmonized
487 sample covers 1,138,305 households of which 1,105,681 have a food consumption and expenditure
488 module available. These households inhabit 4,759,307 individuals which are representative of 2.8
489 billion people. Specific variables available for each country and included in the analysis are reported
490 in SI Table 5.

491 Food consumption data in these surveys are collected through face-to-face interviews with the person
492 responsible for cooking and purchasing food. Depending on the country, data were recorded using
493 either a 7-day consumption recall or a food consumption diary. Some exceptions exist. Food
494 consumption data from Ghana and Sierra Leone are collected with a 5-day reference period. In India,
495 consumption of cereals, cereal substitutes, and pulses was collected with a 30-day reference period,
496 while all other foods were collected using a 7-day reference period. The number of food items
497 surveyed typically ranges from 100 to 300, ensuring comprehensive coverage of household dietary
498 patterns.

499

500 **Household dietary diversity measurement**

501 As a measure of dietary diversity, we use nine food groups of the Household Dietary Diversity Score
502 (HDDS), namely (i) cereals, (ii) roots/tubers/plantains, (iii) pulses/nuts/seeds, (iv) vegetables, (v)
503 fruits, (vi) meat, (vii) fish/seafood, (viii) milk/dairy products, and (ix) eggs. The HDDS is constructed
504 such that a higher score indicates a greater diversity in terms of foods consumed but also macro- and
505 micronutrients. It is associated with better nutritional outcomes and serves as a good indicator of food
506 security, economic access to food, and diet quality^{8,46–48}. Further, the HDDS is a reliable proxy of
507 individual dietary quality of children and adults within the household^{37,49,50}. It is considered a
508 preferred indicator for cross-country analyses compared to other diversity measures such as the food
509 variety score due to cultural differences in dietary habits^{48,51}. The original HDDS is based on twelve
510 food groups with (x) sugar and sugary products, (xi) oils and fats, and (xii) spices, condiments and
511 beverages representing the three additional food groups. However, they add relatively little to
512 micronutrient density^{52,53}. Foods included in these additional groups are also not included in other
513 conventional dietary diversity scores such as the Minimum Dietary Diversity for Women (MDDW)
514 or the Minimum Dietary Diversity for Children. Therefore, we follow recent approaches^{18,25} with
515 only nine more healthy food groups that are particularly relevant for micronutrient density and dietary
516 quality.

517 The HDDS measures the inclusion of distinct food groups in a household’s diet, reflecting dietary
518 variety, a critical indicator of nutrient adequacy. Consistent categorization of food items into nine
519 standard food groups across surveys ensures comparability, making the HDDS a reliable tool for
520 analyzing dietary patterns across diverse contexts. Its flexibility allows it to accommodate data from
521 different collection methods, as long as food group categories remain consistent. For example, the
522 inclusion of cereals, vegetables, fruits, and animal-source foods in the HDDS depends on whether

these food groups were consumed within the recall period rather than their total quantity. By standardizing food groups and focusing on dietary variety, the HDDS facilitates meaningful cross-country comparisons and provides valuable insights into the socioeconomic, geographic, and cultural factors influencing dietary diversity globally^{18,25,48,51}.

To validate the robustness of our results to alternative diversity indicators, we also use a food item count (SI Figure 3, SI Figure 9, SI Figure 12, SI Figure 15) and the MDDW (SI Figure 11). The food item count is the number of food items consumed from each source. Since the number of surveyed food items can be considerably different between surveys, we only display the proportion of items from each source. The MDDW is a diversity indicator originally designed for women of reproductive age, who are often nutritionally vulnerable⁵⁴. On the individuals-level, the MDDW has been shown to reflect micronutrient adequacy, a key dimension of diet quality⁵⁵. The indicator consist of ten food group with fruits and vegetables being more disaggregated compared to the HDDS: (i) grains, white roots and tubers, and plantains, (ii) pulses (beans, peas, and lentils), (iii) nuts and seeds, (iv) dairy, (v) meat, poultry, and fish, (vi) eggs, (vii) dark-green leafy vegetables, (viii) other vitamin A-rich fruit and vegetables, (ix) other vegetables, and (x) other fruits.

Food sources

In the HCES datasets, we identify three food sources: purchased foods, foods consumed from households' own production (own consumption), and foods from gifts and in-kind contributions or payments. Purchased foods comprise items acquired from shops, supermarkets, or street vendors paid by credit cards, mobile money, or cash. Own consumption encompasses food sourced from the own farm or garden and food hunted, fished, or collected in the wild. Food received as a gift or in-kind comprises more diverse sources, such as gifts from family and friends, food aid, in-kind payments, food received in exchange for other goods, or food from own retail shops. The survey from Indonesia

546 does not distinguish between own production and gifts/in-kind and categorizes food from both
547 sources as “other sources”. For our analysis, we consider this category to be own production. Surveys
548 from Ghana, Bhutan and Rwanda did not include foods from gifts/in-kind. In Kenya and Tajikistan,
549 respondents were specifically asked if they consumed food "from own stock," which, for the purposes
550 of our analysis, is categorized under "purchases."

551 We construct the proportional contributions of food consumed from different sources across
552 countries. Proportional measures are inherently standardized as they reflect the relative contributions
553 of food sources (markets, own production, or gifts) regardless of the total consumption recorded.
554 Therefore, proportions are stable and reliable indicator of habitual household practices, even when
555 data collection methods differ. Although total quantities may vary between recall and diary
556 collections, differences in entire food groups consumed are negligible. The broad range of food items
557 captured in these surveys (typically 100–300) ensures robust categorization into food groups,
558 facilitating accurate calculations of sourcing proportions. By incorporating survey-fixed effects, we
559 account for methodological discrepancies. This flexibility enables reliable cross-country comparisons
560 of food-sourcing behaviors, offering critical insights into global patterns of dietary diversity.

561 **Socioeconomic measurements**

562 *Income and expenditure.* We use household per capita consumption expenditure, adjusted to 2017
563 Purchasing Power Parities (PPPs), as a measure of welfare to classify households into categories of
564 international poverty lines and expenditure quantiles. Consumption expenditure serves as a reliable
565 proxy of income in countries with lower income. For higher income countries, we used income when
566 available. Both income and expenditure were spatially deflated where deflators were available.

567 *Occupation.* To classify households based on occupations, we use the “International Standard
568 Classification of Occupations” (ISCO) codes and industry classifications according to the
569 “International Standard Industry Classification of All Economic Activities” (ISIC) codes, both from
570 the International Labor Organization (ILO). We harmonize these codes for the primary and, when
571 available, secondary occupations of the household head and their spouse. We categorize the ISCO
572 codes into five groups: (1) Professionals; (2) Managers, technicians, and associate professionals; (3)
573 Army forces, clerical support, service, sales, craft and related, plant/machine operators, assemblers;
574 (4) Skilled agricultural, forestry and fishery workers; (5) Elementary occupations. We group industry
575 codes into sectors in agriculture, industry, and service, following the ILO recommendations. For our
576 analysis, we primarily use the ISCO and ISIC codes related to the household head's main occupation.

577 Further, we classify households into agrarian and non-agrarian households. A household is considered
578 agrarian if the primary occupation of the household head or spouse falls under ISCO code 6 (Skilled
579 agricultural, forestry, and fishery workers) or, in the absence of ISCO data, under ISIC code A
580 (Agriculture, forestry, and fishing). Recognizing that these codes may only be included for wage-
581 employed individuals in surveys, we also consider responses to questions about engagement in
582 agricultural activities on personal or family farms for those not in wage employment. A household is
583 classified as agrarian if any family member is involved in agricultural activities, irrespective of wage
584 employment or self-employment status. Many household surveys in middle-income countries lack
585 questions on agricultural production, preventing us from defining agricultural households based on
586 the common "any production" versus "no production" criteria seen in other studies.

587 **Selection of countries for seasonal analysis**

588 We analyzed seasonal variation in healthy HDDS and food sources for ten countries. We selected
589 countries in which data was collected for twelve months throughout the entire year. We excluded

590 countries in which urban vs rural proportions varied from month-to-month by more than 10
591 percentage points from the annual mean to rule out that survey roll-out may drive our results.

592 **Statistical analysis**

593 To ensure that our estimates accurately reflect the entire population of each country, we applied
594 household weights that are provided with each survey dataset. HCES surveys utilize a two-stage
595 sampling design, necessitating the use of strata and primary sampling units (PSUs) for appropriate
596 weighting. For global and regional estimates, we weighted each country according to its population
597 size on July 1st in the year the interviews started. Thus, countries with a large population such as
598 Nigeria or Indonesia constitute a large proportion of the estimate.

599 In addition to our main analysis, we performed a regression analysis to assess the association between
600 healthy HDDS of different food sources and various demographic and socioeconomic factors. Our
601 dependent variable is healthy HDDS, a count variable. Hence, we employ a Poisson regression
602 estimation of the following equation:

$$\begin{aligned} 603 \quad \text{Healthy HDDS}_{h,c} = & \beta_0 + \beta_1 \ln exp_h + \beta_2 agehhh_h + \beta_3 maxeduc_h + \beta_4 hhsiz_e_h \\ 604 \quad & + \beta_5 sexhhh_h + \beta_6 agoccup_h + \beta_7 urban_h + \theta_c + \epsilon_h, \end{aligned}$$

605 where h is the household and c represents the country. $\ln exp$ is logarithmized household expenditure
606 per adult-equivalent, $agehhh$ is the age of the household head, $maxeduc$ is the highest education within
607 the household, $hhsiz_e$ is the household size, $sexhhh$ is the sex of the household head, $agoccup$ is
608 agricultural engagement of any household member, $urban$ is rural-urban location of the household,
609 and θ_c are country-fixed effects. Country-fixed effects account for country- and survey-specific

610 characteristics, such as differences in the number of food items surveyed or the methodology
611 employed to collect the consumed food items, the use of recall versus diary in food measurement.

612

613 **Data availability**

614 Most of the data used in this study are publicly available on the websites of the National Statistics
615 Office of each country or the World Bank’s Microdata Library. Data sets that are not publicly
616 accessible were provided by the respective national statistics office (e.g., Bhutan, Indonesia, Jamaica,
617 Kenya). Dataset names and identifier are provided in SI Table 4. Availability of variables by dataset
618 is provided in SI Table 5.

619

620 **Code availability**

621 The code for replicating the results as well as the figures in the manuscript will be made publicly
622 available on GitHub.

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770

		Income classification				Total
		High income	Upper-middle income	Lower-middle income	Low income	
World region	East Asia and Pacific		Indonesia, Marshall Islands	Cook Island, Kiribati, Myanmar, Timor-Leste, Tokelau		7
	Central Asia		Armenia, Georgia	Mongolia	Tajikistan	4
	Latin America and Caribbean	Barbados	Argentina, Colombia, Dominican Republic, Ecuador, Jamaica, Mexico, Suriname	El Salvador		10
	Middle East and North Africa		Iraq	Tunisia		2
	South Asia			Bhutan, India		2
	Sub-Saharan Africa			Angola, Benin, Cote d'Ivoire, Ghana, Kenya, Nigeria, Senegal, Tanzania	Burkina Faso, Democratic Republic of the Congo, Ethiopia, The Gambia, Guinea-Bissau, Liberia, Malawi, Mali, Niger, Rwanda, Sierra Leone, Togo, Uganda	20
Total		1	13	18	13	45

Table 2: Sample countries. Countries are assigned according to the starting year of the survey based on World Bank classifications of income groups and regions. Mongolia has been assigned to Central Asia instead of East Asia and Pacific.

778 **Supplementary Information**

779 Supplementary Information is available for this paper.

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787 **Ethics declarations**

788 **Competing interests**

789 The authors declare no competing interests.

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