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Mapping Layers of Sustainability Consciousness in Food Consumption Using the Item Response Theory (IRT) Approach

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ABSTRACT

Understanding how consumers commit to sustainability in their food choices requires attention to both widely shared values and the points where commitments differ. Drawing on Item Response Theory (IRT), this study examines survey data from more than one thousand consumers to map a continuum of sustainability consciousness. Traditional regression approaches treat all motives as equal; however, the IRT method's main advantage is to highlight which attitudes most distinguish consumers and where the boundaries lie between superficial agreement and deeper commitment. The main research questions are (i) which consumer motives most effectively differentiate levels of sustainability consciousness; (ii) what makes commitments that widely agree become stronger and more demanding endorsements; and (iii) how do the education and gender characteristics shape variation along the continuum of sustainability consciousness. The results show a layered structure. Trust in farmers and assessments of freshness and taste serve as broad entry points, while social influence and ecological concerns result in stronger differentiation. Collective support for local farmers appears to be the most demanding form of commitment. Education and gender do not shape these orientations, suggesting that social characteristics systematically structure sustainability consciousness. For industry and research, product development and communication strategies can be based on widely shared entry points such as taste and trust, while targeted interventions are needed to promote stronger ecological and collective commitments.

1 | Introduction

Food consumption plays a central role in discourse on sustainability, as it links everyday practices to wider social and environmental consequences. Consumer choices affect agricultural production systems, ecological pressures, and public health, making the food industry one of the most important areas for discussing sustainability challenges (Li, C. et al. 2025; Li, S. et al. 2025).

Consequently, sustainable food consumption has become a progressive issue in both public discourse and academic research

(Han et al. 2025; Schulze et al. 2024). Some consider sustainable consumer choices as a key for food system transformation, such as buying local, organic, or environmentally friendly products (Kenger et al. 2025; Woś et al. 2025). However, others question whether these choices can solve the structural problems of industrialized agriculture or note that such choices often remain limited to socio-economically privileged groups (Nguyen et al. 2025; Watson et al. 2023). Sustainable consumption is therefore both promising and controversial, highlighting the need to better understand how consumers commit to sustainability in practice (Delpozo et al. 2025).

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Existing research has identified a range of motives that influence consumers' decisions to choose or avoid sustainable foods. Sensory appearance and health-related benefits often act as entry points into more sustainability-oriented behavior (Erhard et al. 2024; Firoozzare et al. 2024). Trust in farmers and producers reinforces authenticity and reduces uncertainty around trust attributes (Tonkin et al. 2021). Social influences such as peer networks, generational identities, and cultural norms also influence whether sustainability values translate into behavior (Ayhan et al. 2025; Doan et al. 2025; Wu and Yu 2025).

Other motives, such as biodiversity protection, willingness to pay premiums, or support for local farmers, require stronger commitments and are less equally distributed (O'Neill et al. 2023; van Bussel et al. 2022).

Taken together, this evidence points suggest to the structure being layered, with widely accessible motives forming the basis, while ecological and collective commitments develop only among more strongly committed consumers.

Despite these insights, survey-based studies often rely on additive indices or regression models that treat all motives as if they contribute equally and linearly to sustainability orientation. This creates two problems for understanding food preferences. First, it obscures which motives are most important in distinguishing consumers, for instance, whether sensory qualities are as important as ecological responsibility when explaining differences in behavior. Second, it makes it difficult to identify thresholds of commitment because many consumers may agree that local food is 'fresh,' but far fewer strongly encourage that, involving higher costs, such as supporting local farmers. Without tools that capture such gradations, it is hard to know whether consumer agreement reflects superficial consensus or deeper willingness to act.

This study addresses these gaps by applying Item Response Theory (IRT), a methodological approach that estimates how strongly different items differentiate respondents and at which points agreement becomes more demanding.

The main research questions are:

1. Which consumer motives most effectively differentiate levels of sustainability consciousness (sensory appearance, trust, social influence, and ecological values)?
2. What makes widely accepted commitments stronger and more demanding?
3. How do education and gender characteristics affect variation along the continuum of sustainability consciousness?

By addressing these questions, the study highlights how consumers' orientation toward sustainability is layered and unequally distributed. Understanding this structure is essential for designing food products, labels, and communication strategies that target a wide audience while also supporting pathways toward deeper ecological and collective commitments.

2 | Theoretical Framework

Consumers' commitment to sustainability in food consumption cannot be reduced to a single dimension. Motives range from sensory qualities and trust to ecological concerns and collective commitments, each requiring different levels of reflection and willingness to act. The following table summarizes the four complementary theoretical perspectives that we use to capture this complexity (Table 1).

First, the Theory of Consumption Values highlights that functional values such as taste, freshness, and health are easily accessible to consumers (Sheth et al. 1991). These often serve as an 'entry point' into sustainable consumption (Erhard et al. 2024; Tonkin et al. 2021). Social and emotional values, such as peer acceptance or concern for biodiversity, require greater commitment, while conditional values (e.g., supporting farmers despite higher costs) require clear compromises. Second, the Value-Belief-Norm framework explains why ecological concerns often appear in principle as costly practices (Stern et al. 1991). This 'value-action gap' indicates that ecological motives require a higher commitment threshold than sensory or trust-based motives (Nguyen et al. 2025). Furthermore, the Social Practice Theory highlights that food choices are embedded in routines and peer contexts. Generational identities and social norms shape whether values translate into behavior (Shove et al. 2012; Pollicino et al. 2025; Warde 2005; Wu and Yu 2025). This means that social influence is a strong differentiating factor in sustainability consciousness. Finally, the Collective Action Theory emphasizes the public good nature of systemic support for local farmers (Olson 1965; Ostrom 1990). While many consumers agree with minimal support, strong commitments involving higher costs are selective and fragile (Enthoven and Van den Broeck 2021). Such commitments represent the highest threshold of sustainability orientation.

Based on this synthesis, we define sustainability consciousness as a layered continuum: consumers base their decisions on functional values, which are further differentiated based on social influence. They need stronger beliefs and norms to support ecological commitments, and they face the highest threshold when supporting collective action.

Therefore, we test the following hypotheses:

- H1.** Sustainability consciousness is structured in layers, from low-threshold entry points to progressively more demanding commitments.
- H2.** Trust and sensory qualities are widespread, but their discriminatory power is limited.
- H3.** Social influence strongly differentiates levels of sustainability consciousness.
- H4.** Ecological concerns require higher thresholds of commitments.
- H5.** Supporting local farmers is the most demanding form of commitment.

TABLE 1 | Theoretical perspectives and implications for sustainability consciousness.

Perspective	Key contribution	Implication for sustainability continuum
Consumption values theory	Differentiates functional, social, emotional, and conditional motives.	Functional values act as broad entry points; higher-order values require stronger engagement.
Value-believe-Norm theory	Links values, beliefs, and norms to pro-environmental action.	Ecological motives appear at higher thresholds due to the value-action gap.
Social practice theory	Highlights routines, peer influence, and social identity.	Social norms strongly differentiate engagement levels.
Collective action theory	Explains public good dilemmas in food systems.	Support for local farmers is most demanding and selective.

H6. Education and gender shape orientations; women and highly educated consumers are more strongly committed to ecological and collective values.

This framework not only guides the hypotheses but also points to practical applications. If consumers learn about sustainability through functional values such as taste and freshness, product design can highlight these characteristics as key starting points. Labeling systems that highlight farmers' identities or transparent production practices can build trust and increase commitment. Social influence suggests that communication strategies using peer networks, generational identities, or community initiatives can be effective in deepening commitment. At higher thresholds, ecological claims and collective-action messages are more targeted at consumer segments with strong biospheric values or higher levels of education, who are more willing to pay premiums or support systemic change. Therefore, understanding the continuum of sustainability consciousness provides an opportunity to segment consumers more accurately and develop interventions that move different groups toward stronger ecological and collective commitment.

3 | Materials and Methods

3.1 | Survey Design and Sampling

In order to understand how consumers relate to sustainability in food consumption, both conceptual clarity and solid empirical design are needed. This study is based on nationally representative survey data collected in Hungary in June 2021. The survey was conducted by a professional research company using random-digit dialing and quota sampling to ensure representativeness by gender, age, education, settlement type, and region. The final dataset included 1,031 adults aged 18 years and older.

Respondents were asked to indicate their level of agreement with statements related to food preferences and sustainability motives on a five-point Likert scale (1 = strongly disagree, 5 = strongly agree). This sequential format allowed for comparison of items while keeping the order of attitude responses.

The survey questions are based on validated constructs from the literature on food choice and sustainability, including perceptions of food quality, environmental values, and social impacts on

consumption (Erhard et al. 2024; Tonkin et al. 2021). Based on the conceptual framework, we grouped the items into four domains that reflect the hypothesized layering of sustainability consciousness:

1. **Sensory and trust-based qualities**—such as taste, freshness, and trust in manufacturers—are easily accessible, low-threshold motives shared by most consumers.
2. **Social influence**—the perceived importance of peers and social networks—represents a medium level of differentiation, as following social norms requires a certain degree of commitment.
3. **Ecological concerns**—protecting biodiversity, packaging, and environmental impact—represent higher-order values that require moral reflection.
4. **Collective commitments**—supporting local farmers or willingness to share costs—represents the most demanding and selective forms of commitment.

These domains are directly related to theoretical perspectives discussed in Section 2, including the theory of consumption values (Sheth et al. 1991), value-belief-norm theory (Stern et al. 1991), social practice theory (Warde 2005), and collective action theory (Ostrom 1990). In accordance with this framework, we expect a gradual increase in the difficulty of support from sensory motives to collective motives.

3.2 | Analytical Framework

While traditional analyses of such survey data rely on additive indices or linear regressions, these approaches implicitly assume that all motives contribute equally to the overall sustainability score. This assumption obscures significant heterogeneity: agreeing that 'local food is fresh' does not require the same level of commitment as supporting that 'local farmers should be supported through subsidies'. In order to take these differences into account, the study uses the Item Response Theory (IRT), which models the probability of support for a given item as a function of a basic latent trait, referred to here as sustainability consciousness.

Among IRT models, the Graded Response Model (GRM) proved to be the most suitable for ordinal Likert-type data (Samejima 1969). Each item is characterized by a discrimination parameter (α), which indicates how effectively it distinguishes between respondents at different levels of sustainability consciousness, and a set of threshold parameters (β_1 – β_4), which mark the points on the latent continuum where respondents move from one level of agreement to the next.

Items with low threshold values (negative β) are easily accepted, suggesting that they reflect widely shared motives, while items with higher thresholds reflect more demanding attitudes. The α parameter shows the steepness of the item's characteristic curve: high values indicate items that strongly differentiate respondents within the continuum, while low values indicate weak discrimination. Together, these parameters provide a nuanced picture of how different sustainability motives shape consumer orientations.

Model comparisons using the Akaike Information Criterion (AIC) and the Bayesian Information Criterion (BIC) confirmed (Appendix A1) the GRM fits better than the Rating Scale Model (RSM), the Partial Credit Model (PCM), and the Generalized Partial Credit Model (GPCM). Beyond statistical fit, the GRM was also conceptually appropriate, as it allows each survey item to have a unique threshold value, reflecting the unequal psychological 'costs' of supporting different sustainability values. Estimating these thresholds separately is essential for distinguishing between less and more-committed consumers.

3.3 | Incorporating Social Covariates

To examine how sustainability consciousness varies across social groups, we also included gender and education in the GRM framework. We coded gender as a binary variable (0 = male, 1 = female) and measured education in four ordered categories: (1) elementary school or below, (2) high school, (3) postsecondary non-degree, and (4) postsecondary degree.

By including covariates, we can examine whether these demographic factors influence the mean and variance of the latent trait while preserving the invariance of the measurement, i.e., ensuring that items function equally across groups. This distinction is critical: for example, the average difference in sustainability consciousness between men and women is only meaningful if both groups interpret the items in the same way. Therefore, we compared group-level parameter estimates to assess whether demographic characteristics change the distribution of the latent trait or modify the interpretation of individual items.

3.4 | Robustness and Validation

Robustness checks included comparisons between full and reduced models and domain-specific subscales to verify the stability of discrimination and threshold parameters. Fit indices, correlations of latent trait estimates, and test information functions were examined to confirm that the hierarchical structure observed among items was not sensitive to item selection or sample composition. The consistency of item order across models

supports the interpretation of sustainability consciousness as a layered continuum.

4 | Results

The Graded Response Model reveals that sustainability consciousness among consumers follows a hierarchical structure with distinct layers of engagement. Figure 1, Table 2, and Table 3 present the discrimination and difficulty parameters (thresholds between response categories) that characterize how different motive dimensions shape consumer orientations toward sustainable food.

4.1 | Trust in Farmers and Sensory Qualities: Foundational and Discriminating Factors

Trust in farmers and sensory attributes appear to be the most accessible entry points into sustainability consciousness. Discrimination parameters (α) range from 1.334 to 1.486 for sensory qualities and 1.334 to 1.393 for trust-related items. The strong discrimination (α) combined with low entry thresholds (β) suggests that while nearly all respondents acknowledge these qualities, the strength of endorsement differentiates individuals along the underlying continuum. This dual function is illustrated by the 'local food is tasty' (Item 7) ($\alpha = 1.486$).

In our data set the lowest first thresholds were at the 'local food is fresh' (Item 8) and the 'trustworthiness of direct farmers' (Item 9) ($\beta_1 = -4.422$ and -4.071 , respectively), indicating that even consumers with minimal sustainability orientation easily accept these qualities. 'Importance of healthy food' (Item 2) displays universally negative difficulty parameters across all response categories ($\beta_1 = -4.361$, $\beta_2 = -3.374$, $\beta_3 = -1.921$, $\beta_4 = -0.288$), positioning health considerations as the most fundamental shared motive (Figure 1 and Table 2).

Focusing on domain levels—trust, sensory qualities, social influence, ecological concerns, support for farmers, and core values –, trust items average $\alpha = 1.381$ with $\beta_4 = 0.206$, while sensory quality items show $\alpha = 1.410$ with $\beta_4 = 0.151$. These low average difficulties for strong agreement confirm that trust and sensory qualities function as foundational layers, accessible to most consumers while contributing meaningful differentiation across the continuum (Table 3).

4.2 | Social Influence: The Critical Differentiator

Items measuring friends' opinions emerge as the most powerful discriminators. The three social influence items display the highest discrimination values: friends' opinions on healthy food (Item 5) ($\alpha = 1.827$), friends' opinions on the environment (Item 6) ($\alpha = 1.803$), and friends' opinions on local food (Item 4) ($\alpha = 1.657$). These values significantly exceed those of other items, suggesting that social networks have a more pronounced distinguishing effect than any of the other dimensions measured.

The difficulty parameter shows a characteristic pattern. On the one hand, the β values increase continuously for each item, and

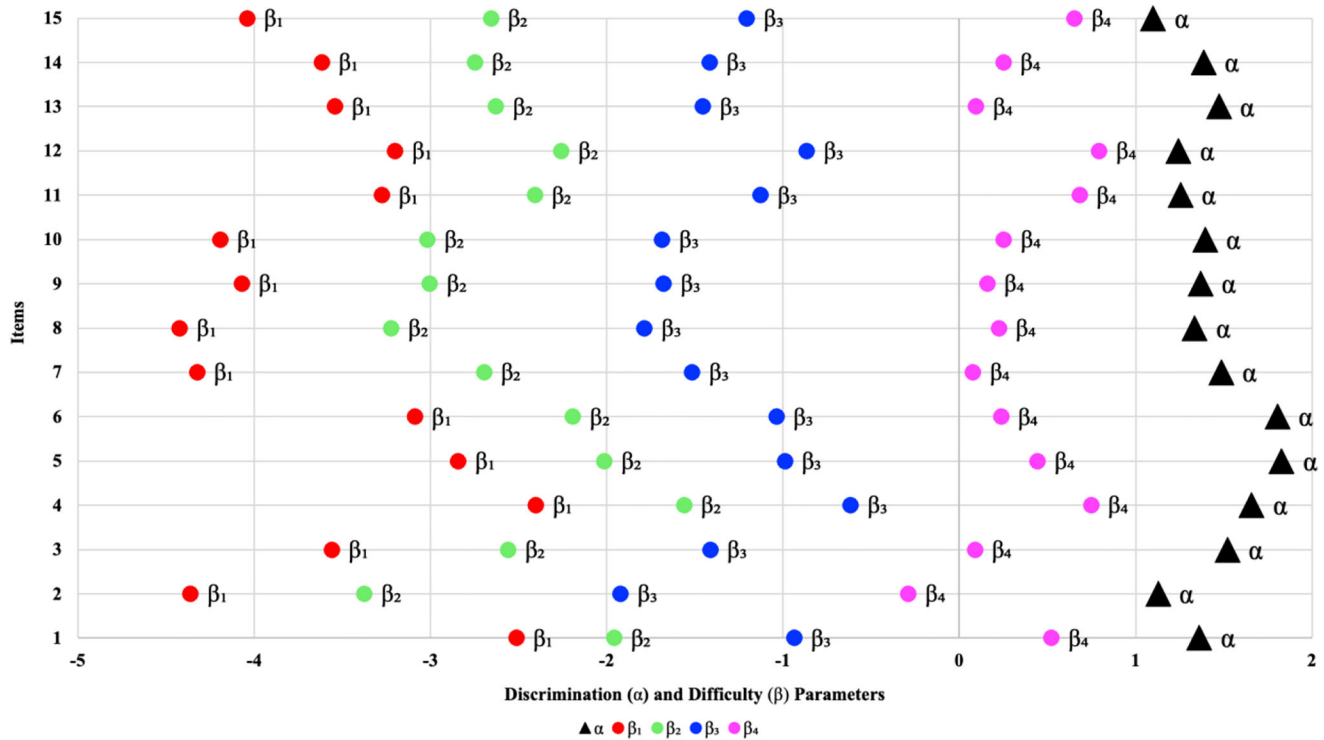


FIGURE 1 | Discrimination (α) and difficulty (β) parameters for survey items.

TABLE 2 | Discrimination (α) and difficulty (β) parameter values for survey items.

Item	Discrimination	Difficulty parameters			
	α	β_1	β_2	β_3	β_4
Importance of local food (Item 1)	1.36	−2.513	−1.959	−0.937	0.523
Importance of healthy food (Item 2)	1.127	−4.361	−3.374	−1.921	−0.288
Local food is environmentally friendly (Item 3)	1.52	−3.56	−2.559	−1.412	0.088
Friends' opinions on local food (Item 4)	1.657	−2.402	−1.561	−0.616	0.748
Friends' opinions on healthy food (Item 5)	1.827	−2.842	−2.012	−0.99	0.445
Friends' opinions on the environment (Item 6)	1.803	−3.088	−2.192	−1.037	0.236
Local food is tasty (Item 7)	1.486	−4.325	−2.697	−1.515	0.077
Local food is fresh (Item 8)	1.334	−4.422	−3.222	−1.785	0.225
Trustworthiness of direct farmers (Item 9)	1.368	−4.071	−3.003	−1.677	0.159
Direct farmers provide healthy food (Item 10)	1.393	−4.193	−3.017	−1.685	0.253
Support for local farmers (Item 11)	1.254	−3.277	−2.409	−1.126	0.683
Environmental burden awareness (Item 12)	1.243	−3.2	−2.257	−0.864	0.794
Importance of pesticide-free food (Item 13)	1.472	−3.542	−2.628	−1.454	0.095
Importance of biodiversity (Item 14)	1.384	−3.618	−2.748	−1.417	0.251
Concerns about packaging (Item 15)	1.099	−4.041	−2.657	−1.205	0.653

Note: Difficulty parameters correspond to thresholds between response categories.

TABLE 3 | Domain-level summary of discrimination (α) and difficulty (β_4).

Domain	Item	Average discrimination (α)	Average β_4 (difficulty for strong agreement)
Trust	Trustworthiness of direct farmers (Item 9) Direct farmers provide healthy food (Item 10)	1.381	0.206
Sensory qualities	Local food is tasty (Item 7) Local food is fresh (Item 8)	1.410	0.151
Social influence	Friends' opinions on local food (Item 4) Friends' opinions on healthy food (Item 5) Friends' opinions on the environment (Item 6)	1.762	0.476
Ecological concerns	Importance of pesticide-free food (Item 13) Importance of biodiversity (Item 14) Concerns about packaging (Item 15)	1.318	0.333
Support for farmers	Support for local farmers (Item 11)	1.254	0.683
Core values	Importance of local food (Item 1) Importance of healthy food (Item 2) Local food is environmentally friendly (Item 3) Environmental burden awareness (Item 12)	1.313	0.279

on the other hand, they fall within a given range. The first, second, and third threshold values remain moderately achievable (between $\beta_1 = -2.402$ and -3.088 ; $\beta_2 = -1.561$ and -2.192 ; $\beta_3 = -0.616$ and -1.037), but the fourth threshold value falls within the positive range (between $\beta_4 = 0.236$ and 0.748). This gradient suggests that acknowledging social influence is widespread, but allowing peer opinions to strongly shape behavior requires considerably higher sustainability consciousness. 'Friends' opinions on local food' (Item 4) shows the highest gradient ($\beta_4 = 0.748$), positioning strong social alignment regarding local food among the most selective commitments.

Social influence is the strongest differentiator, with average discrimination ($\alpha = 1.762$) markedly exceeding all other domains, trust ($\alpha = 1.381$), sensory qualities ($\alpha = 1.410$) and ecological concerns ($\alpha = 1.318$). Combined with moderate average difficulty for strong agreement ($\beta_4 = 0.476$), these parameters position social influence as the critical transition point where consumers move from superficial to substantive commitment. This finding aligns with research on peer effects in food choice, though the magnitude of differentiation exceeds what prior work might suggest (Table 3).

4.3 | Ecological Values: Widespread Acknowledgment, Selective Commitment

Ecological items occupy an intermediate position. Discrimination (α) ranges from 1.243 to 1.520, with accessibility patterns falling between sensory qualities and collective action. The 'local food is environmentally friendly' (Item 3) demonstrates strong discriminative power ($\alpha = 1.520$) combined with a gradient from high accessibility ($\beta_1 = -3.560$) to moderate selectivity ($\beta_4 = 0.088$). Consumers easily approve of environmental benefits in principle, but the strength of their belief varies considerably.

Items addressing specific ecological concerns show greater selectivity. The 'importance of biodiversity' (Item 14) exhibits $\alpha = 1.384$

with $\beta_4 = 0.251$, while the 'importance of pesticide-free food' (Item 13) shows $\alpha = 1.472$ with $\beta_4 = 0.095$. The 'environmental burden awareness' (Item 12) presents the highest difficulty threshold ($\beta_4 = 0.683$), suggesting that approving personal environmental impact represents a more advanced level than the abstract evaluation of environmental protection.

The ecological concerns domain-level average explores moderate discrimination ($\alpha = 1.318$) with average difficulty ($\beta_4 = 0.333$) positioned between sensory qualities ($\beta_4 = 0.151$) and social influence ($\beta_4 = 0.476$). This intermediate position reflects the gap between values and action. Consumers widely approve ecological values, but fewer show sufficient commitment to consistent behavioral change. The parameter pattern suggests that ecological concern represents necessary but insufficient development toward full sustainability consciousness (Table 3).

4.4 | Collective Commitments

Support for collective action, particularly regarding local farmers, emerges as the most selective dimension. The 'support for local farmers' (Item 11) exhibits $\alpha = 1.254$ with $\beta_4 = 0.683$, indicating that while many respondents express minimal agreement ($\beta_1 = -3.277$), strong support only appears among consumers with significantly increased sustainability consciousness.

The characteristic of the difficulty parameter for 'support for local farmers' (Item 11) ($\beta_1 = -3.277$, $\beta_2 = -2.409$, $\beta_3 = -1.126$, $\beta_4 = 0.683$) illustrates a specific transition. The initial agreement proves accessible, but each successive level requires progressively higher consciousness, with the highest increase between moderate and strong agreement. This pattern distinguishes collective commitments from individual benefits. Consumers easily accept local food for personal advantages, but committing to support farmers as a collective goal requires going beyond self-interest.

Support for farmers is the most selective domain ($\beta_4 = 0.683$), despite its relatively moderate discrimination ($\alpha = 1.254$), the

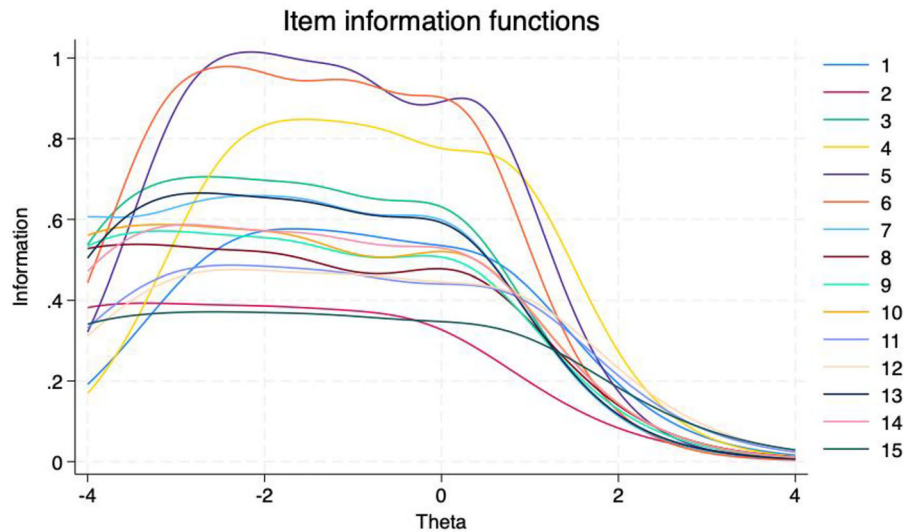


FIGURE 2 | Item information functions.

lowest among all domains. This high threshold of difficulty places collective commitments at the peak of continuity.

This combination suggests that collective action represents a qualitatively different dimension that only emerges when consumers establish trust, sensory evaluation, social alignment, and ecological awareness. This finding extends understanding of how sustainability consciousness evolves from an individual orientation to a collective orientation (Table 3).

4.5 | Measurement Precision and Graphical Analysis (IRT Method)

Item information functions confirm the hierarchical interpretation (Figure 2). Trust items—‘Trustworthiness of direct farmers’ (Item 9), ‘Direct farmers provide healthy food’ (Item 10)—and sensory items—‘Local food is tasty’ (Item 7), ‘Local food is fresh’ (Item 8)—provide maximum information at lower commitment levels ($\theta = -2$ to 0), distinguishing entry-level from developing consumers. Social influence items—‘Friends’ opinions on local food’ (Item 4), ‘Friends’ opinions on healthy food’ (Item 5), ‘Friends’ opinions on the environment’ (Item 6)—and ecological items—‘Importance of pesticide-free food’ (Item 13), ‘Importance of biodiversity’ (Item 14), ‘Concerns about packaging’ (Item 15)—contribute peak information mid-range ($\theta = -1$ to 1), where the critical transition from superficial to substantive commitment occurs. Collective action items discriminate most effectively at higher levels ($\theta = 0$ to 2).

The test characteristic curve indicates optimal performance for mid-range consumers, where social and ecological differentiation occurs (Figure 3).

The test information function confirms measurement precision peaks here ($\theta = -1$ to 1) and decreases at extremes, reflecting the natural distribution in the population and the design focus. This precision pattern is suitable for research and intervention purposes, as mid-range consumers are the primary target group for behavioral change initiatives (Figure 4).

4.6 | Demographic Variation

The grouped Graded Response Model (GRM) results reveal that gender and education influence sustainability consciousness slightly, while the layered structure of motives remains stable across groups (Table 4). The model does not show significant differences in the functioning of items, indicating that men, women, and respondents with different levels of education interpret the survey items similarly. This strengthens the construct’s validity and confirms that observed differences reflect real variation in the latent trait rather than measurement bias.

Women show a slightly higher latent group mean (gender group mean (θ) = 0.17 , $p = 0.01$), corresponding to stronger commitment of ecological and collective items, while foundational motives such as taste, freshness, and trust remain generally accepted. The greater variation among women suggests greater internal diversity, which means that gender segmentation should focus on behavioral differences rather than categorical differences. The descriptive full-model empirical-Bayes latent-score moments: men have a mean of -0.080 and a variance of 0.842 , whereas women have a mean of 0.061 and a variance of 0.889 . These descriptive moments complement, rather than replace, the grouped-GRM comparison.

Although respondents with higher levels of education typically score slightly higher, the effect of education is not statistically significant. This suggests that education might influence ecological reasoning or collective orientation more than overall sustainability consciousness.

In summary, it can be concluded that the hierarchical pattern identified earlier continues to exist. Trust and sensory qualities represent entry-level motives, social influence provides the highest differentiation, ecological concerns indicate intermediate commitment, while collective action represents the most demanding commitment. The fact that this structure applies across demographic groups underscores its robustness and general applicability.

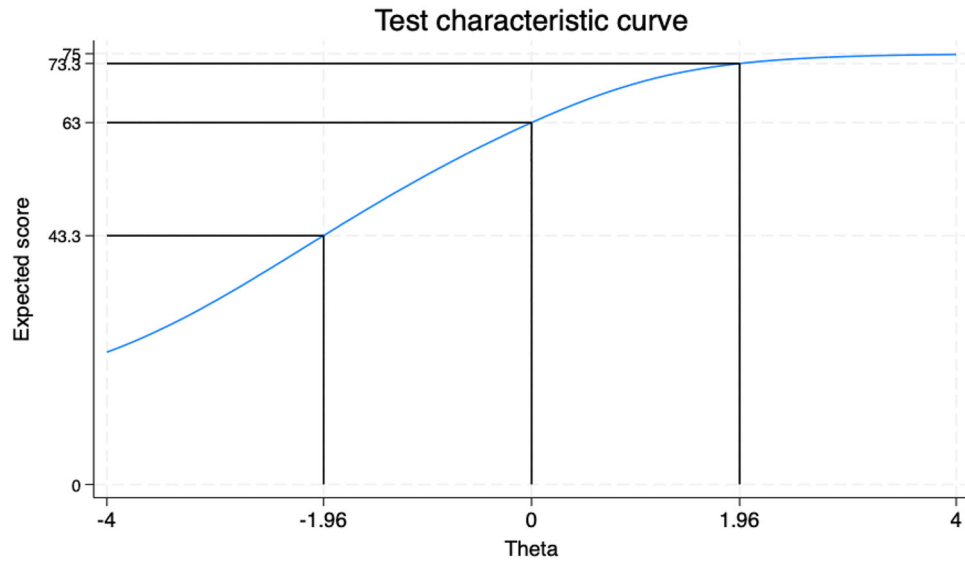


FIGURE 3 | Test characteristic curve.

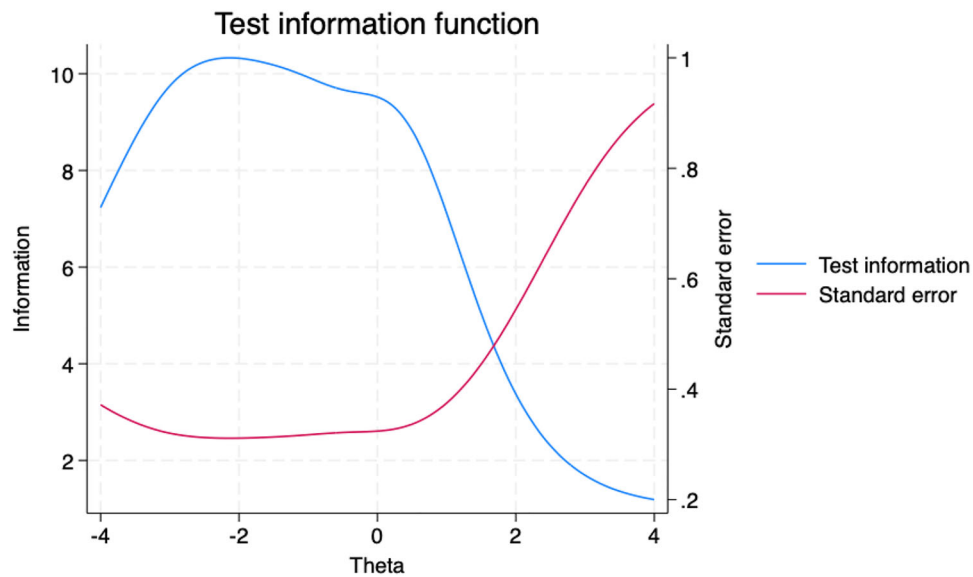


FIGURE 4 | Test information function.

Demographic contrasts only appear at the upper end of the continuum, where strong social and collective commitment occurs. Thus, policy and marketing interventions should prioritize peer-norm and community-based communication to move consumers from basic awareness to higher commitment. While gender and education have only a minor influence on these transitional processes, institutional mechanisms, such as transparent certification and cooperation systems, remain essential for expanding collective commitment. Overall, the GRM results demonstrate that sustainability consciousness is widespread but deep commitment remains selective.

4.7 | Robustness

Stability tests comparing alternative model specifications confirm the hierarchical structure's robustness. A reduced model

excluding trust and sensory items produces nearly identical trait estimates, demonstrating that sustainability consciousness extends beyond these foundational elements. Conversely, a subscale model anchored only in trust and sensory items systematically underestimates higher-order commitments such as biodiversity and farmer support. Detailed fit statistics are summarized (Appendix A2). These comparisons confirm that the full construct requires ecological, social, and collective dimensions alongside foundational elements.

The hierarchical structure proves stable, with trust and sensory qualities providing accessible anchoring, social influence creating high differentiation, ecological values refining mid-range consciousness, and collective commitments defining the peak. This layered understanding clarifies that the challenges of achieving deeper commitment lie not in developing general awareness, but in promoting the transition from individual benefits to sys-

TABLE 4 | Item parameter estimates from the graded response model (GRM) by gender and education level.

Item	Discrimination (α)	Thresholds ($\beta_1, \beta_2, \beta_3, \beta_4$)	Gender group mean and variance (θ)	Education group means and variances ($\theta_1-\theta_4$)
Importance of local food (Item 1)	1.322	-2.49, -1.92, -0.87, 0.63	0.17 (0.01)	-0.00 (1.00) 0.13 (1.11) 0.04 (0.92) 0.04 (0.95)
Importance of healthy food (Item 2)	1.096	-4.39, -3.37, -1.88, -0.20	0.17 (0.01)	-0.00 (1.00) 0.13 (1.11) 0.04 (0.92) 0.04 (0.95)
Local food is environmentally friendly (Item 3)	1.475	-3.57, -2.54, -1.36, 0.19	0.17 (0.01)	-0.00 (1.00) 0.13 (1.11) 0.04 (0.92) 0.04 (0.95)
Friends' opinions on local food (Item 4)	1.604	-2.38, -1.51, -0.54, 0.87	0.17 (0.01)	-0.00 (1.00) 0.13 (1.11) 0.04 (0.92) 0.04 (0.95)
Friends' opinions on healthy food (Item 5)	1.765	-2.84, -1.98, -0.93, 0.55	0.17 (0.01)	-0.00 (1.00) 0.13 (1.11) 0.04 (0.92) 0.04 (0.95)
Friends' opinions on the environment (Item 6)	1.743	-3.09, -2.17, -0.97, 0.34	0.17 (0.01)	-0.00 (1.00) 0.13 (1.11) 0.04 (0.92) 0.04 (0.95)
Local food is tasty (Item 7)	1.446	-4.35, -2.68, -1.46, 0.17	0.17 (0.01)	-0.00 (1.00) 0.13 (1.11) 0.04 (0.92) 0.04 (0.95)
Local food is fresh (Item 8)	1.299	-4.45, -3.22, -1.74, 0.33	0.17 (0.01)	-0.00 (1.00) 0.13 (1.11) 0.04 (0.92) 0.04 (0.95)
Trustworthiness of direct farmers (Item 9)	1.332	-4.09, -2.99, -1.63, 0.26	0.17 (0.01)	-0.00 (1.00) 0.13 (1.11) 0.04 (0.92) 0.04 (0.95)
Direct farmers provide healthy food (Item 10)	1.355	-4.22, -3.01, -1.64, 0.36	0.17 (0.01)	-0.00 (1.00) 0.13 (1.11) 0.04 (0.92) 0.04 (0.95)
Support for local farmers (Item 11)	1.217	-3.28, -2.39, -1.06, 0.80	0.17 (0.01)	-0.00 (1.00) 0.13 (1.11) 0.04 (0.92) 0.04 (0.95)
Environmental burden awareness (Item 12)	1.205	-3.20, -2.23, -0.80, 0.91	0.17 (0.01)	-0.00 (1.00) 0.13 (1.11) 0.04 (0.92) 0.04 (0.95)

(Continues)

TABLE 4 | (Continued)

Item	Discrimination (α)	Thresholds ($\beta_1, \beta_2, \beta_3, \beta_4$)	Gender group mean and variance (θ)	Education group means and variances ($\theta_1-\theta_4$)
Importance of pesticide-free food (Item 13)	1.429	-3.55, -2.61, -1.40, 0.19	0.17 (0.01)	-0.00 (1.00) 0.13 (1.11) 0.04 (0.92) 0.04 (0.95)
Importance of biodiversity (Item 14)	1.346	-3.63, -2.73, -1.36, 0.35	0.17 (0.01)	-0.00 (1.00) 0.13 (1.11) 0.04 (0.92) 0.04 (0.95)
Concerns about packaging (Item 15)	1.069	-4.06, -2.64, -1.14, 0.77	0.17 (0.01)	-0.00 (1.00) 0.13 (1.11) 0.04 (0.92) 0.04 (0.95)

Note: Discrimination (α) parameters indicate how well each item differentiates between respondents with different latent trait levels.

Threshold (β) parameters represent the transition points between response categories (e.g., 'agree' to 'strongly agree').

Gender groups: 0 = male, 1 = female.

Education groups: (1) elementary school or below, (2) high school, (3) postsecondary non-degree, (4) postsecondary degree.

Mean and variance of the latent trait (θ) for each group show that gender and education differences are small, suggesting measurement invariance.

temic commitment through social reinforcement and ecological understanding.

5 | Discussion

This study examines whether consumers' orientations toward sustainable foods follow a layered structure, as suggested in Section 2. The results support this view, motives differ in terms of their accessibility and discriminatory power, resulting in a continuum ranging from trust and sensory qualities to ecological and collective commitments.

H1 predicted a layered structure of sustainability consciousness. The results confirm this, the values of discrimination and difficulty vary systematically across different domains. Our findings are confirmed by other previous studies, which have also demonstrated that sustainable food consumption cannot be treated as a homogeneous orientation. These studies have identified different sustainable patterns and motivations, which occur at different levels, such as attitude, lifestyle or behavioral commitment (Candel et al. 2026; Verain et al. 2012; Verain et al. 2015).

H2 suggested that trust and sensory appeal are widespread but less suitable for distinguishing consumers. As expected, these motives were supported by very low thresholds, confirming previous findings that taste, freshness, and authenticity are key drivers of food choice (Erhard et al. 2024; Firoozzare et al. 2024). This is consistent with previous research, which has identified sensory pleasure and trust as key determinants of food choice and the acceptance of sustainable and organic foods (Cao et al. 2024; Curvelo et al. 2019; Macready et al. 2025). However, the present findings suggest that the discrimination power of these factors is limited. Trust and sensory pleasure are better regarded as general food choice expectations rather than indicators of a

deeper commitment to sustainability. Our results extend previous research by demonstrating that widespread support for trust and sensory pleasure does not necessarily indicate a stronger ecological or collective orientation.

H3 predicts that social influence strongly differentiates consumers, reflecting its role in shared practices. This is supported by the high discrimination values for peer-related items, consistent with research emphasizing the power of sustainable consumption norms. This is consistent with previous research, which confirms that sustainable food consumption is integrated into social and normative processes and that social norms can influence both actual and latent sustainable consumption (Vermeir and Verbeke 2008; Salmivaara et al. 2021; Polyportis et al. 2025; Tonkin et al. 2021; Wu and Yu 2025). Importantly, the results underscore that social influence is not a marginal factor but a central driver that separates moderation from stronger commitment.

H4 predicts that ecological motives require higher thresholds of commitment. Indeed, support for biodiversity protection and pesticide-free production was common at lower levels, but selective at strong agreement. This pattern reflects the well-documented 'value-action gap' and clearly places ecological values in the higher layers of the continuum (Nguyen et al. 2025). This is consistent with previous research suggesting that environmental characteristics are not equally noticeable or motivating to consumers. Whilst the characteristics of pesticide-free and organic production may enjoy relatively strong preference, the benefits associated with biodiversity are less well known and are less likely to be reflected in specific purchasing decisions (Gatti et al. 2022, 2026).

H5 assumed that supporting local farmers would be the most demanding commitment. With the highest threshold values, this hypothesis was confirmed. While minimal agreement was widespread, strong commitment was rare, consistent with collec-

tive action theory (Olson 1965; Ostrom 1990) and recent studies of local food systems (Enthoven and Van den Broeck 2021). A strong commitment to supporting local farmers may represent a more demanding form of commitment to sustainability, one that goes beyond individual consumer preferences. According to previous research, local consumption constitutes a distinct dimension of sustainable food consumption (Kamenidou et al. 2019; Verain et al. 2012).

Finally, **H6 posited** that education and gender would shape orientations. Our results do not clearly confirm this expectation; no significant differences were found in any of the domains. This differs in part from the findings of previous research, which identified gender and education factors as potential predictors of certain forms of sustainable food consumption (Verain et al. 2015) and reported gender differences in the relationship between environmental concerns and sustainable food consumption (Barrera-Verdugo and Durán-Sandoval 2024). With regard to education, previous research finds higher educational attainment to be more sustainable for consumption patterns (Panzone et al. 2016; Klink et al. 2022), although these relationships are not necessarily direct or equally applicable across all dimensions of sustainability.

These results should be interpreted with several limitations. Relying on self-reported survey data raises the question of whether attitudes and actual behavior are consistent. The study is limited to one country, which limits its generalizability. Cultural variation in the expression of trust or ecological motives should be systematically examined in cross-country studies. Furthermore, while IRT provides analytical precision by distinguishing between item thresholds and discrimination, it remains a statistical abstraction. Future research should combine this approach with experimental or behavioral data to validate whether the thresholds identified here truly reflect consumers' actual choices.

The item thresholds should therefore not be seen as estimates of how likely people are to actually buy a product. Rather, they indicate where the agreement expressed by the respondents stands on a latent continuum. In practice, however, what people say they prefer does not always translate into what they buy. For example, a higher price for an eco-labelled product, preferences for taste or freshness, or a lack of trustworthy local or sustainable alternatives may all affect the final choice. The survey does not include actual purchase or experimental choice data, so it cannot show how strongly these factors influence consumers' decisions.

This distinction also helps explain the value-action gap found for ecological items. Consumers may support environmental protection in principle, but this does not always mean they will choose the more sustainable option when shopping. A higher price may be too much for their budget, uncertainty about taste or freshness may lead them to choose a familiar product, and a limited range of products may leave them with no realistic sustainable alternative. The GRM parameters show where respondents become more selective in their stated preferences. However, to determine whether these preferences translate into actual purchases, they would need to be compared with scanner data, stated-choice experiments, or sensory test results.

The theoretical implications are clear. The results confirm that motives have a layered structure, validating the claims of con-

sumption value theory, the VBN framework, social practice perspectives, and collective action theory. Furthermore, the application of IRT advances the methodological toolkit for consumer research by capturing degrees of support that are obscured by traditional regression models.

The political and practical implications are obvious. Core motives such as taste, freshness, and trust can be emphasized in product design, branding, and labeling to appeal to a wide audience. Social influence as a strong differentiator highlights the importance of communication strategies that work through peer networks, generational identities, and communities. At a higher level, ecological and collective commitment is less likely to develop spontaneously. It requires institutional mechanisms such as subsidies, certification, or cooperative programs that reduce barriers and support collective engagement. Positioning consumers on this continuum allows for more accurate segmentation and targeted interventions that move different groups toward deeper commitment.

In summary, sustainable food consumption should be understood not as a binary choice, but as a continuum of layered motives. The entry points are broadly shared, social influence separates the levels of commitment, and ecological and collective commitments represent the highest thresholds. Recognizing this structure helps explain why sustainability often stops at superficial agreement and clarifies where policies, labeling strategies, and product innovations need to intervene to drive lasting change.

6 | Conclusion

This study applied Item Response Theory to examine how consumers relate to sustainability in food consumption. The results confirmed that sustainability consciousness is a layered continuum; trust and sensory qualities serve as broad entry points, social influence strongly differentiates orientations, ecological values require a higher commitment threshold, and collective support for local farmers represents the most demanding form of engagement. Education and gender do not shape these orientations, suggesting that social characteristics systematically structure sustainability consciousness.

Several limitations should be considered. The analysis relies on self-reported survey data, which may not fully reflect purchasing behavior. The study reflects a specific cultural and institutional context, which limits its generalizability. Furthermore, while the IRT approach provides analytical precision in mapping thresholds and discriminative power, it does not establish causal links between motives and actual choices.

Nevertheless, the findings have important implications for policy and practice. Entry-level motives such as taste, freshness, and trust can be used in product design and labeling to make the product widely acceptable. Social influence proves to be a particularly effective tool for achieving effects that go beyond superficial consumer commitment, suggesting that community-based and peer-driven interventions may have a greater impact than individual appeals. However, ecological and collective commitments are unlikely to expand without institutional support. Policies such as certification schemes, subsidies, or cooperative

arrangements can help reduce barriers to commitment, although these involve trade-offs in terms of costs borne by taxpayers or consumers.

Finally, future research should expand on this work by linking the continuum identified here to observed consumer behavior. Longitudinal studies could clarify whether entry-level commitment transforms into deeper commitment, while cross-country comparisons could capture cultural differences in the structuring of sustainability motives. From a methodological perspective, integrating IRT and experimental or behavioral data would strengthen causal inferences and provide a richer basis for designing interventions that promote lasting change.

Author Contributions

Zoltán Bakucs: conceptualization, methodology, writing – original draft, writing – review and editing, data curation, funding acquisition. **Lajos Baráth:** writing – original draft, investigation, writing – review and editing, formal analysis, funding acquisition. **Zsófia Benedek:** writing – original draft, writing – review and editing, investigation, formal analysis, funding acquisition. **Imre Fertő:** conceptualization, methodology, software, writing – original draft, writing – review and editing, visualization. **László Sipos:** supervision, visualization, writing – original draft, writing – review and editing.

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Conflicts of Interest

The authors declare no conflicts of interest.

Data Availability Statement

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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APPENDIX

TABLE A1 | Model selection.

Model	AIC	BIC
RSM	33,523.18	33,617.01
PCM	33,487.89	33,789.13
GPCM	33,433.29	33,803.66
GRM	33,160.33	33,530.71

TABLE A2 | Robustness checks of alternative GRMs.

Model	Items included	Log likelihood	AIC	BIC	Correlation with full θ	Regression slope	Intercept
Full GRM	All 15 items	−16,505	33,160	33,531	—	—	—
Reduced GRM	Excluding trust and sensory (11 items)	−12,514	25,138	25,409	0.95	0.94	≈ 0.00
Trust and Sensory GRM	Only trust and sensory (4 items)	−3,809	7,658	7,757	0.87*	—	—

Note: Correlation for Trust and Sensory GRM based on θ alignment with the full model.