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Sustainable agricultural technologies of the future: Determination of adoption readiness for different consumer groups

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ABSTRACT

The rapid increase in population and unsustainable agricultural practices has significantly damaged the environment. Our study explores how to achieve food security through environmentally friendly methods such as controlled environment agriculture (CEA), genetic editing (GE), and farming automation (FA), with an emphasis on the importance of consumer acceptance of these technologies. Analyzing data from 2138 Australians and 1760 New Zealanders, we employ a two-step clustering method—(1) hierarchical clustering and (2) k-means clustering—to categorize consumers on the basis of their demographic and lifestyle preferences into three segments that capture differences in attitudes toward new agricultural technologies: "Green Urbanites," "Environmentally Unconcerned," and "Skeptical Foodie." Our findings reveal that Green Urbanites are the most open to adopting CEA, GE, and FA, while Skeptical Foodies and Environmentally Unconcerned are more reluctant. We contribute to theory by studying a novel facet of consumer acceptance of sustainable technologies and revealing how consumption, living, and lifestyle patterns motivate new technology acceptance in the agricultural sector. To inform practice, we suggest tailored strategies to increase engagement of the identified segments and promote wider acceptance of sustainable agricultural practices for enhanced food security.

1. Introduction

Rapid population growth and climate events pose significant challenges to global food security (Kogo et al., 2021). In 2022–2023, 11.6 % of the world population was severely affected by food insecurity, and 943 million people are expected to face severe food insecurity by 2025 (Andree et al., 2024). Not only are these developments a threat to emerging markets (Kneafsey et al., 2013), but they are also likely to affect more developed nations. For example, crops in New Zealand were destroyed by severe storms and other adverse weather conditions several years in a row (Bell, 2020; Jones, 2015; Prasad, 2023). While modern agriculture has mostly kept pace with the ever-growing need for human food, current agricultural practices use excessive water and chemicals, leading to the erosion of arable land. Therefore, such practices are not suitable for feeding future generations (Page et al., 2020). Indeed, food production will need to double by 2050 to meet the demands of the world's growing population (Abbate et al., 2023a). Thus, the agricultural sector requires a paradigm shift toward more resilient and sustainable production technologies (Moura et al., 2022; Pavleska and Kerr, 2020; Testa et al., 2022). However, novel technologies[1] will not succeed without consumer adoption (Osburg et al., 2022). As such, it is particularly important to explore consumer acceptance of disruptive agricultural technologies, which are often misunderstood and criticized (RNZ, 2023; Siegrist and Hartmann, 2020).

This research considers three promising technologies, which often face skepticism in the public discourse (e.g., Mason, 2023; Southey, 2023): controlled environment agriculture (CEA), farming automation (FA), and genetic editing (GE). CEA allows for greater control over farming and optimized production (e.g., yields) and protects crops from adverse conditions (e.g., climate events, pests) (McCartney and Lefsrud, 2018). FA technologies rely on big data to support indoor and outdoor agriculture (Wolfert et al., 2017). Examples include harvesting,

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[1] In this paper, "novel" does not refer to the invention of a new agricultural technology, but rather its new introduction to the consumer market (Siegrist and Hartmann, 2020).

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spraying, pollinating, and weeding (Karkee et al., 2021). GE refers to the process by which a plant's genetic makeup is cut and small parts are spliced to improve their properties (Mushtaq et al., 2021).[2] For instance, genes causing the browning of lettuce are altered to attain nonbrowning lettuce. Consumer acceptance rates of these technologies reported in previous research differ vastly, ranging from 43 % for GE technologies to 62 % for CEA (Plant and Food Research, 2023).

The current study draws on the unified theory of acceptance and use of technology (UTAUT) and its extension in UTAUT2 (Kulviwat et al., 2007; Venkatesh et al., 2012) to profile consumers and their attitudes toward new sustainable agricultural technologies. Using representative samples from Australia and New Zealand (n = 3898), we employ a segmentation approach because different consumer groups may react in fundamentally different ways to innovations in (agricultural) technology (e.g., Aschemann-Witzel et al., 2023; van der Stricht et al., 2024; Yoganathan and Osburg, 2024). Understanding and accounting for attitudinal differences in subgroups of the population can help better untangle the inconsistent findings in previous research and identify avenues for increasing consumer acceptance of novel technologies (Osburg et al., 2022). Consumer acceptance and support of these technologies result from a complex interplay of different consumer characteristics, habits, and lifestyle considerations (Errmann et al., 2024). Thus, we describe consumer groups on the basis of important predictors of food (technology) acceptance, namely, consumer trust (e.g., Macready et al., 2020; Rodríguez-Entrena and Salazar-Ordóñez, 2013), environmental concern (e.g., Aschemann-Witzel and Stangherlin, 2021; Ferrari et al., 2021; Worsley et al., 2015), food-buying preferences (e.g., Asioli et al., 2017; Grunert, 2013; Steenhuis et al., 2011), awareness of food security issues (e.g., Godrich et al., 2022; Kneafsey et al., 2013), and lifestyle and sociodemographic factors (e.g., Asioli et al., 2017; Nie and Zepeda, 2011; Verain et al., 2012).

Our analysis includes detailed segmentation to identify three distinct consumer groups ("Skeptical Foodies," "Environmentally Unconcerned," and "Green Urbanites"), outline their unique characteristics, and understand their motives for adopting or rejecting agricultural technologies. We aim to answer the following research questions: (1) What distinct consumer groups exist in the marketplace that differ in their perception of novel agricultural technologies? (2) What are their key defining features? (3) What does an archetypical consumer who accepts/rejects CEA, GE, and FA technologies look like?

Theoretically, we contribute to the literature on consumer acceptance of new technologies (e.g., Nie and Zepeda, 2011; Osburg et al., 2022; Verain et al., 2012). In six propositions, we advance the understanding of consumer trust (Fewer, et al. 2011; Ghazizadeh et al., 2012), environmental concerns (Osburg et al., 2016), buying motives (Asioli et al., 2017), location dependencies (Godrich et al., 2022; Kneafsey et al., 2013), and demographic and lifestyle factors (Venkatesh et al., 2012) as determinants of consumption of and purchase intention toward produce resulting from sustainable agricultural technologies (e.g., Lusk et al., 2014; Siegrist and Hartmann, 2020). We (1) identify new market segments regarding new agricultural technologies in fresh produce categories, (2) profile these segments to understand the drivers and barriers influencing technology adoption, (3) demonstrate significant variations in acceptance rates across different technologies, and (4) propose specific interventions to increase consumer acceptance of these technologies. To inform practice, we provide agricultural technology companies with an estimation of market size and suggest targeting strategies to help differentiate communication policies to promote the acceptance of sustainable agricultural technologies, which is essential for economic prosperity and food security.

[2] GE differs from genetic modification because it does not introduce foreign genes (Kamburova et al., 2017). Instead, it focuses on existing genetic components of plants.

2. A theory of consumer acceptance of sustainable agricultural technologies

UTAUT and its extension in UTAUT2 (Kulviwat et al., 2007; Venkatesh et al., 2012) are conceptually grounded in the technology acceptance model (Davis, 1989). UTAUT2 explains consumers' intentions to use new technologies related to performance, effort, social influence, facilitating conditions, hedonic motivation, price value, habits, and demographics (Venkatesh et al., 2012). It is the most complete theory for exploring consumer attitudes, intentions, and behavior with respect to the diffusion of new technologies and their subsequent acceptance. UTAUT2 is well aligned with the purpose of this research, which is to explore strategies for enhancing the adoption of new agricultural technologies to address pressing challenges related to food shortages. Like the conceptually close theory of planned behavior (Ajzen, 1991), UTAUT2 suggests a complex interplay of attitudes, norms, and perceived control influencing consumer behavior. In applying elements of UTAUT2, we focus on how consumer habits, expectations, social influence, and demographics shape behaviors toward innovative, sustainable agricultural technologies.

A shift toward novel agricultural technologies is crucial for enhancing agricultural productivity and food security (Pavleska and Kerr, 2020). Therefore, understanding consumer behavior is essential (Abbate et al., 2023a), as acceptance by consumers plays a crucial role in integrating produce resulting from sustainable agricultural technologies into the market. With consumers increasingly seeking information about food production methods (Asioli et al., 2017), grasping their perceptions and acceptance of emerging agricultural technologies is of vital importance. While general perceptions of sustainable agricultural technologies could be examined, prior studies suggest that segmenting consumers offers deeper, more meaningful insights. Current food consumption trends and habits—namely, health concerns, sustainability, and convenience (Grunert, 2013)—indicate that different consumer groups prioritize different values in their food purchases. Here, Nie and Zepeda (2011) demonstrate the advantages of identifying distinct food shopper groups and profiling them according to various factors, including environmental, knowledge, and health concerns. Sociodemographic characteristics are not enough to accurately profile consumer segments in food marketing; they must be integrated with other aspects to describe them more effectively (Verain et al., 2012).

Next, we review a range of consumer habits and lifestyle considerations that provide insights into why some consumer groups are more favorable toward novel agricultural technologies than others and how consumer groups can be identified and targeted to improve consumer acceptance of future agricultural technologies.

3. Expectations, consumption, social norms, lifestyle habits, and behavior shaping attitudes toward sustainable agricultural technologies

3.1. Consumer trust

UTAUT2 highlights the critical role of consumers' prior expectations regarding performance, which can significantly influence the adoption of new technologies (Venkatesh et al., 2012). Within this framework, performance expectations are best described as the belief that using new agricultural technologies will be beneficial and safe and ensured through effective governance and responsible business practices (Frewer et al., 2011). Consumers must trust that these new technologies will deliver the expected outcomes: environmentally friendly, high-quality, safe produce. "Trust" is defined as an individual's general expectation and belief that another's words, promises, or oral or written statements can be depended upon (Rotter, 1980). The literature identifies various types of trust that are relevant to this research, including trust in automation (Ghazizadeh et al., 2012), in the industry (Siegrist and Hartmann, 2020), in the food value chain (Macready et al., 2020), in science,

and in regulation (Frewer et al., 2011). Consumers' trust is based on their beliefs in the reliability of actors such as manufacturers, retailers, and government authorities (Macready et al., 2020). Therefore, our focus is on consumer trust as it relates to consumers' confidence in food manufacturers, retailers, and governmental institutions to act in consumers' best interest.

The significance of consumer trust in the willingness to embrace new technology is evidenced by its frequent discussion as an essential addition to the technology acceptance model, notably as a predictor of key variables such as perceived usefulness and ease of use (Ghazizadeh et al., 2012; Wu et al., 2011). Similarly, in food marketing, consumer trust is a predictor of confidence not only in food but also in agricultural technology (Ding et al., 2015; Macready et al., 2020), making it a particularly valuable construct to explore in the context of agricultural technology innovation. For instance, trust in institutions has diminished risk perceptions associated with controversial technologies like genetically modified food (Rodríguez-Entrena and Salazar-Ordóñez, 2013). Industry trust increases the likelihood of consumer acceptance of agricultural technologies (Siegrist and Hartmann, 2020). Consequently, consumer trust is likely higher among consumer groups who favor novel agricultural technologies.

Proposition 1. Consumer groups with stronger preferences for produce grown with the use of future agricultural technologies show higher levels of consumer trust.

3.2. Environmental concern

Environmental concern is an individual's attitude toward protecting the environment (Schultz, 2001). In the context of UTAUT2 and sustainable agricultural technologies, environmental concerns are best understood as performance expectations related to the reduced environmental impact of these technologies. Environmentally conscious consumers are more inclined to purchase eco-friendly products and are more receptive to ecological innovations (Osburg et al., 2016), and this orientation is also likely to apply to the agri-food sector (Pang and Chen, 2024). Similarly, environmental concerns are strong predictors of behaviors. For instance, people with strong environmental concerns are likely to support environmentally conscious food policies, have higher intentions to consume environmentally friendly food (Worsley et al., 2015), and show a greater acceptance of waste-to-value food products (Aschemann-Witzel and Stangherlin, 2021). Beyond environmental responsibility and knowledge, environmental concern correlates with an increased willingness to adopt eco-innovations like electric vehicles (Shanmugavel and Balakrishnan, 2023). Trust in a technology's environmental benefits has also been linked to positive consumer response (Shahzad et al., 2024).

Environmental concerns can also act as indicators of social influence, potentially affecting the rates at which new technologies are adopted. Social norms, which represent expected behaviors within social groups, significantly influence individual actions (Bearden et al., 1989). Consumers have become increasingly aware of the importance of protecting the environment, securing food sources, and adopting more sustainable practices to mitigate climate change and its effects (McKinsey and Company, 2023). As a result, adopting pro-environmental behaviors has become a central concern for many consumers. Future agricultural technologies present a potential strategy to lower greenhouse gas emissions and ensure food security. Therefore, as environmental concerns heighten and consumer knowledge about the application of future agricultural technologies increases, adoption of these technologies may increase due to shifting social norms.

However, some studies indicate that environmental concerns might reduce the acceptance of certain novel agricultural technologies, especially those associated with controversial practices, like GE (Ferrari et al., 2021). Despite such concerns, however, future agricultural technologies are anticipated to enhance food security and contribute to sustainability more effectively than traditional farming methods (Testa et al., 2022). For example, new agricultural technologies could help reduce water and chemical use (Page et al., 2020), which hold particular appeal to people who are concerned about the environment. Environmentally conscious consumers are likely to be more diligent in evaluating the environmental impact of their consumption choices (Osburg et al., 2016; Schultz, 2001). Thus, consumers with high levels of environmental concern are likely to be more open to novel agricultural technologies.

Proposition 2. Consumer groups with stronger preferences for produce grown with the use of future agricultural technologies show higher levels of environmental concern.

3.3. Food-buying preferences

Habits are powerful predictors of new technologies adoption (de Guinea and Markus, 2009). Habits are automatic (often unconscious) behaviors resulting from continuous, repeated prior experiences (Venkatesh et al., 2012). Consumers' food-buying preferences and habits emerge from a range of factors, including intrinsic (e.g., appearance, nutrition, taste) and extrinsic (e.g., sustainability, risk perceptions) product characteristics, situational factors (e.g., time, social and physical surroundings), and positive experiences (Asioli et al., 2017). For example, some consumers prioritize "clean"/natural food products, such as organic produce, with a minimal environmental footprint and reduced chemical usage (Asioli et al., 2017). The perceived "naturalness" of food, from its origin (e.g., soil-grown, sunlit) and production to the final product, shapes buying decisions (Roman et al., 2017). Similarly, other consumers select foods on the basis of their perceived health benefits, perhaps in alignment with specific dietary needs (Grunert, 2013). Consumers' preferences for fresh produce are also shaped by (technological) innovations, which may, for example, incline consumers to expect higher-quality products (Hwang et al., 2021). In addition, product pricing significantly affects choice, particularly for households with limited budgets (Steenhuis et al., 2011). Given the broad spectrum of factors affecting food-buying behavior, this research explores these various influences. We argue that distinct consumer groups can be identified on the basis of their unique preferences and habits.

Proposition 3. Groups of consumers of produce grown with the use of future agricultural technologies differ with regard to their food-buying preferences.

3.4. Awareness of food security issues

Venkatesh et al. (2012) suggest that consumers' previous experiences with similar innovations influence their likelihood of adopting new technologies. While consumers may not have direct experience with sustainable agricultural technologies, they might be familiar with or aware of the increasing prevalence of food shortages and the potential for future food security problems. According to the World Food Summit 1996, food security means that "all people, at all times, have physical and economic access to sufficient safe and nutritious food to meet their dietary needs and food preferences for a healthy and active life" (Pinstrup-Andersen, 2009, pg. 5). Governments and scientists worldwide are working on strategies to ensure food security for billions of people (Fakhri and Tzouvala, 2020). These efforts are impeded by the growing world population, climate change, the recent COVID-19 pandemic, and various other global conflicts. In this context, future agricultural technologies present an option for providing safe and nutritious food (Frewer et al., 2011).

Although it is reasonable to assume that consumers' knowledge and awareness of food security issues may influence their consumption choices, much like the impact of environmental awareness on environmentally conscious purchasing, the literature has largely overlooked consumers' awareness of food security issues. The few studies that do

consider this suggest that consumers do not fully understand the concept of food (in)security, its underlying causes, and associated responsibilities (Kneafsey et al., 2013). Consumers exposed to food insecurity during the pandemic adapted their buying behavior by being more price-sensitive and changing the types and quantities of their purchases (Godrich et al., 2022). Consequently, we expect that consumer groups who are more accepting of future agricultural technologies will be more aware of food security problems.

Proposition 4. Consumer groups with stronger preferences for produce grown with the use of future agricultural technologies show a stronger awareness of food security issues.

3.5. Lifestyle and sociodemographics

In general, the literature has relied on sociodemographic characteristics and lifestyle factors to describe and target consumer groups in various domains, including (eco-)innovations (e.g., McLeay et al., 2018; Osburg et al., 2022) and food consumption (e.g., Nie and Zepeda, 2011; Verain et al., 2012).

Extant literature also supports the role of sociodemographics and consumer characteristics in influencing the adoption of various forms of (environmentally friendly) food innovations. For instance, consumer innovativeness is known to influence consumers' willingness to pay more for innovations in the food sector (Hwang et al., 2021). Likewise, age and gender shape consumers' values and concerns and, ultimately, their intentions to support environmentally friendly food options (Worsley et al., 2015). Sociodemographic characteristics such as age, gender, education, and income have also been used to profile consumer segments' openness to sustainable food products (Verain et al., 2012).

Similarly, consumer lifestyle has been identified as a driver of food choices. For example, consumers who pursue a healthy lifestyle are known to opt for healthier food products more frequently, particularly as they age and want to prevent or minimize the impact of diseases (Asioli et al., 2017). Nie and Zepeda (2011) segment consumers on the basis of their food-related lifestyle choices (i.e., rational, adventurous, careless, and conservative consumers).

Accordingly, we explore how groups of consumers of produce grown with the use of future agricultural technologies differ on these factors.

Proposition 5. Groups of consumers of produce grown with the use of future agricultural technologies can be differentiated on the basis of lifestyle and sociodemographic factors.

3.6. Willingness to buy produce grown with the use of future agricultural technologies

While consumers favor some agricultural technologies, they are more hesitant to accept others (Asioli et al., 2017; Siegrist and Hartmann, 2020). When confronted with novel agricultural technologies, consumers often express risk perceptions, for example, about the products' health-related, economic, social, and environmental impacts. However, these risk perceptions vary among different agricultural technologies (Frewer et al., 2011). The adoption of new technologies will differ on the basis of performance expectations (e.g., safety, industry regulation, quality), habits (i.e., integration into daily life), and facilitating conditions (e.g., price value, availability, social support, urgency) (Venkatesh et al., 2003; Venkatesh et al., 2012).

Although future agricultural technologies are presented as more sustainable solutions than traditional ones, Ferrari et al. (2021) show that consumers with high environmental concerns are less open to GE. Similarly, it has been argued that marketing for genetically modified and GE food is a difficult endeavor (Ding et al., 2015), whereas the outlook for other novel agricultural technologies is more positive (e.g., Frewer et al., 2011; Lusk et al., 2014). Consumers perceive the introduction of gene technology in agriculture as more controversial than other novel agricultural technologies, frequently noting reasons such as high risk, low benefits, unnaturalness, and limited knowledge (Siegrist and Hartmann, 2020). It must be noted, however, that consumers' perceptions also vary between different gene technologies, such that consumers perceive technologies that imply an exchange of genes between different species (e.g., genetic modification) as more problematic (Kronberger et al., 2014). However, knowledge about the differences between GE and genetic modification is not widespread and therefore often perceived as being the same. Thus, consumer acceptance of novel agricultural technologies may differ for CEA, GE, and FA.

Proposition 6. The willingness to buy produce grown with the use of future agricultural technologies differs among the considered technologies, with GE being associated with a lower willingness to buy than CEA and FA.

4. Empirical study

4.1. Data collection

The study used survey data collected from an online panel provider (Qualtrics) in Australia ($n = 2138$) and New Zealand ($n = 1760$) over a four-week period in June 2022. Sampling quotas were applied to ensure that the sample's demographic profile reflected the characteristics of both populations regarding gender, age, and income (see Table 1). The questionnaire included an introductory explanation of CEA, GE, and FA technologies (see Appendix A), followed by questions about food-buying preferences, lifestyle factors, consumer trust, environmental concerns, perceived issues regarding food security, technology attitudes, and participants' attitudes toward fresh produce from farms using the investigated technologies (see Appendix B). All responses were rated on a five-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree). To measure focal constructs, we relied on established measures for food-buying preferences (Steptoe et al., 1995), lifestyle factors (Jenkins-Guarnieri et al., 2013; da Rocha Leal et al., 2011; Schultz, 2001), consumer trust (Kim, 2010), environmental concerns (Gifford and Comeau, 2011), and food security awareness (Rezaei et al., 2022). We developed our own measures to capture consumers' attitudes toward new technologies in broad sense, and more specifically toward CEA, FA, and GE, based on extant literature (e.g., Ferrari et al., 2021; Frewer et al., 2011; Kerschner and Ehlers, 2016) and common measurement

Table 1
Sample demographics.

	Australia		New Zealand	
	n	%	n	%
Gender				
Male	1015	47.5 %	859	48.8 %
Female	1104	51.6 %	893	50.7 %
Gender diverse	14	0.7 %	8	0.5 %
Other	5	0.2 %	0	0.0 %
Age	**n**	**%**	**n**	**%**
Between 18 and 24 years	284	13.3 %	194	11.0 %
Between 25 and 34 years	478	22.4 %	423	24.0 %
Between 35 and 44 years	451	21.1 %	366	20.8 %
Between 45 and 54 years	376	17.6 %	284	16.1 %
Between 55 and 64 years	274	12.8 %	208	11.8 %
Greater than or equal to 65 years	275	12.9 %	285	16.2 %
Income	**n**	**%**	**n**	**%**
Less than $10,000	121	5.7 %	67	3.8 %
$10,001 to $50,000	537	25.1 %	495	28.1 %
$50,001 to $90,000	355	16.6 %	310	17.6 %
$90,001 to $130,000	311	14.5 %	186	10.6 %
More than $130,000	176	8.2 %	191	10.9 %
I'd rather not say	638	29.8 %	511	29.0 %
Area type	**n**	**%**	**n**	**%**
Remote	22	1.0 %	41	2.3 %
Rural	322	15.1 %	269	15.3 %
Suburban	1303	60.9 %	1080	61.4 %
Urban	491	23.0 %	370	21.0 %

development procedures (DeVellis and Thorpe, 2021).

4.2. Analysis steps

We relied on a two-step clustering approach to derive meaningful clusters from the data (Geum et al., 2016). First, we used hierarchical clustering to determine the optimal number of clusters, followed by k-means cluster analysis to derive the final cluster groups. To determine cluster centers, we used 32 items capturing food-buying preferences, lifestyle factors, consumer trust, environmental concerns, perceived issues regarding food security, and attitudes toward technology (see Appendix C). We used a one-way analysis of variance (ANOVA) to profile segments according to their attitude toward new agricultural technologies, lifestyle considerations, and demographic information.

In the first step, we calculated changes in the within-group sum of squares and plotted them in an elbow plot (see Fig. 1), which supports a three- to four-cluster solution. Second, we relied on the hierarchical clustering process of the 'NbClust' package (Charrad et al., 2014) to calculate 30 different indices to obtain the optimal cluster number ranging from two to five (e.g., Davies-Bouldin index, Dunn index). To determine the final cluster number we applied a majority rule, with the cluster number that was favored by most of the calculated indices used as the most appropriate (Charrad et al., 2014). The results of this analysis recommend a three-cluster solution favored by 13 indices. The second-best option was a two-cluster solution, favored by eight indices. The four- and five-cluster solutions each had only one index in their favor.

On the basis of these results, we used a three-cluster solution to run a k-means cluster analysis. We estimated the three clusters using Hartigan and Wong's (1979) k-means algorithm, which resulted in comparatively evenly sized clusters, with cluster one standing out as the smallest of the three (n = 944) (see Table 2 and Table 3). The clusters revealed three distinct market segments that differ according to their food-buying preferences, social life, connectedness to nature, lifestyle, consumer trust, environmental concerns, technology attitudes, and awareness of food security issues (see Appendix C). We refer to these three cluster as "Skeptical Foodies," "Environmental Unconcerned," and "Green Urbanites." Next, we profile the three segments' sociodemographics, lifestyle considerations, and attitudes toward new sustainable agricultural technologies.

4.3. Results

4.3.1. Skeptical foodies

Skeptical Foodies (n = 1515) represent the largest segment. They are predominantly mature females (60.9 %) with above-average incomes (35.2 % report $50,000–$130,000 in annual income) who reside in predominantly suburban areas (67.1 %). They prioritize the taste and quality of food over its appearance, favoring fresh, untreated produce with a minimal environmental footprint and ideally grown in natural soil and sunlight. Although they consider themselves "organic" buyers, their commitment to purchasing from farmers' markets is moderate. Despite their relatively high incomes, price remains a significant factor in their purchasing decisions.

Skeptical Foodies show little interest in social media, are not particularly social, and prefer to stay home, enjoying home-cooked meals over nightlife activities. They lead moderately active lives, have a strong connection to nature, and are dedicated to living a healthy lifestyle. They express significant concern about environmental changes but are skeptical about whether governments and large corporations prioritize their best interests, particularly with regard to food production. This skepticism extends to worries about future food affordability and concerns over the integrity of our food systems, population growth, excessive consumption, and the need for clean water, reflecting their strong commitment to environmental conservation. These concerns sharply contrast with those of the Environmentally Unconcerned segment.

Regarding future agricultural technologies, Skeptical Foodies show moderate attitudes relative to the other groups (for pairwise comparisons, see Appendix D and Table 3). They moderately support CEA and FA and consider CEA beneficial primarily in food-scarce regions. They show limited interest in GE products for personal use. Interestingly, they are more willing to recommend GE products to others than CEA or FA products, indicating a more selective stance toward new agricultural technologies.

4.3.2. Environmentally unconcerned

The Environmentally Unconcerned group (n = 1439) is the second largest cluster. They are relatively balanced in terms of gender (46.4 % female). The group includes individuals of all ages with low to medium income levels (48.5 % report <$10,000–$90,000 in annual income), and

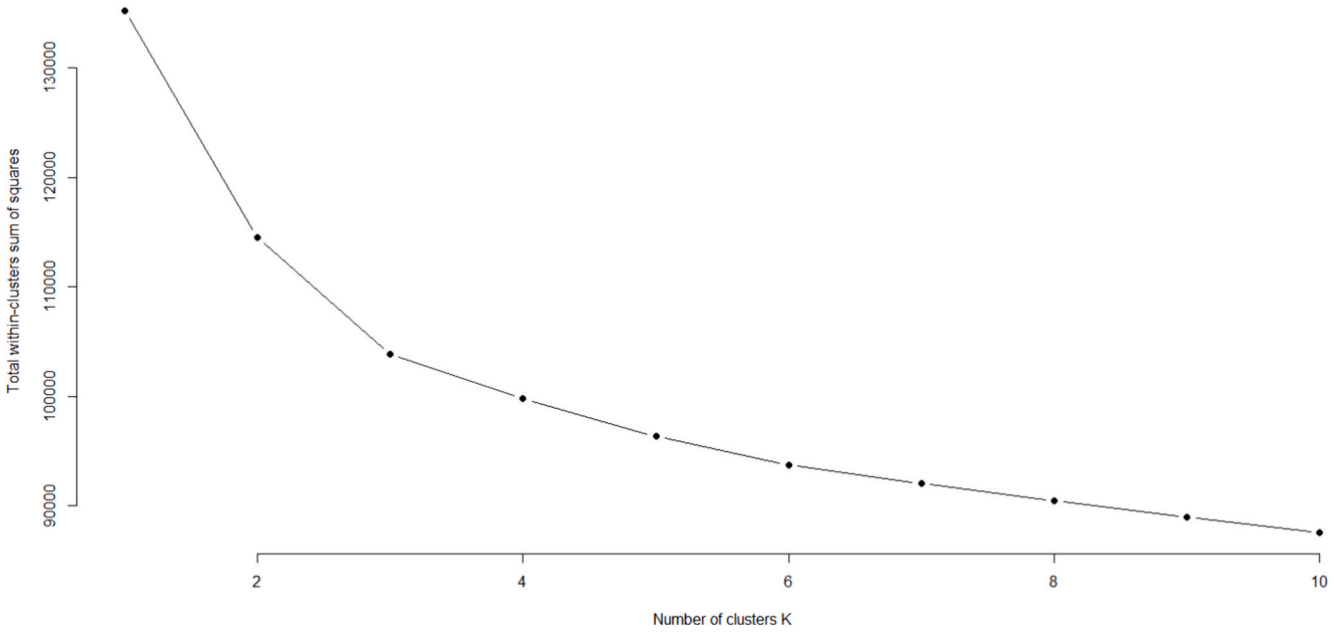

Fig. 1. Scree plot.

Table 2
Demographic profiles of cluster segments.

	$n = 1515$		$n = 1439$		$n = 944$	
	Skeptical Foodies		Environmentally Unconcerned		Green Urbanites	
Demographics						
Country[a]	**n**	**%**	**n**	**%**	**n**	**%**
Australia	803	37.6 %	812	38.0 %	523	24.5 %
New Zealand	712	40.5 %	627	35.6 %	421	23.9 %
Gender[b]	**n**	**%**	**n**	**%**	**n**	**%**
Male	579	38.2 %	760	52.8 %	535	56.7 %
Female	922	60.9 %	668	46.4 %	407	43.1 %
Gender diverse	13	0.9 %	7	0.5 %	2	0.2 %
Other	1	0.1 %	4	0.3 %	0	0.0 %
Age[b]	**n**	**%**	**n**	**%**	**n**	**%**
Between 18 and 24 years	110	7.3 %	186	12.9 %	182	19.3 %
Between 25 and 34 years	249	16.4 %	362	25.2 %	290	30.7 %
Between 35 and 44 years	256	16.9 %	255	17.7 %	306	32.4 %
Between 45 and 54 years	312	20.6 %	231	16.1 %	117	12.4 %
Between 55 and 64 years	277	18.3 %	178	12.4 %	27	2.9 %
Greater than or equal to 65 years	311	20.5 %	227	15.8 %	22	2.3 %
Income[b]	**n**	**%**	**n**	**%**	**n**	**%**
Less than $10,000	68	4.5 %	87	6.0 %	33	3.5 %
$10,001 to $50,000	367	24.2 %	390	27.1 %	275	29.1 %
$50,001 to $90,000	204	13.5 %	221	15.4 %	240	25.4 %
$90,001 to $130,000	148	9.8 %	138	9.6 %	211	22.4 %
More than $130,000	180	11.9 %	149	10.4 %	38	4.0 %
I'd rather not say	548	36.2 %	454	31.5 %	147	15.6 %
Area type[b]	**n**	**%**	**n**	**%**	**n**	**%**
Remote	8	0.5 %	26	1.8 %	29	3.1 %
Rural	247	16.3 %	226	15.7 %	118	12.5 %
Suburban	1016	67.1 %	921	64.0 %	446	47.2 %
Urban	244	16.1 %	266	18.5 %	351	37.2 %

[a] Row percentage.
[b] Column percentage.

they reside predominantly in suburban areas (64 %). They prioritize the taste and price value of their produce. They are relatively unconcerned about the appearance of produce, the use of chemical sprays, environmental impact, growing conditions (soil/sun), genetic modification, and the importance of buying produce at farmers markets.

In terms of lifestyle, the Environmentally Unconcerned segment is characterized by low social activity and only a moderate connection to nature, coupled with a generally inactive lifestyle. Health and well-being are of moderate importance to them, and they show little enthusiasm for cooking or preparing meals from scratch. They are not overly concerned about protecting the environment and view climate change as not threatening to society. They lack trust in the government and large corporations and do not view food security as a significant future concern. In addition, they are only moderately optimistic that technology will enhance their quality of life. This perhaps explains their neutral attitudes toward future agricultural technologies. Different from Skeptical Foodies and Green Urbanites, the Environmentally Unconcerned appear not to have any strong opinions about the use of CEA, FA, or GE technologies. They show a moderate willingness to purchase fruits and vegetables grown with CEA and FA technologies and a lower willingness to purchase produce grown with GE technologies. Surprisingly, across the three groups, the Environmentally Unconcerned are more willing to recommend fruits and vegetables from future agricultural technologies to friends and family.

4.3.3. Green urbanites

The Green Urbanites cluster ($n = 944$) is the smallest segment. It has more males (56.7 %), members tend to be younger (82.4 % are under 45 years of age), and they have higher incomes (52.8 % report $50,000–$130,000 in annual income). Compared with the other two groups, Green Urbanites predominantly live in urban areas (37.2 %).

Green Urbanites favor fresh produce that is nutritious, tasty, and sustainably sourced from traditional farms using soil and natural sunlight. They avoid genetically modified products and prefer purchasing from farmers markets. With regard to lifestyle, they value social interactions, are active social media users, feel connected to nature, maintain an active and healthy lifestyle, and enjoy cooking with raw ingredients. Different from the other two segments, Green Urbanites show trust in the government and large corporations and believe that these institutions have their best interests in mind.

Green Urbanites appear to be ethically conscious consumers who are keen on safeguarding the environment. They do not foresee affordable food as a problem, possibly due to their above-average incomes. Nevertheless, they are aware of broader issues related to food security. Their concerns extend to the quality of food available, the (environmental) impact of food waste, the accessibility of clean drinking water, and related challenges associated with population growth. Overall, they strongly believe in technology, provided it is carefully implemented, and they view all three agricultural technologies positively. In contrast to the other two identified segments, they exhibit significantly higher attitudes toward using CEA, GE, and FA technologies (see Appendix D). Surprisingly, although they would consider purchasing produce developed with these technologies and acknowledge their benefits for combating food shortage, they are less willing to advocate publicly for them or recommend produce grown with these technologies to friends and family. This perhaps suggests a more hesitant approach toward consumption because of limited knowledge and fear of social repercussions. Overall, Green Urbanites appear to be advocates of the zeitgeist, reflecting a younger, well-educated, and affluent generation of metropolitan consumers who struggle to balance modern life with the need to safeguard the environment.

5. Discussion

Agricultural technologies such as CEA, GE, and FA offer potential solutions to achieve food security while limiting the environmental

Table 3
Attitudes toward sustainable agricultural technologies.

ANOVA Results	$n = 1515$ Skeptical Foodies		$n = 1439$ Environmentally Unconcerned		$n = 944$ Green Urbanites		Test Statistics	
Attitudes - controlled environment agriculture (CEA)	Mean	(SD)	Mean	(SD)	Mean	(SD)	*F*-value	*p*-value
I would recommend fruits and vegetables from controlled environment agriculture to family and friends.	3.113 e, g	(1.000)	3.253 s, g	(0.924)	2.299 s, e	(1.163)	277.035	0.000
I think using controlled environment agriculture is fine for the production of fruits and vegetables in locations of severe food scarcity.	4.003 e	(0.873)	3.509 s, g	(0.937)	4.077 e	(0.829)	159.556	0.000
I would be willing to purchase fruits and vegetables from controlled environment agriculture.	3.601 e, g	(0.983)	3.488 s, g	(0.898)	4.166 s, e	(0.830)	169.498	0.000
Attitudes - genetic editing (GE)								
I would recommend genetically edited fruits and vegetables to family and friends.	2.669 e, g	(1.163)	3.013 s, g	(1.002)	2.215 s, e	(1.123)	74.289	0.000
I think using genetic editing is fine for the production of fruits and vegetables in locations of severe food scarcity.	3.374 g	(1.190)	3.259 g	(0.971)	3.961 s, e	(0.946)	66.996	0.000
I would be willing to purchase fruits and vegetables grown using genetic editing.	2.918 e, g	(1.218)	3.189 s, g	(1.002)	3.978 s, e	(0.993)	138.723	0.000
Attitudes - farming automation (FA)								
I would recommend fruits and vegetables grown using automation and robotics.	3.168 e, g	(1.074)	3.307 s, g	(0.986)	2.398 s, e	(1.252)	110.805	0.000
I think using automation and robotics is fine for the production of fruits and vegetables in locations of severe food scarcity.	3.683 e, g	(1.021)	3.424 s, g	(0.951)	4.052 s, e	(0.901)	61.077	0.000
I would be willing to purchase fruits and vegetables grown using automation and robotics.	3.481 g	(1.076)	3.521 g	(0.917)	4.143 s, e	(0.863)	80.263	0.000

Notes: Letters in superscript indicate significant cluster differences between s = Skeptical Foodies, e = Environmentally Unconcerned, and g = Green Urbanites based on Tukey's Honest Significant Difference test.

impact of current food production. Because population growth and unsustainable farming practices have caused significant harm to the environment, understanding consumer preferences, including drivers and inhibitors, toward these technologies is crucial to support solutions to such global concerns (Fakhri and Tzouvala, 2020). We offer six propositions for exploring a theory-driven view of consumer attitudes toward innovative agricultural technologies (i.e., CEA, FA, and GE technologies). We explore these using a profiling and segmentation methodology applied to a representative sample from Australia and New Zealand. This method builds on extant research on general consumer reactions to market innovations (e.g., McLeay et al., 2018; Osburg et al., 2022) as well as agricultural technologies more specifically (e.g., Nie and Zepeda, 2011; Verain et al., 2012). We identify three consumer segments that differ in their readiness to adopt novel agricultural technologies: Green Urbanites, Skeptical Foodies, and Environmentally Unconcerned (for further detail, see Table 4).

Our findings support Proposition 1, which argues that consumer segments with stronger preferences for future agricultural technologies have higher levels of consumer trust. The findings of this study reveal higher levels of consumer trust among Green Urbanites, particularly their trust in government institutions and corporations. Green Urbanites trust that these institutions prioritize citizens' best interests and have positive perceptions of large corporations' role in food production over smaller farmers. This aligns with previous research using technology acceptance models, emphasizing the importance of trust in technology and the influence of that trust on perceived usefulness and ease of use. (Ghazizadeh et al., 2012; Wu et al., 2011).

The empirical study also supports Proposition 2, which suggests that stronger preferences for future agricultural technologies are linked to greater environmental concerns. Previous research has shown that individuals with high levels of environmental concern are more likely to support eco-innovations and make environmentally friendly choices (Osburg et al., 2016). The present study indicates that Green Urbanites, characterized by strong environmental concern, demonstrate a higher acceptance of and willingness to adopt new technologies. Similarly, Skeptical Foodies show relatively high levels of environmental concern combined with moderate support of future agricultural technologies.

According to Proposition 3, consumer groups can be differentiated on the basis of their food-buying preferences, which we also observed in our study. Our findings align with previous research on consumers' food-buying preferences. As Asioli et al. (2017) suggest, consumers consider intrinsic and extrinsic characteristics when making food choices. Green Urbanites prioritize the appearance and nutritional content of produce, suggesting a preference for visually appealing and healthy food options. This corresponds with an emphasis on "clean" natural food products with low environmental impact and low chemical use. A similar but less nuanced picture can be observed for Skeptical Foodies. In contrast, the Environmentally Unconcerned segment does not prioritize avoiding genetically modified food or buying fruits and vegetables grown in soil.

We also find support for Proposition 4, which states that consumer segments with strong preferences for future agricultural technologies are more aware of food security issues. Consumers may be unaware of food security issues depending on their geographic location and how they are affected (Kneafsey et al., 2013). Our study shows that food access may be more salient for Green Urbanites, who tend to live in highly populated cities where there may be urban "food deserts" and supply chain issues that make it difficult to keep food in stock in some places (Godrich et al., 2022). However, given their comparatively high income, food affordability is less of a concern for this segment. While Skeptical Foodies also appear to be aware of food security issues, including food affordability, the Environmentally Unconcerned are less likely to adopt novel technologies due to concerns over food security.

Proposition 5 emphasizes lifestyle and sociodemographic factors, which differ between consumer segments with respect to their readiness to adopt future agricultural technologies. Our findings indicate that different consumer cohorts exhibit varying levels of engagement with social media (e.g., Green Urbanites use social media frequently). Moreover, our study reveals that Green Urbanites lead the most active lifestyle. This is not surprising, as individuals with a greater concern for the environment often engage in activities that promote sustainability and physical well-being. These findings support previous research that has linked lifestyle choices to food preferences, showing that consumers pursuing a healthy lifestyle are more likely to opt for healthier food products (Asioli et al., 2017). Furthermore, we demonstrate that the consumer segments can also be differentiated in terms of income, age, and gender distribution.

Table 4
Overview of identified segments and suggested targeting.

Profile	Demographic Profile	Psychographic Profile	Proposed Targeting Strategy
Skeptical Foodies	➢ 60.9 % female ➢ 59.4 % >45 years old ➢ 35.2 % > $50,000 to $130,000 annual income ➢ 67.1 % suburban population	➢ Value taste and quality of food, price-conscious, moderate organic buyers, little interest in social media, strong environmental and food safety/security concern but skeptical of authorities, prefer home-cooked meals over eating out. ➢ Selective stance toward future agricultural technologies (moderate for CEA and FA, low for GE).	➢ Focus on community-based marketing through local newspapers and community centers, promoting organic and tech-enhanced farming. Host informational sessions and cooking demonstrations to build trust and educate on benefits.
Environmentally Unconcerned	➢ 46.4 % female ➢ All age groups ➢ 48.5 % < $10,000 to $90,000 annual income ➢ 64 % suburban population	➢ Prioritize taste and price over environmental impact, use of chemicals and appearance, moderate health consciousness and connection to nature, inactive lifestyle and low social activity, skeptical of government, low food security concerns, and low perceptions of technology's positive impact on life quality. ➢ Neutral on future agricultural technology (although there is a higher willingness to recommend these than the other clusters).	➢ Use traditional advertising mediums like local television and radio to emphasize cost savings and convenience. Run promotions in suburban grocery stores and restaurants/ cafes, highlighting new agricultural technologies' taste and price benefits. ➢ Make use of their willingness to recommend future agricultural technologies and encourage them to engage in positive word-of-mouth (e.g., through incentives).
Green Urbanites	➢ 43.1 % female ➢ 82.4 % <45 years old ➢ 52.8 % > $50,000 to $130,00 annual income ➢ 37.2 % urban population	➢ Young, ethically conscious, prefer fresh and sustainably sourced produce from traditional farming, active lifestyle, and value of social interactions (e.g., social media use), trust in government and corporations, some food security concerns, and the strong value of technology in agriculture. ➢ Support of all three future agricultural technologies, but hesitant in their advocacy for future agricultural tech.	➢ Target through social media campaigns on platforms like Instagram and X, focusing on sustainability and tech advancements. Partner with urban eco-friendly events and community gardens to demonstrate commitment to the environment. Demonstrate corporate social responsibility. ➢ Highlight benefits for the environment and future food security, and demonstrate support by government and corporations.

Proposition 6 asserts that adoption rates vary depending on the agricultural technology under consideration, with GE being less preferred than CEA and FA. We observed the strongest willingness to buy among the Green Urbanites, who indicated their openness to adopting new technologies in the agricultural sector. One noteworthy aspect is the Green Urbanites' preference for GE technology. This preference might seem counterintuitive, considering the environmental concern associated with GE. Ferrari et al. (2021) have highlighted that consumers with high environmental concerns are less open toward genetic engineering. This suggests that Green Urbanites may perceive GE as a more sustainable and environmentally friendly approach than traditional agricultural methods. In contrast, the other two segments appear less inclined toward GE than FA and CEA. This suggests that both segments may believe that FA and CEA technologies can address their concerns related to food production without the controversial aspects associated with GE. Previous studies have indicated that consumers' risk perceptions vary between different agricultural technologies (Frewer et al., 2011). While GE is perceived as more controversial, other novel agricultural technologies have generally been met with a more positive outlook (Frewer et al., 2011; Lusk et al., 2014).

5.1. Theoretical implications

Our study substantiates and broadens previous research on consumer acceptance of novel agricultural technologies. We present a range of factors linked to consumer acceptance of these technologies. The selection of these factors was informed by previous studies that have underscored their significance in forecasting the acceptance of food-related technologies. This includes research on consumer trust (e.g., Macready et al., 2020), environmental concerns (e.g., Aschemann-Witzel and Stangherlin, 2021), purchasing preferences (e.g., Grunert, 2013), consciousness about food security (e.g., Godrich et al., 2022), and the impact of lifestyle and sociodemographic factors (e.g., Asioli et al., 2017). Our work shows the discriminatory power of these factors in profiling and segmenting specific target groups relevant to the acceptance of new agricultural technologies, thus extending previous findings with a market segmentation approach.

We present and test a theory of consumer acceptance of sustainable agricultural technologies that is conceptually based on technology acceptance models such as UTAUT and UTAUT2. Building our research on this theoretical stream, we can explain and predict how consumers respond to future agricultural technologies and which factors shape their acceptance of them (e.g., Venkatesh et al., 2012). Our study emphasizes the need for structured, theoretically informed approaches to understanding consumer responses to agricultural innovations.

Relatedly, we offer theoretical insights into the drivers of consumer acceptance of novel agricultural technologies by integrating different theoretical streams. We advance the understanding of trust, as examined by Frewer et al. (2011), Ghazizadeh et al. (2012), and Wu et al. (2011), as an important determinant in the acceptance of new agricultural technologies. Building on Osburg et al. (2016), we confirm that environmental concerns are pivotal in consumer acceptance. We also stress the relevance of intrinsic and explicit buying motives in preferences for new agricultural technologies, as Asioli et al. (2017) suggest. Moreover, we further explore the location-dependent nature of food security need awareness, extending the insights of Godrich et al. (2022) and Kneafsey et al. (2013). Based on the work of Venkatesh et al. (2012), we emphasize the discriminatory impact of lifestyle and demographics on acceptance and attitudes toward new technologies.

Furthermore, we demonstrate that consumer acceptance may vary between novel agricultural technologies. Thus, consumer acceptance of future agricultural technologies should not be understood as one-dimensional. Nuanced differences must be acknowledged. GE and genetically modified products appear more prone to consumer skepticism (e.g., Ding et al., 2015; Ferrari et al., 2021). Thus, it is important to note that the acceptance of certain novel agricultural technologies, such as GE, may be lower. The differential acceptance of these technologies suggests that consumers' attitudes and concerns play a crucial role in their acceptance of novel agricultural technologies.

Finally, our research is a testimony to the importance of understanding and accounting for attitudinal differences because consumer responses to innovations can fundamentally vary between segments (e.g., Osburg et al., 2022; van der Stricht et al., 2024; Yoganathan and Osburg, 2024). Our research reveals that the identified segments differ in their acceptance of novel agricultural technologies and exhibit unique (dis)approval of specific technologies and factors. Consequently, it is crucial to profile and gain a deeper understanding of these consumer segments.

5.2. Managerial and public policy implications

This study shows the need for a comprehensive strategy that increases consumer trust, addresses environmental concerns, educates people about food security, and considers demographic and lifestyle differences to enhance the acceptance of new agricultural technologies.

First, this study underscores the significance of adopting a market segmentation perspective to enhance consumer acceptance of future agricultural technologies. Different segments exhibit varying levels of receptiveness to distinct approaches. Table 4 presents a range of targeting strategies tailored to each segment, facilitating practitioners' effective engagement with diverse consumer groups. For instance, Green Urbanites emerge as particularly predisposed to embracing novel agricultural technologies, and they are likely to be persuaded by compelling arguments that highlight the advantages of such technologies. Engaging with them through social media platforms appears to be effective. In contrast, the Environmentally Unconcerned segment is best reached through traditional media channels. Rather than emphasizing environmental and food security benefits, this segment is more receptive to messages centered on taste and price advantages. Despite not exhibiting the highest support for future agricultural technologies, the significance of this segment should not be overlooked, as their willingness to recommend new agricultural technologies could play an important role. As for Skeptical Foodies, targeting them within their community-based environments through marketing initiatives that emphasize the taste, quality, food security, and environmental benefits of new agricultural technologies appears to be the most effective approach.

Second, consumer trust is crucial for the acceptance of new agricultural technologies. Public policies could bolster this trust through enhanced transparency in food safety and technology regulations. Given the observed skepticism about the environmental impacts of these technologies, addressing this topic should be central to public information campaigns. Producers and marketers should focus on building consumer trust by being transparent about the benefits and potential risks associated with these technologies (Frewer et al., 2011). This can be achieved through clear communication and by providing information on the technologies' safety, efficacy, and environmental impact. Collaborating with trusted institutions such as government agencies and reputable research organizations can also help enhance consumer trust (Ghazizadeh et al., 2012; Wu et al., 2011).

Third, in response to concerns about environmental impact, policies must openly communicate the environmental benefits of new agricultural technologies. Despite their energy demands, such technologies can be aligned with renewable energy sources and provide improved water efficiency, disease resistance, and resilience during climate extremes, such as droughts and floods. For instance, in 2023, the Australian Department of Agriculture, Fisheries and Forestry (2023) issued a national statement committing to the need to build a world-leading climate-smart agriculture industry to combat the impacts of climate change for its country. Producers and marketers can emphasize the environmental benefits of technologies such as CEA and GE, including reduced water and chemical usage and their potential to address food scarcity (Osburg et al., 2016). Highlighting the positive environmental impact of these technologies can appeal to consumer segments that are more environmentally concerned and motivate them to support and adopt these innovations.

Fourth, we emphasize the need to promote local and global awareness of food security issues, particularly among consumers who are less informed or concerned about such issues (Kneafsey et al., 2013). By understanding consumer buying preferences, policies can be shaped to encourage food conservation, reduce wasteful consumption, and enhance the stewardship of agricultural resources for the benefit of future generations. For example, in 2023, the New Zealand government launched an interdepartmental campaign to reduce food waste by implementing measures to quantify food waste, improve recycling behaviors, and reduce greenhouse gas emissions resulting from food waste (Ministry for the Environment, 2023). Producers, marketers, and policy makers should engage in educational campaigns and initiatives to increase consumer knowledge about the importance of sustainable food production and the role of novel agricultural technologies in ensuring food security. This might help address concerns related to food security and alleviate barriers to the adoption of these technologies.

6. Limitations and further research

The results of our study translate into several promising directions for further research. First, although this study benefits from a substantial sample size representative of Australia and New Zealand, it is important to recognize that consumer acceptance of future agricultural technologies can vary significantly across different countries and will be influenced by cultural, developmental, and urgency factors. For example, countries with historical experiences of food scarcity, such as Vietnam and Singapore, may be more open to adopting various agricultural technologies than nations with strong food export capacities (Plant and Food Research, 2023). To enhance the generalizability of our findings, research should include participants from diverse countries and replicate the study to confirm these trends.

Second, this research employs a large-scale segmentation approach using data from an online survey to assess consumer perceptions of novel agricultural technologies. However, a potential limitation is that consumers might have limited experience with the technologies studied. To substantiate our findings, fieldwork might be necessary. This could involve studies in which consumers interact directly with the technologies and test the resulting products (Ferreira et al., 2021). Future fieldwork might also consider other determinants of acceptance and choice, such as price variance, availability, and brand strength.

Third, although we have taken appropriate steps in developing the measures we used (DeVellis and Thorpe, 2021), future studies should focus on developing measurement instruments specifically tailored to capture consumer attitudes toward future agricultural technologies. Ideally, multiple samples should be used to validate measures and provide a more multifaceted view of agricultural-specific attitudes. Given the increasing reliance on technologies that support daily life, understanding consumer acceptance of these technologies is a critical and promising area for further research.[3]

Finally, this study examines three specific technologies that enhance the efficiency of agricultural production and reduce environmental impact. The findings reveal significant variations in consumer adoption and intentions to consume produce derived from these technologies across different market segments. Future work should aim to replicate these results in varied technological settings. For example, improvements in communication technologies, such as mixed-reality social networks or spatial computing (i.e., Metaverse), could facilitate the broader adoption of innovative healthcare technologies that promote sustainability through digital transitions (e.g., Abbate et al., 2023b; Abbate et al., 2023c).[4]

CRediT authorship contribution statement

Alexander Schnack: Conceptualization, Data curation, Formal analysis, Methodology, Writing – original draft. **Fabian Bartsch:** Formal analysis, Writing – review & editing. **Victoria-Sophie Osburg:** Writing – original draft. **Amy Errmann:** Data curation, Formal analysis, Methodology, Writing – original draft.

Data availability

The authors do not have permission to share data.

[3] We thank an anonymous reviewer for making this suggestion.
[4] We thank an anonymous reviewer for making this suggestion.

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Appendix A. Study material.

CONTROLLED ENVIRONMENT AGRICULTURE (CEA)

CEA is a way of farming that allows increased control to protect crops from the uncertainties of outdoor growing conditions (e.g., climate events, pests) and allows for optimised production (e.g., yields).

Outdoor farms are the traditional way of farming. Crops grow using sunlight and soil.

'Greenhouses' also called 'hothouses' are common now. Crops grow using hydroponics (nutrient-rich water systems) rather than in soil.

Indoor farms are in buildings or warehouses in controlled optimal environments, 24 hrs/day.

Instead of sunlight, LED lighting is used. Temperature and nutrients are regulated in soil-free growing mediums. Yields can be 5X faster than outdoor farms.

Outdoor Farm

Greenhouse/hothouse

Indoor Farm

Less Control — Some Control — Total Control

Genetic Modification & Genetic Editing

Genes are the basic unit of inheritance passed from parents to offspring. They carry the information that determines traits of an organism. Traditionally, we improve and/or obtain desired traits of crops through breeding them, but modifying or altering specific genes can help to achieve this much faster.

Genetic Modification (GM) is the process of changing the genetic makeup of a plant by incorporating genes from other organisms.

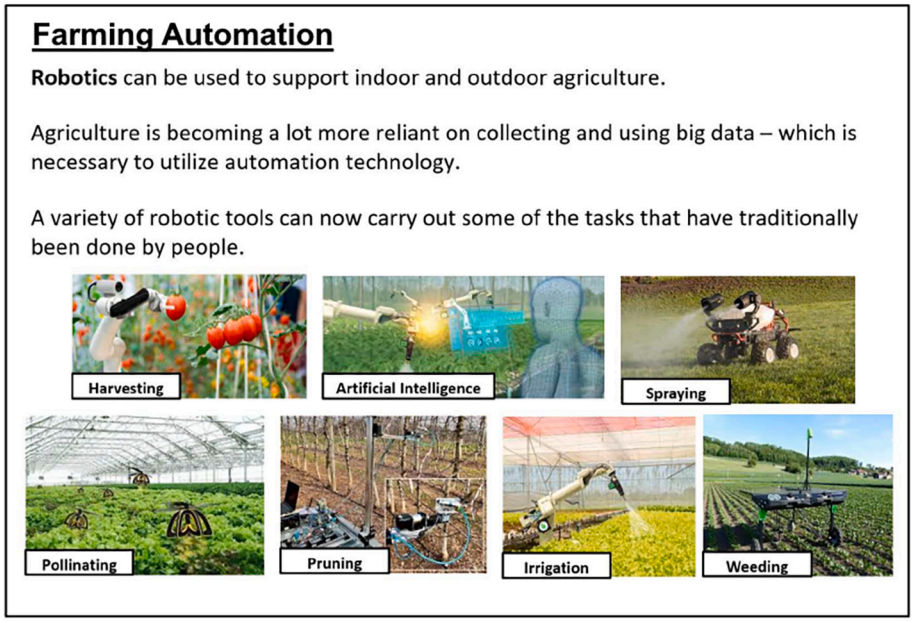
Example: a bacterial gene was introduced to the corn plant and the gene produces insect toxins into the part of the plant where the insect eats, so that the crops become insect-resistant.

GM - introducing new genes from other organisms

Genetic Editing (GE) is the process of cutting and splicing small parts of a plant's existing genetic makeup. It doesn't introduce foreign genes as genetic modification does.

Example: non-browning lettuce that stays green for longer due to alteration of the genes which cause browning.

GE – altering genes that already exist within the crop



Appendix B. Measurements.

Food-buying preferences	Source
How a fruit or vegetable looks in appearance is important to me.	Steptoe et al., 1995
Eating fruits & vegetables that are nutritious is important to me.	
The absence of chemicals and pesticides on fruits & vegetables is important to me.	
Buying fruits & vegetables that have a low impact on the environment is important to me.	
The price of fruits & vegetables is important to me.	
That fruits & vegetables are grown in soil is important to me.	
Fruits & vegetables being grown in natural sunlight is important to me.	
The taste of fruits & vegetables is important to me.	
I try to avoid genetically modified food is important to me.	
Buying fruits & vegetables from a farmers' market is important to me.	
Social life	
Using social media is part of my everyday routine.	Jenkins-Guarnieri et al., 2013
I share many of my day-to-day activities through social media.	
I love night clubs, meeting people, and need the pulse of the city.	
Connectedness to nature	
Being in nature makes me very happy.	Schultz, 2001
I always find beauty in nature.	
Taking care of my plants at home fills me with joy.	
Interest in healthy living	
I live an active lifestyle.	Self-developed
Health and well-being are very important to me.	
Interest in cooking	
I enjoy cooking.	Based on da Rocha Leal et al., 2011
I often prepare meals from raw ingredients.	
Consumer trust	
I trust that big companies always have the consumers' best interests in mind.	Based on Kim, 2010
I trust government institutions will always have citizens' best interests in mind.	
Food production by large corporates rather than smaller farmers is a good thing.	
Environmental concern	
I talk with friends about problems related to the environment.	Gifford and Comeau, 2011
Climate Change is an urgent threat for life on this planet.	

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Food-buying preferences	Source
Awareness of food security issues	
Affordable food will be a problem in the future.	Rezaei et al., 2022
I am worried about the quality of our food in the future.	
The food waste we create will be a real problem.	
The supply of clean drinking water will be a real issue in the future.	
The current rate of population growth poses issues to future food supply.	
Technology attitudes	
Technology cannot be depended upon, so care must be taken in adopting it to perform jobs currently done by people.	Self-developed
New technologies contribute to a better quality of life.	
Attitudes - controlled environment agriculture	
I would recommend fruits & vegetables from Controlled Environment Agriculture to family and friends.	Self-developed
I think using Controlled Environment Agriculture is fine for the production of fruits & vegetables in locations of severe food scarcity.	
I would be willing to purchase fruits & vegetables from Controlled Environment Agriculture.	
Attitudes - genetic editing	
I would recommend genetically edited fruits & vegetables to family and friends.	Self-developed
I think using genetic editing is fine for the production of fruits & vegetables in locations of severe food scarcity.	
I would be willing to purchase fruits & vegetables grown using genetic editing.	
Attitudes - farming automation	
I would recommend fruits & vegetables grown using automation and robotics.	Self-developed
I think using automation and robotics is fine for the production of fruits & vegetables in locations of severe food scarcity.	
I would be willing to purchase fruits & vegetables grown using automation and robotics.	

Appendix C. K-means cluster centers.

Food-buying preferences	Skeptical Foodies	Environmentally Unconcerned	Green Urbanites
How a fruit or vegetable looks in appearance.	3.580	3.345	4.225
Eating fruits and vegetables that are nutritious.	4.661	3.806	4.400
The absence of chemicals and pesticides on fruits and vegetables.	4.353	3.352	4.257
Buying fruits and vegetables that have a low impact on the environment.	3.943	3.003	4.257
The price of fruits & vegetables.	4.503	3.880	4.320
That fruits and vegetables are grown in soil.	3.960	3.130	4.279
Fruits and vegetables are grown in natural sunlight.	4.114	3.240	4.279
The taste of fruits & vegetables.	4.669	3.935	4.350
I try to avoid genetically modified food.	3.980	3.074	4.138
Buying fruits and vegetables from a farmers' market.	3.436	2.820	4.212
Social life			
Using social media is part of my everyday routine.	3.115	3.045	4.168
I share many of my day-to-day activities through social media.	1.888	2.208	4.072
I love night clubs, meeting people and need the pulse of the city.	1.851	2.252	3.887
Connectedness to nature			
Being in nature makes me very happy.	4.328	3.500	4.240
I always find beauty in nature.	4.359	3.558	4.325
Taking care of my plants at home fills me with joy.	3.766	2.969	4.245
Interest in healthy living			
I live an active lifestyle.	3.403	3.047	4.273
Health and well-being are very important to me.	4.317	3.584	4.323
Interest in cooking			
I enjoy cooking.	3.856	3.271	4.276
I often prepare meals from raw ingredients.	4.190	3.430	4.168
Consumer trust			
I trust that big companies always have the consumers' best interests in mind.	2.245	2.657	4.164
I trust government institutions will always have citizens' best interests in mind.	2.534	2.790	4.070
Food production by large corporates rather than smaller farmers is a good thing.	2.415	2.889	4.077
Environmental concern			
I talk with friends about problems related to the environment.	3.525	2.762	4.193

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Food-buying preferences	Skeptical Foodies	Environmentally Unconcerned	Green Urbanites
Climate change is an urgent threat to life on this planet.	4.257	3.257	4.274
Awareness of food security issues			
Affordable food will be a problem in the future.	3.909	3.243	1.996
I am worried about the quality of our food in the future.	4.099	3.183	4.120
The food waste we create will be a real problem.	4.139	3.315	4.220
The supply of clean drinking water will be a real issue in the future.	4.247	3.368	4.219
The current rate of population growth poses issues to future food supply.	4.118	3.420	4.216
Technology attitudes			
Technology cannot be depended upon, so care must be taken in adopting it to perform jobs currently done by people.	3.583	3.226	4.017
New technologies contribute to a better quality of life.	3.513	3.340	4.236

Appendix D. Pairwise comparisons from Tukey's honest significant difference test.

Controlled Environment Agriculture		
I would recommend fruits and vegetables from Controlled Environment Agriculture to family and friends.		
Cluster pair	Difference	*p*
E vs. S	0.140	0.001
G vs. S	−0.814	<0.001
G vs. E	−0.954	<0.001
I think using Controlled Environment Agriculture is fine for the production of fruits and vegetables in locations of severe food scarcity.		
Cluster pair	Difference	*p*
E vs. S	−0.494	<0.001
G vs. S	0.074	0.109
G vs. E	0.568	<0.001
I would be willing to purchase fruits and vegetables from Controlled Environment Agriculture.		
Cluster pair	Difference	*p*
E vs. S	−0.113	0.002
G vs. S	0.565	<0.001
G vs. E	0.678	<0.001

Genetic Editing		
I would recommend genetically edited fruits and vegetables to family and friends.		
Cluster pair	Difference	*p*
E vs. S	0.343	<0.001
G vs. S	−0.455	<0.001
G vs. E	−0.798	<0.001
I think using genetic editing is fine for the production of fruits and vegetables in locations of severe food scarcity.		
Cluster pair	Difference	*p*
E vs. S	−0.115	0.094
G vs. S	0.587	<0.001
G vs. E	0.701	<0.001
I would be willing to purchase fruits and vegetables grown using genetic editing.		
Cluster pair	Difference	*p*
E vs. S	0.271	<0.001
G vs. S	1.060	<0.001
G vs. E	0.789	<0.001

Farming Automation		
I would recommend fruits and vegetables grown using automation and robotics.		
Cluster pair	Difference	*p*
E vs. S	0.139	0.038
G vs. S	−0.770	<0.001
G vs. E	−0.910	<0.001
I think using automation and robotics is fine for the production of fruits and vegetables in locations of severe food scarcity.		
Cluster pair	Difference	*p*
E vs. S	−0.258	<0.001
G vs. S	0.369	<0.001
G vs. E	0.628	<0.001
I would be willing to purchase fruits and vegetables grown using automation and robotics.		
Cluster pair	Difference	*p*
E vs. S	0.039	0.717
G vs. S	0.661	<0.001
G vs. E	0.622	<0.001

Notes: E = Environmentally Unconcerned; G = Green Urbanites; S = Skeptical Foodies.

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