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# Exploring Consumers' Knowledge, Attitudes and Influencing Factors Towards Vertical Hydroponic Farming in Lebanon

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## Title

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## Abstract

Vertical Hydroponic Farming (VHF) is being considered as an alternative to conventional farming to reduce water requirements, particularly in regions with soil deterioration and low water supply and is perceived as environmentally friendly due to its pesticide-free nature and lower water usage. However, this method is faced with some challenges entitled to the consumer’s suspicion about it. To address this challenge this study aimed to uncover Lebanese consumers' knowledge and attitude towards the VHF system, their awareness of its availability in Lebanon and what might influence their desire to consume VHF products. The study utilized a literature review and conducted qualitative in-depth semi-structured interviews online to explore consumer attitudes towards VHF. Convenience sampling was used and 10 female participants responsible for household grocery shopping in Lebanon were recruited. Data analysis involved transcribing and coding interview transcripts and finally identifying themes. The findings highlighted that perceived sustainability is a key driver of consumer acceptance, with consumers more likely to view VHF products as useful and intend to purchase them when they perceive the technology as sustainable. These findings provide insights for marketing strategies and policy decisions related to VHF products.



## Keywords

Vertical hydroponic farming, Lebanon, consumer, attitude, knowledge, sustainability, factors.

# Preface

When I was fifteen years old, we moved to a house with a garden, and that's when I discovered my love for gardening. Since then, I have had a great interest in everything related to agriculture. As I cultivated without the use of pesticides and chemicals, I noticed a difference in taste between the produce from my garden and the products available in the market from conventional farming in terms of quality and flavour. That's when I started to dislike consuming products that contain pesticides and chemicals, which motivated my particular interest in vertical hydroponic farming.

I would like to express my deepest gratitude to my supervisor and the participants who played a crucial role in my master's thesis journey. Without my supervisor’s support, guidance, and valuable contributions, completing this thesis would not have been possible. I would also like to extend my heartfelt appreciation to the participants who willingly dedicated their time and shared their knowledge and experiences for the sake of this research.

# Introduction

Many conventional food production practices rely heavily on chemical inputs, such as fertilizers and pesticides. While these chemicals can effectively increase crop yields, they can also negatively impact human health, soil health, water quality, biodiversity, and greenhouse gas emissions (Mir et al., 2022).

Pesticide poisoning claims the lives of 20,000 individuals annually in poor nations (Mir et al., 2022). The soil's fertility has been negatively impacted by rapid urbanization, natural catastrophes, climate change, and unrestricted use of chemicals and pesticides. Soil fertility has fallen, soil productivity has decreased, and the quantity of land that is accessible to each person has decreased (Lal, 2015; Lambin, 2012; Lehman et al., 2015). Moreover, water resources in the watershed are threatened by a variety of factors, including excessive agricultural water use, unregulated water pollution, and an overall decrease in groundwater levels. The threats to the water resources in the watershed include a changing climate, rising

temperatures, frequent dry periods, and the unpredictability of the weather (Bhanja et al., 2018).

In many developing countries, farmers rely on synthetic pesticides because of their extremely high effectiveness without considering potential effects on human health and the environment (Ekstrom, 2002). By prevalent global practices, the agricultural industry in Lebanon, a developing nation in the Eastern Mediterranean, extensively relies on agrochemicals for crop protection (Ministry of Environment Government of Lebanon 2005). In Lebanon, toxic pesticides that have been outlawed are nonetheless frequently used by farmers since they may still be found there, either illegally or for cheap in the local market (Ministry of Environment Government of Lebanon, 2005). Finally, in Lebanon, food insecurity has become a very significant problem, especially after the repercussions of the Arab Spring and the Syrian War. In addition, Lebanon is a middle-income country with an extremely fragile political, social, and economic system that contributes to the rise in its food insecurity, thus leading to a lack of food capacity as well as numerous other problems that endanger both its social fabric and its agricultural capabilities (Awwad, 2023). Therefore, it is becoming of great importance to find ways to produce more resilient food near urban areas that are less susceptible to supply-chain shocks, particularly in a developing country like Lebanon (Martin & Orsini, 2022).

Vertical hydroponic farming (VHF) methods may be used in Lebanon instead of soil-based farming systems as a supplementary approach to assist in addressing the present scarcity of fertile arable lands and clean water and thus increasing food availability (Mir et al., 2022). VHF uses multi-layer growing systems under artificial illumination (LED lights) in plant factories where plants are grown in water and nutrient solution using an inert medium to support the roots. The grown plants are not affected by climatic change in any manner since the environment is controlled within the chamber. As a result, any crop may be cultivated all year round and is not regarded to have an off-season. Furthermore, VHF systems may easily be automated, which can greatly minimize the labour necessary and remove numerous customary procedures like weeding, spraying, and other similar tasks.

Besides, higher yield is produced with better quality compared to soil-based farming (Kannan et al., 2022). Although the hydroponic farming technique is an excellent way to increase productivity, there are still certain challenges and its obvious challenge is the substantial energy (electricity) requirement for artificial illumination, which is necessary for photosynthesis. Additionally, a large need for cooling and vapour removal is predicted to result from the combination of high crop production density, constrained space, and the absence of natural ventilation (Graamans et al., 2017). Finally, the high start-up costs, the complexity of setting up a VHF, the significant operational and maintenance costs, the high labour costs, and the management of CO2 emitted are all some challenges facing VHF (Ackerman et al., 2014). These problems are typically resolved by the development of affordable, long-lasting, energy-efficient, luminous, spectral-variable, low-temperature LED systems, as well as the installation of renewable energy sources like photovoltaic cells that could be used to provide VHFs with renewable electricity (Graamans et al., 2018). These can also be overcome by the consistent output of the VHF products by the consumer. However, even if technical challenges are overcome, the process and logic behind consumer acceptance and willingness to buy VHF produce (mostly green vegetables) are poorly understood (Coyle & Ellison, 2017). Therefore, due to the lack of literature present in understanding the consumer's propensity to buy VHF products in Lebanon, where half of the population struggles to access food, and a third of the population struggles to maintain a healthy diet because of the difficulty of acquiring food (Awwad, 2023), it is crucial to construct a study in this field.

## Aim

This study will investigate consumers' knowledge and attitude towards VHF, their awareness of its availability in Lebanon and what might influence their desire to consume VHF products.

## Research Questions

1) Do consumers in Lebanon know about VHF technology?

2) What is the level of awareness among Lebanese consumers regarding the availability of VHF in Lebanon?
3) What are consumers' attitudes towards VHF technology as a sustainable agricultural practice?
4) What factors might influence the consumers' purchase decisions of VHF products?

# Literature Review

In this literature review, previous research focusing on VHF in relation to sustainable production and consumption will be presented.

## Vertical hydroponic farming and sustainable food production

Food production is currently a significant concern due to the substantial dangers these issues pose to traditional soil-based agricultural production methods (Lambin & Meyfroidt, 2011). The Johannesburg Plan of Implementation aims to ensure sustainable consumption and production patterns as mentioned in the goal n.12, within the SDGS 17 goals, of the 2030 Agenda for Sustainable Development. The Johannesburg Plan of Implementation called in its Chapter 3 “Changing unsustainable patterns of consumption and production” for governments, relevant international organizations, the private sector, and all major groups to play an active role in changing unsustainable consumption and production patterns and more specifically, through its Paragraph 15, to *"Encourage and promote the development of a 10-year framework of programmes (10YFP) in support of regional and national initiatives to accelerate the shift towards sustainable consumption and production to promote social and economic development within the carrying capacity of ecosystems"* (Sustainable Consumption and Production | Department of Economic and Social Affairs, 2021).

Global interest has been generated by VHF to produce high-yield, high-quality agricultural products from almost any location by managing temperature, humidity, light, water, carbon dioxide, and nutrient concentrations in

manufactured buildings. They achieve this by establishing optimal year-round conditions for plant development. In addition to conventional farming, VHF expands the availability of food, local food security, and better lifestyles by supplying markets with fresh, nutrient-dense, pesticide-free vegetables (Yano et al., 2021). They accomplish this by introducing a variety of technologies that allow for complete process control as well as rapid and accurate traceability. Typically, the farm chambers include thermally regulated growth spaces, ventilation fans, irrigation pumps, $CO_2$ filters, artificial LED lighting, automation robots, and other types of sensors (Manos & Xydis, 2019). Under VHF, plants are grown with the use of mineral nutrition solutions instead of soil and low-energy LED illumination instead of solar energy which also provides space heating. In a flood and drain system, the reservoirs are regularly emptied and replenished while the nutrient-containing water is typically recycled throughout the whole system (Gentry, 2019). Theoretically, inside VHF, all kinds of crops could grow; however, there is a limited list of selected crops suitable for indoor climate-controlled farms, mainly crops that are small in height, planted in high densities, have low purchasing price, and small growth cycle (Perambalam et al., 2021). Crops like leafy greens, herbs, berries (strawberries, blueberries, raspberries), cherry tomatoes, cucumbers, and microgreens are the most financially feasible alternatives (Vatistas et al., 2022).

Hydroponically grown plants are said to be healthier than soil-based plants because they may be produced without the use of pesticides and herbicides besides it eliminates the risk of unintentional adulteration by weeds, soil, or environmental contaminants such as heavy metals in soils. The controlled environment makes it easier to control pests by using beneficial organisms rather than synthetic pesticides, improving the product's value in the eyes of ecologically conscious consumers and removing the potential of unintentional pesticide contamination (Bugbee, 2004; Hayden, 2006). Moreover, growing plants in a highly regulated environment might be an efficient way to maximise plant bioactive chemical synthesis. As a result, if hydroponics is implemented appropriately, with full consideration for plant needs, water, the environment,

growers, and consumer safety, they may provide vegetables with greater nutritional content (Aires, 2018).

In VHF a lot more plants may be grown in each area since they can be grown on different layers, one on top of the other thus conserving large areas of land for other activities (Touliatos et al., 2016). As a result, VHFs can be installed in urban or peri-urban regions, lowering food miles and transportation-related CO2 emissions as well as food waste along the food supply chain (Despommier, 2013). Finally, VHF uses less water than traditional farming, which uses about 10 times as much water (Cho, 2011).

## Vertical hydroponic farming – consumer acceptance and perceptions

Although VHF has just recently emerged on the agricultural scene, the principle behind these modern farming facilities is not new. In 1999, Dr. Dickson Despommier, a Columbia University environmental health sciences professor, led a class to figure out an effective way to feed the population of New York using only urban rooftop agriculture. Despommier and his students developed the idea of a multi-story building with layers of crops grown on each floor: in other words, a contemporary vertical farming tower. Despommier has since become the world's leading specialist and proponent of vertical farms. In 2006, the Japanese company Nuvege created one of the key components for indoor vertical farms: a unique light network that balances light emissions to maximise crop return rates. In 2009, the first contemporary vertical farm was created. Sky Green Farms' Singapore facility comprises over 100 9-meter-tall towers that cultivate green veggies using sunlight and gathered rainwater (Crumpacker, 2018).

VHF has attracted worldwide attention as an innovative food production technology (Yano et al., 2021). Previous studies have shown that consumer acceptance of innovative food products or technologies varied between countries and was often diverse among people (Yano et al., 2021). These researchers claim that societal concerns, economic and sociodemographic factors, consumer’s knowledge and awareness, trust in the food industry and information sources,

perceptions of the "naturalness" of food production, and ethical considerations all have an impact on how consumers react to novel food technologies (Yano et al., 2021). Recent studies examined how fears about food technology have impacted people’s perceptions of meals that are influenced by technology (Costa-Font et al., 2008; Frewer et al., 2011; Rollin et al., 2011; Siegrist, 2008). A study done by Yano et al. (2021) showed that consumer risk/benefit views, perceptions of naturalness, confidence in media and other information sources, and curiosity in innovative technologies were all reflected in their food technology neophobia, as evaluated by the Food Technology Neophobia Scale. As a result, these measurements may be used to anticipate how much consumers will embrace modern technologies. A previous study by Kurihara et al. (2014) suggested that many Japanese customers believed VHF-grown vegetables were sanitary, safe, and/or fresh. However, a fourth of those questioned thought they were artificial or had minimal nutritional value. Thus, it is reasonable to predict that consumer perceptions vary, with some expressing unfavourable judgments regarding the quality and/or naturalness of VHF products. Coyle and Ellison, (2017) interviewed U.S. consumers about the safety, quality, and naturalness of lettuce grown using VHF, greenhouse farming, and field farming, and found that VHF-grown lettuce was seen as "less natural" by respondents. As a result, they were less inclined to purchase it before alternatives (Frewer et al., 2011; Rollin et al., 2011). However, there is a lack of studies on consumer attitudes towards VHF conducted in developing countries and to the author’s knowledge no previous research has been done in this field in Lebanon.

# The Conceptual Framework

This research's objectives use the extended technology acceptance model which is based on the theory of reasoned action (TRA) and the technology acceptance model (TAM) to assess consumer attitudes towards VHF (Jürkenbeck et al., 2019).

The technology acceptance model (TAM) was developed to analyse the utilisation and acceptability of information technologies using verified factors that are specifically connected to information technology (Jürkenbeck et al., 2019). The

underlying ideas and investigations result in the creation of an expanded and customised TAM to assess the adoption of VHF systems. The fundamental determinants of consumer acceptance of technological innovations, according to Davis (1989) and Davis et al. (1989), are perceived usefulness which measures the attitude towards usage (i.e. user's belief that using a particular technology will enhance their performance and productivity), and perceived ease of use; attitude towards usage, in turn, measures the behavioural intention to use in conjunction with the perceived usefulness. The behavioural intention to utilise the system is measured by actual system use. As no prior expertise with the VHF systems is anticipated, the perceived ease of use and actual system usage are excluded from the model (Jürkenbeck et al., 2019).

In the extended (TAM) model, the attitude towards sustainability pertains to perceived sustainability which is an individual's assessment or evaluation of environmental concerns or events based on personal experiences and attitudes towards specific environmental situations. Several studies have identified environmental perceptions, sociocultural perceptions, economic perceptions, and life satisfaction perceptions as critical components of individuals' sustainability perspectives (Lin et al., 2021). The concept incorporates the mindset towards sustainability because VHF systems are frequently advertised as sustainable kinds of agriculture. Furthermore, the perceived sustainability may be influenced by the users' subjective knowledge of the VHF system (Jürkenbeck et al., 2019).

Technology affinity refers to an individual's inclination or preference for adopting and using new technologies. It has been used to forecast customers' behavioural intentions because it is an important barrier to purchase. Some consumers with low technological affinity (food technology neophobic) are cautious about exploring emerging technology-based products/services because they are unfamiliar with them (Jürkenbeck et al., 2019). This sense of unanticipated bad outcomes is known as perceived risk (Joo & Hwang, 2023). However, consumers who seek novelty tend to favour items based on developing technologies. The suggestion that consumers with a high level of technological affinity have a desire to try unusual/novel items even if there are potential risks is known as novelty

seeking (Hirschman, 1980; Hwang et al., 2021). As a result, this study expanded on the suggested paradigm by examining the moderating effect of novelty-seeking on perceived risks and attitudes to anticipate how much consumers will embrace VHF as a modern food technology.

The theory of reasoned action (TRA) focuses on behaviour prediction and is based on attitude towards behaviour and the subjective norm; Additionally, it is expanded by the theory of planned behaviour's determinant of perceived behavioural control (Fishbein & Ajzen, 1975). According to the theory of planned behaviour, perceived behavioural control refers to the attitude towards purchasing and the behavioural intention to purchase (Ajzen, 1985). According to TRA, there is a direct association between attitudes and outcomes, such that if one feels that behaviour will result in a desired or good outcome, one is more likely to have a positive attitude towards that behaviour. If, on the other hand, one feels that a given action will result in an undesirable or unfavourable consequence, one is more likely to have a negative attitude towards the activity and influence the decision to embrace the innovation (Ajzen, 1985). Therefore, if consumers believe VHF has advantages over other forms of agriculture, they are more inclined to support it; if they believe it has risks, they are less likely to support it. Subjective norms refer to an individual's perception of social expectations and norms regarding technology adoption (Ajzen, 1985). It can play a crucial role in affecting consumer's decisions so if the community surrounding the individual views the VHF products as favourable, then the individual is more inclined to consume this product and vice versa. The explained relationships of the model are presented in Figure 1 (Jürkenbeck et al., 2019).

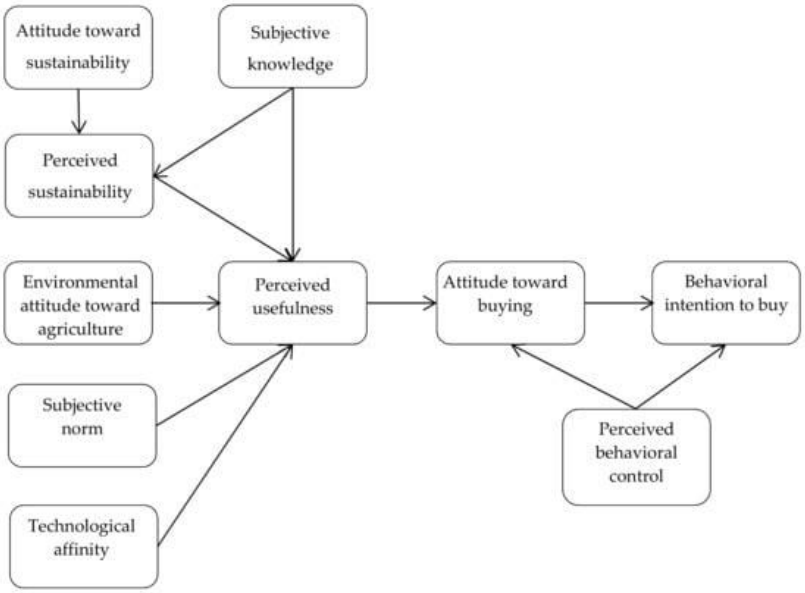


Figure 1. Conceptual framework of the extended technology acceptance model (Jürkenbeck et al., 2019).

# Material and Methods

## Literature review

For the review and identification of the pertinent scientific literature, the study employed the following keywords: “hydroponics,” “vertical farms,” “vertical hydroponic farms,” “energy demand,” “renewable energy sources,” “resource use efficiency,” “nutritional difference,” “Lebanon,” “consumer attitudes,” “consumer acceptance,” “environment,” “knowledge,” and “sustainability,”. The selected list of keywords provided the topic and the study with more extensive and up-to-date research possibilities. Scientific literature was retrieved from the databases of Kristianstad University library “*SuperSearch,”* PubMed Central, ResearchGate, Scopus, and Science Direct. Then, a comprehensive literature review was conducted based on the collected literature, which consists of peer-reviewed publications from 2004 up to date.

## Data collection methods

Quantitative research frequently has a minor impact on practice, but qualitative research, which aims to comprehend what participants’ actions imply, can provide stronger justifications for activity, and so have a bigger impact on practice

(Fenstermacher & Richardson, 2005). Qualitative research focuses on "the why" of consumer behaviour and may examine underlying motivations, beliefs, sentiments, and emotions regarding a certain product.

In this study, qualitative in-depth semi-structured online interviews were employed to gain a thorough knowledge of consumers' attitudes toward VHF (Keegan, 2009). The semi-structured interview is sufficiently structured to address specific aspects of the research question while simultaneously permitting study participants to offer novel perspectives of the study's topic (Galletta, 2013). The importance of asking the interview participants genuine questions that are of actual interest was underlined by Carol Gilligan (personal communication), who explained the disadvantage of making up questions specifically crafted to elicit certain types of data (Maxwell, 2012). Open-ended questions, and the use of an interview guide in which the general areas of interest, occasionally including sub-questions, were established covering a wide range of different VHF-related questions (e.g., on food neophobia, taste, price, sustainability, and availability) to conceal the target consumer attitude toward VHF selection criteria. The interview guide's pre-defined themes were developed from the literature and past research. Finally, a more equal and cooperative connection was established where participants contributed their expertise to the interview questions. The questions that were mainly asked during the interviews are outlined in Appendix 1.

The interviews were held on Zoom, a web-based application with camera, audio, and chat features, where video and audio recordings of the interviews were made. In addition to these improved features, conducting interviews online was more convenient and decreased the stress of travel for both the researcher who lives in Sweden, and the participants who were sought from various parts of Lebanon (Gruber et al., 2008; Redlich-Amirav and Higginbottom, 2014; & Wilkerson et al., 2014). Online interviews have the added advantage of allowing participants to speak comfortably in their home setting, and they have been shown to produce more disclosure than offline techniques (Wilkerson et al., 2014).

The sample consisted of 11 participants; however, one participant was then eliminated by the author because this participant was unable to participate on Zoom and hence the meeting was not recorded, therefore, the final sample consisted of 10 participants and each interview lasted approximately 30 minutes. The interviews were conducted in Arabic because it is the mother tongue language of both the author and the participants, and they felt more relaxed expressing their opinions and feelings through that language. At the beginning of the interview, a short video clipped from an episode of a program (from minute 14:51 to 17:27) introducing the concept of VHF and their benefits, was shown to the participants (Alfozan Social Foundation, 2023). The participants were informed about the technique and benefits of VHF, such as reducing greenhouse gases through fewer food miles, water and land savings, and the advantages of high production in small areas. Besides, to make the price difference between the conventional farm products and VHF products clear to the consumer the author picked a product (kale) and investigated the price of this product in both farms in Lebanon. The VHF Kale is priced 1.95$ for 100 grams at Beirut farm (VHF) while the conventionally farmed Kale is priced 1.1$ at the market. The results were presented to the participants while tackling the economic factor's effect on the consumer's willingness to buy the VHF products.

## Participant recruitment and sample

The participants were selected through convenience sampling where individuals chose to participate after the researcher announced the research on the Instagram story (Stratton, 2021). In the announcement, the author mentioned that only Lebanese participants can participate. However, because few people responded to the Instagram story, the author sent the announcement through a direct Instagram message to be sure that the announcement was seen by the followers. When the participants responded to either the announcement or the direct message the author explained that no one else other than the author was going to be in the interview and no one else would see the recordings and their confidentiality and credibility would be protected. After they agreed to participate an appointment had been decided on. The interviews were done on different days and times

depending on the time that most suited the participant. The participants were all women living in Lebanon in the age range of 20-40 years and had responsibility (or shared responsibility) for their household grocery shopping. The author was somewhat familiar with 4 of the participants from Instagram, while the rest were random individuals. The sample included individuals from different geographic locations in Lebanon (Beirut, Beqaa region, Saida, Koura) to capture a diverse range of perspectives.

## Ethical Considerations

The study followed the rules established by the Swedish Research Council (2017). In terms of ethical issues, the study is deemed low risk since it did not collect any personal information. Before starting the interview, the author obtained informed consent and informed the participants that their privacy and confidentiality were protected. In addition, participant's permissions for video and audio recordings were obtained and the participants were informed that the recordings would be only seen by the author and would be deleted once the study was over. The author chose to study Lebanese because the author has lived there for twenty-five years and has a broad knowledge of Lebanese attitudes and behaviours. The author was aware that this could influence the outcome and introduce potential biases. Therefore, she made a conscious effort to maintain a neutral standpoint.

## Data analysis

After each interview, memos were established to enable analytical thinking about the data and to help remember aspects that may not be included in the transcripts. The interviews were transcribed verbatim through dictation of the recorded interviews on the Word document. Then the Word documents were printed out and analysed using a step-by-step approach. Reading the interview transcripts, observational notes, and documents was the first stage in the analysis (Maxwell, 2012). Before transcription, listening to the recorded interviews several times provided another chance for analysis, as does the actual transcription process itself or the rewriting and rearranging of preliminary observation notes (Maxwell, 2012). Taking notes and memos on what had been heard and seen in the data

throughout this reading and listening process, as well as forming rudimentary concepts about categories and relationships (Maxwell, 2012). In qualitative research, classifying data by category and grouping data based on similarities and differences is a widespread practice known as coding (Maxwell, 2012). Therefore, an initial coding framework was developed by labelling the protocols and transcripts with one or more brief descriptions of the content of a sentence or paragraph. Each transcript was cut out and the entire data set was gone through systematically, giving each data item full and equal attention, and finding intriguing characteristics in the data items that may form the basis of repeating patterns (themes) across the data set. The codes were initially selected and then matched with data extracts that demonstrated that code, considering that all actual data extracts were coded and then gathered within each code. Then the codes were organized into themes, and the data was selectively sampled to support the themes—a deductive approach, where pre-existing theories were identified to guide the analysis. Then the themes presented for the analysis were defined and further refined and finally given concise and punchy names in the final analysis. The codes and themes were then translated by the author from Arabic to English as the interviews were conducted in Arabic.

The 6 themes were as follows:

1) Knowledge and awareness of VHF in Lebanon
2) Perceptions of health, cleanliness, and naturalness
3) Technological acceptance and consumer behaviour
4) Perceptions of affordability and consumer purchase decisions of VHF
5) Environment and sustainability
6) Economic aspects and job opportunities

# Results

## Knowledge and Awareness of VHF in Lebanon

After watching the introductory video almost all the participants expressed that they had not encountered the VHF technology before. One participant expressed surprise, exclaiming:

> "This is the first time I've seen such a thing." (IP 3)

Furthermore, as they engaged in discussions about VHF in Lebanon, a range of viewpoints emerged, reflecting their knowledge of the technology. Interestingly, some participants were completely unaware of the presence of such farms in their country. One participant even questioned if this technology was available in Lebanon, suggesting that it might be located elsewhere. While there were doubts among some participants, with statements like,

> "I think they are present," (IP 6)

others acknowledged that VHF may exist but in limited quantities. However, most participants were pleasantly surprised and pleased to learn about the presence of these farms. They expressed their enthusiasm, saying things like,

> "Nice, I liked that they're present," (IP 3)

> "I liked this technology a lot and didn't expect that such a thing would be available in Lebanon." (IP 8)

## Perceptions of Health, Cleanliness, and Naturalness

The study found that consumers held diverse opinions about VHF products. While most respondents had a positive view, considering these products as healthy and natural, a few had negative perceptions, seeing them as artificial, unnatural, and less nutritious. Most participants emphasized the importance of clean, fresh, natural, and chemical and pesticide-free produce. Most participants reflected on the importance of the products being clean and devoid of soil. They also mentioned that Lebanon suffers from water shortage and the access to clean water required for washing the vegetables is not easy. They were also attracted to the concept of VHF as they believed that it could provide more natural produce compared to conventionally grown options available in the market. They considered factors such as taste and smell of the product. One participant expected that the VHF products would have a natural and desirable taste:

> “I expect these products to have the 100% exact pure right taste since it is pesticide and chemical-free”. (IP 6)

Another participant said that she has a hot pepper plant in a pot on the balcony and because it is pesticide and chemical-free it has the exact right taste, and it is really hot, unlike the ones she buys from the market. Another one expected the VHF product's taste would be even better than the conventional ones since the seeds are wisely selected and the plants are given all the minerals they need for optimal growth. Another participant highlighted the importance of the smell of the product:

> "The product appears from its smell. I mean, in the past, our grandparents used to say that if we just cut tomatoes or watermelon, their smell reached the end of the house. Today, we already know that what we eat is not healthy, and we buy it". (IP 1)

The participants perceived VHF products as a healthier choice, as they believed these products were devoid of harmful chemicals and pesticides commonly used in traditional agriculture. One participant considered VHF as an investment in their health, stating,

> "Health-wise, it is better for health because according to what they said, there are no chemicals and pesticides in them, it is definitely much better for health, and I loved the idea". (IP 8)

Besides, some statements highlighted three participant's deep sense of responsibility and dedication to providing their children with a healthy and chemical-free diet. Those participants prioritize their children's well-being and express a strong desire to take every possible measure to ensure health and safety, including seeking out alternative food sources that align with their concerns:

> "I'm forgetting a little bit about myself. I think more about my son and feel that I don't like to see him sick; I want to surround him with the right environment. I want to feed him healthy things" (IP 2)

> "This thing is also very good for babies or those who are just starting to eat. I am very afraid to feed my son something that contains

> chemicals. So, I might feed him from these products with my mind at ease" (IP 8)

However, one participant expressed a preference for natural food from conventional farms, valuing products that were nourishing and came from their environment. They questioned the compatibility and nourishment provided by VHF products, suggesting that food grown in a different environment might not be as beneficial. This participant also raised concerns about researching the health effects of VHF products.

## Technological Acceptance and Consumer Behaviour

There were different attitudes and motives for exploring a new technology or product. While most of the participants were enthusiastic and certain to try this new technology, few others were hesitant at first owing to causes such as fear, novelty, or safety concerns. Two participants, for example, indicated some fear or hesitation about testing this new technology due to its novelty. They do, however, suggest that they would be prepared to try it if it were more commonly embraced:

> "At first, I'd be afraid to try it because it's a new technology, especially after Coronavirus, but once it's widespread, I'll give it a shot". (IP 5)

> "The idea is still new, I don't know what they might add to them, and they are still under development, with time everything will be clear". "When a new product is initially introduced in limited quantities, people tend to be hesitant or sceptical. However, as the product becomes more widely available, the demand for it increases, and more individuals become willing to try it out." (IP 7)

One of them also considered the influence of technology on the future:

> "Even the idea that they use new technology and are not planted in the soil makes me wonder what our future will be like with all of this technology". (IP 5)

Most participants, however, exhibited a want to try this new technology, motivated by causes such as taste, curiosity, a desire for new experiences, health advantages, and the allure of unique notions. For example, two participants said that they were interested in exploring new experiences,

> "For sure I will try it I'm interested in trying new things". (IP 3)

However, one participant did not accept the VHF technology, stating,

> "I have no problem trying them and I did not deny that these vegetables are living organisms however I do not think they might be a lifestyle for me or my family. I have neither felt the VHF products are positive nor have I accepted them." (IP 10)

## Affordability and Purchase Decisions Regarding VHF Products

**Affordability**: When it comes to affordability, some of the participants initially thought that these products would not be affordable, and this might be either because of the enhanced system of the VHF or the lack of trust in the Consumer Protection Organization. One participant mentioned that:

> "their prices would be extremely high, maybe double or triple compared to the conventional products." (IP 6),

> "We do not have active consumer protection in Lebanon. I cannot guarantee that they do not provide me with wrong information so there isn't much monitoring or trust in it". (IP 4)

Another participant mentioned that it depends on the greediness and profiteering of the seller. She also added that when a new product enters the market, it tends to be priced at a higher level initially. This is because the target audience for new products is often the affluent class, as they are more likely to be early adopters.

**Purchase decisions:** As the participants were asked about their willingness and decisions to purchase products from VHF, a range of viewpoints emerged including affordability, health, convenience, and packaging.

Some participants placed a high value on affordability and expressed that they would only buy the products on rare occasions if they were reasonably priced while also emphasizing the health benefits, stating,

> "If the price is somehow affordable, I will consider buying from time to time because it is healthier," (IP 2)

> "If there is no big difference in prices and I know these are cleaner and healthier, I would buy because these are supposed to enter our body." (IP 3)

The participants also acknowledged the impact of their current financial situation on their purchase decisions. They mentioned that although they wished to buy healthy and organic products, their circumstances sometimes influenced their choices. One participant remarked,

> "We often wish to buy healthy and organic products, but also the circumstances in which a person lives control his purchase decisions sometimes." (IP 7)

On the other hand, some participants prioritized the health advantages and were willing to pay a premium for the products, viewing it as an investment in their well-being. One participant expressed this viewpoint, saying,

> "I would buy even if it would be more expensive because I think instead of putting money into buying medicine, I would put it into buying healthy and fresh products." (IP 8)

Another participant focused on convenience and time efficiency. They explained that they opted not to consume products that required significant time to wash off the soil, citing a lack of time for such tasks. Convenience played a crucial role in

their decision-making process, and they mentioned their willingness to pay a higher price for products that aligned with their interests or preferences.

One participant also highlighted the importance of the packaging of the products:

> “If I found the product packaged in a good way, for example, the cabbage clean and does not require too much washing, I like to buy such products”. (IP 4)

However, after being informed about the price difference between conventional farm products and those from VHF, some participants noted that the price difference was insignificant. This information led some of them to reconsider their options, with phrases like

> "Not so much difference." (IP 3),

> "I would consider buying from time to time." (IP 4)

being expressed.

## Environment and Sustainability

Most participants emphasized the benefits of this innovative technology, which supports sustainability, health, and environmental preservation. Some participants highlighted that because the use of trucks and tractors is eliminated by this technology, therefore, the $CO_2$ emissions that cause air pollution will be reduced. They also added that the use of solar systems is more sustainable for the environment. Most of them highlighted the importance of this technology in water and land conservation because as they mentioned there is a water crisis in Lebanon especially for the participants living in Beirut. They also mentioned that they buy drinking water because the water provided at home is polluted and salty and hence cannot be used to wash fruits and vegetables. Besides, one participant said that because the VHF products do not contain soil, they do not need to be washed with too much water in comparison to the conventional ones that are contaminated with soil. Thus, water will be saved and perhaps she thinks this technology needs great encouragement. Moreover, one participant mentioned that:

> “the groundwater will be protected from contamination with pesticides and chemicals.” (IP 9)

Regarding land conservation they said that the land saved can be used for other purposes especially in a small country like Lebanon such as planting fruitful trees that can compensate for providing $O_2$, constructing buildings and solar systems, and starting new businesses.

## Economic Aspects and Job Opportunities

On the economic level, the participants had diverse points of view. One participant highlighted the importance of starting such farms in offering job opportunities, especially because Lebanon is suffering from an extreme economic crisis in addition to the corruption on many levels in the society. Another participant who lives in an agricultural area in Lebanon highlights the importance of implementing strategies such as VHF to protect crops and maximise profitability in the face of certain challenges posed by environmental factors and pests:

> “In front of us, there is a large and wide garden where tomatoes and bell peppers are being cultivated. However, there are potential risks such as damage from rain, worms, and insects. Taking measures to prevent these issues is crucial to maximize profits”. (IP 9)

On the other hand, some participants reflected on the negative effect of VHF on the economy suggesting that if consumers would shift to consuming VHF produce this might decrease the demand for the conventionally produced ones and this might negatively affect the farmers. Another participant highlighted the high start-up costs needed for this technology, stating,

> “These costs would include expenses that institutions may incur to establish such facilities in easily accessible agricultural areas. It is expected that this investment would result in a cleaner, higher-quality, and healthier crop production that is suitable for our local environment”. (IP 10)

# Discussion

## Result discussion

This study is the first to analyse Lebanese consumers' knowledge of the VHF and their awareness of its presence in Lebanon as well as their attitudes towards VHF and the factors influencing their desire to buy VHF products. As VHF is still a new sector, there are only two small VHFs in Lebanon. In the following, the results will be discussed in terms of the extended TAM model (see Appendix 2).

### Subjective knowledge construct

The findings of this study reveal that the participants did not have previous knowledge about VHF before participating in the interview, thus subjective knowledge, the first construct in the model, has no significant impact on the perceived sustainability of the VHF. This also aligns with previous research on hydroponics production, where most consumers were unfamiliar with the hydroponic system and their products (Gilmour, 2018). Furthermore, the participants in this study expressed a lack of awareness regarding the existence of VHF in Lebanon. This gives an insight that the presence of VHF is still unknown in Lebanon. In research done in Sweden on hydroponics, it turned out that half of the Swedish participants did not know about the technology even though Hydroponics dominates the production of tomatoes, salads, and herbs offered in Swedish supermarkets (Spendrup et al., 2024). Thus, it is not surprising that in a developing country like Lebanon, there is neither knowledge nor awareness regarding VHF. When trying to search for an explanation for this finding, it could be argued that consumers have limited awareness of food production as Song et al. (2022) suggested. Customers prioritise health, nutrition, and taste over the production system when purchasing vegetables (Song et al., 2022).

### Attitude towards sustainability construct

In this study, most participants were aware of a healthy lifestyle especially when it comes to consuming pesticide and chemical-free products that may result in ill-borne illnesses. They perceived VHF as a new technology to maintain food safety.

They also highlighted the importance of clean soilless products and the positive impact of the VHF products on their health. Most participants in this study considered the VHF systems to be environmentally friendly and sustainable, despite their lack of information on VHF, which is one expression of the perceived sustainability construct. Thus, the construct of attitude towards sustainability has a positive influence on the consumers' perceptions of the sustainability of VHF systems. This construct includes remarks like eating a healthy diet and being environmentally friendly. According to a study by Jürkenbeck et al., (2019) a healthy diet is becoming increasingly essential to consumers. The findings of this study are consistent with a previous study by Wibowo et al., (2023) that showed that the consumer's awareness of a healthy lifestyle is the main driver of the acceptance and comprehension of choosing VHF products vs conventional items. Therefore, consumers who are aware that their eating habits influence the environment, aim to be more ecologically responsible, and as a result, they may include VHF products in their food selections (Jürkenbeck et al., 2019).

## Perceived sustainability construct

In this study, the participant's favourable attitude towards sustainability had a positive influence on the perceived sustainability construct. The analysis of this study implies that perceived sustainability mainly the life satisfaction perspectives including health care, is the primary driver of VHF acceptability. According to the extended TAM theory, the more favourable the system's sustainability is regarded, the more likely it is that the system will be perceived as useful, and finally the higher the chance to purchase VHF products and accept this new and innovative technology in food production (Jürkenbeck et al., 2019). The finding that sustainability influences consumers' food choices is consistent with prior research (Hüttel et al., 2018; Vecchio & Annunziata, 2015). Thus, the behavioural intention to buy VHF products depends primarily on the consumers' perceived sustainability.

## The environmental attitude toward agriculture

The environmental attitude toward agriculture positively impacted the perceived usefulness where most of this study's participants viewed pesticide and chemical use in conventional farming methods as excessively high and harmful for the environment. They were pleased to know that VHF uses no pesticides and chemicals. This is consistent with a previous study by Broad et al., (2021) which found that participants who voiced support were pleased by statements about lowering agriculture's dependency on chemical inputs such as pesticides and fertilisers. However, in this study, few participants had concerns about the perceived "naturalness" of VHF products. Those participants prioritized organic or traditional farming methods and perceived VHF as less useful. This is consistent with prior research by Jürkenbeck et al., (2019) in which consumers weakly agreed that VHF agriculture is not too artificial. Therefore, an appropriate next step suggested by Jürkenbeck et al., (2019) will be to investigate how the sacrifice of herbicides and pesticides, and hence the untreated growing situation, is communicated to the consumer.

## Subjective norms construct

Most of the participants were more inclined to purchase the VHF products when the community surrounding the participant views the product as favourable, and as the technology becomes more prevalent. Even the participants who showed food neophobia acknowledged that as a new product becomes more prevalent, they tend to become more confident to try it. Therefore, the perception of the subjective norms, a TRA construct, played a positive role in enhancing the acceptance of consumers towards VHF products. The findings of this study contradict the findings of Al Mamun et al., (2023) which examined the intention and adoption of VHF among Chinese urbanites showed that social influence had no substantial effect on intention.

## Technology affinity construct

VHF, being a novel growth method, introduces some uncertainties, which may differ for consumers with high and low affinities for new food technology, or with varying degrees of understanding about the VHF system (Jürkenbeck et al., 2019).

In this study, most of the participants had a high level of innovativeness, encompassed factors such as curiosity, taste, health advantages, and novelty which played a role in motivating participants to try the new product and have higher expectations regarding its perceived usefulness. On the other hand, two participants had a low affinity for new food technology known as food neophobia and were cautious about exploring emerging technology-based products/services because they were unfamiliar with them. Their perceptions of risks, such as novelty, safety concerns, and future implications, negatively influenced their willingness to explore the technology.

This study reveals a minimal moderating influence of novelty-seeking on consumers' perceived risks and attitudes towards adopting VHF as a modern food technology. Therefore, the technology affinity construct of the extended TAM model positively influences the perceived usefulness of VHF. The findings of this study align with a recent study by Al Mamun et al., (2023) which assumed that Chinese urbanites are generally enthusiastic and driven to attempt novel agricultural methods, such as VHF, giving them a sense of accomplishment in keeping up with the modern world and its transformation.

## Perceived usefulness construct

The viewpoints of the participants in this study regarding the economic implications of VHF align with the TAM's construct of perceived usefulness. The participant who emphasized the importance of starting VHF farms to create job opportunities reflects the perceived usefulness of VHF in addressing the economic crisis and corruption issues in Lebanon. Additionally, the participant living in an agricultural area highlighted the perceived usefulness of VHF in maximizing profitability and protecting crops from environmental factors and pests. On the other hand, few participants expressed concerns about the negative economic effects of VHF. The notion that a shift towards consuming VHF produce might decrease demand for conventionally produced ones and negatively impact farmers reflected the participants' perception of VHF's potential disruption to the existing agricultural market.

The previous four constructs of the extended TAM model (perceived sustainability, environmental attitude towards agriculture, subjective norm, and technological affinity) had a positive impact on perceived usefulness. Therefore, perceived usefulness has a substantial impact on the attitude toward buying. A study by Chen et al., (2020) showed that consumers' perceived usefulness plays a major role in the reference and consumption of VHF-produced microgreens.

## The perceived behavioural control, attitude towards buying and behavioural intention to buy construct

This study examined the factors influencing participants' attitudes and behavioural intentions towards buying VHF products, considering taste expectations, perceived quality factors, affordability considerations, health values, perceived sustainability, and the overall attitude towards buying.

The participants' positive taste expectations created a favourable attitude toward buying the VHF products, as participants saw them as an opportunity to enjoy flavourful and high-quality produce. Perceived quality factors also influenced participants' attitudes toward buying the VHF products as packaging of the VHF products and clear labelling, would instil trust in the participants and positively affect their behavioural intentions to purchase.

Moreover, affordability was an important consideration for some of the participants in this study when forming their attitudes toward buying VHF products. Initially, participants believed that these products might be unaffordable due to factors such as the enhanced system of VHF. These beliefs created a negative attitude toward buying the products. The unfavourable attitude was consistent with Coyle and Ellison (2017), who observed a lower willingness to pay for VHF lettuce than lettuce produced in greenhouses or outdoors. Similarly, Broad et al. (2021) warned that premium pricing might turn off many potential purchasers, limiting the industry's capacity to grow. Finally, a previous study showed that 72.1% of those surveyed responded that the price of VHF products would influence their purchase intentions (Huang, 2019). However, some of this

study's participants valued their health over affordability and were ready to pay a premium for VHF products and even those who placed high value on affordability due to their financial circumstances considered buying from time to time. Finally, as the participants became aware of the actual price difference between VHF products and conventional farm products, some noted that the price difference was not significant. This new information could have shifted their attitude toward buying the VHF products to a more positive or neutral stance.

All in all, most participants in this study believed that VHF had more advantages than other forms of agriculture, hence they were more inclined to support it. The perceived behavioural control construct of the TRA model had a dual impact on the participant's attitude toward buying the VHF products, however, the perceived usefulness construct of the extended TAM model had a positive effect on it.

The behavioural intention to buy is the extended TAM model's final construct (Jürkenbeck et al., 2019), and in this study, it relied to a significant extent on the consumers' perceived sustainability and the attitude towards buying.

## Implications for policymakers, vertical farmers, and marketers

The findings have implications for policymakers, vertical farmers, and marketers. To alleviate worries and promote the quality of VHF vegetables, it is critical to supply the public with adequate and correct information on the vegetables' nutrients, safety, and flavour. Detailed yet easy information regarding VHF growing systems will expand public knowledge of their necessity, characteristics, and benefits (Yano et al., 2021). It is critical to inform consumers that VHF vegetables may be as or even healthier than those grown outdoors particularly because they are concerned about the perceived usage of chemicals and pesticides. Packaging or labelling that includes nutritious information, as well as charts or graphs comparing the contents of VHF and outdoor-grown vegetables, would help consumers evaluate them and increase their confidence. Besides, long-term, educational seminars and school sessions on such topics might improve public comprehension of their nutritional implications (Costa-Font et al., 2008).

Moreover, building product awareness and comprehension on social media is a successful marketing technique, which leads to consumer purchase choices (Wibowo et al., 2023). Finally, consumer perceptions about VHF are anticipated to improve as it becomes more prevalent (Yano et al., 2021).

## Methodological discussion and suggestions for future research

This study has several limitations.

The current study collected data from a small sample hence the findings may not be representative of the wider population, and the generalizability of the results may be limited. The specific characteristics and attitudes of the participants in the study may not accurately reflect the broader population, leading to potential biases in the findings. As a result, it is suggested that future studies on VHF use a larger sample size from a diversified demographic group across different locations in Lebanon to provide a more comprehensive understanding of consumer attitudes towards VHF.

Convenience sampling employed only female participants so this might have affected the results therefore future research might consider including male participants as well.

Due to the participant’s limited prior knowledge of the VHF system, a short video that presented the positive aspects of VHF was shown to the participants and at some points the author tried to explain more about the technique, thus it is plausible that it could have influenced the participants' attitudes and potentially led to more positive responses. While the current study did not indicate such an influence, it is an important consideration for future research.

The author's familiarity with the consumers provided them with a deeper understanding of their attitudes, surpassing that of researchers who lack first-hand experience in Lebanon. However, it is important to acknowledge that this could potentially lead to a narrower perspective or biased interpretations of the data. The researcher's preconceived notions or beliefs may unintentionally influence the

design of the study, the data collection process, and the analysis of the findings, potentially leading to biased results. Therefore, it was also crucial for the author to be aware of their own biases and strive for objectivity throughout the research process to minimize any potential impact on the results. A mixed-methods approach may be used in future studies where quantitative data can provide statistical generalizability and identify patterns and trends. In contrast, qualitative data can provide rich contextual information and capture participants' perspectives in-depth. By combining both types of data, researchers can complement each other's strengths and weaknesses, leading to a more comprehensive understanding of the research topic that can strengthen the validity and reliability of the findings. Further research could examine how knowledge, attitudes, and technological acceptance develop over time as the VHF system gains popularity.

## Relevance for the subject of food and meal science

Vertical hydroponic farming is a modern agricultural practice that involves growing plants in a soilless system, typically in vertically stacked layers. This method of farming has the potential to impact various aspects of the food and meal science field, including sustainable food production, nutrition, food safety, and agricultural technology. Researchers in the field of food and meal science may be interested in studying VHF to understand its implications for food quality, nutritional content, flavour profiles, resource efficiency, and the development of innovative food products. Additionally, VHF can contribute to discussions on food security, urban agriculture, and alternative farming practices, making it a relevant topic in the food and meal science field.

# Conclusions

This study explored Lebanese consumers’ knowledge and attitudes towards VHF, their awareness of the presence of VHF in Lebanon, as well as what influences their desire to buy VHF products. The results were analysed using the extended TAM model that unveiled how the consumer’s attitudes related to their personal characteristics.

The findings of this study showed that the participants had limited prior knowledge about VHF and they were not aware of the presence of VHF in Lebanon. Consumer’s attitudes towards VHF were mainly positive with most of the participants viewing VHF as a sustainable form of agriculture. Few expressed negative opinions about the naturalness of the VHF products. Affordability had a significant influence on consumer’s desire to buy VHF products.

It is critical to increase public understanding of VHF by giving adequate information about its growth methods, food safety management, and yield quality as compared to traditional farming.

It is important to note that these findings are specific to the study's context and may not apply universally. Further research is needed to investigate the impact of information about VHF on consumers' attitudes and purchase intentions towards VHF products.

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# References

Ackerman, K., Conard, M., Culligan, P., Plunz, R., Sutto, M.P., & Whittinghill, L. (2014). Sustainable food systems for future cities: The potential of urban agriculture. *The Economic and Social Review, 45*, 189–206.

Aires, A. (2018). Hydroponic production systems: Impact on nutritional status and bioactive compounds of fresh vegetables. *Vegetables: Importance of Quality Vegetables to Human Health*, *55*. http://dx.doi.org/10.5772/intechopen.73011

Ajzen, I. (1985). In Action Control: From Cognition to Behavior. In *From intentions to actions: A theory of planned behaviour.* Kuhl, J., Beckmann, J., Eds.; Springer: Berlin, Germany, 1st ed., 11–39.

Alfozan Social Foundation. (2023). برنامج سين٢ / مستقبل الأكل - الحلقة ٢٣ كاملة [Video]. Aram Tv. Retrieved April 14, 2023, from https://youtu.be/9KC4XKEn10o?si=29nFjH6uyapXybah

Al Mamun, A., Naznen, F., Jingzu, G., & Yang, Q. (2023). Predicting the intention and adoption of hydroponic farming among Chinese urbanites. *Heliyon, 9*(3), e14420. https://doi.org/10.1016/j.heliyon.2023.e14420

Awwad, N. (2023). Food Security in Lebanon. *Food, Middle East, Sustainable Development*, https://www.ecomena.org/food-security-in-lebanon/

Bhanja, S.N, Mukherjee, A., & Rodell, M. (2018) Groundwater storage variations in India. In A. Mukherjee, (Ed.), *Groundwater of South Asia.* Springer Hydrogeology. Springer, Singapore, 49–59. https://doi.org/10.1007/978-981-10-3889-1_4

Broad, G. M., Marschall, W., & Ezzeddine, M. (2021). Perceptions of high-tech controlled environment agriculture among local food consumers: using interviews

to explore sense-making and connections to good food. *Agriculture and Human Values*, *39*(1), 417–433. https://doi.org/10.1007/s10460-021-10261-7

Bugbee, B. (2004). NUTRIENT MANAGEMENT IN RECIRCULATING HYDROPONIC CULTURE. *Acta Horticulturae*, *648*, 99–112. https://doi.org/10.17660/actahortic.2004.648.12

Chen, H., Tong, X., Tan, L., & Kong, L. (2020). Consumers' acceptability and perceptions toward the consumption of hydroponically and soil grown broccoli microgreens. *Journal of Agriculture and Food Research*, *2*, 100051. https://doi.org/10.1016/j.jafr.2020.100051

Cho, R. (2011). *Vertical Farms: From Vision to Reality*. State of the Planet. https://news.climate.columbia.edu/2011/10/13/vertical-farms-from-vision-to-reality/

Costa-Font, M., Gil, J. M., & Traill, W. B. (2008). Consumer acceptance, valuation of and attitudes towards genetically modified food: Review and implications for food policy. *Food Policy*, *33*(2), 99–111. https://doi.org/10.1016/j.foodpol.2007.07.002

Coyle, B. D., & Ellison, B. (2017). Will consumers find vertically farmed produce" out of reach"? *Choices*, *32*(1), 1-8. https://www.jstor.org/stable/90014636?typeAccessWorkflow=login

Davis, F. D. (1989). Perceived Usefulness, Perceived Ease of Use, and User Acceptance of Information Technology. *MIS Quarterly*, *13*(3), 319. https://doi.org/10.2307/249008

Davis, F. D., Bagozzi, R. P., & Warshaw, P. R. (1989). User Acceptance of Computer Technology: A Comparison of Two Theoretical Models. *Management Science*, *35*(8), 982–1003. https://doi.org/10.1287/mnsc.35.8.982

Despommier, D. (2013). Farming up the city: the rise of urban vertical farms. *Trends in Biotechnology*, *31*(7), 388–389. https://doi.org/10.1016/j.tibtech.2013.03.008

Donoghue, S. (2010). Projective techniques in consumer research. *Journal of Family Ecology and Consumer Sciences /Tydskrif Vir Gesinsekologie En Verbruikerswetenskappe*, *28*(1). https://doi.org/10.4314/jfecs.v28i1.52784

Ekstrom, G. (2002). Pesticide reduction in developing countries. *National (Swedish) Chemicals Inspectorate Solna, Sweden, editor. Encyclopedia of pest management. Sweden: Marcel Dekker*, 598–602. https://pestcontrol.ru/assets/files/biblioteka/file/03-david_pimentel-encyclopedia_of_pest_management-crc_press_2002.pdf

Fenstermacher, G. D., & Richardson, V. (2005). On Making Determinations of Quality in Teaching. *Teachers College Record, 107*(1), 186–213. https://doi.org/10.1111/j.1467-9620.2005.00462.x

Fishbein, M., & Ajzen, I. (1975). *Belief, Attitude, Intention, and Behavior*. Addison Wesley Publishing Company.

Frewer, L., Bergmann, K., Brennan, M., Lion, R., Meertens, R., Rowe, G., Siegrist, M., & Vereijken, C. (2011). Consumer response to novel agri-food technologies: Implications for predicting consumer acceptance of emerging food technologies. *Trends in Food Science & Technology*, *22*(8), 442–456. https://doi.org/10.1016/j.tifs.2011.05.005

Galletta, A. (2013). *Mastering the Semi-Structured Interview and Beyond*. NYU Press. http://books.google.ie/books?id=NdbtHg6sPgIC&printsec=frontcover&dq=Mastering+the+Semi-Structured+Interview+and+Beyond:+From+Research+Design+to+. .+By+Anne+Galletta&hl=&cd=1&source=gbs_api

Gentry, M. (2019). Local heat, local food: Integrating vertical hydroponic farming with district heating in Sweden. *Energy*, *174*, 191–197. https://doi.org/10.1016/j.energy.2019.02.119

Gilmour, D. (2018). *Consumers' Willingness to Pay for Hydroponic Lettuce*. https://scholarworks.uark.edu/cgi/viewcontent.cgi?referer=&httpsredir=1&article=4273&context=etd

Graamans, L., Baeza, E., Van den Dobbelsteen, A., Tsafaras, I., & Stanghellini, C. (2018). Plant factories versus greenhouses: Comparison of resource use efficiency. *Agricultural Systems*, *160*, 31–43. https://doi.org/10.1016/j.agsy.2017.11.003

Graamans, L., Van den Dobbelsteen, A., Meinen, E., & Stanghellini, C. (2017). Plant factories; crop transpiration and energy balance. *Agricultural Systems*, *153*, 138–147. https://doi.org/10.1016/j.agsy.2017.01.003

Gruber, T., Szmigin, I., Reppel, A. E., & Voss, R. (2008). Designing and conducting online interviews to investigate interesting consumer phenomena. *Qualitative Market Research: An International Journal*, *11*(3), 256–274. https://doi.org/10.1108/13522750810879002

Huang. (2019). Consumer Attitude, Concerns, and Brand Acceptance for the Vegetables Cultivated with Sustainable Plant Factory Production Systems. *Sustainability*, *11*(18), 4862. https://doi.org/10.3390/su11184862

Hayden, A. L. (2006). Aeroponic and Hydroponic Systems for Medicinal Herb, Rhizome, and Root Crops. *HortScience*, *41*(3), 536–538. https://doi.org/10.21273/hortsci.41.3.536

Hirschman, E. C. (1980). Innovativeness, Novelty Seeking, and Consumer Creativity. *Journal of Consumer Research*, *7*(3), 283. https://doi.org/10.1086/208816

Hwang, J., Kim, H. M., Kim, J. J., & Kim, I. (2021). Investigation of perceived risks and their outcome variables in the context of robotic restaurants. *Journal of Travel & Tourism Marketing*, *38*(3), 263–281. https://doi.org/10.1080/10548408.2021.1906826

Hüttel, A., Ziesemer, F., Peyer, M., & Balderjahn, I. (2018). To purchase or not? Why consumers make economically (non-)sustainable consumption choices. *Journal of Cleaner Production*, *174*, 827–836. https://doi.org/10.1016/j.jclepro.2017.11.019

Joo, K., & Hwang, J. (2023). Acceptance of Green Technology-Based Service: Consumers' Risk-Taking Behavior in the Context of Indoor Smart Farm Restaurants. *Applied Sciences*, *13*(20), 11433. https://doi.org/10.3390/app132011433

Jürkenbeck, K., Heumann, A., & Spiller, A. (2019). Sustainability Matters: Consumer Acceptance of Different Vertical Farming Systems. *Sustainability*, *11*(15), 4052. https://doi.org/10.3390/su11154052

Kannan, M., Elavarasan, G., Balamurugan, A., Dhanusiya, B., & Freedon, D. (2022). Hydroponic farming – A state of the art for the future agriculture. *Materials Today: Proceedings*, *68*, 2163–2166. https://doi.org/10.1016/j.matpr.2022.08.416

Keegan, S. (2009). *Qualitative Research: Good Decision Making Through Understanding People, Cultures and Markets*.

Kurihara, S., Ishida, T., Suzuki, M., & Maruyama, A. (2014). Consumer Evaluation of Plant Factory Produced Vegetables. *Focusing on Modern Food Industry*, *3*(0), 1. https://doi.org/10.14355/fmfi.2014.0301.01

Lal, R. (2015). Restoring Soil Quality to Mitigate Soil Degradation. *Sustainability*, *7*(5), 5875–5895. https://doi.org/10.3390/su7055875

Lambin, E. F., & Meyfroidt, P. (2011). Global land use change, economic globalization, and the looming land scarcity. *Proceedings of the National Academy of Sciences*, *108*(9), 3465–3472. https://doi.org/10.1073/pnas.1100480108

Lambin, E. F. (2012). Global land availability: Malthus versus Ricardo. *Global Food Security*, *1*(2), 83–87. https://doi.org/10.1016/j.gfs.2012.11.002

Lehman, R., Cambardella, C., Stott, D., Acosta-Martinez, V., Manter, D., Buyer, J., Maul, J., Smith, J., Collins, H., Halvorson, J., Kremer, R., Lundgren, J., Ducey, T., Jin, V., & Karlen, D. (2015). Understanding and Enhancing Soil Biological Health: The Solution for Reversing Soil Degradation. *Sustainability*, *7*(1), 988–1027. https://doi.org/10.3390/su7010988

Lin, Y. H., Lee, T. H., & Wang, C. K. (2021). Influence Analysis of Sustainability Perceptions on Sense of Community and Support for Sustainable Community Development in Relocated Communities. *International Journal of Environmental Research and Public Health*, *18*(22), 12223. https://doi.org/10.3390/ijerph182212223

Martin, M., & Orsini, F. (2022). Life cycle assessment of indoor vertical farms. In A. Kozai and Hayashi (Ed.), *Advances in Plant Factories: New Technologies in Indoor Vertical Farming* (Vol.141). Burleigh and Dodds. https://doi.org/10.19103/AS.2023.0126

Maxwell, J. (2012). *Qualitative Research Design: An Interactive Approach* (3rd ed., Vol. 41). SAGE Publications.

Ministry of Environment Government of Lebanon. (2005). National Implementation Plans for the Management of Persistent Organic Pollutants. Beirut – Lebanon. 106.

Mir, M.S., Naikoo, N.B., Amin, Z., Bhat, T.A., Nazir, A., Kanth, R. H., Singh, P., Raja, W., Fayaz, S., Ahngar, T.A., Palmo, T., Bahar, F.A, Bhat, A., Mahdi, S., & Saad, A.A. (2022). Vertical farming: The future of agriculture: A review. *The Pharma Innovation Journal 11*(2): 1175-1195. https://www.researchgate.net/publication/358749034_Vertical_farming_The_future_of_agriculture_A_review

Perambalam, L., Avgoustaki, D. D., Efthimiadou, A., Liu, Y., Wang, Y., Ren, M., Petridis, A., & Xydis, G. (2021). How Young Consumers Perceive Vertical Farming in the Nordics. Is the Market Ready for the Coming Boom? *Agronomy*, *11*(11), 2128. https://doi.org/10.3390/agronomy11112128

Redlich-Amirav, D., & Higginbottom, G. (2014). New Emerging Technologies in Qualitative Research. *The Qualitative Report*. https://doi.org/10.46743/2160-3715/2014.1212

Rollin, F., Kennedy, J., & Wills, J. (2011). Consumers and new food technologies. *Trends in Food Science & Technology*, *22*(2–3), 99–111. https://doi.org/10.1016/j.tifs.2010.09.001

Siegrist, M. (2008). Factors influencing public acceptance of innovative food technologies and products. *Trends in Food Science & Technology*, *19*(11), 603–608. https://doi.org/10.1016/j.tifs.2008.01.017

Song, X., Bredahl, L., Diaz Navarro, M., Pendenza, P., Stojacic, I., Mincione, S., Pellegrini, G., Schlüter, O. K., Torrieri, E., Di Monaco, R., & Giacalone, D. (2022). Factors affecting consumer choice of novel non-thermally processed fruit and vegetables products: Evidence from a 4-country study in Europe. *Food Research International*, *153*, 110975. https://doi.org/10.1016/j.foodres.2022.110975

Spendrup, S., Bergstrand, K. J., Thörning, R., & Hultberg, M. (2024). Consumer attitudes towards hydroponic cultivation of vegetables – Specifically exploring the impact of the fertilisation strategy (using mineral origin or food waste as fertilisers). *Food Quality and Preference*, *113*, 105085. https://doi.org/10.1016/j.foodqual.2023.105085

Stratton, S. J. (2021). Population Research: Convenience Sampling Strategies. *Prehospital and Disaster Medicine*, *36*(4), 373–374. https://doi.org/10.1017/s1049023x21000649

*Sustainable consumption and production | Department of Economic and Social Affairs*. (2021, August 3). Sustainable Consumption and Production | Department of Economic and Social Affairs. https://sdgs.un.org/topics/sustainable-consumption-and-production

Touliatos, D., Dodd, I. C., & McAinsh, M. (2016). Vertical farming increases lettuce yield per unit area compared to conventional horizontal hydroponics. *Food and Energy Security*, *5*(3), 184–191. https://doi.org/10.1002/fes3.83

Vatistas, C., Avgoustaki, D. D., & Bartzanas, T. (2022). A Systematic Literature Review on Controlled-Environment Agriculture: How Vertical Farms and Greenhouses Can Influence the Sustainability and Footprint of Urban Microclimate with Local Food Production. *Atmosphere*, *13*(8), 1258. https://doi.org/10.3390/atmos13081258

Vecchio, R., & Annunziata, A. (2015). Willingness-to-pay for sustainability-labelled chocolate: an experimental auction approach. *Journal of Cleaner Production*, *86*, 335–342. https://doi.org/10.1016/j.jclepro.2014.08.006

Wibowo, N. S., Ubud, S., & Purnamasari, M. (2023). The Analysis of Consumers' Product Knowledge and Marketing Strategies for Organic and Hydroponic Vegetables: A Case Study of "Say, Yours-From Farm to Table Concept." *E3S Web of Conferences*, *388*, 03004. https://doi.org/10.1051/e3sconf/202338803004

Wilkerson, J. M., Iantaffi, A., Grey, J. A., Bockting, W. O., & Rosser, B. R. S. (2014). Recommendations for Internet-Based Qualitative Health Research with

Hard-to-Reach Populations. *Qualitative Health Research*, *24*(4), 561–574. https://doi.org/10.1177/1049732314524635

Yano, Y., Nakamura, T., Ishitsuka, S., & Maruyama, A. (2021). Consumer Attitudes toward Vertically Farmed Produce in Russia: A Study Using Ordered Logit and Co-Occurrence Network Analysis. *Foods*, *10*(3), 638. https://doi.org/10.3390/foods10030638

# Appendix 1

**Theme: Food Neophobia**

1) If you were served a product from these farms, would you try it? Why? Why not? What factors might you consider?

**Theme: Availability**

2) Do you think they are available in Lebanon?

**Theme: Economy**

3) If you liked the taste of these products, would you buy them?
4) Do you think that the VHF products are affordable?
5) If these are available and affordable, would you buy them?

**Theme: Sustainability**

6) What factors do you consider when making purchasing decisions for fresh produce?
7) How important is the quality of fresh produce in your purchasing decisions?

# Appendix 2

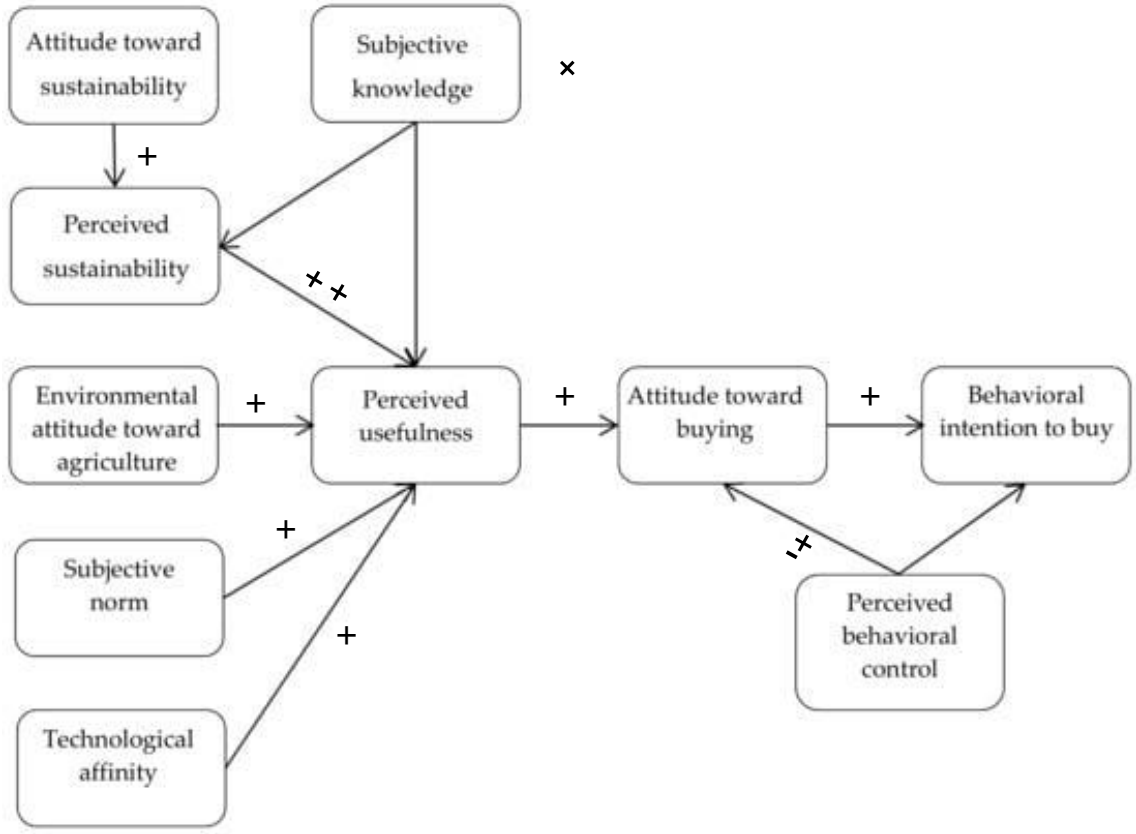


Figure 2 shows the relative effect of the exogenous latent variables on their related endogenous variables in the extended TAM model (Jürkenbeck et al., 2019). Notes: (+) positive effect; (-) negative effect.