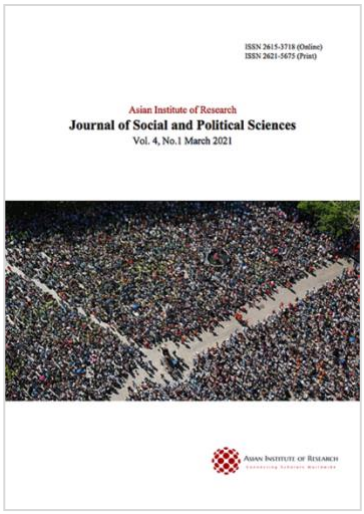

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Sustainable Development: Factors Influencing Public Intention towards Vertical Farming in China and Moderating Role of Awareness

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Abstract
Vertical farming brings an innovation in agriculture sector by improving production of food in optimized space within controlled environment without wastage of natural resources by using an automated technological system. It acquiring prominence around the world however incapable to accomplish goals, reason was lack of awareness, lack of public intention and participation towards vertical farming. This study filled the gap in prior literature and adding more creativity to influence public intention. The research used TPB to investigate the factors influencing public intention toward vertical farming and a moderating role of awareness. Data collected from Chinese consumers by convenience sampling technique, total 335 responses obtained and analyzed by using Structural Equation Model. The result of the study demonstrated that food safety and environmental concern are the best predictors of public intention towards vertical farming. Further awareness significantly strengthened the relationship between food safety concern and public intention. In the conclusion, study proposed appropriate recommendations to local government, stakeholders, urban planners, and food companies for the best practices to facilitate the successful implementation of vertical farming as sustainable for environment and health, which is also profitable business as public intention concurs.

Keywords: Vertical Farming, Environmental Concern, Food Safety Concern, Awareness, Public Intention

1. Introduction

World population increase up to 29% by 2050, arable lands will only increase with less than 5% over the same period. According to report of UN the growth of world population will reach to 8.3 million in 2050 (*World Population Prospects*, 2013). With the rapid growth of universe, many disputes escalating. A major issue occurs is to feed the ever-growing population as a conventional way of food production is inadequate. With ever-growing population urbanization is the biggest challenge that world facing; great shift from rural to urban areas. Studies revealed that many developing countries promoting urban agriculture in response to occurring issues due

to urbanization but the problems still exists. With this rapid growth of population around the world, China is having world biggest population of 1.43 billion. A total land area of China is 9388271 km^2 and 60.8% population is urban with median age of 38.4 years ("China Population ", 2020). According to the UN reported that urban population of China would increase 350 million by 2050 and 219 cities have more than one million populations compare to 35 cities in Europe (*World Population Prospects*, 2013). With this ever-growing urban population China facing various challenges of urbanization, food insecurity and food safety issues, environmental degradation, land deterioration and agriculture pollution, unemployment rate wastage of natural resources, natural disaster and increasing demand of fresh and healthy food and agricultural labor aging problems as young people are not interested to engage with the farming practices and the rest of the farmer are above 60 age (Al-Kodmany, 2018; Dubbeling et al., 2011; Tiraieyari et al., 2019). Urban designer and planner realize the significance of urban agriculture as it is an important urban element which is sustainable development as a global trend towards sustainability (Bailey, 1915), but the conventional way of farming in urban areas is inadequate; its development is not compatible with sustainability and also become reasons of environmental pollution and food safety issues in China. These issues bring policy makers, urban planner and researcher think about innovation in agriculture sector to conquer the surging problems and make sustainable cities, one such innovation is known as Vertical Farming.

According to Despommier Vertical farming is sustainable development in a city level, which increase the growth of food and response positively toward environmental pollution, food safety, urbanization and land deterioration (Despommier, 2010). Vertical Farming grows crops inside tall buildings within controlled environment by the use of an automated system. It also increases the growth of food without the use of chemical spray or pesticides and has no adverse effect of climate changes. Vertical Farming is a new form of sustainable development in a city level which has the ability to perform as an alternative model to conventional farming (Bailey, 1915). It can develop in any part of the world without any limitation of climate changes because plants grow indoor within controlled-environment without any adverse effect of climate variability, which means food grows much faster than conventional farming. The key objective of VF is to improve food security in developing countries or low income countries (Cıceklı et al., 2014). An author reported that CF fed 12.5 people per day by one acre whereas VF fed 97 per day with the same space area (Ankri, 2010). VF can strengthen the local economy by reducing the energy cost, save the cost of fertilizers, preserving the cost of long distance transportation and fuels used to supply food (Safikhani et al., 2014).

Various plant factories also known as vertical farms in China are; Agricultural S&T park in Xiaoshan, Zhejiang with an area of 40,000m^2, Agricultural S&T park in Sunqiao, Shanghai with an area of 50,000m^2 and vertical farms in Shunde, Guangdong with an entire space of 50,000m2, using both artificial and solar lights. The 250m^2 vertical farm in Fuzhou, Fujian produces head 260,000 lettuces. Dr. Yang concluded that "China will develop more indoor Vertical Farms than any other nations, VF improving growth of food uses automated system within controlled environment and less adverse of climate changes are all benefits of vertical farms" (Dr. Qichang Yang, 2015). Vertical farming gain popularity all around the world and China has massive population insides cities because of a great shift from rural to urban areas (Kan, 2009). In China existing vertical farms marketed as sustainable development, but few has not achieved goals, reasons are lack of financial and infrastructure support by a government, lack of public participation and a failure of implementation, lack of public awareness and intentions. People are more concern about environmental protection, food safety, locally food production, the price of food, naturalness, an absence of pesticides, ethics and norms. However, these are important drivers while supporting urban agriculture or purchase of food, agricultural innovation in the developing countries depends on the concern of public (Carola et al., 2013; Corinna et al., 2015; G.Grunerta et al., 2008). This subject is essential because vertical farming is gaining popularity in many countries and views as feeding a growing population, produced food in any region without adverse effect of climate changes, protect the environment and a make city sustainable.

Different researches have been conducted to examine motivating factors that have been found to be substantial in formation of consumer attitude, behavioral intentions and acceptance of urban agriculture, aquaculture, purchasing organic food or systems (Asif et al., 2018; Bilal et al., 2015; Michaelidou et al., 2007; Mingyan Yang

et al., 2015). To best of author understanding some motivating factors in formation of public intention in the context of Vertical Farming as sustainable development was lacking and has not been sufficiently examined. In earlier studies, Lack of awareness among the consumer became obstacles in acceptance and implementation of vertical farming system as sustainable development, but in a various framework, their presence found as best predictors or moderators on behavioral intention (Asif et al., 2018; Jürkenbeck et al., 2019). Prior researches have exposed relationship among influential factors with purchase intention of consumer towards aquaculture, green and organic products.

In the perspective of previous literature, this study aim was to identify the role of motivating factors that are Food safety concern and Environmental concern in predicting Public Intention towards Vertical farming by uses existing *Theory of Planned Behavior*. Factors adopted from the previous theoretical framework are the best predictors in the formation of public intention. Further Awareness was missing in a previous literature play a vital role as moderator in this study to strengthen the relation between factors and public intention intentions towards VF as shown in figure 1.

2. Literature Review

2.1. Theoretical Background

Previous researches related to attitude and behavioral intentions towards organic farming, urban agriculture, aquaculture, organic food among consumers, farmers, agricultural professional and juvenile (Bilal et al., 2015; Gotschi et al., 2007; Krøvel et al., 2019; Stobbelaar et al., 2007). Fewer quantitative researches that identify the public behavioral intention toward vertical farming and purchase of its products have done in China. People recognize naturalness, food safety, environmental protection, an absence of pesticides and price value are important drivers of their food choices and in developing countries agricultural innovation based on the concern of the public. Role of public towards the support of sustainable development is very important. In prior researches, influential factors play a vital role in formation of behavioral intentions toward organic farming, acceptance of vertical farming systems or purchase of food by using various models based on *"Theory of Reasoned Action, Theory of Planned Behavior, Model of Pro-Environmental Behavior, and Technological Acceptance Model"(Bilal et al., 2015; Gotschi et al., 2007; Jürkenbeck et al., 2019)*. The author suggested TPB for future studies as it is the most appropriate and powerful mechanism in predicting behavioral intention by examining interaction between social, individual and environment factor (Koshkaki et al., 2018). In this study Public intention represented the actual behavior of a public and whole concept depends on the theory of planned behavior to examined influential factors on public intentions towards Vertical farming as sustainable development and use of its products in China. Further Role of awareness of VF has been established that missing in previous literature to enhance the relation between factors and public intentions.

2.2. Research Hypothesis

Influential factors play a vital role in this study to positively affect intentions. External factors added in this proposed model adopted from various studies. According to author behavioral intention is the best predictor of actual behavior (Ajzen, 1991).

2.2.1. Environmental Concern [ENC]

Environmental concern defined as public concern about environmental deterioration and willing to solve those issues. An individual's concern for environmental problems has positive intentions towards any subject or system that makes an environment sustainable. People are becoming more environmental conscious and willing to play their role in any way to protect it (Bilal et al., 2015). Researchers recommended that environmental concern, general attitude towards an environment and perceived environmental responsibility are all emotions that support public to have positive an attitude and intentions towards sustainable agriculture activities that help

or make an environment sustainable (Stobbelaar et al., 2007; Storstad, 2003). Many prior studies showed a strong relationship between ENC and BI. Study-related to a green product indicated that ENC positively affect the behavior intention of consumers (Aman, 2012). ENC is one of the strong motivating factors to formed behavior intention in a related study of purchase of organic food and green products (Davies et al., 1995; Hutchins et al., 1997). Environmental protection or concern is one of the important influence behavioral intentions towards the purchase of any product or accept or support of any system. ENC play a critical role influencing the behavior intention of the public toward support of VF and use of its product. People have positive behavioral intention towards support of innovation in urban agriculture which makes a friendly environment. Based on above-mentioned literature following hypotheses developed as;

Hypothesis 1: *Environmental Concern significantly influence public intention towards the Vertical Farming*

2.2.2. Food safety concern [FSC]

Food safety and hygiene are top priority among people. Food safety concern defined as public concern about food-related issues or diseases. People are concern about food safety and have the ability to overcome food-related issues like food poisoning by the use of healthy and safe food. Prior study's author revealed that the consumer's willing to pay for the value linked with safety of food (Henson, 1996). Consumer more concern about health and food safety has positive behavioral intention toward innovation in food production. An author revealed in study that FSC is the most important factor of attitude and intention (Michaelidou et al., 2007). study that FSC is the most important factor of attitude and intention (Michaelidou et al., 2008). In the light of study related to organic food, food safety was a major reason behind the purchase of organic food (Henson, 1996). Food Safety in vertical farming is top priority as food grown organically within controlled environment without the use of the chemical spray or pesticides which greatly lower the risk of diseases in plants (Despommier, 2008). Based on above-mentioned literature following hypotheses developed as;

Hypothesis 2: *Food Safety Concern significantly influence public intentions toward the Vertical Farming*

2.2.3. Moderating Effect of Awareness of VF

Lack of awareness of vertical farming among consumers become obstacles in the acceptance of vertical farming systems and lack of support by the government become a failure of its implementation in city level (Jürkenbeck et al., 2019). Awareness is an individual's perception, knowledge about something or facts of anything. Many people know about conventional farming, urban farming, organic food, but fewer aware of vertical farming as a sustainable development in city level. More people aware about an object the more positive intention they have toward it. Some theoretically established the role of awareness as moderator to strengthen the relation between attitude and intention, it moderate significantly among attitude and intention to purchase. Awareness was a major factor that significantly influence consumer intention toward the purchase of organic food (Kapuge, 2016). In this study awareness act as moderator indicates awareness of vertical farming. It means people more aware of product or benefits have more behavioral intention towards it. The result of study concluded that awareness moderate positively on behavioral intention (Asif et al., 2018).

Hypothesis 3: *Influence of Environmental Concern on Public Intention towards Vertical Farming is moderated by Awareness*

Hypothesis 4: *Influence of Food Safety Concern on Public Intention towards Vertical Farming is moderated by Awareness*

2.3. Research Model

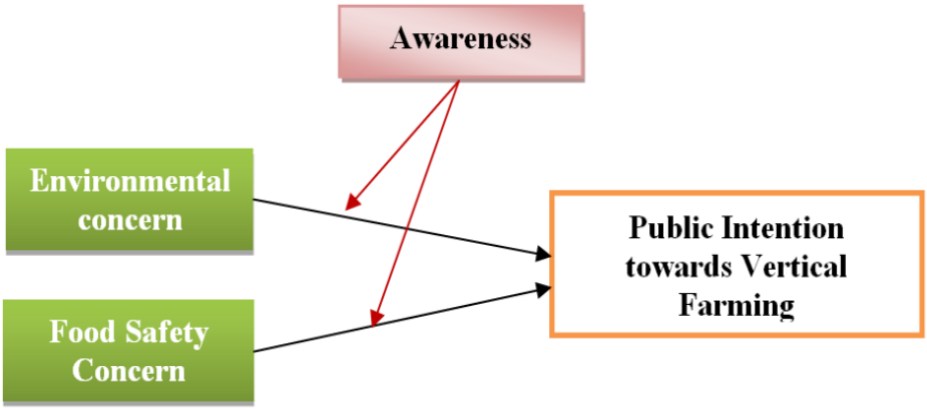

Figure 1: Proposed Research Framework

3. Research Methods and Material

3.1. Data Collection and Sampling

The present study conducted online with the used the method of convenience sampling that gave opportunity to collect a large number of data in limited time and resources. Before data collection questionnaires first translated with the help of experts into Chinese to collect data from Chinese consumers in China, then again translated back into English for analysis. The data collected from Chinese consumers living in Hefei, a city of China. A Chinese citizen had been chosen because China has the biggest population in the world and Chinese people have more capability to reflect their choices about eco-friendly products. The data collected between Septembers to October, 2020. A total 500 questionnaires were circulated among Chinese consumers through online software via email, weChat and QQ. A total 359 questionnaires returned from respondents with high rate, i.e. 72%. Finally, 335 questionnaires used for further analysis after excluded 24 questionnaires due to invalidity. Demographic characteristics of the study were summarized in table 1.

Table 1: Demographic Statistics

	Description	**Frequency**	**Percentage**
Gender	Male	121	36.1
	Female	214	63.9
Age	18-25	188	56.1
	26-35	78	23.3
	36-45	50	14.9
	46-55	16	4.8
	56-65	3	9
Income Level	Less than or equal to 1000	139	41.5

1001-3000	55	16.4
3001-6000	65	19.4
6001-9000	38	11.3
9001-12000	20	6.0
12001-15000	6	1.8
15001 or above	12	3.6
Total	**335**	**100.0**

3.2. Measurement Items

In the present study, the total four constructs that measured by using five Likert scale ranging from [Strongly Agree = 5] to [Strongly Disagree = 1]. The author stated that Likert scale examines the respondent to specify how much they strongly agree or disagree with statements (Malhotra, 2006). In the present study, measurement variables reflected each of the constructs adapted from previous researches. Food Safety Concern has 3-items adapted from (Michaelidou et al., 2007; Nguyen et al., 2019), Environmental Concern has 3-items adapted from (Kilbourne et al., 2008; Paul et al., 2016). Awareness as moderator with 4-items adapted from (Ambali et al., 2014) and Behavioral Intention contains 5-items adapted from (Mostafa, 2009; Paul et al., 2016).

3.3. Tools for Research Analysis

A research analysis was done by the use of IBM SPSS Statistics version 23 and AMOS version 24. A two-step approach was applied to test a measurement model for validity and reliability through different practices as CFA etc. Then a structural model scrutinized to test model fit and hypothesis testing with the help of standardized regression coefficient β and *p-value*. Initially, data was screened through EFA (exploratory factor analysis) and deleted the cross-loading item.

4. Result

4.1. Measurement Model, testing of reliability and validity

CFA was performed to examine the validity of constructs. Before a measurement model item has removed to make a model fitness, the CFA presented good model fit and values were chi-square CMIN: 146.519, DF: 71, CMIN/DF: 2.064, (good of fit index) GFI: 0.943, (adjusted good of fit index) AGFI: 0.916, (Tucker-Lewis index) TLI: 0.957, (comparative fit index) CFI: 0.966 and (root mean square error of approximation) RMSEA: 0.056. All model fit value as AGFI: 0.916 cut of level of .80 (Chau et al., 2001), CFI were 0.966 and all values were well higher than the suggested criteria (Bagozzi et al., 1988). The RMSEA were 0.056, less than 0.08 recommended by (Browne et al., 1993).

Chronbach alpha coefficient is the most common technique to explore the internal consistency of indicators of each construct. Values of chronbach alpha coefficient ranged from 0.741 to 0.893, which were above the suggested value of 0.70 (Hair et al., 2006); Composite Reliability ranged from 0.753 to 0.896 which shows all constructs met the accepted standard of 0.60 or higher (Bagozzi et al., 1988). The values of AVE (Average Variance Extracted) ranged from 0.506 to 0.717 which were above the accepted value of 0.50 (Hair et al., 2006). Factor loadings of each measurement items fall in ranged from 0.645 to 0.894, which exceeding threshold level of 0.50 (Kline, 2011).

Table 2: Measurement Model; Result of Reliability and CFA Analysis

Constructs	Measurement Items	Cronbach's α	Standardized Factor Loading	CR	AVE
Public Intention towards Vertical Farming	BI1	0.893	0.819	0.896	0.634
	BI2		0.748		
	BI3		0.660		
	BI4		0.862		
	BI5		0.872		
Awareness	AW1	0.881	0.894	0.883	0.717
	AW2		0.830		
	AW3		0.814		
Environmental Concern	ENC1	0.769	0.668	0.775	0.535
	ENC2		0.776		
	ENC3		0.747		
Food Safety Concern	FSC1	0.741	0.645	0.753	0.506
	FSC2		0.680		
	FSC3		0.799		

Note: FSC: Food Safety Concern, ENC: Environmental Concern, AW: Awareness, PI: Public Intention

Discriminant Validity calculated as were confirmed adequate validity. As table 3 $\sqrt{AVE}$ greater than the correlation among constructs, which shown values of Discriminant validity larger than a correlation between constructs.

Table 3: Discriminant Validity

	PI	AW	ENC	FSC
PI	**0.796**			
AW	0.504***	**0.847**		
ENC	0.348***	0.199**	**0.732**	
FSC	0.435	0.282	0.319	**0.711**

Note: Bold values represent [Discriminant Validity], others are the correlation among constructs. PI: Public Intention, AW: Awareness, ENC, Environmental Concern, FSC: Food Safety Concern.

4.2. Hypothesis Testing and Structural Model Analysis

Structural Model Analysis used after reliability and validity to examine model fit and hypothesis testing. For structural model fit, the most commonly used measured are CFI, GFI, AGFI, TLI and RMSEA as mentioned in table 4.

Table 4: Result of Structural Model Fit; Indices

Model Fit Indices	Structural Model Fit	Reference Values
Chi-square CMIN	189.600	N/A
CMIN/DF	2.562	>1 & <5[a]
CFI	0.948	≥0.90[a]
GFI	0.926	≥0.90[a]
AGFI	0.895	≥0.80[d]
TLI	0.937	≥0.90[c]
RMSEA	0.068	≤0.08[b]

Note: a Source: (Bagozzi et al., 1988), b. Source: (Browne et al., 1993), c. Source: (Bryne, 2013), d. Source: (Chau et al., 2001)

Further standardized regression coefficient (β-value and p-value) examined to test hypothesis statements of conceptual model. The outcomes of hypothesis testing demonstrated in table 5, outcomes of hypothesis testing supported H1, H2, and H3 excludes H4. Hence evidence proved that the environmental concern with (*β = 0.197,*

p ≤ 0.001) positively significant influence a public intention toward Vertical farming and supported *Hypothesis H1*. Food Safety Concern with evidence (*β = 0.298, p ≤ 0.001*) also strong predictor of Public intention and supported *Hypothesis H2.* To investigate the moderation effect, an interaction term was established by multiplying exogenous composite construct (environmental concern and food safety concern) with a moderator composite construct (awareness). The interaction term of environmental concern was not significant on public intention which showed that awareness was not moderating the relationship between them. Awareness as moderator had a strong effect between food safety concern and public intention toward vertical farming with evidence (*β = 0.095, p ≤ 0.050*). It proved that awareness enhance the relationship between food safety concern and public intention towards the vertical farming. TPB provided theoretical framework to examine a motivating factor that influence public intention. A proposed model explained well squared multiple correlation (Adjusted R^2= .460) in measuring public intention towards the purchase of vertical farming products.

Table 5: Result of Structural Model Fit; Indices

Hypothesis	**Statements**	**Estimates (*β-value)***	**Significance (*p-value*)**	**Result**
H1	*Environmental Concern significantly influence public intention towards the Vertical Farming*	0.197	*p ≤ 0.001*	Supported
H2	*Food Safety Concern significantly influence public intention towards the Vertical Farming*	0.298	*p ≤ 0.001*	Supported
H3	*Influence of Environmental Concern on Public Intention towards Vertical Farming is moderated by Awareness*	-0.038	*p ≥ 0.001*	Not Supported
H4	*Influence of Food Safety Concern on Public Intention towards Vertical Farming is moderated by Awareness*	0.095	*p ≤ 0.050*	Supported

5. Discussion and Conclusion

The present study aim was to investigate the motivating factors that affect public intention towards the vertical farming with a moderating role of awareness. Prior studies conducted to investigate factors influence behavioral intention towards organic farming, organic products, organic food, and aquaculture. The present study filled the gap in literature by investigating factors (Environmental concern and Food safety concern). The outcomes of this study revealed that Environmental concern was a positively significant predictor of public intention towards the vertical farming, which leads towards supporting the finding of previous studies (Bilal et al., 2015; Hutchins et al., 1997). In this study Environmental concern play crucial role and indicated as a strong predictor of public intention, which is aligned with (Aman, 2012; Davies et al., 1995) who found ENC as egoistic motive. The reason behind this is people concern about environment protection supported sustainable development in city level. Vertical Farming is sustainable development in which food growing in a vertical stack insides tall building within a control environment. Consumers who are more environmentally conscious supported the vertical farming production and use of its products.

Secondly, the findings of present study concluded that food safety concern significantly influence intention of public towards vertical farming. Increasing consumer concern about food safety, give chances to policy maker and food industries to understand the intention of public towards vertical farming. Today's world food safety is very important factor people more concern about food safety will not compromise on safety measures and in vertical farming food safety is top priority as food grow in a tall building without the use of chemical spray and pesticides. The result of this study supported the fact and findings of previous research which revealed that food safety concern significantly influence behavioral intention (Henson, 1996; Michaelidou et al., 2007). Further

awareness moderates positively, the estimate of an interaction term of food safety concern was significantly positive with public intention. Food safety concern significantly influence on public intention and its interaction term increase impact on public intention. Awareness as moderator strengthens the relationship among food safety concern and public intention towards vertical farming. Public more concern of food safety has enough awareness about vertical farming supported the purchase of vertical farming products and its development. In case of environmental concern, there is no moderation effect. Environmental concern has significant impact on intention, and the interaction term of environmental concern was negatively non-significant with public intention. Hence, the relation between environmental concern and public intention non-significantly moderated by awareness. The reason was consumers have insufficient awareness about the environmental benefits of vertical farming. A conceptual model developed in this study to examine the public behavioral intention by using **TPB** (Theory of planned behavior). The author suggested a *theory of planned behavior* as the strongest mechanism to inspect behavioral intention, prior studies has used TPB, examined consumers purchase intention in the perspective of organic food (Asif et al., 2018; Paul et al., 2016).

In this study environmental concern and food safety concern found to be the best indicators of public intention towards the vertical farming. Present investigation recommended policy makers, urban planners, food companies and local government to support the successful implementation of vertical farming in city level. People more concern about environment and food safety supported the vertical farming as sustainable development. China has the biggest population in the world and Chinese are more concern about environment protection and food safety. Government should support development of vertical farms by providing funds and subsidies to food companies for the successful implementation of vertical farming without any hurdles. Policy maker and urban planners should provide vacant spaces e.g. a warehouse, unused buildings, shipping containers for the establishment of vertical farming in city level. Chinese supported the development of vertical farming as it grows food within controlled environment and food safety is first priority. Government should implement policy to increase knowledge and endorse benefits of vertical farming, increase the consciousness about risk factors of conventional farming. In this study, where the relationship between food safety concern and intention significantly moderates by awareness, it also not significantly moderates between environmental concern and public intention towards vertical farming. Hence, there is need of more awareness of the benefits of vertical farming, so that it will gain more popularity and make a city sustainable.

Limitation of this study provides route to future researches. Firstly, in this study generalization of a result restricted due to specific target population and sample size. A larger sample size can lead to the meticulous findings of hypothesis testing in future researches. Secondly, in future studies, researchers could investigate more predictors that affect behavioral intention in the context of vertical farming. Further, quantitative studies are essential insight of vertical farming.

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