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## **A HUMAN DIMENSION MODEL FOR THE URBAN VERTICAL HOUSING SUSTAINABILITY THROUGH INDOOR AIR QUALITY**

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### **Abstract**

In urban vertical housing in Jakarta, air conditioning (AC) is mainly used to create comfort in units and spare residents from hazardous outdoor pollution. Residents in urban vertical housing, who have come from the surrounding multi-ethnic area, live in dense conditions. This situation inflicts conflicts of interest that affect indoor air quality (IAQ). This research develops a human dimension model for promoting indoor air quality in dense urban housing using the concept of sustainability, which is an environmental science approach. This study aims to conceptualize the effect of the human dimension in IAQ planning. The method is partial least squares-self equation modelling (PLS-SEM) analysis. The indicator variables of the human dimension related to indoor air quality are room quality, sociocultural factors, open space relief, environmental capacity, economic factors, and room maintenance. This result is a modified model of the fourth pillar of sustainability, according to Hawkes' theory on housing planning. The variable human cultural dimensions are knowledge, perception, behaviour, and participation, which frame the sustainable development concept: the social dimension, environmental dimension, and economic dimension.

**Keywords:** human dimension model; urban vertical housing; indoor air quality; sustainability concept; housing planning.

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## **INTRODUCTION**

The number of people who live temporarily in Jakarta is increasing. This density has forced the government to make the development of apartments for these temporary residents a priority. However, improving the physical and psychological health aspects of apartments has not been a priority. At the same time, the hazardous outdoor air pollution caused by traffic jams and social tension between residents and management frequently happens in Jakarta urban vertical housing. Previous studies reveal that those living in apartments are at a higher risk of air pollution than the general population of the city of Jakarta (Tryanni et al., 2013). These studies revealed that the model had not yet overcome IAQ issues to provide healthier vertical housing in urban areas without social capital (Tham, 2016). A model that could show the sustainability of health in vertical housing for assessing indoor air quality is needed. Preliminary studies show that the perceptions of apartment residents can determine the values of social dimensions, environmental dimensions, and economic dimensions, which theoretically can be the basis of the sustainability assessment of their residence. Thus, we design a theoretical model for the sustainability of indoor air quality in urban vertical housing.

Hawkes states that community values (values of society) are the basis of anything built to achieve the quality of life (Hawkes, 2001). The values of society are the essence of being a healthy and sustainable society in terms of social equity, environmental responsibility, and economic viability. The cultural dimension supports the balance of quality of life, and consists of 3 pillars: social dimensions, environmental dimensions, and economic dimensions that regard sustainable planning (Teng, 2019). Maslow focuses on how perceptions underlie the way in which residents and managers interact, behave, and participate in vertical occupancy (Janis, 1998). Tham (2016) helped compile the Hawkes modification model into a healthy and sustainable residential model. This model was used for middle-income vertical housing built by a private company. Based on these thoughts, the research objective was carried out to conceptualize the influence of the human dimension in IAQ planning.

## **LITERATURE REVIEW**

Sustainability is the availability of energy, cycles, and diversity to support population growth (Miller and Spoolman, 2021). The interactions between interdependent factors within an ecosystem that work in balance are needed (Cunninghams, 2012) to determine ecosystem sustainability. The role of humans in building the values of community interaction (values of society) is the basis of whatever is done to achieve a sustainable quality of life (Hawkes, 2001). The existence of a building not only meets the physical needs of humans (Hutchison, 2018) but also provides psychological comfort. Structured psychological theory helps architects recognize the dimensions of their existence towards the effects

of their designs on self-recognition, orientation, self-reflection, and the creativity of residents (Kalantidou, 2013). Spaces designed by expert planners have a psychological impact on residents.

In 2011, Government Regulation Number 20 of 2011 on vertical housing was made. In this regulation, there are elements of social and economic dimensions. In article 2 of this regulation, there are matters related to health, namely, the provision of the basis for constructing apartments to meet healthy housing standards, meet environmental health requirements, and promote healthy living behaviour. Social, economic, and environmental aspects can determine the physical comfort of housing (Luthfiah, 2010). The physical dimensions of comfort in an apartment include (1) aspects of air, sound, lighting, temperature, and environmental comfort; (2) being free of rubbish, having clean materials, and access to physical activities; (3) safety from minor accidents or natural disasters; and (4) comfort in the service of spatial composition, facility performance (Alfata et al., 2015), and the facility for human circulation (Kang et al., 2014). The physical comfort of urban dwellers can be assessed by satisfaction in air quality (Xue et al., 2016), temperature comfort, and sound quality (Zalejska-Jonsson and Wilhelmsson, 2013). Based on the opinions above, the authors conclude that urban dwellers assess physical comfort based on spatial aspects and aspects that accompany the spatial value: cleanliness, health, warmth, noise, and safety.

The psychological comfort dimensions of occupants in urban dwellings are (1) a passion for life, which is demonstrated by the attractiveness of the residential environment, density, lighting conditions, sound level, and appropriateness of room size; (2) stability, consisting of green space and privacy; (3) pride, consisting of privatization and pride; and (4) security, which consists of mental security and protection from crime and traffic accidents. The psychological dimension of comfort is influenced by the level of the individual's economy (Harianto, 2014). The opinion is that the psychological aspects of high-rise urban dwellings are strongly influenced by the limits of tension, overcrowding, and mental health of individuals (Gifford, 2007).

Hawkes (2001) said the following about urban housing, in his theory of the fourth pillar of sustainability: culture's essential rule in public planning is for humans to feel the value of self-existence to make meaning of their lives. Figure 2 shows the concept of the cultural dimension that supports the balance of quality of life consisting of 3 pillars of the following dimensions: social, environmental, and economical. The three pillars support the quality of life in urban dwellings. The slices of the three pillars of sustainability, adequacy, and responsibility, if implemented, will raise the levels of positive values, aspirations, relationships, diversity, creativity, innovation, and reliability in buildings.

A person has a level of awareness and degree of adaptation that is selectively present in specific environments (Gifford et al., 2010). The adaptation process is based on environmental perception when a difference between design

and reality brings about a reaction. When humans see the composition of an environment, there is a signal that makes them reach a certain conclusion. Behavioural change starts with awareness triggered by knowledge (Barnes, 2014), but knowledge about the environment needs to be accompanied by high commitment (Alford et al., 2002). Maslow uses the terms physiological, security, ownership and love, self-esteem, self-actualization, and self-transcendence to describe patterns that motivate human behaviours.

Miller (2012) states that IAQ is a severe problem in the environmental sciences. According to the Environmental Protection (EPA), indoor pollutants can be 2 to 5 times more dangerous than the pollutants present in outside buildings. EPA (2018) defines indoor air quality as an air quality condition in buildings and their building structures, which is related to the health and comfort of building users. In Indonesia, according to the Ministry of Health Regulation Number 1077 of 2011 on Guidelines for Indoor Air Sanitation, it is a parameter value that indicates the air's physical, chemical, and biological conditions. The physical conditions of the air include humidity, lighting, temperature, and particulates, while the chemical conditions of the atmosphere include SO<sub>2</sub>, NO<sub>2</sub>, CO<sub>2</sub>, CO, and other chemical materials; furthermore, the biological needs of the air are bacteria, fungi, and germ numbers.

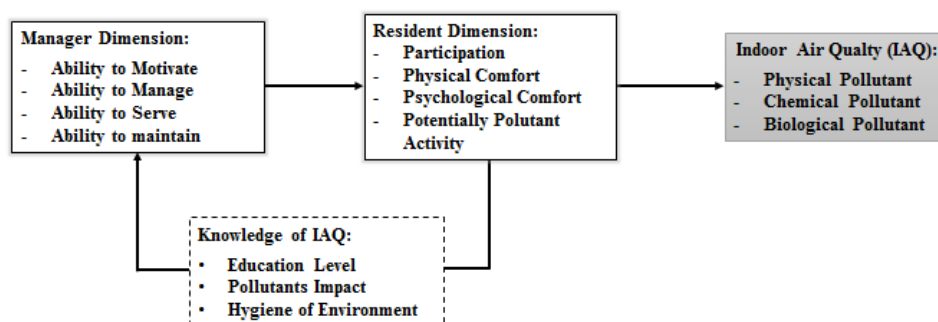
## **RESEARCH METHOD**

The apartment is a mass of U-shaped towers with each floor consisting of 44 units with 25 floors plus two ground floors and basements; one tower consists of 1100 residential units. The area per floor is approximately 1500 m<sup>2</sup>; if 1 unit is occupied by 3 people, 132 people occupy one floor. Therefore, the density per floor is 11.3 m<sup>2</sup>/person. This amount met the minimum standard in Indonesia of 9 m<sup>2</sup>/person at the lowest. The apartment is located on a boulevard, which is a public road that can now be passed by private vehicles from outside the area (Figure 1).



**Figure 1:** The Mass of Towers and Hazardous Pollution from The Main Road and Boulevard

Data collection for PLS-SEM used questionnaires and was assessed with a Likert scale to reflect the attitude or opinion (Barge, 1988). Purposive sampling was used for residents and units. Samples were from towers representing one unit from each floor. To get a sense of the building management as a whole, the population was chosen from residents who had lived in this apartment for at least one year. The samples of managers were five persons per field of work: a human resources employee, a sanitation attendant, a maintenance officer, an engineer, and a customer service employee. The sample of the manager was involved in housing management for one year. Multivariate data analysis was performed by Smart-PLS version 3.2. PLS-SEM (Lay and Anuthra, 2014).



**Figure 2:** The Conceptual Framework of The Model

Figure 2 shows the conceptual framework of the model proposed. It shows that realizing the effectiveness of IAQ depends on the performance of the residents' dimension, which is supported by the residents' knowledge: education level, knowledge of pollutants, and knowledge of hygiene. The residents' dimension that influences the effectiveness of IAQ is determined by the fulfilment of physical and psychological comfort of the living space, resident activities that cause indoor pollutants, and occupant participation in maintaining the cleanliness of the unit and air circulation through openings and ventilation devices (Nurwidyaningrum et al., 2020). Three abilities determine the managers' dimension that influences the effectiveness of IAQ. The ability to regulate unit spaces and shared spaces (social and public), the ability to check the maintenance of space and ventilation equipment, the ability to provide open space relief, economic ease, sociocultural sustainability and the adequacy of environmental support, and the ability to motivate changes in behaviour patterns that are better for the common good.

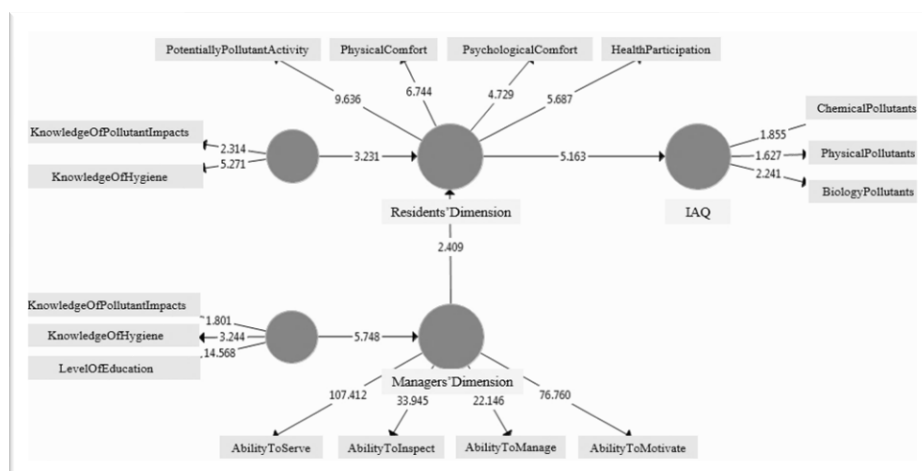
## RESULTS AND FINDINGS

The following is a description of the results of the questionnaire. The managers stated that they had managed well and cleaned the rooms for the residents' social and public spaces. However, 23% of the management respondents think that they have not managed the public space properly, for example, in the parking arrangement. The managers (70%) believed that open space relief had been fulfilled. Forty-nine percent allowed residents to engage in economic activities in residential areas. Seventy-three percent of them had tried to greenify the building environment. Additionally, 87% argue for the importance of sociocultural life for residents. In general, managers have a good perception of their service capability, but they acknowledge that living in vertical housing cannot be economical. The manager behaviour related to IAQ is the inspection of buildings and the maintenance of ventilation equipment that is required for it to work well. Most of them (87%) stated that routine control is always carried out. Questionnaire data show that as many as 68% of managers said they have campaigned for a healthy life.

Furthermore, most residents generally feel that the physical housing conditions are adequate for personal activities (90%), but they think the unit is still not large enough for family activities (61%). Regarding psychological comfort, respondents stated that they felt enough open space relief (87%). Regarding freedom of activities related to sociocultural practices, 62% of residents said that they could carry out these activities even though they still felt uncomfortable. The explanation above shows that most residents feel that their physical and psychological needs are satisfied. However, there are still complaints about family activities, lowcost lifestyle and the ease of sociocultural activities. This fact shows that satisfaction with physical conditions also

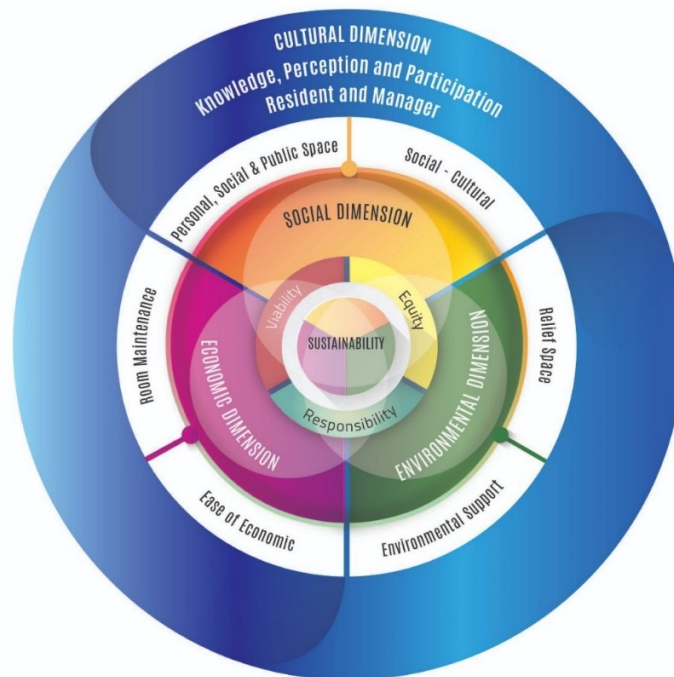
influences psychological conditions, which then affects obedience to the program and the manager's rules (Moersidik et al., 2012; Wiranegara et al., 2013). Additionally, the residents' health participation rate showed that 56% of respondents cleaned furniture routinely, but some did not. Most respondents said they tried to choose fragrances without chemicals (86%). Most also stated that they always checked the condition of the stove and gas to prevent leakage (80%). Additionally, almost all respondents said they opened the window in the morning every day (96%). This behaviour showed that practically all residents have an excellent healthy lifestyle, and these results could be optimized by motivation from managers to follow rules (Kyrö et al., 2012).

The data show that most building managers have a lower knowledge and education level than residents. The level of management who have an education at the undergraduate level is only 49% lower. Ninety percent of residents have an undergraduate education level. Regarding knowledge about indoor pollutants, residents have a better knowledge rate of 76% compared with that of managers, which is 21%. This value gap causes residents to feel uncomfortable. Residents' expectations are higher than those of managers. The lack of IAQ knowledge could cause the loss of this optimization (Müller-Eie and Bjørnø, 2017). The description above shows a gap in fulfilment between managers and residents in this opinion (Taiwo et al., 2021; Rabe et al., 2021). The managers argued they had worked appropriately (70-90%), but the residents stated that they were not satisfied (10-40%). This means that they should be communicable about particular rules and programs to achieve unity management (Roland et al., 2018).



**Figure 3:** The Construct of Smart-PLS that Achieves the Effectiveness of IAQ between Residents and Managers in PLS-SEM (Nurwidyaningrum et al., 2018)

Figure 3 is the optimal PLS-SEM construct model for the unity of residents' and managers' dimensions of IAQ in urban vertical housing. This figure shows that the residents' dimension directly affects the conditions of the IAQ in the unit, and the managers' dimension plays a vital role in encouraging the residents' dimension to produce healthier IAQ. In this construct, knowledge is a variable suppressor. Residents' and managers' knowledge strengthens the influence of residents' dimension on IAQ (5.163), and the T-outer loading value meets the requirement  $>1.96$ . Managers' knowledge is essential to strengthening the value of IAQ (5.748). The knowledge variable is an influencing factor in making IAQ effective. The calculation result of PLS-SEM is 19% for IAQ. This means that the human dimension in urban vertical occupancy has affected the IAQ by 19%, in addition to the technical influence (Razzaghian et al., 2016). These results indicate that to realize healthy housing, there is a need to promote an excellent cultural dimension between residents and managers in order for them to pay attention to aspects of physical and spiritual health to develop a sustainability model. PLS-SEM analysis was used to develop the model of the human dimension for the sustainability of urban vertical housing through IAQ. Then, the variables in Figure 3 entered into the fourth pillar of sustainability of the Hawkes principle (Gang, 2016).



**Figure 4:** The Model of The Human Dimension that Supports IAQ in Urban Vertical Housing



Explanation of the concept model (Figure 4) is a cultural dimension that includes knowledge, perception, behaviour, and participation (Maslow, 2015). The human dimension of residents and managers will interact well based on specific knowledge (Muller-Eie, 2017). Then, this knowledge influences human perception, behaviour, and participation. The perceptions of residents of managers affect their behaviour and cause them to learn from previous behaviours to participate better and continue improving their ways of life to reach the expected point of equity.

Achieving sustainability of health in urban vertical housing is characterized by a balance between 3 dimensions: the social, the environmental, and the economic. In order to achieve residents' health goals, the social dimension needs to pay attention to their satisfaction with personal space, social space, public space, and sociocultural life. The environmental dimension for IAQ health needs to emphasize the space for a pleasant atmosphere and the support of a green environment (Leh, 2018). The economic dimension encourages the maintenance of space and equipment and gives access to the development of the financial capacity of its inhabitants. The three circles of social, environmental, and economic dimensions in the concept of sustainable development show a quality of life that continues with the principles of equity, responsibilities, and viability.

The residents and managers achieved unity when they had the same perspective in perception, behaviour, and participation. Both of them need to have the proper knowledge about IAQ. In environmental science, sustainability is characterized by the balance of the social dimension, the environmental dimension, and the economic dimension (Teng et al., 2019; Brown et al., 2015). The slices of the 3 (three) circles of the social, the environmental, and the economic dimensions show probably friction problems. Therefore, to achieve healthy and sustainable vertical housing, residents and managers maintain the balance of the three social, environmental, and economic dimensions by emphasizing satisfaction with residential spaces, sociocultural activities, open space relief, environmental support, ease in the economy, and maintenance of space.

Compared to that of Hawkes', this model is improved by proposing useable IAQ practices. The variable indicators of the cultural dimension transform from wellbeing, creativity, diversity, and innovation to knowledge, perception, and participation — the spirit then shifts from community wellbeing to housing planning. Additionally, social, economic, and environmental dimensions adapt to spaces of social-cultural, ease of room or building maintenance, and relief of healthy areas supported by the environment around the building. These will be consistent with IAQ completeness in creating healthy housing.

## CONCLUSION

According to the model, apartment managers should survey residents' needs and satisfaction regularly (e.g., once a year), including an appraisal of the health condition of the residents so that they could improve the quality of service appropriately. It would increase the manager's capacity or competency occupancy management and knowledge about changing dynamic urban lifestyles. Creative and experienced managers have a management program that satisfies residents. Creating programs such as these can increase residents' knowledge and encourage the participation of residents to help maintain the sustainability of vertical residential management. In future studies, a healthy and sustainable urban vertical residential model emphasizing the economic dimension should be examined. Furthermore, it should explore the value of long-term routine financing for the physical management of housing and its impact on the social dimension.

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