A Review of Urban Visual Environment in Transit-Oriented Development (TOD): Visual Comfort and Disturbance

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Abstract. Transit-Oriented Development (TOD) is one solution that widely applied to control the density of cities. Seeing the precedent, areas adjacent to public transit will be dominated by high-rise buildings. The issues raised in this paper related to how the phenomenon of high-rise development impacts the urban visual environment. The literature review method is used to determine aspects of the urban environment through visual comfort and visual disturbance. Literature review results in several factors influencing the urban visual environment, consist of the natural landscape, vegetation, exterior building and views, dimension, urban screen, visibility, colors, and materials. It was found that the difference between comfort and disturbance indicators tends to be thin because there is an acceptable disturbance. This situation occurs where visual disturbance can be tolerated as long as psychologically, there is a pleasantness increase. Related to TOD, development around transit areas must be considered for its impact on the urban visual environment. It is expected that through the achievement of a comfortable urban visual environment, the level of satisfaction will increase along with the increasing role of the transit area in supporting the use of public transportation and walkability, which are the goals of the TOD in an urban area.

1. Introduction

The concept of residential zones integrated with public transportation is a new trend, offered as a solution to control urban density development. This concept is known as Transit-Oriented Development (TOD). TOD is an integration between land use and transportation planning, with the aim of encouraging people to maximize the use of public transportation by creating transit areas that are convenient, desirable, and highly walkable [1]. TOD is generally considered to be a mixed-use development oriented towards public transportation facilities [2]. The concept has been applied to city development in several metropolitan areas in Brazil, Columbia, California, France, Hong Kong, and Malaysia.

Referring to precedents in countries that have implemented TOD, areas near transit will have high density [3]. In other words, the architecture will be dominated by high-level buildings that can accommodate a variety of functions with high space effectiveness. Changes will occur where landed buildings slowly transition to high-rise buildings, in line with the dynamics of urban development. One of the direct impacts will be a change in the urban visual environment, where the transit area will be dominated by skyscrapers and public living spaces. The phenomenon of rampant high-rise development near transit areas impacting the urban visual environment is the issue raised in this paper. The role of the urban visual environment is an important contributor to the success of TOD. This is because one of the TOD concept’s goals is the successful transition from a car-centric city to one with public
transportation and high walkability. A comfortable visual environment in the city can influence users to prioritize walking while enjoying the visual experience of the space, especially in transit areas.

2. Methods
The study was conducted to determine the impact of the TOD concept on the urban visual environment, which is predicted to be dominated in the future by the development of high-rise buildings near transit areas. The literature review method is used by comparing several studies of the urban visual environment in cities that have applied the TOD. The urban visual aspects studied were related to urban areas affected by TOD, namely transit areas and their surrounding regions. The urban visual aspect is divided into buildings and streets. Some aspects studied were the use of colour, material, dimensions, layout, and visibility. These five aspects will be examined for their effects on the urban visual environment through visual comfort and disturbance. This method is carried out because urban visual environment issues need to be exposed in order to successfully coordinate applications of future TOD development in countries that want to integrate residential development with public transportation.

3. Discussion
The urban environment quality is influenced by the visual form of the city on the perception and memory of physical space [4]. Image ability is an important factor in forming a visual environment. Image ability produces a space experience where visual comfort and visual disturbance have important roles. Visual comfort and visual disturbance are primarily associated with light quality. Light affects visual comfort in many ways, most of which cannot be measured objectively [5]. Light has a direct influence on users’ mood and motivation. A space experience that attracts people, where they feel comfortable and safe both walking and using public transportation, is an important aspect of the urban visual environment.

3.1. Issues of Visual Comfort and Disturbance in the Urban Environment
Based on the results of the literature review, it appears that people tend to prefer transit areas with many trees, and natural landscapes as opposed to sidewalks lined with cars [4]. This relates to the issue of personal sensitivity, where people feel more secure when they are close to nature [5]. Related research conducted by Ulrich [6] revealed the important role of vegetation in accelerating the postoperative healing process in hospital buildings. Whyte [7] conducted a study in New York’s small urban spaces that revealed the importance of trees and natural landscapes as shade to induce use and satisfaction. Landscaping is an ecological measure that is able to effectively solve urban built environmental problems [8]. Although Palmer’s research [9] reveals that vegetation in urban areas does not have a direct effect on reducing noise, Onder & Akay [10] and Misni & Allan [11] found that vegetation in urban areas can reduce outdoor air temperatures as well as the amount of solar radiation and harsh glare.

Psychologically, vegetation is able to visually screen off the sources of noise; although technically the noise cannot be significantly reduced, psychologically the user is able to feel an increased sense of pleasantness [12,13]. This reveals that the use of proper vegetation in buildings and on streets produces visuals that positively influence a user’s psychological mood and comfort. Therefore, the application of urban planning with a biophilic theme is an important option when developing a visual environment in the transit area.

Exterior buildings with open glass that have natural views tend to provide a high level of pleasantness compared to a massive exterior [14]. Hellinga and Hordijk [15] revealed three characteristics of outside views that have a high level of satisfaction: natural views, views containing water, and distant views. The application of views with these three characteristics outside buildings in the TOD transit area can create visual comfort. This is also in line with Leadership in Energy and Environmental Design (LEED) protocol regulations, where a minimum of 75% of the floor of each room must have a direct line of sight to the outdoors. The window must be no further than 7.5 meters from a view featuring a minimum of two of the following elements: flora, fauna, sky, movement, or objects. The use of windows with wide dimensions can incorporate daylight with proper intensity and produce pleasant views. However, this application can allow large heat gains or losses that affect a building’s energy consumption [16]. Related
to the urban visual environment, the most important effect to consider is the level of visual disturbance, which will increase due to reflective glare (both inside and outside the building).

Dimensions have an important role in the urban visual environment. The closer the distance between buildings, the higher the level of visual disturbance [17]. This is due to the lack of daylight radiation entering the building. If the need for daylight is not fulfilled, the potential for increased energy consumption is higher. This does not apply only to the dimensions between buildings, but also to the relationship between buildings and roads. The width of the road should accommodate users comfortably in order to increase walkability. Likewise, in transit areas, attention must be paid to the angle and dimensions between buildings, street furniture, and signs. One of the spatial planning concepts that can be applied is symmetry. Symmetrical urban planning creates a high level of pleasantness [18], and can also avoid visual overlapping so potential visual disturbances can be minimized.

Street furniture also has an important role in producing visual comfort in transit areas. One feature of street furniture that has a direct impact on the urban visual environment is the urban screen. The urban screen not only impacts the urban visual environment, but also can affect the user’s experience of the space [19]. This is because the experience of the space is directly influenced by what can be seen, and how it is viewed. Urban screen arrangement requires proper dimensions and angles. This is because, in addition to functioning as attractions, urban screens also affect movement in the urban space. Therefore, to avoid visual disturbance, there are three things that need to be considered in the application of street furniture in the transit area: dimensions, materials, and colours.

One of the most important factors in the urban visual environment is visibility. The problem of visibility in the transit area becomes especially important when considering street signs, because the visibility of street signs can be disrupted when there is rain, fog, or hazy weather which can endanger road users. Visibility related to sight distance is a central parameter of the inherent safety of driveways, intersections, and other potential conflict points. One area that becomes important in the transit area is the intersection: potential visual disturbances must be minimized, because insufficient visibility can affect user safety. The Transit Design Guide [20] revealed that compact intersection design can be applied to transit areas by maximizing activity with the sight triangle layout, which provides users a better view of potential hazards.

Creating a comfortable urban visual environment and minimizing visual disturbance by buildings, street furniture, and street signs encompasses three important variables: dimensions, materials, and colours. Attention must be paid to the importance of colours and materials in transit area design. Drivers will have a high potential for difficulty seeing at night if the edge of the road is not painted with colours and materials that reflect light. This is because weather and skylight have major roles in creating the visual image of the city. At the present time, the use of colour tones in buildings is not only based on aesthetics, culture, and ethics, but also safety [21]. Liu et al [22] conducted a visual comfort study of colorscape in hazy weather conditions, and found that the use of analogous colours has a higher level of comfort than monotone.

The use of low values in the cool colour region, such as dark grey, offers weak resistance to environmental conditions with high levels of fog and pollution. Therefore, the recommended colour tones for the urban colorscape all have a weak chroma contrast. The use of material also has a direct influence on visual disturbance. For example, the use of glossy material on urban screens can cause overhead or reflected glare due to excessive light reflection from light sources [23]. This reveals that the urban visual environment can be effective as long as visual comfort is achieved and visual disturbances are minimized.

3.2. Acceptable Disturbance Phenomena in the Urban Visual Environment
A space experience that ensures that people feel safe and comfortable both walking and using public transportation is an important aspect of the urban visual environment. Based on the results of the literature review, the phenomenon “Acceptable Disturbance” was found to occur in the urban visual environment. This situation occurs where visual disturbance can be tolerated by users as long as they feel safe, especially if there is an increase in the pleasantness effect.
For example, people feel more comfortable walking between buildings that have an open glass exterior compared to a massive exterior, even though the open glass exterior has a higher potential of visual disturbance (such as reflective glare). This happens because open glass provides users the psychological impression of being free and not so rigid; thus, even though technically there is visual disturbance, psychologically there is an increase in visual pleasantness. A schema factors that influence visual comfort and visual disturbance in an urban visual environment showed in Figure 1. This is also illustrating the difference between comfort and disturbance indicators that tends to be thin, because there is an acceptable disturbance that can be tolerated due to the pleasantness aspect.

3.3. The Role of the Urban Visual Environment to the Success of TOD

Transit-Oriented Development (TOD) is one of the solutions to urban and transportation development problems. In several developed countries that have implemented TOD, it was found that the TOD concept can overcome congestion problems, reduce the use of private vehicles, and encourage the use of public transportation and walking. An application of TOD in the precedent of developed countries is the application of mixed-use.

The application of mixed-use will causes the area around the transit area to be dominated by vertical buildings rather than landed buildings. This will certainly have an impact on the urban visual image, especially in cities that are generally dominated by low rise buildings which will then be affected by TOD where high-rise mixed-use buildings will dominate. This is the important role of the urban visual environment in the success of TOD. Based on the urban visual environment issue discussed above, the aspects that need to be interpreted to achieve a comfortable urban visual environment are exterior building material, urban layout, visibility, colors, and dimensions between buildings and streets. Figure 2 shows a summary of research about visual comfort and visual disturbance in an urban area that had been discussed above.

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**Figure 1.** A Schema of Factors that Influence Visual Comfort and Visual Disturbance in an Urban Visual Environment
### Table 1. Summary of Research about Visual Comfort and Visual Disturbance in Urban Environment

| Variable                      | Study (reference) | Case Study                  | Findings related to Visual Comfort and Visual Disturbance                                                                 | Reference Year |
|-------------------------------|-------------------|-----------------------------|---------------------------------------------------------------------------------------------------------------------------|-----------------|
| Natural landscapes            | Lynch K [4]       | Transit areas               | People tend to prefer transit areas with many trees and natural landscapes as opposed to sidewalks lined with cars.        | 1960           |
|                               | Zanon S et al [5] | Buildings                   | People feel more secure when they are close to nature.                                                                      | 2019           |
| Vegetation                    | Herrington L P [12]| Urban areas                | Vegetation can visually screen off the sources of noise and increase pleasantness.                                         | 1974           |
|                               | Reethof G and Heisler G M [13] | Vegetation in urban areas | Psychologically the user can feel an increased sense of pleasantness.                                                      | 1976           |
|                               | Whyte W [7]       | Small urban spaces         | The importance of trees and natural landscapes as shade to induce use and satisfaction.                                    | 1980           |
|                               | Ulrich R [6]      | Hospital outdoor areas      | The important role of vegetation in accelerating the healing process.                                                      | 1984           |
|                               | Palmer J F [9],   | Greenspace                  | Vegetation in urban areas does not have a direct effect on reducing noise.                                                    | 1986           |
|                               | Wong N H and Yu C [8] | Urban areas                | Landscaping is an ecological measure that can solve urban built environmental problems.                                    | 2005           |
|                               | Onder S and Akay A [10] | Urban areas                | Vegetation in urban areas can reduce outdoor air temperatures and the amount of solar radiation.                            | 2014           |
|                               | Misni A and Allan P [11] | Buildings                 | Vegetation in urban areas can reduce solar radiation and harsh glare.                                                      | 2010           |
| Exterior Building and Views   | Hewitt H [14]     | Buildings                   | Exterior buildings with open glass that have natural views tend to provide a high level of pleasantness.                    | 1963           |
|                               | Alrubiah M S et al [16] | Buildings                | Exterior buildings with open glass and direct line of sight to the outdoors can allow large heat gains that affect a building’s energy consumption. | 2013           |
|                               | Hellinga H and Hordijk T [15] | Buildings in urban areas | Three characteristics of outside views that have a high level of satisfaction: natural views, views containing water, and distant views. | 2014           |
### Table 1. (continued)

| Variable          | Study (reference) | Case Study          | Findings related to Visual Comfort and Visual Disturbance                                                                 | Reference Year |
|-------------------|-------------------|---------------------|--------------------------------------------------------------------------------------------------------------------------|----------------|
| Dimension         | Pecchinenda A et al [18] | Urban areas         | Symmetrical urban planning creates a high level of pleasantness and also can minimize visual disturbance.                | 2014           |
|                   | US Green Building Council [17] | Regulations        | The closer the distance between buildings, the higher the level of visual disturbance.                                    | 2018           |
| Urban Screen      | Lubis B U and Primasari L [19] | Urban space         | The urban screen not only impacts the urban visual environment but also can affect the user’s experience of the space.    | 2012           |
| Visibility        | National Association of City Transportation Officials [20] | Urban street        | Compact intersection design can be applied to transit areas by maximizing activity with the sight triangle layout to minimized visual disturbance and potential hazards. | 2016           |
| Colors            | Serra J, Garcia A, Torres A, and Lopis J [21] | Buildings          | The use of color tones in buildings is not only based on aesthetics, culture, and ethics but also safety.                 | 2012           |
|                   | Liu Y et al [22] | Urban areas         | The use of analogous colors has a higher level of comfort than monotone.                                                | 2016           |
| Materials         | Boubekri M and Boyer L [23] | Urban space         | The use of glossy material on urban screens can cause overhead or reflected glare due to excessive light reflection from light sources. | 1992           |

The development of the TOD area by paying attention to the quality of the urban visual environment can encourage people to be motivated by using public transportation and walking. The conception of the urban visual environment is important to be applied, especially in the transit area. This is important so that people have a high level of satisfaction when passing through the transit area which will make walkability be achieved. If the visual comfort aspect has been achieved then the urban visual environment area will be much pleasant. It is expected that through the achievement of a comfortable urban visual environment, the level of community satisfaction will increase along with the increasing role of the transit area in supporting the use of public transportation and walkability.

### 4. Conclusion
The application of the TOD concept in the urban development will result in high density dominated by high-rise buildings in transit areas. This will have an impact on the urban visual environment. An urban environment that increases visual pleasantness and decreases visual disturbance can make users feel more comfortable experiencing the space, and thus the purpose of TOD, which is to revive the transit area and increase the use of public transportation and walkability, can be achieved.

The results of the literature study reveal that the natural landscape, vegetation, exterior building and views, dimension, urban screen, visibility, colors, and materials are important factors of an urban visual environment. The urban visual environment includes not only visual comfort and disturbance related to buildings but also encompasses street furniture and street signs in an urban area. The selection of building exteriors in transit areas featuring natural views with glass walls increases pleasantness more...
than massive walls. The closer the distance between buildings, the higher the level of visual disturbance. The application of biophilic themes and symmetrical urban planning are options for developing a high level of visual comfort in the urban transit area. Visibility and sight distance become especially important when there is rain, fog, or hazy weather because sightlines to street signs can be disrupted. Thus, it is important that dimension, color, and material in buildings, street furniture, and street signs reduce visual disturbance to avoid potential difficulty seeing at night.

It was found that visual comfort and visual disturbance closely related to human psychological effects. Visual comfort has a linear relationship with pleasantness and is opposite to visual disturbance. The results of the literature review revealed that in some aspects, visual disturbance can be tolerated as long as there is an increase in the pleasantness of users’ experience of the space. This phenomenon is called acceptable disturbance. Therefore, the application of visual aspects that can increase pleasantness and user comfort becomes an important factor in the development of the urban visual environment. Development around transit areas must be considered for its impact on the urban visual environment, so user comfort can be achieved in accordance with the maximal application of the TOD.

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