Strategy to Reduce the Covid-19 Transmission through Adaptation of Greenship Interior Space (IS) Criteria

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Abstract. Greenship Interior Space (IS) is a set of criteria established by the Green Building Council Indonesia (GBCI) as a rating tool for assessing the interior space of a building. It is mainly used as a guideline that needs to be applied to buildings in order to achieve more sustainable design through energy and resource savings. Hence, it is expected to reduce the building operational costs, improve the users’ health and comfort, as well as to leave the minimum carbon footprint. Greenship IS rating tools consist of several categories, i.e., Appropriate Site Development (ESD), Energy Efficiency and Conservation (EEC), Water Conservation (WAC), Material and Resources Cycle, Building and Environment Management (BEM), and Indoor Health and Comfort (IHC). As the COVID-19 virus pandemic continues to spread, these categories need to be reviewed. Therefore, green building is not merely for sustainability but also expected could reduce the transmission of the Coronavirus that causes the COVID-19. This disease is transmitted through direct or indirect contact with the subject, droplets, and aerosols. This research employed a literature study of Greenship IS adaptation regarding the pandemic situation and followed by the critical analysis that focused on the proposed strategies for the criteria by investigating the cause, prevention, transmission, and impact to the interior space. The adaptation of Greenship IS shows the importance of human health must be achieved apart from the sustainability aspect. From the literature review, it can be concluded that the adaptation of Greenship IS is focused on creating good indoor air quality, appropriate material selection, access to nature for the occupants, maintaining health protocol, and regular disinfection in managing the building to reduce the COVID-19 transmission.

Keywords: COVID-19 Transmission; Greenship; Interior Space

1. Introduction

The Coronavirus (COVID-19) is an infectious disease that has a global effect that started at the end of 2019 in Wuhan until now. In March 2020, the World Health Organization (WHO) declared COVID-19 as a pandemic [1]. Until today, there is no cure for this disease yet. Avoiding transmission is the only way to combat this virus by practicing daily hygiene and isolating the infected people. WHO has declared that COVID-19 can be transmitted through microdroplets or aerosols, highlighting the need to use masks as the most effective means of preventing transmission. The pandemic of COVID-19 challenges people in making adaptations in every aspect of life. Design, particularly in interior architecture, is one among many other aspects that need to adapt and embrace the new normal condition.

The current COVID-19 pandemic has focused on how the impact of viruses in the air can be compounded by poor indoor air quality. Enclosed rooms with inadequate ventilation and air recirculation through air conditioning help to spread the COVID-19 virus transmission. The importance of good
indoor environmental quality has been prioritized in this pandemic situation because people spend most of their time indoors to curb the transmission. Several factors that affect user's health indoors are indoor air contaminants, surface pollution with toxins and microbes, and interactions between people at home, at work, in transportation, and other public and private indoor places will affect the virus transmission risk. During this pandemic, the need to create good indoor environmental quality is important in spatial planning. Greenship IS parameter issued by GBCI that is used as a reference to create a good indoor environmental quality consists of 6 Greenship categories as described in Figure 1. The percentages of each categories respectively are 12%, 13%, 8%, 27%, 28%, and 12% [2].

Approximately 70 to 90% of people's time was spent in an indoor area [3]. During the pandemic, people are forced to stay at home to curb the spread of the COVID-19. This lead to the same issue before the pandemic, where most of the human activities are conducted indoors. Based on this data, this study focuses on the adjustment of Greenship IS criteria. Due to this pandemic, the implementation of Greenship IS criteria must be readjusted in order to provide an indoor environment that could help to mitigate the transmission of the COVID-19. Therefore, this research aims to propose an adaptation of the Greenship IS parameter based on the current pandemic situation.

2. Method
This study presents a literature review of Greenship rating tool adaptation in the context of this current pandemic. The critical analysis focuses on the adjustment that needs to be implemented in Greenship IS criteria that are related to COVID-19: the cause, prevention, transmission, and the impact on interior space. Through systematic literature review, the primary data were collected from the Science Direct database (www.sciencedirect.com), and to complement the main data, secondary data were collected from the Google Scholar website (https://scholar.google.co.id/). The selected data must be published between the year 2010 to 2020 and must be related to the research question 'How do the criteria of Greenship IS could be adapted during a pandemic?'. The keywords used in this search were "COVID-19", "prevention", "transmission", "green building", "indoor environmental quality" and "new normal". The data obtained then compiled in a free reference management software, Mendeley. From the search based on these keywords, there were 44 related articles were obtained. However, after being analyzed, there were only 26 articles that directly related to the research questions. The articles were analyzed to understand the correlations and types of adjustments that need to be made for the proposals of adaptation criteria for Greenship IS as a response to the COVID-19 pandemic.

3. Finding and Discussion

3.1 Greenship Interior Space (IS)
Based on the Greenship IS rating tool, the scope is not only limited to fitting out on its own, but it is also for management policy in the selection process of the building site and management of the tenants.
(operational activities). The concept of sustainable interior space based on the Green Building Council Indonesia [2] mainly aims to:

1) Improve the health and comfort of the occupants
2) Reduce pollution and environmental damage
3) Reduction in energy and resource usages.

There are several criteria for the interior space to be fulfilled in the assessment. Those are:

1) Has the authority to adjust the interior space.
2) The minimum project area of 25 m²
3) At least one person works full-time indoors.
4) Leased for at least 3 years
5) Establishment of a complete spatial plan and land use distribution permit
6) Building protection by displaying building security documents
7) Disclosure of project data for assessment

The Greenship IS consists of six categories that can be explained as follows:

1) Appropriate Site Development (ASD)
2) Energy Efficiency & Conservation (EEC)
3) Water Conservation (WAC)
4) Materials & Resources Cycle (MRC)
5) Indoor Health & Comfort (IHC)
6) Building & Environment Management (BEM)

Each of the categories consists of several criteria that will obtain a credit point on the assessment when the requirements are fulfilled. The summary of the Greenship IS criteria is listed as follows:

### Table 1. Summary of Greenship Interior Space (IS) criteria [2]

| Code | CRITERIA                                      | Max Point | Bonus |
|------|-----------------------------------------------|-----------|-------|
| **ASD – Appropriate Site Development**     |           |         |       |
| ASD P | Motor Vehicle Reduction Policy                | P         |       |
| ASD 1 | GREENSHIP Certified Building                  | 4         |       |
| ASD 2 | Community Accessibility                       | 1         |       |
| ASD 3 | Bicycle                                       | 3         |       |
| ASD 4 | Motor and Vehicle Space Reduction             | 2         |       |
| ASD 5 | Landscaping                                   | 2         |       |
| **Subtotal** |                      | 12 (11.65%) |       |
| **EEC – Energy Efficiency and Conservation** |          |         |       |
| EEC P | Energy Conservation Campaign                  | P         |       |
| EEC 1 | Simple Commissioning                          | 2         |       |
| EEC 2 | MVAC Control                                  | 2         |       |
| EEC 3 | Lighting Power Density and Control            | 5         |       |
| EEC 4 | Energy Monitoring and Control                 | 2         |       |
| EEC 5 | Electrical Equipment and Appliances           | 3         |       |
| **Subtotal** |                      | 14 (13.59%) |       |
| **WAC – Water Conservation**                |           |         |       |
| WAC P | Water Conservation Campaign                   | P         |       |
| WAC 1 | Water Fixtures                                | 4         |       |
| WAC 2 | Water Use Monitoring                          | 2         |       |
| Code  | CRITERIA                   | Max Point | Bonus |
|-------|----------------------------|-----------|-------|
| WAC 3 | Potable Water              | 2         |       |
|       | **Subtotal** |           | 8 (7.77%) |
| MRC   | Material Resource and Cycle|           |       |
| MRC P1| Purchasing Policy          | P         |       |
| MRC P2| Waste Management Policy    | P         |       |
| MRC 1 | Non-ODS Usage              | 2         |       |
| MRC 2 | Existing Material Conservation | 2     |       |
| MRC 3 | Certified Wood             | 3         |       |
| MRC 4 | Low Environmental Impact Material | 14  |       |
| MRC 5 | Green Cleaning Agent       | 2         |       |
| MRC 6 | Waste Management Practice  | 5         |       |
| MRC 7 | Purchasing Practice        | 2B        |       |
|       | **Subtotal** |           | 28 (27.18%) |
| IHC   | Indoor Health and Comfort  |           |       |
| IHC P | No Smoking Campaign        | P         |       |
| IHC 1 | Outdoor Air Introduction   | 1         |       |
| IHC 2 | CO₂ Monitoring             | 2         |       |
| IHC 3 | Chemical Pollutant         | 9         |       |
| IHC 4 | Indoor Pollutant Source Control | 2   |       |
| IHC 5 | Biological Pollutant       | 1         |       |
| IHC 6 | Visual Comfort             | 3         |       |
| IHC 7 | Outside View and Daylight  | 2         |       |
| IHC 8 | Thermal Comfort            | 2         | 2B    |
| IHC 9 | Acoustic Level             | 1         |       |
| IHC 10| Interior Plants            | 2         |       |
| IHC 11| Pest Management            | 1         |       |
| IHC 12| Room Occupant Survey       | 3         |       |
|       | **Subtotal** |           | 29 (28.16%) |
| BEM   | Building Environment Management|   |       |
| BEM P | Green Training             | P         |       |
| BEM 1 | GA/GP as a Member of Project Team | 3   |       |
| BEM 2 | Green Fit-Out Activity     | 5         |       |
| BEM 3 | Invention                  | 4         |       |
| BEM 4 | Green Activities           | 2B        |       |
|       | **Subtotal** |           | 12 (11.65%) |

Total Maximum Point (43 Criteria) 103 (100%)

Reference: Nasir, 2012 [5]

3.2. COVID-19: Cause, Prevention, and Transmission
As mentioned earlier, COVID-19 is a new and extremely infectious virus with no effective treatment yet. Therefore, before the vaccine and an efficient cure are discovered, it is prudent to proceed with prevention and transmission reduction methods. This disease is caused by a virus found in the animal (particularly bats) [4]. The route of transmission and prospects for the origin of other intermediate
animals remains unclear among the many major cases that have spread. Previous research described that the virus is still active up to 72 hours on plastic and stainless steel. Fortunately, COVID-19 viruses were inactive after 4 hours on copper (Cu) and after 24 hours on a cardboard [5]. Specimens obtained from toilet surfaces drain and door handles used by the positive subject also tested positive for the virus. Apparently, the toilet was negative for the infection after being cleaned thoroughly [7]. The COVID-19 can spread both directly (through droplet transmission and human-to-human transmission) and indirectly by contact through polluted particles and airborne infection [8]. The COVID-19 virus in droplets (less than five microns in diameter) remains intact, contagious, and could stay in the air for up to 3 hours [5]. The main routes of the respiratory virus transmission from person-to-person can be explained as follows:

(a) direct/indirect interaction with the infected person/object
(b) large droplets released by coughing/sneezing, which may reach the non-infected person/subject
(c) the inhalation of airborne particles in the air [9], [10], [11]

The transmission of COVID-19 will increase when the building has poor ventilation and air filtration, as well as where the air recirculates in the closed spaces [6]. People inside the building are at high risk when the occupancy is high, long duration, and exposed to aerosol infection. Inadequate sanitation and drainage systems can also increase the threat of COVID-19 transmission [12]. The safety protocols which are conducted to prevent the transmission of the COVID-19 virus has been established as a preventive measure. The common safety protocols are isolation, quarantine, social distancing, practicing hand hygiene [13], reducing social activities, avoiding crowded places, and avoiding poorly ventilated spaces [12]. The building management should also increase the frequency of disinfection of its premises. Aside from those protocols, the building itself should enhance the health of the occupants. The minimum requirement of air exchange rates is suggested to be increased to 12 ACH [14]. Moreover, the buildings should also make an adjustment on the numbers of adequate ventilation, air infiltration, humidity regulation, and temperature control [6]. In relation to adequate ventilation, proper ventilation and minimization of air recirculation in buildings are essential strategies to limit the airborne spread of viruses. Effective ventilation is significant to remove airborne viruses [15]. The use of an antimicrobial filter, such as a HEPA filter, is recommended in the air conditioning system [14]. The setting should take concern on thermal comfort as well as controlling airborne contaminants; hence central air conditioning should be avoided. A strategy to air filtration by using potted plants is required at least one plant per m² [16].
During the pandemic, people are forced to stay at home to curb the transmission. This condition has created a new demand to create an environment that could maintain well-being, particularly during the lockdown period. The indoor environment that is connected with nature is recommended to be applied in order to create a positive as well as healing atmosphere. Two basic elements that are needed in the healing atmosphere are light and water. One of the design approaches that take a huge concern on how a building is connected to living structures is biophilic design. According to Salingaros, biophilic design can be categorized into three: (i) Nature in Space, (ii) Natural Analog, and (iii) Nature of Space. Each category consists of biophilic design patterns. The Natural in Space includes the concepts such as visual relationships with nature, non-visual relationships with nature, non-rhythmic sensory input, variations in airflow and heat, presence of water, dynamic and ambient illumination, and connection to natural systems. Meanwhile, Natural Analog includes other concepts, such as biomorphic shapes and patterns, the relation of material to nature, complexity, and order. Lastly, the Nature of the Space is associated with values such as possibility, place of residence, mystery, and risk [16][17].

3.3. The Adaptation Strategy of Greenship Interior Space (IS)
Aiming to create a better indoor environmental quality that suits the current pandemic issue, the criteria of Greenship IS are studied based on the cause, prevention, and reduction of virus transmission strategy to obtain a proposal adjustment for adaptation of the Greenship IS criteria.

| Code | Greenship IS Criteria | Proposal of Adjustment |
|------|------------------------|------------------------|
| ASD  | Motor Vehicle Reduction Policy | No adjustment needed |
| ASD P| GREENSHIP Certified Building | No adjustment needed |
| ASD 1| Community Accessibility | No adjustment needed |
| ASD 2| Bicycle | No adjustment needed |
| ASD 3| Motor Vehicle Space Reduction | No adjustment needed |
| ASD 5| Landscaping | Landscape in interior space in the form of plants on the balcony, terrace, wall, or courtyard in the interior is needed to provide healing effects, reduce stress levels, and increase the immunity of the occupants (biophilic design) |
| EEC | Energy Conservation Campaign | No adjustment required |
| EEC 1| Simple Commissioning | Independent testing and commissioning on the frequency of disinfection, air exchange rates, the use of antimicrobial system [12], the opportunity of thermal and airflow variability [16]. |

Visual access to nature indicates an improvement in healing. [18], [19]

Immune functions are enhanced, and stress levels are decreased in the biophilic atmosphere [17].
| Code   | Greenship IS Criteria                                      | Proposal of Adjustment                                                                 |
|--------|------------------------------------------------------------|----------------------------------------------------------------------------------------|
| EEC 2  | MVAC Control                                               | Choosing and completing AC System with advanced control for energy efficiency as well as healthy air quality [12]. |
| EEC 3  | Lighting Power Density and Control                         | No adjustment required                                                                  |
| EEC 4  | Energy Monitoring and Control                              | No adjustment required                                                                  |
| EEC 5  | Electrical Equipment and Appliances                         | No adjustment required                                                                  |
| WAC    |                                                            |                                                                                        |
| WAC P  | Water Conservation Campaign                                | No adjustment required                                                                  |
| WAC 1  | Water Fixtures                                             | All of the water fixtures beside must have a maximum output capacity below standard. It is also necessary to minimize contact with the hands using automatic sensor taps. Related to hand hygiene protocols, the intensity of handwashing will be increased [20]. All water fixtures in the used area should have lower discharge capacity compared to the existing standard [2]. |
| WAC 2  | Water Use Monitoring                                       | Show inspection and maintenance system, including regular monitoring to prevent leakage and waste of water consumption, as well as an unsanitized condition [6]. |
| WAC 3  | Portable Water                                             | As with other water fixtures, the portable water system should also be inspected and maintained and regularly monitored to prevent leakage and waste of water consumption, as well as an unsanitized condition [6]. |
| MRC    |                                                            |                                                                                        |
| MRC P1 | Purchasing Policy                                          | No adjustment required                                                                  |
| MRC P2 | Waste Management Policy                                    | No adjustment required                                                                  |
| MRC 1  | Non-ODS Usage                                              | No adjustment required                                                                  |
| MRC 2  | Existing Material Conservation                             | No adjustment required                                                                  |
| MRC 3  | Certified Wood (MRC 3)                                     | No adjustment required                                                                  |
| Code | Greenship IS Criteria | Proposal of Adjustment |
|------|-----------------------|------------------------|
| MRC 4 | Low Environmental Impact Material | Needs additional criteria material selection, antimicrobial material, and hard-wearing for high contact surfaces. Antimicrobial agents such as copper alloys that can prevent pathogens from multiplying are recommended for a surface with high contact [6]. Antimicrobial agents ensure that the growth of bacteria and a larger variety of virus species, protozoa, and fungi can be stopped. Examples of material that can be used:  
• Kydex (an advanced thermoplastics with antimicrobial properties),  
• Lamishield (contains silver-ions that help reduce surface growth by 99.9%),  
• Solid surface (which allows continuous surfaces to be coated without noticeable joints, avoiding the accumulations of the pathogens) [21]. Hard-wearing means the material is resistant to degradation and can withstand heavy chemicals. For examples, material in this category:  
• sheet vinyl (aids in infection control, easy to clean and slip resistance)  
• thermoformed material (durable, contain hygienic properties)  
• clear acrylic (hard-wearing as guard screen) [21]. |
| MRC 5 | Green Cleaning Agent | To use environmentally cleaning products to disinfect the room. Regular disinfection on high contact surfaces and close the lid before flushing [12] |
| MRC 6 | Waste Management Practice | No adjustment required |
| MRC 7 | Purchasing Practice | No adjustment required |
| IHC | | |
| IHC P | No Smoking Campaign | No adjustment required |
| Code  | Greenship IS Criteria         | Proposal of Adjustment                                                                 |
|-------|------------------------------|----------------------------------------------------------------------------------------|
| IHC 1 | Outdoor Air Introduction     | Maximizing the outdoor air and avoid air recirculation to maintain the air quality indoor. |
|       |                              | Increasing outdoor air exchange rates (6-12 room air changes every hour) [10].           |
|       |                              | Stop air recirculation [12].                                                            |
|       |                              | Central air conditioning should be closing the recirculation damper and maximize the outdoor air. In the case of split air condition, additional ventilation through a window or other mechanical system is needed [22]. |
| IHC 2 | CO2 Monitoring               | To keep the CO₂ concentration low by avoiding meeting/activities in the group, maintaining physical distancing, and reduce the space occupancy. |
|       |                              | Reducing the number of occupancy in a closed space by 50% [22].                       |
| IHC 3 | Chemical Pollutant          | No adjustment needed                                                                  |
| IHC 4 | Indoor Pollutant Source Control | No adjustment needed                                                               |
| IHC 5 | Biological Pollutant        | To reduce biological pollutants through air conditioning systems with additional disinfection devices and methods. |

Strategy to reduce airborne transmission [22]

Needs of regularly air disinfection methods: space air purifier (using a filter, UV light, and other devices for
disinfection) and upper room UV germicidal (GUV) [10].

UV systems/ionization units/HEPA filters can be used for air purification to minimize the accumulation of viral aerosols effectively [12].

For a badly ventilated room, the need for additional air-cleaning devices, such as ultraviolet germicidal (UV or UVGI), may be beneficial [22].

| Code | Greenship IS Criteria | Proposal of Adjustment |
|------|------------------------|------------------------|
| IHC 6 Visual Comfort | | No adjustment required |
| IHC 7 Outside View and Daylight | Access to outside view and daylight is more important than ever because, during the pandemic, most of the people stay indoors. |
| IHC 8 Thermal Comfort | ASHRAE recommends the Relative Humidity level for the indoor environment is between 40 to 60% for thermal comfort, but US-EPA recommends retaining the Relative Humidity level between 30% to 50% to decrease the mold growth apart from optimizes thermal comfort [24]. |
| IHC 9 Acoustic Level | No adjustment required |
| IHC 10 Interior Plants | Further research is needed to investigate the effectiveness of indoor landscape in improving indoor air quality. Built-in green wall technology can be paired with the designs to have a significant effect on indoor |
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4. Conclusion
Before the COVID-19 vaccine is clinically proven to prevent the disease, one of the feasible approaches is to plan and construct an environment to minimize and reduce the virus transmission, especially in the indoor environment where people do most of their activities during pandemics. Embarking from the current Greenship IS criteria, this research aims to provide several recommendations to adjust the existing criteria to suit the pandemic condition. The proposal adjustment of Greenship IS criteria shows the importance of human health as a priority that needs to be achieved in addition to sustainability. The criteria for a Greenship IS as one of the approaches need to be adjusted.
From the discussion, it can be concluded that in each category there are several adjustments as follows: 1P ASD + 5 ASD criteria (1 criterion adjustment), 1P EEC + 5 EEC criteria (2 criteria adjustment), 1P WAC + 3 criteria (3 criteria adjustment), 2P MRC + 7 MRC criteria (2 criteria adjustment), 1P IHC + 12 IHC criteria (7 criteria adjustment), 1P BEM + 4 BEM criteria (4 criteria adjustment). Adjustments are prioritized in the IHC category aiming to create good indoor air quality, then followed by BEM, WAC, and EEC. These are related to operational and maintenance activities by the building management to ensure the activities are not only environmentally friendly but also prioritizing human health by maintaining health protocols with routine disinfection. Meanwhile, the MRC criteria adjustment emphasizes the selection of materials during the pandemic. Lastly, the natural elements that are included in the landscape in ASD criteria must be considered to increase immunity, reduce stress levels, and provide a healing effect for the occupants. Following the proposal adaptation criteria, it is expected to help in mitigating the transmission of the virus. Further research is needed to fulfill the gaps in the detail of implementation and credit point adjustment in the assessment process.

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