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Biosecurity-Based Architecture as a Surabaya Zoo Resilience Approach

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ABSTRACT

The Covid-19 pandemic has a direct impact on conservation institutions such as zoos. Although the Surabaya Zoo is now recovering along with the decline in cases, it requires a resilience strategy to face the threat of similar zoonotic diseases in the future. These threats have a negative impact not only on humans, but also on the welfare of the animals. This research looks at biosecurity as a form of risk management and problem prevention. Isolation, circulation systems, and waste treatment technology are the most important biosecurity components for zoos. The method begins by examining the biosecurity strategies implemented and planned by zoo associations around the world. The results of the analysis were then implemented at the Surabaya Zoo. It is necessary to analyze design elements in zoos such as entrances, circulations, and animal enclosures that still do not meet the concept of biosecurity. The study's findings include the implementation of a biosecurity strategy at the Surabaya Zoo from an architectural standpoint, a circulation system devoted to entry/exit access, and the provision of service areas that can be accommodated in one zone of Service Facilities. Also, noise mapping simulation shows that it is necessary to reduce noise in the facilities**.**

Keywords: biosecurity-based architecture, resilience, zoo

1 Introduction

The Covid-19 pandemic has affected not only people but also animals kept in zoos and other conservation facilities [1]. The majority of the zoos directly impacted by Covid-19 had trouble feeding their animals [2]. This took place because the government regulations relating to the Implementation of Community Activity Restrictions caused the zoo's revenue to decrease. The Surabaya Zoo was one of the zoos that experienced a drop in revenue as a result of being restricted and closed as a result of the restrictions' implementation [3]. Another impact that is no less significant than the zoo's decreased revenue is the anxiety felt by some

animals who are not accustomed to the quiet zoo environment as well as the concern of zoo staff and keepers regarding the animals' health and welfare because the zoo has not yet reopened [4].

Future threats include not only the risk posed by SARS-cov but also those posed by numerous other zoonotic diseases. Zoonoses are illnesses and infections that can spread from animals to people and vice versa [5]. A number of zoonotic diseases, including avian influenza and swine flu, had struck China [6] and could at any time pose a threat to the general public and zoos. In Indonesia, the swine flu virus can potentially spread from pigs to people in addition to the bird flu virus infecting poultry and humans [7].

Of course, prevention and resolution are necessary for these various potentially dangerous threats. The Surabaya Zoo needs a resilience strategy because zoos are expected to not only be able to adapt to environmental changes as they occur but also to survive these threats. Resilience is the capacity to adjust and persevere in trying circumstances [8], so this approach to problem-solving is appropriate for dealing with threats and dangers of the same nature in the future.

The Hierarchy of Hazard Controls describes several methods for controlling hazards [9]. Figure 1 depicts the hazard control hierarchy, which includes the processes of elimination, substitution, engineering control, administrative control, and personal protective equipment (PPE). The removal technique will completely eliminate the hazard from the site. The substitution technique alters the danger but only seeks to reduce its severity. Engineering control techniques modify and perform engineering in the control of potential hazards. Administrative control techniques include standard operating procedures (SOP), standard settings, and working hours, among other things. The final technique is to control the hazard by using Personal Protective Equipment (PPE).

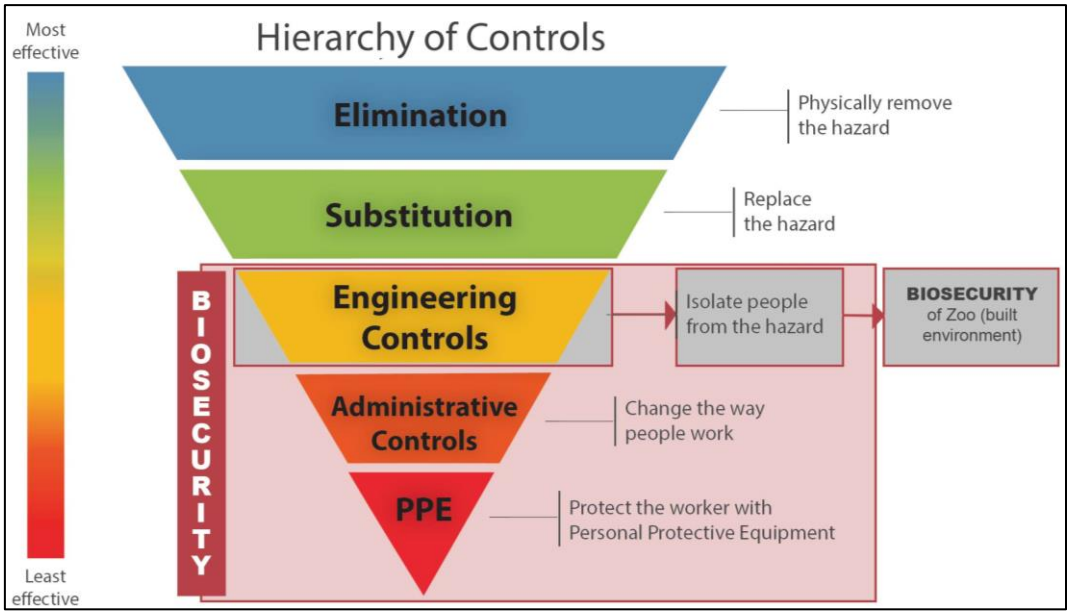


Figure 1 Hazard Control Hierarchy for Zoos Adapted from Cdc.gov

Varela claims that the Hazard Control Hierarchy's elimination and substitution techniques are the most challenging ones [10]. This is due to the fact that hazards cannot be completely eliminated or reduced in a short amount of time. As a practical illustration, consider the length of time required for Covid-19 research and vaccine production. Engineering controls, administrative controls, and rules for the use of PPE are all doable and practicable things. The core components of biosecurity are these three things. The primary Covid-19 prevention strategy in zoos, according to [11], is biosecurity.

A series of precautions known as "biosecurity" is taken with the primary goal of reducing the risk of infectious diseases spreading to animal or human populations. Engineering controls, administrative controls, and PPE use regulations are all part of biosecurity. Additionally, administrative control methods and the use of PPE are simple to implement but less efficient because they rely too much on the individual. Engineering control is the most practical and successful biosecurity tactic to use, especially in the field of architecture, out of the five hazard controls.

In order to address these issues, this study starts by identifying and analyzing biosecurity as a type of resilience strategy for addressing potential zoonoses at the Surabaya Zoo. The field of architecture, which is concerned with isolation, circulation, and the management of sanitation and waste, is the only one where biosecurity is at issue. The Surabaya Zoo's zoning concept, quarantine room design, service zone, and circulation design are all based on the findings of the biosecurity analysis. The findings of this study are anticipated to be used by Indonesian designers and conservation organizations.

2 Literature Review

Zoo Biosecurity

It is necessary to conduct a zoo biosecurity analysis based on standards set by international zoo associations to identify the elements that require attention. The National Zoo of Australia's National Zoo's biosecurity module and checklist are referenced in Table 1, a list of zoo biosecurity elements. There is a conformity of crucial elements that must be taken into account in zoo biosecurity based on these two standards. Isolation, circulation, sanitation and waste management, animal feed, animal condition and management, and pest control are the six areas that require attention.

Table 1 Zoo Biosecurity Components Adapted from Reiss [12] and Australia's National Zoo Biosecurity

No.	Data	National Zoo Biosecurity Manual	Australia's National Zoo Biosecurity Manual Self-Audit Checklist Ver 1.1
1	Isolation	- Zoo locations & layouts - Isolation & treatment of sick animals	- perimeter security - general quarantine practice - vet investigation during quarantine
2	Circulation manage-ment	- employee, tourist, construction worker, and courier movement - transportation of animals to and from outside the zoo - building work, constructed facilities	- input and output system - movement of animals in the zoo - movement of vehicles into and out of the zoo area - management of animals, vehicles and equipment when transporting animals

No.	Data	National Zoo Biosecurity Manual	Australia's National Zoo Biosecurity Manual Self-Audit Checklist Ver 1.1
3	Sanitation and waste manage-ment	- waste management methods - control drainage and waste disposal - staff and visitor hygiene procedures	- maintenance of cages and soil - drainage and waste disposal - work procedures and hygiene for workers and visitors - carcass disposal
4	Animal food	- source of clean water supply - source of food supply - ensure food, water, equipment and work practices do not invite or spread pests and diseases	- food quality and food supply - water quality and supply
5	Animal condition and managerial	- species, origin and number of animal collections - disease status from animal collection - disease status and distance to animals in the surrounding area - potential for zoonotic disease - preventive treatment program for all zoo animals - inspection, testing and quarantine of animals entering zoos, including animals to be bred for release as part of an approved recovery program - Veterinary investigations of disease and death in animal collections	- information recording - animal identification - zoonotic disease risk management - animal health and preventive medicine - management of sick animals - priority investigations and trigger points - animal death, post-mortem examination - staff training and documentation - zoo facility design, construction and contractor - institutional biosecurity planning -emergency biosecurity response plan
6	Pest control	- presence and types of wildlife and pest species - control of wild, wild and nuisance animals	- pest species control - control of wild animals and domestic animals

Table 1 shows that isolation, circulation control, cleanliness, food, and waste management are architectural factors that must be taken into account in zoos that adopt biosecurity.

Zoo Isolation

In an effort to protect both humans and animals, isolation involves separating or insulating an animal's presence. This can be produced by altering the layout and zoning. To safeguard animals from zoonotic diseases, animal layout arrangements are created. Figure 2 shows that Covid-19 only affects mammals; therefore, if a similar zoonotic disease arises, the zoo does not need to close entirely because the treatment is sufficient to isolate the afflicted animals in accordance with their genetic makeup. To hasten recovery, isolation zones must be handled carefully [13].

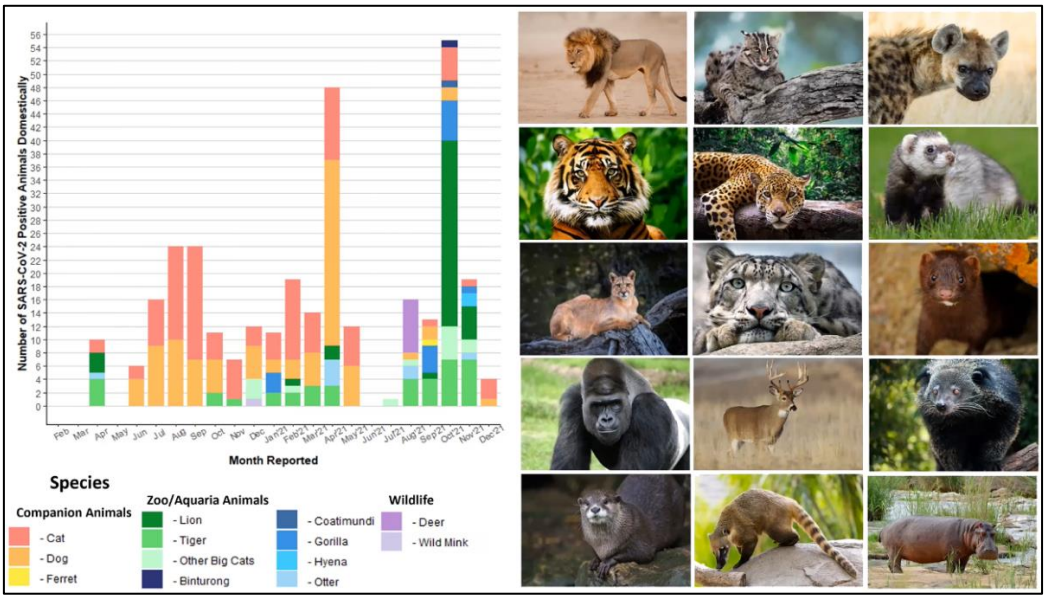


Figure 2 Graphics of Animals Infected with Covid-19 in the United States [11]

Zoo Circulation

The zoo's circulation system aims to control entry and exit for all individuals entering and leaving, including guests, staff, animals, and construction workers. Users say that a good zoo has several entrances. It is best to separate access for humans (employees, workers, visitors). This is done in an effort to lessen the chance of disease spreading while still allowing circulation users the necessary access.

Zoo Animal Feed Management, Sanitation, and Waste

A zoo quarantine facility can be a service zone where clean water and animal feed management are combined. The service zone can also contain animal waste in the form of carcasses and animal waste. The waste from dead animal carcasses must go through several processes before it can be destroyed by burning or burying it. The decision to dispose of dead animals is shown in Figure 3's decision tree, which shows that not all dead animals must be buried or destroyed, but also that some may be used as food for other animals, their skins may be reused, or they may be composted [14].

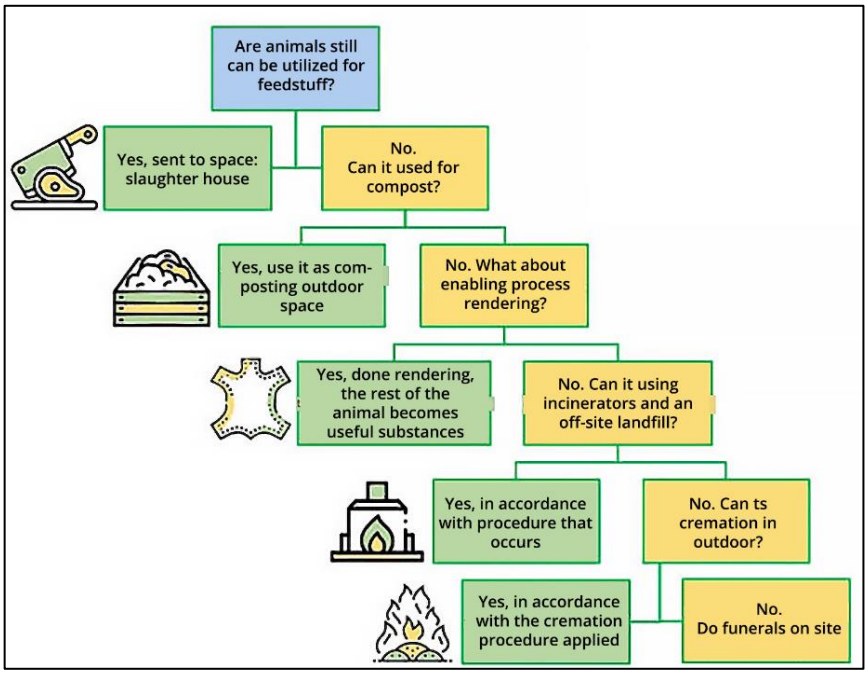


Figure 3 Dead Animal Disposal Decision Tree Diagram

3 Methods

By analyzing the key elements of biosecurity, this study describes architectural resilience ideas and strategies in conservation institutions, especially zoos. This study specifically discusses the study of isolation, circulation, sanitation, and waste management at the Surabaya Zoo as a case study from a conservation institution. It also limits biosecurity in the architectural field. Figure 4 illustrates that the Surabaya Zoo is the research site. The Surabaya Zoo was chosen as the study's subject because it is one of East Java's largest institutions for conservation and was severely impacted by the Covid-19 pandemic.

Figure 4 Research Locations at the Surabaya Zoo, Indonesia

The method used in this study begins with analyzing the biosecurity strategy from an architectural perspective that has been carried out and planned by zoo associations in the world and related stakeholders. Zoos that have implemented biosecurity strategies can also be used as comparisons. The Association of Zoos in Australia also publishes a module guide for handling and managing zoos. One of the topics covered biosecurity for national zoos. The guide in the form of a module is used as a reference in analyzing the zoo's biosecurity strategy.

The Surabaya Zoo then put the analysis that came from the biosecurity strategy into practice. For later proposed improvement designs, it is necessary to analyze design components in zoos that still do not adhere to the concept of biosecurity. The Surabaya Zoo's current conditions are examined first, along with its zoning, entrances and exits for guests, animals, and staff, as well as its service areas, which include animal feed storage areas, enclosures, and sanitation areas.

Figure 5 depicts the Surabaya Zoo's current zoning according to the genetic division of vertebrate animals. Animals are categorized genetically into five groups: fish, reptiles, amphibians, aves, and mammals. There is a collection of nocturnal animals at the Surabaya Zoo, but there is no collection of amphibians. The nocturama zone is populated by a variety of avian, reptilian, and mammalian species that are active at night. The fact that educational facilities are the focus of this zoning division makes it significant. Due to limited space, infrastructure, and degree of mobility, some animal cages—such as those housing komodo dragons in the reptile zoning and pelicans and eagle collections in the aves zone—are not combined into one zone.

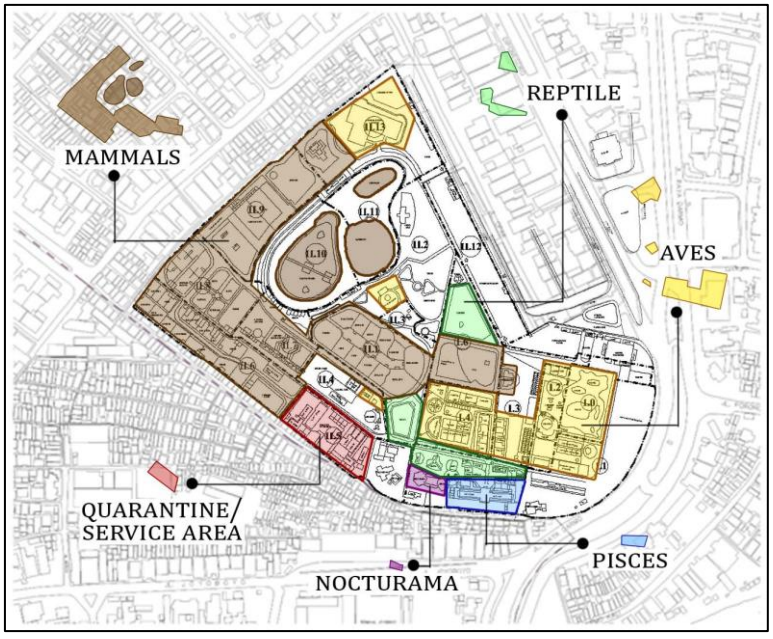


Figure 5 Zoning of Existing Animals at the Surabaya Zoo Based on Genetics

It is possible to further discuss the findings of the analysis about biosecurity and its application in accordance with the circumstances at the Surabaya Zoo. A summary of significant biosecurity issues, including the role of conservation organizations that can be applied to zoos, is included in the conclusion. Additionally, the

conclusion is the outcome of applying biosecurity in accordance with the circumstances at the Surabaya Zoo. Lastly, a noise mapping simulation with dBmap Noise Mapping Tools will be used to determine whether the design position is good acoustically since an animal quarantine room needs to be low noise.

4 Results and Analysis

Application of Biosecurity Strategy at Surabaya Zoo

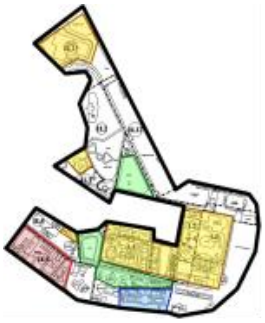
A good zoo with biosecurity-based aims to prevent the entry of infectious diseases and contaminate its animals, the spread of disease from infected areas to uninfected areas within the zoo, the spread of infectious diseases from inside the zoo to outside animals, and the transmission of infectious diseases from animals to humans or humans to animals in the other direction [12]. It is necessary to conduct a biosecurity analysis that focuses on the zoo case, analyzes the Surabaya Zoo as it currently exists, and results in a design that can be implemented at the Surabaya Zoo.

Isolation in Surabaya Zoo

The Surabaya Zoo can use a number of biosecurity techniques, including the concept of animal zoning isolation, circulation systems, the provision of quarantine zones, animal feed, and waste management. Table 2 outlines the Surabaya Zoo's isolation policy.

Table 2 Surabaya Zoo's Isolation Policy

No.	Affected/ Infected animals	Plan	Explanation
1	Pisces and Reptile (and nocturama)		Isolation in the Pisces and Reptile Zone. The aves and mammal zones can still be visited so the zoo doesn't need to close completely.
2	Aves		Isolation in the Aves Zone. The pisces, reptile and mammal zones can still be visited so the zoo doesn't need to close completely.

No.	Affected/ Infected animals	Plan	Explanation
3	Mammal		Isolation in the Mammal Zone. The pisces, reptile and aves zones can still be visited so the zoo doesn't need to close completely.

To prevent and lessen the risk of zoonotic disease transmission in Surabaya Zoo, the distance between animals and people (visitors) is also regulated, with a minimum distance of 6 feet or roughly 2 meters [10]. If the zoo's existing cage does not meet the required minimum distance, this can be fixed by putting up a temporary fence. The general isolation/quarantine area and sick animal care area used by veterinarians and zoo staff are two additional things to be aware of.

Figure 6 Setting the Distance 2 meters From the Cage to Visitors [10]

Circulation Management in Surabaya Zoo

Figure 7 depicts the current circulation in the zoo. The entrance and exit are accessible from three points. There are main entrances and exits in the east that are used as the main access for visitors, employees, construction workers, couriers, and animals at the Surabaya Zoo as it currently exists. The second entrance is close to the restricted-use visitor parking area. The third entrance, which is in the southern section close to the Joyoboyo Terminal, is used to transport construction vehicles, livestock, and animal feed. On weekends and holidays, it is also open to special visitors. In accordance with the biosecurity strategy, visitors should be directed to the main entrance and Joyoboyo access should only be used specifically for animals and services, supporting the development plan for the Joyoboyo underpass that is currently being constructed.

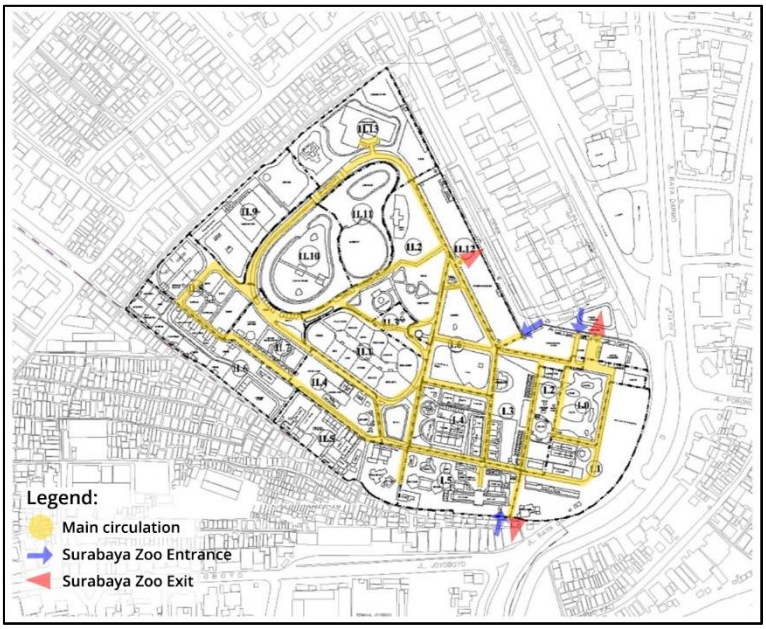


Figure 7 Surabaya Zoo Existing Circulation and Access

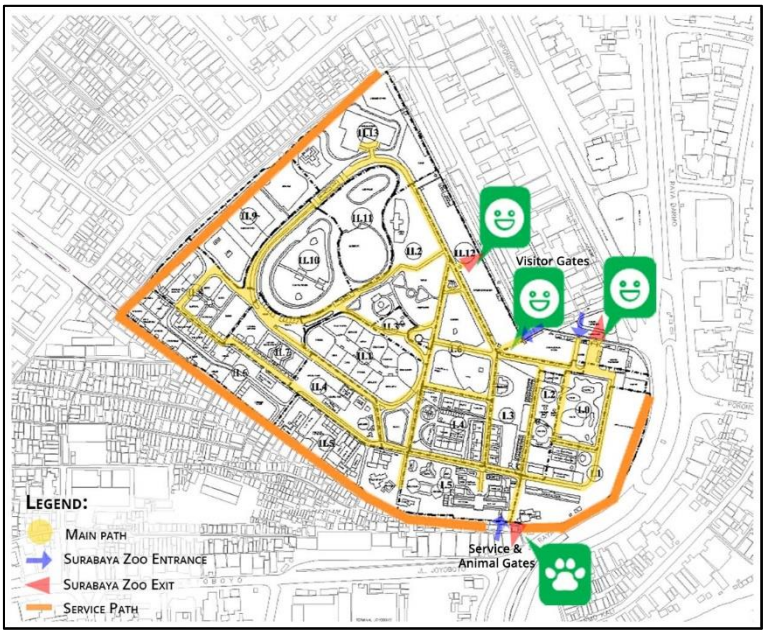


Figure 8 Surabaya Zoo with Adding New Service Path and Access

Service Facilities

Figure 9 shows the layout of the Surabaya Zoo's quarantine facility. As part of its biosecurity plan, the Surabaya Zoo uses this quarantine zone as a service area to meet its needs. Animals needing intensive care that need to be isolated can use quarantine rooms. The area also provides for the management of animal feed, sanitation, and waste, particularly animal waste.

Figure 9 Service Plan: Quarantine Facilities and Feed Supplies for Surabaya Zoo

Animal waste and zoo site waste are the two main focuses of waste management at the Surabaya Zoo. Visitors' trash and animal food scraps make up the waste at the zoo location. Dead animals and animal waste are both examples of animal waste. Currently, the Surabaya Zoo's trash is taken outside the zoo's boundaries, and dead animals are also disposed of elsewhere after being autopsied at the animal hospital. It can solve issues and meet needs in relation to biosecurity strategies by offering a service area that has been designed.

Noise Mapping Simulation

A noise mapping simulation is carried out to estimate whether the location of the Service Facilities is good acoustically, because a room for animal quarantine requires a room that is protected from noise so that sick animals can rest properly. The simulation conditions used are as follows: The height of the zoo wall is 2 meters high. The noise that is commonly used as a sound source in the simulation is white noise 100 dB [15]. Figure 10 shows results from the simulation results using the dBmap Noise Mapping Tools, it is found that the noise in the Service Facilities area is 45 dB. This noise is still considered moderate noise because WHO stated that noise in conservation areas must remain low [16], so noise management is necessary.

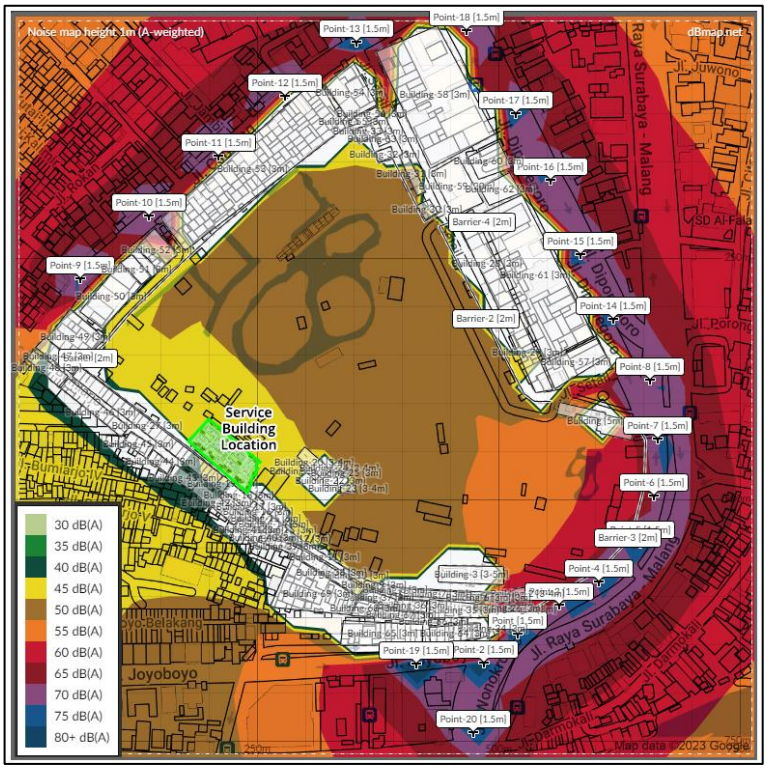


Figure 10 Surabaya Zoo Noise Mapping Simulation Results

5 Conclusion

Zoos and other institutions dedicated to conservation are subject to biosecurity as a form of risk management. According to the study's findings, six areas in the biosecurity strategy require attention, particularly for zoos: isolation, circulation, sanitation & waste management, animal feed, animal condition & management, and pest control. Architecturally, the Surabaya Zoo's implementation of the biosecurity strategy is focused on isolating animals according to their genetic zones, creating circulation systems that are specific to entry/exit access, and providing service areas that can fit in one zone, like animal quarantine rooms, sanitation feed management areas, and animal waste areas. From the noise mapping simulation, it is found that noise still does not meet the requirements so noise reduction is needed.

It is still possible to expand on this research for future research. It would be interesting to talk about the Surabaya Zoo's circulation planning in relation to circulation zoning and the selection of entry/exit access points also the need for efforts to reduce noise. Additionally, there is a high level of complexity in the spatial planning of the zoo's service area, specifically the interior of the quarantine room, providing food, and destroying animal carcasses, allowing for further investigation.

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