SYSTEM DYNAMICS
COVID-19 IN
INDONESIA

REPORT

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SYSTEM DYNAMICS CENTER
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COVID-19 research in Indonesia was developed with a modeling simulation analysis tool with a System Dynamics Approach, the result of simulation was seen from the number of positive COVID-19 cases. In projecting the COVID-19 case in Indonesia, it is very specific and unique because Indonesia is an archipelagic country.

The application to inhibit the rate of development of cases and break the chain of spread is call for alertness, health protocol implementation including Healthy Living Movement, social distancing, disinfectant spraying, adequacy of medical devices and health facilities, Stay At Home or Work Form Home and also the option of limiting the region both regionally partially closed down and lockdown.

“it is estimated that the number of cases will reach the peak on day 80th to 110th”

*Scenario Condition*
1. INTRODUCTION

Since the emergence of Corona Virus 2019, COVID-19, which was first discovered in December 2019 in Wuhan City, Hubei Province, China, it has been determined as a pandemic by the World Health Organization because this plague that has spread out in a short period of time throughout the world is infectious. Moreover, this has a continuous infection line and causes a lot of victims. In this case this had been 3 months until the end of March 2020, and there have been as many as 719,000 people who have been declared exposed to this virus with and 33,673 people who were claimed dead. According to WHO 2020, this virus has spread to 202 countries as shown in Figure 1.

In Indonesia itself, this has started from March 1, 2020 and within a month there has been a significant number of cases, in which the number of confirmed cases of COVID-19 was 1,528 people. There were 136 people who died, or the death rate was 8.9%, which is spread over 32 provinces. This illustrates that there is 94% of provinces which have confirmed COVID-19 cases, and this can still continue to increase due to the growing trend of cases. The highest number of COVID-19 cases is in DKI Jakarta, that is, 50.9% of all confirmed cases in Indonesia, followed by West Java Province by 12.7% and Banten Province by 9.3%. Of the three provinces, there has been 70.74% of cases confirmed as the main core area for the cases. The complete information is presented in Figure 2.
In projecting the COVID-19 case in Indonesia, it is very specific and unique because Indonesia is an archipelagic country, so we cannot just project by comparing based on the population in Indonesia. It is necessary to perform an opportunity occurrence based on the number of residents with a constant case of events in each province or island that is different, so the contact opportunities that will occur can be found out. On the other hand, this can illustrate the vulnerability of the region based on the number of cases and consideration of regional economic mobility.

To anticipate the increasing number of cases, a strategy is needed to inhibit the rate of growth and spread. Looking at the projected conditions in the future is very important, so we can anticipate with a variety of policy scenario choices. The system dynamics approach is very optimal to see the conditions that will come from the simulation results as well as the scenarios that can be chosen. The ease of seeing the interrelation of variables is reflected from the causality that is formed and the behavior that will occur with the implementation of the scenario. This study aims to see the behavior of the maximum number of cases in Indonesia and the selection of policy scenarios to slow down and resolve COVID-19 cases in Indonesia.

This system dynamics projection is strengthened by the choice of scenarios to see the projection, so that it is possible to know the possibility of COVID-19 cases in Business As Usual, Moderate, Optimistic and even uncontrolled conditions if there is an explosion of cases on other islands that will disrupt patterns in Jakarta. With the description of Business As Usual, it can help anticipate all the stakeholders’ roles, including the Government, the Community and directly involved institutions that seek to minimize the COVID-19 case in Indonesia.

2. DEVELOPMENT METHOD AND ANALYSIS TOOL

The study has observed the beginning of COVID-19 occurrence in Wuhan until now and also the first case that happened in Indonesia. To see the graph of Corona Virus growth behavior, some data obtained from various sources, like WHO (World Health Organization) to see the data in the world and National Disaster Management Agency to see the data in Indonesia are needed. COVID-19 research in Indonesia was developed with a modeling simulation analysis tool with a System
Dynamics and with the consideration of ease to visualize the dashboard to the users. While technically, the formulation was developed from various data from *Statistical Framework integration with Dynamics Complexity*. The Display of Dashboard developed is shown in Figure 3.

![System Dynamics COVID-19 in Indonesia](image)

**Figure 3. The Display of Dashboard developed System Dynamics COVID-19 In Indonesia**

### 3. CONCEPTUAL OF MODEL

In making a simulation, this can be carried out from the number of cases that exist for some time, but in a system dynamics, this is not only about projecting the existing data. In a system dynamics, it is important to make the relationship first among the variables related to the case and the combination from various projections of the variables forming COVID-19 case.

The development of *systems thinking* is in casual relationship (*causal loop diagram*). This is the basis for building the interrelation among variables. There are several specific terms used for people who experience the symptoms to facilitate the understanding of the COVID-19 case in Indonesia, that is, people under monitoring (PUM) and patient under treatment (PUT). PUM is for those who experience fever (>38°C), cough and cold or Acute Respiratory Tract Infection or URI (*Upper Respiratory Tract Infection*) without Pneumonia and they have a travel history to other countries/regions in which there is a case of COVID. While PUT is for those who experience fever (>38°C), cough and cold or Acute Respiratory Tract Infection or URI (*Upper Respiratory Tract Infection*), and Pneumonia from mild to severe, and they also have a travel history to countries/regions in which corona virus occurs and they also have a direct contact with those who are positive.

The first case occurred because there was a carrier and this led to an exposure of people in contact with the carrier. However, because there was an incubation time of 2-14 days, this slowed down to see whether the people were infected or not. If the people were categorized into positive, thus, they would be treated and cared specifically (isolated) so that the virus would not spread out to others. The fast growth of this virus is because there will be some people who are likely positive but they are not categorized into (PUM/PUT), the virus could be transmitted to other people. The speed of transmission
depends on the number of contacts, both from people who are likely to be positive directly or indirectly through other infectious media or the region resulting the surge of case in which there are people who are infected or even already positive.

It is necessary to apply the policy model in inhibiting or cutting off the speed of transmission of COVID-19 in various ways. The application to inhibit the rate of development of cases and break the chain of spread is call for alertness, health protocol implementation including Healthy Living Movement, social distancing, disinfectant spraying, adequacy of medical devices and health facilities, Stay At Home or Work From Home and also the option of limiting the region both regionally partially closed down and lockdown. A description of the relationship and causality of the developed model is shown in Figure 4.

![Causal Loop Diagram Model COVID-19 in Indonesia](image)

**Figure 4. Causal Loop Diagram Model COVID-19 in Indonesia**

4. **REGIONAL VULNERABILITY ANALYSIS**

Before conducting the simulation, it was crucial to conduct a regional vulnerability analysis because it could cause differences in the number of vulnerability people in each region. This regional vulnerability was seen from the large number of cases in each region and the opportunity for individual contact with residents of the region. On the other hand, interaction among regions could also be a factor in calculating the level of vulnerability, in which high mobilization among regions would lead to higher contact possibilities. Therefore, this would lead to a greater vulnerability of the region. A description of the percentage of the cases in each region is presented in Figure 5.
Based on the results of the analysis, it can be seen that almost 90% of cases (7 provinces) are concentrated in Java Island, island or other provinces which have quite an influential case, that is in South Sulawesi. While the case in other islands was only 10% from the whole islands in Indonesia. However, this doesn’t close the possibility that there will be an increase in other islands if there is no anticipation from now. From the percentage, the opportunity of contact can be seen in each region.

The area vulnerability calculation was based on the number of cases in each region and the average likelihood of a contact during a 2-14 day incubation period, in which the average contact is 10-15 people per day. The illustration of the regional vulnerability level is shown in Figure 6.
Based on the picture of the vulnerability level, especially the case of the total population, it can be seen that the region that has the highest level of vulnerability is the Province of DKI Jakarta with a weight value of 17.18 of the average case and the Province of Banten with a value of 2.59. While the next level of vulnerability is the South Sulawesi region (1.51), DI. Yogyakarta (1.42), Bali (1.17) and East Kalimantan (1.15), while other provinces are still in the small category. If viewed from the structure of income and regional mobilization based on cases and economic mobility, it can be seen that regions have high mobility, including Jakarta with a value of 14.72, West Java (5.22), Banten (3.40), Central Java (3.25) and East Java (3.12), then the next province which is categorized into the middle is South Sulawesi at 1.61. The results of this analysis show that based on population, the number of cases and economic mobility in each region is different. If drawn structurally among regions, it can be seen as shown in Figure 7.
5. **MODELING SIMULATION**

After obtaining the possibility of contact from each region with different constant, it could be found out that the possibility of Indonesian categorized into vulnerability was 10,500,000 to 11,000,000 people. Data simulation was carried out to see how long, how many possible cases will occur, and the estimation of when this case will reach a peak. The result of simulation was seen from the number of positive COVID-19 cases. The estimation of those who died was determined from the percentage of research cases and the level of people who were vulnerable. The number of patient needed to be treated both from the positive and from the PUT.

The policy scenario was carried out in a number of conditions including moderate, optimistic and uncontrolled. This system dynamics can provide an overview to stakeholders who want to see the results of their simulations because simulation scenarios can be carried out in accordance with the hope or ability that can be performed in an effort to minimize COVID-19 cases in Indonesia. For the scenario condition, it is presented in table 1.

From some of these conditions, it can be chosen the possibility of policy that can be undergone especially the possibility of cases in *Business As Usual*, while the optimization of policy scenarios is done under moderate and optimistic conditions and in uncontrolled condition, a very significant surge can be clearly seen. For Business As Usual condition, it is shown in Figure 8.
<table>
<thead>
<tr>
<th>No</th>
<th>Condition</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Business As Usual</td>
<td>•Conditions where there is still a deficiency of medical needs for health control, but the healthy life and social distance increases</td>
</tr>
<tr>
<td>2</td>
<td>Business As Usual (Deficiency of medical needs)</td>
<td>•Conditions where there is still a deficiency of medical needs for health control, but the healthy life and social distance increases but slowly</td>
</tr>
<tr>
<td>3</td>
<td>Uncontrolled /Extreme</td>
<td>•Precautionary Caution is not optimal implemented</td>
</tr>
<tr>
<td></td>
<td></td>
<td>•Stay at home is not running optimally, because of the activities still carried out</td>
</tr>
<tr>
<td></td>
<td></td>
<td>•There were highgrowth case on other islands following the core cases islands (DKI, West Java and Banten)</td>
</tr>
<tr>
<td>4</td>
<td>Maximum</td>
<td>•Conditions where there is still a deficiency of medical needs for health control</td>
</tr>
<tr>
<td></td>
<td></td>
<td>•The healthy life and social distance increases but slowly</td>
</tr>
<tr>
<td></td>
<td></td>
<td>•Precautionary Caution is not optimal implemented</td>
</tr>
<tr>
<td>5</td>
<td>Moderate</td>
<td>•All scenario variables are moderate, and stay at home runs at 60%</td>
</tr>
<tr>
<td>6</td>
<td>Optimistic</td>
<td>•All scenario variables are moderate, and stay at home runs at 60%, after day 50 the regionally partially closed down</td>
</tr>
</tbody>
</table>

Figure 8. Simulation Results of Some Business As Usual Conditions before Optimizing the Policy Scenarios.
Based on the simulation results there are 2 conditions (figure 8.1), in which the first condition is if it has not been anticipated in advance or an appeal to the community for vigilance when starting the first case drawn on the red line appears. Whereas the second condition on the blue line, this shows that there has been an alert call during the first case, but what needs to be considered is 2-14 days before the first case. In fact the person has made contacts with several other people. In the second graph there is still an increase, this is possible if it does not make progressive treatment and the limited number of health facilities and medical personnel. Whereas in Figure 8.4, it can be seen the number of patients who are positive or PUT needed to be treated in hospitals. Consequently, there will be a surge in the number of patients feared for lack of bed health facilities and equipment for handling COVID-19 cases.

The peak estimation of COVID-19 in Indonesia is the 80th to 110th day with a high enough number of cases reaching around 15,000 at the optimum point, and the decrease of case number is subsequently quite slow. This shows that there has been a slight slowdown in the decrease of the maximum possible number of cases, but it can at least reduce the number of people dying. While the mortality rate is around 8-9% for now, so it is around 1,200-1,400 people, with a note that this is due to the limitations of health facilities and medical equipment for handling cases. It is not impossible that this will be even higher if other regions outside of Java perform the same pattern as in Jakarta or Java. In addition to handling in Jakarta and nearby areas, anticipation in other provinces is important in order to inhibit the same pattern of spread rate. The overview of dashboard for simulation scenarios is presented in Figure 9.

![Figure 9. Dashboard of Business As Usual Simulation](image)

6. POLICY SCENARIO

Minimization of COVID-19 in Indonesia needs to apply a number of policy so that it will run effectively and efficiently. Some scenarios of policy and the stimulation of model drive variables or programs that are applied with the moderate condition and they are applied progressively (optimistic).
With the selection of variables, the policy simulation scenarios can be performed on the simulation requirements according to its implementation capability, but from this initial case of study up to the 30th day with business as usual conditions and some moderate improvements have been made. Policies that have been implemented in stages such as health protocols, the Healthy Living Community Movement, and the provision of work at home with a value of 60%. Stay at home is still quite difficult to carry out maximally. This can be seen that there are still many business owners and small-medium sized business owners who mobilize highly in order to fulfill their daily need.

Whereas the optimistic conditions were carried out as business as usual conditions until the 30th day, it was then only implemented on day 40th to be a progressive (optimistic) unless the spraying is performed in the condition of moderate because this is quite difficult to carry out to the whole areas. Stay at home can be really applied up to 90%. This cannot be performed completely 100% because some people still need to do their activities. In this condition, the most important thing is the adequacy of facilities and medical devices. In some regencies/cities, the red category needs to be limited in its region (regionally partially closed down)

- **Uncontrolled Condition**

  In this uncontrolled condition, this means that there is a similar pattern of explosion of cases, such as in the island of DKI Jakarta, West Java and Banten. It is estimated that cases will increase to 27,000-30,000, which reaches its peak on day 100-120. This happens when there is an increase in contact, a decrease in *social distancing*, and government’s appeal. For the simulation projection results, this is presented in Figure 11.

![Figure 11. The Result of Uncontrolled Condition Simulation](image-url)
**Moderate Condition**

The simulation of scenario in the moderate condition can slow the increase rate of cases to only 9,000 positive cases of COVID-19 that occur (Figure 8.2), in which the pattern still remains the same as the present condition. It is crucial to start the restriction outside of the Java Island. However, if the region does not apply the same thing, it is likely to increase the cases.

If this can be applied, the cases will slow down on day 90\text{th}, and begins to decrease by half. From these results, it seems that there has been a decrease of one third of the maximum cases. This is already quite significant, but there is still a slight increase and the maximum point of day 90\text{th}. The decline is slightly slower due to the positive cases, and the existence of PUM and PUT around the community, on the other hand, the activity will have started to run again.

For the case of death, it can be minimized because the handling of the hospital capacity is very sufficient, but the slowdown will still occur because there have been a limitation of medical devices for handling COVID-19 since the initial case occurred. The result of moderate scenario is completely shown in Figure 12.

![Figure 12. The Result of Moderate Condition Simulation](image-url)
• **Progressive Condition (Optimistic)**

For the simulations on progressive or optimistic conditions, it is very influential to the suppression and decrease of COVID-19 positive cases sharply. Based on the simulation results in this condition, the 45th-65th day (6,000 Cases) can be reduced by the rate of case estimated at around 3,000-4,000 cases on day 70th and 80th. The number of existing cases have started to decrease greatly, in which the point is slowly declining even though there are still some cases but these cases are absolutely solvable. The application of this is similar. In other word, this is done together to all regions so that this can run effectively. In the red zones, it is very urgent to do **regionally partially closed down**. Hence, the number of death cases will not exceed 300 people. The simulation of this result is completely presented in Figure 13.

![Simulation Result of Optimistic Condition](image)

**Figure 13. Simulation Result of Optimistic Condition**

Based on the number of simulation results and system dynamics scenarios, these can help estimate the condition of COVID-19 in Indonesia, but it is inseparable from the choice of policy scenarios and community participation to jointly break the chain of distribution or minimize the cases that occur. To place each best scenario with some consideration of various aspects is important to resolve COVID-19 in Indonesia, therefore, it is crucial to follow the health protocols and regulations that are applied, and it is better to stay at home as long as the cases are still increasing.
CONCLUSION
The conclusion of these research results with System Dynamics to handle COVID-19 cases in Indonesia, in which the assumption limitation of the regions outside Java Island do not imitate the pattern of the core areas of Covid-19, or permanent constant application is used compared to the core areas, but on the other sides, the regions have applied all the same applications applied in the core areas of Covid-19, then the conclusion results are as follows:

- In Business As Usual condition, it is estimated that the number of cases with a maximum point of around 15,000 cases and the cases will reach the peak on day 80th to 110th, and then the case will start to slowdown.

- Application of moderate conditions with precautionary calls, implementation of health protocols including healthy living movement, social distancing, disinfectant spraying, adequacy of medical devices and health facilities, implementation of Stay At Home or Work From Home can delay the maximum number of cases around 9,000 and its peak is on the day 90th, after that the cases will decline slowly.

- In addition to applying moderate condition in optimistic condition, the optimistic condition is increased. Moreover, there is an addition of regional restriction policy that is selected together or regionally partially closed down. It is estimated that the maximum cases are 6,000 cases and the peak cases are on day 45th to 65th, can be reduced by the rate of case estimated at around 3,000-4,000 cases on day 70th and 80th.
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