An illustrated story of
How Space Technology Applications Contributed to Combating

Acknowledgments:
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Experts at the National Institute of Aeronautics and Space of Indonesia (LAPAN) developed the LAPAN Hub COVID-19 to integrate satellite-derived, geospatial and statistical data in a user-friendly interface designed to help decision-makers identify high-risk areas and contain the spread. To share the experiences and methodology with other country and city counterparts, experts at LAPAN worked in collaboration with ESCAP, to jointly develop a manual, deliver a workshop and training to participants across multiple sectors in Asia and the Pacific.

To further help communicate the innovative approach, ESCAP provided funding and guidance to develop this illustrated story. It aims to provide a better understanding of how data integration contributes in responding to COVID-19 risks in an easy-to-read format,

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*Disclaimer:
The boundaries and names shown and the designations used on this map do not imply official endorsement or acceptance by the United Nations.
COVID-19 and Space Technology

The spread of COVID-19 has been very fast and widespread over the world. According to WHO, small indoor gatherings and crowded places are where coronavirus is spreading the fastest.

Space technology applications and remote sensing data can be used to provide important information to deal with the COVID-19 pandemic, especially regarding information on potential risk zones. Then this information is delivered to the government and public rapidly, near-real time, and continuously through a reliable platform.
LAPAN created a platform to disseminate information related to COVID-19. This platform is a portal and website for remote sensing applications based on the Geographic Information System (GIS). Called LAPAN Hub COVID-19.

**Data Integration**

The platform accommodates the output of data processing. Many kinds of data such as remote sensing satellite data, COVID-19 cases data, and locations must be integrated, analyzed, and mapped.
Data relating to the hazards of the COVID-19 pandemic can be obtained related to the location of the infected COVID-19 patients (confirmed cases).

Location of Cases

The number of suspected people, probable cases, people in close contact and travellers.
Information on COVID-19 at the village or sub-district level is obtained from the Ministry of Health. These data are in tabular data (data listed in a table) on the related website and have not yet become spatial data (data with specific locations geographically).

**Data Formats**

These data are in tabular data (data listed in a table) on the related website and have not yet become spatial data (data with specific locations geographically).
The tabular data obtained is processed with a digital map of administrative boundaries for village or sub-district level by using Joint Table Analysis Process. Then it is transformed into spatial information with specific locations using Geographic Information System (GIS) software. Thus, the vector data points are obtained.

**Methodology to Improve Point Value**

Point data, which represents the number of confirmed cases and possible cases of COVID-19, is processed to fill the value of a missing variable (gaps) in a data range. This is called interpolation, a spline interpolation technique is selected to process the data.

**Interpolation Technique**

Point interpolation using the spline technique is used to fill data gaps by connecting adjacent data points with a straight line. The result of spline interpolation is a set of straight lines connecting the data points.
This function is usually used to convert the yield value of each parameter or variable. It creates the same uniformity limit and value scale to standardize the data.

Data Standardization

The result of interpolation data is then standardized by putting different parameters on the same scale, this is performed using the Fuzzy Set Membership (FSM) function. Data standardization is important to make sure each data is consistent and has the same content and range.
Point value is then rescaled using linear function between the minimum and maximum values. Absolute value with 0 as minimum and 1 as maximum is set up to have the same range for each data.

Mapping Potential Hazard to COVID-19

Producing spatial hazard assessments using the previously outlined steps turns tabular data into spatial distributions to produce maps with potential hazard zones. Ultimately, this method integrates geospatial and statistical data into one common format for easy analysis, visualization and decision making.
The parameters can be obtained with spatial and remote sensing data. Remote sensing data can detect settlement locations and road access. The advanced process is needed to have the exact assessment for each parameter, using algorithms for remote sensing data.

**Incorporating Vulnerability Variable**

The vulnerability factor for COVID-19 can be caused by many things. The limitation of this activity is only using three main parameters to analyze, which are settlement and non-settlement density, public transportation facility density, and strategic locations of people's mobility (road access).

**Vulnerability Parameters Remotely Sensed**

The parameters can be obtained with spatial and remote sensing data. Remote sensing data can detect settlement locations and road access. The advanced process is needed to have the exact assessment for each parameter, using algorithms for remote sensing data.
For the parameters used in this activity, two algorithms have been selected. The first one detects built up land, using Normalized Difference Built-Up Index (NDBI). The second one detects vegetation presence, using Normalized Difference Vegetation Index (NDVI). Then, they are integrated to make the Built Up Index (BUI).

Math Algorithm Used in Settlements Density

Settlement and Non-settlement Density
The settlement density zone is obtained based on the extraction of settlement locations derived from the calculation of the built-up index. Technically, this index is calculated based on NDVI and NDBI.
The parameters for public transportation facilities are obtained from Geospatial Agency and Open Street Map Indonesia, based on the location of terminals, train stations, airports and harbors. Then, High-Resolution Satellite Imagery is combined with road network infrastructure information to obtain the latest information related to environmental road access conditions.

Public Transportation Facility Density
The density analysis of these conditions can be obtained by using the line density technique, while information density analysis at the location of other public transportation facilities is made using the point density technique.

Strategic Location Parameters

The strategic location parameters are obtained based on information on public facility locations such as markets, malls, restaurants, schools, offices, hospitals, banks. As in the previous parameter, High-Resolution Satellite Imagery combined with strategic location data to obtain the latest information related to these locations.

Strategic Locations Density

The density analysis of these strategic locations is conducted using the point density technique.
The combination of the main three parameters is then carried out using GIS software to determine spatial distribution vulnerability to COVID-19.

Weighting of the Vulnerability Parameters
All parameters previously outlined are then weighted to find out which factor increases the risk of COVID-19 vulnerability the most. The method used to determine the weighting is the Analytical Hierarchy Process method.

Mapping Vulnerability to COVID-19
The combination of the main three parameters is then carried out using GIS software to determine spatial distribution vulnerability to COVID-19.
Information regarding locations or areas that have implemented a social restriction policy is used as a parameter for the assessment. However, with a note whether the policy has been implemented properly or not by the local community.

Important Policies for Addressing COVID-19

The large-scale social restriction policy allows people to do all their activity at home such as work from home and study from home. These are key to social or physical distancing, which can affect the decrease in the spread of COVID-19. This analysis assumes equal access to stable Internet connections, and home environments conducive to working and studying from home.

Understanding of Social Policy as a Parameter

Information regarding locations or areas that have implemented a social restriction policy is used as a parameter for the assessment. However, with a note whether the policy has been implemented properly or not by the local community.
Social restriction policy information is used to develop capacity assessment. Capacity assessment is calculated based on government policies related to social restriction policy. This information is used to establish whether the implementation of the policy could reduce the spread of COVID–19.

Scenario in Social Restriction Policy
Three policy scenarios are set up for this analysis. These scenarios are based on the key successes of social restriction policy.

- Scenario 1 is social high-restriction policy
- Scenario 2 is social low-restriction policy
- Scenario 3 is no-restriction policy

Methodology Weighting Social Policy Parameters

Capacity assessment is conducted by weighting the parameters using Analytical Hierarchy Process method. It is a method for decision making to support a prediction model that is able to break down a complex multi-factor or multicriteria problem into a hierarchy.

Mapping Capacity Zones to COVID-19

The administrative boundary in vector data and weighting criteria for several social restriction categories is used to produce capacity zone in GIS software. Finally, capacity zone in raster format type is obtained.
The Formula of Risk Assessment

\[
\text{Risk} = \text{Hazard} \times \frac{\text{Vulnerability}}{\text{Capacity}}
\]

Risk Assessment to COVID-19

A COVID-19 risk assessment is needed to provide information and spatial identification of areas that are currently at high risk. It is also used to minimize the spread of the virus to the regional scale. COVID-19 risk determination is obtained by formulating the calculation of Hazard, Vulnerability, and Capacity.

Weighting Mechanism in Risk Assessment

It is then combined and calculated based on the weighting mechanism for each parameter and risk component. Each parameter is compared using pairwise comparisons (PB) based on a questionnaire developed by a team of experts to make a comparative assessment of the relative importance weight of each pair of criteria (BNPB, 2012).

<table>
<thead>
<tr>
<th>Risk components of COVID-19</th>
<th>Parameters</th>
<th>Weights of main criteria</th>
<th>Weight of the risk component</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hazard</td>
<td>Area with affected people</td>
<td>0.47</td>
<td>0.27</td>
</tr>
<tr>
<td></td>
<td>Areas surrounding those with affected people</td>
<td>0.34</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Areas without affected people</td>
<td>0.16</td>
<td></td>
</tr>
<tr>
<td>Settlement area</td>
<td>Settlement area</td>
<td>0.76</td>
<td>0.18</td>
</tr>
<tr>
<td></td>
<td>Non-settlement area</td>
<td>0.21</td>
<td></td>
</tr>
<tr>
<td>Public facility</td>
<td>Medical facilities</td>
<td>0.22</td>
<td>0.20</td>
</tr>
<tr>
<td></td>
<td>Educational facilities</td>
<td>0.16</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Trade facilities</td>
<td>0.11</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Worship facilities</td>
<td>0.14</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Office facilities</td>
<td>0.13</td>
<td></td>
</tr>
<tr>
<td>Vulnerability</td>
<td>Primary road network</td>
<td>0.07</td>
<td>0.16</td>
</tr>
<tr>
<td></td>
<td>Secondary road network and others</td>
<td>0.09</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Terminal</td>
<td>0.22</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Railway station</td>
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<tr>
<td></td>
<td>Airport</td>
<td>0.14</td>
<td></td>
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<tr>
<td></td>
<td>Port</td>
<td>0.17</td>
<td></td>
</tr>
<tr>
<td>Capacity</td>
<td>Restriction policy</td>
<td>0.09</td>
<td>0.19</td>
</tr>
<tr>
<td></td>
<td>Semi-restriction policy</td>
<td>0.04</td>
<td></td>
</tr>
<tr>
<td></td>
<td>No restriction policy</td>
<td>0.16</td>
<td></td>
</tr>
</tbody>
</table>

Model for Determining the Risk of COVID-19

The model used to determine the risk weight of COVID-19 involves mapping Hazard, Vulnerability, and Capacity.

Risk = 0.27 x Hazard x \( \frac{0.54 \times \text{Vulnerability}}{0.19 \times \text{Capacity}} \)

Mapping Risk Potential to COVID-19

Mapping of Hazard, Vulnerability, and Capacity zone in raster file then combined and calculated into the model given. Thus, risk potential zone of COVID-19 is generated.
This platform is an example of the value integrating geospatial and statistical data into a common format and visualizing it on a map. Practices like this platform support implementation of the Asia-Pacific Plan of Action on Space Applications for Sustainable Development (2018–2030). Countries can tailor this system to their needs by following the manual guidance provided on tinyurl.com/COVID19LAPAN

Disseminating Risk Potential to COVID-19 on LAPAN Hub

References


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