Tree Aplication on Natural Disaster Risk Management System in Indonesia

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***Abstract*— Due to Indonesia's Geographical position, Indonesia is always in the face of the constant risk of natural disasters. Being located in an area with a high degree of tectonic activity, Indonesia has to cope with a series of natural disasters. Natural disasters always take a massive toll on every aspect of people's lives. Anyone can not prevent natural disasters as it is due to a natural occurrence, but the government can take post-disasters actions to optimize the response and recovery. This paper will discuss the application of the tree on how to make the right system for handling natural disasters.**

***Keywords*—Natural disasters, Indonesia, Decision Tree, Response and Recovery.**

I. Introduction

Natural disasters are responsible for 0.1 % of global deaths each year. On average, natural disasters have taken a heavy toll of 60,000 lives each year in the last decade. In Indonesia, on the span of 10 years from 2010 to 2020, Natural disasters take on 8,388 death. The four major natural disasters in Indonesia are earthquakes, tsunamis, floods, and volcanic eruptions.

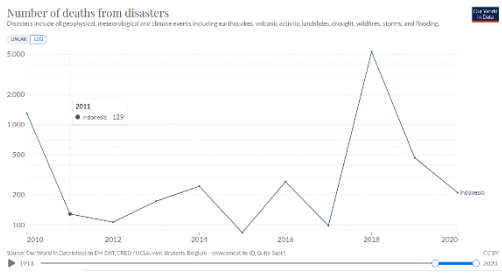

Figure 1. Graph of Indonesia' Deaths from Natural Disasters
https://ourworldindata.org/natural-disasters

Indonesia has launched a national-scale project called IDRIP (Indonesia Disaster Resilience Initiatives Project) as an attempt to optimize the process of response and recovery in the face of natural disasters in Indonesia. This is one of Indonesia's Government's actions to cope with Indonesia's constantly occurring natural disasters. The government is hoping to see, with this project, the increasing awareness, and responsibility regarding natural disasters in Indonesia.

Many obstacles occurred in dealing with natural disasters in Indonesia. One of them is that Indonesia is an archipelago country that makes Indonesia's mobility quite tricky. Also, Indonesia has over 30 provinces with their regional autonomy. Indonesia's infrastructure is heavily concentrated in the Java Islands, making it quite challenging for the government to take quick action if national disasters occur.

II. Theoretical Framework

A. Graph

A graph is a discrete structure consisting of vertices/node and edge and represents the relation of those objects (node and edge). A graph could be denoted as G = (V, E), where V is a non-empty set of nodes and E is a set of edges that connect the nodes.

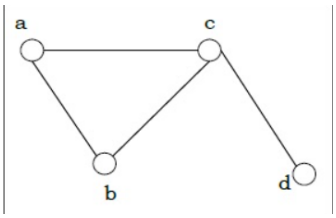

Figure 2. A graph with 4 nodes and 4 edges
https://www.tutorialspoint.com/discrete_mathematics/graph_and_graph_models.htm

A basic graph could be categorized based on two things. One whether the graph has loops and multiple edges or not, and two whether the graph has direction associated with them or not.

A graph with neither loops nor multiple edges is called a simple graph in the first category.

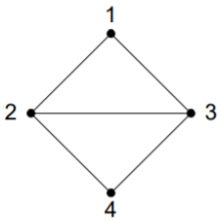

Figure 3. A simple graph without loops or multiple edges
https://informatika.stei.itb.ac.id/~rinaldi.munir/Matdis/2020-2021/Graf-2020-Bagian1.pdf

A graph with either loops or multiple edges or both is called an un-simple graph, with the graph consisting of loops is called a pseudo graph, and the one consisting of multiple edges is called a multi-graph.

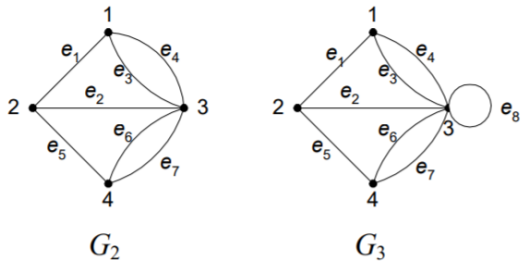

Figure 4. Un-simple graph with multiple and loop edges
https://informatika.stei.itb.ac.id/~rinaldi.munir/Matdis/2020-2021/Graf-2020-Bagian1.pdf

A graph without direction associated with them is called an undirected graph in the second category, while the one with direction on each edge is called a directed graph.

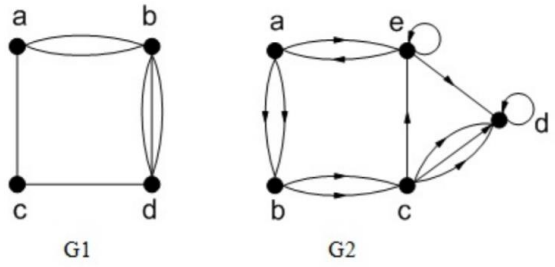

Figure 5. An undirected (left) and directed(right) graph
https://informatika.stei.itb.ac.id/~rinaldi.munir/Matdis/2020-2021/Graf-2020-Bagian1.pdf

To summarize the types of basic graphs, the table below could help show each type's difference.

Type	Edge	Multiple edge ?	Loop edge ?
Simple	Undirected	No	No
Multi	Undirected	Yes	No
Pseudo	Undirected	Yes	Yes
Directed	Directed	No	Yes
Multi-Directed	Directed	Yes	Yes

Table 1. Graph types, based from :
https://informatika.stei.itb.ac.id/~rinaldi.munir/Matdis/2020-2021/Graf-2020-Bagian1.pdf

There is some basic terminology on a graph that we should know; some of them are :

1. Adjacent
   Two nodes are said to be adjacent to each other if they are directly connected by an edge.
2. Incident
   A node is incident to an edge if it is one of the nodes connected by the edge.
3. Isolated Node
   A node is called an isolated node if it is not incident to any edge.
4. A null graph
   A null graph is graph that does not has any edge or its edge set is an empty set.
5. Degree
   A degree of a node is the sum of the edge it is incident to.
6. Path
   A length in a graph is an alternating sequence of nodes and edges.
7. Circuit
   A circuit is a path that started and ended in the same node.
8. Subgraph
   A graph G=(V1, E1) is called a subgraph of another graph H=(V2, E2) if V1 ⊆ V2 and E1 ⊆ E2.

B. Tree

A tree is one of the implementations of a graph. A tree is a collection of nodes in a connected, undirected graph that does not have any circuit.

One of the properties of a tree is that a tree with N nodes will contain N-1 edges.

Figure 6. A tree with 7 nodes and 6 edges.
https://informatika.stei.itb.ac.id/~rinaldi.munir/Matdis/2020-2021/Graf-2020-Bagian1.pdf

There is some other property of a tree :

1) A single path connects each pair of nodes in a tree.
2) Adding one edge to a tree will make only one circuit.
3) All edges of a tree are bridges (an edge that, if removed, causes the tree to split into two components).

A tree, in general, could be classified into four types. Those four types are:

1. Spanning Tree
   A subgraph of a connected graph obtained from terminating a circuit on the graph, is called a spanning tree. A minimum spanning tree is a spanning tree with minimum weight.
2. Rooted Tree
   A tree with one of its nodes based on a root and made as a directed graph.
3. Ordered tree
   A rooted tree with order on its children.
4. N-ary tee
   A rooted tree in which each node has maximum N children. One of the most used and famous forms of the N-ary tree is the binary tree. The decision tree is one of the applications of a binary tree (Note: A decision tree does not have to be a binary tree).

C. Rooted Tree

A tree with one of its nodes based on a root and made as a directed graph (could be undirected to make it more accessible) is called a rooted tree. There is also some terminology in a rooted tree that we should know (based on the figure below) :

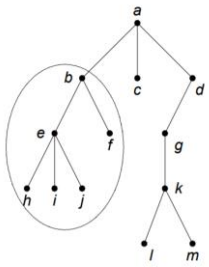

Figure 7. A rooted tree
https://informatika.stei.itb.ac.id/~rinaldi.munir/Matdis/2020-2021/Graf-2020-Bagian2.pdf

1) Child/ children and parent: a is the parent, and b,c,d are the children.
2) Path: The path from a to k is a, d, g, k, and the length is 3.
3) Sibling: h, i, and j are siblings, but they are not siblings with k because they have a different parent.
4) Subtree: The one inside the circle is called a subtree.
5) Degree: A degree of a node in a rooted tree is based on the number of the subtree or the children it has. Node a has three, node d has one, while node c has zero.
6) Leaf: A node that has zero degrees is called a leaf. Node h, i, j, f, c, l, and m is a leaf.
7) Internal nodes: Nodes with a child or children are called internal nodes.
8) Level: The tree's root is on level 0, and each time it descends to its children, the level goes up by 1. a is on level 0 while l and m are on level 4.
9) Height/Depth: The height or depth of a rooted tree is the highest level. The tree has a height/depth of 4.

D. Decision Tree

A decision tree is one of the applications of a rooted tree that is often used to solve regression, classification problems or as a support tool to make a decision.

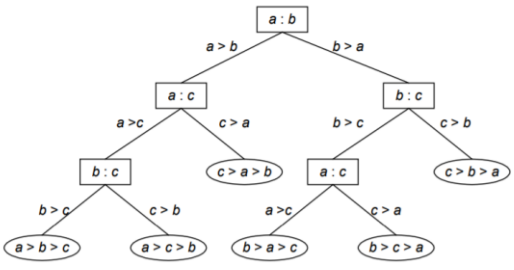

Figure 8. A Decision Tree
https://informatika.stei.itb.ac.id/~rinaldi.munir/Matdis/2020-2021/Graf-2020-Bagian1.pdf

In a decision tree, a parent will act as a question, problem, or condition that will be sorted or checked out; the path will act as the answer or decision, and the nodes or children will act as the temporary or the final answer or decision.

A decision tree is widely used in many aspects of learning, whether low or high-level learning. Due to its advantages, a decision tree application is commonly used in machine learning, data mining, civil, law, business planning, and many others.

III. Natural Disasters in Indonesia

In 10 years, from 2011 to 2020, Indonesia has experienced 25,753 natural disasters. Since the 2004 tsunami, Indonesia has experienced at least one major natural disaster each month, including earthquakes, tsunamis, volcanic eruptions, and climate change events.

Indonesia has faced the challenges of natural disasters for hundreds of years. From 1990 to the present, Indonesian citizens have been hit by numerous natural disasters over the last three decades, including more than 12 major natural disasters. Indonesia maintains an extensive network of end-to-end early warning systems. However, Indonesia's disaster risk management budget is limited, and the entire system is not maintained correctly. Despite the prevalence and frequency of natural disasters, public awareness of disaster risk prevention and management remains low. Increasing knowledge about natural disasters and managing sustainable development across the country is vital to Indonesia's resilience to natural disasters.

A. Earthquakes

Indonesia is located in the Pacific Ring of Fire, and more than 60% of Indonesians live in earthquake-prone areas. In 2020, there were about 8,260 earthquakes in Indonesia, compared to 11,500 in the previous year.

In Indonesia, earthquakes are a constant threat due to the impact of large tectonic plates and volcanic activity in the region. On average, Indonesia has an earthquake of magnitude 6 or greater per year, causing both casualties and damage to infrastructure and the environment. The following table shows a list of recent earthquakes in Indonesia that have caused critical damage.

Location	Date	Magnitude	Casualties
Lombok	05 August 2018	6.9	565
Lombok	29 July 2018	6.4	20
Sumatra	07 December 2016	6.5	104
Sumatra	02 July 2013	6.1	42
Sumatra	25 October 2010	7.7	435
Sumatra	30 September 2009	7.6	1,117
Java	02 September 2009	7.0	81
Sumatra	12 September 2007	8.5	23
Sumatra	06 March 2007	6.4	68
Java	17 July 2006	7.7	668
Java	26 May 2006	6.4	5,780
Sumatra	28 March 2005	8.6	1,346
Sumatra	26 December 2004	9.2	283,106

Table 2. Recent Major Earthquakes in Indonesia
https://www.indonesia-investments.com/business/risks/natural-disasters/item243

B. Floods

December to March is the rainy season in Indonesia. Rainfall increased during this period. With deforestation and waterways clogged with debris, rivers can overflow and cause floods. In 2020, around 1,080 floods occurred in Indonesia, up from 784 in 2019.

Much of Indonesia is affected by floods, resulting in hundreds of deaths, destruction of homes and other infrastructure, and disruption of local businesses. Even in big cities like Jakarta, floods occur regularly due to heavy monsoon rains and poor water management. As a result, Indonesia tends to have higher inflationary pressures in January and February, when monsoon rains peak. The La Niña phenomenon that occurs every five years on average can exacerbate moist conditions. Therefore, it will rain more than usual in Southeast Asia from November to February.

C. Volcanic Eruptions

Indonesia experiences at least one major volcanic eruption each year. However, this usually does not cause significant damage to the environment and does not lead to human casualties. Indonesia is the most volcanically active country in the world. There are an estimated of 129 volcanoes in Indonesia, and each volcano is closely monitored by the Volcanic and Geological Hazard Mitigation Center. It is also estimated that over 5 million people live in the volcano's danger zone.

In addition to human life, the volcanic eruption can cause significant damage to the local economy and damage small businesses in tourism, food, commercial accommodation, agriculture, farms, and livestock.

The following table shows a list of recent volcanic eruptions in Indonesia that have caused critical damage.

Volcano	Location	Date of Eruption	Casualties
Merapi	Central Java	03 November 2010	353
Kelut	East Java	10 February 1990	35
Galunggung	West Java	05 April 1982	68
Merapi	Central Java	06 October 1972	29
Kelut	East Java	26 April 1966	212
Agung	Bali	17 March 1963	1,148
Merapi	Central Java	25 November 1930	1,369
Kelut	East Java	19 May 1919	5,110
Awu	North Sulawesi	07 June 1892	1,532
Krakatau	Sunda Strait	26 August 1883	36,600
Galunggung	West Java	08 October 1822	4,011
Tambora	Sumbawa	10 April 1815	71,000+

Table 3. Recent Major Volcanic Eruptions in Indonesia
https://www.indonesia-investments.com/business/risks/natural-disasters/item243

D. Tsunami

In 2004, the Indian Ocean earthquake and subsequent tsunami-affected most of the world. Although large-scale tsunamis such as the 2004 tsunami are rare, Sumatra is often affected by land earthquakes that could potentially cause tsunamis. After an earthquake, Indonesians living in towns or cities near the coast often refuge in hills. They fear being victims of a tsunami. On average, once every five years, a colossal tsunami occurs in Indonesia, mainly Sumatra and Java. In general, damage to infrastructure exceeds the loss of life. There are warning systems installed in many coastal areas, but there are reports that not all of these systems are working correctly.

IV. Indonesia's Natural Disaster Risk Management System Implementation Using Tree

Indonesia's disaster risk management budget for the fiscal year 2020 is approximately IDR 12.49 trillion. In 2020, the budget increased significantly as funding for the COVID-19 pandemic was added to the regular budget. Disaster risk management budgets in Indonesia generally increase year-round. These additional budgets mainly come from external sources such as the World Bank, Asian Development Bank, or Islamic Development Bank.

Indonesia periodically builds a national disaster management system. This national system includes several aspects like Legislation, Institutional and funding.

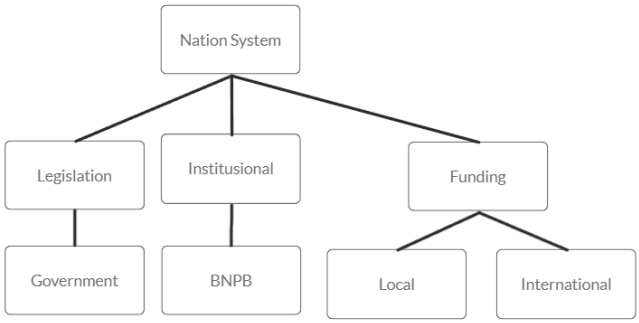

Figure 9. Tree showing the national disaster management system

In terms of law, the Indonesian government has passed the "Undang-Undang Nomor 24 Tahun 2007" on disaster management, including government ordinances, presidential ordinances, government agency chief ordinances, and regional regulations. Under this law, disaster management systems aim to :

1) Protect communities from imminent disasters by coordinating existing laws and regulations.
2) Ensure a comprehensive, integrated, and coordinated implementation of disaster management.
3) Respect local culture.
4) Build both public and private participation and partnerships.
5) Foster a spirit of cooperation, solidarity, and generosity to bring peace in the life of society, nation, and state.

Both central and regional governments are responsible for carrying out the law. Both the interest and the responsibility of both partis have to be aligned, mainly because each region has its regional autonomy.

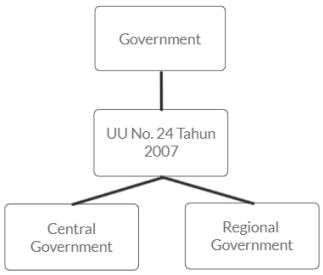

Figure 10. Tree showing the Government side on the system

The Central Government is responsible for implementing disaster management under the law as follows:

1) Disaster risk mitigation and integration of disaster risk management into development programs.
2) Protection of the community from the impact of disasters.
3) Guarantee the fulfillment of the rights of communities and refugees affected by disasters fairly and following minimum service standards.
4) Recovery from the effects of the disaster.
5) Adequate allocation of disaster management budget in the State Revenue and Expenditure Budget (APBN).
6) Providing a civil protection budget in the form of turnkey funds.
7) Maintain genuine and reliable archives or documents from the dangers and consequences of a disaster.

The central government also has the authority to carry out disaster management:

1) Establish a disaster management policy in line with the national development policy.
2) Creating a development plan that includes elements of civil protection policy.
3) Determining the status and extent of national and regional disasters.
4) Determination of cooperation policies in disaster management with other countries, agencies, or international parties.
5) Develop guidelines for the use of technologies that may pose a threat or disaster risk.
6) Policy formulation to prevents the control and depletion of natural resources that exceed the ability of nature to recover.
7) Management of collection and distribution of money or goods at the national level.

Local governments also have responsibility and authority in disaster management. Local governments are responsible for implementing disaster management, including:

1) Ensuring the rights of disaster-affected communities and refugees according to minimum service standards.
2) Protection of the community from the impact of disasters, disaster risk reduction, and disaster risk reduction with development programs.
3) Adequate allocation of funds for disaster management in the regional budget (APBD).

In addition to its responsibility, local governments also have authority in implementing disaster management, including:

1) Determination of disaster management policies in its territory in line with regional development policies.
2) Creating a development plan that includes elements of civil protection policy.
3) Implementation of cooperation policies in disaster management with other states and / or districts or cities.
4) Regulation of the use of technology has the potential to be a source of threats or disasters in the area.
5) Formulate strategies to manage and prevent depletion of natural resources that exceed the region's natural capacity.
6) Manage the collection and distribution of money and goods at the state, district, or city level.

In terms of formal institutional, BNPB acts as an institution that focuses on research, fundraising, education, and natural disaster management in Indonesia. Both with the central and regional government, BNPB could determine the level or category of the disaster that occurred using following indicators:

1) Number of victims.
2) Loss of property.
3) Damage to infrastructure and facilities.
4) Coverage of the area affected by the disaster.
5) Socio-economic impacts caused

In terms of non-formal institutional, forums both at the national and local levels were established to strengthen the implementation of disaster management in Indonesia. A National Platform (Planas) is formed at the national level, consisting of elements of civil society, business, universities, media, and international institutions. We know the Yogyakarta DRR Forum and the East Nusa Tenggara DRR Forum at the local level.

The funding for the disaster management system come from both locally and internationally. The Government of Indonesia's concern and seriousness towards disaster problems are very great, especially for mainstreaming disaster risk reduction in development, such as the following :

1) DIPA Funds (APBN/APBD)
2) Contingency Fund
3) On-call funds
4) Grant-patterned Social Assistance Fund
5) Funds from the community
6) International community support fund

The international community also supports the Government of Indonesia in developing better disaster management. The World Bank Board of Executive Directors has approved a US$160 million loan for the Indonesia Disaster Resilience Initiatives Project (IDRIP) to support Indonesia's efforts to develop a comprehensive approach to disaster resilience.

V. CONCLUSION

One of the applications of graphs is trees. Trees can be used to describe a relationship between each of its members in the form of parents and children. One application that utilizes trees is the creation of a system. This paper describes how natural disasters risk management systems can be formed by utilizing tree applications. In this system, three main parts support its running. Each part plays an essential role with equal position and importance. With this system, it is hoped that the Indonesian government can give equal attention and focus and utilize all available resources and logistics and work together, embracing all relevant parties to achieve an Indonesia that is responsive and alert to natural disasters.

VI. ACKNOWLEDGEMENT

First of all, the author would like to thank God Almighty because of His blessings and grace that the author was able to complete this paper. Also, the writer would like to thank all the lecturers of IF2120 Discrete Mathematics 2021/2022, especially Ms. Nur Ulfa Maulidevi, who has taught and provided understanding to the author so that this paper can be done. Finally, the author apologizes if there are many mistakes in the delivery or choice of words.

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PERNYATAAN

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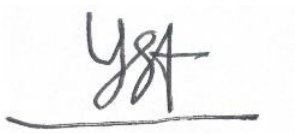
Jakarta, 6 Desember 2021



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