

Research Article

Weaving the Nodes: Actor Relations in Forest Fire Handling

Mutia Rahmah^{1*}, Halilul Khairi², Wike Anggraini¹, Nur Saribulan¹, and Muchlis Hamdi¹

¹Faculty of Government Politics, Institut Pemerintahan Dalam Negeri, Sumedang, Indonesia

²Faculty of Government Management, Institut Pemerintahan Dalam Negeri, Sumedang, Indonesia

ORCID

Mutia Rahmah: <https://orcid.org/0000-0002-8282-5684>

Abstract.

This study aims to identify and describe the actor-network on forest fire handling in South Sumatra in its all three stages. This study collects data through interviews and documents. R Studio is used to analyze and visualize the connection between actors. The results of this study show a formal division of activities among actors in forest fire handling based on Governor decree involving state and non-state actors. However, non-state actors were not involved in every operational activity, especially in the pre-disaster stage. Furthermore, the Head of the Forest and Land Fire Control Section plays an essential role in the pre-disaster stage, the Regional Disaster Management Agency in the emergency stage, while there is no actor interactions in the post-disaster stage. Such situation requires a better actor-network by weaving the nodes to ensure effective coordination considering the role, interaction, and intervention of the actors as well as the nature of inclusiveness through the involvement of all actors, especially that of non-state actors. The limitation of this study is dealing with its focus just on one perspective that is based on the legal framework. Future research is expected to broaden the perspective with empirical and factual research.

Keywords: forest fire handling, network, social network analysis, south Sumatra

1. Introduction

Literature on networks has been the object of much discussion, dealing with the context of natural sciences (1), Information Technology (2), as well as social sciences (3,4). In the context of social science, networks are also experiencing development, ranging from social networks to organizational networks (5), and even inter-organizational networks (6,7). In its development, on the one hand, networks are defined as relationships between nodes (8), namely actors that include people or organizations (9), groups and systems are linked among many aspects of human relationships (10). On the other hand, the network is also defined as a tool related to statistical data (11,12). With this network definition, social networks focus on analyzing patterns of relationships between people,

Corresponding Author: Mutia Rahmah; email: mutiarahmah@ipdn.ac.id

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organizations, countries, and social entities (13), this relationship can even be depicted through a graph (14).

Social networks include not only digital and online networks but also include networks such as face-to-face relationships, political associations and connections, economic transactions between businesses, and geopolitical relationships between countries and international institutions (15). Social network analysis is characterized by analyzing processes of change that emphasize the structural environment shaped by civil society actors and what constrains them, as well as how actors choose to position themselves at different times in the disaster recovery process (16). In addition, this social network analysis approach also provides important details about the relative contributions of different aspects of social ties that other approaches to social support may lack (17).

Social network analysis is an interesting concept related to disasters, among other things, to analyze the complexity of patterns of social relations and the attachment of humans and the environment (18). In addition, social network analysis has been used in research related to disaster management (19–21), including community conflict (22), Structural equality and international conflict (23), Covid-19 (24), earthquake (25), forest fires (26,27).

Forest fires are an event that continues to occur in Indonesia. As a country that has an extensive forest area, which is about 63% of the land area, Indonesia has the forest around 120.6 million hectares (28). The breadth of forest area will be a challenge for the government in its management. In 1997, Indonesia experienced forest fires of 383,870 ha and became the world's attention (29,30). During 2000-2019, Indonesia had a fire stretch of 5.7 million ha (31).

Most forest fires are caused by human activities dealing with land clearing for agricultural, forestry, or plantation purposes. It was also exacerbated by the natural phenomenon of El Nino (32). Forest fires frequently indeed lead to the rise of deforestation. Deforestation in Indonesia increased by about 1.13 – 1.51 per year from 2009-2013 (33). Forest fires and the rate of deforestation in Indonesia is dominated by the region of Sumatra and Kalimantan. Both have extensive forest fires and the highest deforestation. Interestingly, compared to Kalimantan, the impact in Sumatra not only caused smog in neighboring countries, but also caused air pollution, forest fires even had an impact on the government to approve the ratification of ASEAN's agreement on transboundary haze pollution (34). The forest fire incident in South Sumatra impacted the government's action, which later approved the ratification of the ASEAN Agreement on Transboundary Haze Pollution (AATHP) as stipulated in Law Number 26 of 2014. In addition, the highest

forest fires occurred in 2015 and 2019, making this province with the highest forest fire area in Indonesia (31).

From the total land that is burning and tends to deforest in the Sumatra region, South Sumatra is one of the provinces with a total servant of which have encountered the impact of a forest fire. Throughout the year 2019, a forest fire that occurred in South Sumatra reached 336,798 ha. The comparison of the increase significantly in 2018 is as wide as 16.226,60 3,625.66 ha of land and as wide as in 2017 (35). In 2020, 950 ha of forest fires occurred at 4.516 point hotspots (31,36).

The Indonesian government has attempted to address this issue for 18 years without success. Forest fire handling seems to have been triggered by the extensive forest and land fires occurring in 2015 and 2019. In 2016, The President of Indonesia, Joko Widodo, initiated to establish a Peatland Restoration Agency, although it still has not reached success partly because of a lack of transparency (37,38). The serious action is conducted after the big forest fire in 2019, as the Governor of South Sumatra formed an integrated team for the prevention and control of forest and land fires. That team consists of coordination forum regional leaders (Forkopimda) and the related agencies involved (36). The integrated team was formed for mitigation, emergency, and post-disaster forest and land management based on the bylaw issued by the local government.

Forest fires handling have been widely carried out with a focus as illustrated by the keywords forest fires handling, which are presented in Figure 1. This research includes examining forest fires handling from the perspective of actor-networks (27,37,39), media agenda building (40), policy implementation (41), GIS-based information system (42), intelligent Digital Mobile Radio (DMR) nodes and a Social Internet of Things (SIoT) platform (43), and collaboration governance (44).

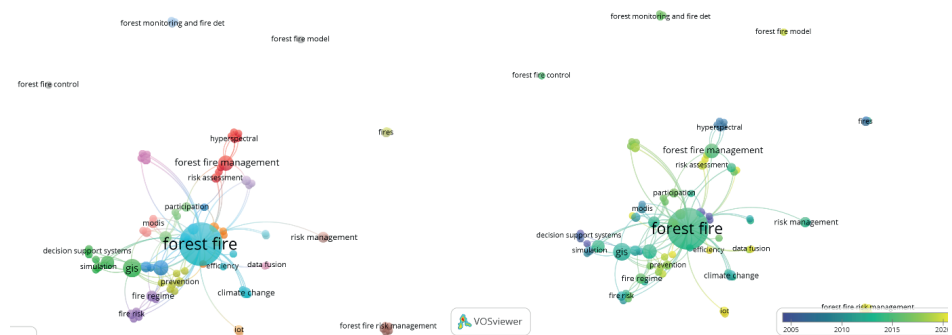


Figure 1: Research Trend on Forest Fire. Source: Scopus Database, 2023.

Prior study had been carried out to see the actor roles in the case of misused land. Such actors in that case can be differentiated into three classes, that is, the key players, the second cast, and subject actors as the receiver benefits from the first actors. The key

players are related to actors who have commercial interests, such as Huge-scale Palm Oil Enterprises, small-scale woodland enterprises, and regional landholders. Second cast players and subject actors are related to workers or farmers and the community (27). The finding of another study shows the actors dealing with forest fire, that is, four types of actors who are related to conservation areas of forest fire, namely, government authorities, local entrepreneurs, non-government agencies, and local communities who have pivotal roles or functions to prevent wildfire. Among those stakeholders, non-government agencies stand as the central actor who has more connections to other stakeholders (26).

The research scope of those two studies does not cover all stages of disaster management consisting of three stages, namely, pre-disaster, emergency response, and post-disaster. Both studies only cover the pre-disaster stage. On the other hand, several other studies also focused on the emergency stage (45,46). This condition shows that it is urgent to study actor-networks covering all stages of forest fire handling. Based on that, this study aims to identify and describe the actor-network on forest fire handling in South Sumatra in mitigation, emergency, and post-disaster stages.

2. Methods

This study uses a qualitative method with data collection techniques in the form of interviews with 30 informants from the government, community, and private sector who are members of an integrated team for preventing and controlling forest and land fires in South Sumatra Province as stipulated in the Decree of the Governor of South Sumatra Number 115 / KPTS/DLHP/2021. The government elements consist of governments at the provincial, district, sub-district, and village levels. From elements of society, namely, communities directly affected by forest fires, the Fire Care Community, which was formed by Manggala Agni, and Village Communities. From the private sector, namely representatives of the Indonesian Forest Entrepreneurs Association.

This study uses social network analysis to measure and analyze the nature of the network structure of interdependent relationships between actors (47,48). Social network analysis concerned on actor (nodes) connection (49). Thus, social network analysis becomes a technique that is suitable for researching social phenomena as the flow of information in social networks and, coordination cooperation, or the trust between groups of people (47). The network of this forest fire handling consists of three stages, namely, the pre-disaster, emergency, and post-disaster stages. Actors of each stage in this network joined an integrated team for the prevention and control of forest and

land fires in the province of South Sumatra as stipulated in the decree of the Governor of South Sumatra Number 115/KPTS/DLHP/2021 based on the workgroup as shown in Figure 2.

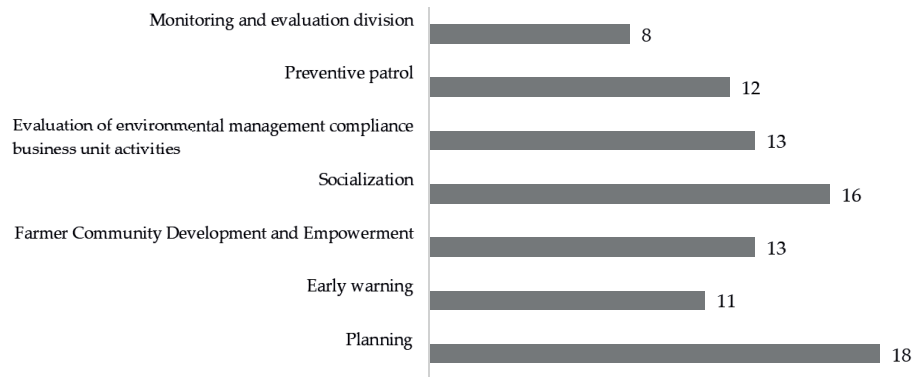


Figure 2: Divisions of the Integrated Team of Forest and Land Fire in South Sumatra Province. Source: Proceed from Governor of South Sumatra Number 115/KPTS/DLHP/2021, 2023.

Social Network Analysis discussed in this study includes, first, degree centrality, which refers to the number of edges a vertex has to other vertices (50). It is used to measure closeness centrality and betweenness centrality using the 0 and 1 values (15). If the value is 0, it indicates no relationship between nodes or actors, and the value of 1 show if there is a relationship between actors. Second, closeness centrality calculated based on the nearest distance between average nodes (47). A measure of node centrality is calculated based on the average closest distance between nodes. Third, betweenness centrality, which is the size of a node in a network based on the number of the closest pass (47). It means counting how often a node is leading up to a particular node in the network. In this study, to analyze this actor-network used R Studio. This software in the past few years, has rapidly increased for social network analysis (51).

3. Results and Discussion

3.1. Result

3.1.1. Pre-disaster Stage

In the pre-disaster stage, based on the decision of the Governor of South Sumatra Number 115/KPTS/DLHP/2021 regarding the Integrated Forest and Land Fire Team Working Group for South Sumatra Province, the actors involved are presented in Figure 3. The team consists of elements from government, business, and community.

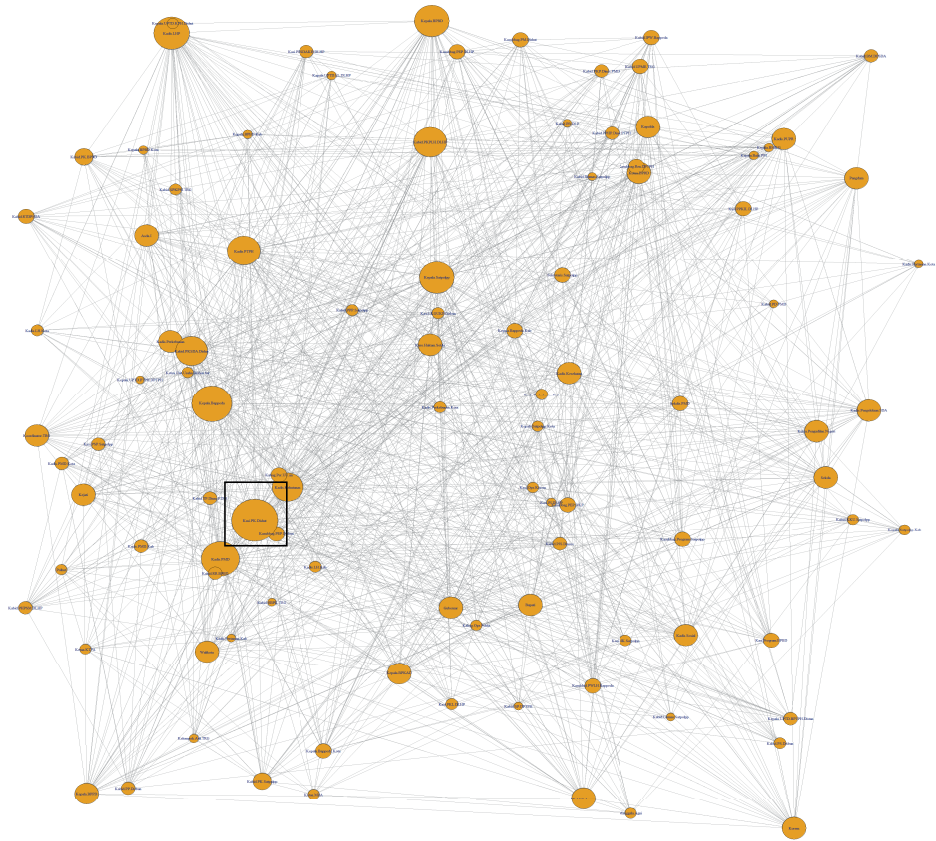


Figure 3: Actor-Network in the Pre-Disaster Stage of Forest Fire Handling in South Sumatra.
Source: Authors, 2023.

Based on the visualization of Figure 3, there are two terms in the actor-network, namely nodes (node points) and edges (relationship lines). Nodes are marked in orange, while edges are marked in grey line. This figure shows there are 100 nodes and 3,952 edges. In this stage, the nodes are defined as individual actors in the network, while edges are defined as interactions that occur between nodes. This means that out of 100 actors who play a role in the pre-disaster stage, there are only 3,952 relationships or interactions between actors in the network.

In determining who the key actors in a network are, the centrality measurement is used (52). The results of this centrality measure will show the actor playing the most role as well as having the most relationships with other actors in the pre-disaster stage. The measure of centrality in each actor can be seen in Table 1.

The measure of degree centrality refers to the number of interactions from a node to other nodes. Degree centrality is divided into two types, namely in-degree and out-degree. In-degree indicates the direction of interaction from other nodes towards the node to be measured, while out-degree indicates the direction of interaction from the node to be measured towards other nodes. Degree centrality, as shown in Figure 3,

TABLE 1: The Top 10 Actor in Network Centrality Value at Pre-disaster Stage.

Node	Degree Centrality	Betweenness Centrality	Closeness Centrality
Head of the Environment and Land Agency	80	7,361,906,225	0.006329114
Head of the Forestry Agency	70	3,971,000,000	0.006134969
Head of the Agriculture, Food Crops, and Horticulture Agency	74	9,047,184,397	0.006211180
Head of the Village and Community Empowerment Agency	86	9,054,017,336	0.006451613
Head of the Regional Development Planning Agency	90	14,624,666,667	0.006535948
Head of the Regional Disaster Management Agency	78	7,945,943,262	0.006289308
Head Civil Service Police Unit of South Sumatra	78	7,945,943,262	0.006289308
Head of Forest Fire Control at the South Sumatra Province Forestry Agency	104	16,443,811,663	0.006369427
Head of Resource Protection and Conservation Natural Resources of the Forestry Agency	72	5,053,378,251	0.005847953
Head of Environmental Damage Control and Maintenance Division of South Sumatra Province Environment and Land Agency	74	8,555,000,000	0.005780347

Source: Authors, 2023

is measured by using the 'all' types, both in-degree and out-degree measures. This value is closely related to betweenness centrality. The higher the value of the degree centrality of a node compared to other nodes, the higher the value of its betweenness centrality will be. Betweenness centrality shows how much of the node is traversed by other nodes and is the closest path between other nodes to communicate with each other.

Table 1 shows the actors that can be identified as having a high degree of centrality in the network of actors at the pre-disaster stage. Their number is ten actors coming from different agencies at management and operational levels. Subsequently, the data shows that there are ten actors who play a significant role and relate to other actors in the network at the pre-disaster stage. Of the ten actors, there is one actor with the highest degree and betweenness centrality values, namely, the Head of the Forest and Land Fire Control Section at the South Sumatra Province Forestry Agency with a degree centrality value of 104 and a betweenness centrality of 16,443,811,663, as marked with a black box in Figure 3. Besides, this actor also plays as a bridge between nodes

among four of the seven pre-disaster working groups that can be seen from the color difference, as shown in Figure 4.

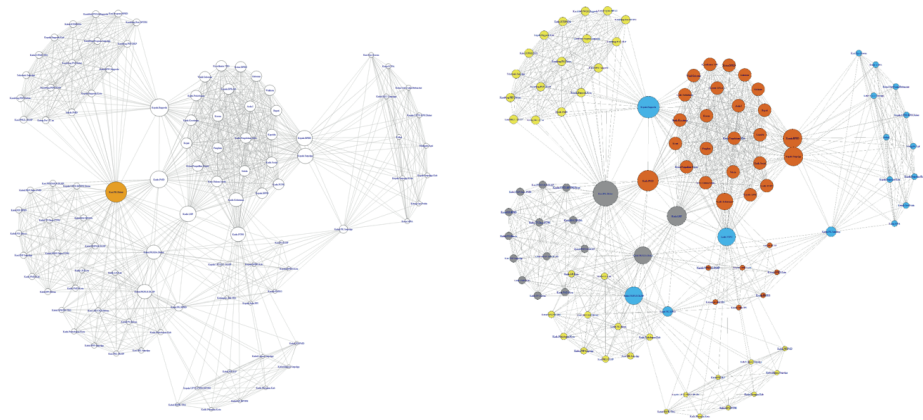


Figure 4: The Most Central Actor Position in the Network. Source: Authors, 2023.

Besides the value of betweenness centrality, the study also looks at the value of closeness centrality, which is the average distance or minimum distance between a node and all the other nodes in the network. Table 2 shows that the Head of the Regional Development Planning Agency of the South Sumatra Province, whose position at the management level, is the actor with the highest closeness centrality value, which is 0.006535948.

3.1.2. Emergency Stage

At the emergency stage, some actors are interconnected and bound by the Decree of the Governor of South Sumatra number 235/KPTS/BPBD-SS/2021. This integrated team in emergency response includes members of the Regional Leadership Coordination Forum and other officials from relevant regional apparatus in the South Sumatra Province, as well as district officials whose areas are exposed to forest fires. The network of integrated team members in forest fire handling at the emergency stage can be seen in Figure 5.

Figure 5 shows there are 37 nodes and 366 edges. This means that of the 37 actors playing a role in forest fires handling and there are 366 relationships or interactions among actors in the network. Further measures of centrality can be seen in Table 2.

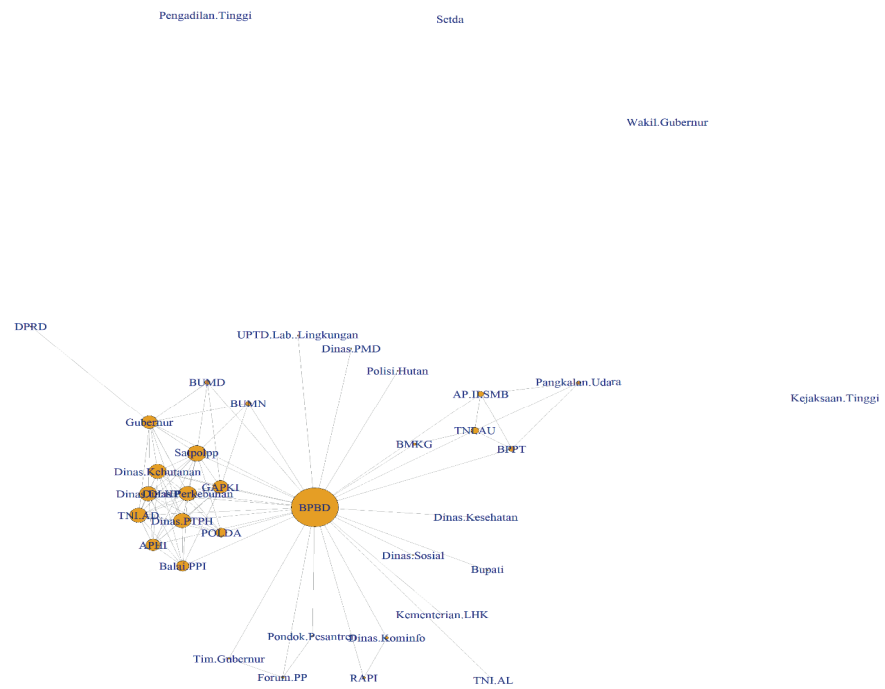


Figure 5: Actors Network in Emergency Stage. Source: Author, 2023.

3.1.3. Post-disaster Stage

The post-disaster stage is in the form of monitoring and evaluating the implementation of forest fire handling, both after pre-disaster and emergency stages. Based on the Decree of the Governor, the post-disaster stage involves local government officials who are directly related to forest fire handling. Legally, those actors are mandated to work in a team based on their respective working groups. In fact, based on the interview with the related agencies, they explained that there is no meeting or discussion on the evaluation at the post-forest fire, although there has been a working group formed with the task of carrying out evaluation activities. In fact, the actors did not work as a team. Consequently, there are no edges or interactions between actors in post-disaster activities.

3.2. Discussion

Networks are analytical constructs that facilitate an understanding of interdependence between actors (53) and interact freely (54). This network can be actors or non-actors (55) includes people, institutions, countries (56), events, locations, and information. A

TABLE 2: Centrality Value of Actor-network in Emergency Stage.

Number	Node	Degree Centrality	Betweenness Centrality	Closeness Centrality
1.	Governor	20	675,000,000	0.0049261084
2.	Deputy Governor	0	0.0000000	0.0007507508
3.	Indonesian Army	22	34,722,222	0.0049504950
4.	Regional Police of Indonesia	14	0.0000000	0.0048309179
5.	Regional People's Representative Assembly	2	0.0000000	0.0042735043
6.	High Prosecutor	0	0.0000000	0.0007507508
7.	High Court	0	0.0000000	0.0007507508
8.	Regional Secretariat	0	0.0000000	0.0007507508
9.	Regional Disaster Management Agency	58	7,746,388,889	0.0054945055
10.	Indonesian Airforce	10	223,333,333	0.0048076923
11.	Indonesian Navy	2	0.0000000	0.0046948357
12.	Forestry Agency	22	34,722,222	0.0049504950
13.	Plantation Agency	22	34,722,222	0.0049504950
14.	Food, food crops, and horticulture Agency	22	34,722,222	0.0049504950
15.	Environment and Land Agency	22	34,722,222	0.0049504950
16.	Civil Service Police Unit	24	133,888,889	0.0049751244
17.	Meteorology Climatology and Geophysics Agency	4	0.0000000	0.0047393365
18.	Regent	2	0.0000000	0.0046948357
19.	RAPI Taskforce	4	0.0000000	0.0047169811
20.	Communication and informatics Agency	4	0.0000000	0.0047169811
21.	Center for Climate Change and Forest & Land Fire Control	16	0.0000000	0.0048543689
22.	Indonesian Forest Entrepreneurs Association	18	0.2500000	0.0048780488
23.	Indonesian Palm Oil Association	22	44,166,667	0.0049261084
24.	State-own Enterprises	6	0.2222222	0.0047846890
25.	Regional Own Enterprises	6	0.2222222	0.0047846890
26.	Sri Mulyono Herlambang Air Base	6	0.0000000	0.0042194093
27.	Angkasa Pura Sultan Mahmud Badarudin II	8	183,333,333	0.0047846890
28.	Agency for the Assessment and Application of Technology	8	183,333,333	0.0047846890
29.	Ministry of Environment and Forestry	2	0.0000000	0.0046948357
30.	Forest Ranger	2	0.0000000	0.0046948357
31.	Village Community Empowerment Agency	2	0.0000000	0.0046948357
32.	Health Agency	2	0.0000000	0.0046948357
33.	Social Agency	2	0.0000000	0.0046948357
34.	Environmental Laboratory Unit	2	0.0000000	0.0046948357
35.	PP Forum	2	0.0000000	0.0047393365
36.	Governor Team	4	0.0000000	0.0047169811
37.	Islamic Boarding School	4	0.0000000	0.0047169811

Source: Author, 2023

network is strong and can achieve common results when the institutions are also developed strongly (57). With regard to actors, the concept of actor-network was developed by Michel Callon, Bruno Latour, and John Law in the context of science and technology studies in the 1980s (58). On the other hand, actor-networks are also referred to as social network analysis when they are used to study the relations between different ethnic and business groups, as well as dynamics, sentiment analysis, and activities involving other networks (56,59,60). Briefly, social network analysis is interpreted as a study of human relations through graphic theory (14). It requires strong coordination that really needs the idea of joint and holistic work between actors so that the goals of the actor-network can be achieved (61).

Based on the results, the network of actors in forest fire handling in South Sumatra is more formal in nature indicated by two issues. First, claims about network phenomena are based more on the existence of normative arrangements regarding the involvement of state and non-state actors. At the empirical level, the actors involved are only state actors, while non-state actors (the community and the business) are only involved by state actors with roles either as target groups or subjects who are encouraged to contribute and participate, especially in the emergency stage. On the other hand, the community and private sector should become active actors in every stage of forest fires handling. This has been regulated in the policy of prohibiting forest fires, which also regulates the obligation of the community and the private sector to be involved in forest fires management consciously (62). In other countries, such as Nepal, it is also shown that community involvement is the most important activity in forest fires management (63). How important these community actors are, they are the key to forest survival through the integration of local wisdom, conservation values, and sustainable livelihoods (64), especially at the preventive stage (65).

Second, in the field, the forest fires handling is very focused on the emergency stage, and even this is reactive in nature, as represented by the view that forest fires handling is complete when the fire can be extinguished. On the one hand, forest fire handling focusing only on the emergency stage can quickly extinguish forest fires. However, on the other hand, when data shows that almost 99% of forest fires are caused by human activities (32,66), then the success of managing them at the emergency stage is only temporary as shown by the repeated occurrences of forest fires from year to year (67). This fact mentions the significance of another stage of forest fires handling, namely, the prevention and rehabilitation stages. Regarding this, for example, Sudhakar (68) argues that it is essential to mitigate forest fire by preventing it through identifying and anticipating in an early stage. Subsequently, success in the pre-disaster stage is

the main foundation for effective management of forest fires along with the critical involvement of the community and business as the main actors at that stage. Overall, this fact shows that effective management of forest fires requires the involvement of many actors covering all stages, from pre-disaster to emergency and post-disaster.

This study has also shown that the involvement of the community and the business is only incidental, namely, when these two groups of actors are directed not to be the cause of forest fires. This involvement is symbolized by the existence of a forest fire alert group, which was formed voluntarily by the community and is idealized as the main forum for community participation in forest fires handling. In practice, these normative directives do not build a conducive atmosphere when state actors do not facilitate and educate the community. As a result, people who have institutionalized the habit of burning as a method of land clearing are not motivated to reduce or eliminate such habit. This situation shows that forest fires handling should not only involve the community but also map out this involvement in a clear and structured manner. Clear in terms of community involvement has certainty regarding the type of role for each actor; and structured in term of with the understanding that interactions between actors are based on their respective roles in a systematic framework and involvement.

Based on the previous description, it can be stated that the network of actors will be woven proportionally based on two conditions. First, there is a balanced participation between state and non-state actors. Second, there is an alignment of activity between each stage of forest fire handling from pre-disaster, emergency, and post-disaster stage. The combination of these two conditions can be created through a forest fire handling model based on three main elements namely role, interaction, and intervention, as shown in Figure 6.

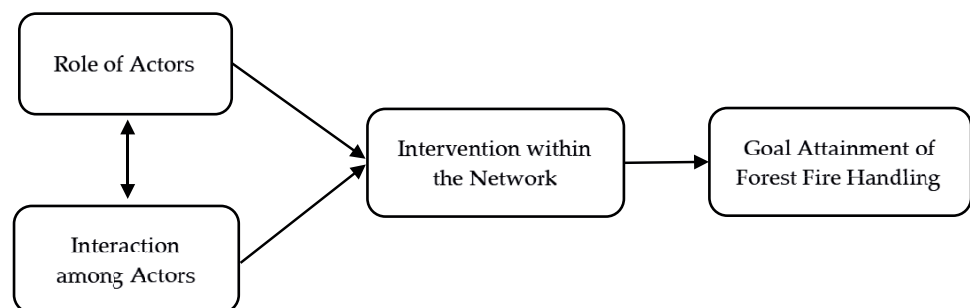


Figure 6: Main Elements of Forest Fire Handling. Source: Author, 2023.

Role can be interpreted as the realization of the functions carried out because of a position or activity frame that is attached to a person’s social position. Roles in the

context of cooperation or organizations relate to the position or level of authority held. In this relationship frame, roles can take place according to the nature of the relationship frame. In a relationship frame with a hierarchical structure, roles take place with hierarchical mechanisms and patterns that are task-based, and on the other hand, in a non-hierarchical relationship frame, roles can be realized through a volunteer-based equality mechanism.

The implication of these two potential relationship frames in the context of a actor-network is that role management becomes one of the main pillars. Based on the research results, the role in forest fires handling is reflected in the centrality played by the actors. In the pre-disaster stage, the biggest role is played by the Head of the Forest and Land Fire Control Section. This fact reveals that the actor is, whose position at the operational level, is the most central and key actor in the context of aligning technical activities in actor-networks. This actor is also the actor most often traversed by other nodes or become a bridge between nodes. Along with this, the highest closeness centrality is owned by the Head of the Regional Development Planning Agency. This measure denotes three meanings. First, this actor has the fastest access to all the other actors. Second, the actor has the minimum distance compared to other actors to access other actors. Third, the actor has the visibility to know what happens in the network. Furthermore, at the emergency stage, the actor playing the most role is the organization, namely the Regional Disaster Management Agency. Such a role is suitable for the function of that agency. It means that the dynamic of the role is related to the appropriate function of the actor. Consequently, the role of this actor should be further strengthened by facilitating such roles with proper interaction as well as with planned intervention.

Interaction is an inevitable, planned relationship formed between two or more actors. Interaction always shows a two-way relationship, which can be in the form of a process of encoding and decoding in communication, or a process of action and reaction in achieving decision making and agreement. Interactions can be supportive or opposing, which in turn, can cause a double loop in relations between actors, which can be interpreted as a positive or negative correlation. Thus, related to the network of actors, the meaning of edges can be interpreted in at least two ways. First, edges can show the intensity of the relationship that occurs between two or more actors. In this sense, edges can be a marker of the degree of role an actor has, namely, from less important to very important. Second, edges can also show the dynamics of relationships that occur between two or more actors. In this case, the meaning of edges is not only the sum of the frequency of relations between two or more actors, but also, expressing the nature of

relations that occur between actors in relation to the possibility of positive or negative correlation. Thus, interpretation of relationship intensity needs to pay attention to its dynamic tendencies. Only with a large role and interaction with positive correlation, an intervention in the activities of the network of actors can be carried out and is expected to guarantee the effectiveness of achieving goals.

Intervention within the framework of a network of actors is a choice of ways to realize goal achievement. Based on this understanding, intervention can reflect the results of the decision-making process and forming agreements within the network of actors. Thus, interventions that are expected to be successful are characterized by at least two requirements, namely, being deliberative and inclusive in the process, and having sufficient and relevant resources.

Based on this view of role, interaction, and intervention, to build relationships between actors so that effective forest fires handling takes place, it is necessary to design connectivity between roles, interaction, and intervention. In detail, the connectivity design is related to affirming the character of roles, interactions and interventions as follows:

1. Clear and internalized roles of actors, namely, as policy makers, field operators, operational links, and supporters of operational continuity.
2. Multi-actor interactions (linkages or ties) are systemic and constitute a connected series of actions.
3. Intervention with systematic and proportional activities during the pre-disaster, emergency, and post-disaster stage, both internally at each stage and among stages.

4. Conclusion

Formally, there is a certain division of activities among actors in forest fire handling in South Sumatra Province in pre-disaster, emergency, post-disaster stage. It is done through a task force established by the Governor of South Sumatra Province involving state and non-state actors. However, non-state actors were not involved in every operational activity, especially in the pre-disaster stage. Furthermore, the Head of the Forest and Land Fire Control Section plays an essential role in the pre-disaster stage, the Regional Disaster Management Agency in the emergency stage, while there is no actor interacts in the post-disaster stage. Such situation requires a better actor-network by weaving the nodes to ensure effective coordination considering role, interaction, and

intervention of the actors as well as the nature of inclusiveness through the involvement of all actors, especially that of non-state actors. The limitation of this study is dealing with its focus just on one perspective that is based on the legal framework. Future research is expected to broaden the perspective with empirical and factual research.

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