

Article

Not peer-reviewed version

Investigating Stakeholders Networks; Case Study on Cidanau Watershed in Indonesia

[Moh Sofyan Budiarto](#)*, [Ida Widianingsih](#)*, [Entang Adhy Muhtar](#), [Rd Ahmad Buchari](#), Herie - Saksono

Posted Date: 22 June 2023

doi: 10.20944/preprints202306.1598.v1

Keywords: social network analysis; cidanau watershed management; fkdc; Banten province



Preprints.org is a free multidiscipline platform providing preprint service that is dedicated to making early versions of research outputs permanently available and citable. Preprints posted at Preprints.org appear in Web of Science, Crossref, Google Scholar, Scilit, Europe PMC.

Copyright: This is an open access article distributed under the Creative Commons Attribution License which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

Article

Investigating Stakeholders Networks; Case Study on Cidanau Watershed in Indonesia.

Moh Sofyan Budiarto ^{1, 2, *}; Ida Widianingsih ^{1, *}; Entang Adhy Muhtar¹; Rd Achmad Buchori ¹; Herie Saksono ³

¹ Public Administration Graduate Program, Faculty of Social and Politic, Universitas Padjajaran, Jl. Bukit Dago Utara No.25, Bandung, Jawa Barat, Indonesia 40135; sofyan20002@mail.unpad.ac.id, ida.widianingsih@unpad.ac.id; entang.apunpad@gmail.com; ahmad.buchari@unpad.ac.id

² Regional Development Planning Agency Banten Province, Jl Syeh Nawawi Al Bantani, KP3B, Serang City, Banten, Indonesia 25171; sofyan20002@mail.unpad.ac.id

³ The National Research and Innovation Agency, Jl. MH Thamrin No 8, Jakarta, Indonesia 10430; herie_saksono@kemendagri.go.id

* Correspondence authors: sofyan20002@mail.unpad.ac.id, ida.widianingsih@unpad.ac.id

Abstract: Social network analysis is extensively employed for the examination of relationships and networks among actors across diverse disciplines and thematic research domains. Nevertheless, the utilization of this approach in agriculture and natural resources, particularly pertaining to watershed management, has been relatively limited. The objective of this study is to conduct an analysis of the social interaction and networks of Cidanau Watershed Management (CWM) stakeholders and measure the nodes of units as individuals or organizations to the role and influence of each other through a quantitative approach. The results of the data analysis show that Fkdc has a high degree of centrality and centrality betweenness. This shows that Fkdc has a strong influence and controls CWM network interaction. Conversely, Hs (households) have a low degree of centrality, and centrality betweenness values had a low influence and role in actors' networks. According to the closeness centrality parameter, it is observed that both Households (Hs) and Universities (Univ) have exhibited the shortest geodesic distance in relation to other stakeholders within the network, thus indicating their highest level of closeness. It means that Hs (Households) and Univ (Universities) had interdependency and control by others. The closeness centrality of Fkdc is the lowest, which means that Fkdc had independency of influence and high control access to others. There are 4 CWM network clusters based on total link strength. Fkdc demonstrates outstanding leadership qualities, enjoys a strong reputation, and possesses a high degree of popularity within the network. Furthermore, Fkdc serves as a central node that effectively brings together the interests of all actors, fostering a collective commitment towards shared goals and mutual rewards. In the CWM case, Fkdc is a sustainable watershed organization that acts as a central network body and plays a fundamental role as an intermediary of network and interaction. The process of sustainable watershed management entails the establishment of the Watershed organization as a central network entity, assuming a crucial role as a medium for the dissemination of information, exchange of ideas, and exertion of influence among its members. How does Fkdc manage the Cidanau watershed with its central role, and to what extent can Fkdc survive the ever-changing situations and problems (dynamics) in the management of the watershed, become an interesting research theme to be investigated further.

Keywords: social network analysis; cidanau watershed management; fkdc; Banten province

1. Introduction

Network-based representation and analysis have experienced significant growth as an increasingly potent methodology for data analysis across diverse applications. Technological advancements

have directly and profoundly impacted the field of social network analysis and mining, enabling the creation of comprehensive frameworks for social networking and automating the analysis of social networks (İlhan et al., 2014). New technologies have recently enabled information to practitioners, researchers, developers, and end users to examine social interaction data from a variety of angles. Doing social network analysis requires tools to be able to process data so that it can be visualized and represented in a form that is easy to understand. There are numerous social network analysis tools available for visualizing and obtaining optimal results. To achieve the best outcomes, it is imperative to utilize the most suitable tools for executing the analysis. The number of research outcomes and the number of research groups working on social networks has rapidly increased over the past decades due to the recognition of the social network methodology as an effective model to develop unique solutions for some vital problems (İlhan et al., 2014).

Social network analysis (SNA) serves as a tool that enables the modeling, visualization, and analysis of interactions among individuals within groups and organizations (Springer & de Steiguer, 2011) (Scott & Carrington, 2015). It aids in comprehending the interdependencies among social entities within the data, elucidating their behaviors and the impact they have on the overall network both in the present and over time (Tabassum et al., 2018). A social network is composed of individual nodes (persons, teams, or organizations) and ties (also called relationships, connections, edges, or links) between these individual nodes (Fu et al., 1994). Typically, these networks are represented using graphs, wherein vertices symbolize the social entities and edges symbolize the connections formed between them.

Several academics showed a social network is a scientific tool that examines the types of interactions between stakeholders (Borgatti et al., 1999) (Borgatti et al., 2002) (Chaudhary & Radhakrishna, 2018) (Majeed et al., 2020). According to (April et al., 2009) (Zaphiris & Pfeil, 2007), the immersion of people to collaborate become one of the most powerful notions the social networks. Social network theory offers an explanation for how individuals come together to form enduring and functional societies (Kempe et al., 2015; Springer & de Steiguer, 2011).

This capability empowers researchers to derive insights regarding the structure, dynamics, and participation patterns inherent in these groups. It encompasses various measures, such as degree (indicating the number of connections an individual has with other members), betweenness centrality (highlighting an individual's significance in the network as a bridge between other participants), closeness centrality (illustrating the proximity of an individual to others in the network), and eigenvector centrality (assessing an individual's prominence based on their connections with other influential individuals in the network).

Literature Review

SNA is widely used to analyze the relationships and networks of actors in various disciplines and thematic research. Disciplines including sociology, business management, and public health have widely utilized social network analysis (SNA) to address diverse organizational and network scenarios (Springer & de Steiguer, 2011), anthropology, social psychology, communication studies, information sciences (İlhan et al., 2014). Nevertheless, despite its value in studying these relationships, social network analysis (SNA) has seen limited applications in the context of agriculture and natural resources, such as watershed management.

Water and watersheds play an important part in societal economic and communal well-being (Guppy & Anderson, 2017) (Widianingsih et al., 2021). Within each watershed, there exists an institutional landscape—an intricate yet predominantly imperceptible terrain comprising rules and organizations that shape and impact human decision-making, resource utilization, and the interplay between individuals and the natural environment. Institutions encompass determinations regarding the inclusion of participants in decision-making processes, the manner and conditions under which actions can be undertaken, the delineation of jurisdictions for various issues, and the mechanisms through which current actions and previous decisions can be scrutinized, evaluated, and revised by relevant stakeholders (Schlager & Blomquist, 2008). According to (Bodin & Norberg, 2005) (Lienert

et al., 2013)(Sayles & Baggio, 2017), complex interactions between different actors and sectors help in characterizing environmental policy and decision-making. This makes stakeholders vertically change from the traditional policy to comprehensive or participatory management (Fatemi et al., 2021)(Prell et al., 2009)(Ansell & Torfing, 2016). SNA is discuss the interaction of the actor involved on watershed management who have different interests and goals. How actors develop interactions and create networks for a common goal will determine the success and sustainability of watershed management.

Network analysts perceive these networks as the fundamental constituents of the social realm, as they not only gather distinctive forms of data but also approach their analyses from a fundamentally distinct standpoint compared to researchers employing individualist or attribute-based perspectives (Scott & Carrington, 2015). Social network analysis is founded on the principle that social existence is primarily and significantly shaped by relationships and the patterns that emerge from these connections. Individuals engage in social networks through interactions with their families, friends, colleagues, and other individuals or groups. Social networks establish links among people based on shared interests and/or various forms of interdependencies (Scott & Carrington, 2015).

Network mapping and social network analysis serve as techniques for visually representing the quality and quantity of connections within a network of partners. They enable the observation of collaborative relationships, resource exchanges, levels of trust and value among partners, and numerous other factors. By obtaining such visibility, one can identify opportunities for enhancement and develop a data-driven strategy to drive positive change. In the framing of watershed management, social networks is becoming the key point in the nexus of sustainability. This study emphasizes the participants' network and investigating the actor's networks for sustaining CWM. How does the networks of the actors frame the dynamic change of CWM. We used social network analysis of Cidanau watershed management as method to identify the social interaction and networks of all stakeholders and measuring the node of units as individual or organization to the role and influence of each other.

3. Materials and Methods

3.2. Research Area

In the 1990s, there is a fast conversion from dry land and swamp forests to residential neighborhoods and agricultural rice fields in the upstream regions of the Cidanau watershed and Rawadanau swamp (midstream of Cidanau watershed) due to poverty (Kunihiko et al., 2003) (Laila et al., 2014) (Yoshino & Ishioka, 2005). This generates chemical build-up from fertilizers because the lack of sewage treatment degrades the water quality (Heryansyah, 2005)(Arien et al., 2007)(Kato et al., 2002). According to (Khairiah et al., 2016), rehabilitation programs, security patrols, surveillance, and infrastructure upgrades are efforts made to prevent the problem related to a top-down policy. This helps to reduce the Cidanau watershed's role and satisfy water requirements, specifically during the dry season.

The Cidanau watershed assists to deliver sufficient and high-quality water to prevent harm to upstream ecosystems(Heyde et al., 2012) (Renaud Lapeyre et al., 2015)(Munawir & Vermeulen, 2007)(Sunaedi et al., 2018)(Wulansari, 2015). Cidanau watershed is established to generate economic growth in Banten Province's western section (Kunihiko et al., 2003)(Renauld Lapeyre et al., 2011), by supplying industrial and domestic raw water, as well as becoming a reservoir with a suitable outflow (Sunaedi et al., 2019).

The water quality and quantity become an impediment to industrial and household demands, socioeconomic, ecological, and environmental growth if there is available water (Kunihiko et al., 2003)(Hartanto et al., 2019)(Hartanto et al., 2021). In the middle of the Cidanau watershed, there is a 2,500-hectare Rawa Danau Nature Conservations area (Priyanto & Titiresmi, 2006). According to (Priyanto & Titiresmi, 2006), this area is the main reservoir that exists on Java island. Based on previous study, indicated that the Cidanau watershed become a critical raw water supply that is far more than satisfying the societies because it has an average discharge of 80–100 liters/second.

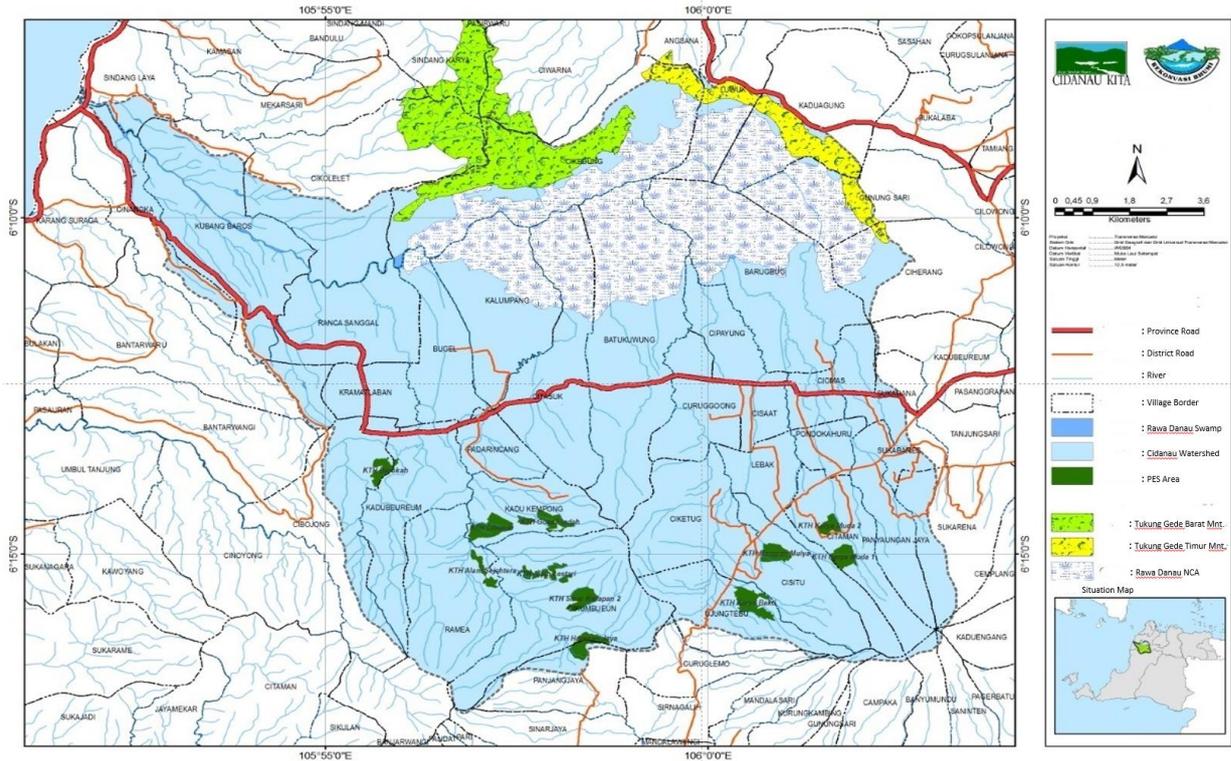


Figure 1. Research area of CWM. Sources : Env. and Forestry Agency of Banten Province.

3.2. Social Networks Analysis Method

In the context of Cidanau Watershed Management (CWM), the logical collection of real data necessitates the utilization of analysis tools and appropriate methodologies, owing to the diverse array of stakeholders involved (Budiarto et al., 2022). The present study employed a social network as a scientific methodology to evaluate the nature of relationships that exist among actor (Prell et al., 2009) (Lienert et al., 2013) (Fatemi et al., 2021). The data collected through limited group discussion with knowledgeable actors to Cidanau watershed management. The data generated through conversation to informant's interview involved and understanding the trajectory on CWM to elicit facts or statements from the interviewer (see table 1). UCINET software used to analysis complex relationships among diverse individuals in a single group or social network (Stephen P Borgatti et al., 2002). UCINET is a computer program of a general purpose designed for network analysis (Borgatti et al., 1999). UCINET is a comprehensive software package that facilitates the analysis of social network data, along with other 1-mode and 2-mode data. While it can accommodate a maximum of 32,767 nodes (with certain exceptions), the practical efficiency of various procedures tends to diminish when dealing with 5,000 - 10,000 nodes. This user-friendly program encompasses fundamental graph theoretical concepts, positional analysis, and multidimensional scaling, making it a valuable tool for social network analysis.

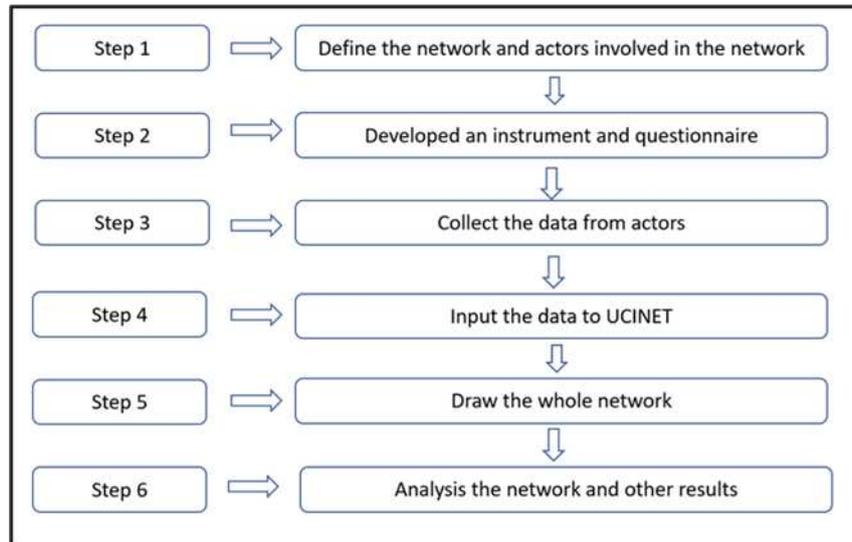


Figure 2. Procedures of social network analysis. Sources: (Chaudary & Warner, 2018).

According to (Chaudary & Warner, 2018), social network analysis is conducted using six steps. The first step is to identify the particular network that is needed while considering if there are formal rules governing the relationships between actors. Meanwhile, the second is to administer effective questionnaires or surveys to stakeholders for SNA data collection and analysis. The third step is to use specialist software to collect, record, and store the data, while the fourth is to present it in picture or diagram form. Furthermore, the fifth step is to draw the network and identify the interconnection between nodes. The final step is to recommend appropriate action and analyze the data which is presented and displayed by the SNA. The Data collected through limited group discussion to key actors deliberated CWM.

4. Results

4.1. The Data Matrix of CWM

The first stage is to identify the actors (individuals, government, non-government organization, public organizations, industry, university, etc) involved in CWM. Researchers identified 23 actors involved in CWM from upstream to downstream of the Cidanau watershed. To make it easier to analyze, the researcher uses an abbreviation (node variable) for each actor involved. Actor data involved in CWM, Table 1 displays the aforementioned information.

Table 1. Presents the stakeholders involved in Cidanau Watershed Management.

Node Variable	Actors	Node Variable	Actors
Rg	Province Government	Fkdc	Cidanau Multi-Stakeholder Watershed Communication Forum
Rga	Development Planning Agency of Banten Province	Rkb	Rekonvasi Bumi as Non-Government Organisation
Rgb	Service Office of Environment and Forestry of Banten Province	Cga	Natural Resources Conservation Agency as a subsidiary of the Ministry of Environment and Forestry
Rgc	Public Work Services of Banten Province	Cgb	Watershed Management Department as a Subsidiary of the Ministry of Environment and Forestry

Rd	District Government	Cgc	River Basin Development Agency as a subsidiary of the Ministry of Public Infrastructure
Rda	Serang District	Fmr	Famers
Rdb	Pandeglang District	Gfmt	Group of famers
Rdc	Cilegon District	Univ	University
Kti	Krakatau Tirta Industry (Water Company)	Ingo	International Non-Government Organisation
Ash	Private Company		
Pdam	District Company on Water Service	Pht	Perhutani as State Forestry Enterprises
Hs	Households in Cilegon city as water user	Il	Others Company

Data collection was carried out by means of a Limited Group Discussion Forum for participants/actors involved in CWM. The Group Discussion Forum is conducted for representatives of actors who have knowledge and involved in CWM. Participants asked to fill in a matrix showing the relationship between one actor and another. The existence of a relationship between actors is given a score of 1, while there is no relationship between actors is given a score of 0. Figure 3 provides an overview of the comprehensive relationship among actors in CWM.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
	Rg	Rg	Rg	Rg	Rd	Rd	Rd	Rd	Kt	As	Pd	Hs	Fk	Rk	Cg	Cg	Cg	Fm	Gf	Un	In	IL	Ph
	a	b	c		a	b	c	i	h	am	dc	b	a	b	c	c	r	mr	iv	go		t	
1	Rg	0	1	1	1	1	1	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
2	Rga	1	0	1	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
3	Rgb	1	1	0	1	1	1	1	1	0	0	0	1	1	1	1	0	0	0	0	0	0	1
4	Rgc	1	1	1	0	1	1	1	1	0	0	0	1	0	0	0	1	0	0	0	0	0	0
5	Rd	1	0	1		0	1	1	1	0	0	0	1	0	0	0	1	0	0	0	0	0	0
6	Rda	1	0	1	1	1	0	1	1	1	0	1	0	1	0	0	0	0	0	0	0	0	0
7	Rdb	1	0	1	1	1	1	0	1	1	0	1	0	1	0	0	0	0	0	0	0	0	0
8	Rdc	1	0	1	1	1	1	0	1	0	1	1	1	1	0	0	0	0	0	0	0	0	0
9	Kti	0	0	1	0	0	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0	1	0
10	Ash	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	1	0
11	Pdam	0	0	0	0	1	1	1	1	0	0	1	1	0	0	0	0	0	0	0	0	0	0
12	Hs	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
13	Fkdc	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1
14	Rkb	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
15	Cga	0	0	1	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0
16	Cgb	0	0	1	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0
17	Cgc	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
18	Fmr	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0
19	Gfmr	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
20	Univ	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
21	Ingo	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
22	IL	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0
23	Pht	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Figure 3. Matrix data set of Cidanau watershed stakeholders.

4.2. Sociogram Analysis

The sociogram visually represents the social interactions among actors in CWM by conceptualizing individuals or organizations as nodes and their relationships as ties between the nodes. In the sociogram, two nodes that have a relationship are connected by a tie, while nodes without a tie indicate the absence of a relationship. Nodes are differentiated by color, size, and shape, reflecting individual-level characteristics, whereas ties are represented by various characteristics of the

relationship, such as communication frequency or relationship strength. Through the mapping of connections among actors, the network analysis reveals the variations in influence, interests, and objectives of each actor involved in CWM. Some actors possess significant influence, while others have limited influence within the CWM context. There are actors who have high influence, but there are those who have low influence in CWM. There are actors who have certain interests and there are actors who have less interest in CWM. However, all actors involved in the management of the Cidanau Watershed have made a common-sense commitment to preserve the Cidanau Watershed for sustainability.

4.2.1. Network Degree Centrality of CWM

A highly centralized network is one in which a small number of persons or organizations control a greater fraction of the connections than is proportional to their size (Fatemi et al., 2021). When regarded in this node size, the metric is a useful tool for considering power and equity in a network in terms of how the network is structurally structured. Degree network centrality of CWM is measures how important a person or organization is to a network or the power of an actors in a network. Centrality used to identify essential members in a CWM network. Depending on the metric utilized, centrality measures reflect the extent to which a network is directly connected to numerous others (degree centrality), indirectly linked to many others (closeness centrality), or the degree to which an individual exercises control over information or resources within the network and acts as a critical intermediary between multiple nodes (betweenness centrality).

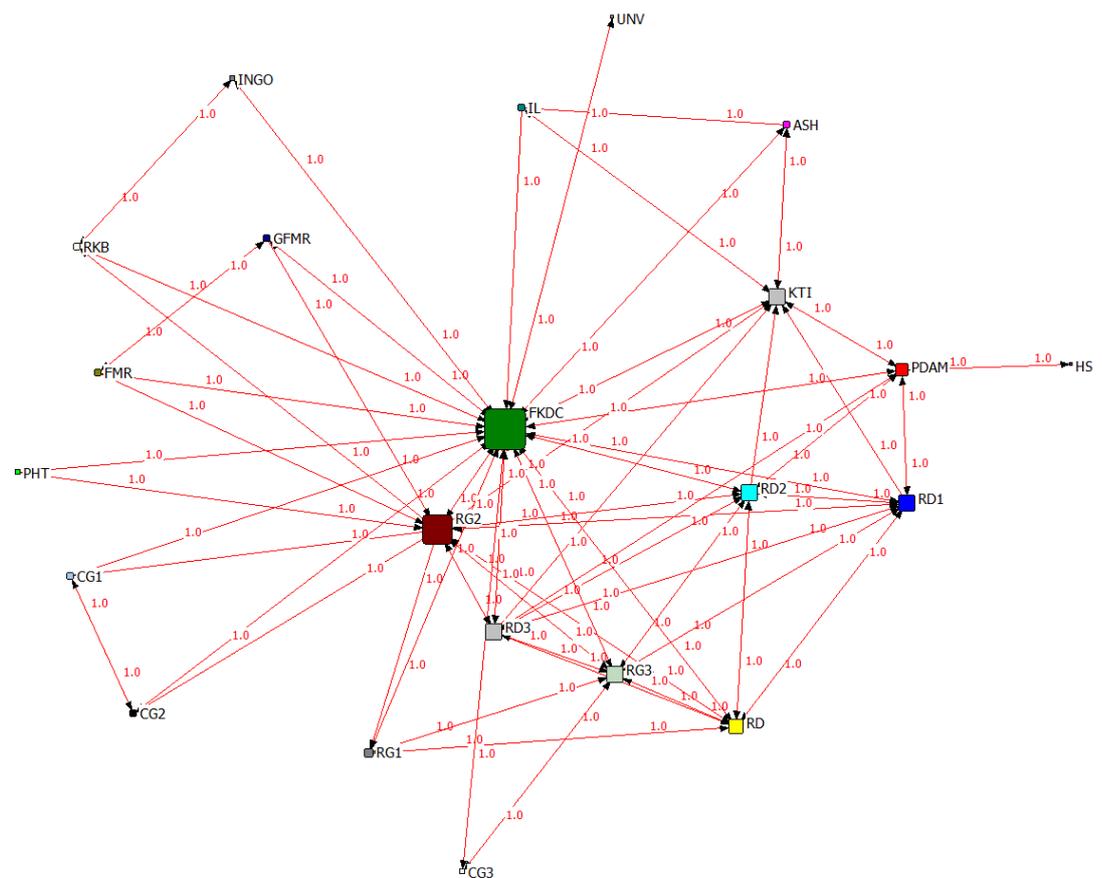


Figure 4. Trust network degree centrality index of CWM.

The centrality index identifies nodes that hold critical positions within a network, often associated with exceptional leadership, high popularity, or an excellent reputation within the network. Central positions always get equated with remarkable leadership, good popularity or excellent

reputation in the network. Figure 4, demonstrates that Fkdc is the major node of interaction and network for all entities participating in CWM. The larger size of the Fkdc nodes signifies a higher degree centrality, indicating that Node Fkdc attained the maximum frequency. Furthermore, Fkdc demonstrated the highest level of trust among all other actors involved in CWM. The second highest degree centrality is Rg2, because it was the most connecting to others actor in CWM. Fkdc and Rg2 had higher social influence, promoting trust links and influencing network dynamics in the management of the Cidanau watershed. The lowest degree centrality is node Hs (households), because only one ties connected to node Pdam (District water services company). Households is the passive actors and less network to other stakeholder, but it should be educated to be wise as water user.

4.2.2. Trust Network Due to Output Betweenness Centrality.

Betweenness centrality reveals the presence of actors holding distinctive positions within a network, serving as communication bridges that other actors must pass through to connect with other network members. The greater the number of actors relying on such intermediaries for communication, the higher their influence. Nodes with high betweenness centrality values play a significant role in facilitating communication within the network. Betweenness centrality considers the number of shortest paths in the network that pass through a node, taking into account the connectivity of the node's neighbors and assigning greater value to nodes that bridge clusters.

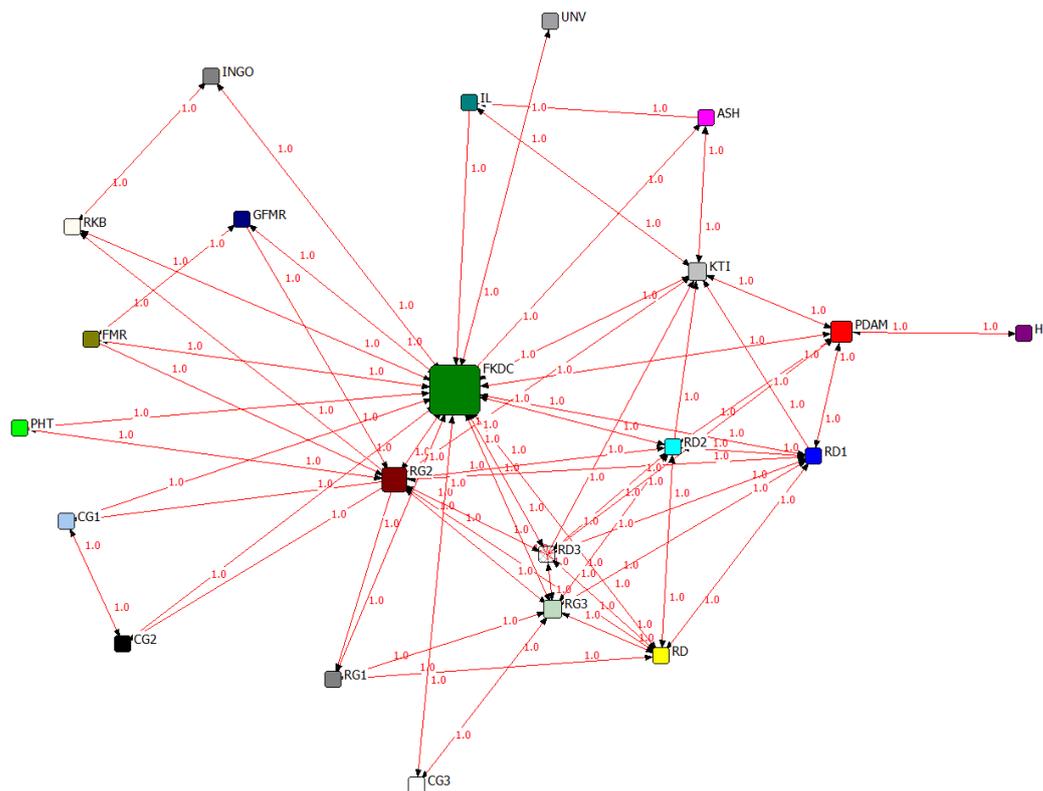


Figure 5. Trust network due to output Betweenness Centrality.

Figure 5 illustrates that Fkdc attained the highest betweenness centrality, positioning it as one of the key actors within the trust network of stakeholders in CWM. Fkdc occupies a central position within the network, strategically positioned to exercise significant control and serve as a broker for transactions among other stakeholders. All actors are connected to Fkdc, this shows that Fkdc is trusted mediator for others in CWM network. Rg2 also has high betweenness centrality, beside Fkdc. Rg2 is a government institution at the provincial level, which acts as an intermediary for stakeholders, especially for other government institutions. Households have the lowest betweenness centrality, this

is because households are passive actors (water users) and are not directly involved in CWM management. Households only indirectly connected to PDAM.

4.2.3 The trust network exhibits output closeness centrality as a determinant factor.

Closeness centrality, which is defined as the reciprocal of the average geodesic distance, serves as a measure of proximity within a network. It represents the average of all geodesic distances between a given actor and other actors in the network. A higher value in closeness centrality indicates that the node is reachable with fewer links, reflecting the actor's ability to quickly access others within the network.

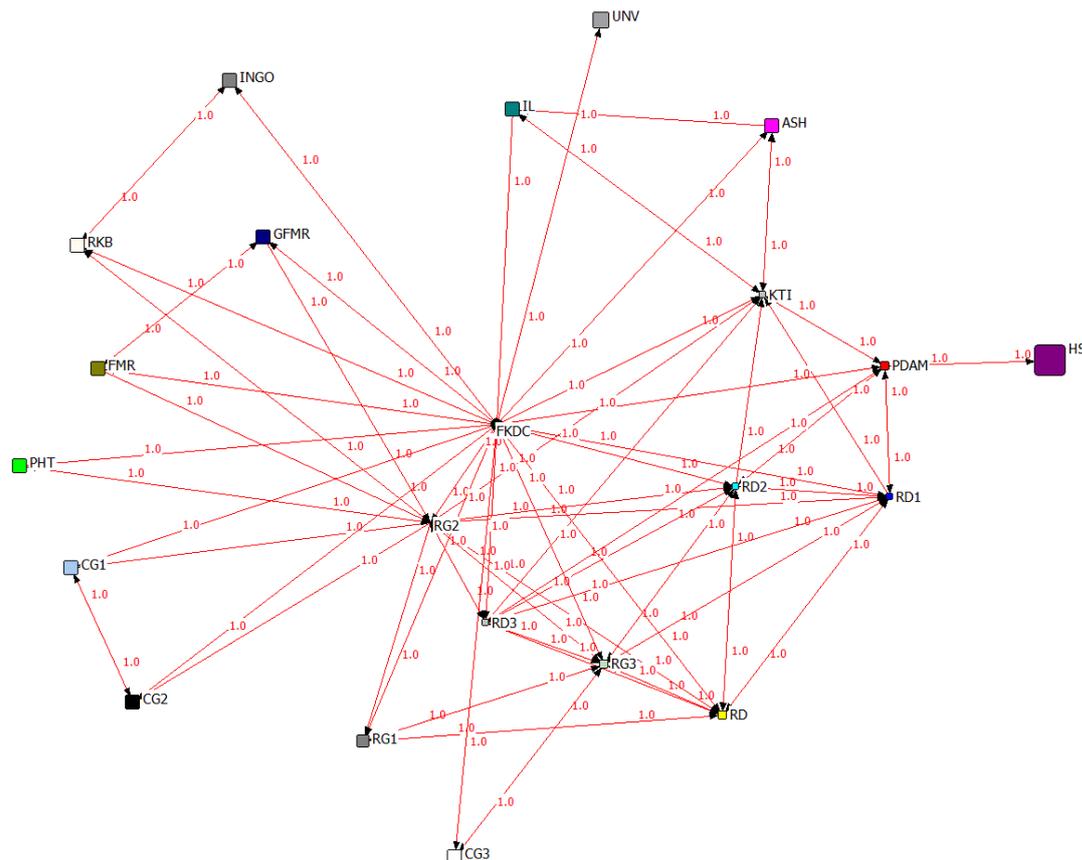


Figure 6. The trust network exhibits output closeness centrality as a determinant factor.

In Figure 6, it can be observed that Households (Hs) and University (Univ), represented by the purple color, have the shortest geodesic distance with other stakeholders in the network and possess the highest closeness centrality. Households, as water users, are directly connected to Pdam, the local public water services company. Similarly, the University is connected to Fkdc, which serves as the central node in the network. The high closeness centrality of these nodes indicates their effectiveness in exchanging content within the network, their easy accessibility to other nodes (stakeholders), and their crucial role in distributing information or content among other stakeholder groups in the CWM network. This implies that if an idea or information exists somewhere in the network, it is likely to reach a node with high closeness centrality after a few interactions.

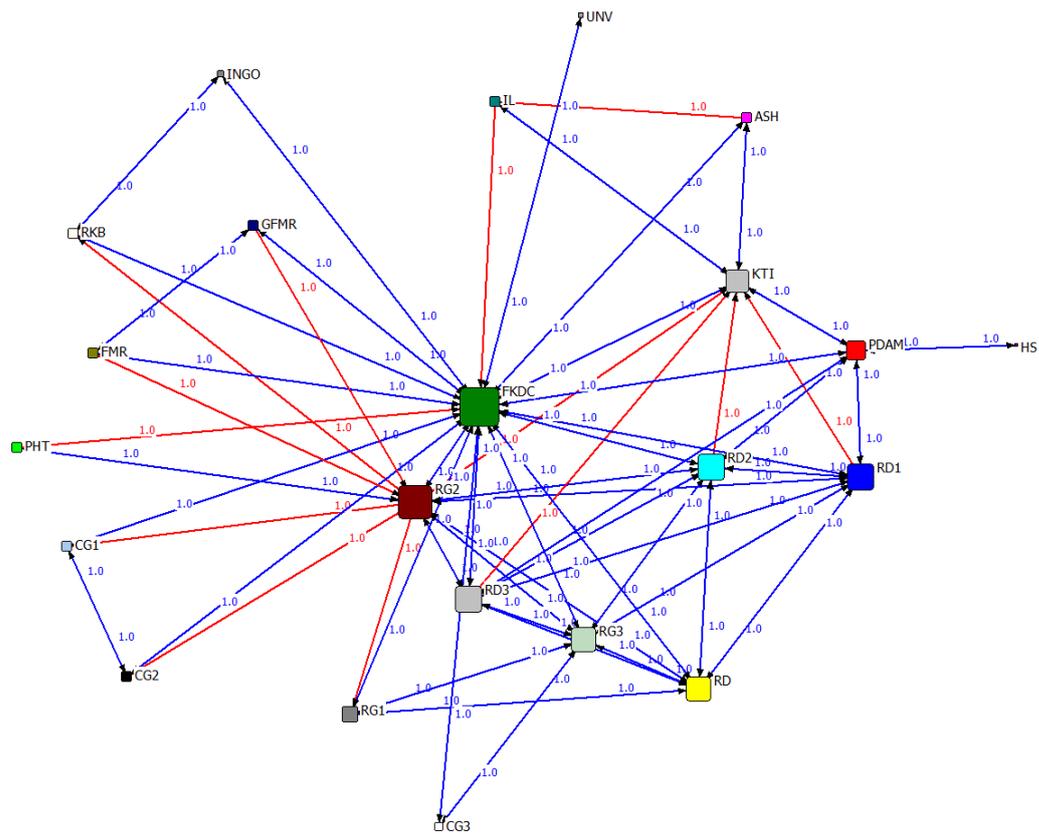


Figure 7. The trust network demonstrates reciprocal degree as a determining factor.

Reciprocal degree serves as a metric to depict the presence of reciprocal relationships among actors and the level of sustainability and cohesion within the network. In networks where an actor can select another actor in multiple instances, the links between nodes can be assigned weights. The strength of a node is measured by the cumulative weight of its links and can be seen as analogous to the degree of a node. Typically, two types of strength are considered: in strength, which represents the sum of weighted links directed towards a node, and out strength, which represents the sum of weighted links originating from a node.

Fkdc has the largest number of links (in strength), in this case Fkdc can be a facilitator node for other actors. This shows that Fkdc is a trusted and important actor in the network because almost all actors involved in CWM have ties to Fkdc. Meanwhile, in strength, Fkdc only has 2 links, namely links to Il and Pht, because the two actors are parties whose level of involvement in CWM is low and to be increasing in involvement.

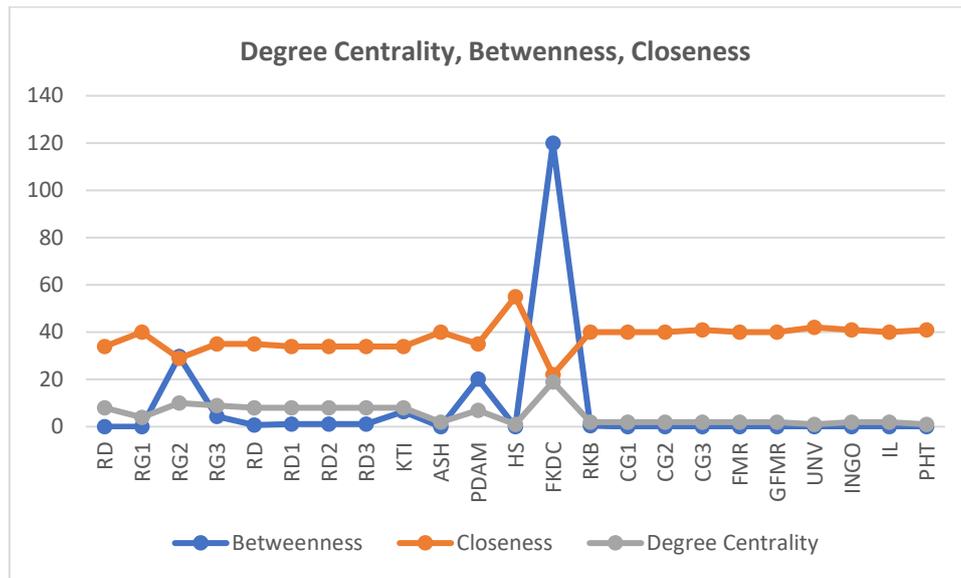


Figure 8. Fkdc formalize as Cidanau watershed management.

Figure 8 displays the values of betweenness centrality, closeness centrality, and degree centrality. Fkdc has the highest centrality betweenness score but the lowest centrality closeness. This shows that Fkdc has the highest degree of a node, which means it is connected to the most nodes and has the highest geodesic distance. Whereas Hs (Household) has the lowest node degree, which means it has the fewest connected nodes with the shortest geodesic distance. In contrast, households have the lowest centrality betweenness but the highest centrality closeness. The inverse of the mean geodesic distance is centrality (closeness). This implies that if an idea exists somewhere in the network, some version of it will reach a node with a high degree of closeness after a few interactions.

The Fkdc was initiated by the local government elements (Rda, Rdb, Rdc), Rekonvasi Bumi (Rkb), and Krakatau Tirta Industri (Kti) to become a collective institution on performing the Cidanau watershed management. Meanwhile, decentralization is not always synonymous with the government's role in the CWM (Annahar, et al., 2023). This makes the Banten Provincial government strengthen Fkdc in the connectivity network and driving the society to be involved in managing Cidanau water resources. However, the Banten government plays an important role by allowing public and private sectors to prevent conflicts and water crises in the future (Sulistyaningsih et al., 2021). Certain parties were resistant to the government's domination to enable it to hinder or cause the failure of a watershed. In the CWM, FKDC is a collective institution that builds commitment and integration between stakeholders because it allows knowledge sharing and strengthens societal participation.

5. Discussion

Networks and interrelationships between actors are determining factors for the success of watershed management. Several previous studies state that failure to build networks is the cause of failure in watershed management. According to (Erdogan, 2013)(Gamboa, 2014), actors networks are important when combining human activities and natural processes. The watershed management network depends on the characteristics of the watershed, actors, and watershed management policies themselves. The more complex the watershed (area, number of actors, watershed problems), the more complicated and difficult it will be to build networks between the actors involved in a watershed management.

The Cidanau watershed has dynamics critical challenges, as well as threats because it involves 23 actors (individual, organisation, business entities, government, etc). The Banten Province government has a major role in CWM, which involves public and private participation in the form of positive synergies, empowering all actors in order to prevent conflicts and environmental crises in the future

and strengthening connectivity networks within and between various government institutions, non-government and communities, as well as the dynamics that support the development of watershed management knowledge and practices. The Banten Governor's Decree No. 124.3/Kep.64.-Huk/2002 formally strengthened the Cidanau multi-stakeholder communication forum (Fkdc) as a watershed organization or bridging institution to organizes and manages the Cidanau watershed and to overcome classic problems on the watershed development sectors (Pujatmiko, 2006)

5.1. Network Cluster of CWM.

Total link strength can be used to measure the linkages between entities and determine how these entities are connected to other entities. For example, if an entity has many links that connect to other entities, then that entity may have a high total link strength. Conversely, if an entity only has a few links that connect to other entities, then that entity may have a low total link strength. Total link strength can be used to group entities based on their relatedness, or to discover relationships that might not be apparent in other ways

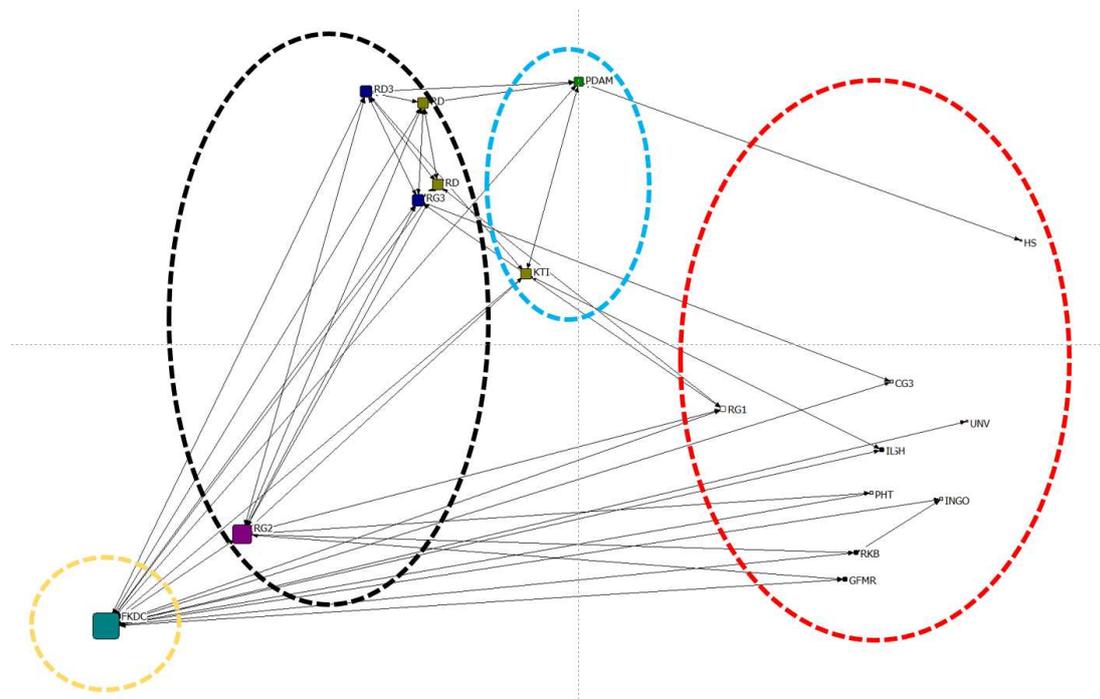


Figure 9. Network cluster of CWM.

Based on Figure 9, the researcher found actors cluster network in CWM. Clustering is based on total strength networks of a node/s. Cluster one is the Fkdc (size and green color) nodes which are the center cluster with the largest number of networks. Fkdc is a source of information and a share network for almost all actors involved in CWM. The second cluster is Rg2, Rg1, Rd, Rd1, Rd2 which is moderate influence for collaborative center network of other actors. Rg1, Rg2, Rd, Rd1, Rd2 are government institutions in provincial level and district level that have authority in implementing policies and strengthening networks in watershed management. Government institutions still have a major role in building networks between CWM stakeholders. The 3rd cluster is Kti and Pdam, which is a cluster, building a network with water users, both industry and households into three clusters. Cluster 4 is only connected to a few actors' interactions and networks, and it comprises University (Univ), farmers (Fmr), NGO (Ingo), household, Rkb, as well as Perhutani (Pht).

5.2. The Dynamic Centre Network Body of CWM

The Fkdc was initiated by the local government elements (Rda, Rdb, and Rdc), Rekonvasi Bumi (Rkb), and Krakatau Tirta Industri (Kti) to be a collective institution for performing CWM. Meanwhile, decentralization CWM is not always synonymous with the government's role in the CWM. This drives the Banten Provincial government to strengthen Fkdc's connectivity network and encourage society to participate in the management of Cidanau's water resources. However, the Banten government plays an important role by allowing the public and private sectors to prevent conflicts and water crises in the future (Sulistyaningsih et al., 2021). Certain parties were resistant to the government's dominance, which enabled it to hinder or cause the failure of a watershed.

CWM is the first initiation of a watershed management model in Indonesia, which is based on integrated watershed management through forming a centre network body (Fkdc) as watershed organization. According to (Laila et al., 2014)(Pujatmiko, 2006), Fkdc is also one of the Indonesian initiatives watershed organisation and established until today. Sustainability of CWM depends on development of the social network of the actors itself. The involvement of actors on CWM is influenced by the role and influence through Fkdc as centre network body.

The degree of centrality and centrality betweenness shows that Fkdc is the central point of the Cidanau watershed management network. This shows that Fkdc has a vital role as a source of information, information sharing and an arena for collaboration between actors in CWM. The shared commitment in establishing Fkdc made it easier for Fkdc to be accepted as the center network body in CWM. Fkdc is a collective institution that builds commitment and integration between stakeholders because it allows knowledge sharing and strengthens societal participation. These institutions help in strengthening and bridging actors and their interests (Davies & White, 2012; Medema et al., 2017; Munawir & Vermeulen, 2007). In accordance with the opinion (Medema et al., 2017) (Ferreira & Beard, 2007), watershed organization (WO) and a multi-stakeholder forum become one of the approaches to solving problems that arise. Also, the WO motivates stakeholders to interact, collaborate, and share knowledge (Davies & White, 2012) (Okumah et al., 2020) (Leach et al., 2002).

Fkdc is a centrality network entity that connects upstream actors, middle stream actors and downstream actors of CWM. Upstream CWM actors is perhutani, farmer, group of farmers. Downstream actors are Pdam, household, other industries. Based on figures 4.3, 4.4 and 4.5 above, it proved that Fkdc facilitates all the interests of the actors involved in CWM. Hence, Fkdc is expected to bring marginalized actors participated of the CWM. Therefore, the existence of these groups is equal to other parties because those in the upstream are often marginalized and less access to Fkdc. Fkdc become a joint institution that strengthens the farmers (Fmr) and group of farmers (Gfmr) participation through reciprocal dialog and networks in preserving the upstream Cidanau watershed landscape. This finding statement against (Hauck et al., 2016) statement that farmers serve as the primary decision-makers regarding land use, including selecting from different types of ecological focus areas within greening measures, such as choosing between cash crops and field elements like hedge rows or flower strips. Their substantial influence on the effectiveness of these measures in promoting biodiversity in rural areas has been recognized. These groups are strategically crucial as they contribute to land conservation in upstream areas to uphold the integrity of the hydrological cycle. Meanwhile, Perhutani (Pht) is a state-owned enterprises institution that has been managed upstream forest state concession of Cidanau watershed need to fostering the involvement in preserving forest areas to sustaining the availability of water resources.

In other reason, sustainability of the Fkdc on CWM is determined by mutualism network and inclusive participation (Annahar, et al., 2023) of all stakeholders. The mutualism network establishes a shared objective among all stakeholders, with participation shown to enhance the legitimacy of recommendations and yield positive social outcomes in management practices. (Hauck et al., 2016). Fkdc helps to determine the collective action and networks of all stakeholders to achieve a common goal and mutual benefit. According (Cash et al., 2006), In situations where actors sharing the same resource exhibit divergent values and conflicting interests, it becomes imperative to comprehend the distinct perspectives of the involved actors in order to facilitate effective governance. According (Gordon et al., 2020) finding, that collaboration or interaction of all actors makes it easier to bring their

disparate interests together. Furthermore, it is necessary to examine the role of each stakeholder to enable the watershed model to be replicated or implemented elsewhere

6. Conclusions

From the viewpoint of the institutional landscape, every watershed will have a distinct level of complexity in terms of actors, objectives, and a common goal for sustainability. In the watershed management, WO has various forms and functions. In some watersheds, the WO only functions as a project and activity coordinator, while in some others it only functions as a stakeholder facilitator. Degree centrality, centrality betweenness in CWM shows Fkdc functioning as WO and center network body. The Fkdc was initiated to bring actors' interests and concerns into the CWM. Cidanau watershed decentralization is not only synonymous with local governments but also allows the public to be fully involved in all development sectors through forming a center network body. Decentralization of watershed management will not work if it fails to build a network of actors into management. The network of actors is influenced by the conditions that allow all actors to sit together, build shared commitments and formulate joint management goals. In this case, the government supports and encourages citizens' participation by providing legal enforcement to forming Fkdc. The Fkdc is a center network body and bridging organization that unites all actors' interests in a single commitment, common aims, and shared rewards. As the center network body, Fkdc is an entity that connects the disconnected and deliberates the miscommunicated parties to be involved in Cidanau watershed governance. The sustainability factor in CWM is determined by how Fkdc becomes a centered WO in framing public participation through an active network and interaction. Finally, in the perspective of CWM, a Watershed Organization should be a center network body to motivates stakeholders to interact, collaborate, and share knowledge to stakeholders. How does the Fkdc manage the Cidanau Watershed with its central role, and to what extent can the Fkdc survive the ever-changing situations and problems (dynamics) in the management of the watershed, become an interesting research theme to be investigated further.

Author Contributions: BMS: conceptualization, investigation, formal analysis and writing—original draft. WI: writing, review and editing, funding acquisition, project administration, supervision. MEA: methodology, resources. BRA: data curation and software. SH: visualization, validation and redactional check. All authors have read and agreed to the published version of the manuscript.

Funding: This research funded by Nasional Research and Innovation Bureau of Indonesia Government, and the publication fee funded by University of Padjajaran, Indonesia.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: Data were mainly obtained through limited group discussion of Cidanau Watershed stakeholders

Acknowledgments: Author delivered many Thanks Dr Laksono Tri Handoko as The Head Office of National Research and Innovation Bureau of Indonesia Government.

Conflicts of Interest: There is no conflict of interest among all authors

References

- Annahar, N., Widianingsih, I., Muhtar, E. A., & Paskarina, C. (2023). The Road to Inclusive Decentralized Village Governance in Indonesia. *Sustainability (Switzerland)*, 15(11). <https://doi.org/10.3390/su15118616>
- Annahar, N., Widianingsih, I., Paskarina, C., & Muhtar, E. A. (2023). A bibliometric review of inclusive governance concept. *Cogent Social Sciences*, 9(1). <https://doi.org/10.1080/23311886.2023.2168839>
- Ansell, C., & Torfing, J. (2016). Introduction: Theories of governance. *Handbook on Theories of Governance*, 1–17. <https://doi.org/10.4337/9781782548508.00008>
- April, C., Page, S. E. E. L., Borgatti, S. P., Mehra, A., Brass, D. J., & Labianca, G. (2009). Network Analysis in the Social Sciences. *Science*, 323(April), 892–896.
- Arien, H., Akira, G., Masakazu, M., & Muhamad, Y. (2007). Development of a Watershed Water Quality Model

- in Indonesia nited Graduate School , Tokyo University of Agriculture and Technology (Utsunomiya University) increasing the need for water resources , and at the same purifier , are deeply diminishing . Prop. *Trans JSDRE*, 251, 573–582.
- Bodin, Ö., & Norberg, J. (2005). Information network topologies for enhanced local adaptive management. *Environmental Management*, 35(2), 175–193. <https://doi.org/10.1007/s00267-004-0036-7>
- Borgatti, Everett, M., & Freeman, L. (1999). UCINET 5 for Windows: Software for Social Network Analysis. *Natick: Analytic Technologies.*, January.
- Borgatti, S., Everett, M. G., & Freeman, L. C. (2002). Ucinet for Windows: Software for social network analysis (Version 6.102). *Harvard, MA: Analytic Technologies*, October 2015.
- Budiarto, M. S., Widianingsih, I., Buchari, R. A., & Muhtar, E. A. (2022). *Research Landscape On Watershed Management In Indonesia ; A Bibliometric Analysis*. 2021(September), 386–394.
- Cash, D. W., Adger, W. N., Berkes, F., Garden, P., Lebel, L., & Olsson, P. (2006). *Scale and Cross-Scale Dynamics : Governance and Information in a Multilevel World*. March 2016. <https://doi.org/10.5751/ES-01759-110208>
- Chaudary, A. C., & Warner, L. A. (2018). Introduction to Social Network Research: Application of Social Network Analysis in Extension. *Angewandte Chemie International Edition*, 6(11), 951–952., 10–27.
- Chaudhary, A. K., & Radhakrishna, R. (2018). Social network analysis: A methodology for exploring diversity and reach among extension programs and stakeholders. *Journal of Extension*, 56(6).
- Davies, A. L., & White, R. M. (2012). Collaboration in natural resource governance: Reconciling stakeholder expectations in deer management in Scotland. *Journal of Environmental Management*, 112, 160–169. <https://doi.org/10.1016/j.jenvman.2012.07.032>
- Erdogan, R. (2013). Stakeholder Involvement in Sustainable Watershed Management. *Advances in Landscape Architecture*. <https://doi.org/10.5772/55798>
- Fatemi, M., Rezaei-Moghaddam, K., & Pourghasemi, H. R. (2021). Social networks` analysis of rural stakeholders in watershed management. *Environment, Development and Sustainability*, 23(12), 17535–17557. <https://doi.org/10.1007/s10668-021-01399-9>
- Ferreyra, C., & Beard, P. (2007). Participatory evaluation of collaborative and integrated water management: Insights from the field. *Journal of Environmental Planning and Management*, 50(2), 271–296. <https://doi.org/10.1080/09640560601156532>
- Fu, X., Luo, J. Der, & Boos, M. (1994). Social Network Analysis, Interdisiplinary Approaches and Case Studies. In *Analytictech.Com* (Vol. 22, Issue 1954). <http://www.analytictech.com/mb109/slides/networks.pdf%0Ahttp://www.sas.com/solutions/fraud/social-network/index.html>
- Gamboa, M. H. T. C. (2014). *Stakeholder engagement to enhance integrated water management in the context of a river basin in Portugal*. <http://usir.salford.ac.uk/id/eprint/33222/>
- Gordon, D., McKay, S., Marchildon, G., Sacha Bhatia, R., & Shaw, J. (2020). Collaborative governance for integrated care: Insights from a policy stakeholder dialogue. *International Journal of Integrated Care*, 20(1), 1–11. <https://doi.org/10.5334/ijic.4684>
- Guppy, L., & Anderson, K. (2017). Global Water Crisis. *Water Resources*, 2012, 2015–2016.
- Hartanto, P., Delinom, R. M., & Hendarmawan, H. (2019). Kualitas Air pada Puncak Musim Kemarau di Daerah Rawa Danau Kabupaten Serang. *RISSET Geologi Dan Pertambangan*, 29(1), 13. <https://doi.org/10.14203/risetgeotam2019.v29.1021>
- Hartanto, P., Syah Alam, B. Y. C. S. S., Lubis, R. F., & Hendarmawan, H. (2021). The origin and quality of the groundwater of the rawadanau basin in Serang Banten, Indonesia. *Rudarsko Geolosko Naftni Zbornik*, 36(2), 11–24. <https://doi.org/10.17794/rgn.2021.2.2>
- Hauck, J., Schmidt, J., & Werner, A. (2016). Using social network analysis to identify key stakeholders in agricultural biodiversity governance and related land-use decisions at regional and local level. *Ecology and Society*, 21(2). <https://doi.org/10.5751/ES-08596-210249>
- Heryansyah, A. (2005). *Analisis Kapasitas Reservoir Untuk Suplai Air : Studi Kasus Das Cidanau*. 2–5.
- Heyde, J., Lukas, M., & Flitner, M. (2012). *Payments for Environmental Services in Indonesia: A Review of Watershed-Related Schemes*. *working pa*(186).
- İlhan, N., Gündüz-Öğüdücü, Ş., & Etaner-Uyar, A. Ş. (2014). *Introduction to Social Networks: Analysis and Case Studies*. https://doi.org/10.1007/978-3-7091-1797-2_1
- Kato, T., Soumura, H., & Goto, A. (2002). Water Quality Forecast Model of Cidanau Watershed, Indonesia, for Watershed Management Planning. *Water Quality Forecast Model of Cidanau Watershed, Indonesia, for Watershed Management Planning*, 2002(43), 3–12. https://doi.org/10.11408/jierp1996.2002.43_3
- Kempe, D., Kleinberg, J., & Tardos, É. (2015). Maximizing the spread of influence through a social network. *Theory of Computing*, 11(4), 105–147. <https://doi.org/10.4086/toc.2015.v011a004>
- Khairiah, R. N., Prasetyo, L. B., Setiawan, Y., & Kosmaryandi, N. (2016). Monitoring Model of Payment for Environmental Service (PES) Implementation in Cidanau Watershed with stands Density Approach. *Procedia*

- Environmental Sciences*, 33, 269–278. <https://doi.org/10.1016/j.proenv.2016.03.078>
- Kunihiko, Y., Masaya, I., & Setiawan, B. I. (2003). in *Cidanau Effects Economic of Recent West Java , Southeast Indonesia : Asia Watershed , of the Crisis Abstract Conseroation of water quality and quantity is needed in Cidanau Watershed , West Java of Indonesia , for the sake of agriculatural and industria.* 44(44), 27–41.
- Laila, N., Murti Laksono, K., & Nugroho, B. (2014). Kelembagaan Kemitraan Hulu Hilir Untuk Pasokan Air Das Cidanau, Provinsi Banten. *Jurnal Penelitian Sosial Dan Ekonomi Kehutanan*, 11(2), 137–152. <https://doi.org/10.20886/jsek.2014.11.2.137-152>
- Lapeyre, Renaud, Pirard, R., & Leimona, B. (2015). Payments for environmental services in Indonesia: What if economic signals were lost in translation? *Land Use Policy*, 46, 283–291. <https://doi.org/10.1016/j.landusepol.2015.03.004>
- Lapeyre, Renaud, Pirard, R., & Leimona, B. (2011). Payments for Environmental Services in Indonesia: What if economic signals were lost in translation? *Social Service Review*, 85(2), ii–ii. <https://doi.org/10.1086/661506>
- Leach, W. D., Pelkey, N. W., & Sabatier, P. A. (2002). Stakeholder Partnerships as Collaborative Policymaking: Evaluation Criteria Applied to Watershed Management in California and Washington. *Journal of Policy Analysis and Management*, 21(4), 645–670. <https://doi.org/10.1002/pam.10079>
- Lienert, J., Schnetzer, F., & Ingold, K. (2013). Stakeholder analysis combined with social network analysis provides fine-grained insights into water infrastructure planning processes. *Journal of Environmental Management*, 125, 134–148. <https://doi.org/10.1016/j.jenvman.2013.03.052>
- Majeed, S., Uzair, M., Qamar, U., & Farooq, A. (2020). Social Network Analysis Visualization Tools: A Comparative Review. *Proceedings - 2020 23rd IEEE International Multi-Topic Conference, INMIC 2020.* <https://doi.org/10.1109/INMIC50486.2020.9318162>
- Medema, W., Adamowski, J., Orr, C., Furber, A., Wals, A., & Milot, N. (2017). Building a foundation for knowledge co-creation in collaborative water governance: Dimensions of stakeholder networks facilitated through bridging organizations. *Water (Switzerland)*, 9(1). <https://doi.org/10.3390/w9010060>
- Munawir, & Vermeulen, S. (2007). *Fair deals for watershed services in Indonesia.* International Institute for Environment and Development (UK).
- Okumah, M., Yeboah, A. S., & Amponsah, O. (2020). Stakeholders' willingness and motivations to support sustainable water resources management: Insights from a Ghanaian study. *Conservation Science and Practice*, 2(3), 1–14. <https://doi.org/10.1111/csp2.170>
- Prell, C., Hubacek, K., & Reed, M. (2009). Stakeholder analysis and social network analysis in natural resource management. *Society and Natural Resources*, 22(6), 501–518. <https://doi.org/10.1080/08941920802199202>
- Priyanto, B., & Titiresmi, T. (2006). Beberapa Aspek Rawa Danau Sebagai Sumber Air Baku. *J. Tek. Ling*, 7(3), 277–283.
- Pujatmiko, R. (2006). *Efektifitas forum DAS dalam membantu kelembagaan pengelolaan DAS (studi kasus Forum Komunikasi DAS Cidanau di Provinsi Banten)*. 1, 1–2.
- Sayles, J. S., & Baggio, J. A. (2017). Social-ecological network analysis of scale mismatches in estuary watershed restoration. *Proceedings of the National Academy of Sciences of the United States of America*, 114(10), E1776–E1785. <https://doi.org/10.1073/pnas.1604405114>
- Schlager, E., & Blomquist, W. (2008). Embracing watershed politics. In *Embracing Watershed Politics*. University Press of Colorado. <https://doi.org/10.5860/choice.46-4130>
- Scott, J., & Carrington, P. J. (2015). *Social Network Analysis* (Vol. 29, Issue 9). Sage Publication.
- Springer, A. C., & de Steiguer, J. E. (2011). Social network analysis: A tool to improve understanding of collaborative management groups. *Journal of Extension*, 49(6).
- Stephen P Borgatti, Martin G Everett, & Linton C Freeman. (2002). Ucinet for Windows: Software for social network analysis (Version 6.102). *Harvard, MA: Analytic Technologies, October 2015.*
- Sulistyaningsih, T., Nurmandi, A., Kamil, M., Roziqin, A., Salahudin, Jainuri, Sihidi, I. T., Apriyanto Romadhan, A., & Loilatu, M. J. (2021). Formulating Sustainable Watershed Governance Model: A Meta-analysis of Watershed Governance. *Academic Journal of Interdisciplinary Studies*, 10(2), 90–104. <https://doi.org/10.36941/ajis-2021-0041>
- Sunaedi, N., Hadi, S. P., & Bambang, A. N. (2018). Essential Water Supply Resources through Payment for Environmental Services Program in the Cidanau Watershed, Banten Province, Indonesia. *IOP Conference Series: Earth and Environmental Science*, 145(1). <https://doi.org/10.1088/1755-1315/145/1/012133>
- Sunaedi, N., Hadi, S. P., & Bambang, A. N. (2019). Community-Based Environmental Management Through the Payments for Environmental Services Program in Cidanau Watershed, Banten Province, Indonesia. *IOP Conference Series: Earth and Environmental Science*, 338(1). <https://doi.org/10.1088/1755-1315/338/1/012002>
- Tabassum, S., Pereira, F. S. F., Fernandes, S., & Gama, J. (2018). Social network analysis: An overview. *Wiley Interdisciplinary Reviews: Data Mining and Knowledge Discovery*, 8(5), 1–21. <https://doi.org/10.1002/widm.1256>

-
- Widianingsih, I., Paskarina, C., Riswanda, R., & Putera, P. B. (2021). Evolutionary Study of Watershed Governance Research: A Bibliometric Analysis. *Science and Technology Libraries*, 40(4), 416–434. <https://doi.org/10.1080/0194262X.2021.1926401>
- Wulansari, D. (2015). *Optimasi penggunaan lahan di das cidanau banten desi wulansari: Vol. Skripsi*.
- Yoshino, K., & Ishioka, Y. (2005). Guidelines for soil conservation towards integrated basin management for sustainable development: A new approach based on the assessment of soil loss risk using remote sensing and GIS. *Paddy and Water Environment*, 3(4), 235–247. <https://doi.org/10.1007/s10333-005-0023-5>
- Zaphiris, P., & Pfeil, U. (2007). *Introduction to social network analysis*. 2, 1–30. <https://doi.org/10.14236/ewic/hci2007.89>