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Unveiling Transboundary Challenges in The Ciliwung River Flood Management

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Abstract. Due to massive development in the urban and rural areas, there is a dramatic increase in the impacted area and the amount of economic loss from the Ciliwung River Floods every year. Even though several research studies have identified the key drivers of the flood risk along the Ciliwung River Basin (CRB), addressing the problem has been limited to administrative boundaries. Because Ciliwung River Basin crosses two provinces and several cities and regencies, it is important to tackle future flood events using a transboundary approach. This study uses MICMAC analysis to recognize strategic flood risk drivers from key stakeholders' perspectives. In this study, 13 significant flood drivers were identified. Among those drivers, lack of control of spatial plans and weak stakeholder coordination and cooperation are found to be the critical drivers which influence all other flood drivers. Finally, this study proposes that a national-level development control regulation and an acting commission are established as a priority action for transboundary flood risk management in Ciliwung River Basin.

Keywords: Flood risk driver, Ciliwung river basin, transboundary management, MICMAC analysis, Greater Jakarta

1. Introduction

Jakarta Metropolitan Area (JMA), or known as Greater Jakarta (Jabodetabek), has been one of the most appealing locations for both domestic and foreign investment. It has a large number of entrepreneurs and skilled laborers, as well as high access to decision-makers (Firman, 1998). According to Euromonitor International, Jakarta is set to become the most prominent city globally, with a population of 35.6 million by 2030. The Indonesian capital will overtake Tokyo to be the number one megacity.

Greater Jakarta is geographically crossed with one big river, namely the Ciliwung River. Being situated in a watershed consequently make Greater Jakarta exposed to hydro-meteorological risks, such as flood. Severe floods due to the Ciliwung River's flow have been recorded in 1996, 2002, 2007, 2012, and 2013 (Dewi & Ast, 2017), while the most severe one took

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place in early 2020. A total of 13 administrative units in Jakarta, Banten Provinces, and West Java Provinces are flooded as of 1 January 2020. The losses due to the flood tripled from the 2007 event, with an estimation of around IDR 5.2 trillion.

According to Presidential Decree Number 12 of 2012, the Ciliwung River is 140 kilometers long. It crosses three major cities and one regency in two different provinces: Bogor Regency and Bogor City in the upstream, Depok in the middle stream, and Jakarta in the downstream, with a catchment area of nearly 438 kilometers2. The overall population is approximately 25 million with growth rate around 1.4 percent. The flood-prone areas are primarily located in the densely populated DKI Jakarta province in the downstream area.

Several factors have contributed to the increased magnitude of flood impacts in Greater Jakarta over the past few decades (Budiyono et al., 2016). While the Ciliwung River bears responsibility as a transboundary river that incorporates the development of megapolitan, complex flood risk drivers have come in many regions and many aspects consequently.

Studies of flood risk drivers recognize the need for expanding the spatial scales from the upstream to the downstream area (Dawson et al., 2009). In recent years, scholars have analyzed particular drivers of the Ciliwung Flood. For instance, (Texier, 2008) analyzed the root causes of disaster vulnerability in Jakarta Province, (Emam et al., 2016) studied the effect of climate and land use change in the Upper Ciliwung River, (Asdak et al., 2018), and (Texier, 2008) analyzed problems in downstream flood, and (Sagala et al., 2013) highlighted Greater Jakarta flood vulnerability.

Of those studies, however, no one mentioned which drivers are the most critical in the transboundary management of the Ciliwung River flood. Flood risk managed by a single authority is indeed complicated enough and becomes much more complex when dealing with the transboundary river. Thus, to untangle the complexity of the Ciliwung River flood, we must dig at the roots instead of just hacking at the leaves.

"What are the main transboundary challenges to managing the Ciliwung River flood?” or "What are the most strategic transboundary flood drivers in the Ciliwung River Flood?” up until recently, this question remains unsolved.

Therefore, this study aims to unveil the main challenges in the Ciliwung River Flood using a transboundary approach. The purposes of the paper are (1) to define the key flood risk driving variables of the Ciliwung River Flood using MICMAC analysis and (2) to depict the actual condition of the driving variables.

A total of six sections are presented in this paper. The first section discusses the problems and gaps in previous studies associated with the Greater Jakarta floods. The second one reviews related key flood drivers from the literature and defines selected drivers to be examined in this study. The third one explains the ways in which the transboundary approach is used in this study and why MICMAC analysis is a suitable tool to define critical flood drivers. The next section elaborates upon the MICMAC diagram results and further explains the key flood drivers' findings in the Ciliwung River Basin. Afterward, how the results and findings of those key flood drivers match up with flood drivers' theoretical explanations will be discussed. The last section draws a way forward and a conclusion to tackle the challenges and future research regarding understanding further the key flood risk drivers. The summary of drivers is written by (O’Donnell & Thorne, 2020), as presented in **Table 1.**

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Table 1: Summary of Flood Drivers by (Evans et al., 2006) and (O'Donnell & Thorne, 2020)

Group	Driver
	Temperature
	Precipitation
Source	Sea-level rise
	Storm surges
	Waves
	River morphology
	River vegetation
	Sediment supply
	Groundwater flooding
Pathway	Sewer conveyance
	Urbanization
	Land-use change
	Environmental regulation
	Stakeholder behavior
	Urban impact
	Buildings
Receptor	Infrastructure impact
	Economic impact
	Social impact

2. Framework of Flood Risk Drivers

Floods have emerged as one of society's most dangerous risks (Beese et al., 1999) There has been a significant increase in damages caused by catastrophic flooding over the past 50 years (Munich Re Group 2003). The flood risk is created by the combination of flood hazards and flood vulnerabilities (Beese et al., 1999; UNISDR, 2009). It refers to the likelihood and exposure of elements to flood hazards.

This study defines flood risk drivers as an event that can modify the condition of a flooding system and are characterized using the source-pathway-receptor (SPR) paradigm defined by (Evans et al., 2006). A flood source can be defined as any event or condition that may cause flooding due to meteorological conditions (e.g., extreme rainfall, sea level rise), pathways to transfer floodwaters to locations where they may impact receptors, and receptors are people and built environments that may be impacted by flooding.

Extreme precipitation is known to significantly affect Greater Jakarta floods (Mishra et al., 2018). Greater Jakarta Flood occurred not only by upstream precipitation but also due to downstream rainfall. According to rainfall spatial distribution

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data, most of the Greater Jakarta floods were caused by evenly distributed rainfall along the Ciliwung River Basin (Saputra 2020).

Floods occur when rivers do not have sufficient capacity to pass flow rates from upstream to downstream (Asdak, 1995). The narrowing of the Ciliwung River's capacity is due to sedimentation and waste, as well as the construction of settlements on uncontrolled riverbanks. To decrease the flow rate, in a higher area, several infrastructures such as Situ (Lake) and Dams in Bogor Regency and Depok City, are built to control flood peak discharge in the up-stream and mid-stream areas of the Ciliwung River Basin (Nugraheni et al., 2020).

As the downstream area, Jakarta experienced more severe floods compared to other regions due to its geographical condition. Despite extensive efforts by the Dutch and Indonesian governments, Jakarta is still prone to flooding due to its location in a major river delta (Asdak et al., 2018). Morover, some of the city areas are a few meters below sea level. It is caused by land subsidence, which is estimated to be 1 to 15 centimeters per year, both spatially and temporally (Latief et al., 2018).

The Jakarta flood control system is based on Prof. H. Van Breen's (Master Plan 1973) concept, in which load overflow rain from outside Jakarta flows via flood canals (west flood canals and east flood canals) that circle Jakarta. Run-off within the city of Jakarta is discharged through local drainage by gravity and discarded with a polder system, including water pump and pond retention in low areas (Kusuma et al., 2010).

Apart from natural causing factors, rapid urbanization and massive growth in population led to an increase in the susceptibility and vulnerability to Jakarta flood (Harkunti P Rahayu & Nasu, n.d.), causing a land conversion from the catchment area to the built environment. A change in land use over time can have significant effects on run-off (Mishra et al., 2018). Uncontrolled land-use change due to poor spatial planning along the Ciliwung River Basin makes the flooding becoming more complicated to handle (Asdak et al., 2018). Thus, in order to control current developments and minimize future risks, strong governance with long-term spatial planning are needed (Harkunti Pertiwi Rahayu et al., 2019). It is expected that spatial planning will contribute to flood mitigation in floodplain areas (White & Howe, 2002; White & Richards, 2007) by regulating the land use types, spatial pattern, development scales, and physical structure designs. It can affect the likelihood of floods and its consequential damage (Neuvel & van den Brink, 2009; White & Richards, 2007)

The emergence of Law 23/2014 resulted in the right and obligatory sharing between central and local government, known as Decentralization. Decentralization and power-sharing expanded disaster management responsibility at local levels with national and international policy impacting it (Sunarharum et al., 2021). Since Ciliwung River Basin flows along transboundary regions, central, provincial as well as city governments and plans are responsible for flood risk management. While governments may be able to mitigate flood risk, communities, especially those affected by floods, must be included in flood risk management decisions (Faulkner et al., 2007). However, as flood risk management involves various stakeholders (i.e., governments, communities, academics, media, and privates) and multiple objectives, conflicts may also arise. Up until recently, the coordination among stakeholders in the Ciliwung River Basin still meets many challenges and as a result, affects the decision-making (Sunarharum et al., 2021)

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Based on the primary work of this study (Rahayu, 2022) there are several key flood drivers based on Source Pathway Receptor (SPR) Concepts, as shown in **Figure 1**.

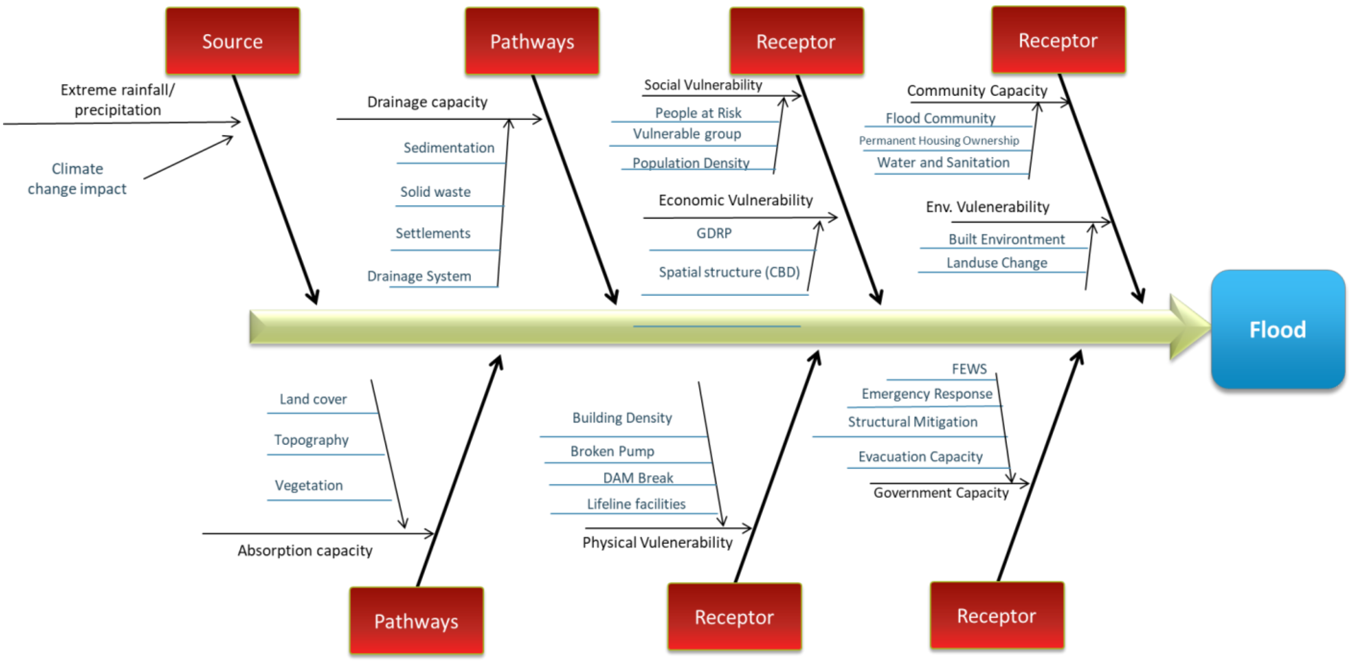

Figure 1: Key Flood Drivers

This study adopts several drivers related to the Ciliwung River flood case based on the framework **Table 1** and **Figure 1**, with a few modifications in terms, as shown in **Table 2** below**.** There are thirteen variables identified to be the drivers of the Ciliwung Key River Flood.

Table 2: Identified Ciliwung Key Flood Risk Drivers

Codes	Drivers	Terms and Classification based on Table 1
A1	Extreme Rainfall	Precipitation (Source)
A2	Waste and Sedimentation	Sediment Supply (Pathway)
A3	Drainage Capacity	Sewer Conveyance (Pathway)
A4	River Capacity	River Morphology (Pathway)
A5	Urbanization	Urbanization (Pathway)
A6	Growth Population	Urbanization (Pathway) Social Impact (Receptor)
A7	Catchment Area	River Vegetation (Pathway)
A8	Built Environment	Urban Impact (Receptor),

Codes	Drivers	Terms and Classification based on Table 1
		Rural Land Management (Pathway)
A9	Ground Water Exploitation	Groundwater flooding (Pathway)
A10	Stakeholder Cooperation and Coordination (Government, Lifelines, Business, Community)	Stakeholder Behaviour (Pathway)
A11	Land Subsidence	Groundwater flooding (Pathway)
A12	Spatial Plan	Environmental Regulation (Pathway)
A13	Flood Controls / Structural Mitigation (Dams, Levees, Reservoirs, Water Pump, Dikes)	River Conveyance (Pathway)

3. Methodology

When rivers cross many states, various stakeholders are involved in river management decision-making. According to Ministry of Public Works Law Number 13/PRT/M/2006, the Ciliwung River is a transboundary river that crosses two provinces and four cities/regencies and is controlled by the Central Government in collaboration with local stakeholders.

This study involves a qualitative and quantitative approach using primary data from in-depth interviews. The interviews were conducted from September until December 2020; while amidst that period, there were several Ciliwung flood events that occurred in Greater Jakarta, making the obtained data more relevant and up to date. Face-to-face and online interviews are used for the interview methods as the consequence of Indonesia's Large Scale Social Restriction due to the Covid-19 Pandemic. Both kinds of interview methods perform the same quality of content.

To have reliable results in a case of transboundary river management, the interviews included cross-level governments, i.e., central, provincial, and city/regency governments, along Ciliwung River Basin. According (Dewi & Ast, 2017), river basin-related institutions are defined as follows:

1. An institution with a main role in the planning process at each of the national, provincial, and city/regency levels.
2. Institutions responsible for the implementation process of flood management projects, also at each of the national, provincial, and city/regency levels; institutions that have the power of coordination.

Based on those criteria, thirteen experts from different levels and regions are selected, as shown in **Table 3.**

Table 3: Selected Experts and Their Roles

No	Institution	Roles
1	National Planning and Development Agency (BAPPENAS)	Coordinates Development Planning and Financing for Transboundary Regions
2	Ciliwung-Cisadane River Basin Authority (BBWS	Executes Ciliwung River Program, i.e., flood control

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No	Institution	Roles
	Ciliwung Cisadane)	development and maintenance
3	Ministry of Spatial Planning (Kementerian ATR)	Coordinates Spatial Planning and Controlling for Transboundary Regions
4	Jakarta Provincial Planning and Development Agency (Bappeda Provinsi DKI Jakarta)	Coordinates Development Planning and Financing in Jakarta Provincial
5	Jakarta Provincial Water Resource Agency (Dinas Sumber Daya Air Provinsi DKI Jakarta)	Executes flood control development and maintenance in Jakarta Provincial
6	West Java Provincial Planning and Development Agency (Bappeda Provinsi Jawa Barat)	Coordinates Development Planning and Financing in West Java Provincial
7	West Java Provincial Water Resource Agency (Dinas Sumber Daya Air Provinsi Jawa Barat)	Executes flood control development and maintenance in West Java Provincial
8	Depok City Planning and Development Agency (Bappeda Kota Depok)	Coordinates Development Planning and Financing in Depok City
9	Depok City Public Work and Spatial Planning Agency (Dinas PUPR Kota Depok)	Executes flood control development and spatial planning in Depok City
10	Bogor City Planning and Development Agency (Bappeda Kota Bogor)	Coordinates of Development Planning and Financing in Bogor City
11	Bogor City Public Work and Spatial Planning Agency (Dinas PUPR Kota Bogor)	Executes of flood control development and spatial planning in Bogor City
12	Bogor Regency Planning and Development Agency (Bappeda Kabupaten Bogor)	Coordinates of Development Planning and Financing in Bogor Regency
13	Bogor Regency Public Work and Spatial Planning Agency (Dinas PUPR Kabupaten Bogor)	Executes of flood control development and spatial planning in Bogor Regency

Given a set of flood risk drivers as presented in **Table 1**, all experts, as listed in **Table 2**, were required to mention the key flood risk drivers of the Ciliwung River flood and its interrelations with justifications. They were also asked to explain the actual condition of each driver based on their empirical knowledge and scope of work. Grounded theory, as the qualitative method, is then used to interpret experts' statements into codes. The grounded theory method involves gathering and analyzing data in order to generate a middle-range theory (Charmaz, 1995). Analytic processes consist of coding data, developing, checking, and integrating theoretical categories, and constructing analytic narratives (Glaser & Strauss, 2017).
In order to identify driving power (influential) and dependence power (influenced), a quantitative method called Matriced' Impacts Croisés Appliquée á un Classement (MICMAC) is used (Attri et al., 2013) (Saxena et al., 1990) argue that MICMAC analysis is a significant tool for an in-depth analysis of the program or system. The method defines the level of power and dependency by analyzing the interrelation among the drivers. In 1973, Duperrin and Godet proposed MICMAC,

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which may be applied to categorizing drivers into four main groups: autonomous, linkage, dependent, and independent factors. These four classifications are as follows (Jharkharia & Shankar, 2005)

1. Autonomous factors have extremely little driving power while also having little dependent power. These drivers have little to no interaction with other drivers.
2. Linkage factors with a high driving and dependency power. Because these drivers are extremely unstable, any action taken on them will have an adverse effect on other drivers and the linkage drivers.
3. Dependent factors, which include drivers with low driving ability but high reliance power. Because these drivers rely heavily on other drivers, any action taken by other drivers will have an impact on the dependent drivers.
4. Independent factors are rarely influenced by other drivers and consist of drivers with strong driving power but low dependence power.

In disaster risk reduction, MICMAC analysis was previously used to discover important factors of resilient humanitarian supply chain that emerge during post-disasters (Singh et al., 2018). The study's findings will help government agencies and policymakers make proper strategic decisions to increase resilience. Furthermore, it assists emerging countries in minimizing massive losses and improving economic growth for the benefit of society. However, up to these days, there is no published study in discovering key flood drivers using the MICMAC method.

In this research, the MICMAC analysis includes the following steps.:

1. A literature review was used to identify the factors influencing flood risk. The flood risk drivers list is presented in **Table 1**
2. Through interviews, experts' judgements are used to establish a conceptual link among the drivers. In this study, there are 13 drivers responsible for impacting the flood risk. Those drivers could also be impactful to each other. The drivers' relative responses were obtained by calculating the collected opinion in the interviews. Expert judgement assists in depicting the suitable interaction between these drivers. These variables are characterized using a pair-wise relationship as either "influencing" other drivers or being "influenced" by other drivers.
3. Structural Self Interaction Matrix (SSIM) has been acquired to associate among 13 drivers.
4. Using VAXO symbols, four symbols have been defined to demonstrate the linkage between i and j drivers. Then SSIM matrix is converted to Initial Reachability Matrix (IRM) using the specified rules shown in **Table 4**.

Table 4: SSIM and IRM Value

Relation	SSIM Symbols	IRM value
driver i influencing driver j	V	1
driver j influencing driver i	A	1
drivers i and j influencing each other	X	1
drivers i and j are not associated	O	0

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The **Table 5** below compiles all the experts' opinions into the SSIM matrix.

Table 5: SSIM Matrix

i/j	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11	A12	A13
A1	V	0	V	V	0	0	0	0	0	0	0	0	V
A2		V	V	V	0	0	0	A	0	A	0	0	V
A3			V	V	0	0	A	0	0	0	0	A	V
A4				V	0	0	A	0	0	A	0	A	X
A5					V	V	0	0	0	0	0	0	0
A6						V	0	V	0	0	0	V	0
A7							V	A	0	A	0	A	A
A8								V	V	0	0	A	0
A9									V	0	V	0	0
A10										V	0	X	V
A11											V	0	V
A12												V	V
A13													V

After creating an SSIM matrix, the symbol of its cells is then converted into IRM value referred to **Table 3.** The converted cells formed into IRM Matrix shown in **Table 6**.

Table 6: IRM Matrix

i/j	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11	A12	A13
A1	1	0	1	1	0	0	0	0	0	0	0	0	1
A2	0	1	1	1	0	0	0	0	0	0	0	0	1
A3	0	0	1	1	0	0	0	0	0	0	0	0	1
A4	0	0	0	1	0	0	0	0	0	0	0	0	1
A5	0	0	0	0	1	1	0	0	0	0	0	0	0
A6	0	0	0	0	0	1	0	1	0	0	0	1	0
A7	0	0	1	1	0	0	1	0	0	0	0	0	0
A8	0	1	0	0	0	0	1	1	1	0	0	0	0
A9	0	0	0	0	0	0	0	0	1	0	1	0	0
A10	0	1	0	1	0	0	1	0	0	1	0	1	1
A11	0	0	0	0	0	0	0	0	0	0	1	0	1

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i/j	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11	A12	A13
A12	0	0	1	1	0	0	1	1	0	1	0	1	1
A13	0	0	0	1	0	0	1	0	0	0	0	0	1

5. Run the MICMAC graph

After formulating the IRM matrix, a four-quadrant graph can be used using the MICMAC application version 6.1.2, developed by Godet and Francois in 1989. The result of MICMAC analysis is presented in the next section.

4. Result

The results of MICMAC model shown **Figure 2** diagram below.

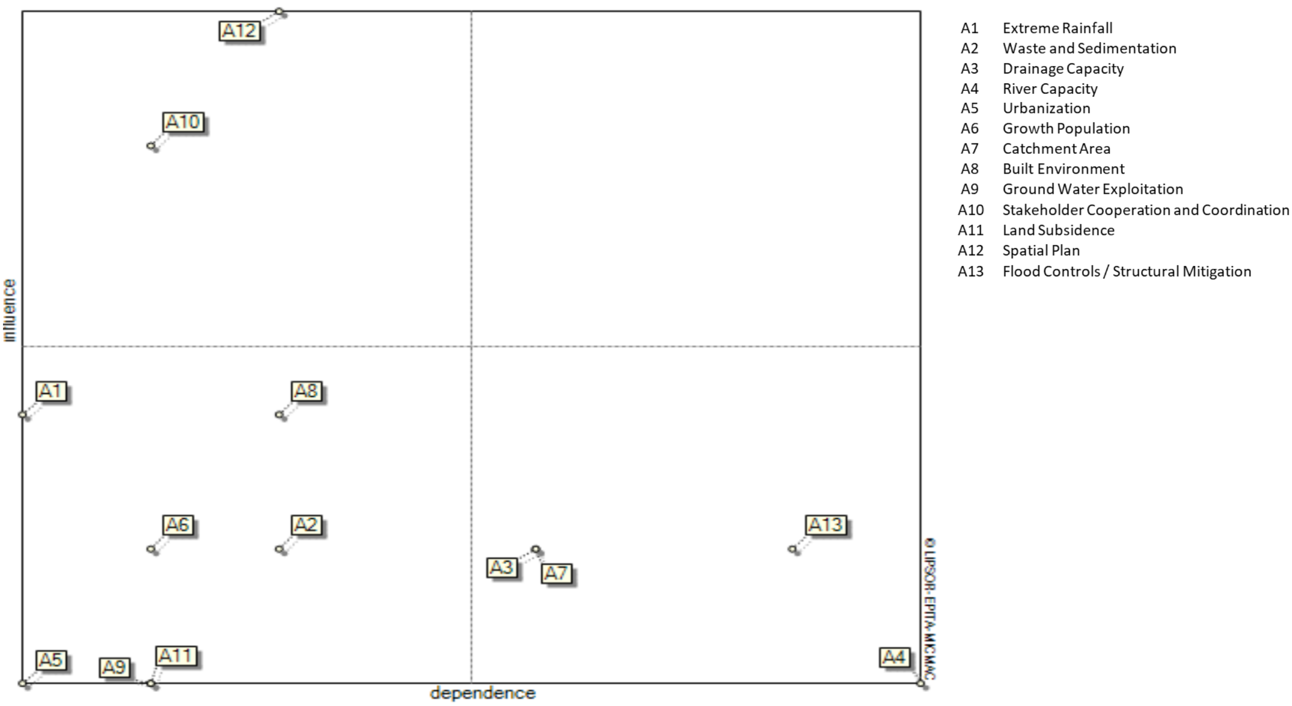

Figure 2: MICMAC model result diagram

Figure 2 shows the flood drivers mapping into four quadrants: autonomous, linkage, dependent, and independent. Extreme rainfall, built environment, population expansion, waste and sedimentation, urbanization, groundwater exploitation, and land subsidence are autonomous drivers with low driving power and dependability. Only a few strong drivers are strongly linked to them.

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River capacity, drainage capacity, catchment area, and flood controls are the drivers that have a low driving power but a high dependence power. In other words, they get inclined by other strong drivers. River capacity appears as the most dependent driver, indicating it is the end of the driver chain in the system.

In this study, there are no linking parameters, which means all the stated drivers are stable. Further, spatial planning, as well as coordination and cooperation among stakeholders, are the independent drivers that impact other drivers. These are termed as key drivers, which have the most powerful influence on other drivers.

5. Discussion

Through MICMAC analysis, spatial plan, as well as stakeholders' cooperation and coordination, are emerged as critical flood risk drivers in Ciliwung River Basin. Refer to SPR (Source-Pathway-Receptor) model in **Table 2**; it is found that in the case of the Ciliwung River Flood, while flood management is conducted across transboundary regions, 'pathway 'such as stakeholder behavior and environmental regulation gives the main influence in the set of flood risk drivers.

5.1 Spatial Plan

Many flood risk reduction regulations are included in spatial plans, such as land use regulation, structural mitigation development, catchment area preservation, and river maintenance. Besides each of the administrative units (2 provinces and 3 cities/municipalities) in the Ciliwung River Basin has its own spatial plan, the Ministry of Spatial Plan creates Greater Jakarta Spatial Plan in Government Law Number 60/2020 to incorporate all those local spatial plans. Also, Ciliwung-Cisadane Watershed Agency formulates a plan in the Ministry of Public Works Decree No 26/KPTS/M/2015 to integrate Ciliwung-Cisadane river management program. It appears from the interviews that spatial planning has significantly affected drainage capacity, river capacity, catchment area, built environment, stakeholder cooperation, and flood control development.

Experts believe that development control in the Ciliwung River Basin appeared to be weak as land-use changes emerged upstream, midstream, and downstream. Urban and regional development is increasingly not considering catchment area provision over time due to economic pressure. Although spatial plans have been created on many levels, development control remains powerless to retain the catchment area. Some upstream regions have been turned into residences, hotels, villas, and restaurants, resulting in increased water run-off, but in Jakarta, new settlements are created without regard for spatial planning, affecting water absorption.

5.2 Stakeholder Coordination and Cooperation

Based on the interviews, stakeholder cooperation among governments, communities, academics, lifelines, and business significantly affects other drivers, namely waste and sedimentation, river capacity, catchment area, built environment, groundwater exploitation, spatial and development plan, and flood controls.

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The imperative issue takes place in coordination and cooperation among governments. The transboundary governance forum for Ciliwung River Basin management has been reformed many times. Two previous forms are the Ciliwung River Basin Forum in 2007, led alternately by the Governor in the Ciliwung River Basin, and the Ciliwung Water Resource Management Coordination Team in 2011, led alternately by each of the Planning and Development Agency in the Ciliwung River Basin.
According to experts' experience, the reformation keeps occurring due to the ineffectiveness of the forum mechanism, the powerless leader, and the conflict of interest. There was no clear framework for the forum and no legal agreement about how coordination and cooperation among institutions should work. This eventually resulted in no clear action. Each institution merely understands its own jobs and pays attention to their interest or said as sectoral egos. Also, there was no strong figure who could lead the forum.

5.3 Recommendation

Land use plans are supposed to substantially impact the basin's development (Wang et al., 2010). Therefore, spatial planning is a critical tool for reducing flood risk. (Neuvel & van den Brink, 2009). (Budiyono et al., 2016) investigate the great potential for urban planning to mitigate flood risk. It demonstrates that if Jakarta's land use follows the 2030 spatial plan, flood risk will be reduced by 12%. This highlights the great potential of land use planning for flood risk reduction.
Having a rigid spatial plan is not enough to reduce flood risk unless followed by robust development control. Strict development control must be applied at the basin level, which means not only in Jakarta Provincial but also in Depok City, Bogor City, and Bogor Regency as part of the Ciliwung River Basin regions.
Development control regulation in the Ciliwung River basin may differ from upstream to downstream municipality depending on physical, environmental, and institutional Characteristics. Development control in the upstream area mainly aims to preserve the catchment area, while in the downstream area, it primarily aims to prevent groundwater exploitation and higher physical vulnerability. The central government, along with the local government, must create tight instruments for development control, while the local government itself must carry out strict surveillance and give penalties for all development violations.
To strengthen development control in the Ciliwung River basin, a holistic regulation regarding development control (mechanism, instrument, zoning technique, and executor (i.e., task force)) in the Ciliwung River basin level must be legalized as a national policy. The President should make this a national priority program, considering the areas impacted and the number of losses that the Ciliwung River flood has generated. Up until recently, integrated development control policy in the Ciliwung river basin has not been developed yet, even though there has been the Greater Jakarta Spatial Plan (Law of President Number 60/2020) and Ciliwung-Cisadane Watershed management program (Ministry of Public Works Decree No 26/KPTS/M/2015).
Moreover, difficulties may arise in their management and governance when dealing with transboundary river management. Several critical institutions are involved in flood risk reduction, i.e., Governments at national, sub-national, and local levels,

utility companies, private businesses, and community groups (Jha et al., 2012). Coordination is required both between actors at different authority levels (vertical coordination) as well as among actors within administrative boundaries (horizontal coordination).

As transboundary river basin governments have many flood drivers to overcome, it has to meet concrete criteria to have an appropriate arrangement for river basin management. Firstly, clear roles and responsibility-sharing among river management institutions are essential for effective coordination (Jha et al., 2012). Therefore, a negotiation procedure and coordination mechanism are required (Barbazza & Tello, 2014). Secondly, a coordination mechanism is also important to enhance information and data flows and coordinate decision-making and implementation. Thirdly, leadership and power to enforce coordination contribute to the fragmentation of the institutional arrangement (Brown, 2005). Therefore, an effort to make a governance forum in the Ciliwung River Basin must follow those three criteria to waive ineffectiveness.

According to (Millington, 2006). there are two types of river basin forum. Those are (1) the river basin coordinating committee and (2) the river basin commission. Firstly, a river basin coordinating committee is formed for stable and mature river basin management. This model mainly relies on the fair cooperation and participation of its members. The committee has no executive authority and cannot override the member organization's tasks and operations. The coordinating committee would be made up of major water-related agencies from each of the basin's states.

Second, when problems happen frequently, a river basin committee is formed. A basin commission is a more formalized group than a committee. It would consist of a management board that would establish objectives, goals, policies, and strategic direction. The commission would be supported by a technical office of water, natural resource, socioeconomic planning, and management experts, many of whom would be drawn from existing agencies in the basin. To offer ultimate power, a Ministerial Council could lead the commission, and the basin commission would then focus on strategic natural resource management of the rivers and catchments. The fact that Ciliwung River Basin management still meets conflict and is not stable in management attests that the river basin commission might be the fittest model for Ciliwung river basin governance.

6. Conclusion

In recent years Greater Jakarta has developed tremendously as a megapolitan region and has become a competitive player for economic growth. This development has contributed to complex water-resource issues, such as increased flooding. Since the previous Greater Jakarta flood impacts trillion IDR losses, it is essential to avoid future flood events by unveiling critical challenges among complex drivers.

Based on MICMAC analysis, it is found the spatial plan and stakeholder cooperation and coordination are key flood risk drivers in the transboundary management perspectives. While the former one brings issue in the lack of development control, the latter one carries issue in the failure of transboundary river governance arrangement. “How to strengthen development control in the Ciliwung river basin?" and "What suitable form for transboundary river governance in Ciliwung river basin?". Concentrated efforts to address both challenges are paramount above others to reducing the flood risk.

Finally, to accelerate Ciliwung flood risk reduction, this study suggests a formulation of national policy regarding development control in the Ciliwung river basin and establishment of the Ciliwung river basin commission. Furthermore, to formulate an in-depth strategy, future research to deeply investigate development control problems in each region and transboundary institutions' interaction in the Ciliwung River Basin management are required.

Data Availability Statement

All data, models, or codes that support the findings of this study are available from the corresponding author upon reasonable request.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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