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A Study on River Management of the Ciliwung watershed in Indonesia*

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Abstract

This study is to suggest an effective management plan for watersheds in Indonesia. This study found that Indonesia already has a master plan, current laws, and standards for water resources management. However, based on field surveys, literature reviews, expert interviews, and a survey of local residents conducted around Ciliwung waterfront in Jakarta, it appears that water quality management is still inactive and insufficient. Therefore, this study established indicators for waterside management through FGI and conducted IPA to determine whether these indicators are actually effective in the field. As a result of the study, data on the status of aquatic organism habitats and the green area ratio, the status of hydraulics, land use type, and hydraulic structures, seasonal distribution of pollution sources, landfill status, water quality status of the main and tributary streams, status of sewage treatment plants, and location of oil spills are need to be accumulated for management of Riparian buffer zone in the Ciliwung river for improvement.

Key Words: Riparian buffer zone, Indonesia, Ciliwung watershed, Jakarta

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Ⅰ. Introduction

A riparian zone is a type of watershed management area for water quality management that serves as a buffer zone or protection zone to block pollutants from entering public waters (김선희 2000). Currently, the Ciliwung River is divided into six parts, and research and local government implementation plans have been applied (The Ministry of Environment and Forestry 2023). It is classified geographically, and tributaries and administrative districts also affect this unit of management (BPLHD 2011). However, it appears that watershed management according to these divisions does not help improve water quality. According to reports from the local administration in Jakarta (DKI Jakarta provincial government 2021), there is no consistent management across these divisions. In fact, the Ministry of Environment and Forestry (KLHK) said that the Water Quality Index (IKA) score in Indonesia was 54.59 points in 2023. Although statistics show that water quality is gradually improving, the fact that it is at a level similar to that of 10 years ago raises doubts about the effectiveness of water resource-related laws (The Ministry of Environment and Forestry 2023).

In the case of Korea, the riparian zone system designates riparian zones within a certain distance from the river boundary to limit sources of pollution and enhance their function as buffer zones to purify pollutants (김옥선 외. 2006). The UK also designated waterfront areas and monitored their effects following the revision of the Water Act in 1989 (Newson 1991). These precedents demonstrate the importance of designating detailed waterfront areas. Therefore, the

purpose of this study is to present indicators for determining appropriately sized waterfront areas. The results of this study will help to improve the policy validity of planning and management of waterfront areas in Indonesia.

Ⅱ. Literature Review

The watershed is an area adjacent to a river and is an important passage for the flow of energy or circulation of materials in the basin (Malanson 1993; Forman 1997). In order to utilize water resources, it is important to investigate, classify, and evaluate the area by identifying individual elements that constitute the waterfront. A waterfront unit is a part of the entire water resource that feels visually homogeneous and is divided into a single spatial area with a clear boundary (Bastain 2000). These physical units not only have visual characteristics, but also serve as spatial expression units that show the characteristics and current status of the ecosystem (Laurie 1976). This is based on homogeneous units that have the same vegetation type, terrain relief, land use, etc. based on map information such as vegetation and topography (Aragao et al. 2005). Units can be ranked according to these characteristics and are determined according to the purpose of distinction. It is also determined according to natural boundaries such as rivers, lakes, ridges, waterfronts, drainage systems, and soil characteristics (Lugeri et al. 2000). In particular, watersheds and basins are very important criteria for determining landscape units and can become geomorphological units in themselves (Sahin 2000).

When classifying these environmental units, it is necessary to follow a value-neutral management plan and not just consider resource development, conservation value, or administrative boundaries (British Columbia 1996). The direction of this study is to determine water resource-related policies through previous studies (Staffordshire County Council 2001) and it has a positive effect on the ecological restoration of rivers (Junker and Bucheker 2008). Accordingly, this study examines the current status of the Ciliwung waterside through the current law and devises a practical waterside management plan through the opinions of local experts and residents on site.

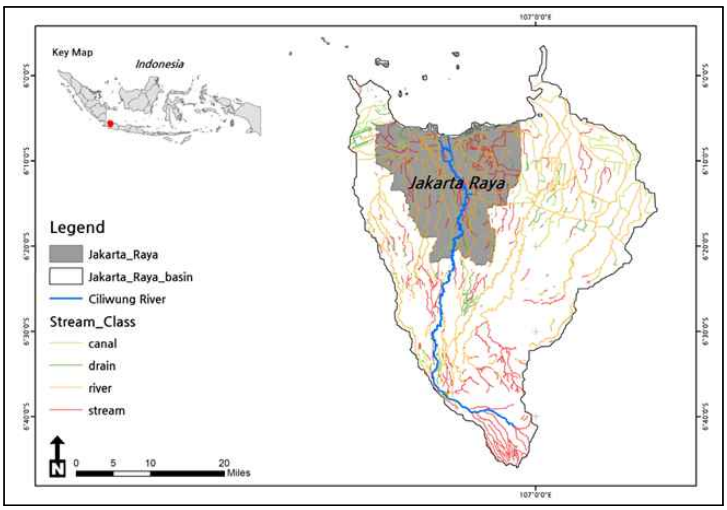
Ⅲ. Methodology

1. Research area

The Ciliwung River is one of the rivers that flow into DKI Jakarta and is one of the River Watersheds (DAS) in critical condition (Figure 1). The Ciliwung River Watershed (DAS) is experiencing changes in land use, where previously many catchment areas have now turned into residential and urban areas (Ciliwung Depok Community 2022). And this change had a significant impact on the water quality of the Ciliwung River. For these reasons, analyzing this research area have policy implication in the future.

This research was conducted using survey method beginning in January 2025 in the Ciliwung watershed.

<Figure 1> Map of research area



The Ciliwung watershed is geographically located between 6°14' - 6º38' S and 106°52' - 106º51' E. This research was conducted in the Ciliwung Hulu Sub-watershed, which is in the administrative area of the Jakarta Regency, West Java Province. The Ciliwung Hulu watershed has an area of 15,265 ha. Watershed around Cilliwung river has significant implication geographically and symbolically, however its water quality and management are poor as shown in Figure 2. Figure 2 shows that the Ciliwung Hulu watershed has experienced very high land degradation, with the erosion rate in 2010 reaching 44 tons/ha/month and in 2025 reaching 74.7 tons/ha/month (BPS 2023). Meanwhile, the SPTH (Sertifikasi dan Perbenihan Tanaman Hutan) data shows that the erosion rate is between 160.32 -334 tons/ha/year. The sedimentation rate took place in the Upper Ciliwung River in 2010 reached 19.70 tons/ha/year and in 2025 reached 36.96

tons/ha/year. The decline in the quality of land resources can be seen from the area of critical land spread across the Ciliwung Hulu watershed area. This condition illustrates that the Ciliwung Hulu watershed requires land rehabilitation and conservation efforts to improve its function as productive agricultural land and as a catchment area for the downstream area (SPTH data 2025).

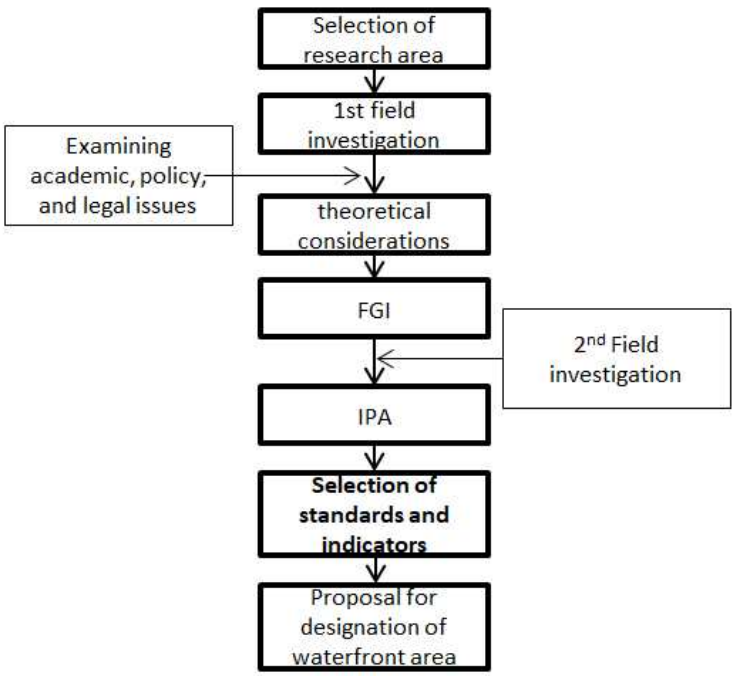
<Figure 2> Pictures of Ciliwung River in Jakarta

2. Research model

Although it was confirmed through fieldwork (Figure 2), in order to accurately judge the current situation, a literature review on current laws and related regulations was conducted as the first research methodology of this study. This is because laws have characteristics that require consideration of the structural relationship between the enforcement and implement institutions (Fiorino 1999). Second, in order to designate indicators for accurate designation of waterfront areas, indicators were set through expert opinions using FGI. Deeper and richer data are generated based on focus group interview (Thomas et. al 1995; Green et. al 2003). Third, in order to examine the

accuracy of the indicators, an IPA was conducted with university students in Jakarta and Bogor where the area crossed by the Ciliwung river to increase the reliability of the indicators required for designation of waterfront areas.

<Figure 3> Research diagram



(1) FGI

FGI was conducted from 5 professional fields: university professors, engineers, and water resource workers. For example, researchers for civil society such as Ciliwung Depok Community (KCD) and The Ciliwung Care Community (KPC), Interview with an

expert in University of Indonesia and Bogor agricultural university, and the Indonesian government officials at the ministries and local government levels.

(2) IPA

In the IPA survey, the importance and satisfaction of 51 management plan element indicators based on the result of FGI were evaluated on a 5-point scale. In terms of the general status of the respondents, the fields were “academic (university) and research institutes” for 38 people (78.4%), “other environmental workers” for 12 people (23.5%), and “public institutions” for 1 person (2.0%). In terms of career experience, 40 people (78.4%) were identified as having “less than 1 to 5 years” and they were mostly environmental majors, while 6 people (11.8%) had “more than 5 to 10 years,” 4 people (7.8%) had “more than 10 years,” and 1 person (2.0%) had “more than 20 years.” In terms of research experience on rivers and streams, 23 people (45.1%) answered “experienced” and 28 people (54.9%) answered “no experience” (Table1).

<Table 1> Descriptive statistics of IPA

classification	respondents	proportion (%)
public institution	1	2.0
Academic (university) and research institutes	38	78.4
Other environmental workers	12	23.5
Total	51	100
experience or not	respondents	proportion(%)
Yes	23	45.1
No	28	54.9
Total	51	100

work experience	respondents	proportion(%)
Less than 1 to 5 years	40	78.4
More than 5 to 10 years	6	11.8
More than 10 years	4	7.8
More than 20 years	1	2.0
Total	51	100

Ⅳ. Result

1. Current law analysis

In this context, the Indonesian government has emphasized environmental issues, including long-term water resource management, in Indonesia's mid- to long-term economic development. The condition of water quality and quality degradation in Indonesia is illustrated in Government Regulation No. 19 of 2020 concerning the 2020-2024 RPJMN (National Mid-Term Development Plan). The Ministry of Environment and Forestry has stated that the water availability is already rare and critical in most areas of Java and Bali. It is estimated that the water-critical area will increase from 6% (2000) to 9.6% (2022), including the southern part of Sumatra, West Nusa Tenggara, and southern Sulawesi (Ministry of Environment and Forestry 2022).

However, the quality of river water decreases because of sediment transported by increased erosion which is quite high as well as Changes in land use or the application of inappropriate agro-technology can also affect the quality and quantity of water flowing downstream in Cliliwung river (BPS 2023). In this context, this paper

assumes that related law affects policy more than the master plan by government. Accordingly, we have summarized the current waterfront-related legislation. In this study, the current laws are broadly classified into 1) water quality improvement, 2) water resource usage, 3) waterfront management, and 4) river management. The plan for improving water quality in Indonesia follows the global universal standard (STORET, Pollution index). This was in accordance with a ministerial decree promoted by the Ministry of Environment in 2003 and was introduced to improve water quality through objective indicators. The second includes water-use legislation. In areas where many urban residents reside, such as the Ciliwung River, it is assessed that the level of public awareness of water resource use is low (Table 2). Accordingly, bills to promote the related campaign (clean river programs) and improve public awareness of water pollution have been legislated in numerous ways, including governmental and ministerial laws (Prima et. al 2022).

<Table 2> Current status of regulation regarding watershed management in Indonesia

Classification	Detail	Regulation
Water quality	The specific standards and method for water quality status: ①STORET Method ②the pollution index method.	DECREE OF THE MINISTER OF STATE FOR THE ENVIRONMENT NUMBER 115 OF 2003 ON GUIDELINES FOR DETERMINING WATER QUALITY STATUS
Water use	Definition of a clean river and about “Clean River Program”	Decree of the State Minister for the

		Environment No. 35 of 1995: Clean River Program
	EXAMPLES OF APPLYING RESOURCES PRINCIPLES; (1) Use Water As Efficiently As Possible (2) Collect rainwater as a family water supply (3) Absorb Rainwater into the Soil by building an Infiltration Well (4) Don't Pollute Water Sources	REGULATION OF THE MINISTER OF PUBLIC WORKS Number 06/PRT/M/2011 ABOUTWATER RESOURCES USE GUIDELINES
	Replaced previous irrigation facilities laws (Law Number 11 of 1974) according to the importance of water resources and management.	LAW OF THE REPUBLIC OF INDONESIA NUMBER 7 OF 2004 REGARDING WATER RESOURCES
Watershed management	Forest and land damage which has an impact on reducing water absorption capacity and increasing surface water runoff continues to occur, giving rise to various floods, landslides and droughts;	REGULATION OF THE MINISTER OF FORESTRY NUMBER: P. 70/Menhut-II/2008 ABOUT TECHNICAL GUIDELINES FOR FOREST AND LAND REHABILITATION
	In accordance with the provisions of Article 18 of Law Number 7 of 2004 concerning Water Resources, some of the government's authority in managing water resources can be exercised by regional governments, to support the implementation of River Watershed management;	GOVERNMENT REGULATIONS OF THE REPUBLIC OF INDONESIA NUMBER 37 OF 2012 ABOUT RIVER FLOWER MANAGEMENT
River management	(1) As a water source, rivers have an important function in meeting community needs and increasing national development; (2) It is deemed necessary to execute regulations regarding rivers which include the protection, development, use and control of rivers with Government Regulations;	Government Regulation No. 35 of 1991: Rivers

	In the context of river conservation, and development, and controlling the destructive power of river water as intended in Article 25 paragraph 3, Article 36 paragraph 2, and Article 58 paragraph 2 of Law Number 7 of 2004 concerning Water Resources needs to establish Government Regulations regarding Rivers;	GOVERNMENT REGULATIONS OF THE REPUBLIC OF INDONESIA NUMBER 38 OF 2011 REGARDING RIVERs

An Analysis the contents of these legislation shows that Indonesia's watershed management-related policies are neither insufficient nor at a low-level as a developing country. As policies and guidelines have already been established, their continued emergence indicates that a different approach to waterfront management is required. Therefore, this study emphasized the need for field work and organized the opinions of local experts for improving Ciliwung waterside management into priority groups using the FGI and IPA methodologies.

2. Result of FGI and IPA survey

In this study, the following research methods were utilized to derive the management elements necessary for establishing a riparian ecological resource management plan for the Ciliwung River watershed in Indonesia. First, 132 questionnaire items necessary for establishing a management plan were formulated through a literature review and understanding the current status of the Ciliwung River watershed. These were established as 51 items through the first Focus Group Interview (FGI) expert questionnaire. Second, 51 selected

management plan elements were classified into ecological resources, hydraulics, and point pollution sources, and an IPA survey was conducted with experts from academic, research, and educational institutions.

The first FGI survey was conducted with five experts, including university professors, engineers and water resource relations workers. Of the 51 indicators selected because of the survey, 14 were ecological resources, 22 were hydraulics, and 15 were point sources of pollution (Table 3).

<Table 3> Indicators from the FGI survey

Ecological resources	Hydraulics / hydrology	Pollution discharge
	Inflow and outflow pattern	
	Outflow amount	
Riverbank settlement	Hydraulic status	Cultivated land ratio
culture	Soil map	Livestock status
Riverbank settlement	Land use type	Industrial plant status
housing	Precipitation	Sewage treatment plant status
Riverbank settlement	Daily rainfall intensity	Location of oil spill area
industry	Evaporation	Livestock breeding status
Riverbank vegetation	Climate	Soil erosion status
status	Topography	Forest logging status
Forest resource location	Slope	Mining activity ratio
Wetland resource status	Aspect	Water quality of confluence
Green area type	Forest tree species status	area
Green area ratio	Velocity and flow rate	Landfill status
Forest area status	Water inflow	Dense residential area
Aquatic habitat status	River depth	Water quality of main stream
Aquatic biota distribution	River slope	and tributary streams
Grassland area ratio	Water temperature	Seasonal distribution of
Watershed fauna status	Open channel flow	pollution sources
Watershed flora status	River width	Rainfall distribution status
	River sediment status	
	Hydraulic structure	

In the IPA survey, the importance and satisfaction with 51 management plan element indicators were evaluated using a 5-point scale. “Importance” evaluated the scale of indicators necessary for the management of riparian ecological resources in the Ciliwung River in Indonesia. Additionally, “Satisfaction” evaluated whether the government or companies are building or providing indicators for the management of riparian ecological resources.

The overall average of the 51 indicators in the IPA survey analysis results was 4.36 for importance and 2.82 for satisfaction, and the average scores for each indicator are shown (Table 4).

<Table 4> The results of the IPA survey

Ecological resources	Importance	Satisfaction
Forest resource location	4.7	2.9
Wetland resource status	4.0	2.7
Green space type	4.6	2.9
Green space type	4.7	2.7
Forest area status	4.4	3.1
Aquatic habitat status	4.4	2.5
Distribution of aquatic biota	4.2	2.8
Culture around riverbank settlement	4.0	1.8
Riverbank settlement housing	4.0	1.6
Riverbank settlement industry	3.8	1.9
Grassland area percentage	3.9	2.6
Current status of river vegetation	4.4	2.5
Current status of the fauna in watershed	4.2	2.8
Current status of the flora in watershed	4.5	2.9
Hydraulics / hydrology	Importance	Satisfaction
Inflow / outflow type	4.7	3.2
Volume of flow	4.6	2.9
Hydraulics/Hydrological status	4.4	2.8
Soil map	4.2	2.6

Land use pattern	4.5	2.4
Precipitation	4.3	2.6
Daily rainfall intensity	4.5	3.5
Evaporation	4.1	3.2
Climate	4.5	3.3
Topography	4.5	3.2
Slope	4.1	3.1
Aspect	4.2	3.0
Forest tree species status	4.2	3.3
Velocity and flow rate	4.4	3.3
Water inflow	4.5	3.0
River depth	4.6	3.3
River slope	4.4	3.3
Water temperature	3.7	3.2
Open channel flow	4.4	3.2
River width	4.5	3.0
River sediment status	4.3	2.4
Hydraulic structure	4.5	2.8
Pollution discharge	Importance	Satisfaction
Cultivated land ratio	4.6	3.0
Livestock status	4.0	3.1
Industrial plant status	4.5	2.7
Sewage treatment plant status	4.7	2.5
Location of oil spill	4.6	2.5
Livestock breeding status	4.0	3.0
Soil erosion status	4.4	3.0
Forest logging status	4.4	2.7
Mining activity ratio	4.3	2.7
Water quality of confluence area	4.4	3.0
Landfill status	4.6	2.6
Dense residential area	4.6	2.9
Water quality of main stream and tributary streams	4.6	2.6
Seasonal distribution of pollution sources	4.5	2.2
Rainfall distribution status	4.5	3.3

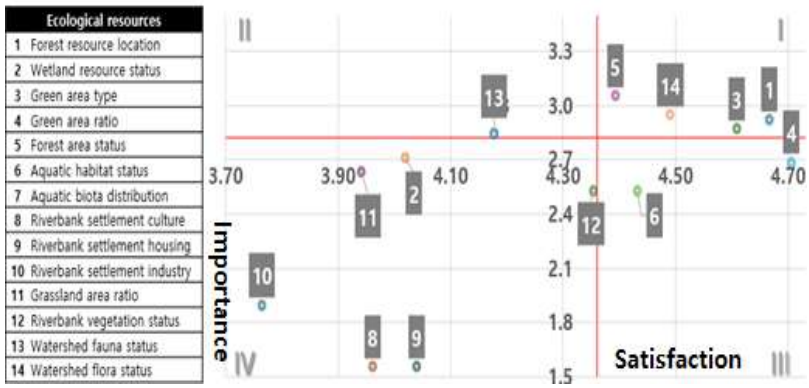
V. Finding

According to these results, Indonesia has enacted legislation for waterfront management, related research is active, and meetings are becoming regular. Additionally, the case study reveals that efforts are being made not only by the government, but also by local communities and related companies. To suggest the efficient data for water resource in Cliliwung for management, the derived indicators were displayed in a quadrant graph and analyzed to provide an overview of the indicators required for monitoring watershed around Ciliwung river. The IPA survey results were divided into four quadrants. Indicators in Quadrant Ⅰare “importance” indicators in the maintenance area, and the information is currently being provided to users in Indonesia. Quadrant II is an area with high satisfaction compared to its importance, and it is necessary to find ways to increase utilization rather than indicators that need to be improved, as they are currently being constructed at the government level. Quadrant III is an indicator that needs to be prioritized, and is judged to have the highest improvement effect and usability. Lastly, Quadrant IV is the area for improvement; it is an indicator that is judged to require restructuring in this study, is given low priority as for the long-term perspectives due to relatively low degree of “importance” and “satisfaction” from experts.

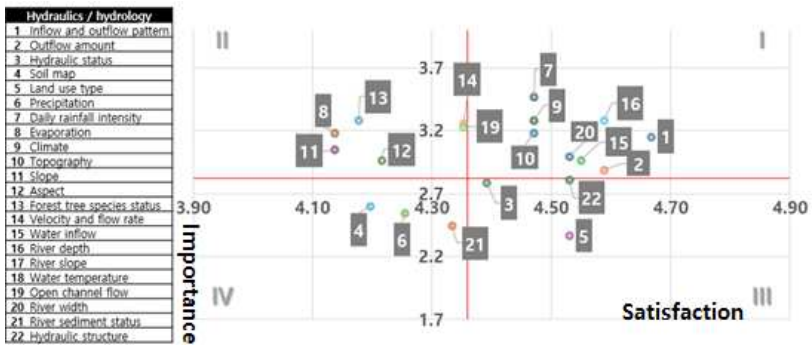
Among the indicators of ecological resource classification, those that urgently need improvement in Quadrant III include the status of aquatic organism habitats and the green area ratio, whereas in the maintenance management area of Quadrant I, the status of forest

areas, flora status in the watershed, location of forest resources, and green area types were identified.

<Figure 4> Quadrant graph on the IPA survey results (ecological indicators)



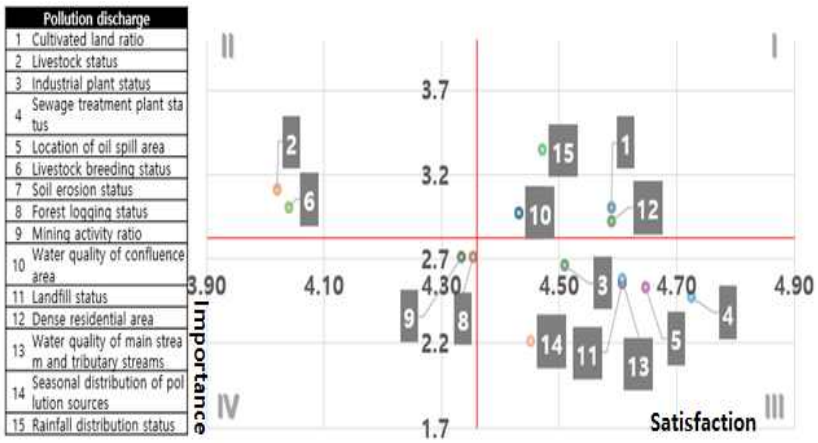
<Figure 5> Quadrant graph on the IPA survey results (Hydraulics / hydrology)



Among the indicators of hydrological classification, indicators in Quadrant III should be urgently developed. Specifically, indicators

such as hydrological status, land-use type, and hydraulic structure need to be improved. In contrast, in the maintenance area of Quadrant I, climate, daily rainfall intensity, topographic status, river depth, river width, water inflow, outflow, and inflow/outflow type were confirmed. The indicators of Quadrant I are currently provided through Indonesia's climate-related platform. If data such as hydrological status, land-use type, and hydraulic structures are added in the future, the basin-level approach is expected to improve further.

<Figure 6> Quadrant graph on the IPA survey results (Pollution discharge)



Among the indicators of point pollution source classification, the maintenance area of Quadrant I were confirmed as data types provided in existing studies, such as soil erosion status, confluence water quality, rainfall distribution status, farmland ratio, and residential areas. In Quadrant II, the livestock industry and livestock breeding statuses were relatively low in the watershed around the Ciliwung River. Therefore, the degree of “importance” from experts

was relatively low. Indicators in need of urgent improvement in Quadrant III include industrial plant status, seasonal distribution of pollution sources, landfill status, main stream and tributary water quality status, sewage treatment plant status, and oil spill locations. The indicators with high importance, “distribution status of point pollution sources,” were confirmed on-site as indicators that directly affect water quality pollution and were judged to have high priority. In Quadrant IV, the mining activity ratio and forest logging status were important compared with the overall level; they were judged to be highly useful indicators if improved because they directly affect rainfall runoff.

Ⅵ. Conclusion

In conclusion, when analyzing Indonesia's water resource-related laws, existing research, and current status, we found that Indonesia, despite being a large maritime country, Indonesia has limited water resources and needs to improve its water quality. Despite the Indonesian government enacting water resource-related policies and installing water quality monitoring devices, water quality and management in Indonesia, especially Ciliwung watershed around the capital city of Jakarta, has not improved. Furthermore, the case study found that the academic community is already aware of the severity of water pollution around Jakarta, and that civic groups and international organizations are also highly involved. However, field research, interviews and surveys reveal that despite investing

substantial budget, the water resources around Jakarta are still severely polluted and unusable. In addition, it shows that the sustainability of civic group activities is limited, and the participation of local communities is non-existent.

For effective and efficient management we proposed priority management of Ciliwung River to collect indicators and data suitable for the environment, focusing on the path flowing around the capital city of Indonesia. To examine the research results, we derived a data index using FGI and IPA survey methodologies.From the FGI, 51 indicators were selected, including 14 ecological resources, 22 hydraulics resources, and 15 point pollution sources. The second IPA survey, centered on the selected indicators, evaluated the “importance” and “satisfaction” of the indicators on a 5-point scale. Consequently, among the indicators of ecological resource classification, the indicators in urgent need of improvement were the status of aquatic organism habitats and the green area ratio. Among the hydraulic classification indicators, the status of hydraulics, land use type, and hydraulic structures need urgent improvement. Among the indicators of the point pollution source classification, those in urgent need of improvement were the status of industrial plants, seasonal distribution of pollution sources, landfill status, water quality status of the main and tributary streams, status of sewage treatment plants, and location of oil spills. In other words, it is necessary to establish applicable and effective management for water resource around the Ciliwung River. The changes of current policies and activities in Indonesia are implemented based on the indicators derived from this study, water quality management can be further

improved, which will help protect Indonesia's water resources. In addition, this study is expected to be fundamental data to improvements in water resource quality and management of entire rivers in Indonesia.

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<국문초록>

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본 연구는 인도네시아 칠리웅 수변의 효과적인 관리 방안을 제시하고자 본 연구 대상의 수변 관리의 필요성과 수변 관리 계획안에 대해 논의한다. 선행 연구를 통해 인도네시아는 이미 수자원 관리를 위한 종합계획, 현행법 및 기준을 갖추고 있음을 확인하였다. 그러나 현지 조사, 현행법, 전문가 인터뷰, 주민 설문조사를 진행한 결과, 수질 관리가 비효율적인 것으로 나타난다. 따라서 본 연구에서는 FGI를 통해 수변 관리를 위한 지표를 수립하고, IPA 분석을 통해 이러한 지표들이 현장에서 실제로 효과적인지 검증하였다. 본 연구는 칠리웅 강의 수변 완충지대를 개선하기 위해서는 수생생물 서식지 현황 및 녹지율, 수리학적 현황, 토지 이용 형태 및 수리구조물 현황, 매립지 현황, 본류 및 지류의 수질 현황, 하수처리장 현황, 유류 유출 발생 위치 등의 자료를 확보하여 칠리웅 강의 수변 완충지대의 관리 우선 순위가 필요하다는 결과를 도출하였다. 이런 결과를 기반으로 본 연구가 자카르타 외 인도네시아 외곽 도서(島嶼)의 수변 관리에도 정책적 시사점을 제공하길 기대한다.

주제어: 강 완충지대, 인도네시아, Ciliwung 유역, 자카르타