

DYNAMICS OF CENTRAL AND PROVINCIAL GOVERNMENT COOPERATION SECTOR BALANCING AUTHORITY AND BUDGET IRRIGATION POLICY IN INDONESIA

DINÂMICA DA COOPERAÇÃO ENTRE O GOVERNO CENTRAL E OS GOVERNOS PROVINCIAIS SETOR DE EQUILÍBRIO ENTRE AUTORIDADE E ORÇAMENTO POLÍTICA DE IRRIGAÇÃO NA INDONÉSIA

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Abstract

This study aims to explore the dynamics of cooperation between the central and regional governments in supporting irrigation policies in Indonesia, focusing on West Java Province. The research uses qualitative analysis methods, examining intergovernmental relations through four main indicators: vertical relations, authority and autonomy, budget allocation, and regulations and institutions. Primary data were obtained through interviews with the Head of the Water Resources Operations and Maintenance Section of West Java Provincial Water Resources Office, while secondary data were collected from official ministry documents. The findings show that support for irrigation infrastructure is still limited due to budget allocations that do not match the extent of irrigated land. The mismatch between national irrigation planning and local conditions in West Java leads to inefficient resource

Resumo

Este estudo tem como objetivo explorar a dinâmica da cooperação entre os governos central e regional no apoio às políticas de irrigação na Indonésia, com foco na província de Java Ocidental. A pesquisa utiliza métodos de análise qualitativa, examinando as relações intergovernamentais por meio de quatro indicadores principais: relações verticais, autoridade e autonomia, alocação orçamentária e regulamentações e instituições. Os dados primários foram obtidos por meio de entrevistas com o chefe da Seção de Operações e Manutenção de Recursos Hídricos do Escritório Provincial de Recursos Hídricos de Java Ocidental, enquanto os dados secundários foram coletados a partir de documentos oficiais do ministério. Os resultados mostram que o apoio à infraestrutura de irrigação ainda é limitado devido às alocações orçamentárias que



allocation. The study concludes that synergy between the central and regional governments has not yet been fully realized, given the gap in planning and budget allocation, which impacts the implementation of irrigation policies. Therefore, better coordination between the two levels of government is essential to enhance the effectiveness of irrigation infrastructure development, supporting food security and agricultural sustainability in West Java. This study contributes to the theory of intergovernmental relations, emphasizing budget allocation as a critical factor in supporting irrigation policies.

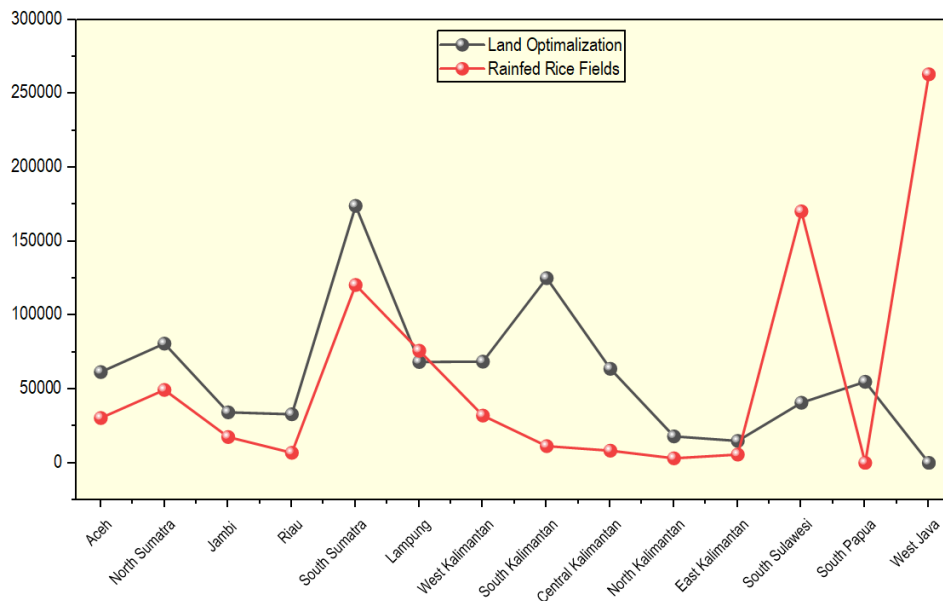
Keywords: Irrigation Infrastructure. Intergovernmental Relations. Water Resources. Budget Allocation.

não correspondem à extensão das terras irrigadas. A incompatibilidade entre o planejamento nacional de irrigação e as condições locais em Java Ocidental leva a uma alocação ineficiente de recursos. O estudo conclui que a sinergia entre os governos central e regional ainda não foi totalmente realizada, dada a lacuna no planejamento e na alocação orçamentária, o que afeta a implementação das políticas de irrigação. Portanto, uma melhor coordenação entre os dois níveis de governo é essencial para aumentar a eficácia do desenvolvimento da infraestrutura de irrigação, apoiando a segurança alimentar e a sustentabilidade agrícola em Java Ocidental. Este estudo contribui para a teoria das relações intergovernamentais, enfatizando a alocação orçamentária como um fator crítico no apoio às políticas de irrigação.

Palavras-chave: *Infraestrutura de Irrigação. Relações Intergovernamentais. Recursos Hídricos. Alocação Orçamentária.*

1 INTRODUCTION

Irrigation is a crucial sector in supporting global food security, particularly in countries that rely heavily on agriculture. Globally, climate change and rapid population growth have increased pressure on water availability for irrigation, thereby affecting agricultural productivity and food security (Cai, 2025). In Indonesia, the irrigation sector plays a vital role in food production, particularly for rice, which requires stable irrigation (Azis & Mundra, 2020). An efficient irrigation system impacts not only agricultural yields but also the country's environmental and economic sustainability. However, this sector often faces challenges related to funding, inequitable water resource management, and inadequate infrastructure (Salman et al., 2022). The Indonesian government has launched various policies and programs to improve the efficiency and sustainability of irrigation systems, but challenges in coordinating among government agencies and involving various stakeholders remain significant (Alaerts, 2020).

Figure 1*Strengthening Irrigation Infrastructure on Intensified Land (In Hectares)*

Source: Ministry of Agriculture of the Republic of Indonesia, 2025

The gap between central government policies and their implementation at the regional level often hampers the effectiveness of the irrigation sector. This highlights the importance of Research exploring the dynamics of policy and cross-governmental collaboration in the irrigation sector, with a focus on efficient water resource management. While numerous studies have highlighted the role of policy in irrigation management, few have examined how collaboration between the central, regional, and community governments can strengthen policy implementation. This study aims to fill this gap by examining how cross-governmental collaboration influences irrigation policy implementation in Indonesia and how budget and policy alignment can improve irrigation management efficiency (Gusweni et al., 2025).

With its rich volcanic is a land where agriculture is at the heart of its economy and culture (Betancur-corredor et al., 2025). From the lush rice terraces of Bali to the sprawling plantations of Sumatra, the nation's agricultural sector is the backbone of rural livelihoods and food security (Ngadi & Nagata, 2022). However, beneath this green expanse lies an effective irrigation system: an unseen force that sustains and nurtures this vibrant sector. Indonesia's agricultural sector is about feeding its 270 million people and sustaining the rural economy, where millions of smallholder farmers depend on their

crops for survival (Andani et al., 2022). An effective irrigation system empowers these farmers by giving them control over their water supply, allowing them to plan their planting and harvesting more accurately. This reliability directly translates into better crop yields, higher incomes, and improved food security nationwide. Indonesia's diverse agricultural landscape, which includes coffee plantations, fruit orchards, and vegetable fields, also benefits immensely from well-managed water resources. In regions like West Java and Sumatra, where cash crops such as coffee and palm oil dominate, irrigation systems support the continuous growth of these commodities, which are vital for both local economies and soil and diverse climates, Indonesia international trade. an effective irrigation system is the silent force that sustains Indonesia's agricultural sector (Fajarini et al., 2025; Sahara et al., 2024). It ensures that the fields remain green, the harvests bountiful, and the farmers prosperous. As the nation looks to the future, investing in and maintaining these systems cannot be overstated. For Indonesia, where agriculture is the heartbeat of its rural communities, adequate irrigation is not just necessary. The lifeblood keeps the nation thriving (Tirtalistyani et al., 2022).

Irrigation policy is a critical instrument in managing water resources, optimizing agricultural productivity, and reducing the impacts of climate change (Liem et al., 2024; Qadir et al., 2024). It provides the framework within which water is allocated, used, and conserved, ensuring that this vital resource can continue to support life on our planet. As the challenges of the 21st century unfold, the importance of sound irrigation policy will only grow, guiding the global agricultural sector toward a more sustainable and resilient future. In Indonesia, the development and implementation of irrigation policy involve both central and regional governments (Winarno et al., 2025). Non-integrated efforts between central and regional governments in developing irrigation policy in Indonesia can lead to significant challenges, including inconsistent policy implementation, resource duplication, fragmented water management, and reduced capacity for crisis response (Sharofiddinov et al., 2024). Addressing these issues requires better coordination, communication, and alignment of priorities across all levels of government to ensure the sustainable and equitable development of irrigation systems throughout the country (Akbar et al., 2024). Therefore, the role of the central and regional governments is needed to create a stable irrigation system through policy design and budget support. This study addresses the problem of irrigation implementation patterns in West Java province by

asking how the implementation of cooperation between the central and regional governments regarding budget and policy aspects is to realize the West Java irrigation program.

2 RESEARCH METHODS

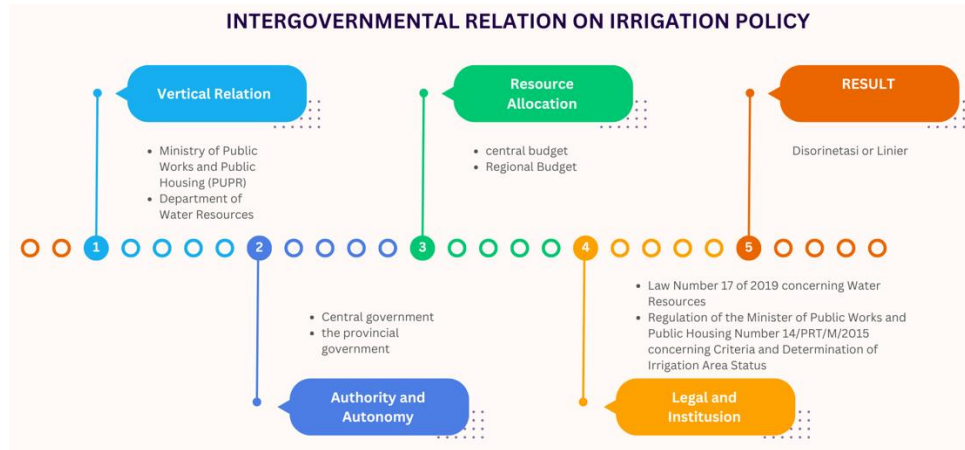
This research uses qualitative analysis, specifically analyzing qualitatively the relationship between the central government and regional governments in the context of irrigation policy. The central government, in this case, the highest authority of the Republic of Indonesia, collaborates with the West Java provincial government. The primary data for this study are the results of interviews with informants who were deliberately selected and relevant to the research needs. The informants were representatives of the West Java provincial government, namely the Head of the Water Resources Operations and Maintenance Section of the West Java Provincial Water Resources Office. The interviews were conducted with a neutral and objective approach. This study guarantees the confidentiality of the personal identities of other informants and agrees to be used as informants without coercion or pressure from any party. Secondary research data uses documents about the central government and regional government budgets. Next are documents on irrigation regulations and policies. This research limits the use of data from 2021-2024.

Intergovernmental relations are an appropriate framework to explain central and regional government cooperation on irrigation policy. Intergovernmental Relations (IGR) theory is a critical framework in political science, especially in the study of federalism and the interactions between various levels of government (Nilsson, 2020; Tosun & Peters, 2018). IGR examines how central, regional, and local governments collaborate and navigate the complexities of shared governance (Trujillo et al., 2022; Valero, 2024). Traditionally, IGR has been dominated by informal processes and power relationships. However, recent trends indicate a shift towards greater formalization and institutionalization, which can provide more certainty and protection for sub-national governments when dealing with central authorities (Evans et al., 2024). The degree of institutionalization, the extent to which IGR is decision-making in character, and the transparency of these processes also play significant roles in defining IGR systems (Alves

& Araujo, 2024). study of IGR involves understanding the role of bargaining in intergovernmental interactions.

Figure 2

Intergovernmental Relation on Irrigation Policy



This research highlights the vertical relationships between central government institutions, especially the Ministry of Public Works and Public Housing (PUPR) and the Department of Water Resources. These institutions oversee the development and implementation of irrigation policies at the national level, ensuring consistency across the West Java province. Then, it emphasizes the distribution of authority and autonomy between the central and provincial governments. While the central government sets overall policies and guidelines, provincial governments are given some autonomy to implement and adapt those policies to local needs and conditions. Furthermore, this research analyzes how financial resources for irrigation projects are divided between central and regional budgets. The national government manages the central budget, while regional or provincial governments control regional budgets. They are analyzing the legal and institutional framework that regulates irrigation policy, referring to Law Number 17 of 2019 concerning Water Resources and Regulation of the Minister of Public Works and Public Housing Number 14/PRT/M/2015 concerning criteria and determining the status of irrigation areas. Finally, this research found that intergovernmental relations and policies can lead to disorientation or linear and coherent implementation.

3 RESULTS AND DISCUSSION

3.1 Result

3.1.1 Vertical relationship between the central government and West Java province

The vertical relationships between the central and regional governments play a crucial role in the development of sustainable irrigation infrastructure. Cooperation between the two levels of government is indispensable for the timely completion of irrigation infrastructure projects. The central government, through budgetary and regulatory support, can provide the necessary framework for regional governments to steer provincial irrigation policy. This collaboration involves central government institutions such as the Ministry of Public Works and Housing (PUPR) and the Ministry of Water and Mineral Resources, working closely with regional entities such as the West Java Provincial Water Resources Office. This cooperation ensures that asset mapping, budgeting, and regulatory compliance are aligned with national policies.

The emergence of various programs aimed at facilitating housing provision for low-income people is an essential and effective solution to ensure that they have a decent place to live (Prastiyo et al., 2022). Despite the unwavering effort and determination required to participate in these programs, low-income people have shown remarkable resilience in overcoming the challenges they face. This resilience is a source of inspiration and hope, demonstrating that even in the face of adversity, the dream of a decent home can be realized.

Tabel 1

Irrigation Area Distribution by River Basin in West Java

River Area	Cross District/City (Ha)	Whole District/City (Ha)	District/City Pond (Ha)	Total Area (Ha)	Number of Irrigation Areas Across Districts/Cities	Total number of irrigation areas in districts/cities	Number of District/City Pond Irrigation Areas	Total Number of Irrigation Areas
Ciliwung-Cisadane	2522	2574	0	5096	8	2	0	10
Cisadea-Cibareno	1276	15530	0	16806	3	10	0	13

Citarum	8303	24472	6864	39639	19	15	6	40
Cimanuk- Cisanggarung	7376	19915	0	27291	15	12	0	27
Citanduy	3565	1258	0	4823	6	1	0	7
Ciwulan- Cilaki	595	6350	0	6945	1	6	0	6

However, despite the institutional efforts, challenges persist in the effective realization of irrigation programs. A notable issue is the mismatch between national irrigation planning and on-the-ground conditions in West Java, resulting in inefficient resource allocation. For instance, the budgeting process often overlooks the specific needs of irrigation areas in the region, resulting in slow development and maintenance of critical irrigation infrastructure. The high rate of damage to irrigation facilities (45.67%) in West Java further underscores the gap between policy objectives and their on-the-ground implementation. This misalignment suggests that while vertical coordination between levels of government exists, it is insufficiently responsive to local needs. The central government's broader policy objectives do not always account for the unique challenges provincial governments face, especially in resource allocation. This discrepancy warrants further attention, as it impedes the efficient use of available budgets and the timely realization of irrigation infrastructure projects.

3.2 Authority and autonomy in irrigation policy

The provincial government has the task of developing and managing the irrigation system as a single system in the irrigation area, which is the authority of the provincial government. In contrast, the district/city regional government has the task of developing and managing the irrigation system as a single system in the irrigation area, which is the authority of the district/city regional government. This is different from the central government; apart from having the task of developing and managing irrigation systems as a unified system in irrigation areas, which is the authority of the center, it also has the authority to determine the status of irrigation areas in various authorities.

Table 2*Distribution of Authority for Development and Management of Irrigation Systems (PPSI)**Based on Law Number 17 of 2019 concerning Water Resources*

Duties and Authorities of PPSI	Central	Provincial Area	Regency/City Area
TASK	Develop and manage the irrigation system as a unified system in the irrigation area, which is the centre's authority.	Develop and manage the irrigation system as a unified system in the irrigation area, which is the authority of the provincial government.	Develop and manage the irrigation system as a unified system in the irrigation area, which is the authority of the district/city regional government.
AUTHORITY	Determining the Status of Irrigation Areas	-	-

The authority to determine the status of irrigation areas belongs only to the Central government. This implies that the status of regionally authorized irrigation areas, both provincial and district/city, must be determined by a ministerial regulation in charge of water resources and irrigation. In this regard, the mapping of irrigation areas' status and area size is regulated in the Regulation of the Minister of Public Works and Public Housing Number 14/PRT/M/2015 concerning Criteria and Determination of the Status of Irrigation Areas. Based on the data presented in the ministerial regulation, it can be seen that the total national irrigation area reaches 9,136,029 ha. If we look at the type of irrigation, there are 5 (five) types of irrigation, namely: (1) surface irrigation (7,145,168 ha); (2) groundwater irrigation (113,601 ha); (3) pump irrigation (44,230 ha); (4) swamp irrigation (1,643,283 ha); and (5) pond irrigation (189,747 ha).

The surface irrigation type dominates the entire national irrigation area in Indonesia, namely 78%, followed by swamp irrigation at 18%, and other irrigation types are relatively minimal, the pump irrigation type at 0.5%, groundwater irrigation at 1%, and pond irrigation at 2%. Apart from that, if we look at the irrigation management authority, the irrigation management area under regional authority for various types of irrigation is relatively large, namely 65.60% or 5,993,497 ha. Meanwhile, the central irrigation area with various types of irrigation reached 34.40% or an area of 3,142,532 ha.

3.3 Sources of allocation for irrigation infrastructure development

The financial resources for irrigation infrastructure development in Indonesia come from three main sources: the State Budget (APBN), the Provincial Budget (APBD), and the Regency/City Budget (APBD). Each level of government is responsible for managing and allocating funds to irrigation projects within its jurisdiction. However, discrepancies in budget allocations between the central and regional governments have created significant disparities in the quality and maintenance of irrigation infrastructure.

Table 3

Irrigation APBD Allocation (PPSI) Based on Land Area under Provincial and Regency Authority for 2021 – 2023

No.	Local government	Irrigation Area (ha)	Irrigation APBD Allocation for Fiscal Year (IDR/Ha)			Average (IDR/Ha)
			2021	2022	2023	
1.	Province	1.105.476	4.007.362	1.067.339	1.124.659	2.066.453
2.	Regency	3.663.172	3.233.458	869.087	860.235	1.654.260
Average (IDR/Ha)		4.768.648	3.412.866	915.046	921.534	1.749.825

Table 4

APBN Irrigation Allocation (PPSI) Based on Land Area under Central Authority for 2019 – 2021

Government	Irrigation Area (ha)	Irrigation APBD Allocation for Fiscal Year (Rp/ha)			Average (Rp/ha)
		2019	2020	2021	
Central	2.376.521	17.286.984	13.100.458	23.937.933	18.108.458

Source: Archive document of the Minister of Water and Mineral Resources, 2024

The value of the irrigation area budget allocation per hectare is much lower than that of the Central authority. Based on data from the Performance Report of the Directorate General of Water Resources for the 2019 – 2021 period, it can be seen that the total amounted to IDR 129.11 trillion, consisting of irrigation budget allocations in 2019 amounting to 41.08 trillion, 2020 amounting to 31.13 trillion, and in 2021 amounting to 56.89 trillion. If linked to the central authority area of 2,376,521 ha, then the budget allocation for irrigation in 2019 is IDR 17,286,984/ha. In 2020, it was IDR 13,100,458/ha; in 2021, it is IDR 23,937,933/ha, and the average total during the 3 (three)

year period was IDR 18,108,458. In West Java, the provincial government's ability to fund irrigation projects is limited, with the average allocation for irrigation maintenance falling well below the actual needs of the irrigation networks. For example, the West Java Provincial Government's average budget allocation of IDR 2,066,453 per hectare for irrigation maintenance is far from sufficient to cover operational and maintenance costs, which range from IDR 600,000 to IDR 900,000 per hectare. In contrast, the central government allocates a significantly higher amount, averaging IDR 18,108,458 per hectare for its irrigation areas.

This disparity in budget allocations is closely linked to the poor condition of irrigation infrastructure in regions under provincial and district authority. The relatively lower budget per hectare in the provinces and districts correlates with higher rates of infrastructure damage. The central government's more substantial funding enables better maintenance and less infrastructure deterioration, highlighting the need for a more equitable distribution of funds across all levels of government. Ensuring that regional governments have sufficient financial resources to manage and maintain irrigation infrastructure is essential to improving Indonesia's irrigation systems' overall performance. The inequality in budget allocation for infrastructure for irrigated agricultural areas between central, provincial and district authorities become linear with the condition of damage to the irrigation network based on their respective authorities. The irrigation budget allocation for central authorities, on average, reaches IDR 18,108,458/ha, which is quite large or higher than provinces and districts/cities, which has implications for the level of damage to the irrigation network of 22.54%. This is different from the irrigation budget allocation for regional authorities, both provincial and city districts, amounting to IDR 2,066,453/ha (province) and IDR 1,654,260/ha (district), respectively. This has implications for the average level of irrigation network damage above 50%, namely provincial authority of 53.41% and district/city authority of 54.91%.

3.4 Irrigation regulations

Law number 17 of 2019 concerning Water Resources is a comprehensive legal framework to ensure that water resources management is carried out by considering

social, environmental and economic aspects in a balanced manner. This law emphasizes the state's role in regulating and managing water resources for the benefit of the people and the importance of community involvement in the management and monitoring process. Implementing this law can ensure the sustainability of water availability and its use for the greatest prosperity of the people.

Table 5

Key Regulations Governing Irrigation in Indonesia and West Java

No	Regulation	Level
1	Law Number 17 of 2019 concerning Water Resources	National
2	Regulation of the Minister of Public Works and Public Housing Number 14/PRT/M/2015 concerning Criteria and Determination of Irrigation Area Status	National
3	West Java Province Regional Regulation No. 4 of 2008 concerning Irrigation	Regional

Regulation of the Minister of Public Works and Public Housing Number 14/PRT/M/2015 is a comprehensive and structured regulation to ensure irrigation management is carried out effectively and efficiently, with a clear division of authority between the central, provincial and district/city governments. A focus on community involvement and active participation of farmers is at the core of sustainable and equitable irrigation system management. In addition, flexibility in changing the status of irrigation areas allows adjustments according to actual conditions on the ground so that this regulation can continue to be relevant in the long term. Regional Regulation No. 4 of 2008 is a comprehensive regulatory effort to ensure that irrigation management in West Java Province is participatory, fair and sustainable, involving various parties, from local government to farming communities. This regulation not only regulates the technical aspects of irrigation management but also includes monitoring mechanisms, community empowerment and law enforcement to ensure the effectiveness of its implementation.

One of the main issues is the rigidity of the regulatory framework, particularly the central government's control over irrigation area classification. This centralized approach limits regional governments' ability to make adaptive changes tailored to their specific needs. Furthermore, the involvement of local communities and stakeholders in irrigation management remains insufficient, despite the regulations' emphasis on participatory approaches. Enhancing community engagement in irrigation decision-making processes

would help ensure that local knowledge and priorities are incorporated into policy implementation, fostering a more inclusive and sustainable irrigation management system.

4 DISCUSSION

Irrigation systems are essential to support agricultural activities. They can be used in areas with erratic rainfall (COHEN et al., 2021; Liu et al., 2021). West Java's irrigation system is not yet supported by adequate infrastructure. The percentage of infrastructure damage remains high, hampering agricultural activities. Poor infrastructure is strongly related to the government's budgetary capacity (Mazele & Amoah, 2021). The West Java provincial government has not yet fully funded the irrigation system. Dependence on allocations from the central government is essential to achieving a perfect irrigation system (Nurzaman et al., 2023). Budgetary support from the central government is a hope for regions with agricultural sectors (Pandit & Dhakal, 2022; Massagony et al., 2025). Mapping assets that support irrigation policies by the central government must align with central government financial support (He et al., 2024).

The central government's desired irrigation policy to support food security in the agricultural sector can be achieved through collaboration with regional governments. The central government fully controls irrigation policy in Indonesia. The central government has primary responsibility for establishing national policies on irrigation and water resource management (García-moll et al., 2024), creating regulations, allocating budgets, and monitoring and evaluating policy implementation (Anyango et al., 2024). The authority to determine regional irrigation status rests solely with the central government. The West Java regional government does not have full authority over irrigation policy. The provincial government manages medium and small irrigation networks serving agricultural areas in various regencies/cities (Hashemi et al., 2024). To facilitate regional governments' irrigation policy decisions, the central government needs to provide technical regulations that regional governments can control in determining policies, such as regional irrigation status. The autonomy granted to provinces allows for the provision of infrastructure and adaptation to local needs, which are crucial for achieving long-term policy success (Witjaksono et al., 2020). The relationship between the central and

provincial governments is often marked by coordination challenges (Amir et al., 2020). One of the main challenges is budget allocation, which may need to be commensurate with regional needs (Lotfi et al., 2024). Regarding budget allocation, if the central government is too dominant, provincial governments will feel their autonomy is limited, and it will be difficult for the central government to implement programs that align with regional needs (Arabzadeh, 2024).

Local governments are better informed about the actual condition of agricultural land and its water needs. Financial support for accelerating irrigation infrastructure is crucial. A stable budget combined with professional government performance is one of the two important agricultural irrigation strategies (Taking et al., 2025; Chen et al., 2024). West Java's irrigation infrastructure has not yet fully addressed the challenges of water irrigation in supporting the agricultural sector. Poor financial conditions can hinder irrigation system development (Narayanamoorthy, 2022; Hezam et al., 2024). The West Java government still requires budget support from the central government. The regional government's irrigation asset mapping strategy serves as a data-based bargaining tool for requests for assistance from the central government.

5 CONCLUSION

This study explores cooperation between the central and West Java provincial governments in developing irrigation policies and infrastructure. Irrigation issues in Indonesia are generally under the central government's authority, such as determining the status of regional irrigation. The West Java provincial government is only given a small portion of authority over district-level irrigation areas. This limited authority forces the West Java provincial government to determine the status of its areas for irrigation. The West Java government is mapping irrigation assets to complete the documents required for cooperation with the central government. During the development of irrigation systems in the region, regulatory independence is required to determine the status and needs of irrigation development. West Java's irrigation infrastructure is severely damaged, with a percentage of 45.6%. The damage to West Java's irrigation infrastructure represents the financial condition of the irrigation sector. The West Java government's fiscal condition is not yet fully capable of developing irrigation infrastructure.

Cooperation assistance in financial and policy aspects is essential to support the West Java irrigation system. Budget allocations sourced from the Regional Budget (APBD) and the National Budget (APBN) for building irrigation infrastructure must be balanced with the needs of the irrigation network in the West Java region. There are three government regulations, namely Law Number 17 of 2019 concerning Air Resources, Regulation of the Minister of Public Works and Public Housing Number 14/PRT/M/2015, and Regional Regulation of West Java Province Number 4 of 2008 concerning Irrigation. However, in practice, these three regulations have not fully provided independence for West Java in determining irrigation status, which has an impact on determining the priority scale or not for West Java irrigation development. Ultimately, this study provides a theoretical contribution to intergovernmental relations, stating that vertical relations are a key factor in irrigation policy. Good coordination in authority, budget allocation, and policies will significantly influence the acceleration of irrigation infrastructure development. This study only discusses the role of government institutional levels in irrigation policy; further research can analyze policies that provide opportunities for the private sector to invest in irrigation infrastructure development in the region.

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Authors' Contribution

All authors contributed equally to the development of this article.

Data availability

All datasets relevant to this study's findings are fully available within the article.

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