*Jurnal Ekonomi dan Studi Pembangunan, 17 (2), 2025*
*ISSN 2086-1575 E-ISSN 2502-7115*

# The Impact of Dams on Regional Economic Growth: Empirical Evidence from National Strategic Projects in Indonesia

Muhammad Nur Hidayat[1,*], Irfani Fithria Ummul Muzayanah[2]

[1,2]Master's Degree Program in Economic Planning and Development Policy, Faculty of Economics and Business, University of Indonesia

*E-mail: mn.hidayat07@gmail.com

Received: April 21, 2025; Accepted: September 18, 2025; Published: October 16, 2025
**Permalink/DOI:** https://dx.doi.org/10.17977/um002v17i22025p131

**Abstract**

This study analyzes the impact of dam operations on regional economic growth in Indonesia by applying the economic base theory within a Difference-in-Differences (DiD) framework. The panel dataset covers 259 regencies/municipalities surrounding 48 National Strategic Project (PSN) dams, categorized into core regions, immediate neighbors, and second-tier neighbors over the 2018–2023 period. The results indicate that dam operations significantly increase Gross Regional Domestic Product (GRDP) in agrarian regions, with estimated gains of IDR 2.6 trillion in core regions and IDR 2.4 trillion in immediate neighbors, while effects remain statistically insignificant in non-agrarian regions. Trend analysis indicates a declining positive impact in agrarian core regions, an increasing negative impact in non-agrarian core regions, and a strengthening positive impact in neighboring areas. These findings underscore the relevance of economic base theory in explaining spatial variations of dam impacts and provide insights for developing more contextual and sustainable strategies to maximize the benefits of dam infrastructure.

**Keywords:** Dams, Economic Base Theory, Economic Growth, PSN
**JEL Classification:** O18, R11, Q25

## INTRODUCTION

The International Commission on Large Dams (ICOLD, n.d.) emphasizes that dams play a vital role in water resource management by storing water during periods of surplus and releasing it during times of scarcity. Their core functions include water supply, irrigation, flood control, navigation, sediment management, and hydropower generation. According to the World Register of Dams (WRD, 2023), most large dams globally are utilized for irrigation, with 47% used exclusively for this purpose and around 60% operating as part of multipurpose systems.

According to the World Commission on Dams (WCD, 2000), dams, as long-term strategic investments, offer broad benefits, including regional development, job creation, and the growth of base sectors that support exports. The number of large dams increased significantly, from around 5,000 in 1949 to more than 45,000 by the end of the 20th century (WCD, 2000). However, such large-scale investments are often controversial due to their complex cost-benefit structures and long-term economic and environmental consequences, such as ecosystem degradation or the risk of investment misallocation (Dillon & Fishman, 2019; Jeuland, 2020)

Jeuland (2020) emphasizes the need for a comprehensive analytical approach to evaluate the impacts of dams, in order to capture their multi-sectoral effects. These impacts extend beyond the direct effects on agricultural productivity to include indirect effects through intersectoral linkages and induced impacts arising from changes in household income and expenditures, which generate broader economic effects (Bhatia, Cestti, Scatasta, & Malik, 2008). However, the distribution of these effects is often geographically uneven (Dillon & Fishman, 2019), highlighting the importance of applying spatially differentiated approaches, such as those employed by Duflo and Pande (2007).

Duflo & Pande (2007) found that while dams improve irrigation and agricultural production in downstream areas, they may also lead to agricultural output instability in areas near the dam site. Other studies (Li, Liao, & Dai, 2022) (Mary, Craven, Stoler, & Shafiq, 2023), and (He, 2023) show that the impacts of dams are highly context-dependent, with significant variations between upstream and downstream regions. Similarly, Shi, Chen, Liu, and Sivakumar (2019) highlighted that dam impacts also vary by a country’s economic level, showing that the significance of these impacts depends on national development status. While these approaches capture geographic variations in impact, comprehensive measurements reflecting both direct and indirect economic effects remain limited.

According to production theory (Mankiw, 2016), economic growth is determined by the output of goods and services produced using capital and labor as the main inputs, expressed as $Y = F(K, L)$, where output (Y) is a function of capital (K) and labor (L). As public infrastructure, dams represent a form of capital (K) within this framework, contributing to economic output in the agricultural sector primarily through irrigation, and in non-agricultural sectors through additional functions such as electricity generation and flood control (Bhatia, Cestti, Statasta, & Malik, 2008; Mankiw, 2016; WCD, 2000; WRD, 2023).

The economic base theory, popularized by Tiebout in the 1960s, posits that the basic sector—characterized by high productivity and export orientation—is the main engine of regional economic growth (Edwards, 2007). Improvements in this sector generate a series of effects: direct impacts (such as income and employment creation), indirect impacts (through the spending of workers in the basic sector), and induced impacts (through increased demand for goods and services in the non-basic sector), all of which contribute to stimulating regional economic activity (Edwards, 2007).

Based on this theory, increased economic output resulting from dam operations can initiate intersectoral economic linkages—particularly when the impacts occur within the basic sector (Edwards, 2007). These indirect effects are often more substantial than the direct ones, including increased demand for production inputs, expansion of employment, and higher consumption of goods and services from other sectors, thus promoting broader regional economic development (Bhatia, Cestti, Scatasta, & Malik, 2008). Moreover, both direct and indirect impacts give rise to induced effects, such as higher household income and consumption, which in turn create economic multiplier effects that ultimately boost the Gross Regional Domestic Product (GRDP), reflecting regional economic growth (Bhatia, Cestti, Statasta, & Malik, 2008; Edwards, 2007).

Thus, the economic base theory provides an alternative framework for understanding the varying impacts of dams on regional economic growth. This theory distinguishes between the basic sector—key industries that produce outputs for export or for sale outside the region—and the non-basic sector, which serves local consumption needs (Edwards, 2007). The basic sector functions as the main driver of local economic growth by injecting external income into the regional economy, which subsequently generates a multiplier effect through increased demand for goods and services in the non-basic sector (Edwards, 2007; Nakamura & Paul, 2009).

In the context of dam development, the primary function of dams as providers of irrigation (WRD, 2023) positions the agricultural sector as a potential basic sector in regions where it dominates the economic structure. According to the economic base theory (Edwards, 2007), the significance of dam impacts thus largely depends on whether agriculture serves as a basic sector in a given region. In agrarian regions, where agriculture constitutes the main source of exported output and external income, the direct impact of dams—particularly through improved irrigation—is expected to have a pronounced effect on economic growth by enhancing sectoral productivity. In contrast, in non-agrarian regions where agriculture is not a basic sector, the influence of dams is more likely to occur through indirect mechanisms, such as strengthened inter-sectoral linkages that stimulate broader economic activity.

In Indonesia, large-scale dam construction began in 1911 with the establishment of the Nglangon Dam in Grobogan Regency, Central Java (PUPR, 2017). As of October 2023, a total of 231 dams have been operational across 92 regencies/municipalities in 19 provinces (PUPR, 2023). These dams serve a wide array of functions, including irrigation, raw water supply, flood control, and hydroelectric power generation, as well as complementary roles in environmental conservation, fisheries, and tourism development (Government of the Republic of Indonesia, 2010).

In 2016, the Government of Indonesia included 60 dam projects in its list of National Strategic Projects (PSN) with the explicit goal of stimulating regional economic growth (President of the Republic of Indonesia, 2016). This list was revised in 2023 to include 48 dam projects across 44 regencies/municipalities (Coordinating Minister for Economic Affairs of the Republic of Indonesia, 2023), with 20 of them already operational since 2021, according to the Committee for the Acceleration of Priority Infrastructure Provision (KPPIP, 2023). These PSN dams are all classified as large dams by the standards of the International Commission on Large Dams (ICOLD, 2011), with storage capacities ranging from 1.68 million $m^3$ to 314.70 million $m^3$ and an average of 55.98 million $m^3$ per dam (KPPIP, n.d.). In terms of functionality, they are capable of irrigating between 300 and 25,000 hectares (average 5,941 hectares) and generating between 0.13 and 10.80 megawatts of electricity (average 3.06 megawatts (KPPIP, n.d.).

Data from KPPIP, the Ministry of Public Works and Housing (PUPR), and Statistics Indonesia (BPS) indicate that GRDP growth trends in regions where PSN dams have been operational during 2021–2023 tend to outperform those in regions where PSN dams are still under construction (see Figure 1). This provides initial empirical support for the proposition that dam infrastructure contributes positively to regional economic performance. Nevertheless, rigorous empirical research on the effects of large-scale dam construction in Indonesia—particularly PSN dams—that accounts for geographical heterogeneity and differences in regional economic structures remains scarce. For instance, Aribowo & Yudhistira (2021), using a distance-based estimation approach, demonstrated that the welfare impacts of dams varied depending on proximity, indicating the need for more nuanced, spatially aware analyses.

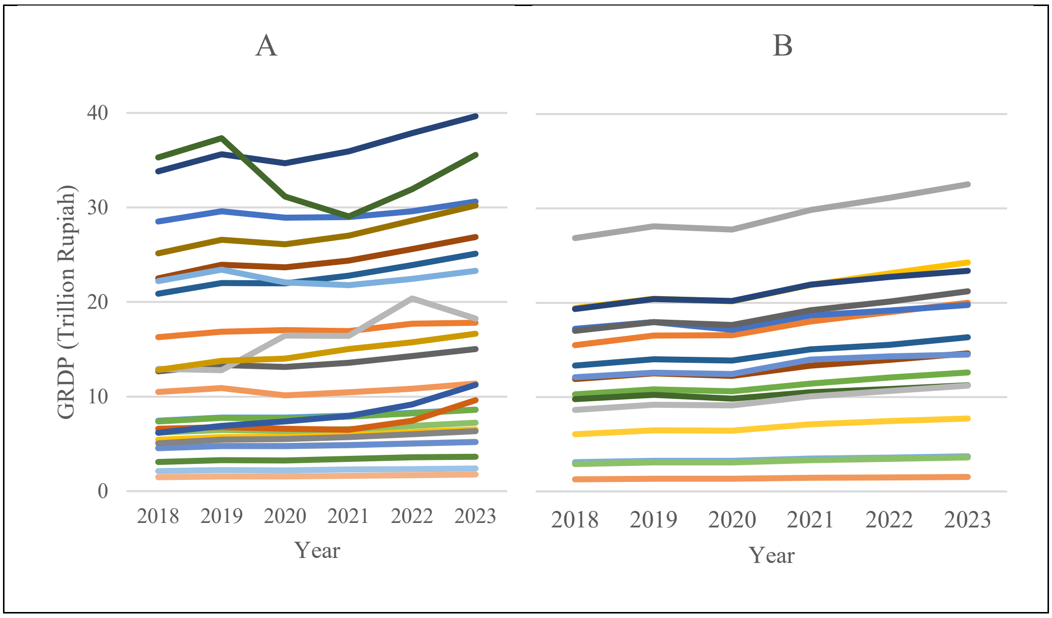


**Figure 1.** GRDP Trends in Regencies/Municipalities with Operational (A) and Non-Operational (B) PSN Dams
Source: KPPIP (2023), PUPR (2023), and BPS (2023) (processed)

Given their designation as large-scale infrastructure intended to promote regional economic development (President of the Republic of Indonesia, 2016) and their geographical dispersion across diverse regions (Coordinating Ministry for Economic Affairs of the Republic of Indonesia, 2023), PSN dams offer a valuable case for analyzing heterogeneous impacts based on regional economic structures. Drawing on economic base theory, this study investigates the differential effects of dams in agrarian and non-agrarian areas. This theoretical lens provides a more nuanced and comprehensive framework for understanding how dam infrastructure affects regional economies with varying base sectors and structural characteristics.

Figure 2 illustrates the conceptual framework of this study. Based on production theory and economic base theory, the framework models the transmission mechanisms through which strategic dam development—primarily designed for irrigation—affects regional economic growth. It outlines four channels of influence: direct effects, indirect effects, induced effects, and spillover effects.

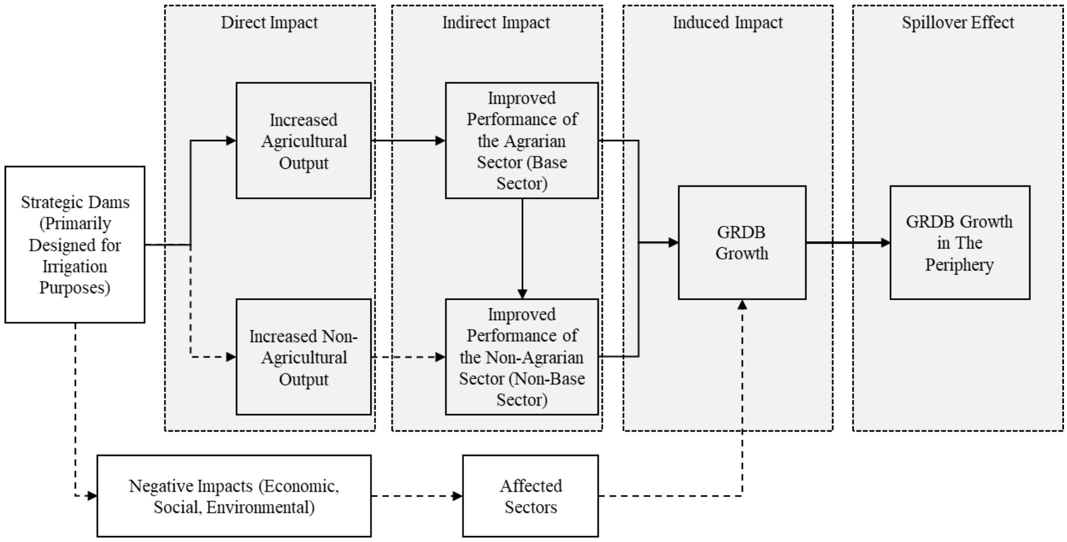


**Figure 2.** Conceptual Framework of PSN Dam Impacts on GRDP
Source: Adapted from (Bhatia, Cestti, Scatasta, & Malik, 2008), (Jeuland, 2020), (Mankiw, 2016), (WCD, 2000), and (WRD, 2023)

Direct effects include increases in agricultural output and gains in non-agricultural sectors such as hydropower and tourism. These lead to indirect effects through productivity spillovers and inter-sectoral linkages. Together, these dynamics culminate in induced effects, reflected in the growth of Gross Regional Domestic Product (GRDP). This process also generates spillover effects, where economic gains in key sectors stimulate growth in surrounding regions. While potential negative externalities (e.g., environmental, social, or economic) are acknowledged, the framework assumes these are mitigated through strategic infrastructure planning, thereby preserving the overall positive effect on GRDP. It is important to note that this framework is designed to conceptualize causal pathways, not to estimate sector-level or output-specific impacts, as this study focuses on the aggregate impact of dams on regional GRDP.

This study seeks to answer three central questions. First, what is the impact of PSN dams on economic growth in agrarian regions where agriculture functions as the base sector? Second, does the impact of PSN dams in non-agrarian regions differ significantly from their impact in agrarian regions? Lastly, can the application of economic base theory—by distinguishing regions based on their base sectors—help explain geographical variation in dam impacts and provide insights into the direct and indirect channels of influence?

This research is expected to contribute to the literature on dam-induced regional economic growth by offering an alternative approach to identifying geographical variations and explaining both direct and indirect economic effects. The findings aim to inform more effective dam development policies by aligning investments with regional economic structures, thereby maximizing benefits and minimizing risks. Furthermore, the study can serve as a reference for future research developing more comprehensive methods to assess the economic impact of dams.

# METHOD

## Data and Sample

This study utilizes panel data on Gross Regional Domestic Product (GRDP) at constant 2010 prices as an indicator of regional economic growth at the regency/municipality level for the period 2018–2023. The data, sourced from the publications of Statistics Indonesia (BPS), cover both the pre-operation phase (2018–2020) and the post-operation phase (2021–2023) of several National Strategic Project (PSN) dams. The list of PSN dams is based on the Regulation of the Coordinating Minister for Economic Affairs Number 7 of 2023. The operational status of the dams is derived from biannual reports published by the Committee for Acceleration of Priority Infrastructure Delivery (KPPIP) from 2016 to 2023, as well as from data provided by the Ministry of Public Works and Housing (PUPR).

Additional data include population statistics from the Ministry of Home Affairs, road length and labor force data from BPS publications, agricultural land area from the 2023 Agricultural Census published by BPS, and the percentage of urban areas—used to reflect the level of urbanization—sourced from the 2020 Urban-Rural Village Classification.

The research sample consists of 259 regencies/municipalities: 44 hosting PSN dams (core regions), 119 directly bordering the core regions (immediate neighbors), and 96 bordering the immediate neighbors (second-tier neighbors). The sample was selected to improve comparability across regions that fall within the eligibility criteria for PSN dam development and to assess the extent to which these dams influence economic growth in surrounding areas.

The research sample is divided into two groups based on the operational status of PSN dams: the treatment group, which includes regencies/municipalities with dams already in operation, and the control group, which includes regencies/municipalities with dams that have not yet become operational. This classification refers to data from the Ministry of Public Works and Housing (PUPR) as of December 31, 2023, indicating that out of 48 PSN dams, 20 were operational, while the remainder were still in the planning or construction stage.

Each treatment and control group is further classified into agrarian and non-agrarian categories using the *Location Quotient* (LQ) method. The agricultural sector is considered a base sector in a regency and municipality if the LQ value is greater than 1. The LQ is calculated using the following formula:

$$\rho_{ij} = \frac{GRDP_{ij}/GRDP_{*j}}{GDP_{i*}/GDP_{**}} \quad (1)$$

where:

$\rho_{ij}$ = LQ value indicating the relative specialization of sector i in regency and municipality j;

$GRDP_{ij}$ = average GRDP of sector i in regency and municipality j;

$GRDP_{*j}$ = average total GRDP in regency and municipality j;

$GDP_{i*}$ = average GDP of sector i;

$GDP_{**}$ = average total GDP.

The distribution of treatment and control groups by tier, group, and regional characteristics is presented in Table 1.

**Table 1.** Distribution of Sample Regencies and Municipalities

| Tier | Group | Agrarian | Non-agrarian | Total |
|---|---|---|---|---|
| Tier 1 (Core region) | Treatment | 16 | 2 | 18 |
| | Control | 20 | 6 | 26 |
| | Subtotal | 36 | 8 | 44 |
| Tier 2 (Immediate neighbors) | Treatment | 38 | 7 | 45 |
| | Control | 58 | 16 | 74 |
| | Subtotal | 96 | 23 | 119 |
| Tier 3 (Second-tier neighbors) | Treatment | 18 | 19 | 37 |
| | Control | 40 | 19 | 59 |
| | Subtotal | 58 | 38 | 96 |
| Total | | 190 | 69 | 259 |

Source: PUPR and KPPIP, processed

## Analytical Model

The estimation model adopts a production function framework, where regional economic output (Y), measured by GRDP, is defined as:

$$Y = f(Dam, Land, Road, Labor, Urban) \quad (2)$$

Here, Dam represents dam operations, Land is agricultural land area, Road denotes road infrastructure, Labor is the labor force size, and Urban reflects the percentage of urbanized areas.

To estimate the impact of dam development on regional economic growth, this study employs the Difference-in-Differences (DiD) approach. This method compares changes in GRDP between the treatment and control groups before and after the intervention, while controlling for time-invariant differences across regions. The DiD model used in this study is illustrated in Figure 3.

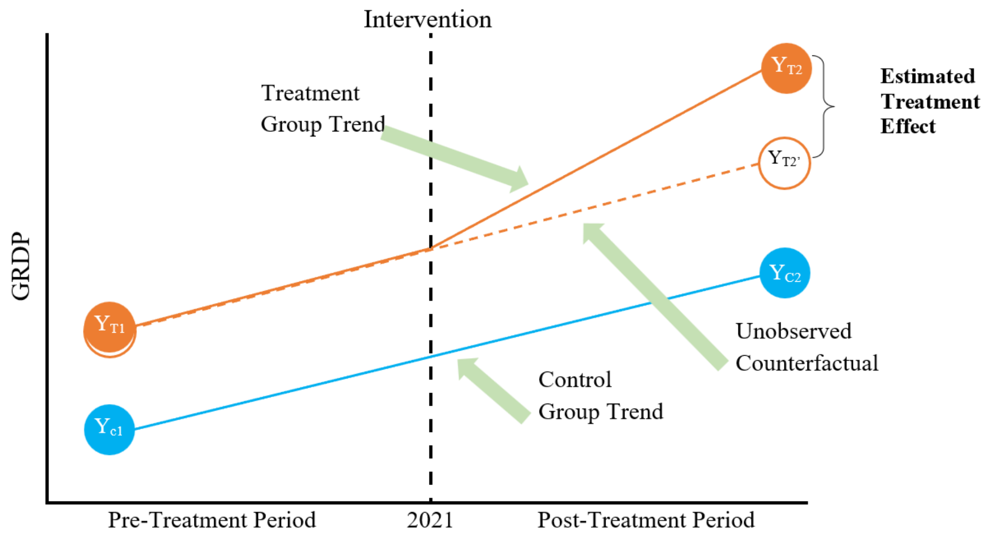


**Figure 3.** DiD Model for Estimating the Impact of Dams on GRDP
Source: Author's analysis

The analysis proceeded in three stages: (i) the full sample, (ii) agrarian regions, and (iii) non-agrarian regions. Each stage involved estimating both the overall impact of dam operations and the annual impact trend, assessed across three spatial tiers: core areas (Tier 1), immediate neighbors (Tier 2), and second-tier neighbors (Tier 3).

The DiD regression model was specified within the framework of a production function, with the inclusion of a Java dummy variable to distinguish between regencies/municipalities located on Java Island and those outside Java, given the substantial differences in GRDP levels between the two regions. The estimation model is specified as follows:

$$grdp_{it} = \alpha + \beta_1 dam_i + \beta_2 period_t + \beta_3 (dam_i \, X \, period_t) + \beta_4 land_{it} + \beta_5 road_{it} + \beta_6 labor_{it} + \beta_7 urban_i + \beta_8 java_i + \varepsilon_{it} \quad (3)$$

Here, $\beta_3$ captures the impact of dam operations on GRDP, while the control variables are included to improve estimation accuracy.

To analyze the annual impact trend, the model is extended by incorporating yearly dummy variables ($year_k$) as follows:

$$grdp_{it} = \alpha + \beta_1 dam_i + \sum_k \gamma_k year_k + \sum_k \delta_k \, (dam_i \, X \, year_k) + \beta_2 land_{it} + \beta_3 road_{it} + \beta_4 labor_{it} + \beta_5 urban_i + \beta_6 java_i + \varepsilon_{it} \quad (4)$$

In this specification, $\delta_k$ represents the year-specific effects of dam operations.

Table 2 provides an overview of the variables employed in this study, including the outcome variable, key explanatory variable, and control variables, and regional dummy.

**Table 2.** Variable Descriptions

| Variable | Description |
|---|---|
| grdp | Outcome variable representing the value of Gross Regional Domestic Product (GRDP) (in trillion rupiah) in regency/municipality i in year t. |
| dam | Dummy variable indicating whether regency/municipality i belongs to the treatment group affected by the dam (1) or to the control group (0). |
| period | Dummy variable indicating whether year t falls after the dam began operating (1) or before the operation (0). |
| year | Year-specific dummy variable: 0 for pre-intervention years (2018–2020), 1 for 2021, 2 for 2022, and 3 for 2023 (used for trend analysis). |
| land | Control variable representing the area of agricultural land (in thousand hectares) in regency/municipality i in year t. |
| road | Control variable representing the length of roads (in thousand kilometers) in regency/municipality i in year t. |
| labor | Control variable representing the number of workers/labor force (in millions) in regency/municipality i in year t. |
| urban | Control variable indicating the percentage of urban area in regency/municipality i. |
| java | Dummy variable indicating whether a regency/municipality is located on the island of Java or outside Java |

Source: Processed from BPS, KPPIP, and Ministry of Public Works and Housing (PUPR)

According to Gertler et al. (2011) and Angrist & Pischke (2008), the Difference-in-Differences (DiD) method effectively eliminates bias arising from unobserved time-invariant heterogeneity between treatment and control groups. However, its validity depends on the parallel trends assumption being satisfied prior to the intervention. To reinforce this assumption and ensure the robustness of the estimates, a parallel trends test is conducted, and control variables are incorporated to mitigate potential bias from external factors. This approach enables a more comprehensive assessment of the impacts of dam operations on regional economic growth across both agrarian and non-agrarian areas.

To enhance the validity of the impact estimation, this study applies Propensity Score Matching (PSM) prior to conducting the DiD regression to assess the effect of dam operations on GRDP. As a quasi-experimental method, PSM mitigates selection bias by matching treatment and control units based on propensity scores derived from relevant covariates, namely road infrastructure (road), labor force size (labor), agricultural land area (land), and the degree of urbanization (urban). Propensity scores are estimated using both logistic and probit regressions, and units with similar scores are matched through the nearest neighbor method with a 0.05 caliper. Only units within the region of common support are retained for treatment effect estimation. This approach follows Rosenbaum and Rubin (1983, 1984), who emphasize that PSM effectively reduces self-selection bias in observational studies.

Table 3 presents the comparison of outcomes (GRDP) before and after matching. Prior to matching, the treatment and control groups exhibited a significant difference in average GRDP of 26.17 (T-stat = 9.65). After matching, this difference was substantially reduced to 2.76 and became statistically insignificant (T-stat = 0.69). These results suggest that the initial gap was largely driven by imbalances in group characteristics rather than the direct effect of dam operations, indicating that the application of PSM effectively improved the comparability between the treatment and control groups.

**Table 3.** GRDP Comparison Before and After Matching

| Sample | Treatment Group | Control Group | Difference | Std. Error | T-stat |
|---|---|---|---|---|---|
| Unmatched | 44.51 | 18.34 | 26.17 | 2.71 | 9.65 |
| Matched (ATT) | 36.67 | 33.92 | 2.76 | 3.97 | 0.69 |

Source: Author’s calculation

Table 4 reports the distribution of common support. A total of 35 treatment units fall outside the common support region and are therefore excluded to ensure the validity of the treatment effect estimation. The majority of units, however, lie within the region of common support, suggesting that the propensity score matching procedure was effectively implemented and that the treatment and control groups are comparable within the retained sample.

**Table 4.** Common Support Distribution

| Group | Off Support | On Support | Total |
|---|---|---|---|
| Untreated | 0 | 1,140 | 1,140 |
| Treated | 35 | 721 | 756 |

Source: Author’s calculation

All DiD analyses in this study are conducted using data obtained through PSM. This approach enhances the reliability of the estimated impact of dams on GRDP by mitigating potential selection bias, which is a common issue in observational studies. By matching treatment and control units based on propensity scores, the comparison between groups becomes more balanced and equitable, thereby allowing the results to better reflect causal effects. Consequently, the findings are not only empirically relevant but also provide credible insights to inform policy decision-making.

## RESULTS AND DISCUSSION

### Descriptive Statistics of Research Variables

Table 5 presents the descriptive statistics of the main variables after applying the PSM procedure, highlighting the contrasts between agrarian and non-agrarian regions.

**Table 5.** Descriptive Statistics of Key Variables

| Variable | Full Samples | Agrarian | Non-agrarian |
|---|---|---|---|
| grdp | 33.696 | 13.990 | 78.887 |
| | (65.945) | (11.810) | (105.314) |
| land | 14.292 | 16.517 | 9.190 |
| | (15.843) | (15.983) | (14.284) |
| road | 1.223 | 1.170 | 1.343 |
| | (1.379) | (0.486) | (2.390) |
| labor | 0.582 | 0.484 | 0.806 |
| | (0.664) | (0.628) | (0.693) |
| urban | 0.455 | 0.318 | 0.770 |
| | (0.321) | (0.219) | (0.295) |

Note: The values reported are means; figures in parentheses represent standard errors.
Source: Processed from BPS, KPPIP, and Ministry of Public Works and Housing (PUPR).

The average GRDP in agrarian regions amounts to IDR 13.990 trillion with relatively small variation, whereas non-agrarian regions record an average of IDR 78.887 trillion with considerably larger variation. Agricultural land area in agrarian regions (16,517 thousand hectares) is substantially larger than in non-agrarian regions (9,190 thousand hectares). In contrast, road length, labor force size, and the proportion of urban areas are all higher in non-agrarian regions. Overall, the average GRDP across the entire sample is IDR 33.686 trillion, reflecting significant structural differences in the economies of the two groups of regions.

### Parallel Trends Test

To ensure the validity of the DiD model, a parallel trends test was conducted by examining the average GRDP trends prior to the intervention (2018–2020) across the full sample (Figure 4), agrarian regions (Figure 5), and non-agrarian regions (Figure 6). In addition, trends before and after matching were compared to assess the extent to which PSM improved group balance.

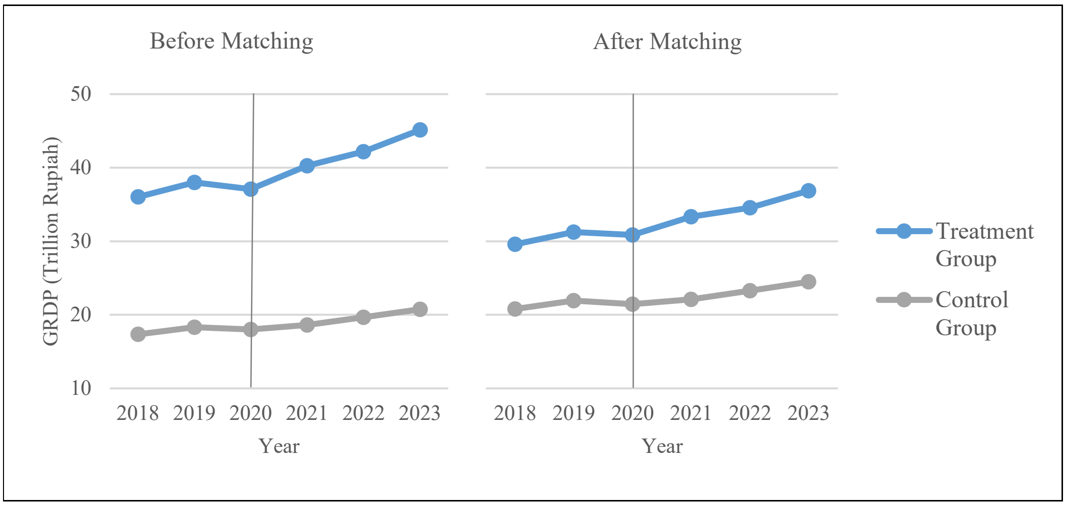


**Figure 4.** Average GRDP Trends (Full Sample)
Source: Processed from BPS data

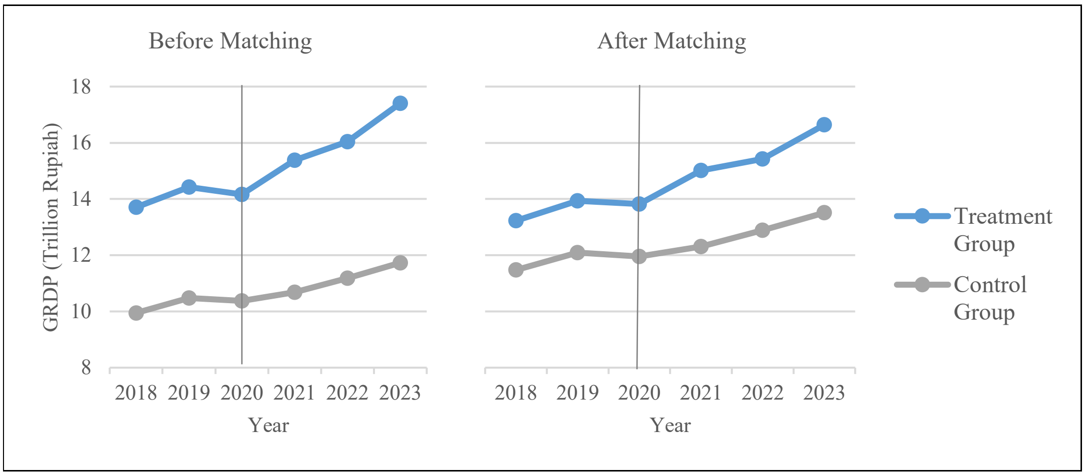


**Figure 5.** Average GRDP Trends (Agrarian Regions)
Source: Processed from BPS data

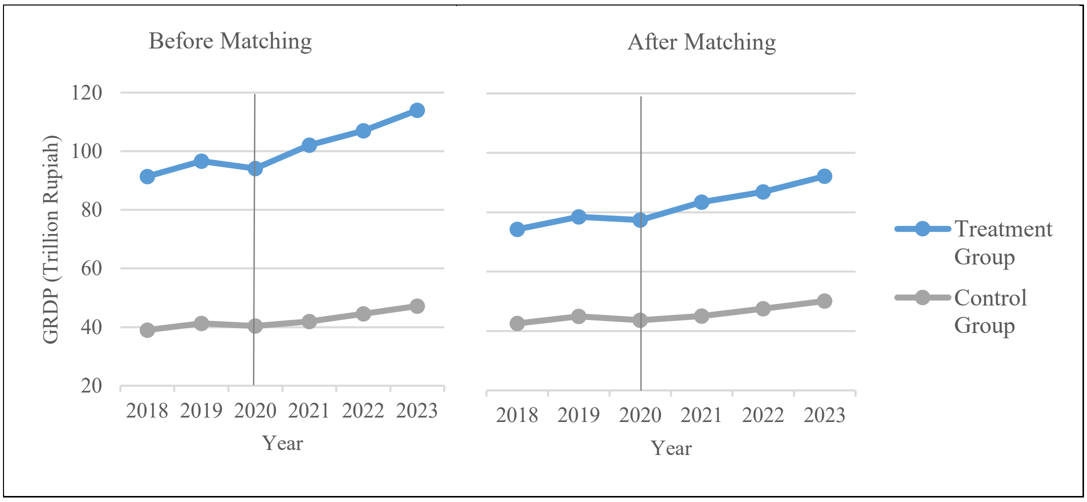


**Figure 6.** Average GRDP Trends (Non-Agrarian Regions)
Source: Processed from BPS data.

The three figures indicate that, prior to matching, there remained noticeable differences in pre-intervention GRDP trends between the treatment and control groups, both in the full sample and within agrarian and non-agrarian classifications. Nonetheless, these trends were already relatively parallel, as the sample regencies and municipalities were either PSN dam construction sites or neighboring areas expected to share similar economic characteristics. After matching, the trends of the two groups became more parallel and displayed a more balanced pattern. This confirms that PSM effectively strengthened the validity of the parallel trends assumption in the DiD framework, thereby enhancing the credibility and reliability of the estimated treatment effects.

**Estimation Results for the Full Sample**

The initial estimation was conducted to identify the impact of PSN dam construction on GRDP across the full sample, without distinguishing between agrarian and non-agrarian areas. The results presented in Table 6 indicate that the operational impact of PSN dams on GRDP is statistically insignificant across all tiers—namely, core areas (Tier 1), immediate neighboring areas (Tier 2), and second-tier neighboring areas (Tier 3). The direction of the impact also varies, with negative effects observed in core areas and positive effects in neighboring areas.

**Table 6.** Estimated Impact of Dams on GRDP (Full Sample)

| Variable | Tier 1 | Tier 2 | Tier 3 |
|---|---|---|---|
| dam | -0.578 | 5.826 | -5.5310 |
| | (3.913) | (3.997) | (5.293) |
| period | 7.011* | -1.967 | -1.576 |
| | (3.912) | (4.399) | (6.26) |
| dam*period | -5.439 | 3.996 | 6.346 |
| | (4.598) | (5.424) | (7.45) |
| land | 0.142** | -0.231** | -0.327** |
| | (0.056) | (0.104) | (0.146) |
| road | -1.235 | -5.021* | 24.306*** |
| | (2.105) | (2.788) | (0.820) |
| labor | 48.344*** | 67.876*** | 9.032*** |
| | (2.232) | (3.967) | (1.989) |
| urban | 12.165* | 33.392*** | 28.918*** |
| | (6.695) | (6.196) | (7.185) |
| java | -15.421*** | -34.996*** | 37.116*** |
| | (2.802) | (4.038) | (5.742) |
| Constant | -5.822 | -6.699 | -24.938*** |
| | (4.700) | (5.073) | (5.279) |
| Observation | 154 | 387 | 306 |
| R-squared | 0.843 | 0.561 | 0.817 |

Note: Figures in parentheses are standard errors; *** significant at the 1% level; ** significant at the 5% level; * significant at the 10% level
Source: Author’s calculation

Table 7 presents the estimated trends of the PSN dam impact on GRDP during the post-operational period. Overall, most estimations indicate statistically insignificant effects across all tiers throughout the observation period, although the direction and trend patterns vary by region. In core areas, the negative impact intensifies over time and becomes statistically significant in the third year. In immediate neighboring areas, the impact shows a steadily increasing positive trend, though it remains statistically insignificant up to the third year. Meanwhile, in second-tier neighboring areas, the impact exhibits a fluctuating and inconsistent trend.

**Table 7.** Estimated Trends of Dam Impact on GRDP (Full Sample)

| Variable | Tier 1 | Tier 2 | Tier 3 |
|---|---|---|---|
| dam | -0.814 | 5.741 | -5.553 |
| | (3.894) | (4.000) | (5.323) |
| year1 | 3.855 | 2.657 | -2.870 |
| | (5.053) | (6.271) | (9.113) |
| year2 | 3.200 | 1.435 | 3.682 |
| | (4.907) | (6.078) | (9.115) |
| year3 | 14.817*** | -9.649 | -5.069 |
| | (5.181) | (6.068) | (8.692) |
| dam*year1 | -1.279 | -0.406 | 7.148 |
| | (6.074) | (7.716) | (10.772) |
| dam*year2 | -1.186 | 0.226 | 1.604 |
| | (5.965) | (7.568) | (10.772) |
| dam*year3 | -14.630** | 11.780 | 9.820 |
| | (6.181) | (7.522) | (10.419) |
| land | 0.143** | -0.212** | -0.332** |
| | (.056) | (0.104) | (0.147) |
| road | -1.729 | -5.201* | 24.294*** |
| | (2.107) | (2.797) | (0.824) |
| labor | 48.389*** | 68.151*** | 8.986*** |
| | (2.221) | (3.979) | (2.001) |
| urban | 12.676* | 34.393*** | 28.712*** |
| | (6.664) | (6.225) | (7.231) |
| java | -15.498*** | -35.783*** | 37.458*** |
| | (2.788) | (4.064) | (5.796) |
| Constant | -5.219 | -7.005 | -24.875*** |
| | (4.683) | (5.086) | (5.309) |
| Observation | 154 | 387 | 306 |
| R-squared | 0.849 | 0.564 | 0.817 |

Note: Figures in parentheses are standard errors; *** significant at the 1% level; ** significant at the 5% level; * significant at the 10% level
Source: Author's calculation

The estimation results for the entire sample indicate that, without distinguishing between agrarian and non-agrarian characteristics, the operation of PSN dams has not yet produced a significant effect on GRDP during the observation period, either in the core regions or in the surrounding areas. However, the increasing negative trend in the core regions culminated in a significant adverse effect in the third year. Conversely, the upward trend in positive effects in neighboring areas suggests the potential for significant long-term benefits.

**Estimation Results for Agrarian Regions**

Subsequently, the analysis examines the impact of PSN dams in agrarian regions. The estimation results presented in Table 8 indicate that dam operations generate a positive and significant effect on GRDP in the core area, amounting to IDR 2.563 trillion, and in the immediate neighboring area, amounting to IDR 2.389 trillion, while the effect in the second neighboring area remains insignificant.

**Table 8**. Estimated Impact of Dams on GRDP (Agrarian Regions)

| Variable | Tier 1 | Tier 2 | Tier 3 |
|---|---|---|---|
| dam | -3.439*** | -3.795*** | 2.281 |
| | (1.097) | (1.01) | (1.788) |
| period | -1.160 | -.0306 | -2.859 |
| | (1.130) | (1.146) | (2.109) |
| dam*period | 2.563** | 2.389* | 3.935 |
| | (1.276) | (1.366) | (2.557) |
| land | .0094*** | 0.149*** | -0.057 |
| | (0.019) | (0.027) | (0.053) |
| road | -0.3270 | 4.009*** | 12.319*** |
| | (0.718) | (0.755) | (1.287) |
| labor | 25.674*** | 17.334*** | 0.88 |
| | (1.991) | (1.423) | (0.558) |
| urban | 4.333** | 14.957*** | 18.459*** |
| | (1.729) | (2.174) | (3.448) |
| java | -3.834*** | -2.644** | 19.464*** |
| | (1.061) | (1.268) | (2.634) |
| Constant | 2.574* | -2.359* | -12.636*** |
| | (1.388) | (1.299) | (2.295) |
| Observation | 125 | 312 | 160 |
| R-squared | 0.889 | 0.804 | 0.691 |

Note: Figures in parentheses are standard errors; *** significant at the 1% level; ** significant at the 5% level; * significant at the 10% level
Source: Author’s calculation

The trend analysis in Table 9 further shows that, within the core area, the positive impact tends to decline over time and becomes insignificant by the third year of operation. Conversely, in the neighboring areas, although initially insignificant, the positive trend consistently increases and may potentially reach significance in the longer term. These findings suggest that, in agrarian regions, PSN dams deliver strong but temporary benefits in the core area, while the spillover effects appear more promising in neighboring areas.

**Table 9**. Estimated Trends of Dam Impact on GRDP (Agrarian Regions)

| Variable | Tier 1 | Tier 2 | Tier 3 |
|---|---|---|---|
| dam | -3.410*** | -3.809*** | 2.273 |
| | (1.109) | (1.014) | (1.804) |
| year1 | -1.235 | 0.647 | -2.068 |
| | (1.518) | (1.692) | (2.73) |
| year2 | -0.935 | -0.530 | -1.832 |
| | (1.414) | (1.641) | (3.055) |
| year3 | -1.353 | -0.871 | -5.908* |
| | (1.557) | (1.563) | (3.507) |
| dam*year1 | 3.040* | 0.823 | 2.941 |
| | (1.730) | (1.997) | (3.421) |
| dam*year2 | 2.780* | 2.453 | 3.112 |
| | (1.637) | (1.958) | (3.685) |
| dam*year3 | 1.893 | 3.706** | 6.982* |
| | (1.766) | (1.880) | (4.069) |
| land | .0093*** | .150*** | -0.064 |
| | (0.020) | (0.027) | (0.054) |
| road | -0.337 | 4.016*** | 12.341*** |
| | (0.738) | (0.760) | (1.299) |
| labor | 25.840*** | 17.306*** | 0.860 |
| | (2.013) | (1.431) | (0.563) |
| urban | 4.338** | 15.027*** | 18.330*** |
| | (1.745) | (2.202) | (3.495) |
| java | -3.901*** | -2.692** | 19.943*** |
| | (1.073) | (1.284) | (2.697) |
| Constant | 2.535* | -2.370* | -12.593*** |
| | (1.419) | (1.305) | (2.318) |
| Observation | 125 | 312 | 160 |
| R-squared | 0.889 | 0.805 | 0.693 |

Note: Figures in parentheses are standard errors; *** significant at the 1% level; ** significant at the 5% level; * significant at the 10% level
Source: Author's calculation

### Estimation Results for Non-Agrarian Regions

The analysis then proceeds to non-agrarian regions. As shown in Table 10, the estimated impacts of dam operations on GRDP are not statistically significant across all tiers. However, the trend analysis in Table 11 uncovers a different dynamic: in the core area, the effect remains insignificant and shows a tendency toward increasing negative impacts over time, whereas in the neighboring areas, the positive impact gradually strengthens. Notably, in the immediate neighboring area, the effect becomes both positive and significant by the third year. These results indicate that, in non-agrarian regions, the benefits of dams are not yet realized in the core area but begin to emerge in neighboring areas—particularly the immediate neighbors—and may contribute more substantially to regional economic growth in the future.

**Table 10.** Estimated Impact of Dams on GRDP (Non-agrarian Regions)

| Variable | Tier 1 | Tier 2 | Tier 3 |
|---|---|---|---|
| dam | 161.049*** | 19.684 | 1.835 |
| | (51.622) | (11.805) | (9.568) |
| period | 16.471* | -5.746 | 7.380 |
| | (8.293) | (10.573) | (11.24) |
| dam*period | -2.866 | 17.010 | 2.985 |
| | (12.419) | (14.943) | (13.029) |
| land | -2.229*** | 5.498*** | -0.798*** |
| | (0.708) | (0.629) | (0.296) |
| road | 39.901*** | 26.201*** | 22.277*** |
| | (10.249) | (7.700) | (1.032) |
| labor | -16.510 | 3.187 | 53.685*** |
| | (19.037) | (12.019) | (6.104) |
| urban | -98.229*** | 102.638*** | 18.132 |
| | (29.24) | (16.053) | (13.593) |
| java | 47.863** | -56.204*** | 17.541* |
| | (17.523) | (9.438) | (9.413) |
| Constant | 34.208** | -51.529*** | -30.344** |
| | (14.080) | (16.025) | (13.457) |
| Observation | 29 | 75 | 146 |
| R-squared | 0.937 | 0.821 | 0.865 |

Note: Figures in parentheses are standard errors; *** significant at the 1% level; ** significant at the 5% level; * significant at the 10% level
Source: Author's calculation

**Table 11.** Estimated Trends of Dam Impact on GRDP (Non-agrarian Regions)

| Variable | Tier 1 | Tier 2 | Tier 3 |
|---|---|---|---|
| dam | 159.476** | 20.888* | 1.798 |
| | (55.998) | (11.652) | (9.696) |
| year1 | 10.686 | 13.479 | 14.448 |
| | (11.017) | (13.845) | (21.522) |
| year2 | 15.476 | -7.949 | 9.862 |
| | (11.865) | (13.556) | (16.412) |
| year3 | 23.992* | -25.916* | 3.618 |
| | (11.68) | (14.452) | (13.735) |
| dam*year1 | 0.430 | -5.477 | -6.162 |
| | (17.701) | (20.184) | (23.495) |
| dam*year2 | -4.622 | 18.076 | -0.823 |
| | (18.094) | (19.995) | (18.921) |
| dam*year3 | -5.162 | 41.648** | 10.167 |
| | (18.030) | (20.619) | (16.671) |
| land | -2.142** | 5.697*** | -0.796*** |
| | (0.775) | (0.628) | (0.300) |
| road | 37.558*** | 25.790*** | 22.289*** |
| | (11.519) | (7.607) | (1.046) |
| labor | -15.379 | 1.021 | 53.460*** |
| | (20.696) | (11.952) | (6.207) |
| urban | -83.215** | 111.176*** | 17.563 |
| | (34.867) | (16.278) | (13.811) |
| java | 42.264** | -57.889*** | 17.716* |
| | (19.792) | (9.333) | (9.604) |
| Constant | 30.214* | -56.182*** | -29.837** |
| | (15.551) | (15.925) | (13.664) |
| Observation | 29 | 75 | 146 |
| R-squared | 0.942 | 0.837 | 0.866 |

Note: Figures in parentheses are standard errors; *** significant at the 1% level; ** significant at the 5% level; * significant at the 10% level
Source: Author's calculation

## Discussion

Overall, the estimation results indicate variations in the impact of PSN dams on GRDP between agrarian and non-agrarian regions. In agrarian regions, dams generate positive and significant effects, both in the core area and in directly adjacent areas. In contrast, in non-agrarian regions, the impacts are not significant, resulting in an overall insignificant aggregate effect across the full sample.

These findings are consistent with Li, Liao, & Dai (2022), Mary et al. (2023), and Xi (2023), who demonstrate that dams can enhance agricultural productivity through irrigation. This is further supported by production theory (Mankiw, 2016) and economic base theory (Edward, 2007), which argue that public infrastructure such as dams can stimulate output in the base sector, particularly agriculture in agrarian regions. The increase in agricultural output subsequently generates direct, indirect, and induced effects (Bhatia et al., 2008) through productivity gains, worker expenditures, and local economic activities. Thus, PSN dams trigger significant economic dynamics in agrarian regions through interactions between base and non-base sectors, while also producing spillover effects in neighboring areas.

Trend analysis further highlights distinct patterns between the two types of regions. In agrarian regions, the positive impacts in the core area tend to decline over time and may become insignificant, whereas in non-agrarian regions, the trend indicates a growing negative effect. By contrast, in neighboring areas—both in agrarian and non-agrarian regions—the positive impacts tend to increase, with some becoming significant over time. These findings align with Duflo & Pande (2007), who suggest that while dams can increase agricultural output in downstream areas, they may simultaneously create instability in areas surrounding the dam.

Taken together, these results underscore that the effectiveness of dams in fostering economic growth is highly contingent on regional economic structures. In agrarian regions, agriculture as the base sector drives significant multiplier effects that foster sustained growth. Conversely, in non-agrarian regions, where agriculture is not the base sector, the direct effects of dams are insufficient to generate meaningful indirect effects, thereby limiting their contribution to economic growth. This suggests the need for complementary interventions tailored to the characteristics of non-agrarian economies in order to maximize the potential benefits of dams.

## CONCLUSION

The study demonstrates that the impact of PSN dam operations on GRDP varies according to spatial characteristics and economic structure. In the initial analysis of the full sample, the effect of dams was not statistically significant across all areas. Trend analysis, however, revealed differing patterns, with a tendency for increasing negative effects in the core areas and increasing positive effects in the immediate neighboring areas.

When analyzed separately, agrarian regions exhibited more pronounced impacts. PSN dams had positive and significant effects on GRDP in both core areas and immediate neighboring areas, while the effect in second-tier neighboring areas was not significant. Trend analysis showed that the positive effect in core areas tends to decline over time, whereas the effects in surrounding areas, including second-tier neighboring areas, increase, indicating potential long-term benefits.

In non-agrarian regions, the direct impact of dams was not significant across all areas. Nonetheless, trends indicate emerging positive effects in immediate neighboring areas, while core areas exhibit an increasing negative trend over time.

Overall, the effectiveness of PSN dam operations in fostering economic growth depends on the local economic context. In agrarian regions, benefits are first realized in core areas and then spill over to surrounding areas. In non-agrarian regions, although direct benefits remain limited, positive spillover potential begins to emerge in immediate neighboring areas. However, the declining positive impact in core areas of agrarian regions and the increasing negative trend in core areas of non-agrarian regions pose risks to the sustainability of benefits and may limit future spillover effects.

These findings reinforce the relevance of the economic base theory in explaining variations in dam impacts between agrarian and non-agrarian regions. Infrastructure benefits are stronger when the local economic base—such as agriculture in agrarian areas—can directly leverage it. Accordingly, strategies for dam utilization should be tailored to the characteristics of non-agrarian regions to maximize indirect effects. This study demonstrates that the economic base approach provides a valuable framework for understanding both direct and indirect impacts of dam infrastructure.

This study has several limitations. First, it focuses solely on PSN dams, limiting generalizability to non-PSN dams. Second, the short study period (2018–2023) provides only an initial overview, leaving long-term, indirect, and induced impacts largely unexamined. Third, dam functional capacities—such as irrigation, hydropower, and flood control—are not differentiated, which may affect impact estimates. Fourth, the analysis considers only GRDP, excluding other economic dimensions such as household income, employment, and industrial output. Future research should expand the data scope, extend the analysis period, account for dam functions, and incorporate broader economic indicators for a more comprehensive assessment.

From a policy perspective, planning and utilization of dams should align with local economic structures and base sectors. In agrarian core areas, strategies should sustain positive impacts, while in non-agrarian core areas, mitigation strategies are needed to minimize potential negative effects. Additionally, spillover benefits in neighboring regions should be optimized through the development of local economic sectors leveraging dam infrastructure. This approach ensures that dam development strategies are contextually appropriate, effective, and sustainable.

## REFERENCES

Angrist, J. D., & Pischke, J.-S. (2008). *Mostly Harmless Econometrics: An Empiricist's Companion.* New Jersey: Princeton University Press.

Aribowo, G., & Yudhistira, M. H. (2021). Large Dams and Welfare: Empirical Study in Indonesia. *Economics Development Analysis Journal, 10 (1)*, 70-85.

Bhatia, R., Cestti, R., Scatasta, M., & Malik, R. (2008). *Indirect economic impacts of dams: Case studies from India, Egypt, and Brazil.* New Delhi: Academic Foundation.

Coordinating Ministry for Economic Affairs of the Republic of Indonesia. (2023). *Regulation of the Coordinating Minister for Economic Affairs Number 8 of 2023 concerning the Fourth Amendment to Regulation Number 7 of 2021 on the Amendment to the List of National Strategic Projects.* State Gazette of the Republic of Indonesia of 2023 Number 904.

Dillon, A., & Fishman, R. (2019). Dams: Effects of Hydrological Infrastructure on Development. *Annual Review of Resource Economics, 11*, 125-148.

Duflo, E., & Pande, R. (2007). Dams. *The Quarterly Journal of Economics, 122 (2)*, 601-646.

Edwards, M. E. (2007). *Regional Urban Economics and Economic Development: Theory and Method.* New York: Auerbach Publications.

Gertler, P. J., Martinez, S., Premand, P., Rawlings, L. B., & Vermeersch, C. M. (2011). *Impact Evaluation in Practice.* Washington: The International Bank for Reconstruction and Development/The World Bank.

Government of the Republic of Indonesia. (2010). *Government Regulation of the Republic of Indonesia Number 37 of 2010 concerning Dams.* Jakarta: Minister of Law and Human Rights of the Republic of Indonesia.

He, X. (2023). Dams, cropland productivity, and economic development in China. *China Economic Review, 81*, 102046.

ICOLD. (2011). *Constitution Status.* Chatou: ICOLD.

ICOLD. (n.d.). *Role of Dams*. Retrieved July 27, 2024, from International Commission on Large Dams: https://www.icold-cigb.org/GB/dams/role_of_dams.asp

Jeuland, M. (2020). The Economic s of Dams. *Oxford Review of Economic Policy, 32 (1)*, 45-68.

KPPIP. (2023). *Laporan KPPIP Semester II Tahun 2023.* Jakarta: KPPIP.

KPPIP. (n.d.). *Proyek Strategis Nasional Bendungan dan Irigasi*. Retrieved 07 21, 2024, from Komite Percepatan Penyediaan Infrastruktur Prioritas: https://kppip.go.id/proyek-strategis-nasional/bendungan-dan-irigasi/

Li, J., Liao, L., & Dai, X. (2022). Economic and Agricultural Impacts of Building a Dam Evidence from Natural Experience of the Three-Gorges Dam. *Agriculture, 12*, 1372.

Mankiw, N. G. (2016). *Macroeconomics.* New York: Worth Publishers.

Mary, S., Craven, K., Stoler, A., & Shafiq, S. (2023). Revisiting the Impact of Dams on Malaria and Agriculture. *Economies, 11*, 173.

Nakamura, R., & Paul, C. J. (2009). Measuring Agglomeration. In R. Capello, & P. Nijkamp, *Handbook of Regional Growth and Development Theories* (pp. 101-117). Cheltenham: Edward Elgar Publishing Limited.

President of the Republic of Indonesia. (2016). *Presidential Regulation Number 3 of 2016 on the Acceleration of the Implementation of National Strategic Projects.* State Gazette of the Republic of Indonesia of 2016 Number 4.

PUPR. (2017). *Modul Kebijakan Dalam Pengembangan Bendungan.* Jakarta: Ministry of Public Works and Housing.

PUPR. (2023). *Bendungan*. Retrieved October 29, 2023, from Open Data PU: https://data.pu.go.id/dataset/bendungan

Rosenbaum, P. R., & Rubin, D. B. (1983). The central role of the propensity score in observational studies for causal effects. *Biometrika, 70(1)*, 41–55.

Rosenbaum, P. R., & Rubin, D. B. (1984). Reducing bias in observational studies using subclassification on the propensity score. *Journal of the American Statistical Association, 79(387)*, 516–524.

Shi, H., Chen, J., Liu, S., & Sivakumar, B. (2019). The Role of Large Dams in Promoting Economic Development under the Pressure of Population Growth. *Sustainability, 11*, 2965.

WCD. (2000). *Dams and Development: A New Framework for Decision Making.* London: Earthscan Publications Ltd.

WRD. (2023). *General Synthesis*. Retrieved July 27, 2024, from World Register on Dams: https://www.icold-cigb.org/GB/world_register/general_synthesis.asp