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Large Dams and Welfare : Empirical Study in Indonesia

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Abstract

In addition to solving the problem of water shortage for irrigation, energy and consumption, the policy of building large dam is also expected to improve population-welfare. However, previous studies suggest that people living near dams have less benefit from the existence of large dam. This study aims to provide empirical evidence the effect of large dam development on welfare to household living in sub-districts around large dam placement using National Socio-Economic Survey (SUSENAS) data in 2013-2018 from Central Bureau of Statistics and spatial large dam data in Indonesia. Estimated results indicate that addition large dam tend to be negatively correlated by 2.4-3.1 % with household consumption implying a tendency of decreasing welfare in local households. Estimated findings using Indonesia Family Life Survey (IFLS) in 2007 and 2014 show negative correlation likely to be caused by lower agricultural productivity and work activity. This result show there are economic agents who suffer from large water - infrastructure especially households living in sub-districts close to the dam.

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INTRODUCTION

The For many countries, large dams have become an ideal infrastructure for supporting water needs either consumption, irrigation or hydropower (Chen *et al.*, 2016). Moreover, irrigation investment in developed countries is seen to have played role in reducing poverty levels (Nguyen *et al.*, 2017; Yigzaw *et al.*, 2019). As a result, attempts to increase the number of large dams continued in accordance with the rise in national and regional economic growth in many countries (Shi *et al.*, 2019).

Dam technology implies that residents who are downstream or in service areas get greater benefits from irrigation, flood hazards, hydropower and dependence on rainfall, while residents in upstream areas only benefit from construction activity and potential economic activities around the reservoir (Duflo and Pande, 2007). Increased economic activity during construction at the site where the dam was constructed occurred resulting in increased job opportunities and shifts in local labor market, even though the household did not participate in agriculture (Mettetal, 2019). This mechanism affects households who living close to the dam and surrounding region's potential for economic well-being differences. Even the general concept show the development of agricultural infrastructure will have a positive impact on output. Nevertheless, the distribution of economic output may vary across regions.

Previous well-known study by Duflo & Pande, (2007) using agricultural output data from 1971-1999 along with poverty level data for 1973,1983, 1987, 1993 and 1999 in 374 districts in India shows that large dams have lower economic spill-over impacts to households in district

Surrounding area. This result was further elaborated in Africa countries by Blanc & Strobl, (2014); Mettetal, (2019); Sarsons, (2015); Strobl & Strobl, (2011) and found variations in the distribution of the benefits both agricultural and revenue using watershed border concept which across districts area. In line with this study , Takeshima, (2018) in Nigeria examined the differences in consumption expenditure for households living in the watershed areas where the dam was built and find lower household-expenditure to the household living near dams placement. Almost previous studies made focus study in continental country, using more aggregate administrative or watershed area which . Our present study aims to estimate the magnitude of distributional benefit mechanism in more disaggregate administration border unit sub-districts (kecamatan) in archipelago countries.

Meanwhile, most study in Indonesia demonstrating the negative impact of large dams on residents around the dam site have related to resident resettlement (Nakayama *et al.*, 1999; Fujikura and Nakayama, 2013) as well as environmental and health problems on residents around the reservoir (Kibret *et al.*, 2015, 2017, 2019; Kirchherr and Charles, 2016). (Ansar *et al.*, 2014) reveal construction of large dams potentially exceed than the projection estimated. Means large dams development cost might be exceed the benefit.

Specifically, this study aims to find empirical evidence effect of large dams development to economic welfare at the household level especially in sub-district area around dams placement. While there are handful of studies on the welfare effect of large dams in large countries (India, China and Africa) , literature on the effect large dams development to economic welfare using household level data in Indonesia may scant. Limited economic development data for smaller administrative unit, geographical characteristic variation (archipelago), and social-economics proves that providing the causal inference of large dams effect to economic welfare at household level in Indonesia remains challenging. This present study investigates whether large water infrastructure development in Indonesia has a different effect to economic welfare at household level who living near dams location as measuring by household-expenditure using National Social Economic Survey (SUSENAS) data.

We use Indonesia, as one of the most populous countries in the world. Since 2014 Indonesian government actively working to speed up the development of new large dams. Sixty-five new large dams were established in national strategic program (PSN) to support government goals fulfilling water resilience and energy sustainability (PUPR, 2015). However, the number of large dams is much smaller than China, India and United States[1]. There are only 12.68 billion cubic meter or 50 cubic meter per capita per year can be handle by a dam water availability despite Indonesia have water capacity up to 3.9 trillion cubic meter per year[2].

We only use operated large dam data to measuring effect to household expenditure as a proxy of economic welfare. This study argue that in archipelago countries like Indonesia, large dams may increase welfare to local economic development especially to community relatively close to the dams region.

In order to see the mechanism of the impact of large dams on the household - welfare, this study also explores effect of large dams on agricultural production as proxied by crop frequency and employment as proxied by work activity based on Indonesia Family Life Survey (IFLS) data. We used availability administration code in dataset to combine with our spatial dams data. This technique refers to Duflo & Pande, (2007); and Mettetal, (2019) in different scope of study area. This is the best we do considering limited information from dataset to quantify dam-affected household in sub-district (kecamatan) border.

The number of large dams is the variable of interest. In addition, we use control variables consisting of large dams characteristics (dam height, storage volume, and capacity), household characteristics and geographical characteristics (elevation and rainfall) to reduce spurious correlation and bias estimation. Five series SUSENAS dataset on 2013, 2014, 2016, 2017, and 2018 were construct and combining with spatial and dams characteristics to estimates effect of large dams development to household-expenditure as a proxy of economic welfare. Meanwhile we used IFLS 2007 and 2014 to estimate effect large dams development to work activity and agricultural production briefly.

Estimated results indicate that the growth in the number of large dams in Indonesia has a negative correlation in shifts in household consumption as a welfare proxy by 2.4%. Therefore the estimation results show that the effect of large dams on household food consumption is more significant than non-food consumption. Another effect of large dams on economic activity can be seen in lower agricultural productivity and work activity in household that living closer to the dams based on our estimates using IFLS data. Estimated result indicate a potential decline in welfare in households around the dam due to reduced agricultural productivity and work activities. This is corresponds to the study of Takeshima, (2018) which states that food consumption - expenditure tends to be lower in households living around dams.

The limitation of this study is that the existence of large dams is non-random. Dam placement might depend on geographical characteristics and policy intervention. This may potentially generate bias estimates (Mettetal, 2019). Previous study by Duflo & Pande, (2007); Mettetal, (2019); and Strobl & Strobl, (2011) suggest river gradient instrumental variable to control for endogenous dams placement. Attempts we use to minimize potential bias are taken by use control variable and fixed effect. Limitation at the sub-district level of river gradient data restrict us to use instrumental variable similar with previous study.

Our study contributes to the literature in three aspects. First, this study provide empirical

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[1] Dani Prabowo. https://properti.kompas.com/read/2018/07/30/223000221/bendungan-di-indonesia-kalah-banyak-dibanding-china-dan-amerika?page=all pada 10 Januari 2020.

[2] Strategic Planning Document, Directorate General of Water Resources 2015, the capacity lower than regional countries in South East Asia such as Thailand (1.277 m^3 per capita) and one level higher than Ethiopia (38 m^3 per capita).

evidence of the effect of large dam on local communities at household level in a smaller administrative area in archipelago country. Most recent studies in Indonesia only show role of large dams to agricultural sector in more aggregate area such as district at particular dams. Although several research in continental countries have shown the impact of large dams to regional economy, they never evaluate the policy of large dams in archipelago countries such as Indonesia. Our result suggest that closer population live to the dams area, lowering their economic-welfare. Addition of large dams could not trigger household welfare especially who relatively close to the dams. Several previous study suggest variation in the distributional impact of large dams and find lower welfare in the upstream area and its surrounding.

Second, this study contributes the effects of a decline in the welfare of the population within the boundaries in a more disaggregated area. This study also explores the effect on agricultural productivity and work activities of large dams, follow previous research by Mettetal, (2019); dan Strobl & Strobl, (2011). Third, this study adds findings to research on the effect of all large dams on welfare in Indonesia, which tends to take advantage of the agricultural production perspective at the aggregate level, as far as the authors are concerned. Other previous studies in Indonesia are more likely to estimate the effects of relocation during the construction using particular large dam data and their characteristics. Therefore, the effect of spill-over on households in the administrative vicinity of the dam could not be seen in previous study. This study intends to be used in the national strategic project acceleration plan for 65 dam as a method for assessing the long-term effect of dams on economic growth.

This paper structured as follows. Section 2 discusses research methods of our identification strategy and elaborates the data source. Section 3 result and discussion the effect of large dams on household welfare by consumption, agricultural productivity and employment. Section 4 acknowledgement. Section 5 conclusion and the final section references.

The annual national population growth rate of Indonesia in 2000-2010 stood 1.49 % in average[3]. In order to supply increasing water demand either consumption, electricity and irrigation, government build new large dam in term of national strategic projects (PUPR, 2015). Since the Old Regime Era (Orde Lama), the primary function of dams has been to help the supply of agricultural irrigation water (Kasiro *et al.*, 1995). That was because farm irrigation is part of efforts to improve the economic development of Indonesia, which still depends on the agricultural sector (Hussain *et al.*, 2006). Recently, dams not only for irrigation but also future water storage, in the context of water security and energy independence, along with the more multipurpose type of large dam.

Dam planning begins with a survey of potential dam mapping by technical agencies by Ministry of Public Work and Housing rely on technical and socio-economic studies of each area. An economic feasibility analysis and methodology were performed based on the findings of the technical recommendations. Funding through the National Development Planning Agency (BAPPENAS) with decrees issued by the central government. As outlined in a presidential regulation along with a list of national strategic projects, the central government sets goals for large dam infrastructure development. Since large dams are complex and have their own infrastructure, the approval process for production must then also go through a review system by the safety committee for the dam.

Technical approval is a technical guidance for the design, development, filling and operation of the dam. Technically, then, without this method, large dams are physically unfit to construct without this procedure. Furthermore, the central and local governments entered into an arrangement to decide the site of

[3] Based on population growth rate dataset from Center Statistical Bureau 2000-2010.

major dams, along with the dam building process. Given regional planning and agreement with the local government, the central government only constructs large dams while land acquisition serve by local government.

The criteria for large dam in Indonesia refer to the regulations of the ICOLD *(International Conference on Large Dam)* [4]. Location of large dam majority follow the distribution of agricultural irrigation areas that prefer to be on the island of Java. For a number of years, the island of Java has been the center of agricultural development, promoting the national production of food crops. As we can see in Figure 1. This is also supported by regional economic development and by the proportion of the population on the island of Java, which is denser, requiring more water and energy resources. By 213 large dams reported, there are 2,200 dams in Indonesia, (World Bank, 2018). However, we only use large dams data as our research study based on data availability.

Based on our dataset, more than 19 % of the large dams in Indonesia are over 50 years old. The longer the dam operates, the more sedimentation will increase and reduce operation year (Schellenberg et al., 2017). In order to preserve the protection of the dam from the risk of failure and fulfill the purpose of the reservoir, improvement efforts are therefore required. World Bank supports this initiative in external debt financing assistance in form of the Dam Operational Investment and Safety Program (AIIB, 2017). Thus in addition to fulfill demand to construct new dams, and initiative to restore protection and optimal functioning of old dam is a major responsibility in order to meet the national goal of water storage capacity in accordance with the national strategic plan.

Characteristically, in Indonesia, 67% of dams are embankment dams. This large dams type is widely produced in Indonesia due to the ease of finding raw materials for hoarding, cost and resistance to tectonic symptoms (Kasiro et al., 1995). The average height of large dams in Indonesia is 31 meters, with an average storage capacity of 113 million cubic meters. The height of the dam affects the area of the irrigation service. The average area of irrigation for large dams is 7258 hectares, but because of variations in rainfall and other technical factors, such as the length of the reservoir water channel, elevation and distance to the coverage area, the area of irrigation is theoretically lower than the plan (Zainuddin, 2012). The number of large dam-owned water reservoirs affects the area of the service area, both the irrigation area, the discharge of water use and the capacity to mitigate floods. Therefore type and characteristics of large dams has potentially affect socio-economic conditions of surrounding households.

RESEARCH METHODS

The model of estimation refers to previous research by Mettetal, (2019) dan Duflo & Pande, (2007) with several adjustment to the effect on household welfare. We use Pool Ordinary Least Square Regression (PLS) because the form of data owned is cross-sectional data that has different observations and distributions each year (Wooldridge, 2010).

First estimation model to examine the effect of dams on household welfare is as follows ;

$$\ln y_{idt} = \beta_0 + \beta_1 dam_{dt} + \beta_2 karuta_{idt} + \beta_3 kardam_{dt} + u_t + v_t + \varepsilon_{idt} \text{........................(1)}$$

Where $ln\ y_{idt}$ is the household expenditure logarithm i in sub-district d and year t, while dam_{dt} is the sum of dams in sub-district d in year t. Because of the addition of large dams, the coefficient β_1 explains the change in household consumption. If the addition of dams is shown to be advantageous to the household, the hypothesis of coefficient β_1 is positive and not statistically worth 0. $karuta_{idt}$ is a control variable that has the potential to influence results and is time-variant for the characteristics of households i live in sub-

[4] *International Comission on Large Dams (ICOLD*), categorize large dam with height level more than 15 meter from the base or 5-15 meter with minimal storage more than 3 million cubic.

district d during the year t. Household control consists of demographics such as age, number of family members, marital status, employment status, education, and head-family job. In sub-district d in year t, which consists of height, operating length, capacity, and flooding area, variable dam characteristics. In addition, the fixed effect is used in the model to remove the time-invariant effect. $kardam_{dt}$ is characteristics variable in year t sub-district, consisting of height, operating duration, capacity, and flood area. In order to prevent the effects of time-invariant characteristics of the field, the fixed effect is also used in the model. u_t is *fixed - effect* variabel of district or municipalities, v_t year *fixed effect* and ε_{idt} *error term.* We use clustered standard error in sub-district to omitted time-varying correlation between same sub-district.

In addition to see the mechanism effect of large dam development to household welfare, this study also estimates other economic impacts of large dams to household farm-productivity and work-activity. Economically dams may create labor opportunity during the construction period (Mettetal, 2019).

We also pool longitudinal dataset from IFLS wave 4 (2007) and 5 (2014) to estimates effect to agricultural productivity and employment opportunity to the household living close to dam region. We combine administrative identity of household on IFLS dataset with our spatial administrative data from Center Statistical Bureau (BPS) 2014 and coordinate from dams placement.

This second dataset was different from the first model since we want to describe briefly in what extent existing large dams potentially reduce household welfare. Limited data availability on agriculture and employment in sub-district level to estimate effect of large dams was the reason why we use agriculture and employment dataset in IFLS 2007 and 2014. Estimation model (2) dan (3) as follow ;

$$y_{idt} = \beta_0 + \beta_1 dam_{dt} + \beta_2 karuta_{idt} + \beta_3 kardam_{dt} + u_{dt} + v_t + \varepsilon_{it} \qquad (2)$$

$$y_{idt} = \beta_0 + \beta_1 dam_{dt} + \beta_2 karuta_{idt} + \beta_3 kardam_{dt} + u_{dt} + v_t + \varepsilon_{it} \qquad (3)$$

Where y_{idt} is the rate of rice harvest in farm households i in sub district d and year t, while y_{idt} is the frequency of household work in sub district d and year t in model (3). dam_{dt} is the number of dams in sub-district d in year t. The defined model also uses the regular error cluster in sub-district to achieve consistent estimates. Limitations of IFLS Wave 4 and IFLS Wave 5 sample household data are noticed by the fact that the household observation is much smaller than the SUSENAS data.

The strategy of identification would likely potentially bias estimates values because of the heterogeneity. The decisions on the location of the dam are based on geography (Zainuddin, 2012). The choice of a dam site may also be attributed to higher productivity in a region and a larger population (Mettetal, 2019). Added control variables with fixed effects at the sub-district and year u_{dt} and clustering standard error to control time-invariant effect.

This study compiles household survey cross-section data from 2013 to 2018 with spatial administrative sub-districts across Indonesia using multiple data sources. The author also integrates the spatial data for from large dams to estimate the effect of large dams to welfare in Indonesia at household level.

Household-expenditures – Data on household expenditures using household-consumption data set which is collected from (SUSENAS). The data obtained structure of socio-economic information, consisting of national representatives on population, health education, employment, fertility, household and domestic consumption. SUSENAS dataset were collected from 2013 until 2018. SUSENAS dataset for 2015 is excluded due to the lack of administrative information at the sub-district level.

Household-expenditures consist of food and non-food consumption and its represented by the head of the household constitute the key information used for this study. From five years, 1,453,308 household samples[5] were collected and 172,089 households lived in districts over a radius of 10 kilometers from large dams after selecting samples based on their geo-space location. Household consumption data have widely used data to assess the effect of large dams on domestic welfare (Sarsons, 2015) .

Large dams data – The large dam database is obtained from the Ministry of Public Works and Housing. Large dam databases contain information on the location of major dams, specifications and year of construction. The criteria for large dams in Indonesia refer to the criteria for the International Conference on Large Dams (ICOLD) and the Regulation of the Minister of Public Works and Public Housing No. 27 of 2015 about dams. There are 216 registered dams on 2018 data. There are 4 large dams as tailing dam that are excluded from the estimation because they do not have sufficient location data and complete technical specifications so that the study sample used is 212 large dams. The author calculates the location coordinates based on the available large dam database. In this dataset, the dam has a lack of historical construction time, so it is assumed that a large dam that has been built has the same completion year as the construction period.

We use geographic data for the region such as rainfall and elevation data from external data sources. The average height dams data in this sub-district is used as a time invariant control of regional characteristics. The use of elevation and rainfall control variables was used in the study (Duflo & Pande, 2007; Hussain et al., 2006; Metteta, 2019; Sekhri, 2017; Strobl & Strobl, 2011; Weir et al., 2018; Yigzaw, Mburu, Ackello-Ogutu, Whitney, & Luedeling, 2019).

In addition, this study also uses dataset from the Indonesia Family Life Survey (IFLS) in 4 and 5 waves to obtain additional information to see the effects of dam construction on welfare in terms of agricultural productivity, especially the frequency of rice harvests[6] and employment (Mettetal, 2019). The selection of estimates using the frequency of rice harvest due to limited agricultural production data within the administrative boundaries of the sub-district. The unit of analysis is households living in the subdistricts location within a 10 kilometers radius of the dam coordinate.

This study uses administrative maps of sub-districts throughout Indonesia in 2014 combined with location data for dam coordinates. ArcGis software is used to estimate the sub-district area within a 10 kilometers radius of the dam location (appendix 1). This technique is used to gain a sample of sub-district around dam region. We derive 997 sub-district in 10 kilometers as our sample region. Furthermore, it is merged with household characteristic data in SUSENAS based on the similarity of the administration code. Our sampling method strategy refers to previous study by Zhao et al., (2013). Moreover, to obtain the effect of the location of the household to the dam, the measurement of the distance from the location of the dam to the residence of the household was carried out using the principle of distance from the centroid[7] (the center point of the subdistrict of the household location to the coordinate point of the dam).

RESULTS AND DISCUSSION

This study examines the effect of dams on household welfare as proxied by household expenditure. Household expenditure proxies were used in the study (Duflo and Pande, 2007) but in this study the authors used expenditure data on types of food and non-food

[5] Household samples in 2013, 2014, 2016, 2017, 2018 are 284.063, 285.400, 291.414, 297.276, and 295.155

[6]The sample of households in IFLS 4 was 13,500 households, while in IFLS 5, there were 15,900 households that were selected based on the location of the households per district. The weakness of agricultural data in IFLS is that it does not show the location of agricultural land in the same residence, but it is assumed that households work not far from the location of their agricultural land..

[7] The location of the selected sub-districts was determined using ArcGis by combining the dam coordinate data with the sub-district coordinates. The selected sub-district location is the location estimate based on the calculation of the distance of the dam coordinate point to the polygon data of the sub-district administration area.

consumption to see which types of household expenditure were most affected. Hadush, (2019) and Takeshima, (2018) study also used a proxy for household consumption expenditure to examine the impact of large dams in case of Ethiopia and Nigeria.

Table 1. Base Result Estimation Result To Household Expenditure (Consumption)

	Dependent variable : ln (household expenditure)				
	-1	-2	-3	-4	-5
	Total	Total	Total	Food	Non Food
Number of dams	-0.006	-0.0179	-0.0244*	-0.019*	-0.0272*
	-0.0128	-0.0132	-0.0131	-0.011	-0.0162
Observations	95,759	90.987	81,677	81,677	81.677
R-squared	0.251	0.45	0.446	0.481	0.393
Sub-district	997	997	997	997	997
Controls :					
Sub-district FE	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes
Dam characteristics	-	Yes	Yes	Yes	Yes
Household	-	Yes	Yes	Yes	Yes
Geography	-	-	Yes	Yes	Yes

Source : Data processed (SUSENAS y2013 – y2018)

Notes : The dependent variable in natural logarithm household expenditure as a proxy of household economic welfare. Standard error clustered in sub-district level are reported in parentheses. Contemporaneous dam covariates includes dams height, volume, operational period, and reservoir capacity. Household covariates includes age, education, household size, job, migration status, farm/non farm. Geography covariates includes elevation and rainfall data. These estimation using sub-district unbalanced panel-cross section data. ***, **, * indicates statistical significance at 1%, 5% and 10%.

Table 1 shows the multiple steps to get our preferred specification to estimate large dam effect. These models use observation of dam sub-districts as 0 kilometers from the large dam position. We applied *pooled least square* (PLS) regression of operated large dams on household expenditure (equation 1). In every column, the dependent variable is the ln of household expenditure as a proxy of welfare.

We estimate equation 1 using only sub-district fixed effect in column (1) and then in column (2) and (3) we introduce year fixed effect. The result seems to suggest that household expenditure has 0.6- 1 % negative coefficient and not significant at this level. We add control groups such as household characteristics, dams, and geography in column (3) and find a significant result at 10% level.

Estimation result using all control group in table 1 column 3 show that statistically the addition of a dam at the sample location correlates to a decrease in household welfare by 2.4% by using a proxy for total household consumption. Further estimation result effect of adding a dam has a correlation of 1.9% on food consumption, while on non-food consumption there is a correlation of 2.7% for all household locations within a 10 kilometers radius. There was a bigger effect on non-food expenditure than food expenditure by 0.8 % which indicates decrease of welfare were not caused by ability to get daily food but rather non-food such as housing, clothes, tax (BPS, 2015). These general results are associated with research results (Duflo and Pande, 2007) which show a decrease in expenditure of households living around the dam in a case study in India with a negative value of 28.9 %. Meanwhile, previous study by Takeshima, (2018) also shows a negative correlation in household consumption of 24.7 %. From those previous study indicates decrease of household welfare by adding large dams. However, the estimation results the decrease due to the presence of the dam is relatively smaller than in studies in India and Africa. This indicates that effect of large dams has a relatively small negative impact on household welfare in the long term in case of Indonesia. This is probably due to the difference in efforts to improve population empowerment policies by the government around the dam.

Report by (WCD, 2000) reveal decrease of welfare in households near the dam potentially to be caused by decreased land fertility due to waterlogging and increased soil salinity. Several previous studies estimates, the impact of decreasing household welfare in one dam was more due to lack of road access, electricity, education and health in the case study of the Wonorejo dam construction (Sisinggih, Wahyuni and Juwono, 2013). Based on the results of previous research, there is also the possibility that in the long term there is a potential main objective of dam construction that does not correlate with the welfare of the population, which is reflected in a decrease in consumption expenditure for both households working in the agricultural and non-agricultural sectors (Karimi and Taifur, 2013; Sarsons, 2015; de Faria *et al.*, 2017).

We further investigate whether there is a different sign or magnitude in a certain distance between of the large dam effect. We ran multiple approaches to check heterogeneous treatment effect of large dams. Firs, we replicate our baseline result by comparing estimates between all sub district around 10 kilometres radius and all sub-districts outside 2.5 kilometers radius up to 10 kilometers radius from nearest large dams. This study divides into 4 area clusters, using household variations with distances to the dam between 0-2.5 kilometers, 2.5-5 kilometers, 5-7.5 kilometers and 7.5-10 kilometers using the specification model (1) with all control variables. We adopt study by Zhao *et al.*, (2013) who use distance variation to measure impact of dams development to land use in surrounding area.

Regression results reported in Table 2 show that there are no different direction across household samples that are locate between a subdistrict. However, the coefficient remain bigger and statistically significance at 1 % in sub-district radius 0-2.5 kilometres which indicates household who living 0-2.5 kilometres from dam sub-district tend to lower welfare 6.7 % as proxied by household expenditure. Therefore, distance variation has a significant effect to household welfare. These finding also correlates with base line result where the magnitude of large dam effect are bigger 0.8 % to non-food consumption than food consumption and significant to sub-district in radius 0-2.5 kilometres from dams location. Coefficient result for food expenditure is 5.9 % statistically significant at 1 % and non - food expenditure is 6.7% statistically significant at 5% level. These results are similar to the study by Takeshima, (2018) which shows a negative relationship between the number of dams and a decrease in household welfare in the upstream area using a variable proxy for household food expenditure in case large dams development in Nigeria. These results inform the finding that households who live closer to the dam area actually experience difficulties in accessing consumption for their daily needs. World Ccomission on Dams Report (2000), state that there is a decrease in the welfare of households living around the dam.

Estimation result in table 1 dan table 2 using SUSENAS data show that number of large dams significantly affect decrease of household welfare who living in sub-district close dam location and this result vary across sub-district distance. However, this result potentially have bias estimates since dams placement are depend on geography and policy intervention. Previous study by Mettetal, (2019) in and Strobl and Robert O Strobl, (2011) in Africa use river gradient as one of instrumental variable to made a robust estimation. Limited river gradient data in sub-district level in

Indonesia restrict us to elaborate in our estimation model. We use clustered standard error and fixed effect to minimize bias estimates in our (1) model.

Understanding how large dams affect household welfare remain confused. Study by Mettetal, (2019) eksplore relevant channel to employment. Meanwhile, study by Strobl and Robert O Strobl, (2011); and Takeshima, (2018) eksplore relevant household welfare by agricultural production. Dams has become large part of agriculture in the world. Moreover, large dams may affect household employment in local sub-district even they not involved in agriculture. Based on previous study we develop estimation (2) and (3) using pool IFLS dataset 2007 and 2014. Limited employment and agricultural data availability in sub-district level suggest use IFLS data than SUSENAS.

Table 2. Heterogeneous Treatment Effect (Robustness Check)

	Dependent variable : ln (household expenditure)				
	0-2.5	2.5-5	5-7.5	7.5-10	0-10
	-1	-2	-3	-4	-5
Panel A : ln (total household expenditure)					
Number of dams	-0.067***	-0.026	-0.031	-0.03	-0.024*
	-0.0247	-0.0183	-0.0205	-0.0293	-0.0131
Observations	8.022	21.201	27.377	25.077	81.677
R-squared	0.536	0.497	0.486	0.463	0.473
Panel B : ln (total household expenditure) food					
Number of dams	-0.059***	-0.0228*	-0.0251	-0.037	-0.019*
	-0.02	-0.012	-0.0188	-0.022	-0.011
Observations	8.022	21,201	27.377	25.077	81.677
R-squared	0.547	0.493	0.487	0.483	0.48
Panel C : ln (total household expenditure) non food					
Number of dams	-0.0671**	-0.0275	-0.0403	-0.0232	-0.031*
	-0.031	-0.032	-0.0268	-0.0406	-0.0179
Observations	8.022	21,201	27.377	25.077	81.677
R-squared	0.393	0.447	0.417	0.415	0.383

Source : Data Processed (SUSENAS Food and Non-Food Expenditure y2013-y2018)

Notes : All in clustered standard error at the sub-district in parentheses. Sub-district buffer 0-2.5 km, 2.5-5 km, 5-7.5 km and 7.5-10 km based on ArcGis calculation. Food and non food household expenditure based on SUSENAS data. ***, **, * indicates level of significance in 1%, 5% dan 10%.

Irrigation is one of the main parts of agriculture and a stable supply of irrigation can be improved with the presence of adequate irrigation infrastructure. The dam provides a stable supply of irrigation water that is not affected by changes in weather which can affect planting frequency. Harvest frequency agricultural crops such as rice are used in cost-benefit calculations for development dam (Zainuddin, 2012). The implication is that with more planting frequency, the production is also higher. Agricultural production data at the sub-district level are not available in the SUSENAS data, therefore the authors use the frequency of harvest time in the 2007 and 2014 IFLS data as a proxy for agricultural productivity that provides household-level agricultural data to the sub-district administrative boundaries.

Table 3. Estimation Result To Agricultural Productivity

	Dependent variable : harvest frequency				
	-1	-2	-3	-4	-5
	0-2.5	2.5-5	5-7.5	7.5-10	0-10
Number of dams	-0.103	-0.46	-0.203	0.213*	-0.229
	-0.277	-0.67	-0.09	-0.0243	-0.0747
Observations	58	177	242	243	720
R-squared	0.225	0.486	0.25	0.348	0.17
Controls :					
Sub-district FE	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes
Dam characteristics	Yes	Yes	Yes	Yes	Yes
Household	Yes	Yes	Yes	Yes	Yes
Geography	Yes	Yes	Yes	Yes	Yes

Source : Data Processed (IFLS y2007and IFLS y2014)

Notes : The dependent variable is harvest frequency as a proxy of agricultural productivity. Clustered standard error at sub-districts in parentheses. Households covariates in IFLS dataset are sex, education, marriage status. Number of harvest frequency from Indonesia Family Life Survey (IFLS) waves 4 and 5 in 2007 and 2014 Section Farm Business. ***, **, * indicates level of significant at 1%, 5% dan 10%.

The overall estimation results for households living within 10 kilometers of the dam location show a negative and insignificant correlation between number of dam and rice harvest frequency in agricultural households. By using variations in distance, this study found that at a relatively further distance, the effect of dams on the frequency of rice harvests had a positive and significant correlation by 21.3 frequency at 1 % level. These results indicate that agricultural productivity tends to be lower in districts or areas closer to dams (Duflo & Pande, 2007; Strobl & Strobl, 2011; Takeshima, 2018). These result correlates with estimation (1) using SUSENAS data where household-expenditure has statistically significant and negative direction in sub-district close to dam sub-district. These findings also show that the decline in welfare from the expenditure side could be due to lower agricultural productivity in terms of harvest frequency.

Besides having an impact on agriculture, dam construction also has an effect on increasing local economic activity around the reservoir and opening up job opportunities (Mettetal, 2019). Economic activities that arise from the operation of the dam in areas near the dam, such as fisheries and tourism (Duflo and Pande, 2007) apart from construction activities. One of the economic activities that grow in large dams in Indonesia is aquaculture in floating cages (Abery et al., 2005) in addition to local tourism. Although not all dams have similar economic activity due to restrictions from the dam manager. Estimates were carried out to prove how the impact of the dam on work activities using household samples in the 2007 and 2014 IFLS in Book 3 of the Labor Section according to the location of the sub-district.

IFLS data can provide an overview of household activities based on the work activities of the head of the household from several questions, namely whether the household worked trying to earn or help earn at least one hour of income during the past week[8]. Mettetal, (2019) uses a projection based on the Household

[8] This information is listed in IFLS Book 3A which contains 1 if the answer works and 0 if it does not work. The definition of work according to the Central Statistics Agency defines working as an economic activity with the intention of obtaining or helping to obtain income or or profit at least 1 (one) hour uninterrupted during the past week.

Survey in South Africa questionnaire which contains whether households worked in the last week to see the effect of dams on labour activities.

Estimation results suggest number of large dams statistically significant 5.07% to working activity in 10% level. Nevertheless, using distance variation there were indicates lower working activity from 0-2.5 kilometers than 2.5-10 kilometers subdistrict distance. Estimation (2) and (3) suggest potentially lower household welfare as proxied by household expenditure correlates with lower agriculture and working activity in subdistrict surround dam placement.

CONCLUSION

The estimation results show that statistically the addition of a dam has a negative correlation with household welfare, especially those living in an area of a radius of 10 kilometers from a large dam, both for food and non-food expenditure. Although the correlation is relatively small, the results of this estimate indicate the potential for economic agents to suffer from the existence of large infrastructure, both from agricultural productivity, work activities, and household consumption. These findings are in line with the findings of Duflo and Pande, (2007) in case study in India, as well as the findings of Strobl & Strobl, (2011) and (Takeshima, 2018) in the African region which implies a decrease in food consumption expenditure on households living in the dam region.

The correlation of decreasing household expenditure can be seen from the perspective of agricultural productivity which shows that the agricultural productivity side of the area around the reservoir is more affected by the construction of dams because at a further distance from the location of the dam shows a more positive harvest frequency in line with the findings (Duflo and Pande, 2007). Meanwhile, in terms of work activities as the influence of the existence of large dams in line with previous study by Mettetal, (2019), which shows that the construction of this dam is in line with an increase in employment as proxied by work activity even though it is not significant. Even there were potential work activity during dams operation but its not significantly increase household welfare around dams placement. This findings indicate that there are households that experience losses from the construction of large dams from the economic outcome.

This study was the first attempt to measure effect of large dams policy to welfare in household level in all sub-district especially in Indonesia. Similar studies in Indonesia only use qualitative data in a small sample of communities in certain sub-district focusing on environmental effect of large dams (Nakayama et al., 1999; Abery et al., 2005; Sisinggih, Wahyuni and Juwono, 2013; Subijanto et al., 2013; Yoshida et al., 2013). However, there were some weakness in this study due to the limited data catchment and command area to see the comparison of welfare based on the upstream and downstream concepts which can be elaborated in further research. In addition, the construction of large dams is not random and potentially have biased estimates. Efforts to use instrumental variables to obtain a causality relationship using river gradients, as performed by (Duflo and Pande, 2007), Mettetal, (2019) have not been able to do because of limited geographic data at the sub-district level. Nevertheless, these potential bias estimates have been minimized with clustered standard error and fixed effect in the model. This limitation data hopefully can be presented further in future research.

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APPENDIX

Table 4. Estimation Result To Employment

	Dependent variable : Work Activity				
	0-2.5	2.5-5	5-7.5	7.5-10	0-10
	-1	-2	-3	-4	-5
Number of dams	-0.0507*	0.0197	0.0132	0.00311	0.00154
	-0.027	-0.0189	-0.0268	-0.0391	-0.0123
Observations	174	544	675	789	2,182
R-squared	0.03	0.062	0.064	0.036	0.039
Control :					
Household	Yes	Yes	Yes	Yes	Yes
Geography	Yes	Yes	Yes	Yes	Yes
Dams characteristics	Yes	Yes	Yes	Yes	Yes

Source : Data Processed (IFLS y2007and IFLS y2014)

Notes : The dependent variable is employment as proxied by household work activity. Clustered standard error at sub-districts in parentheses. ***, **, * ***, **, * indicates level of significant at 1%, 5% dan 10%. Work activity as a proxy of employment measured from number of working hour in a last week based on Book 3 of the Labor Section IFLS data.

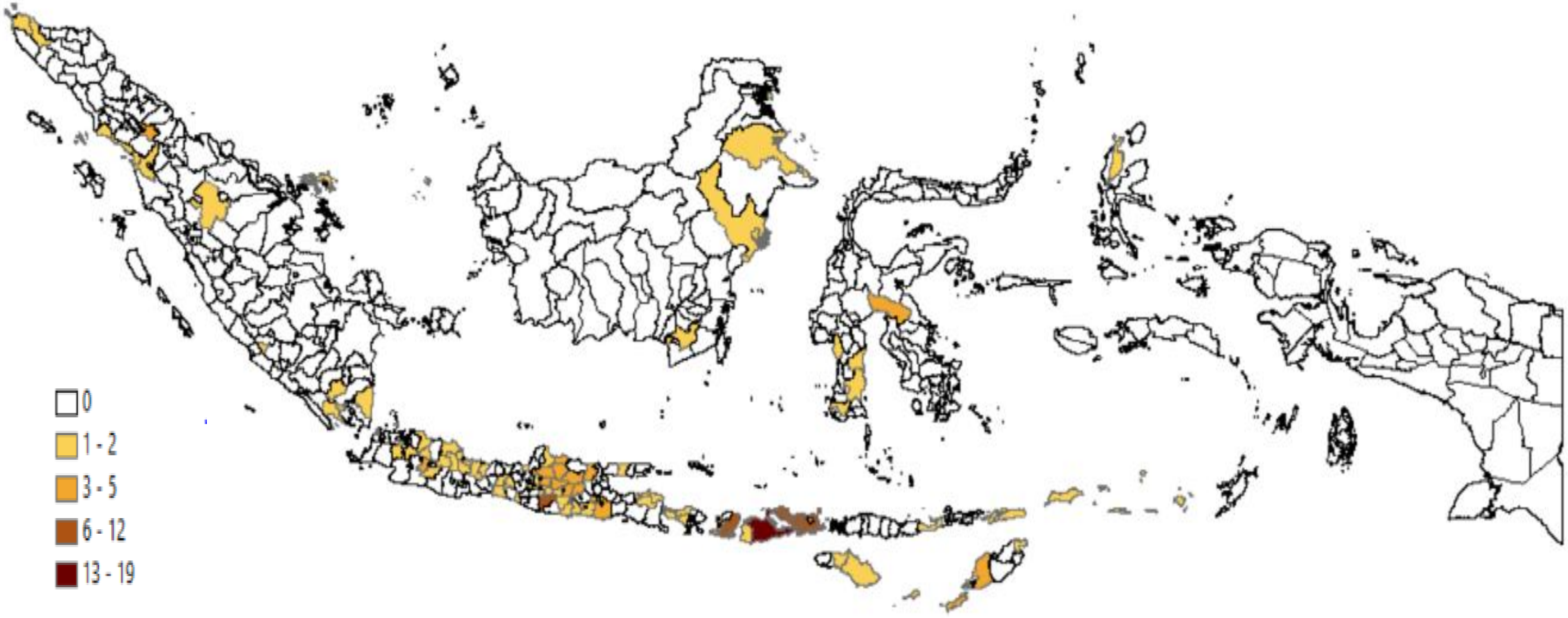

Figure 1. Number of Large Dams In Indonesia.
Source : Dams Safety Office, Ministry of Public Work and Housing. 2019
Notes : White area means large dams doesn't exist, Dark line means administrative border in district (kabupaten)