Potential impacts of dam construction on environment, society and economy based on community perceptions

T Sayektiningsih\(^1\)\(^*\) and N Hayati\(^1\)

\(^1\)Environment and Forestry Research and Development Institute of Makassar. Jl. Perintis Kemerdekaan Km. 16,5, Makassar, South Sulawesi, Indonesia

\(^*\)t.sayekt@yaho.com (ORCID ID: 0000-0001-6703-625X)

Abstract. Dam construction is one of the climate change adaptation strategies. Numerous studies on community perceptions related to the impacts of the dam after construction have been conducted. However, research on community perceptions towards the potential impacts of the dam before construction is limited. Accordingly, this research aimed to observe community perceptions towards potential impacts of the Budong-Budong dam construction on the environment, society, and economy. Data were collected in November 2020 in Salulekbo village, Topoyo district, Central Mamuju regency. This research used a qualitative approach. The data were collected through in-depth interviews using questionnaires with 26 respondents. The findings showed that 19 respondents (76% of total respondents) stated that dam construction will cause negative impacts on the environment, such as flooding downstream (if the construction failed) and landslides. On the social aspect, dam construction can bring both positive and negative impacts for the village, such as community displacement and social bond weakness. Furthermore, on the economic aspect, 21 out of 26 respondents argued that dam construction will affect the community’s economy negatively in the form of income reduction (76%) and cost for buying a piece of land (4%). This research hopefully can be a guide to secure the sustainable livelihood of the local community after dam development by providing resettlement areas, job opportunities, capacity building and community assistance, and socializing related policies and regulations.

1. Introduction

Dam construction is one of the forms of climate change adaptation. As known, climate change would affect water supply due to the change in a hydrological system [1]. To reduce the severe effects of the phenomenon, numerous dams are constructed. Today, there are hundreds of dams built in Indonesia [2]. A dam has a wide range of advantages such as irrigation, hydroelectric power, flood control, a source of drinking water, tourism, fisheries, and water conservation [3]. Therefore, dam construction is not only relevant to answer a global challenge but also for a human being.

Many studies revealed that dam construction negatively affected the environment and community. For instance, [4] reported that the dam construction in Sikkim, India contributed to landslides, damaged forest, and threatened the source of sustainable livelihood of the local community in agriculture. Furthermore, dam construction could also displace communities [5], decrease social bonds among community members [4], and cause a reduction in livestock [6]. In spite of having negative consequences for the environment and community, the construction of the dam can have positive
impacts on the community such as creating job opportunities [7]. The effects of dam construction in Indonesia vary from increasing crop yield [8] to land conflicts [9].

The Indonesian government is planning to build the Budong-Budong dam [3]. At the end of 2020, land measurement had been conducted. Besides, the staff of the Ministry of Public Works and Housing had also recorded communities’ properties such as agricultural lands and plants. The Budong-Budong dam is situated in Central Mamuju regency, West Sulawesi, particularly in Salulekbo village, Topoyo district. The main function of the dam is for flood control since the four sub-villages are susceptible to flooding during the rainy season. According to a preliminary study carried out by [3], the dam will inundate 4 sub-villages where communities live, namely Batu Dinding, Batu Papan, Batu Tangnga, and Salunusu. The researcher predicts that the Budong-Budong dam would have environmental, social, and economic impacts on the community. Many studies have tended to focus on the community perceptions relating to the impacts of the dam after the construction [6,8,4] rather than the community perceptions relating to the potential impacts of the dam before construction. Understanding the issue is crucial in order to provide inputs for the government to secure sustainable livelihood for those affected. Accordingly, this study aimed to observe community perceptions towards potential impacts of the Budong-Budong dam construction on the environment, society and economy. This research hopefully can be a guide to secure the sustainable livelihood of the local community after dam construction.

2. Methodology

Primary and secondary data were collected during fieldwork. Primary data were respondents’ characteristics as well as their perceptions towards the Budong-Budong dam construction. Meanwhile, secondary data were obtained from documents related to the dam construction. Primary data were collected in November 2020 in 4 sub-villages, namely Batu Papan, Batu Dinding, Salunusu, and Batu Tangnga. Those sub-villages are located within the area of Borrow-to-Use Permits of Forest Areas (Ijin Pinjam Pakai Kawasan Hutan/IPPKH) Budong-Budong (Figure 1). The sub-villages are part of Salulekbo village, Topoyo district, Central Mamuju regency. To reach the sub-villages, people need ± 4 hours from Mamuju city: Mamuju – Topoyo – Tabolang sub-village – Salurea sub-village – Kalando sub-village – Karomana sub-village – Salulekbo village – Batu Papan sub-village – Salunusu sub-village – Batu Tangnga sub-village – Batu Dinding sub-village [3]. The four sub-villages, which are Batu Papan, Batu Dinding, Salunusu, and Batu Tangnga, are directly impacted by the dam construction. Buildings, such as schools, houses, health facilities, and agricultural fields located in those sub-villages will be inundated.

Figure 1. Location of the study site.
This research used a qualitative approach. [10] used this approach to obtain more detailed information since this approach allows the researcher to record respondents’ responses naturally. The data were collected through in-depth interviews using questionnaires. Questionnaires were designed openly in order to obtain as much as information from respondents. First, the researcher asked about respondents’ characteristics such as age, educational background, occupation, race, length of stay, and land ownership. After asking about respondents’ characteristics, the researcher then asked about the respondents’ knowledge of the dam construction, the importance of dam construction, and respondents’ approval and perceptions towards the dam construction in the environment, society, and economy. Respondents were chosen purposively. Respondents were those whose houses and agricultural lands would be inundated by the dam. There were 26 respondents: 24 males and 2 females. The main respondents were the heads of the family because they have a big role in cultivating lands. Nevertheless, the researcher would interview the female respondents or someone who had the ability to answer the questions if the researcher was not able to interview the male respondents. During the data collection process, the researcher reviewed related reports to support the interview data. Then, all data were analyzed descriptively.

### 3. Results and discussion

#### 3.1. Respondents’ characteristics

Most of the respondents who live in the dam construction site come from West Sulawesi and South Sulawesi. They have lived in the sub-villages since 1998 and 2017. Most of them said that their arrival was influenced by their relatives who live before. Others mentioned that they came to the sub-villages unintentionally because they were looking for fields. After that, they then decided to settle down and build a family. Until this study was conducted, respondents enjoy living in the sub-villages.

In terms of age, respondents were in the productive age. Their ages varied from 24 to 80 years with the mean 43.15 (SD=11.43). Out of 26 respondents, 9 respondents were Petae race (34.62%), followed by Mamasa (n=5; 19.23%), Toraja (n=4; 15.38%), Makassar (n=3; 11.54%), Polmas (n=2; 7.69%) Polman (n=1; 3.85%), Mamuju (n=1; 3.85%), and Mandar (n=1; 3.85%). Based on data provided in Table 1, it showed that educational background of respondents was poor. Almost half of respondents graduated from elementary school (n=12) (Table 1).

| Level                        | Numbers | %   |
|------------------------------|---------|-----|
| Unschooled                   | 3       | 11.54|
| Elementary school (not graduated) | 2       | 7.69 |
| Elementary school            | 12      | 46.15|
| Junior high school           | 2       | 7.69 |
| High school                  | 7       | 26.92|

All respondents work as farmers. Cacao is a plant that is widely cultivated by the community. Cacao is considered to be the main source of income for farmers. It can be harvested year-round. But, the peak harvest season is twice a year. In one season, farmers can harvest up to 1 ton depending on land size. Farmers usually sell the dried seeds of cacao to the middleman for IDR 30,000 – 31,000/kg. Besides cacao, farmers also grow crops such as corn and rice. People do not sell rice in the market unless the harvest is excessive. They keep some part of the harvested seeds to be planted in the next season. People in the study sites also plant banana, durian (Durio sp.), and longkong (Lansium sp.). Additionally, palm oil is also cultivated, but only in a very small number compared to crops and fruits. Distance and high cost required to sell the seeds to the nearby city are the main reason why palm oil is not grown massively in the sites.
Then, in terms of land ownership, farmers mostly cultivated their own land but some rent from family or neighbors. Due to the availability of land resources, lands are commonly owned personally. There was no sign of slash and burn method during the research. To maintain soil fertility, farmers apply the shifting cultivation technique particularly for those having more than a piece of land. The farmers’ agricultural lands range from 1 to 5 ha.

3.2. Respondents’ perceptions on the dam construction

The ongoing dam construction project has been known by all respondents (100%). They stated that the uppermost of the dam is in Batu Dinding sub-village. Respondents also realized when the dam construction is completed, they will lose their lands and houses. The knowledge on the dam construction was acquired from the former village head, staff of the Ministry of Public Works and Housing, and community members. Likewise, the army officer (Bintara Pembina Desa) was also active in socializing the Budong-Budong dam construction project.

The 25 respondents (96%) mentioned that the dam is important since it will have various benefits in the future. According to a respondent, the dam can be used to flood control. Flood is an annual problem experienced by the community during heavy rain. Due to the limited accessibility of water disposal, the impact of the flood will be severe such as flooded roads and overflowing rivers that would hinder community mobility. Furthermore, another respondent stated that the dam construction will give an advantage for infrastructure development such as road development. Then, according to the respondents’ responses showed in Table 2, other benefits of the dam construction are irrigation, tourism, source of drinking water, fisheries, and hydroelectric power. The respondents’ responses mentioned before should be a concern for the government on how to manage and develop the dam in the future [10]. It is important because many studies concluded that negative impacts of dam outweighed its positive impacts [6,5,4].

| Benefits             | Numbers of respondents | %  |
|----------------------|------------------------|----|
| Flood control        | 1                      | 5  |
| Road                 | 2                      | 10 |
| Source of water      | 3                      | 15 |
| Fisheries            | 1                      | 5  |
| Hydroelectric power  | 3                      | 15 |
| Tourism              | 2                      | 10 |
| Increase economy     | 4                      | 20 |
| Did not state benefits of the dam | 11 | 55 |

Remarks: The 25 respondents stated that the dam was important, 20 of which provided the reason why the dam is a benefit for them and 5 respondents did not mention the reason. Every respondent could state > 1 benefits.

One of the respondents rejected the project in the sub-village because the dam will damage houses and agricultural fields. However, the majority of the respondents (96%) accepted the project. They argued that the dam construction will change their life substantially since they have to sacrifice lands and houses. Resettlement areas do not secure their sustainable livelihood. The main reason why respondents agree with the resettlement scheme is merely due to the compensation received.

The majority of the respondents worried if the dam give negative impacts on them. There are 19 or 76% respondents confirmed that the dam have negative effects on environment. Seven respondents said that the dam construction will not impact on environment. The dam can cause a disaster such as a flood downstream (Topoyo district) if there is a failure in construction. People whose families live in Topoyo are more concerned about this issue. Besides, respondents also mentioned landslides upstream as the negative impact of the dam construction due to forest cutting for roads and supplementary infrastructures during dam construction (Figure 2). The respondents’ responses are in line with [4] who
find that landslides are not only caused by forest conversion into other land uses but also contributed by drilling and blasting activities during development.

Figure 2. The percentage of respondents’ perceptions towards negative effects of the dam.

The researcher showed that respondents’ perceptions of environmental impacts of the dam construction were limited because respondents did not encounter those impacts before. Nevertheless, the communities need to anticipate potential impacts derived from the construction. Therefore, this research provides a list of the environmental impacts due to dam construction (Table 3).

Table 3. Potential environmental impacts due to the dam development

| Impacts                              | References |
|--------------------------------------|------------|
| Reduced ground water                 | [4]        |
| Disturbing migratory fishes’ livings | [11]       |
| Habitat loss due to forest conversion| [12]       |
| Accelerating the growth of weeds     | [13]       |
| Heat storage                         | [14]       |
| Sedimentation in downstream          | [14]       |
| Influencing hydrological regime      | [14]       |
| Reducing air quality                 | [15]       |

In this research, all respondents reported that the dam construction will impact their social life both positively and negatively. One respondent stated that the project can make the village livelier due to the infrastructure development and the presence of the workers. Recently, roads connecting the sub-villages and nearby cities are in bad condition that hinders people’s mobility. Regarding social network, infrastructure development will provide access for the communities to interact with other who live in other areas. Furthermore, the presence of workers provides an opportunity for the community to gain skills and knowledge. On the other hand, 80% of respondents revealed that dam construction will bring a profound effect, namely displacement. This finding is confirmed by a study conducted by [16], [17] adds that displacement of local society has drawbacks in terms of employment, income, and welfare. Besides, displacement to a new environment requires them to adapt to a new social life [18]. Furthermore, 4% of respondents stated that the dam project will distract social networks among community members. [4] found that the dam construction in Sikkim, India, lessened social networks among people. In terms of agriculture, agricultural fields are mostly worked by some farmers. However, due to the project, farmers have become commodities.

The majority of respondents (96.15%) thought that the dam construction will affect their income positively and negatively. The negative impacts were a decrease in income (76%) and cost for buying land (4%). When local residents migrate, they might encounter changes in terms of land properties, such
as size, ownership, and quality. Then, in terms of land quality, the soil fertility in the new area may be lower than in the previous area that will affect the crops yield. As a consequence, the income received will decrease significantly. The negative impact of the dam construction is in line with [15] who found that the dam construction of Logung is contributed to an income reduction of the local community and a change in livelihoods. Furthermore, the dam construction has a positive impact on the economy since the construction allows improvement to infrastructure such as road (4%) and provides compensation for the community (4%).

Displacement and possession are crucial issues found in this study. These findings are consistent with a previous study conducted by [19]. Displacement and possession will impact the sustainable livelihood of the community [20]. Therefore, this research recommends several steps to secure the sustainable livelihood of impacted communities in the future.

First, resettlement should be taken into account seriously. In accordance with Presidential Regulation No. 88/2017, resettlement is one of the conflict resolution schemes within forested areas. The importance of resettlement is in line with [21]. [21] reported that unresolved resettlement hindered an inundation process of the Jatigede dam in 2013. Resettlement aims to prevent forest encroachment that may be done by the affected community. Resettlement should be facilitated by the Ministry of Public Works and Housing. Besides, the local government should provide public facilities such as schools, health facilities, and religious facilities. Second, as one of the strategies for preventing poverty after megaproject construction, employees must receive attention since their arable lands and houses have been sacrificed for national development. In other words, providing job opportunities is an obligation. Employing local community in future dam-related management may be an option in solving social welfare problems. However, these are likely to be a difficult effort. In this context, community training will be needed.

Third, capacity building appears to be crucial to help affected communities to acquire new skills. In dam construction, communities’ well-being can be greatly impacted as they have to adapt to new environments if they have to move to other areas. In addition, their sources of income may be reduced or lost. It encourages them to look for a new job even if it is not fit for them [22]. If the environment changes, the communities might change their source of sustainable livelihood. For example, when farmers adapt to the new environment, they can shift their skills from land cultivation to animal husbandry. [21] stated that at the beginning it was difficult but later [21] suggested minimizing the probable impacts in order to avoid poverty and psychological effects. Therefore, the government needs to build the capacity of the affected community, enabling them to have skills and knowledge to survive. The importance of the capacity building is reported by [20]. In their study, [20] suggested involving multi-stakeholders in capacity-building planning for effective outcomes. In terms of Budong-Budong dam, the issues related to the capacity building include cacao cultivation, land cultivation, animal husbandry, and financial management. Capacity building should be followed by community assistance involving the local government. Financial and marketing assistance are good strategies to solve this issue. Fourth, displacement might create a new problem like forest conversion [23]. In the long term, the practice does not only pose risks to humans but also plants and animals living in a forest. Forest conversion also contributes to an increase in global temperature. Regarding affected community, they must know regulations and policies related to forested and conservation areas, social forestry, etc. The local government and related ministry can work with NGOs, universities, and conservation activists to resolve the issue.

4. Conclusions
The impacts of dam construction vary from negative to positive. The Budong-Budong dam construction affects the community’s life in four sub-villages namely Batu Papan, Batu Dinding, Salunusu, and Batu Tangnga. The dam construction give positive impacts on the community such as flood control, road development, source of water both for irrigation and drinking, fisheries, hydroelectric power, tourism, and economic development. Then, in terms of the environment, the construction can cause potential negative effects including flooding downstream and landslides due to forest conversion. Furthermore,
on the social impacts, this construction can give both positive and negative impacts. The positive impact is giving the opportunity to interact with outsiders supported by infrastructure development, meanwhile, the negative impacts are displacement and social bond distraction. On the economic aspect, the dam will affect community’s income negatively in the form of income reduction and cost for buying a piece of land. There are several recommendations to secure sustainable livelihood: resettlement, providing job opportunities, capacity building and community assistance, and dissemination of related policies and regulations.

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References
[1] Maurer EP 2007 Uncertainty in hydrologic impacts of climate change in the Sierra Nevada, California, under two emissions scenarios. Climate Change 82 309–329
[2] Soetjiiono C 2010 Gagasan Revitalisasi Bendungan Urugan dalam Mendukung Pengelolaan Sumber Daya Air. Jurnal Sumber Daya Air 6(1) 59–74
[3] Kementerian Pekerjaan Umum dan Perumahan Rakyat 2020 Dokumen Perencanaan Pengadaan Tanah Pembangunan Bendungan Budong-Budong Kabupaten Mamuju Tengah. Balai Wilayah Sungai III
[4] Chandy T, Keenan RJ, Petheram RJ and Sheperd P 2012 Impacts of Hydropower Development on Rural Livelihood Sustainability in Sikkim, India: Community Perceptions. Mountain Research and Development 32(2) 117-125
[5] Manatunge J and Takesada N 2013 Long-term perceptions of project-affected persons: a case study of the Kotmale Dam in Sri Lanka. International Journal of Water Resources Development 29(1) 87-100
[6] Gebreyes M, Bazzana D, Simonetto A, Muller-Mahn D, Zaichik B and Gilioli G 2020 Local Perceptions of Water-Energy-Food Security: Livelihood Consequences of Dam Construction in Ethiopia. Sustainability 12 1–19
[7] Wiejaaczka L, Pirog D, Tamang L and Prokop P 2018 Local Residents’ Perceptions of a Dam and Reservoir Project in the Teesta Basin, Darjeeling, Himalayas, India. Mountain Research and Development 38(3) 203–210
[8] Novandi AS, Wasino and Jayusman 2019 Dampak Pembangunan Waduk Kedung Ombo Terhadap Kehidupan Sosial Ekonomi Masyarakat Petani di Kabupaten Grobogan Tahun 1989-1998. Indonesian Journal of Conservation 8(2) 122–130
[9] Amila M and Malihah E 2016 Konflik Pembebasan Lahan Pembangunan Bendungan Jatigede di Desa Wado. Sosietas 6(2) 1-8
[10] Diduck AP, Prapat D, Sinclair AJ and Deane S 2013 Perceptions of impacts, public participation and learning in the planning, assessment and mitigation of two hydroelectric projects in Uttarakhand, India. Land Use Policy 33 170-182
[11] Wang QG, Du YH, Su Y and Chen KQ 2012 Environmental Impact Post-Assessment of Dam and Reservoir Projects: A Review. Procedia Environmental Sciences 13 1439–1443
[12] Fearnside PM 2001 Environmental Impacts of Brazil’s Tucurui Dam: Unlearned Lesson for Hydroelectric Development in Amazonia. Environmental Management 27 (3) 377–396
[13] Shiamah NL and Nawiayanto 2020 Pengaruh Bendungan Wingi Terhadap Lingkungan dan Ekonomi Masyarakat di Sepanjang Saluran Irigasi Lodayo Tulungagung Tahun 1970-1990. Historia 2(2) 187-199
[14] McCartney M 2009 Living with dams: managing the environmental impacts. *Water Policy* **11** 121–139

[15] Swela A, Santosa E and Manar D 2017 Analisis Dampak Pembebasan Lahan Tanah dan Ganti Rugi Terhadap Ekonomi Masyarakat dalam Pembangunan Waduk Logung di Desa Kandangmas dan Desa Tanjungrejo Kabupaten Kudus. *Journal of Politics and Government Studies* **6**(2) 41–50

[16] Ahsar R and Hamdan M. Development, Displacement and Resettlement a Challenge for Social Sustainability: A Study on Mega Development Project (Bakun Dam) in Sarawak. *Int’l Journal of Advances in Agricultural and Environmental Engg.* **3**(1) 47–51

[17] Huang Y, Lin W, Li S and Ning Y 2018 Social Impacts of Dam-Induced Displacement and Resettlement: A Comparative Case Study in China. *Sustainability* **10** 1–18

[18] Fathy R 2019 Modal Sosial: Konsep, Inklusivitas dan Pemberdayaan Masyarakat. *Jurnal Pemikiran Sosiologi* **6**(1) 1-17

[19] Neef A and Singer J 2015 Development-induced displacement in Asia: conflicts, risks, and resilience. *Development in Practice* **25**(5) 601–611

[20] Nguyen HT, Pham TH and de Bruyn LL 2017 Impacts of Hydroelectric Dam Development and Resettlement on the Natural and Social Capital of Rural Livelihood in Bo Hon village in Central Vietnam. *Sustainability* **9** 1–15

[21] Purnama Y 2015 Dampak pembangunan waduk Jatigede terhadap kehidupan sosial budaya masyarakat. *Patanjala* **7**(1) 131-146

[22] Anisa D and Wahyu 2017 Bentuk Strategi Adaptasi Sosial Ekonomi Masyarakat Petani Pasca Pembangunan Waduk Jatigede. *Jurnal Sosietas* **7**(2)

[23] Iftekhar MS and Hoque AKF 2005 Causes of forest encroachment: An analysis of Bangladesh. *GeoJournal* **62** 95-106