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## Assessment of the Small Dam Performance for Its Support in the Semi-Arid Area

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**Abstract:** This research aimed at the performance assessment of small dams for effective small dam performance index modeling. From the implementation report of water source network (PJSA) river area institution NT II, 2022, it is known that from the 22 regencies where are in the Nusa Tenggara, there are 321 small dams have been assessed for knowing the percentage average of damage to the small dams. From the three islands that are chosen as the research locations, it is known that the regency that has the highest average percentage of damage is the Ende regency located on the Flores Island. The methodology consists of: 1) Studying literature on the performance model that has been developed and the performance factors that are affected; 2) Analyzing the data and the small dam condition; 3) Drafting the parameter of the small dam performance index parameter. The results show that the average physical condition of small dams in the Nusa Tenggara Timur is moderate: 61-80% out of 100%, which is a good small dam condition. The average condition of small dam operation and maintenance performance in the Nusa Tenggara Timur is atrocious: 39% out of 100%. The average condition of small dam organization management in the Nusa Tenggara Timur is atrocious because there is no group of small dam water users. This result can be used for supporting the modeling of the small dam performance index in the semi-arid area as the validation scheme. Small dams are one of the water sources that very help fulfilling the water need in the Nusa Tenggara Timur region, and the amount is high enough until 2020; there are 3,658 small dams.

**Keywords:** assessment, small dams, condition, semi-arid area.

## 半干旱地区小坝支护性能评价

**摘要:** 本研究旨在对小型水坝进行性能评估, 以建立有效的小型水坝性能指标模型。从水源网络(PJSA)河流区域机构新台币二 2022 年的实施报告中得知, 在努沙登加拉的 22 个县中, 有 321 个小水坝已经被评估, 以了解破坏的平均百分比。从小水坝从被选为研究地点的三个岛屿中, 可知平均受灾率最高的摄政区是位于弗洛雷斯岛的恩德摄政区。该方法包括: 1) 研究有关已开发的性能模型和受影响的性能因素的文献; 2) 分析数据和小坝状况; 3) 草拟小坝性能指标参数。结果表明, 努沙登加拉帖木儿小坝的平均物理条件适中: 100% 中的 61-80%, 属于良好的小坝条件。努沙登加拉帖木儿的小型水坝运行和维护性能的平均状况非常糟糕: 100% 中的 39%。努沙登加拉帖木儿的小坝组织管理的平均状况是恶劣的, 因为没有

小坝用水者群体。该结果可作为验证方案支持半干旱地区小坝性能指标建模。小型水坝是非常有助于满足努沙登加拉帖木儿地区用水需求的水源之一，而且水量足够高到 2020 年；有 3,658 座小水坝。

**关键词：**评估、小水坝、状况、半干旱地区。

## 1. Introduction

Small dams are one of the water sources that can be dependable enough mainly for the semi-arid areas, where the natural surface water sources are a river and limited spring. A small dam is a water conservation structure [1] that forms as a pond or basin that can store run-off or water [2] from the other sources. Water that is stored by the small dam can come from river run-off, spring, rainfall [3, 4], and run-off of irrigation drainage channels.

Although there is the spring, the problem that can hinder the operation will certainly someday happen. The operation and maintenance that has not been fulfilled as being hoped can cause the physical and technical design not to be effective. To solve the problem of fulfilling continuously increasing water need [3, 5], it is necessary to return the function of water resource facility and infrastructure [6, 7], especially the small dam facility and infrastructure, and optimize the water resource development [8] gradually regarding the priority and available funding ability. However, there is often a constraint such as less information and databases about the performance level of developed infrastructure in supporting the sustainability of available functions [9].

Small dams are one of the water sources that very help fulfilling the water need in the Nusa Tenggara Timur region, and the amount is high enough until 2020; there are 3,658 small dams (BPS-NTT, 2021) in the NTT province. The developed small dams experienced a lot of damage, decreasing function, or did not function at all. Remembering that the role of small dam in fulfilling the water need in the NTT region, it is necessary to carried out the assessment of the development success of a small dam, and it can be assessed by evaluating the performance of small dams [10].

A small dam is said to be good or success if it is reviewed from the physical aspect that there is no damage in the components of the small dam physics. If it is reviewed from the operation and service aspect of a small dam being said to be success, it can be used by various parties in the scheme to produce each small dam unit [10]. If reviewed from the environment safety, the small dam is not disturbed. If reviewed from the institution aspect, it is said success if it is well managed and all is running normally regarding the

small dam provision. This research intends to assess the conditions of small dams for effective performance index modeling [11, 12] of small dams.

## 2. Materials and Method

### 2.1. Research Location

This research is conducted in the 49 small dams that are in the Timor Island about 29 small dams, Sumba Island about 10 small dams, and Flores Island about 10 small dams that are built by the river region institution of Nusa Tenggara II. The research locations are spread and can be seen in Fig. 1.

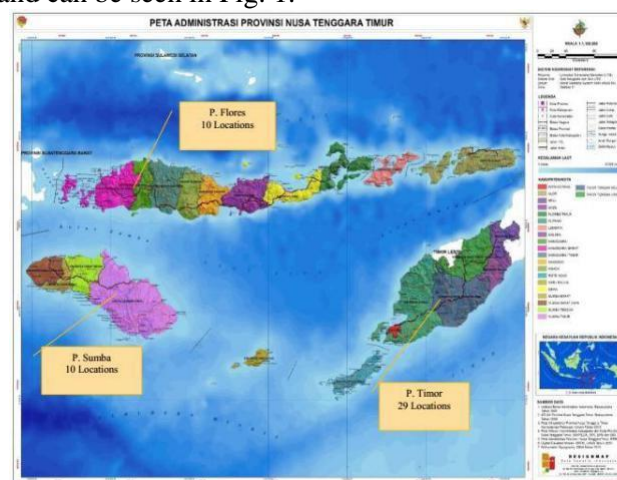


Fig. 1 Map of the research location (Report of RTRW-NTT Province, 2020)

The small dams in the NTT are built by considering the hydrology where they are located in the outlet of the catchment area of about 15 ha for storing the run-off; the slope sharpness may not be more than 25% and has clay. The location of the small dams is in the higher land from the population residence, which allows directing the water that is stored through gravitation piping. The ecosystem of the small dams and weirs is centered in the reservoir by the whole bio-physic process (life of freshwater biota, evaporation, infiltration, and sedimentation), water catchment area by the whole bio-physic process (vegetation, husbandry, wild fauna, and agriculture) in the downstream and piping networks, water tubs, and the utilization by society in the downstream.

**2.2. Dangerous Problems in Small Dams**

Some problems that endanger the small dam that should be addressed by the Research and Development Center of Water Resources are as follows:

1. Wet area due to the seepage through the landfill of small dam body and foundation;
2. Wet area that elongated in the small dam body;
3. The horizontal crack in the small dam body;
4. Straight and arch in the horizontal crack of a small dam;
5. High vegetation in the spillway;
7. The local scour in the spillway.

**2.3. Management of Small Dams**

The determination criteria for the physical condition of a building are as follows:

- a. Good condition, if the damage is < 10% from the initial condition;
- b. Light damage condition, if the damage is 10-20% from the initial condition;
- c. Medium damage, if the damage is 21-40%;
- d. Heavy damage, if the damage is > 40%.

However, to determine the building function, the classification of determination criteria is as follows:

- a. Good function, if the building function level is > 80% from the initial condition;
- b. Less, if the building function level is 70-80%;
- c. Bad, if the building function level is 40-69% from the initial condition;
- d. Not functioning, if the building function is < 30% from the initial condition.

The physical buildings of small dams can be classified into some components that are small dam body, spillway, intake, outlet, inspection road, and supporting building or facility, which each component is classified again into some sub-components. For facilitating the field inspection implementation, the application form of assessment or inspection for each component of the small dam building is made.

The evaluation of water resource system performance is illustrated by three criteria: reliability, resilience, and vulnerability. The reliability illustrates the system failure possibility; the resilience illustrates how heavy the possible failure is. These can be used for helping in selecting the design alternative and operation policy.

**2.4. Research Method**

The general classification that is used in the physic performance evaluation system of small dam infrastructure can be seen in Table 1.

Table 1 General condition assessment (Rule of Dam OPP Dam Part 1, Institution of Dam Safety, 2003)

| <u>Level of Condition</u> | <u>General Sense</u>  |
|---------------------------|---|
| 1                         | Building condition is still new, good, and well maintained and can be perfectly operated. |

Continuation of Table 1

|   |  |
|---|--|
| 2 | At Point 1, however, the little damage signs are observed that need the relatively soft improvement like in the first-level condition.   |
| 3 | Generally, it functions well, but there is a real indication of damage, which, if it is left, will affect the performance. It needs a rather heavy improvement to the first-level condition. |
| 4 | The damage is more severe and affecting the building performance, even some of them need the total improvement in maintaining the function.  |
| 5 | The damage is classified as very heavy and is seen as a serious structural problem, which can damage the building performance. Generally, it needs the <u>total improvement</u> .            |

Based on the assessment of the general condition above, it can be concluded that the infrastructure condition of a building is as follows: Condition-1: no risk; Condition-2: insignificant risk; Condition-3: small risk; Condition-4: moderate risk; Condition-5: big risk.

This research consists of: 1) Studying literature on the performance model developed and the factors that are affected; 2) Analyzing the data and small dam condition; 3) Drafting the assessment parameters of the small dam performance index. Fig. 2 presents the flowchart of the study.

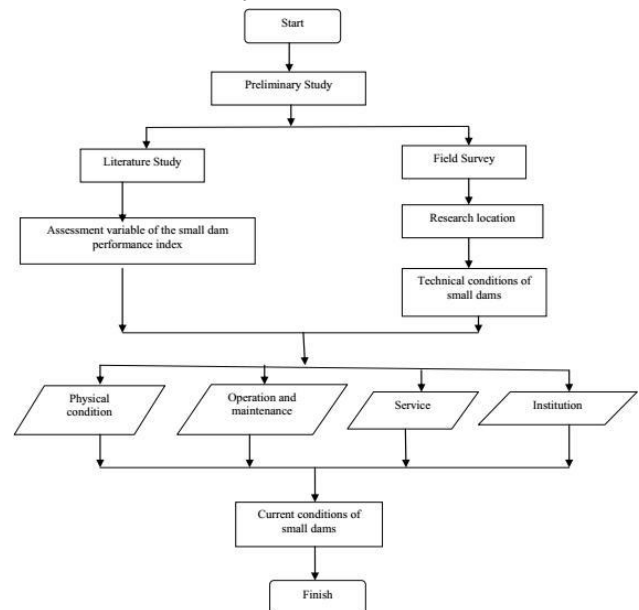


Fig. 2 Flowchart of the study (Own study)

**3. Results and Discussion**

A survey for the assessment of the conditions of small dams in the semi-arid area has been carried out. The assessment survey covers the physical aspect, operation and maintenance performance, organization management, and water availability. Tables 2-4 present the survey result recapitulation for the physical aspect, operation and maintenance performance, and organization management and water availability, respectively.

Table 2 Survey result for the physical aspect performance in the current condition of semi-arid areas' small dams (Own study)

| No | Location of Small Dam | Assessment Criteria of Small Dam Physical Aspect |          |          |          |              |          |                      |          |               |           |                        |          |
|----|-----------------------|--|----------|----------|----------|--------------|----------|----------------------|----------|---------------|-----------|------------------------|----------|
|    |                       | Embankment                                       |          | Spillway |          | Storage Pool |          | Distribution Network |          | Service Basin |           | Complementary Building |          |
|    |                       | Score  | Category | Score    | Category | Score        | Category | Score                | Category | Score         | Category  | Score                  | Category |
| 1  | Embung Kiubiblian     | 65   | Moderate | 59       | Bad      | 76           | Moderate | 65                   | Moderate | 48            | Bad       | 45                     | Bad      |
| 2  | Embung Naioni I       | 65   | Moderate | 55       | Bad      | 72           | Moderate | 50                   | Bad      | 32            | Very Bad  | 41                     | Bad      |
| 3  | Embung Naioni II      | 65   | Moderate | 31       | Very Bad | 75           | Moderate | 30                   | Very Bad | 32            | Very Bad  | 0                      | Very Bad |
| 4  | Embung Manulai II     | 70   | Moderate | 52       | Bad      | 70           | Moderate | 30                   | Very Bad | 45            | Bad       | 61                     | Moderate |
| 5  | Embung Oekolo         | 67   | Moderate | 59       | Bad      | 70           | Moderate | 65                   | Moderate | 45            | Bad       | 15                     | Very Bad |
| 6  | Embung Nunu Sa        | 65   | Moderate | 57       | Bad      | 70           | Moderate | 30                   | Very Bad | 49            | Bad       | 46                     | Bad      |
| 7  | Embung Bisti          | 65   | Moderate | 55       | Bad      | 70           | Moderate | 50                   | Bad      | 29            | Very Good | 14                     | Very Bad |
| 8  | Embung Hoenabab       | 60   | Bad      | 23       | Very Bad | 67           | Moderate | 40                   | Very Bad | 32            | Very Good | 14                     | Very Bad |
| 9  | Embung Kiubiblian II  | 60   | Bad      | 65       | Moderate | 69           | Moderate | 50                   | Bad      | 32            | Very Good | 60                     | Bad      |
| 10 | Embung Topkole        | 62   | Moderate | 63       | Moderate | 75           | Moderate | 81                   | Good     | 39            | Very Bad  | 20                     | Very Bad |
| 11 | Embung Fatubibi       | 57   | Bad      | 68       | Moderate | 70           | Moderate | 78                   | Moderate | 60            | Bad       | 24                     | Very Bad |
| 12 | Embung Hoateta        | 65   | Moderate | 37       | Very Bad | 67           | Moderate | 75                   | Moderate | 32            | Very Bad  | 39                     | Very Bad |
| 13 | Embung Kaedoki        | 85   | Good     | 44       | Bad      | 69           | Moderate | 67                   | Moderate | 70            | Moderate  | 42                     | Bad      |
| 14 | Embung Ina Koabatun   | 65   | Moderate | 44       | Bad      | 69           | Moderate | 67                   | Moderate | 21            | Very Bad  | 21                     | Very Bad |
| 15 | Embung Ale            | 65   | Moderate | 54       | Bad      | 65           | Moderate | 45                   | Bad      | 32            | Very Bad  | 20                     | Very Bad |
| 16 | Embung Oe Ana         | 70   | Moderate | 58       | Bad      | 62           | Moderate | 45                   | Bad      | 32            | Very Bad  | 51                     | Bad      |
| 17 | Embung Menpoko        | 70   | Moderate | 59       | Bad      | 78           | Moderate | 50                   | Bad      | 45            | Bad       | 21                     | Very Bad |
| 18 | Embung Huibaki        | 33   | Very Bad | 61       | Moderate | 75           | Moderate | 65                   | Moderate | 26            | Very Bad  | 21                     | Very Bad |
| 19 | Embung Bisuaf         | 85   | Good     | 85       | Moderate | 80           | Moderate | 82                   | Good     | 60            | Bad       | 30                     | Very Bad |
| 20 | Embung Eno Ana        | 62   | Moderate | 67       | Moderate | 70           | Moderate | 70                   | Moderate | 41            | Bad       | 43                     | Bad      |
| 21 | Embung Stelan         | 65   | Moderate | 49       | Moderate | 70           | Moderate | 85                   | Good     | 85            | Good      | 45                     | Bad      |
| 22 | Embung Kobelima       | 65   | Moderate | 71       | Moderate | 63           | Moderate | 45                   | Bad      | 75            | Moderate  | 48                     | Bad      |
| 23 | Embung Tekes          | 65   | Moderate | 70       | Moderate | 69           | Moderate | 85                   | Good     | 51            | Bad       | 48                     | Bad      |
| 24 | Embung Oelbosen       | 65   | Moderate | 66       | Moderate | 67           | Moderate | 50                   | Bad      | 32            | Very Bad  | 0                      | Very Bad |
| 25 | Embung Oelnitep       | 65   | Moderate | 63       | Moderate | 67           | Moderate | 50                   | Bad      | 32            | Very Bad  | 47                     | Bad      |
| 26 | Embung Subun Bestobe  | 65   | Moderate | 51       | Moderate | 67           | Moderate | 65                   | Moderate | 34            | Very Bad  | 44                     | Bad      |
| 27 | Embung Sebe           | 78   | Moderate | 66       | Moderate | 73           | Moderate | 65                   | Moderate | 60            | Bad       | 34                     | Very Bad |
| 28 | Embung Palaman        | 65   | Moderate | 61       | Moderate | 72           | Moderate | 65                   | Moderate | 69            | Moderate  | 71                     | Moderate |
| 29 | Embung Pantae         | 85   | Good     | 65       | Moderate | 82           | Good     | 30                   | Very Bad | 10            | Very Bad  | 0                      | Very Bad |
| 30 | Embung Longga         | 80   | Moderate | 76       | Moderate | 87           | Good     | 85                   | Good     | 60            | Bad       | 87                     | Good     |
| 31 | Embung Ega            | 80   | Moderate | 78       | Moderate | 87           | Good     | 85                   | Good     | 60            | Bad       | 87                     | Good     |
| 32 | Embung Ulu Aeraso     | 80   | Moderate | 82       | Good     | 84           | Good     | 85                   | Good     | 63            | Moderate  | 54                     | Bad      |
| 33 | Embung Alolai         | 78   | Moderate | 81       | Good     | 75           | Moderate | 75                   | Moderate | 53            | Bad       | 53                     | Bad      |
| 34 | Embung Kembo II       | 78   | Moderate | 77       | Moderate | 75           | Moderate | 55                   | Bad      | 53            | Bad       | 45                     | Bad      |
| 35 | Embung Jong I         | 80   | Moderate | 69       | Moderate | 75           | Moderate | 50                   | Bad      | 53            | Bad       | 17                     | Very Bad |
| 36 | Embung Tasik Terong   | 75   | Moderate | 70       | Moderate | 79           | Moderate | 55                   | Bad      | 48            | Bad       | 44                     | Bad      |
| 37 | Embung Waekobe II     | 50   | Moderate | 80       | Moderate | 81           | Good     | 39                   | Very Bad | 80            | Moderate  | 70                     | Moderate |
| 38 | Embung Pore           | 73   | Moderate | 60       | Moderate | 75           | Moderate | 45                   | Bad      | 65            | Moderate  | 0                      | Very Bad |
| 39 | Embung Alodube        | 75   | Moderate | 72       | Moderate | 75           | Moderate | 55                   | Bad      | 55            | Bad       | 0                      | Very Bad |
| 40 | Embung Kahabilangga   | 60   | Moderate | 80       | Moderate | 69           | Moderate | 63                   | Moderate | 55            | Bad       | 38                     | Very Bad |
| 41 | Embung Pau            | 60   | Moderate | 65       | Moderate | 67           | Moderate | 65                   | Moderate | 54            | Bad       | 26                     | Very Bad |
| 42 | Embung Kahi           | 68   | Moderate | 76       | Moderate | 67           | Moderate | 72                   | Moderate | 73            | Moderate  | 26                     | Very Bad |
| 43 | Embung Palanggai      | 65   | Moderate | 50       | Bad      | 69           | Moderate | 40                   | Very Bad | 32            | Very Bad  | 52                     | Bad      |
| 44 | Embung Daiwa I        | 70   | Moderate | 71       | Moderate | 71           | Moderate | 70                   | Moderate | 52            | Bad       | 30                     | Very Bad |
| 45 | Embung Pawolung       | 70   | Moderate | 67       | Moderate | 71           | Moderate | 65                   | Moderate | 52            | Bad       | 67                     | Moderate |
| 46 | Embung SMP            | 70   | Moderate | 57       | Bad      | 66           | Moderate | 40                   | Very Bad | 65            | Moderate  | 26                     | Very Bad |
| 47 | Embung Langira Padaka | 60   | Moderate | 72       | Moderate | 67           | Moderate | 40                   | Very Bad | 40            | Very Bad  | 73                     | Moderate |
| 48 | Embung Dikir          | 67   | Moderate | 59       | Bad      | 70           | Moderate | 30                   | Very Bad | 26            | Very Bad  | 26                     | Very Bad |
| 49 | Embung Dello          | 65   | Moderate | 62       | Moderate | 69           | Moderate | 30                   | Very Bad | 46            | Bad       | 0                      | Very Bad |

Based on Table 2, the average physical condition of small dams in the Nusa Tenggara Timur is moderate: 61-80% out of 100%, which is a good small dam condition. From the moderate condition, it is also known that the embankment condition has the information as follow: embankment peak condition is overgrown by wild grass and there is no indication of embankment body decline. The spillway condition is overgrown by bushes and long-life trees, however. No

damage indication is found. The condition of small dam inundation storage pool declines but on a small scale, and there is a sediment precipitate on a small scale. The distribution network has a damaged pipe and is truncated in some parts but still can be improved, and the available distribution pipe has been missed so it disturbs the function. The complementary building is still good but for the condition of the safety fence has already rusted and it is needed painting.

Table 3 Survey result for the usage performance at the current condition of semi-arid areas' small dams (Own study)

| No | Location of Small Dam | Assessment Criteria of Operation and Maintenance Performance Aspect |          |                                |          |                  |          | Assessment Criteria of Utilization Performance Aspect |          |       |          |
|----|-----------------------|---|----------|--------------------------------|----------|------------------|----------|---|----------|-------|----------|
|    |                       | Implementation of O & M Guard Officer of Small Dam                  |          | Availability of O & M Facility |          | Water Allocation |          | Service Basin Availability                            |          |       |          |
|    |                       | Score   | Category | Score                          | Category | Score            | Category | Score   | Category | Score | Category |
| 1  | Embung Kiubiblian     | 0   | Very Bad | 0                              | Very Bad | 0                | Very Bad | 66  | Moderate | 34    | Very Bad |
| 2  | Embung Naioni I       | 0   | Very Bad | 0                              | Very Bad | 0                | Very Bad | 66  | Moderate | 17    | Very Bad |
| 3  | Embung Naioni II      | 0   | Very Bad | 0                              | Very Bad | 0                | Very Bad | 66  | Moderate | 32    | Very Bad |
| 4  | Embung Manulai II     | 0   | Very Bad | 0                              | Very Bad | 0                | Very Bad | 62  | Moderate | 37    | Very Bad |
| 5  | Embung Oekolo         | 0   | Very Bad | 0                              | Very Bad | 0                | Very Bad | 66  | Moderate | 33    | Very Bad |
| 6  | Embung Nunu Sa        | 0   | Very Bad | 0                              | Very Bad | 0                | Very Bad | 66  | Moderate | 45    | Bad      |
| 7  | Embung Bisti          | 0   | Very Bad | 0                              | Very Bad | 0                | Very Bad | 64  | Moderate | 26    | Very Bad |
| 8  | Embung Hoenabab       | 0   | Very Bad | 0                              | Very Bad | 0                | Very Bad | 64  | Moderate | 38    | Very Bad |
| 9  | Embung Kiubiblian II  | 0   | Very Bad | 0                              | Very Bad | 0                | Very Bad | 62  | Moderate | 30    | Very Bad |
| 10 | Embung Topkole        | 0   | Very Bad | 0                              | Very Bad | 0                | Very Bad | 47  | Moderate | 39    | Very Bad |
| 11 | Embung Fatubibi       | 0   | Very Bad | 0                              | Very Bad | 0                | Very Bad | 47  | Moderate | 49    | Bad      |
| 12 | Embung Hoateta        | 0   | Very Bad | 0                              | Very Bad | 0                | Very Bad | 47  | Moderate | 32    | Very Bad |
| 13 | Embung Kaedoki        | 0   | Very Bad | 0                              | Very Bad | 0                | Very Bad | 47  | Moderate | 85    | Bad      |
| 14 | Embung Ina Koabatun   | 0   | Very Bad | 0                              | Very Bad | 0                | Very Bad | 59  | Moderate | 26    | Very Bad |
| 15 | Embung Ale            | 0   | Very Bad | 0                              | Very Bad | 0                | Very Bad | 47  | Moderate | 28    | Very Bad |
| 16 | Embung Oe Ana         | 0   | Very Bad | 0                              | Very Bad | 0                | Very Bad | 41  | Moderate | 33    | Very Bad |
| 17 | Embung Menpoko        | 0   | Very Bad | 0                              | Very Bad | 0                | Very Bad | 59  | Moderate | 57    | Bad      |
| 18 | Embung Huibaki        | 0   | Very Bad | 0                              | Very Bad | 0                | Very Bad | 64  | Moderate | 26    | Very Bad |
| 19 | Embung Bisuaf         | 0   | Very Bad | 0                              | Very Bad | 0                | Very Bad | 64  | Moderate | 60    | Bad      |
| 20 | Embung Eno Ana        | 0   | Very Bad | 0                              | Very Bad | 0                | Very Bad | 64  | Moderate | 40    | Very Bad |
| 21 | Embung Stelan         | 0   | Very Bad | 0                              | Very Bad | 0                | Very Bad | 66  | Moderate | 79    | Moderate |
| 22 | Embung Kobelima       | 0   | Very Bad | 0                              | Very Bad | 0                | Very Bad | 66  | Moderate | 56    | Bad      |
| 23 | Embung Tekes          | 0   | Very Bad | 0                              | Very Bad | 0                | Very Bad | 66  | Moderate | 36    | Very Bad |
| 24 | Embung Oelbosen       | 0   | Very Bad | 0                              | Very Bad | 0                | Very Bad | 66  | Moderate | 36    | Very Bad |
| 25 | Embung Oelnitep       | 0   | Very Bad | 0                              | Very Bad | 0                | Very Bad | 64  | Moderate | 36    | Very Bad |
| 26 | Embung Subun Bestobe  | 0   | Very Bad | 0                              | Very Bad | 0                | Very Bad | 65  | Moderate | 34    | Very Bad |
| 27 | Embung Sebe           | 0   | Very Bad | 0                              | Very Bad | 0                | Very Bad | 65  | Moderate | 60    | Bad      |
| 28 | Embung Palaman        | 0   | Very Bad | 0                              | Very Bad | 0                | Very Bad | 64  | Moderate | 50    | Bad      |
| 29 | Embung Pantae         | 0   | Very Bad | 0                              | Very Bad | 0                | Very Bad | 64  | Moderate | 10    | Very Bad |
| 30 | Embung Longga         | 0   | Very Bad | 0                              | Very Bad | 0                | Very Bad | 64  | Moderate | 56    | Bad      |
| 31 | Embung Ega            | 0   | Very Bad | 0                              | Very Bad | 0                | Very Bad | 66  | Moderate | 60    | Bad      |
| 32 | Embung Ulu Aeraso     | 0   | Very Bad | 0                              | Very Bad | 0                | Very Bad | 60  | Bad      | 61    | Moderate |
| 33 | Embung Alolai         | 0   | Very Bad | 0                              | Very Bad | 0                | Very Bad | 60  | Bad      | 49    | Bad      |
| 34 | Embung Kembo II       | 0   | Very Bad | 0                              | Very Bad | 0                | Very Bad | 60  | Bad      | 49    | Bad      |
| 35 | Embung Jong I         | 0   | Very Bad | 0                              | Very Bad | 0                | Very Bad | 53  | Bad      | 49    | Bad      |
| 36 | Embung Tasik Terong   | 0   | Very Bad | 0                              | Very Bad | 0                | Very Bad | 53  | Bad      | 74    | Moderate |
| 37 | Embung Waekobe II     | 0   | Very Bad | 0                              | Very Bad | 0                | Very Bad | 50  | Bad      | 50    | Bad      |
| 38 | Embung Pore           | 0   | Very Bad | 0                              | Very Bad | 0                | Very Bad | 49  | Bad      | 55    | Bad      |
| 39 | Embung Alodube        | 0   | Very Bad | 0                              | Very Bad | 0                | Very Bad | 38  | Very Bad | 45    | Bad      |
| 40 | Embung Kahabilangga   | 0   | Very Bad | 0                              | Very Bad | 0                | Very Bad | 65  | Moderate | 46    | Bad      |
| 41 | Embung Pau            | 0   | Very Bad | 0                              | Very Bad | 0                | Very Bad | 62  | Moderate | 65    | Moderate |
| 42 | Embung Kahi           | 0   | Very Bad | 0                              | Very Bad | 0                | Very Bad | 70  | Moderate | 56    | Bad      |
| 43 | Embung Palanggai      | 0   | Very Bad | 0                              | Very Bad | 0                | Very Bad | 56  | Bad      | 32    | Very Bad |
| 44 | Embung Daiwa I        | 0   | Very Bad | 0                              | Very Bad | 0                | Very Bad | 64  | Moderate | 52    | Bad      |
| 45 | Embung Pawolung       | 0   | Very Bad | 0                              | Very Bad | 0                | Very Bad | 64  | Moderate | 46    | Bad      |
| 46 | Embung SMP            | 0   | Very Bad | 0                              | Very Bad | 0                | Very Bad | 42  | Bad      | 51    | Bad      |
| 47 | Embung Langira Padaka | 0   | Very Bad | 0                              | Very Bad | 0                | Very Bad | 64  | Moderate | 42    | Bad      |
| 48 | Embung Dikir          | 0   | Very Bad | 0                              | Very Bad | 0                | Very Bad | 53  | Bad      | 34    | Very Bad |
| 49 | Embung Dello          | 0   | Very Bad | 0                              | Very Bad | 0                | Very Bad | 52  | Bad      | 25    | Very Bad |

Based on the recapitulation in Table 3, the average condition of small dam operation and maintenance performance in the Nusa Tenggara Timur is atrocious: 39% out of 100%. The operation and maintenance (OP) are not carried out in the field, no implementation application is used in the OP guidance, and there are no guard officers of small dams, manual of OP, and equipment for OP activity implementation in the field. However, the average condition of small dam usage performance in the Nusa Tenggara Timur is sufficient for water allocation and atrocious for service basin

availability. The water allocation is authorized by some persons/private/only the owner of the area. There is a conflict in the water allocation so there is society which destroys the distribution network. There are three service basins: human basin built but not used by society because the condition is far from residences' expectations, animal basin built but not used by society because there is no husbandry in the development location, and garden service built but not used by society because it is not in the plantation area.

Table 4 Survey result for the organization management and water availability at the current condition of semi-arid areas' small dams (Own study)

| No | Location of Small Dam | Organization Management Aspect |          |                |          | Small Dam Water Availability Aspect |          |                   |          |        |          |
|----|-----------------------|--------------------------------|----------|----------------|----------|-------------------------------------|----------|-------------------|----------|--------|----------|
|    |                       | Organization                   |          | Member Meeting |          | Volume of Inundation                |          | Availability Time |          | Inflow |          |
|    |                       | Score                          | Category | Score          | Category | Score                               | Category | Score             | Category | Score  | Category |
| 1  | Embung Kiubiblian     | 0                              | Very Bad | 0              | Very Bad | 70                                  | Moderate | 70                | Moderate | 70     | Moderate |
| 2  | Embung Naioni I       | 0                              | Very Bad | 0              | Very Bad | 70                                  | Moderate | 70                | Moderate | 70     | Moderate |
| 3  | Embung Naioni II      | 0                              | Very Bad | 0              | Very Bad | 65                                  | Moderate | 65                | Moderate | 65     | Moderate |
| 4  | Embung Manulai II     | 0                              | Very Bad | 0              | Very Bad | 65                                  | Moderate | 65                | Moderate | 65     | Moderate |
| 5  | Embung Oekolo         | 0                              | Very Bad | 0              | Very Bad | 65                                  | Moderate | 65                | Moderate | 65     | Moderate |
| 6  | Embung Nunu Sa        | 0                              | Very Bad | 0              | Very Bad | 65                                  | Moderate | 65                | Moderate | 65     | Moderate |
| 7  | Embung Bisti          | 0                              | Very Bad | 0              | Very Bad | 65                                  | Moderate | 65                | Moderate | 65     | Moderate |
| 8  | Embung Hoenabab       | 0                              | Very Bad | 0              | Very Bad | 65                                  | Moderate | 65                | Moderate | 65     | Moderate |
| 9  | Embung Kiubiblian II  | 0                              | Very Bad | 0              | Very Bad | 70                                  | Moderate | 70                | Moderate | 70     | Moderate |
| 10 | Embung Topkole        | 0                              | Very Bad | 0              | Very Bad | 70                                  | Moderate | 70                | Moderate | 60     | Bad      |
| 11 | Embung Fatubibi       | 0                              | Very Bad | 0              | Very Bad | 75                                  | Moderate | 75                | Moderate | 75     | Moderate |
| 12 | Embung Hoateta        | 0                              | Very Bad | 0              | Very Bad | 75                                  | Moderate | 75                | Moderate | 75     | Moderate |
| 13 | Embung Kaedoki        | 0                              | Very Bad | 0              | Very Bad | 75                                  | Moderate | 75                | Moderate | 75     | Moderate |
| 14 | Embung Ina Koabatun   | 0                              | Very Bad | 0              | Very Bad | 75                                  | Moderate | 75                | Moderate | 75     | Moderate |
| 15 | Embung Ale            | 0                              | Very Bad | 0              | Very Bad | 65                                  | Moderate | 65                | Moderate | 70     | Moderate |
| 16 | Embung Oe Ana         | 0                              | Very Bad | 0              | Very Bad | 65                                  | Moderate | 50                | Bad      | 50     | Bad      |
| 17 | Embung Menpoko        | 0                              | Very Bad | 0              | Very Bad | 75                                  | Moderate | 75                | Moderate | 60     | Bad      |
| 18 | Embung Huibaki        | 0                              | Very Bad | 0              | Very Bad | 75                                  | Moderate | 75                | Moderate | 70     | Moderate |
| 19 | Embung Bisuaf         | 0                              | Very Bad | 0              | Very Bad | 75                                  | Moderate | 75                | Moderate | 70     | Moderate |
| 20 | Embung Eno Ana        | 0                              | Very Bad | 0              | Very Bad | 70                                  | Moderate | 60                | Bad      | 70     | Moderate |
| 21 | Embung Stelan         | 0                              | Very Bad | 0              | Very Bad | 60                                  | Bad      | 70                | Moderate | 70     | Moderate |
| 22 | Embung Kobelima       | 0                              | Very Bad | 0              | Very Bad | 60                                  | Bad      | 70                | Moderate | 70     | Moderate |
| 23 | Embung Tekes          | 0                              | Very Bad | 0              | Very Bad | 65                                  | Moderate | 65                | Moderate | 70     | Moderate |
| 24 | Embung Oelbosen       | 0                              | Very Bad | 0              | Very Bad | 65                                  | Moderate | 65                | Moderate | 70     | Moderate |
| 25 | Embung Oelnitep       | 0                              | Very Bad | 0              | Very Bad | 65                                  | Moderate | 65                | Moderate | 65     | Moderate |
| 26 | Embung Subun Bestobe  | 0                              | Very Bad | 0              | Very Bad | 70                                  | Moderate | 70                | Moderate | 65     | Moderate |
| 27 | Embung Sebe           | 0                              | Very Bad | 0              | Very Bad | 70                                  | Moderate | 70                | Moderate | 65     | Moderate |
| 28 | Embung Palaman        | 0                              | Very Bad | 0              | Very Bad | 70                                  | Moderate | 70                | Moderate | 65     | Moderate |
| 29 | Embung Pantae         | 0                              | Very Bad | 0              | Very Bad | 70                                  | Moderate | 70                | Moderate | 70     | Moderate |
| 30 | Embung Longga         | 0                              | Very Bad | 0              | Very Bad | 75                                  | Moderate | 75                | Moderate | 75     | Moderate |
| 31 | Embung Ega            | 0                              | Very Bad | 0              | Very Bad | 85                                  | Good     | 80                | Moderate | 80     | Moderate |
| 32 | Embung Ulu Aeraso     | 0                              | Very Bad | 0              | Very Bad | 80                                  | Moderate | 80                | Moderate | 80     | Moderate |
| 33 | Embung Alolai         | 0                              | Very Bad | 0              | Very Bad | 80                                  | Moderate | 80                | Moderate | 80     | Moderate |
| 34 | Embung Kembo II       | 0                              | Very Bad | 0              | Very Bad | 75                                  | Moderate | 80                | Moderate | 80     | Moderate |
| 35 | Embung Jong I         | 0                              | Very Bad | 0              | Very Bad | 75                                  | Moderate | 75                | Moderate | 80     | Moderate |
| 36 | Embung Tasik Terong   | 0                              | Very Bad | 0              | Very Bad | 75                                  | Moderate | 80                | Moderate | 75     | Moderate |
| 37 | Embung Waekobe II     | 0                              | Very Bad | 0              | Very Bad | 50                                  | Moderate | 50                | Bad      | 65     | Moderate |
| 38 | Embung Pore           | 0                              | Very Bad | 0              | Very Bad | 75                                  | Moderate | 75                | Moderate | 75     | Moderate |
| 39 | Embung Alodube        | 0                              | Very Bad | 0              | Very Bad | 75                                  | Moderate | 75                | Moderate | 75     | Moderate |
| 40 | Embung Kahabilangga   | 0                              | Very Bad | 0              | Very Bad | 70                                  | Moderate | 70                | Moderate | 70     | Moderate |
| 41 | Embung Pau            | 0                              | Very Bad | 0              | Very Bad | 70                                  | Moderate | 70                | Moderate | 70     | Moderate |
| 42 | Embung Kahi           | 0                              | Very Bad | 0              | Very Bad | 70                                  | Moderate | 70                | Moderate | 70     | Moderate |
| 43 | Embung Palanggai      | 0                              | Very Bad | 0              | Very Bad | 70                                  | Moderate | 70                | Moderate | 70     | Moderate |
| 44 | Embung Daiwa I        | 0                              | Very Bad | 0              | Very Bad | 70                                  | Moderate | 70                | Moderate | 70     | Moderate |
| 45 | Embung Pawolung       | 0                              | Very Bad | 0              | Very Bad | 70                                  | Moderate | 70                | Moderate | 70     | Moderate |
| 46 | Embung SMP            | 0                              | Very Bad | 0              | Very Bad | 70                                  | Moderate | 60                | Bad      | 70     | Moderate |
| 47 | Embung Langira Padaka | 0                              | Very Bad | 0              | Very Bad | 70                                  | Moderate | 60                | Bad      | 70     | Moderate |
| 48 | Embung Dikir          | 0                              | Very Bad | 0              | Very Bad | 70                                  | Moderate | 65                | Moderate | 70     | Moderate |
| 49 | Embung Dello          | 0                              | Very Bad | 0              | Very Bad | 70                                  | Moderate | 60                | Bad      | 70     | Moderate |

Based on the recapitulation in Table 4, the average condition of the small dam organization management in the Nusa Tenggara Timur is atrocious because there are no small dam water user group, member meeting, and member with the ability in the simple carpentry for maintaining the component of small dams, and they must be asked from the other place. However, the average condition of the small dam management in the Nusa Tenggara Timur is sufficient. The small dam has

the following conditions: the inundation area and inundation volume are very different from the initial design because there is damage in the small dam structure. Water in the small dam inundation is very little because the amount of available water is much less than that of water usage and loss, and the inflow comes from rainfall at a channel width of less than 0.5 m in average.

## 4. Conclusion

This research intended to assess the conditions of small dams for an effective performance index modeling of small dams in the semi-arid area in NTT, Indonesia. Small dams are one of the water sources that very help fulfilling the water need in the Nusa Tenggara Timur region, and the amount is high enough until 2020; there are 3,658 small dams (BPS-NTT, 2021) in the NTT province. A small dam is said to be good or success if it is reviewed from the physical aspect that there is no damage in the components of the small dam physics. If it is reviewed from the operation and service aspect, a small dam is said to be success; however, it can be used by various parties in the scheme to produce each small dam unit.

Based on the analysis carried out, it can be concluded that the average physical conditions of small dams in the Nusa Tenggara Timur are moderate: 61-80% out of 100%, which is a good small dam condition; the average condition of small dam operation and maintenance performance in the Nusa Tenggara Timur is atrocious: 39% out of 100%; the average condition of small dam organization management in the Nusa Tenggara Timur is atrocious because there is no small dam water user group. The average condition of the small dam management in the Nusa Tenggara Timur is sufficient because the small dam has the following conditions: the inundation area and inundation volume are very different from the initial design because there is damage in the small dam structure. Water in the small dam inundation is very little because the amount of water available is much less than that of water usage and loss, and the inflow comes from rainfall.

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