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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。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.

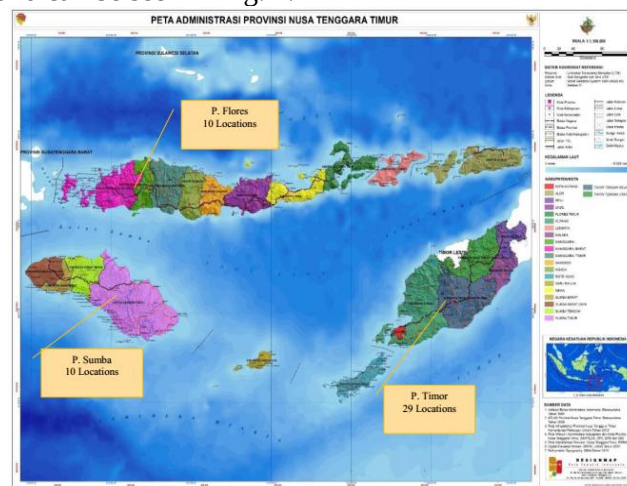


Fig. 1 Map of the research location (Report of RTRW-NTT Province, 2020)

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;
6. Ruins 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)

Level of Condition	General Sense
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 total improvement.

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.

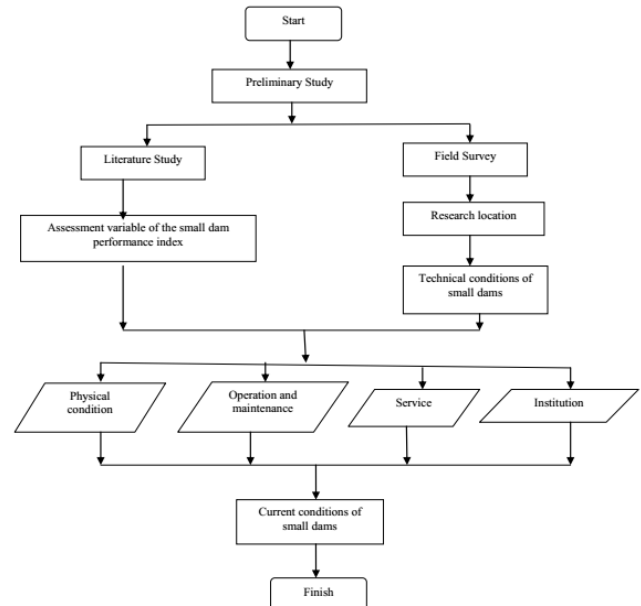


Fig. 2 Flowchart of the study (Own study)

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	Embuung 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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