

Optimization Analysis Of Heavy Equipment Management In The Local Government Of West Sumatra Province

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ABSTRACT

Heavy equipment plays a critical role in supporting infrastructure development and post-disaster recovery handled by the Highways, Human Settlements, and Spatial Planning Department of West Sumatra Province. This study aims to assess the optimization level of heavy equipment management through an economic feasibility analysis. Employing a qualitative method with primary and secondary data, the research examines equipment condition, utilization, and operational costs. Results indicate that equipment usage—both for internal operations and external rental—averaged only 20% of normal capacity, signaling inefficiency. To address this, the study proposes: revising policies on equipment functions and budgeting; developing utilization plans and performance evaluations; integrating digital management systems; updating and enforcing maintenance SOP; and enhancing operator and technician competencies. Properly optimized equipment usage would ensure better infrastructure performance, longer equipment lifespan, and significantly higher local revenue (PAD) for the provincial government. These findings offer strategic input for improving heavy equipment governance in regional public service delivery.

Keywords: heavy equipment, heavy equipment management, efficiency, effectiveness, optimization, infrastructure development.

1. INTRODUCTION

Infrastructure development plays a vital role in driving economic growth in a region, including in West Sumatra Province. In this context, heavy equipment serves as a crucial component that accelerates the completion of construction projects, such as the development of roads, bridges, and other facilities. The Department of Highways, Human Settlements, and Spatial Planning of West Sumatra Province is responsible for managing the heavy equipment used in regional infrastructure development. However, sub-optimal management of this equipment has adversely affected the effectiveness and efficiency of project implementation, as evidenced by low utilization rates and various technical issues.

In carrying out its duties, the Department of Highways, Human Settlements, and Spatial Planning, through the Technical Implementation Unit of Workshop and Equipment, currently manages 13 types of heavy equipment, totaling 58 units. These machines are used both for departmental needs and for rental purposes to generate additional regional revenue (PAD) for West Sumatra Province. In addition to supporting infrastructure development, the equipment also plays a critical role in accelerating post-disaster recovery efforts across the region. According to the 2024 data from the Technical Implementation Unit of Workshop and Equipment, 49 units (84%) are in good condition, 4 units (7%) are slightly damaged,

and 5 units (9%) are severely damaged (Department of Highways, Human Settlements, and Spatial Planning, 2024). Despite this, the available equipment has not been utilized optimally in supporting the service performance of the Department of Highways, Human Settlements, and Spatial Planning. Furthermore, the West Sumatra Provincial Inspectorate in 2022 found that the existing facilities and infrastructure had not been fully leveraged to support road infrastructure management activities.

Revenue data from the Department of Highways, Human Settlements, and Spatial Planning regarding the rental of heavy equipment show that the actual regional income (PAD) from such rentals over the past five years (2019–2023) has consistently fallen short of the established targets—except in 2019. That year, rental revenue reached IDR 1,131,503,000 against a target of IDR 750,000,000, achieving 151% of the target. However, in subsequent years, the highest achievement rate did not exceed 62%. Notably, in 2023, the revenue reached only 22% of the target, with a realization of IDR 337,865,000 against a target of IDR 1,550,000,000. According to Sari et al. (2021), several factors hinder the management of equipment and machinery rental revenues: (1) inadequate facilities, (2) limited budgets, (3) insufficient quantity and quality of human resources, (4) private sector competition, and (5) low user demand (Sari et al., 2021).

To optimize the management of heavy equipment, it is essential to conduct an analysis of its utilization level and economic feasibility. The findings should inform policy recommendations aimed at improving productivity, cost efficiency, equipment lifespan, workplace safety, and increasing regional revenue.

Previous studies highlight the importance of heavy equipment in expediting construction projects. For instance, research by Rivana et al. indicates that efficient time and cost management in the use of heavy machinery is critical for completing construction projects more quickly and effectively (Rivana et al., 2024). This aligns with Kumara's findings, which emphasize that heavy equipment is a key resource in construction projects and that equipment selection analysis is vital to achieving productivity efficiency (Kumara & Ariana, 2023). Implementing appropriate maintenance strategies, such as preventive and condition-based maintenance, can reduce downtime and enhance equipment availability (Darestani et al., 2020; Solms & Meyer, 2021). Moreover, sound management practices contribute to occupational safety by reducing the risk of accidents due to equipment failure (Almaskati et al., 2024). Conversely, poor management can increase costs and delay project progress. This study aims to provide new insights into the optimal management of heavy equipment, particularly in the context of local government in West Sumatra.

Furthermore, Yanuar et al. emphasize that heavy equipment is designed to perform various construction functions, such as earthworks and material handling, that significantly shorten project execution time (Yanuar et al., 2024). Similarly, Janizar et al. stress that the use of heavy equipment at each stage of a construction project is crucial for achieving effective and efficient outcomes (Janizar et al., 2023). Therefore, heavy machinery not only accelerates processes but also ensures higher-quality work.

The significance of this study lies in the fact that more efficient heavy equipment management can accelerate the achievement of development goals outlined in the 2021–2026 Regional Medium-Term Development Plan (RPJMD) of West Sumatra Province. These goals include a mission to enhance equitable and sustainable infrastructure development. This research also provides a deeper economic analysis of heavy equipment and offers practical, applicable recommendations for its management. Ultimately, this can support infrastructure development in West Sumatra and increase PAD as a key source of regional development funding. The study aims to analyze the optimization level of heavy equipment management based on an economic feasibility analysis of the equipment under the Department of Highways, Human Settlements, and Spatial Planning. The findings will be used to generate implementable recommendations for more efficient and productive equipment management, thereby contributing to increased PAD for the West Sumatra Provincial Government.

2. METHODS

This research was conducted from January to November 2024. The study sites included all locations where the construction equipment was deployed. According to data from the Workshop and Equipment Technical Implementation Unit of the Department of Highways, Human Settlements, and Spatial Planning of West Sumatra Province, the equipment managed by the Department is not only located at the Technical Implementation Unit of Workshop and Equipment pool but also distributed across all Technical Implementation Units for Roads and Bridges. Therefore, the study area encompassed the Technical Implementation Unit of Workshop and Equipment and the operational areas of the Technical Implementation Unit of Roads and Bridges from Region I to Region VI, covering Padang City, Padang Pariaman Regency, West Pasaman Regency, Payakumbuh City, Solok City, Sawahlunto City, and Bukittinggi City.

This study employed a qualitative approach, utilizing data collection techniques such as observation, interviews, focus group discussions (FGD), and documentation. Interviews were conducted with heavy equipment operators, equipment coordinators, and mechanics at each Technical Implementation Unit. Additionally, interviews were carried out with the management of a private heavy equipment rental company based in Padang City. FGD were held with the heads of Roads and Bridges Technical Implementation Unit, the head of the Technical Implementation Unit of Workshop and Equipment, and their respective staff. The data used in this study consisted of both primary and secondary sources. Primary data were obtained through direct observation of the physical condition of the equipment on-site and interviews with relevant stakeholders, including managers, users, Technical Implementation Unit of Workshop and Equipment staff, and private sector actors involved in equipment management. Secondary data were gathered from relevant archives and reports, such as revenue records, operational costs, maintenance logs, and equipment inventory data.

The population of this study included 58 units of heavy equipment managed by the Department of Highways, Human Settlements, and Spatial Planning of West Sumatra Province, distributed across six operational regions of the Technical Implementation Unit of Roads and Bridges and the Technical Implementation Unit of Workshop and Equipment.

The research sample was selected using purposive sampling based on specific criteria, including the type of equipment, condition, and the year of acquisition—both the newest and oldest. Based on these criteria, 16 units were selected as representative samples of the various types of heavy equipment used in the field. Data collected in accordance with these criteria were analyzed qualitatively to identify the current conditions of equipment management. The types of heavy equipment and sample sizes are presented in Table 1.

Table 1. Types and Number of Heavy Equipment Samples

No.	Type of Equipment	Condition				
		Number of Units	Good	Minor Damage	Major Damage	Sample
1	Baby Roller	11	9	1	1	2
2	Backhoe Loader	10	8	2		2
3	Bulldozer	1		1		1
4	Dump Truck	10	10			2
5	Excavator	3	3			2
6	Motor Grader	3	1		2	1
7	Tandem Roller	5	5			1*
8	Truck Crane	10	10			2
9	Mobile Crane	1			1	0
10	Forklift	1	1			1
11	Wheel Loader	2	1		1	1
12	Truck Tronton	1	1			1
	Total	58	49	4	5	16

Source: Processed from Technical Implementation Unit of Workshop and Equipment, Department of Highways, Human Settlements, and Spatial Planning, West Sumatra Province.

The economic feasibility analysis was conducted using methods such as Break-Even Point (BEP), Net Present Value (NPV), and Internal Rate of Return (IRR). The collected data were analyzed to provide insights into the operational feasibility of the equipment and to formulate recommendations for more efficient management strategies targeted at policymakers.

3. RESULT AND DISCUSSION

3.1. Heavy Equipment Management Condition

The condition of heavy equipment under the management of Department of Highways, Human Settlements, and Spatial Planning of West Sumatra Province is classified into three

categories: good, minor damage, and major damage. Equipment is categorized as being in good condition if it is still fully operational and suitable for technical activities. Equipment is considered to have minor damage if it remains functional but requires maintenance or minor repairs to prevent further degradation. Equipment is categorized as having major damage if it has sustained significant defects requiring extensive repairs or complete replacement to restore operational status.

As of 2024, the Department of Highways, Human Settlements, and Spatial Planning manages a total of 58 units of heavy equipment. Of these, 49 units (84%) are in good condition, 4 units (7%) are classified as having minor damage, and 5 units (9%) are in a state of major damage. The overall condition of the equipment is illustrated in Figure 1.

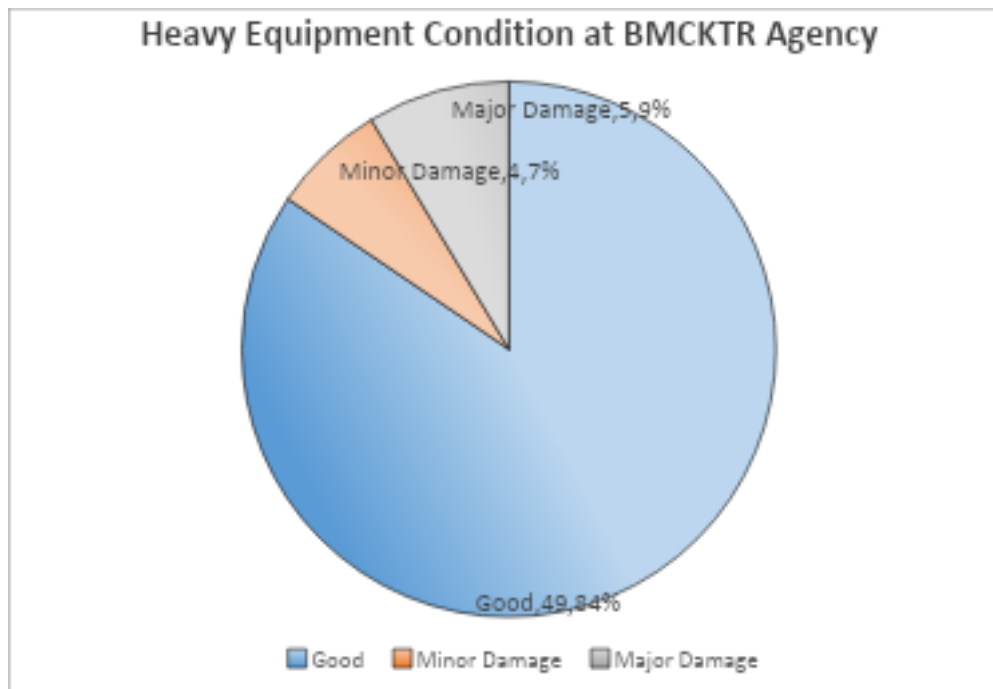


Figure 1. Condition of Heavy Equipment at the Department of Highways, Human Settlements, and Spatial Planning of West Sumatra Province (2024)

The Department of Highways, Human Settlements, and Spatial Planning employs 31 personnel in the Technical Implementation Unit of Workshop and Equipment unit, comprising both civil servants and non-permanent staff. The organizational structure is headed by a unit chief, supported by a sub-section head of administration and two section heads. However, most of these personnel hold structural or administrative roles, while only a limited number are directly involved in the operational handling of heavy equipment. Currently, the unit has 9 equipment operators and only 1 maintenance technician, assisted by 2 supervisors responsible for monitoring operations. This number is significantly inadequate compared to the quantity of equipment being operated. A summary of personnel at the Technical Implementation Unit of Workshop and Equipment is presented in Table 2.

Table 2. Personnel Recapitulation at the Technical Implementation Unit of Workshop and Equipment, Department of Highways, Human Settlements, and Spatial Planning, 2024

No.	Position	Number
1	Head of Technical Implementation Unit of Workshop and Equipment	1
2	Head of Administrative Subdivision	1
3	Finance Manager	1
4	Administrative Officer for Facilities and Infrastructure	1
5	Head of Equipment and Disruption Services Section	1
6	Technical Infrastructure Analyst	1
7	Public Works and Housing Planning Manager	1
8	Heavy Equipment Operator	9
9	Head of Workshop and Logistics Section	1
10	Heavy Equipment Operations Supervisor	2
11	Equipment Maintenance Staff	1
12	General Staff	11
Total		31

Source: Technical Implementation Unit of Workshop and Equipment, Department of Highways, Human Settlements, and Spatial Planning (2024), processed

The current equipment management policy mandates that each Technical Implementation Unit of Roads and Bridges receives a standard equipment package from the Technical Implementation Unit of Workshop and Equipment. This package typically includes a backhoe loader, truck crane, baby roller, and dump truck, which are used primarily for routine road and bridge maintenance such as roadside clearing, surface and drainage cleaning, crack repairs, and pothole patching. In addition, heavy equipment plays a vital role during emergency responses to natural disasters such as landslides and soil subsidence.

As shown in Table 2, the Technical Implementation Unit of Workshop and Equipment currently has only 9 operators and 1 technician. To address this shortage, some Technical Implementation Units have recruited their own operators. However, interviews with Technical Implementation Unit officials revealed that hiring decisions are often based more on practical field experience than on formal certification (SIO – Operator Work License). Many believe that experienced operators produce better results than those with certifications

alone. Interviews with operators further revealed that most daily operations are performed based on personal experience, with little adherence to standard operating procedures (SOP), despite SOP being critical for ensuring consistency, safety, and efficiency.

Interviews with supervisors at the Technical Implementation Unit of Workshop and Equipment indicate that the Department of Highways, Human Settlements, and Spatial Planning has yet to implement continuous training for operators and management staff. In contrast, a private heavy equipment rental company in Padang regularly conducts training programs, both internally and through collaboration with external experts, including equipment vendors. Skilled and experienced human resources are essential to improving productivity and minimizing operational risks (Agustina et al., 2023; Alvionita et al., 2022). Therefore, investing in human resource development should be a strategic priority for institutions managing heavy equipment.

Heavy equipment at the Technical Implementation Unit of Roads and Bridges is mainly used for in-house operations and is not rented out to third parties, as the authority for equipment rental lies exclusively with the Technical Implementation Unit of Workshop and Equipment. The rental process is regulated through local government policies.

Interviews with Technical Implementation Unit staff from Regions I through VI identified several challenges in the current equipment rental system: (a) Rental rates set by the government are often not competitive with those offered by private companies, which can provide additional incentives such as discounts and bonuses, (b) Government units cannot accommodate deferred payment systems commonly offered by private firms, which creates a barrier to attracting third-party clients, (c) Equipment is frequently required for urgent internal needs, especially during natural disasters, reducing its availability for rental, (d) Technical Implementation Unit of Roads and Bridges units are not responsible for achieving revenue targets from rental services—this responsibility lies solely with the Technical Implementation Unit of Workshop and Equipment, (e) A lack of incentives for personnel involved in equipment rentals reduces motivation for promoting rental services.

Although the Department of Highways, Human Settlements, and Spatial Planning has several SOP in place for equipment management, including SOP for equipment usage, lending, maintenance, and repairs—there are areas for improvement. For example, the SOP for maintenance and repairs allocates an excessively long time for repairs, often extending over several weeks. This increases equipment downtime and idle capacity, thereby risking underachievement of revenue targets from rental services. Additionally, existing SOP lack detailed technical procedures such as daily inspection routines, spare parts replacement guidelines, scheduled maintenance instructions, and clear monitoring protocols. This is in stark contrast to the private heavy equipment rental company in Padang, which has comprehensive technical and managerial SOP covering various aspects of equipment operations.

The Department of Highways, Human Settlements, and Spatial Planning of West Sumatra Province has not yet implemented information technology in managing its heavy equipment assets. In fact, the use of information technology can significantly enhance the

effectiveness and efficiency of heavy equipment management. This is exemplified by private heavy equipment companies in Padang City that have already adopted such technologies in their operations. There are several advantages associated with the application of information technology in heavy equipment management. In general, these include: (1) monitoring working hours (Hours Meter/HM), routes, distance travelled, and equipment speed; (2) preventing collusion between field operators and equipment renters; (3) preventing collusion between equipment operators and renters; (4) improving operator productivity through an overtime system; (5) monitoring loading/unloading activities of ready-mix trucks; (6) tracking equipment location in real-time; (7) managing service and maintenance schedules; (8) reducing delays in equipment deployment; (9) analyzing fuel consumption costs; and (10) improving customer service quality (Trisnawati et al., 2020). Moreover, the use of information technology facilitates data collection and analysis necessary for better decision-making, which in turn enhances productivity and reduces operational costs (Anugrah et al., 2024; Ferbi et al., 2020). Furthermore, a study by Ripanti and Novriando (2023) emphasizes that an integrated information system in heavy equipment management can help improve the utilization rate of equipment in the field (Ripanti & Novriando, 2023).

3.2. Feasibility Analysis of Heavy Equipment

Idle Capacity

Idle capacity is calculated by subtracting the utilized capacity either through self-operation or rental from the established normal capacity. For equipment with rental measured in Hours Meter (HM), the standard normal capacity is set at 1,260 HM per year. For equipment rented by the day, the normal capacity is established at 180 days per year. This benchmark is based on an assumption of 20 working days per month, 7 working hours per day, and a 75% adjustment factor to account for moving or rotation time. This standard is significantly lower than that used by a private company in Padang, which sets a normal capacity of 2,000 HM per year.

Table 3. Idle Capacity of Heavy Equipment

No.	Heavy Equipment	Brand/Type	Inventory No.	Year of Acquisition	Normal Capacity per Year	Average In-House Use (3 Years)	Average Rental Use (3 Years)	Total Utilization	In-House Utilization (%)	Rental Utilization (%)	Idle Capacity (%)
1	Baby Roller	Sakai/HV8 OST	6	2012	180 days	0	0	0	0%	0%	100%
2	Baby Roller	Sakai/HV8 OST	10	2014	180 days	7	23	30	4%	13%	83%

3	Backhoe Loader	Case/580SR	2	2007	1.260 hours	142	80	222	11%	6%	82%
4	Backhoe Loader	Case/570T	10	2019	1.260 hours	542	40	582	43%	3%	54%
5	Bulldozer	CAT/D6R	1	2010	1.260 hours	18	194	212	1%	15%	83%
6	Dump Truck	Isuzu/NKR 71 HD	1	2012	180 days	49	7	56	27%	4%	69%
7	Dump Truck	Isuzu/NKR 71 HD	9	2014	180 days	51	0	51	28%	0%	72%
8	Excavator	CAT/320D	1	2011	1.260 hours	99	188	287	8%	15%	77%
9	Excavator	Yanmar/Vio 50	3	2019	1.260 hours	534	76	610	42%	6%	52%
10	Motor Grader	CAT/120K	3	2011	1.260 hours	111	474	585	9%	38%	54%
11	Tandem Roller	Sakai/SW3 00	5	2020	1.260 hours	77	89	166	6%	7%	87%
12	Truck Crane	Isuzu/NKR 71 Elf	2	2013	1.260 hours	2,7	1	3,7	0%	0%	98%
13	Truck Crane	Isuzu/NKR 71 Elf	10	2014	1.260 hours	10,67	2,33	13	1%	0%	93%
14	Forklift	CAT/PD30	1	2011	1.260 hours	0	0	0	0%	0%	100%
15	Wheel Loader	CAT/924Hz	1	2010	1.260 hours	113	31	144	9%	2%	89%
16	Truck Tronton	Mitsubishi/FN	1	2005	180 days	15	4	19	8%	2%	90%
Average									12%	7%	80%
Maximum									43%	38%	100%
Minimum									0%	0%	52%

Despite the relatively conservative estimate for normal capacity, actual utilization remains markedly low. As indicated in Table3, the average utilization of heavy equipment managed by the Department of Highways, Human Settlements, and Spatial Planning during the 2021–2023 period was only about 20% of the normal capacity. Consequently, 80% of the total capacity remains underutilized. Notably, some equipment showed no usage

whatsoever during the observed period, such as the Sakai HV80ST baby roller (acquired in 2012, wall number 6) and the CAT PD30 forklift (acquired in 2011, wall number 1).

The highest recorded utilization was for the Yanmar Vio 50 excavator (acquired in 2019, wall number 3), which reached 48% of its normal capacity. The bulldozer was predominantly used for rental purposes rather than internal mobilization (no usage was recorded for self-operation). Of the total 212 HM bulldozer usage, 194 HM (91%) was from rentals. Similarly, the motor grader was heavily used for rental; of the 585 HM total usage, 474 HM (81%) came from external rental services.

These findings underscore the under-utilization of heavy equipment assets. Although the bulldozer, motor grader, and excavator are among the most frequently rented units, all of them remain significantly underutilized relative to their normal capacity. Specifically, idle capacity reached 83% for the bulldozer, 54% for the motor grader, and 77% for the excavator. Some units, such as the baby roller and forklift, remained completely idle throughout the period. Such high idle capacity can result in substantial financial losses for the equipment management unit, as fixed costs must still be borne even when equipment is not in use. Therefore, understanding the underlying causes of idle capacity is essential to improving operational efficiency and asset productivity (Firda et al., 2023).

Interviews with heads and staff of the Technical Implementation Unit of Roads and Bridges units revealed several contributing factors to this low utilization rate. These include the need to keep heavy equipment on standby in landslide-prone areas during the rainy season, delays in the procurement of spare parts (many of which require long lead times), and prioritization of road and bridge repairs by regional Technical Implementation Unit, which often leads to reluctance in renting out equipment. In addition, limitations on hot mix asphalt procurement, which often requires minimum purchase quantities, as well as insufficient budget allocations for equipment maintenance, repairs, and roadwork, further contribute to this inefficiency.

These challenges demonstrate that, despite the availability of equipment, the management practices have not yet reached optimal efficiency. Considering the substantial investment required for acquiring and maintaining heavy equipment, effective management is crucial to ensure operational efficiency and financial viability (Jiang and Jiang, 2011; Jambol et al., 2024).

Calculation of Rental Revenue Surplus (Deficit)

Table 4. Summary of Feasibility Analysis of Heavy Equipment Management at the Department of Highways, Human Settlements, and Spatial Planning of West Sumatra Province

NO	Heavy Equipment	Brand/ Type	Surplus (Deficit) Without Opportunity Cost (avg. 3 years)	Surplus (Deficit) With Opportunity Cost (avg. 3 years)	BEP (% kap BEP dari KN)	NPV (DF 10%)	IRR (DF 10%)	More Efficient (Self Operated/Renting)
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			without deprecia tion	with deprecia tion	without deprecia tion	with deprecia tion				
1	Baby Roller	Sakai/ HV80S T	NA	NA	Defisit	Defisit	40 days (22%)	Positive IDR 15 Million (3 years)	NA	
2	Baby Roller	Sakai/ HV80S T	Defisit	Defisit	Defisit	Defisit	54 days (30%)	Positive IDR 19,5 Million (4 years)	NA	Renting
3	Backhoe Loader	Case/5 80SR	Surplus	Defisit	Surplus	Defisit	283 HM (22%)(	Positive IDR 81 Million (5 years)	34%	
4	Backhoe Loader	Case/5 70T	Surplus	Defisit	Surplus	Defisit	254 HM (20%)	Positive IDR 14 Million (4 years)	14%	Self Operated
5	Bulldozer	CAT/D 6R	Defisit	Defisit	Defisit	Defisit	184 HM (15%(	Positive IDR 774 Million (4 years)	NA	Self Operated
6	Dump Truck	Isuzu/N KR 71 HD	Defisit	Defisit	Defisit	Defisit	38 days (21%)	Positive IDR 25 Million (8 years)	NA	
7	Dump Truck	Isuzu/N KR 71 HD	NA	NA	Defisit	Defisit	33 days (18%)	Positive IDR 43 Million (9 years)	NA	Self Operated
8	Excavator	CAT/32 0D	Surplus	Surplus	Surplus	Surplus	98 HM (8%)	Positive IDR 125 Million (3 years)	NA	
9	Excavator	Yanmar /Vio 50	Surplus	Defisit	Surplus	Defisit	236 HM (19%)	Positive IDR 91 Million (6 years)	32%	Self Operated
10	Motor Grader	CAT/12 0K	Surplus	Surplus	Surplus	Surplus	121 HM (10%)	Positive IDR 155 Million (4 years)	NA	Renting
11	Tandem Roller	Sakai/S W300	Defisit	Defisit	Defisit	Defisit	305 HM (24%)	Positive IDR 12 Million (7 years)	13%	Renting
12	Truck Crane	Isuzu/N KR 71 Elf	Defisit	Defisit	Defisit	Defisit	31 days (17%)	Positive IDR 168 Million (9 years)	NA	
13	Truck Crane	Isuzu/N KR 71 Elf	Defisit	Defisit	Defisit	Defisit	43 days (24%)	Positive IDR 179 Million (10 years)	NA	Self Operated
14	Forklift	CAT/P D30	NA	NA	Defisit	Defisit	120 HM (9%(	Positive IDR 131 Million (8 years)	NA	Self Operated

15	Wheel Loader	CAT/92 4Hz	Defisit	Defisit	Defisit	Defisit	137 HM (11%)	Positive IDR 161 Million (8 years)	NA	Self Operated
16	Truck Tronton	Mitsubishi/FN	Defisit	Defisit	Defisit	Defisit	31 days (17%)	Positive IDR 105 Million (9 years)	NA	Self Operated
Average							18%			
Highest							30%			
Lowest							8%			

Table 4 presents a summary of the feasibility analysis of heavy equipment management at the Department of Highways, Human Settlements, and Spatial Planning of West Sumatra Province. Based on this table, an analysis of 16 heavy equipment units reveals that 5 units (29%) generated a rental revenue surplus during the 2021–2023 period, excluding opportunity cost and without accounting for depreciation costs. These units were: the backhoe loader (2007), backhoe loader (2019), excavator (2011), excavator (2019), and motor grader (2011). In contrast, 3 units generated zero rental revenue over the same period: the baby roller (2012), dump truck (2014), and forklift (2011).

When depreciation is included in the cost analysis, only 2 equipment units (12%) (the excavator (2011) and motor grader (2011)) still reported a surplus. This is because the depreciation costs for these older assets have already reached zero, meaning that the total cost with and without depreciation remains the same.

In a separate analysis that incorporates opportunity cost, the findings remain consistent. Without depreciation, 5 units (29%) produced a rental surplus during the 2021–2023 period, identical to the previous scenario. However, once depreciation is considered, only 2 units (12%) again, the excavator (2011) and motor grader (2011) continued to generate surplus revenue, for the same reason.

Department of Highways, Human Settlements, and Spatial Planning Department applies the straight-line method for calculating depreciation over a useful life of 10 years. Consequently, equipment acquired in 2014 or earlier has fully depreciated, resulting in a book value of zero. Therefore, the total cost after including depreciation is equal to the sum of maintenance, repair, and technician salary expenses, and surplus revenue remains unchanged.

Overall, most heavy equipment units incurred rental revenue deficits, as the income generated was insufficient to cover maintenance, repair, and labor costs. This deficit persisted even when opportunity cost was taken into account, which reflects the lost rental income from using the equipment for in-house (self-operated) projects. The primary cause of this deficit is the low utilization rate, both for rentals and self-operation, which averaged only 20% of normal capacity during 2021–2023.

Research by Febrianti and Zakia (2019) underscores the importance of analyzing both the cost and duration of equipment usage, as sub-optimal utilization can lead to waste and reduced profitability (Febrianti and Zakia, 2019). Therefore, it is essential to improve the utilization of heavy equipment, both for self-operated projects and rental services. Increasing utilization for internal infrastructure work can help maintain the quality and functionality of roads and bridges, while enhancing rental usage can increase local revenue (PAD), which is critical for supporting regional development efforts.

Break-Even Point (BEP) Calculation and Potential for Local Revenue (PAD)

The Break-Even Point (BEP) analysis conducted by the Department of Highways, Human Settlements, and Spatial Planning assumes that the utilization of heavy equipment can be optimized up to its normal capacity. The analysis further assumes that 30% of the equipment's normal capacity (excluding bulldozers) can be allocated for rental, while the remaining 70% is used for in-house (self-operated) activities. For bulldozers, all unused capacity not allocated for self-operated activities is assumed to be fully available for rental purposes.

Fixed costs, which include maintenance and repair costs, mechanic salaries, and depreciation, are proportionally allocated between bulldozers (70%) and other heavy equipment (30%). The BEP is calculated by dividing the allocated fixed costs by the rental rate of each unit. The results show an average BEP of 18% of the normal capacity. Thus, if 30% of the equipment's capacity is rented, it would generate an average rental surplus of 12% (30% - 18%).

The highest BEP was found in the baby roller (2014) at 30%, while the lowest BEP was recorded for the excavator (2011) at 8%. With optimal usage reaching the designated normal capacity 1,260 Hours Meter (HM) per year for most equipment and 180 days per year for trucks, Department of Highways, Human Settlements, and Spatial Planning has the opportunity to increase its local revenue (PAD) through equipment rental.

Although the designated normal capacity is lower than that used by private companies in Padang (2,000 HM per year), the actual utilization during the 2021–2023 period was still significantly below optimal, averaging only 20% of normal capacity. The gross PAD potential from renting out 30% of normal capacity is estimated at IDR 1,454,850,000, with a net PAD of IDR 1,163,024,000 after deducting maintenance and repair costs, technician salaries, and depreciation expenses.

This demonstrates a substantial revenue potential, especially considering that the estimated income is derived from utilizing only one-third of the existing heavy equipment fleet. To harness this potential effectively and efficiently, good management practices are necessary, including improvements in planning, organizing, implementing, and monitoring the available resources (Sari et al., 2021). As previously discussed, Department of Highways, Human Settlements, and Spatial Planning still exhibits weaknesses in all of these management aspects.

Net Present Value (NPV) and Internal Rate of Return (IRR) Analysis

The Net Present Value (NPV) is calculated through the following steps: Annual cash inflows are estimated based on the assumption that 30% of the normal capacity of heavy equipment is rented. Cash outflows include maintenance and repair costs, technician salaries, and the initial investment. The book value of each unit as of December 31, 2023, is considered the initial investment. For equipment with zero book value, the initial investment is assumed to be zero. The remaining economic life of each unit is estimated based on the remaining HM or kilometers relative to their useful life. A discount rate of 10% is used, derived from the risk-free investment rate (e.g., government bonds) plus a risk premium for managing heavy equipment.

As shown in Table 4, all heavy equipment units in the sample yielded positive NPV values, indicating that each unit is economically viable, as the present value of cash inflows exceeds that of cash outflows. This means the rate of return for each unit exceeds the minimum acceptable return of 10%.

In terms of the Internal Rate of Return (IRR), all units exhibit an IRR above 10%, confirming their investment feasibility. IRR represents the discount rate at which the present value of future cash inflows equals the initial investment. If the IRR is greater than the required return, the investment is considered acceptable; otherwise, it should be rejected (Hanafi, Mandagie and Moektiwibowo, 2020). For instance, the excavator (2019) has an IRR of 32%, reflecting an excess return of 22%. In cases where the book value is zero, the IRR is marked as NA, as there is no initial investment; nevertheless, these units are economically highly feasible.

Decision-Making: In-House Operation (Self Operate) vs. Rent Heavy Equipment

A critical question arises regarding whether it is more beneficial for Department of Highways, Human Settlements, and Spatial Planning to operate heavy equipment through in-house (self-managed operation) mechanisms or to rent such equipment from external providers. If the in-house option is selected, the associated cost outflows include the following components: 1) Maintenance and repair costs, 2) Technician salaries, 3) Fuel expenses, 4) Operator or driver salaries, 5) Initial equipment investment cost. The initial investment value is based on the 2024 procurement prices obtained from vendors or listed in the Government Procurement Policy Agency's (LKPP) e-catalogue, as shown in Table 5.

Table 5. Price List of Selected Heavy Equipment in August 2024

NO	Construction Equipment	Brand/Type	Reg. Number	Year Acquired	Acquisition Cost (Rp)	Purchase Price 2024*) + PPN 11%	Notes
1	Baby Roller	Sakai/HV80ST	10	2014	209.999.950	465.733.800	Sakai/HV80ST
2	Backhoe Loader	Case/570T	10	2019	1.107.370.000	1.470.750.000	570 SV
3	Bulldozer	CAT/D6R	1	2010	2.489.137.200	4.345.650.000	CAT D6R

4	Dump Truck	Isuzu/NKR 71 HD	9	2014	367.827.675	703.185.000	NMR HD
5	Excavator	Yanmar/Vio 50	3	2019	866.832.000	1.010.100.000	Yanmar/Vio 50
6	Motor Grader	CAT/120K	3	2011	1.763.832.400	3.075.232.800	120K
7	Tandem Roller	Sakai/SW300	5	2020	680.900.000	1.219.890.000	Sakai/SW354
8	Truck Crane	Isuzu/NKR 71 Elf	10	2014	684.970.000	1.327.560.000	Hino Crane 3.2T
9	Forklift	CAT/PD30	1	2011	376.200.000	721.500.000	DP30NB
10	Wheel Loader	CAT/924Hz	1	2010	1.760.000.000	2.578.530.000	924K
11	Truck Tronton	Mitsubishi/FN	1	2005	187.500.000	1.887.000.000	Izuzu FVZ6x4

*) Price based on e-catalog from the National Public Procurement Agency (LKPP) and vendors.

One notable advantage of in-house operation is the potential to generate revenue by renting out idle equipment, thereby increasing the local revenue (PAD) of the Provincial Government of West Sumatra through Department of Highways, Human Settlements, and Spatial Planning. If it is assumed that 30% of the normal operational capacity of the equipment can be rented out, then fuel expenses and operator/driver salaries can be reduced by 30%, as these costs are typically borne by the equipment renters. Therefore, the remaining 70% of fuel and operator-related costs would be accounted for under the in-house operational model.

If Department of Highways, Human Settlements, and Spatial Planning opts not to manage its own heavy equipment and instead rents from external parties for road and bridge maintenance activities, the cash outflows for renting will consist of the following components: 1) Rental fees, 2) Fuel costs, 3) Operator/driver wages. These rental-related costs are then compared against in-house operational costs to determine the more efficient option.

The cost comparison between in-house operation and renting is conducted over the economic lifespan of the equipment, which is standardized at 10 years, both for newly acquired and currently operating equipment. Cash outflows from both operational models are discounted over a 10-year period using a 10% discount rate.

As shown in Table 4, using the Net Present Value (NPV) approach, the in-house operation model proves to be more cost-efficient, resulting in a total savings of approximately IDR 14 billion over 10 years, or an average of IDR 1.4 billion per year. Out of the 11 types of heavy equipment evaluated, 7 types are found to be more economical when operated in-house: backhoe loader, bulldozer, dump truck, excavator, truck crane, forklift, and heavy-duty truck. The remaining 4 types—baby roller, motor grader, tandem roller, and wheel loader—are more cost-efficient under the in-house model only without NPV, but become more efficient to rent when NPV is taken into account.

According to Sari et al. (2021), the adjustment of heavy equipment rental tariffs is a key planning indicator in equipment management that should be carefully considered (Sari et al.,

2021). The current comparison is based on existing rental rates and operational costs. However, recent increases in the procurement prices of certain heavy equipment types suggest that tariff adjustments may be necessary in the future. With higher rental tariffs, the in-house operation model would become increasingly favorable. This observation aligns with the findings of Dwiputrianti and Zandrato, who noted that low rental tariffs are one of the indicators of sub-optimal heavy equipment management in the Public Works Department of Gunungsitoli (Dwiputrianti et al., no date).

4. CONCLUSION

The management of heavy equipment at the Department of Highways, Human Settlements, and Spatial Planning of West Sumatra Province remains not optimal, as evidenced by several indicators. First, the rental policy for heavy equipment is solely the responsibility of the Technical Implementation Unit for Workshop and Equipment, while the Technical Implementation Unit for Roads and Bridges has no obligation to rent out unused equipment. Second, the human resources managing the equipment are inadequate. Most operators and technicians rely solely on experience without continuous training or professional certification, increasing the risk of operational errors and prolonging repair times. Third, equipment utilization during the 2021–2023 period only reached 20% of normal capacity, leaving 80% of capacity idle. Fourth, most of the equipment units generated rental revenue deficits, even after considering opportunity costs. However, if utilization is optimized to normal capacity (1,260 hours or 180 days per year), and 30% of this capacity is allocated for rental, most equipment units are still economically viable, generating positive rental income, profit, positive Net Present Value (NPV), and high Internal Rate of Return (IRR), thus contributing to an increase in locally-generated revenue (PAD).

Furthermore, Standard Operating Procedures (SOP) and technical guidelines for equipment management remain inadequate. Key management functions—including equipment selection, operation, maintenance, and renewal are not fully implemented. Not all activities are supported by SOP, and several existing SOP are not executed effectively. Technical guidelines for operation, maintenance, and repair are unavailable. The Technical Implementation Unit for Workshop and Equipment lacks sufficient planning and control mechanisms, especially in the procurement of spare parts, which often takes considerable time and causes delays in repairs. Equipment monitoring and supervision are still carried out manually, without integrated, technology-based systems, resulting in limited access to real-time operational information.

An economic analysis using the NPV method indicates that in-house operation (self managed) is more efficient than renting, with a total efficiency gain of approximately IDR 14 billion over 10 years (averaging IDR 1.4 billion per year). Out of 11 types of heavy equipment analyzed, 7 are more efficient when operated in-house under both with and without NPV scenarios, while the remaining 4 types are only efficient without NPV.

These findings indicate that optimizing heavy equipment management through both in-house operation and external rentals can enhance economic feasibility and operational efficiency within the provincial government of West Sumatra.

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