

# Measuring the efficiency of the Indonesian Air Police using Data Envelopment Analysis with BCC Model

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**Abstract.** As part of the Indonesian National Police, one of the tasks of the Air Police is to support the Ministry of Environment and Forestry in preventing deforestation. With the available resources, the Air Police must be able to carry out their duties efficiently. This study measures the efficiency of the support performance of ten Air Police under the Control of the Regional Police covering ten provinces to prevent deforestation. Each operations control (OC) represents a Decision-Making Unit (DMU). Using Data Envelopment Analysis (DEA) with the Banker, Charnes, Cooper (BCC) model, the results showed that two OCs (Bali and North Sulawesi) were identified as efficient, while eight OCs were inefficient.

**Keywords:** Police, deforestation, efficiency, data envelopment analysis, BCC, VRS

## 6. Introduction

Domestic security based on Law Number 2 of 2002 concerning the Indonesian National Police is the main requirement in supporting the realization of a just, prosperous, and civilized civil society based on Pancasila and the 1945 Constitution of the Republic of Indonesia. A situation marked by the assurance of security and public order, as well as the enforcement of the law and the implementation of protection and services to the community [1]. Based on the main tasks and functions of the National Police in accordance with Police Regulation Number 5 of 2019 concerning the Organizational Structure of the Police Work Procedure, one of the elements in the police that has the authority to carry out security maintenance is the Air Police [2]. The Air Police, following their main duties and functions, carry out all functions of the Air Police throughout the territory of the Republic of Indonesia, both in the context of providing operational support to the National Police Headquarters and regional units, as well as providing support for all functions of the Police, regions, and ministries or institutions [3]. One of the Air Police's supports to the Ministry is cooperation in supporting the prevention of illegal logging or deforestation with the Ministry of Environment and Forestry.

The forest area in Indonesia is 125,797,052 hectares with the realization of the determination until December 2021 covering an area of 90,233,159 hectares with a total of 2,157 decrees. A significant increase in the area of forest area designation in the last 10 years to 72% of the total forest area in Indonesia [4]. This can result in increased deforestation. Regarding deforestation, to find out the existence and area of land cover, both forested and non-forested, both within forest areas (conservation, protection, and production forest) and outside forest areas (areas of other uses), the Ministry of Environment and Forestry must always conduct monitoring and supervision. In this case, good performance from the Air Police is needed to be able to support the duties of the Ministry of Environment regarding deforestation. One way to assess performance is to measure efficiency, whereby the resources (input) owned by the Air Police can produce the highest possible output, which in this case is countermeasures against deforestation. One of the methods used in measuring performance efficiency is data envelopment analysis (DEA).

DEA is a linear programming (LP) method that combines effort (input) and performance (output) to streamline each homogeneous decision-making unit (DMU) [5]. The application of DEA specifically

in the military or police field can be used to measure the efficiency of the performance of the Police station [6], main duties and functions [7], such as preventing crime [8] and traffic accidents [9], to the analysis of office facilities and service performance [10] as the basis for allocating funds and resources from the government. In a military operation situation, the DEA can be used to measure how efficient the absorption of the state budget on defence is against the operational activities of the armed forces [11], as well as the efficiency of selecting military transportation routes [12] and war schemes [13] as recommendations in determining the success or failure of an operation in a war situation. In terms of operational equipment, DEA can be applied to measure the efficiency of selecting military vehicles based on mobility in military operations activities [14], and from the defence industry side, it can be used as a basis for the allocation of R&D funds in producing weapons systems [15]. With the limited resources owned by Air Police, and with different locations (both regions and characteristics) of each Regional Police Operational Control (OC), this study will measure the performance efficiency of each OC in preventing deforestation by using DEA. This is intended to guide the Air Police's efforts to improve operational efficiency.

## 7. Methodology

DEA tries to maximize the efficiency of organizational units, expressed as a comparison between outputs and inputs, by comparing the efficiency of a particular unit with the performance of a group of similar service units that provide the same performance. In the process, if there is a unit that achieves 100 percent efficiency, it is called a relatively efficient unit, while a unit with an efficiency value of less than 100 percent is called an inefficient unit [16]. The DEA linear programming model was formulated according to Charnes, Cooper, and Rhodes in 1978 [17], and is referred to as the CCR Model. The CCR model is also called the constant return to scale (CSR) model because it has the assumption that the addition of input and output is the same, which means that if there is an additional input of  $n$ , the output variable also gets the same amount of addition. Thereafter in 1984, Banker, Charnes, and Cooper [18] developed the CCR model into the BCC Model. The opposite of CCR, in the BCC Model, if there is an additional input of  $n$  then it has no impact on the addition of the output or is called return to scale variable (VRS). Due to differences in resources, locations, and characteristics of each DMU, the analysis is input-oriented and carried out locally with the assumption that each DMU is not operating optimally. Therefore, this study uses the BCC Model.

In using DEA, the first thing to do is define input and output variables. And in this study, we use data on regional operations that have been carried out by the Air Police as input. The operation of the area consists of the number of air patrols and flying hours in 2021. And the amount of deforestation recorded by the Ministry of Environment and the Indonesian Central Statistics Agency in 2021 is an output (Ha/Year). While the DMU is the Regional Police OC supported by the Air Police. The size of the DMU used is twice the number of input and output. This study uses ten DMUs in North Sumatra, Riau (covering the Riau Islands), South Sumatra, West Kalimantan, Central Kalimantan (covering South Kalimantan), North Kalimantan (covering East Kalimantan), Bali (covering West and East Nusa Tenggara), North Sulawesi (covering North Maluku), South Sulawesi (covering West Sulawesi), and Southeast Sulawesi (covering Central Sulawesi). The input and output variables can be seen in Table 1.

**Table 1.** Input and Output Variables

	<b>Variables</b>	<b>Data Sources (2021)</b>
<b>Input</b>	<b>(I<sub>1</sub>)</b> Air patrol (times/year)	Air Police of the Republic of Indonesia
	<b>(I<sub>2</sub>)</b> Flight hours (hours/year)	
<b>Output</b>	<b>(O<sub>1</sub>)</b> Deforestation rate (Ha/Year)	Ministry of Environment and Forestry

*The second step is to develop an objective function to find the set of  $O$  coefficients associated with each output and  $I$  coefficients associated with each input, which will later be evaluated to maximize*

the efficiency of DMU as high as possible. The objective function and all constraints are ratios rather than linear functions and the equation is restated as a linear function by arbitrarily scaling the inputs for the unit under evaluation to a sum of 1.0. The objective function with the BCC model is stated in equation (1) with limitations in equations (2) to (4), and the stages of this study are described in a flow chart which can be seen in Figure 1.

$$\text{MAX. Eff}_e = u_1 O_{1e} + u_2 O_{2e} + \dots + u_M O_{Me} \quad (1)$$

Subject to the constraint that

$$v_1 I_{1e} + v_2 I_{2e} + \dots + v_N I_{Ne} = 1 \quad (2)$$

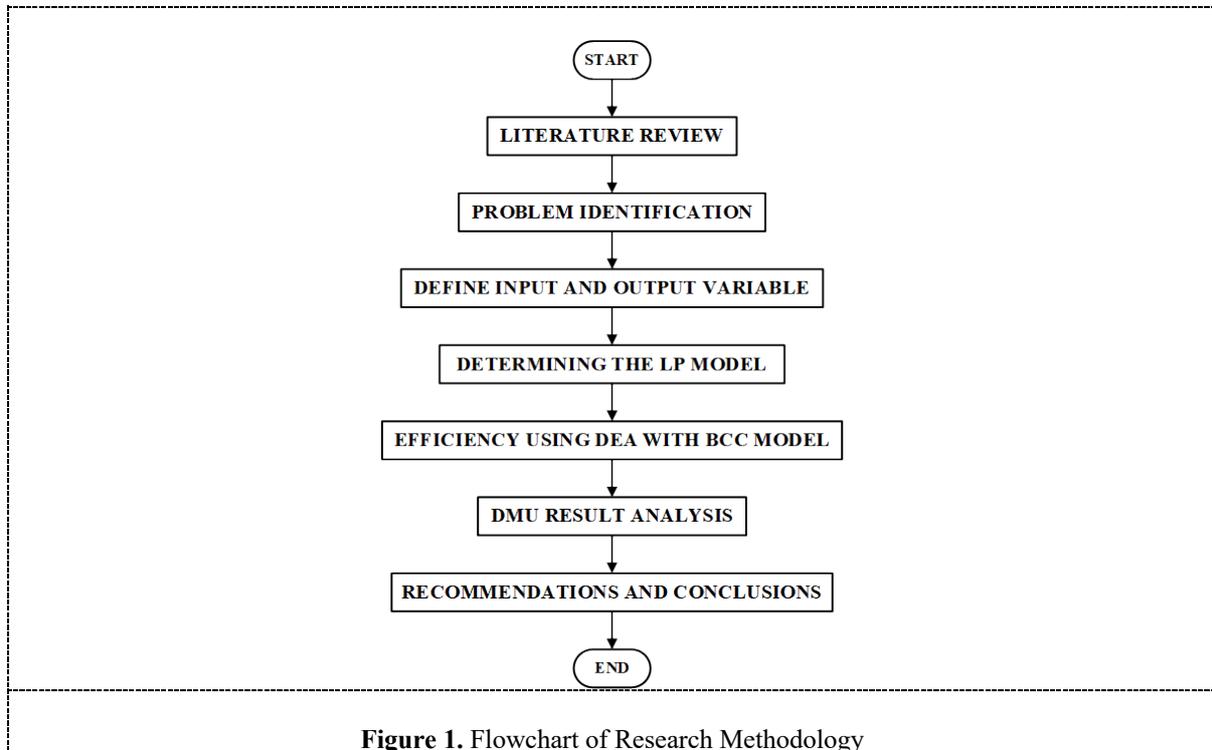
Let  $E_e$  as efficiency ratio,  $u_M$  and  $v_N$  are the coefficients of the output and input, then  $O_{Me}$  and  $I_{Ne}$  are the values of the input and output. For each DMU is subject to the constraint that

$$(u_1 O_{1k} + u_2 O_{2k} + \dots + u_M O_{Mk}) - (v_1 I_{1k} + v_2 I_{2k} + \dots + v_N I_{Nk}) \leq 0, k = 1, 2, \dots, n \quad (3)$$

where

$$u_j \geq 0, j = 1, 2, \dots, M \quad (4)$$

$$v_i \geq 0, i = 1, 2, \dots, N \quad (5)$$



## 8. Result and discussion

In the application of the DEA method, DMU is said to have been efficient if it reaches a value of 1 which means 100%. The calculation of DEA with the BCC Model in this study was carried out with the help of RStudio version 1.1.456 software. Table 2 shows the results of DEA calculations in measuring the efficiency of Air Police support for preventing cases of illegal logging or deforestation.

**Table 2.** DEA result

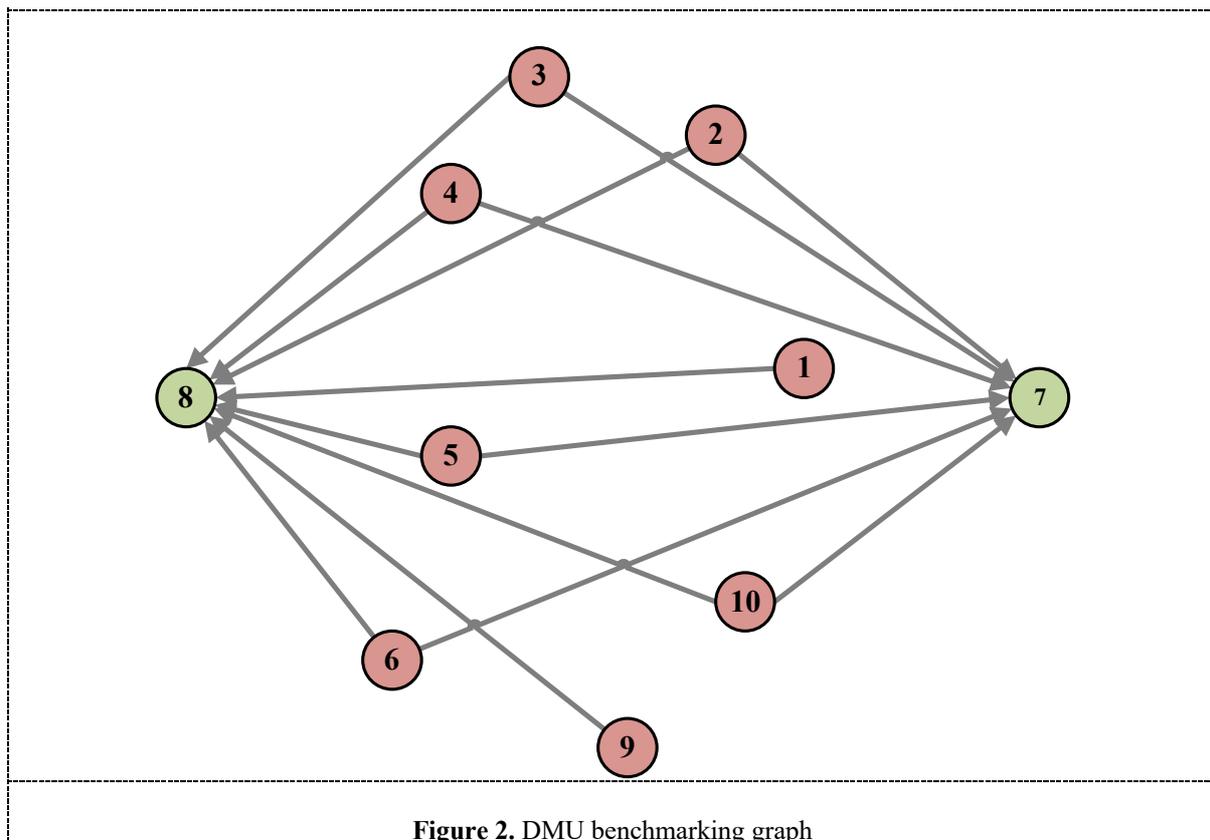
DMU	Variables	Eff.	Original Val.	Movements		Projected Val.	References	
				Radial	Slack		Peers	$\lambda$ weight
(1)	Air patrol rate		57	6.035	0	8		
North Sumatra	Flight hours	0.25	196.15	0	0	48.3	8	1
	Deforestation rate		1,233.6	0	775.6	2009.6		
(2)	Air patrol rate		76	13.872	0	11.644	7	0.3037
Riau	Flight hours	0.34	243.4	0	0	81.721		
	Deforestation rate		7,880.6	0	0	7,880.6	8	0.6963
(3)	Air patrol rate		58	12.654	0	8.187	7	0.0157
South Sumatra	Flight hours	0.36	139.205	0	0	50.023		
	Deforestation rate		2,312	0	0	2,312	8	0.9843
(4)	Air patrol rate		62	22.726	0	16.891	7	0,741
West Kalimantan	Flight hours	0.64	203.2	0	0	129.843		
	Deforestation rate		16,334.5	0	0	16,334.5	8	0.259
(5)	Air patrol rate		64	22.588	0	15.727	7	0.644
Central Kalimantan	Flight hours	0.6	199.05	0	0	119.17		
	Deforestation rate		14,459.5	0	0	14,459.5	8	0.356
(6)	Air patrol rate		28	0	0	13.369	7	0.4475
North Kalimantan	Flight hours	0.48	206.3	0.961	0	97.545		
	Deforestation rate		10,660.5	0	0	10,660.5	8	0.5525
(7)	Air patrol rate		20	0	0	20		
Bali	Flight hours	1	158.35	0	0	158.35	1	1
	Deforestation rate		21,342.4	0	0	2,1342.4		
(8)	Air patrol rate		8	0	0	8		
North Sulawesi	Flight hours	1	48.3	0	0	48.3	1	1
	Deforestation rate		2,009.2	0	0	2,009.2		
(9)	Air patrol rate		60	8.732	0	8		
South Sulawesi	Flight hours	0.28	173.2	0	0	48.3	8	1
	Deforestation rate		1,134.8	0	874.4	2,009.2		
(10)	Air patrol rate		40	10.703	0	14.627	7	0.5523
Southeast Sulawesi	Flight hours	0.63	172.25	0	0	109.083		
	Deforestation rate		12,687.5	0	0	12,687.5	8	0.4477

In Table 2, DMU 7 and 8 are efficient because they have a value of 1. The two DMUs are Air Police support in the provinces of Bali and North Sulawesi and eight findings of inefficient DMUs with technical efficiency scores below 1. In DEA, the calculation of efficiency is done on a relative basis. The two efficient DMUs from the efficiency frontier will serve as a benchmark for the other DMUs. The deviation of the inefficient DMUs to the efficiency frontier can be seen in Table 3. The largest deviation is in DMU 1, namely North Sumatra by 0.75. This means that the input in DMU 1 must be

reduced by 0.75 to achieve its efficiency or increase to 1. Figure 2 shows the DMU benchmarking graph, where the input variables owned by the two DMUs are considered to provide the best results among other DMUs, so that it can be said to be best practice. Therefore, DMUs 7 and 8 can be used as a reference for other DMUs that have not yet achieved an efficiency score of 1, to improve their efficiency.

**Table 3.** Deviation from inefficient DMU

DMU	Efficiencies	Deviations
1 North Sumatra	0.25	0.75
2 Riau	0.34	0.66
3 South Sumatra	0.36	0.64
4 West Kalimantan	0.64	0.34
5 Central Kalimantan	0.60	0.40
6 North Kalimantan	0.48	0.52
9 South Sulawesi	0.28	0.72
10 Southeast Sulawesi	0.63	0.47



**Figure 2.** DMU benchmarking graph

This study uses a DEA input-oriented BCC model with the result that the target input is divided into slack and radial. DMUs that have inefficient performance always result in slack, namely improvements by adding output or reducing input required by a DMU to achieve an efficient level of performance. If one of the models produces a score of 1 (efficient) then the slack value is zero. Slack

can be seen as an allocation inefficiency in the DMU. While radial is the target of redundant input, in order to achieve relative efficiency, the input to the DMU must be reduced.

## 9. Conclusions

The efficiency of the Air Police in preventing deforestation crimes is measured using the DEA with the BCC model. The focus of this research is on the institutional support of the Air Police to the Ministry of Environment and Forestry in preventing deforestation in Indonesia. Ten provinces were analyzed to pursue the level of research validity, of which two DMUs were identified as efficient so that they could be used as benchmarks for eight inefficient DMUs. The contribution of this study is to present a measure of technical efficiency to analyze which support has been efficient and which is inefficient. Then, from the support that has not been efficient, it can be used for improvements that refer to the support of the Air Police which is already efficient. The methods and results of this study can be used as recommendations in measuring efficiency in the Air Police institution.

Efficiency measurement using DEA is highly dependent on input and output variables. And to avoid less important findings, the selection of input and output variables must be identified carefully. In addition, because the calculation of efficiency using DEA is relative, hence, if there is an additional DMU, it is necessary to re-calculate the DEA to determine the efficiency value of each DMU. Therefore, for future studies, the application of DEA combined with Machine Learning can be applied to build a predictive model or estimation of efficiency measurement in the event of an additional DMU.

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