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Research on Predicting Skilled Labor Availability to Enhance Sustainability Building Practices

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ABSTRACT

The construction industry belongs to a very large industry within a country. Therefore, the construction industry contributes greatly to the national economy and is consistent in providing jobs for many people. There are various problems faced in the construction industry, one of which is the limitation in the provision of certified workers in Indonesia. The problem of the challenges of the construction industry at this time is that the current construction workforce in Indonesia is very lacking in terms of the number of workers, labor certification, and the distribution of certified workers in terms of experts and skilled (SKA & SKT) which in fact is still experiencing inequality if you look at the total workforce currently owned. This study aims to analyze the profile of expert and skilled certified construction workers in 2021, analyze the relationship between the number of construction work and construction absorption that exists at this time, and analyze the projection modeling of expertly and skilled certified construction workers from 2013-2020 in the future. In research objective 3, a research method was carried out using ARIMA (Autoregressive Integrated Moving Average) forecasting analysis. The results of this study obtained forecasting results in each province for expert and skilled certified construction workers for the next 2-4 years starting from 2022-2025. Overall, this research has the potential to improve the competitiveness of Indonesia's construction sector in an era of more sustainable development, while addressing the skills gap issues that exist in the industry today.

1. INTRODUCTION

The construction industry belongs to a very large industry within a country [1]. Therefore, the construction industry contributes greatly to the national economy and is consistent in providing jobs for many people [2]. Studies on the contribution of construction industry activities to the economic development process of a country have been widely published and it has been found that the relationship that occurs has a positive correlation [3]. The construction industry is the main factor driving economic growth in developing countries [4]. The rapid development of the construction industry in Indonesia requires the readiness of many qualified workers in order to support the process of quality, safe, and sustainable construction work [5]. The availability of competent construction labor is urgently needed. Not only to meet the needs of the domestic job market but also foreign countries, especially at the Southeast Asian regional level. To make it happen requires education, training, Competency Standards, and of course recognition of the competency itself or certificates [6]. Based on data from the Construction Services Development Institute, currently, the number of construction workers who already have a work competency certificate is 641,595 or around 7.54 percent referring to LPJK data, November 2020, from the number of around 8.5 million construction workers in Indonesia referring to BPS 2019 data, and it can be said that the certified construction workforce is still very small compared to the total workforce in Indonesia. [7].

This study aims to find out an overview of the projection model of certified construction labor profile in Indonesia [8]. Based on the related background, this study was also conducted to analyze the projection modelling of an expert and skilled certified construction workforce from 2013-2020 in the future [9].

1.1 Overview of construction labor

To organize a project, one of the resources that determines its success is manpower [10]. Estimating the amount of labor required, that is, by converting the scope of the project from the number of hours-people to the number of workers. Theoretically, the average requirement of the amount of labor can be calculated from the total scope of work of the project expressed in man-month or man-month hours divided by the period of implementation [11].

1.2 Profile

A profile is a view of a person [10]. A profile [12] is a side view, outline, or biography of a person or group of the same age. Profiles are graphs, diagrams, or writings that describe a state of affairs that refer to the data of a person or something [13]. From the understanding according to the expert above, it can be understood and concluded that a profile is a photo or picture of a person's data seen from one particular view.

1.3 ARIMA

ARIMA is often also called the Box-Jenkins time-winning method. ARIMA is very good for short-term forecasting, while for long-term forecasting the accuracy of forecasting is not good [14]. It will usually tend to be flat for a fairly long period [14]. The Autoregressive Integrated Moving Average (ARIMA) model is a model that completely ignores independent variables in making forecasting [15]. ARIMA uses the past and present values of dependent variables to produce accurate short-term forecasting. ARIMA is suitable if the observations of the time series are statistically related to each other (dependent) [16].

1.4 Assumption of stationaryity

Stationaryity means that there is no drastic change in the data [17]. Data fluctuations are around a constant average value, independent of the time and variance of such fluctuations [17]. Time series data is said to be stationary if the average and variance are constant, there is no trend element in the data, and there is no seasonal element. Stationaryity is divided into 2 [18], namely:

1.4.1 Stationary in the mean (average)

Stationary in the mean is the fluctuation of data being around a constant average value, independent of the time and variance of such fluctuations [19]. From the form of the data plotting it can often be noticed that the data is stationary or not stationary [20]. When viewed from the ACF plot, the autocorrelated values of the stationary data will drop to zero after the second or third time lag [21].

1.4.2 Stationaryity in variance

A time series data is said to be stationary in variance if the data structure over time has fixed or constant and invariable data fluctuations [22]. Visually, this can be helped by using a time series plot, namely by looking at data fluctuations over time.

2. RESEARCH SIGNIFICANCE

This research explores the construction industry's pivotal role in Indonesia's economic development, emphasizing its contribution to national prosperity [23]. By analyzing the availability and projection of certified construction labor, it addresses crucial needs for sustainability and efficiency [24]. The study offers valuable insights into workforce dynamics and future trends, guiding policymakers, industry players, and educational institutions in strategic planning [25]. Through targeted interventions, it aims to enhance workforce readiness and industry competitiveness, fostering long-term economic growth and sustainability both domestically and regionally [26]. Based on the above literature review, it can be concluded that improving sustainable building practices in Indonesia requires significant investment in education and workforce training. The government needs to develop policies that support the development of a skilled workforce through incentives for companies that invest in green training, as well as providing wider access to technical training programs in sustainable building [27]. In addition, collaboration between educational institutions, industry and government can accelerate the development of relevant curricula and deliver effective training to create a workforce capable of supporting sustainable development. To address the skills gap, an accurate prediction model is needed to estimate the future demand and availability of skilled labor. Research by Chae et al. [28] used a machine learning approach to predict labor needs in the construction sector, including in the context of sustainable building. The model uses data from previous construction projects, demographic trends, and education and training data to estimate the demand for skilled labor [29]. Their results show that the use of comprehensive data can provide a more accurate picture of labor needs, which in turn can help with training and employment policy planning [30].

3. RESEARCH METHODS

Data on Construction Workers who are certified Experts and Skilled in 2021 are obtained through the List provided by LPJK [31]. In the data recapture, a division was carried out into 6 islands to facilitate data processing [32]. Furthermore, data processing is carried out with descriptive analysis in the formation of profiles, where the resulting statistical data will be described or described according to the data that has been processed [33].

The formulation of the research questions is described in several formulations, which are used as the basis for determining the research methods. This relationship is detailed in Table 1. The formulation of the research problem question is as follows [34]:

1. Research Question 1 (RQ1): How is the analysis of the profile of an expertly certified and skilled construction workforce in 2021?
2. Research Question 2 (RQ2): How is the relationship between the number of construction workers and construction absorption?
3. Research Question 3 (RQ3): How is the projection modeling of an expertly & skilled construction workforce from 2013 – 2020 in the future?

Table 1. Research methods according to the form of research questions to be used

Research Question	Research Method	Output
RQ3: How?	Arima Analysis (Forecasting)	Projection Modeling of Certified Construction Workforce Profiles for the next 2-4 years

3.1 Research operational model and diagram flow of research

Referring to the research strategy above, a research operational model is further developed as stated in Figure 1 [35].

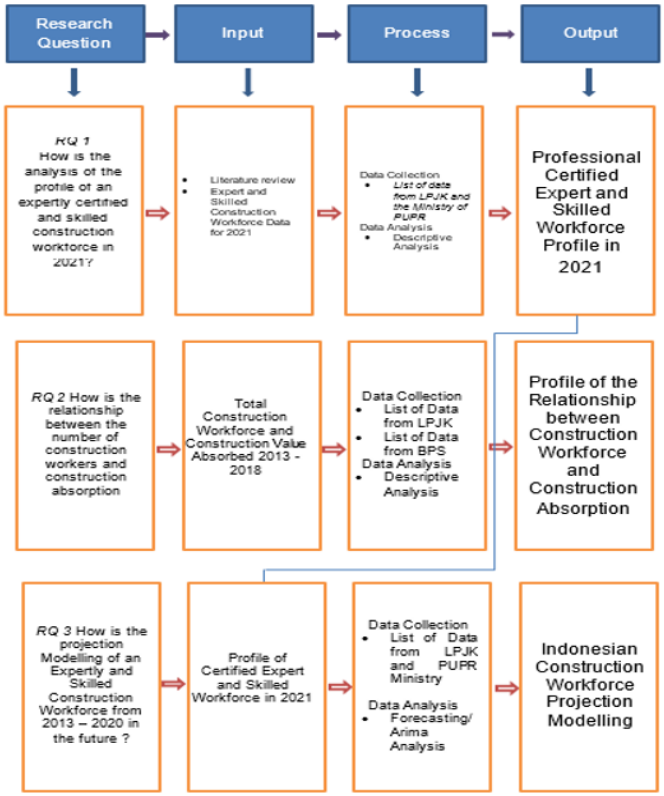

Figure 1. Research operational model [36]

3.2 Data analysis methods

Analysis of the data that has been obtained needs to be analyzed where certain methods are needed to carry out the analysis [37]. The analysis carried out is a descriptive analysis to answer questions number 1 and 2, while to answer question number 3 is carried out with ARIMA forecasting analysis [38].

The following is the stage of the data analysis method that will be carried out (Figure 2):

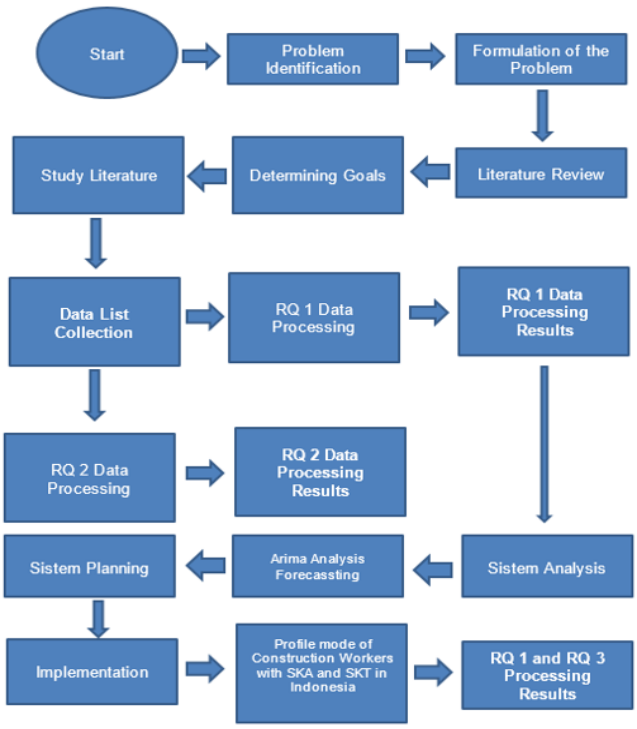

Figure 2. Diagram flow of research [41]

3.2.1 Identification stage

It is the initial stage that is carried out to determine the problem quickly in order to be able to provide the right solution that has been obtained in the background of the problem and the formulation of the problem [39].

3.2.2 Defining goals

Determining the objectives at the beginning of the study is carried out in order to obtain answers to the problems studied and the research does not leave the subject matter. The purpose of the research must be clear and well-directed, so that it can be useful for the wearer [40].

3.2.3 Studying literature

The literature studied in this study is written literature such as books, scientific papers, articles, theses and various sources from the internet that can help research the application of models and simulations [42]. The literature studied focuses on theories about simulations and ARIMA methods [43].

3.2.4 Collecting data

The data collection techniques that will be carried out are observation techniques and also List Data from LPJK and the Ministry of PUPR [44].

3.2.5 Analysis stage

At the system analysis stage, identification of the needs of the system will be carried out or evaluate various kinds of problems and obstacles that may occur from the system being built.

3.2.6 Processing data with arima forecasting analysis

The step in data analysis on the Box-Jenkins method consists of several stages. The first stage is the examination of data patterns. Plotting data is necessary to see trends and patterns in the data.

3.2.7 Data stationarity test

The next step is to test the stationarity of the data. Stationarity tests in variance are performed using the Box-Cox Transform [45]. If the value of the rounded value or lambda (λ) is more than equal to 1, then the data is said to have been stationary in variance. But if not, it must be transformed until the rounded value in Box-Cox is worth 1 or more than 1 [46]. The stationarity test in means is carried out by analyzing the ACF graph from data already stationary in variance [47]. Data that has been stationary in means then the process can proceed to the next step, which is the identification of temporary models. However, if the data is not stationary at its mean value (means), then a difference process is carried out. The difference level will also determine the value (d) in the model, if there is a seasonal pattern, then there is also a seasonal difference process as much as the repeated seasonal pattern.

3.2.8 Provisional modelling

Data that are already stationary in both variance and means then the next step is to establish a temporary model (tentative) ARIMA (p,d,q)(P,D,Q)s as appropriate. For data that is not subject to surgery (difference) then the value (d) is 0, if the data is stationary after the 1st difference then d=1, and so on. Likewise, in seasonal data, if the data experiences a difference of 1 then the value (D) is 1, and so on. Establishing the orders p, q, P, and Q can be seen by observing the Autocorrelation

Function (ACF) and Partial Autocorrelation Function (PACF) patterns that have been seasonally differenced.

3.2.9 Model parameter estimation

The next stage is the estimation of the parameters of the model, whether the parameter obtained from the temporary ARIMA model is significant or not. A model is significant if the significance value is less than alpha (α) with the value of α is 0.05 [48].

3.2.10 Model diagnostic examination

The next stage is a diagnostic examination to prove the model is sufficient or already good for use in forecasting [49]. The diagnostic tests carried out are white noise tests and normality tests. The best ARIMA model that has been obtained will be used for the forecasting process for the next 2-4 years to forecast the Growth of the Construction Workforce who are certified experts and skilled.

3.2.11 Forecasting with the best models

After determining the model, a forecasting analysis is carried out [50].

4. DISCUSSION RESULTS

Data on Construction Workers who are certified Experts and Skilled in 2021 are obtained through the List provided by LPJK. In the data recapture, a division was carried out into 6 islands to facilitate data processing. Furthermore, data processing is carried out with descriptive analysis in the formation of profiles, where the resulting statistical data will be described or described according to the data that has been processed.

Furthermore, data to determine the projection modeling of construction workers who are certified experts and skilled for the next 2-4 years, are obtained through a list of data collected through BPS and LPJK data in the period 2013 - 2020. After obtaining the data, project modeling is carried out using the Arima Analysis Forecasting method.

Data on Construction Workers who are certified Experts and Skilled in 2021 are obtained through the List provided by LPJK. In the data recapture, a division was carried out into 6 islands to facilitate data processing. Furthermore, data processing is carried out with descriptive analysis in the formation of profiles, where the resulting statistical data will be described or described according to the data that has been processed.

The following is the preliminary data of the recap per archipelago attached to Table 1.

Table 2. Number of expert certificate holders

No.	Province	Number of SKA Holders	Percentage
1	Sumatra	133675	46.42
2	Kalimantan	11719	4.07
3	Sulawesi	39552	13.74
4	Maluku & Papua	5341	1.85
5	Javanese	91476	31.77
6	Bali & Nusa Tenggara	6177	2.15
	Total	287940	100.00

In Table 2, the number of expert certificate holders for the total is 287,940 people, with each Sumatran archipelago at 46.42%, Kalimantan at 4.07%, Sulawesi at 13.74%, Maluku & Papua at 1.85%, Java at 31.77%, and Bali & Nusa Tenggara at 2.15%

Table 3. Number of skilled certificate holders

No.	Province	Number of HCS Holders	Percentage
1	Sumatra	382616	49.59
2	Kalimantan	44605	5.78
3	Sulawesi	99145	12.85
4	Maluku & Papua	29433	3.81
5	Javanese	187890	24.35
6	Bali & Nusa	27845	3.61
	Total	771534	100.00

In Table 3, the number of skilled certificate holders for the total is 771,534 people with each Sumatra island at 49.59%, Kalimantan at 5.78%, Sulawesi at 12.85%, Maluku &Papua at 3.81%, Java at 24.35%, and Bali & Nusa Tenggara at 3.61%.

4.1 Forecasting of ARIMA

Forecasting in the construction workforce is certified expert and skilled for the next 2-4 years starting from 2022 to 2025 using the Box-Jenkins or ARIMA method.

Figure 3 shows data on Expert Certificate holders in Aceh Province showing an up and down trend and has the highest peak in 2016 with a total of 11,011 expert certificate holders.

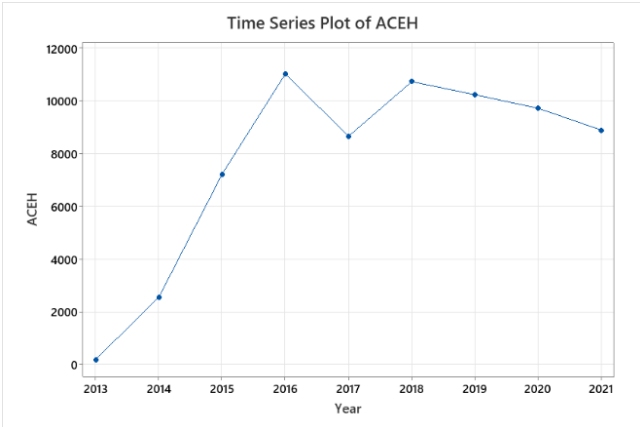

Figure 3. Plots of Aceh Province SKA holder data

Figure 3 shows data on Expert Certificate holders in Aceh Province showing an up and down trend and has the highest peak in 2016 with a total of 11,011 expert certificate holders.

4.2 Data stationerity check

In Figure 4, a stationery check was carried out in the provincial data that showed the rounded value on the Box-Cox plot was equal to 1 with a confidence interval of 95%. Data can be said to be a stationer if the value of the rounded value is greater than or equal to 1, so it can be said that the data is already stationer to the variance.

Furthermore, a stationery check was carried out on the means. Stationer data against means or cannot be seen in ACF (Autocorrelation Function) plots. The lag on the ACF plot shows the autocorrelation value on the data.

In Figure 5 there are 8 lags according to the amount of data, and it can be seen that there is no line that crosses the red line, which shows that the plot data is already stationer against means.

In Figure 6 of the 8 lags, all are inside the red line indicating that the data has also been stationed against the means. From these results, it can also be continued to identify the model that will be used for forecasting.

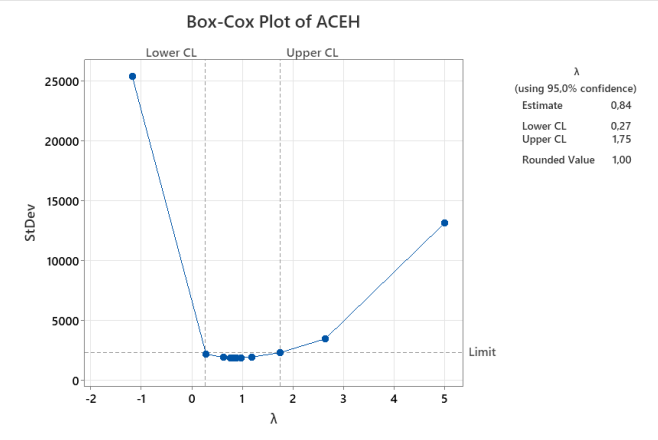

Figure 4. Stationarity checks on data

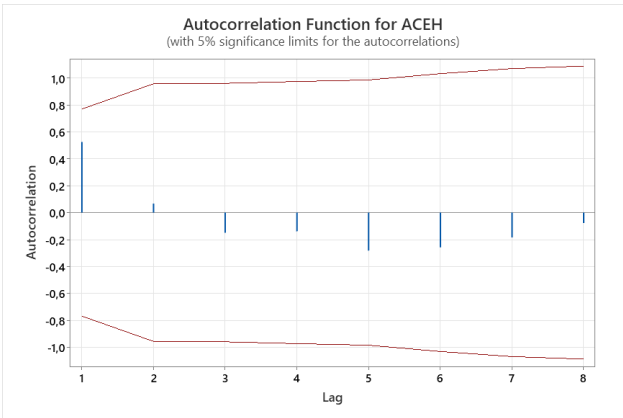

Figure 5. Plot ACF data

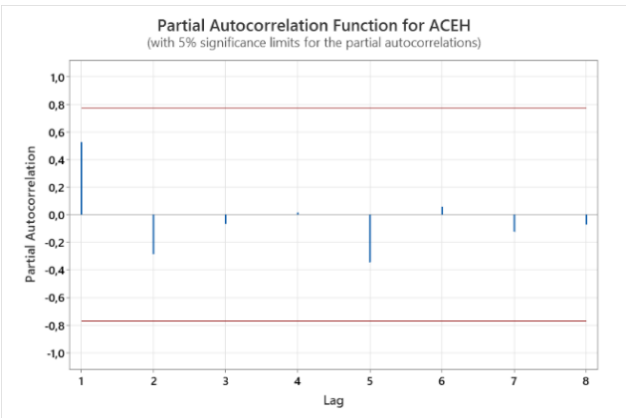

Figure 6. Plot PACF data

4.3 Identification of temporary ARIMA models

From the results of the box-cox plot as well as the ACF and PACF, it can be seen that the data has been stationerized against means and variances and no 1st or 2nd differences are needed. To establish the order p,d,q can be seen by observing the autocorrelation function (ACF) and partial autocorrelation function (PACF) patterns. The ACF plot experienced a dying down in the initial lag, while in the PACF plot, it experienced a Cut Off pattern in the second lag. Thus, from this data can be determined several models. (1,0,0), (1,0,1), and (0,0,1).

4.4 Estimation of model and diagnostic parameters

In this stage, an estimation of the model parameters is carried out by considering the alpha value of whether the temporary ARIMA model is significant or not. If the significance value is less than the alpha value with the alpha value is 0.05 (Figure 7).

Final Estimates of Parameters

Type		Coef	SE Coef	T-Value	P-Value
AR	1	1,016	0,107	9,46	0,000

Figure 7. Parameter estimation [51]

It can be seen in the P-value value of 0.000, where this significance value is smaller than the alpha value with a value of 0.05 (Figure 8).

Residual Sums of Squares

DF	SS	MS
8	52513092	6564136

Back forecasts excluded

Figure 8. Diagnostic examination [52]

Next is to compare several temporary ARIMA models by looking at the values of the SSE. The results of the ARIMA model (1,0,0) were chosen as the best model in forecasting by considering the MS value.

4.5 Forecasting with the best models

After all the tests are carried out, then the forecasting is then carried out (Figure 9).

Forecasts from period 9

		95% Limits		
Period	Forecast	Lower	Upper	Actual
10	9025,24	4002,60	14047,9	
11	9171,82	2010,82	16332,8	
12	9320,78	478,49	18163,1	
13	9472,17	-822,18	19766,5	

Figure 9. Forecasting results for 2022-2025 [53]

Based on the results of the forecasting carried out, the results from 2022 to 2025 were obtained, namely, 9025, 9171, 9320, and 9472. In this forecast, the number of expert certificate holders in Aceh Province has increased every year.

4.6 Plot data forecasting

The following is the result of forecasting data that has been carried out on 34 provinces in Indonesia using the best ARIMA model that has been obtained.

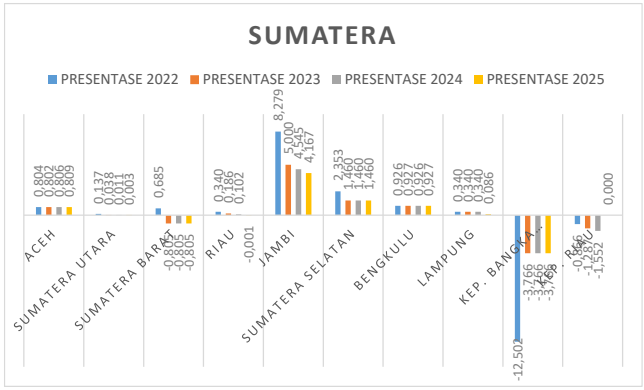

Figure 10. Plot chart forecasting Sumatra islands expert certificate holders [54]

Figure 10 visualizes the predicted number of expert certificate holders in Sumatra island over a given period, covering a wide range of skill areas related to the sustainable construction industry. This chart is important for mapping the availability of skilled labor in the region to support the implementation of sustainable building technologies.

Figure 11 shows the predicted number of expert certificate holders in Java Island, which is the center of economic activity and development in Indonesia. These expert certificate holders have skills related to sustainable construction and technology, which are crucial to the development of an environmentally-friendly construction industry.

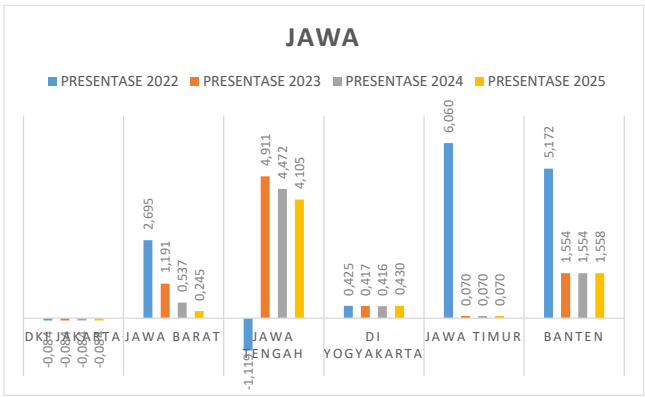

Figure 11. Plot chart forecasting Java islands expert certificate holders [55]

Figure 12 illustrates the predicted number of expert certificate holders on the island of Sulawesi, which includes skilled labor in the construction sector and sustainable building technologies. With the region growing in terms of infrastructure and industry, this prediction is important to gauge the availability of experts capable of supporting green building projects.

Figure 13 visualizes the predicted number of expert certificate holders in the Maluku and Papua Islands, which are regions with great potential in the development of the sustainable construction industry. Expert certificate holders are skilled workers who have participated in training programs and obtained certification in the field of construction and environmentally friendly technology.

Figure 14 displays the predicted number of expert certificate holders in Bali and Nusa Tenggara Islands, regions known for their natural beauty and thriving tourism sector. Expert certificate holders are individuals who have completed training programs and obtained certifications in specific fields, such as construction, tourism, and sustainable technology, which are critical to supporting sustainable development in the region.

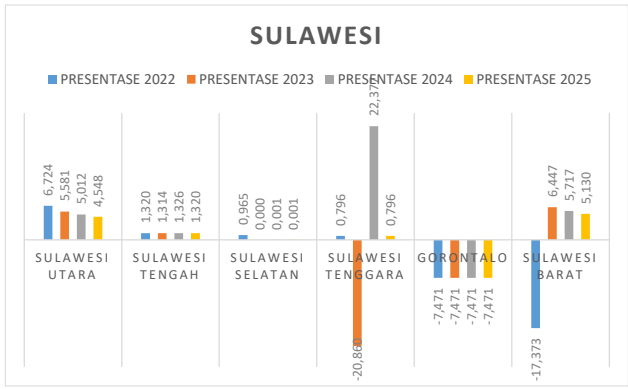

Figure 12. Plot chart forecasting Sulawesi islands expert certificate holders [56]

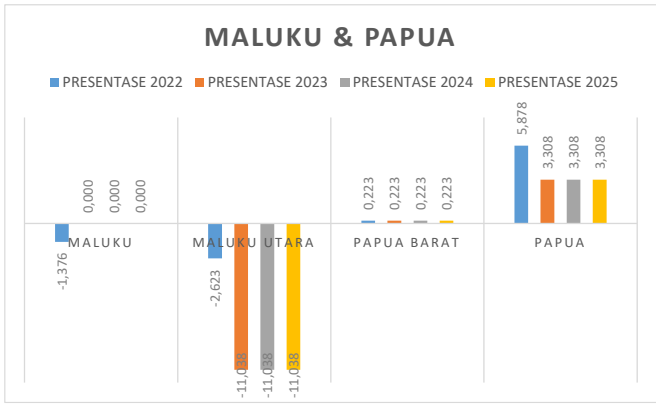

Figure 13. Plot forecasting charts of expert certificate holders of the Maluku and Papua islands [57]

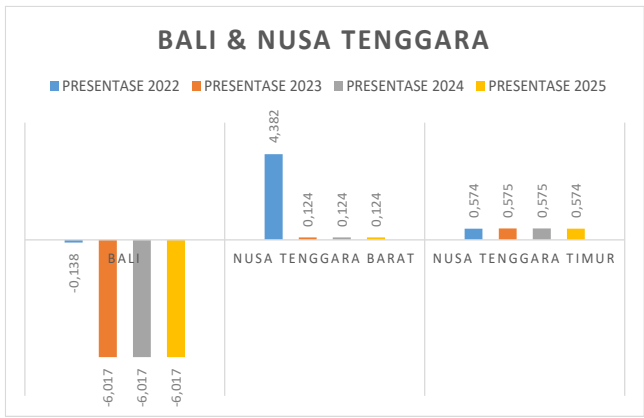

Figure 14. Plot forecasting chart holders of Bali islands and Nusa Tenggara expert certificates holders [58]

Figure 15 presents the predicted number of expert certificate holders in Kalimantan Island, which is crucial for the development of a skilled workforce in the field of sustainable construction and technology. Expert certificate holders are individuals who have undergone specialized training and earned certification, making them a valuable asset in supporting environmentally friendly development projects.

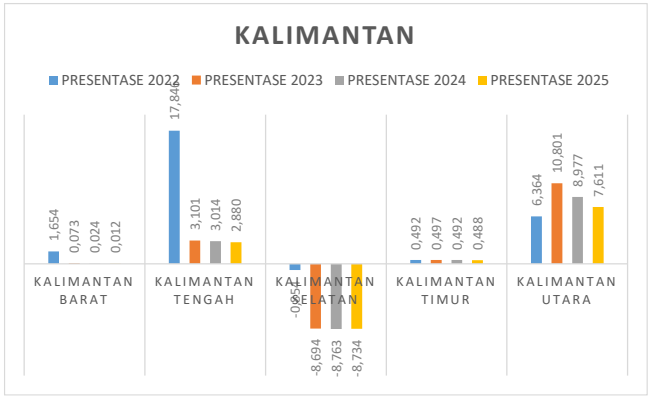

Figure 15. Plot forecasting chart of Kalimantan islands expert certificate holders [59]

Figure 16 displays the predicted number of skilled certificate holders on the island of Sumatra, focusing on workers who have qualifications and expertise in various sectors, including construction and sustainable technology. Skilled certificate holders are individuals who have completed formal training programs and earned certifications, making them ready to meet the growing demands of the job market.

Figure 17 presents the predicted number of skilled certificate holders in the Borneo Islands, which includes workers who have skills and qualifications in key sectors, including construction, mining and sustainable technology. Skilled certificate holders are individuals who have undergone formal training and received certification, so they are prepared for the increasing demands of the industry.

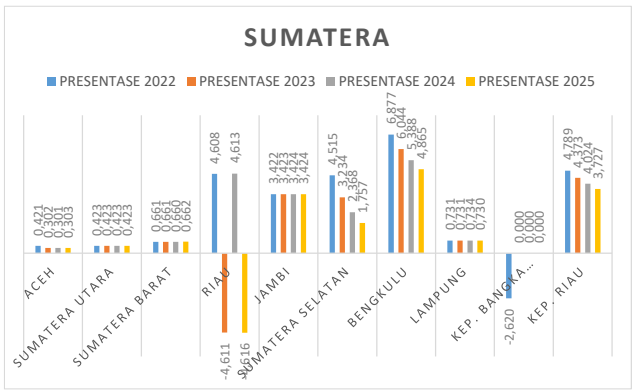

Figure 16. Plot chart forecasting certificate holders skilled Sumatra islands [60]

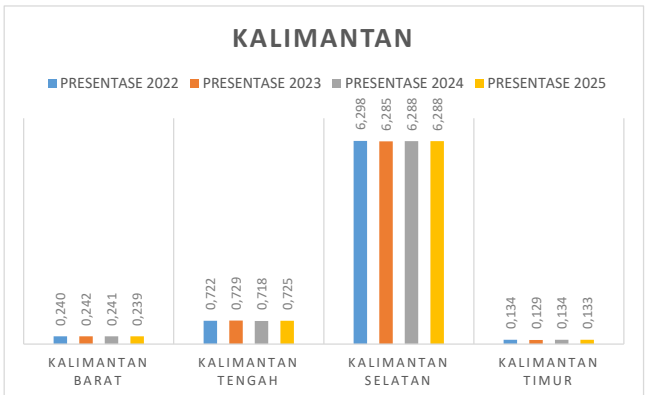

Figure 17. Plot chart forecasting certificate holders skilled Borneo islands [61]

Figure 18 visualizes the predicted number of skilled certificate holders in Java Island, which is the economic and industrial hub of Indonesia. Skilled certificate holders consist of individuals who have completed formal training programs and obtained certifications in various fields, including construction, technology, and other sectors that contribute to sustainable development.

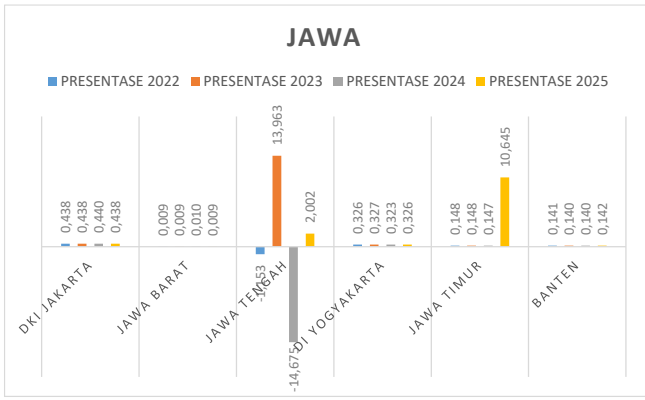

Figure 18. Plot forecasting chart of Java islands skilled certificate holders [62]

Figure 19 presents the predicted number of skilled certificate holders on the island of Sulawesi, which is a region with great potential for industrial development and skilled labor. Skilled certificate holders are individuals who have completed formal training and earned certifications in various fields, including construction, agriculture, and sustainable technology sectors.

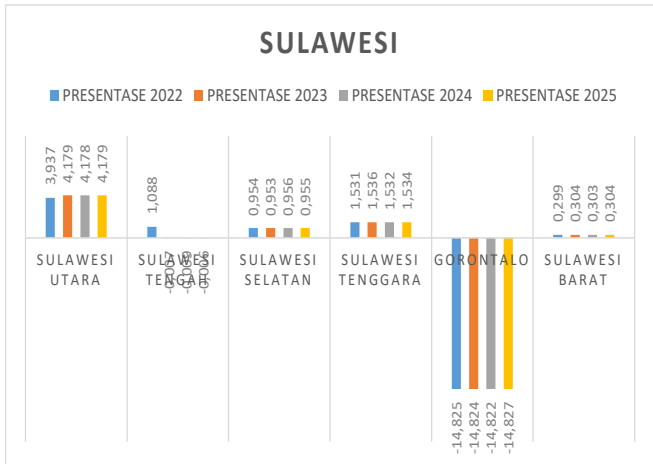

Figure 19. Plot forecasting chart of Sulawesi islands skilled certificate holders [63]

Figure 20 displays the predicted number of skilled certificate holders in the Maluku and Papua Islands, which are regions with significant resource diversity and development potential. Skilled certificate holders are individuals who have completed formal training programs and obtained certification in specific fields, such as construction, agriculture and sustainable technology.

Figure 21 presents the predicted number of skilled certificate holders in Bali and Nusa Tenggara Island. The region is known for its booming tourism sector and sustainable development initiatives. Skilled certificate holders are individuals who have completed formal training programs and

obtained certifications in various fields, such as construction, tourism, and green technology.

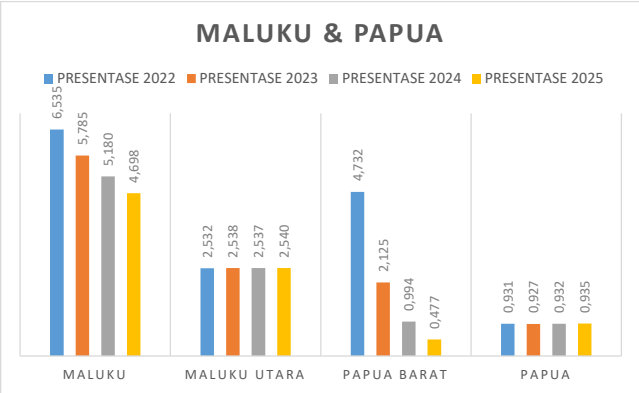

Figure 20. Plot chart forecasting certificate holders skilled in Maluku islands and Papua [64]

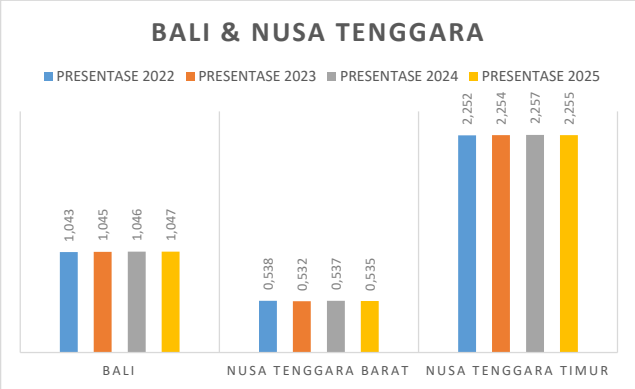

Figure 21. Plot forecasting chart of Bali and Nusa islands skilled certificate holders [65]

5. CONCLUSION

After experimenting with several ARIMA models to get the best results, the forecasting stage was carried out using the 1 best model. In the implementation of this forecasting, it is carried out in each province for both Expert and Skilled Certified Construction Workers. In the forecasting stage, it is carried out with the ARIMA Method to get forecasting results in the next 2-4 years starting from 2022 - 2025. In the results of forecasting or forecasting for Construction Workers Holding Expert Certificates in each province, there is a positive trend or increase in 31 provinces from a total of 34 provinces, where in the Provinces of North Maluku, Bali, and South Kalimantan Experienced a decrease in the number of Expert-certified Construction Workers. Skilled Certified Construction Workers also experienced a positive trend or increase in 30 provinces from 34 provinces, where in the provinces of North Kalimantan, Gorontalo, Riau, and Central Java experienced a decline. From this conclusion, the author recommends some suggestions.

1. Modeling is done with a greater amount of data in other words having a long period of time to get optimal results.
2. More optimal data collection to be neatly arranged to make profile analysis in a broader form.
3. From the results of this study, it is hoped that it can provide input to the Ministry of Public Works and Public Housing in making decisions and actions in preparing future plans by taking into account related factors. And also provide data on the projection of certified construction workers in Indonesia in the future.

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