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Original Research

Fraud Detection in Subsidized LPG Gas Distribution at the Base Level as a Monitoring System Using the Mamdani Fuzzy Logic Algorithm

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ABSTRACT

The distribution of subsidized Liquefied Petroleum Gas (LPG) at pangkalan levels is still prone to fraud, such as discrepancies between stock and distribution volumes, sales above the maximum retail price (HET), and undelivered distributions, all of which are still mostly supervised manually. These conditions make it difficult to quickly and objectively detect the presence of a fraudulent distribution pattern. This research develops a Mamdani Fuzzy Logic-based fraud detection engine that functions as a real-time monitoring system for subsidized LPG gas distribution. The system was developed using the Waterfall method, which includes requirements analysis, design, implementation, and testing, and was built with Laravel, React.js, and Inertia.js as a Single Page Application (SPA) architecture. Fraud-indication analysis involves three fuzzy input variables — remaining stock, daily distribution volume, and the Purchase Order (PO) submitted to the agent. They are processed through fuzzification, a 27-rule rule base, MIN-MAX inference, and Centroid of Area defuzzification. The output is three categories: safe (aman), alert (waspada), and irregular/indicative of fraud (menyimpang). Real transaction data from Pangkalan Gas Asmalia for May 2026 shows that a daily distribution of 18 cylinders against a daily quota of 46 cylinders resulted in a crisp output of 16.20, which falls under the Safe category and is in line with actual field conditions. This system would enable the pangkalan operators to identify early fraud signals, have more structured and objective decision-making, and enhance the accountability of subsidized LPG distribution.

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1. INTRODUCTION

The subsidized Liquefied Petroleum Gas (LPG) distribution is one of the most important components to fulfill the energy need of the Indonesian people, mainly for households and micro-enterprises. The Government, through the Ministry of Energy and Mineral Resources, has set the Subsidized LPG quota at 8.3 million metric tons for 2024 [1]. The large scale at which this is distributed requires an effective and structured monitoring system to ensure that fraud does not take place during the process. However, the base level of distribution remains mostly manual, recording simply being stock and distribution, hence no real-time monitoring.

Fraud in the context of subsidized LPG distribution would be any action that causes distribution to deviate from the regulations, intentional or due to weak controls, including mismatches in stock and sales levels, allocation irregularities, sales beyond the Maximum Retail Price (MRP), and inflated purchase orders to dealers. According to information from the INDEF Policy Brief, nearly 62.3% of 3 kg LPG subsidies are still enjoyed by financially capable groups of people [2], which means that the distribution of LPG at subsidized rates can be prone to targeting irregularities and may be considered a kind of fraud in energy subsidies. Research has indicated that about 40% of 3 kg LPG subsidies are still facing problems with distribution targeting deviations [3], making it quite an off-target distribution.

Previous research on LPG distribution monitoring has been mainly concerned with the manual monitoring of price and distribution compliance. A study in Batam City indicated that LPG sales over the HET still took place, indicating that the distribution monitoring was not running optimally [4]. Another study created a web-based system for LPG stock and distribution information at Pangkalan Mujitahid. It improved data recording but did not include automatic analysis for irregularities in distribution [5]. In another field, research on an early warning system through continuous auditing and monitoring in public-sector procurement showed that automated early detection could continuously and in real time identify irregularities [6]; however, such an approach has not been adopted in subsidized energy distribution at the base level.

One of the intelligent computational methods for fraud detection in LPG distribution is the Mamdani Fuzzy Logic method. It can handle dynamic and uncertain data by using linguistic values such as low, medium, and high [7]. Based on the identified research gap, which is the absence of an integrated system that combines web-based LPG distribution monitoring with automatic fraud detection using an AI method at the base level, this study proposed the construction of a distribution monitoring system for Pangkalan Gas Asmalia with a fraud detection engine based on Mamdani Fuzzy Logic. The proposed system uses three input variables: remaining stock, daily distribution volume, and Purchase Order (PO) to the agent. The system was developed using Laravel, React.js, and Inertia.js applying a Single Page Application (SPA) architecture so that fraud detection runs automatically and in real time each time distribution data is saved.

Based on these issues, the research objectives are: (1) to design and build a web-based LPG gas distribution monitoring system using SPA architecture; (2) to build real-time LPG stock and distribution monitoring features; (3) to apply the Mamdani Fuzzy Logic method [8–11] as a fraud detection engine to analyze distribution irregularity levels; and (4) to produce safe, alert, and irregular output categories as the basis for decision-making in distribution supervision at Pangkalan Gas Asmalia.

2. RESEARCH METHODS

This study applies the Waterfall software development method. The Waterfall model is a type of sequential and structured development model in software engineering, in which progress is seen as flowing steadily downwards through the phases of conception, initiation, analysis, design, construction, testing, production/implementation, and maintenance [12]. This method was chosen because the requirements and scope of the LPG distribution fraud detection system were well defined at the beginning, so that each stage could be carried out in a focused and measurable manner. The research stages include problem identification; data collection through observation and literature study; and system development, which includes analysis, design, implementation, and testing. The research stages also include the development of the Mamdani Fuzzy fraud detection engine (fuzzification, rule base formation, MIN inference, MAX aggregation, and Centroid of Area defuzzification) and end with system results and research conclusions.

2.1. Research Object and Data Sources

The research object is Pangkalan Gas Asmalia as a subsidized LPG distribution case study. Primary data were collected through direct observation in the form of warehouse stock data, daily distribution summaries, and monthly Purchase Order (PO) data from the base to the agent for May 2026. These data were used both as the basis for system requirements analysis and as test data for the Mamdani Fuzzy algorithm.

2.2. Current System Analysis and Proposed System

The Pangkalan Gas Asmalia gas station currently still records inventory and delivery data in a fully manual mode, and fraud is only identified manually by the station manager, which carries the core defects of delayed recognition and subjective judgment. In the original system, base specialists are responsible for receiving inventory, maintaining accounting ledgers, delivering LPG, and entering delivery data, while the station manager is responsible for verifying reports, conducting inspections, tracing delivery histories, and issuing delivery evaluations. This study puts forward a full-process digital upgrade scheme, under which all business data is entered into a web-based system. Every time delivery data is saved, the Mamdani Fuzzy fraud detection engine is triggered automatically.

2.3. Functional and Non-Functional Requirements

Functional requirements include: (a) role-based user authentication for the Base Owner and Base Officer; (b) automatic execution of Mamdani Fuzzy analysis when distribution data is saved; (c) presentation of distribution condition analysis results in the Safe, Alert, or Irregular categories; and (d) a real-time LPG distribution monitoring dashboard. Non-functional requirements include responsive system performance for real-time monitoring, role-based authentication security, compatibility with modern web browsers, ease-of-use interface, and online accessibility.

2.4. System Architecture Design

The system is designed using a client-server architecture [13] with a Model-View-Controller (MVC) pattern on the backend. The backend was built using the Laravel framework [14], providing routing, authentication, database migration, and Eloquent ORM features for interaction with the MySQL database [15]. The user interface was built using React.js with a component-based approach and Virtual DOM for faster rendering [16, 17]. Inertia.js serves as the bridge between Laravel and React.js, enabling a Single Page Application (SPA) without separating frontend and backend into two separate projects [18]. In this architecture, the Model component manages LPG stock, distribution, and fuzzy analysis result data; the View component renders the user interface via React.js and Inertia.js; and the Controller component manages application logic, monitoring processes, and executes the Mamdani Fuzzy fraud detection engine.

2.5. Mamdani Fuzzy Logic as the Fraud Detection Engine

The fraud detection engine in this study is implemented on the backend using the Mamdani Fuzzy method, selected for its ability to process dynamic and uncertain data using linguistically interpretable rules [7]. The Mamdani inference process consists of four stages: fuzzification, rule base formation, inference (rule evaluation), and defuzzification [19].

a. Variable Determination

Variables are determined based on the daily quota of the base, derived by dividing the monthly quota of 1,200 cylinders by 26 effective working days per month to obtain a daily quota of 46 cylinders, as shown in Equation (1):

$$\text{Daily Quota} = \frac{1200}{26} \approx 46 \text{ cylinders/day} \tag{1}$$

Three input variables are used: remaining LPG stock, daily distribution volume, and Purchase Order (PO) submitted by the base to the agent, with one output variable representing the LPG distribution fraud indication level. Table 1 presents the complete variable specifications.

Table 1: Input and Output Variables of the Fraud Detection System

No.	Variable	Value Range	Linguistic Category
1	Remaining LPG Stock (Input)	0 – 46 cylinders	Low, Medium, High
2	Daily Distribution Volume (Input)	0 – 46 cylinders	Low, Medium, High
3	Purchase Order / PO to Agent (Input)	0 – 46 cylinders	Low, Medium, High
4	Fraud Indication Level (Output)	0 – 100	Safe, Alert, Irregular

b. Fuzzification

Fuzzification is the process of converting crisp input values into linguistic values using a triangular membership function. Function parameters are set based on the daily quota of 46 cylinders divided into three proportional zones with inter-zone overlap following the basic principles of fuzzy logic. For a triangular membership function with parameters a (lower bound), b (peak), and c (upper bound), the degree of membership $\mu(x)$ is computed as Equation (2):

$$\mu(x) = \begin{cases} 0, & x \leq a \\ \frac{x-a}{b-a}, & a < x \leq b \\ \frac{c-x}{c-b}, & b < x \leq c \\ 0, & x > c \end{cases} \tag{2}$$

where a = lower bound, b = peak, c = upper bound, and x = crisp input value. Table 2 presents the membership function parameters for all variables.

Table 2: Membership Function Parameters for Input and Output Variables

Fuzzy Set (Input)	a	b	c	Fuzzy Set (Output)	a	b	c
Low (Rendah)	0	0	15	Safe (Aman)	0	0	40
Medium (Sedang)	11	23	35	Alert (Waspada)	20	50	80
High (Tinggi)	31	46	46	Irregular (Menyimpang)	60	100	100

c. Rule Base

With three input variables and three fuzzy sets per variable, the number of rule combinations formed is $3^3 = 27$ IF-THEN rules. Rules are constructed to represent all possible combinations of remaining stock, distribution volume, and PO to agent as early indicators of distribution fraud. Table 3 presents the complete rule base.

Table 3: Rule Base for LPG Distribution Fraud Detection

Rule	Stock	Dist.	PO	Output	Rule	Stock	Dist.	PO	Output
1	Low	Low	Low	Alert	15	Medium	Medium	High	Safe
2	Low	Low	Medium	Alert	16	Medium	High	Low	Alert
3	Low	Low	High	Irregular	17	Medium	High	Medium	Irregular
4	Low	Medium	Low	Alert	18	Medium	High	High	Irregular
5	Low	Medium	Medium	Irregular	19	High	Low	Low	Safe
6	Low	Medium	High	Irregular	20	High	Low	Medium	Safe
7	Low	High	Low	Irregular	21	High	Low	High	Alert
8	Low	High	Medium	Irregular	22	High	Medium	Low	Safe
9	Low	High	High	Irregular	23	High	Medium	Medium	Safe
10	Medium	Low	Low	Safe	24	High	Medium	High	Alert
11	Medium	Low	Medium	Alert	25	High	High	Low	Alert
12	Medium	Low	High	Alert	26	High	High	Medium	Alert
13	Medium	Medium	Low	Safe	27	High	High	High	Irregular
14	Medium	Medium	Medium	Alert					

As a fraud interpretation example, Rule 17 (Medium Stock, High Distribution, Medium PO $\rightarrow$ Irregular) represents a condition where distribution far exceeds what is reasonable relative to available stock, which may indicate off-target distribution or inflated distribution recording, patterns commonly found in the field.

d. Inference (Rule Evaluation)

The inference stage uses the MIN method as the implication function to determine the truth value of each active rule, taking the smallest membership value from the three input variables in that rule [19], as formulated in Equation (3):

$$\mu_{\text{inference}} = \min(\mu_{A_1}, \mu_{A_2}, \mu_{A_3}) \tag{3}$$

where μ_{A_1}, μ_{A_2}, and μ_{A_3} are the membership degrees of the first, second, and third input variables respectively. Results from all active rules are then combined using the MAX (aggregation) method to obtain the fuzzy output set, as in Equation (4):

$$\mu_{\text{aggregation}} = \max(\mu_{R_1}, \mu_{R_2}, \ldots, \mu_{R_n}) \tag{4}$$

where μ_{R_1} through μ_{R_n} are the inference results of each active rule.

e. Defuzzification

Defuzzification is performed using the Centroid of Area (CoA) method, which finds the centroid of the aggregated fuzzy output area as the crisp output value [4]. Before computing the centroid, a clipping process is applied to the fuzzy set based on the α-predicate value from inference. For the triangular output fuzzy set with parameters a, b, c clipped at α, the right-side clipping point is determined by Equation (5):

$$x_1 = c - \alpha(c - a) \tag{5}$$

The crisp output value z^* is then computed by the CoA formula in Equation (6):

$$z^* = \frac{\int \mu(z)\, z\, dz}{\int \mu(z)\, dz} \tag{6}$$

where z^* is the crisp output, $\mu(z)$ is the membership degree of the aggregated output, and z is the value on the output axis. A higher crisp output value indicates a greater indication of conditions requiring further attention, including potential distribution fraud.

2.6. Research Tools

Hardware: Intel Core i5-10300H @ 2.50 GHz processor, 16 GB RAM, 477 GB SSD storage, NVIDIA GeForce GTX 1650 Ti 4 GB. **Software:** Windows 11 64-bit, Visual Studio Code, PHP 8.2.12, Laravel 11, React.js 19.0.0, Inertia.js 2.0.0, Node.js 22.15.1, Composer 2.8.9, MySQL 8.4, and XAMPP 3.3.0.

2.7. Testing Method

System testing was carried out using the Black Box Testing method, which focuses on system functionality without examining internal code structure. Testing was performed by providing specific inputs and verifying whether the resulting outputs — including fraud indication categories, matched expectations. Test coverage includes role-based authentication, LPG stock and distribution data management, Mamdani Fuzzy analysis process, distribution category result display, and the real-time monitoring dashboard.

3. RESULTS AND DISCUSSION

3.1. Fraud Detection System Design Results

The design results show that the proposed system successfully integrates LPG stock and distribution recording functions with the Mamdani Fuzzy fraud detection engine. Each time the Base Officer saves distribution data, the system automatically runs fuzzy analysis, triggered through an include relationship on the Manage LPG Stock and Manage LPG Distribution processes, producing a Safe, Alert, or Irregular output category without requiring additional action from the user. The Base Owner can directly view the analysis results on the monitoring dashboard and use them as the basis for decision-making and distribution evaluation.

3.2. Fraud Detection Calculation Results Using Real Data from Pangkalan Gas Asmalia

The calculation was tested using real data from Pangkalan Gas Asmalia for the period 22–25 May 2026, with a daily quota of 46 cylinders ($1,200$ cylinders $\div$ 26 working days). Input values used were: remaining warehouse stock = 30 cylinders, daily distribution = 18 cylinders, and PO/demand to agent = 40 cylinders.
Fuzzification results for each input variable were calculated as follows:

$$\mu_{\text{Medium}}(30) = \frac{35 - 30}{35 - 23} = \frac{5}{12} = 0.417 \tag{7}$$

$$\mu_{\text{Medium}}(18) = \frac{18 - 11}{23 - 11} = \frac{7}{12} = 0.583 \tag{8}$$

$$\mu_{\text{High}}(40) = \frac{40 - 31}{46 - 31} = \frac{9}{15} = 0.600 \tag{9}$$

Table 4 summarizes the complete fuzzification results.
The active combination is Stock = Medium (0.417), Distribution = Medium (0.583), PO = High (0.600), corresponding to Rule 15 in Table 3 with output Safe (Aman). Applying the MIN inference method per Equation (3):

$$\mu_{\text{Aman}} = \min(0.417, 0.583, 0.600) = 0.417 \tag{10}$$

Table 4: Fuzzification Results for Test Case Data

Variable	Value	μ Low	μ Medium	μ High
Remaining LPG Stock	30	0	0.417	0
Daily Distribution Volume	18	0	0.583	0
PO / Demand to Agent	40	0	0	0.600

Since only one rule is active, the MAX aggregation produces: $\mu_{\text{Aman(aggregation)}} = \max(0.417) = 0.417$. Defuzzification using the Centroid of Area method on the Safe fuzzy set ($a = 0, b = 0, c = 40$) clipped at $\mu = 0.417$:

$$x_1 = 40 - 0.417(40 - 0) = 40 - 16.68 = 23.32 \tag{11}$$

$$z^* = \frac{40^2 + 40 \times 23.32 + 23.32^2}{3 \times (40 + 23.32)} = \frac{3076.62}{189.96} \approx 16.20 \tag{12}$$

Table 5: Fraud Detection Output Classification and Case Study Result

Crisp Value Range	Category	Operational Description
0 – 33	Safe	Distribution running normally, no fraud indication
34 – 66	Alert	Distribution requires attention / further verification
67 – 100	Irregular	Distribution is indicated as fraudulent
16.20	**Safe**	**Result for Pangkalan Gas Asmalia (25 May 2026)**

These results show that daily distribution of 18 cylinders is well below the daily quota of 46 cylinders and proportional to available stock, so distribution in this period was assessed as normal and not indicative of fraud.

3.3. System Interpretation of Fraud Indication Scenarios

To illustrate the system's detection capability, a comparison with other scenarios from Table 3 is instructive. For example, if remaining stock is Low while daily distribution is High and the PO to agent is also High (Rule 9), the system produces an Irregular output, indicating a mismatch between physical stock and recorded distribution — a pattern commonly found in the field as off-target distribution or inflated distribution recording. Conversely, a combination of stock and distribution that is proportional to demand, as tested with real data on Rule 15, produces a Safe category. The systematically constructed rule base is thus capable of mapping distribution variable combination patterns to measurable and consistent fraud risk levels.

3.4. Comparison with Previous Studies

Table 6 presents a comparison of the proposed system with relevant prior research on LPG distribution supervision and irregularity detection.

Table 6: Comparison of Fraud Detection Capabilities with Prior Studies

Study	Focus	Automatic Detection	Real-Time
Dewi et al. [20]	Subsidized LPG price & distribution supervision (manual)	No	No
Saddami et al. [5]	Web-based LPG stock & distribution information system	No	Yes (recording)
Pamungkas & Khalida [6]	Early warning continuous auditing for public procurement	Yes	Yes
This Study	**LPG distribution monitoring + Mamdani Fuzzy fraud engine**	**Yes**	**Yes**

The study by Dewi et al. [20] shows that manual LPG distribution supervision was unable to prevent above-HET sales, while Saddami et al. [5] provided web-based stock and distribution recording but lacked automatic irregularity detection. The early warning approach via continuous auditing by Pamungkas & Khalida [6] demonstrated that automated real-time detection is feasible, but only in the public procurement domain. This study addresses the gap by adapting early detection to the subsidized energy distribution context at the base level, combining web-based data recording with an automatically running Mamdani Fuzzy fraud detection engine.

3.5. System Strengths and Limitations

The system's main strength is its ability to automatically and in real time generate fraud indication categories each time data is saved, without requiring manual analysis by the Base Owner, using three variables relevant to real base operations. Limitations include: testing was only performed on one base as a case study so generalizability requires validation at other bases; only three input variables were used without considering others such as consumer transaction history; and no comparative performance evaluation against other fuzzy or machine learning methods for distribution fraud detection was conducted.

3.6. Practical Implications

Practically, this system can help Base Owners and Officers supervise gas distribution more effectively, simplify stock and distribution data recording, and provide early warnings against fraud indications so they can be addressed before escalating into larger irregularities. For the broader development of subsidized energy distribution information systems, this study provides an implementation example integrating a web-based system with an intelligent analysis method to improve the accountability and transparency of distribution.

3.7. Discussion

The evaluation of the proposed fraud detection system using real transaction data from Pangkalan Gas Asmalia demonstrates the efficacy of the Mamdani Fuzzy Logic algorithm in translating complex, daily operational variables into actionable intelligence. The test scenario, which recorded a daily distribution of eighteen cylinders against a maximum daily quota of forty-six, yielded a crisp output of 16.20, categorizing the day's operations as safe. This mathematical outcome aligns perfectly with empirical field conditions, as distributing less than half of the daily quota while maintaining proportional stock and purchase order levels represents normal, non-fraudulent business activity. By successfully mapping this proportional relationship through fuzzification and the centroid of area defuzzification, the system proves its capacity to function as a reliable baseline monitor that avoids generating false alarms during standard operational days, thereby establishing trust in its analytical capabilities.

Beyond baseline monitoring, the true strength of the system lies in its twenty-seven-rule base, which is specifically engineered to capture the nuanced, multi-variable patterns of subsidized LPG fraud. Unlike rigid threshold systems that might only flag a violation if a single metric exceeds a hardcoded limit, the Mamdani inference engine evaluates the relational dynamics between remaining stock, distribution volume, and purchase orders. For instance, the rule base is designed to trigger an irregular alert when physical stock is low but recorded distribution and purchase orders are simultaneously high. This specific linguistic combination effectively identifies sophisticated fraudulent behaviors, such as inflated distribution records or off-target sales to unauthorized industries, which are common in the field but easily masked in simple ledger reviews. The ability of the system to process these dynamic uncertainties using linguistic variables allows it to mimic the intuitive reasoning of an experienced auditor while maintaining mathematical consistency.

Technologically, the integration of this fuzzy inference engine within a Single Page Application architecture utilizing Laravel, React.js, and Inertia.js addresses a critical latency issue present in earlier monitoring solutions. Previous studies focused on basic web-based information systems for LPG stock successfully digitized record-keeping but failed to provide automated anomaly detection, leaving the analytical burden entirely on the base manager. Furthermore, traditional manual supervision has repeatedly proven inadequate in preventing violations like sales above the maximum retail price. By embedding the Mamdani algorithm directly into the backend logic, the proposed system triggers a comprehensive fraud analysis instantaneously every time a base officer saves distribution data. This real-time processing paradigm shifts the operational workflow from reactive, end-of-month auditing to proactive, continuous monitoring, ensuring that irregularities are flagged at the exact moment of data entry.

The practical implications of this real-time monitoring capability extend significantly toward the broader goal of energy subsidy accountability. While continuous auditing and early warning systems have demonstrated success in public sector procurement, applying these intelligent computational methods to the grassroots level of subsidized LPG distribution fills a vital gap in current literature and practice. By providing base owners with an objective, automated dashboard that categorizes daily operations into safe, alert, or irregular statuses, the system mitigates the subjective biases and delayed recognition inherent in manual oversight. This structured decision-making support not only empowers local operators to correct operational discrepancies before they escalate but also provides a scalable technological framework that could assist policymakers in ensuring that the massive subsidized LPG quota reaches its intended household and micro-enterprise demographics.

Despite these contributions, the study acknowledges several limitations that outline the trajectory for future research. The current validation was restricted to a single case study at Pangkalan Gas Asmalia, meaning the generalizability of the rule base and membership functions across bases with different geographical or demographic characteristics requires further empirical testing. Additionally, the model relies exclusively on three operational variables, omitting potentially critical indicators such as consumer transaction histories, geographical distribution anomalies, or historical fraud patterns of specific buyers. Future investigations should focus on expanding the input variables to capture a more holistic view of the distribution ecosystem, validating the system across a diverse network of bases, and benchmarking the Mamdani approach against other computational intelligence methods, such as Tsukamoto fuzzy logic or advanced machine learning classifiers, to continually optimize the accuracy and robustness of subsidized energy fraud detection.

4. CONCLUSION

This study successfully designed and built a web-based LPG gas distribution monitoring system for Pangkalan Gas Asmalia, equipped with a fraud detection engine using the Mamdani Fuzzy Logic method. The system processes three input variables, remaining stock, daily distribution volume, and Purchase Order to agent, through fuzzification, a 27-rule rule base, MIN-MAX inference, and Centroid of Area defuzzification, automatically producing Safe, Alert, or Irregular categories in real time each time distribution data is saved. Testing using real data from Pangkalan Gas Asmalia for May 2026 yielded a crisp output value of 16.20 with a Safe category for a daily distribution of 18 cylinders against a daily quota of 46 cylinders, consistent with normal field distribution conditions. The main contribution of this research is the integration of web-based LPG distribution recording and monitoring functions with automatic AI-based fraud detection at the base level, a combination not previously found in studies on LPG distribution supervision. This system is expected to help base operators and policymakers detect energy subsidy fraud indications more quickly, in a more structured and objective manner. This study has limitations in that testing was only performed on one base with three input variables. Future research is encouraged to validate the system on multiple bases with different characteristics, add additional variables relevant to distribution fraud patterns, and compare the performance of the Mamdani Fuzzy method with other fuzzy approaches or machine learning methods for detecting subsidized LPG distribution irregularities.

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Author Contributions:

M. Syahrul: Conceptualization, Methodology, Software, Writing – Original Draft.
R. Wisnu Prio Pamungkas: Supervision, Methodology, Writing – Review & Editing.
Fried Sinlae: Manuscript Review, Journal Writing Support, Writing – Review & Editing.

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