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Application of the Fuzzy Time Series (FTS) Method to Estimate the Increase in Stunting at the North Sumatra BKKBN

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Abstract

Stunting is one of the chronic nutritional problems that remains a major concern in Indonesia, particularly in North Sumatra Province. This condition occurs due to prolonged nutritional deficiencies that affect children's physical growth and cognitive development. The National Population and Family Planning Agency (BKKBN) of North Sumatra plays an essential role in monitoring and reducing stunting rates. However, the prediction methods currently used are still conventional and have not utilized modern predictive technologies. As a result, the forecasting accuracy is often low because stunting data tends to be fluctuating and influenced by various dynamic factors. This study aims to apply the Fuzzy Time Series (FTS) method to predict the increase in stunting cases at BKKBN North Sumatra. The FTS method is selected because it can handle data uncertainty and non-linear patterns, making it more effective in recognizing trends in stunting cases over time. The data used in this study were obtained from BKKBN North Sumatra, consisting of the number of stunting cases in 2023 and 2024 across 33 districts and cities. The research stages include data collection, fuzzification, fuzzy relation formation, defuzzification, and the implementation of the results into a web-based application using PHP programming and MySQL as the database. The results show that the Fuzzy Time Series method can effectively predict the upward and downward trends of stunting cases, where 16 districts/cities experienced an increase and 17 districts/cities experienced a decrease in stunting numbers for the following year. The developed system helps BKKBN analyze data more quickly, accurately, and efficiently. Therefore, the application of the Fuzzy Time Series method proves to be effective as a decision-support tool for planning prevention and mitigation programs for stunting in North Sumatra.

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1. Introduction

The National Population and Family Planning Agency (BKKBN) continues to encounter significant challenges in predicting stunting rates in Indonesia, particularly in North Sumatra, where stunting persists as a serious public health issue. Stunting, which results from chronic malnutrition beginning during pregnancy until a child reaches two years of age, is influenced by complex and interrelated determinants. These factors include socioeconomic vulnerabilities, limited maternal nutritional literacy, suboptimal parenting practices, inadequate sanitation, and unequal access to quality health services. Previous studies have shown that low maternal awareness and limited understanding of nutrition significantly contribute to stunting prevalence in several regions of Indonesia (Adhyka et al., 2023; Noviaming et al., 2022). This complexity underscores the need for robust predictive models capable of capturing multidimensional variations in stunting-related data. In North Sumatra, BKKBN still relies heavily on conventional monitoring and delayed reporting mechanisms, leading to difficulties in timely policy formulation. Without accurate and responsive forecasting tools, interventions may fail to effectively target vulnerable populations or address high-risk areas. Therefore, improving predictive accuracy is crucial for strengthening efforts to reduce stunting prevalence and enhancing public health planning across the province (Haganta et al., 2024).

To date, stunting prediction methods used by BKKBN and related institutions have primarily employed traditional analytical approaches such as linear regression and trend averaging. Although these methods are convenient and widely understood, they are limited by their assumption that data patterns remain linear, stable, and predictable over time. In reality, stunting data fluctuates due to external pressures such as shifting economic conditions, changing food security levels, evolving public health behavior, and variations in sanitation and environmental quality. These dynamic elements make traditional models insufficient for capturing nonlinear characteristics inherent in real-world public health data. Furthermore, delays in data collection, inconsistent documentation across districts, and limited adoption of digital technologies complicate the accuracy of traditional forecasts (Kesuma et al., 2021; Nurliana Nasution et al., 2023). As a result, forecasting outcomes often lack precision, reducing their usefulness for early intervention and resource allocation. This highlights the urgent need for modern prediction techniques capable of adapting to uncertain and rapidly changing datasets. Such tools are essential for improving evidence-based decision-making and enhancing the effectiveness of stunting reduction programs in North Sumatra and other regions (Sari, 2021).

A growing body of research has demonstrated that the Fuzzy Time Series (FTS) method is highly effective for forecasting datasets characterized by uncertainty, nonlinear behavior, and fluctuating trends. For example, Hamdani et al. (2020) successfully applied the FTS method to predict web-based sales at CV. AGVA with high accuracy, emphasizing the method's capability in modeling dynamic commercial data. Another study by Mubarak et al. (2020) showed that FTS could predict fish catch volumes with an accuracy of 82.83%, a domain known for extreme variability due to environmental factors. In the context of meteorology, Aliana et al. (2021) used FTS logic to model rainfall in Bandung, achieving an accuracy of 96.15%. The Lee Model of FTS has also been applied effectively to pharmaceutical forecasting, where it predicted antibiotic drug sales with an accuracy of 84.86% (Listyaning Pangestu et al., 2024). Additionally, an average-based FTS model was able to accurately predict the development of COVID-19 confirmed cases with 89.50% accuracy (Wuryanto et al., 2021). These findings collectively highlight the robustness, flexibility, and reliability of FTS across various forecasting contexts, demonstrating its suitability for application in complex public health prediction scenarios such as stunting.

Given its demonstrated performance across multiple fields, the Fuzzy Time Series method offers a promising solution for improving stunting prediction accuracy at BKKBN. Unlike traditional statistical models, FTS does not depend on linearity assumptions and is inherently designed to capture uncertainty and dynamic changes within time-dependent data. This makes FTS particularly suitable for analyzing stunting-related indicators that fluctuate due to shifts in economic stability, maternal behavior, sanitation improvements, and healthcare accessibility. By utilizing fuzzy sets and linguistic variables, FTS can interpret data patterns that are imprecise or incomplete—conditions commonly encountered in public health datasets (Mukhlisin et al., 2019). The adoption of FTS could significantly enhance BKKBN's ability to detect early warning signals of stunting surges, optimize resource planning, and respond more effectively to social and environmental changes. Furthermore, integrating

FTS into digital forecasting platforms, as demonstrated in various information system applications (Ramadhan et al., 2023; Saputra et al., 2023), can support real-time monitoring and improve the accessibility of prediction results for policymakers. Thus, the incorporation of FTS represents a strategic step toward modernizing stunting prediction frameworks and enhancing evidence-based policymaking within Indonesia's public health system.

2. Research Methodolgy

a. Metode Fuzzy Time Series

The Fuzzy Time Series Method is a data prediction method that uses basic fuzzy principles developed by L. Zadeh and then further developed by Song and Chissom in 1993 to solve the problem of predicting new student enrollment using time series data. It was then further developed by Chen, utilizing arithmetic operations to solve the same problem.

1) Steps of the Fuzzy Time Series Method

1. Collect Data
   Take the time series data you want to predict (e.g., stock prices, sales, etc.).
2. Normalize Data
   Transform the data to fall within the [0, 1] range to simplify calculations.
   Formula:
   $Xnorm = \frac{X - Xmin}{Xmax - Xmin}$...(1)
3. Create a Fuzzy Set
   -Divide the data into intervals (e.g., low, medium, high).
   -Each interval has a membership function (usually triangular or trapezoidal).
4. Create a Fuzzy Rule
   -Define the relationship between intervals at time tt and t+1t+1.
   -Example rule: "If low, then medium."
5. Predict Value
   -Use the fuzzy rule to predict the next value.
   -Example: If the current data is "low," then the next prediction is "medium."
6. Test Accuracy
   Compare the predicted results with the original data to evaluate accuracy.

b. Data Collection

Data collection was conducted at the research site, the National Population and Family Planning Agency (BKKBN), with the following stages and steps:

1. Field Research

a. Observation

In this stage, the researcher conducted observations at the BKKBN to obtain stunting data.

b. Interviews

In this stage, the researcher interviewed Mr. Heri Pranata Satria, S.Kom, Head of the North Sumatra BKKBN Working Group to obtain unclear data regarding stunting.

1) What problem does the BKKBN take seriously regarding stunting?
   Answer: The National Population and Family Planning Agency (BKKBN) faces a serious problem related to the high rate of stunting (child stunting) in Indonesia. The stunting rate in Indonesia remains high, and the BKKBN needs a tool to accurately predict the increase in stunting cases. Without accurate predictions, prevention and intervention efforts cannot be planned effectively.
2) What impacts does stunting have?
   Answer: The impact of stunting not only affects children's physical growth but also their cognitive development and future productivity. At a macro level, stunting can hamper economic growth and increase the national health burden. Without accurate predictions

of the increasing trend in stunting, prevention and intervention efforts undertaken by the National Population and Family Planning Board (BKKBN) will be less effective.

3) Does the BKKBN not use calculations to predict stunting?
Answer: The BKKBN does not use calculations because stunting data is often incomplete or fluctuates, making it difficult to predict using the usual method of simply looking at previous periods. Therefore, a method capable of addressing this uncertainty is needed.
4) What data can be obtained from the BKKBN to predict stunting management?
Answer: Data can be obtained from the BKKBN, specifically from stunting survey and monitoring data conducted by the BKKBN. This data includes information on stunting prevalence, nutritional status, and social and economic factors that influence stunting.
5) How can we identify problems from the data obtained and the need for a method?
Answer: To identify problems from the data obtained and the need for a method, researchers can analyze historical data. Researchers can identify stunting trends and patterns and determine the need for the FTS method to predict future increases in stunting. This method helps the National Population and Family Planning Board (BKKBN) plan more targeted and efficient prevention programs.
6) What Should Be Done When an Estimated Increase in Stunting Is Known?
Answer: By increasing nutritional interventions, providing education on the importance of balanced nutrition, strengthening the stunting monitoring system, and collaborating with various parties to address this issue. Stunting predictions also help formulate data-driven policies, so that resources can be optimally allocated to areas most in need.
7) What is the estimated number of stunting cases?
Answer: Knowing the estimated number of stunting cases is essential for early prevention, planning effective programs, and evaluating implemented policies. Therefore, the application of the FTS method is expected to assist the BKKBN in reducing stunting rates and improving the quality of life for future generations.
8) What can be done to prevent stunting?
Answer: Prevention that can be done is by knowing the areas or groups at risk, BKKBN can carry out early intervention to prevent stunting, predictive data helps in designing programs that are targeted and efficient, ensuring that resources (funds, personnel, and logistics) are allocated to areas that need them most, and can assess the effectiveness of programs that are already running and make improvements if necessary.

c. Research Data

In this stage, researchers took several references from previous research and data from the research sites to use as samples for this study. The following is data on stunting sufferers:

NO	KABUPATEN	JUMLAH KELUARGA	JUMLAH KELUARGA SASARAN	KATEGORI KELUARGA BERISIKO STUNTING					
				RISIKO					
				PERINGKAT KESEJAHTERAAN 1	PERINGKAT KESEJAHTERAAN 2	PERINGKAT KESEJAHTERAAN 3	PERINGKAT KESEJAHTERAAN 4	PERINGKAT KESEJAHTERAAN > 4	TOTAL
1	2	3	4	5	6	7	8	9	10
01	TAPANULI TENGAH	79.788	42.123	5.732	5.187	3.441	2.953	8.373	25.686
02	TAPANULI UTARA	76.145	34.826	3.204	2.998	2.874	2.381	6.674	17.331
03	TAPANULI SELATAN	79.567	39.769	3.046	5.273	1.280	3.437	10.574	23.610
04	NIAS	29.347	16.451	2.969	3.364	2.298	1.586	4.129	14.376
05	LANGKAT	279.267	150.832	7.882	6.300	5.822	4.887	13.017	37.908

06	KARO	100.840	58.393	4.436	2.095	5.137	3.939	6.858	22.467
07	DELI SERDANG	520.151	288.963	6.393	6.396	7.331	10.464	38.712	69.296
08	SIMALUNGUN	244.373	117.329	6.421	5.513	2.686	5.121	17.666	37.407
09	ASAHAN	190.558	107.245	4.858	4.303	2.248	2.730	14.609	28.746
10	LABUHANBATU	107.826	64.062	3.995	4.459	4.412	3.981	10.393	27.240
11	DAIRI	73.435	34.521	2.170	3.474	3.598	1.986	6.342	17.570
12	TOBA	50.347	22.780	1.737	2.160	901	1.465	3.551	9.814
13	MANDAILING NATAL	104.274	57.227	5.777	6.270	2.889	6.582	16.136	37.654
14	NIAS SELATAN	59.598	34.396	7.125	6.604	4.565	3.290	8.327	29.915
16	HUMBANG HASUNDUTAN	48.779	22.085	2.026	2.108	1.201	997	4.134	10.456
17	SAMOSIR	35.985	14.883	1.892	1.868	868	621	3.581	8.832
18	SERDANG BEDAGAI	173.264	94.865	3.449	3.746	2.381	4.036	10.391	24.003
19	BATU BARA	111.882	62.426	4.035	3.127	3.624	2.570	5.701	19.061
20	PADANG LAWAS UTARA	63.680	31.836	3.138	2.358	2.148	1.528	4.928	14.099
21	PADANG LAWAS	65.959	39.684	3.118	5.262	3.239	2.529	5.976	20.124
22	LABUHANBATU SELATAN	71.293	44.213	2.903	2.957	2.369	2.533	5.388	16.129
23	LABUHANBATU UTARA	90.463	63.276	3.701	4.179	3.688	2.613	5.624	19.805
24	NIAS UTARA	29.774	17.056	4.041	3.458	1.452	1.180	3.287	13.338
25	NIAS BARAT	19.882	18.389	2.648	1.972	973	494	2.505	8.592
25	NIAS BARAT	19.882	16.389	2.648	1.972	973	494	2.585	8.592
26	KOTA MEDAN	480.968	232.086	10.688	9.267	7.238	6.073	30.199	63.450
27	KOTA PEMATANG SIANTAR	67.885	28.747	1.216	1.120	831	683	4.791	8.641
28	KOTA SIBOLGA	20.923	11.297	1.237	1.848	725	851	3.457	7.118
29	KOTA TANJUNG BALAI	46.294	25.110	968	807	638	471	2.688	5.074
30	KOTA BINJAI	72.114	38.538	608	748	548	810	3.494	6.108
31	KOTA TEBING TINGGI	45.287	23.027	896	776	419	527	2.712	5.329
32	KOTA PADANG SIDEMPUAN	51.753	26.976	1.599	2.222	1.557	1.159	5.539	12.076
33	KOTA GUNUNGSITOLI	32.584	17.611	2.375	1.318	629	621	5.197	10.140
	JUMLAH	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Figure 1. Data on Stunting Sufferers in 2023

NO	KABUPATEN	JUMLAH KELUARGA	JUMLAH KELUARGA SASARAN	RISIKO					
				PERINGKAT KESEJAHTERAAN 1	PERINGKAT KESEJAHTERAAN 2	PERINGKAT KESEJAHTERAAN 3	PERINGKAT KESEJAHTERAAN 4	PERINGKAT KESEJAHTERAAN > 4	TOTAL
1	2	3	4=10+11	5	6	7	8	9	10=∑(5:9)
1	TAPANULI TENGAH	83.288	45.060	4.878	4.028	2.506	2.126	8.190	21.528
2	TAPANULI UTARA	77.313	36.950	2.197	2.138	1.410	1.690	6.052	13.490
3	TAPANULI SELATAN	77.624	37.969	1.826	2.427	694	1.513	4.815	11.075
4	NIAS	28.338	17.412	2.733	3.103	2.100	1.595	4.560	14.100
5	LANGKAT	288.213	155.003	6.842	4.681	4.301	3.470	10.405	28.899
6	KARO	101.813	53.200	3.808	1.711	3.017	2.951	6.157	18.244

7	DELI SERDANG	619.027	299.101	3.454	3.440	3.850	5.813	25.475	42.042
8	SIMALUNGUN	240.141	117.982	4.268	3.496	1.740	3.129	11.933	24.566
9	ASAHAN	189.738	198.844	3.558	3.062	1.567	1.881	10.723	20.783
10	LABUHANBATU	109.860	65.632	3.088	3.218	3.195	2.871	8.388	20.751
11	DAIRI	73.688	35.801	1.778	2.812	2.774	1.581	5.565	14.510
12	TOBA	50.278	23.835	1.088	1.324	616	964	3.020	7.012
13	MANDAILING NATAL	106.478	62.873	4.844	5.006	2.369	5.122	13.268	30.609
14	NIAS SELATAN	61.079	36.877	8.855	6.190	4.310	3.124	8.386	28.675
15	PAKPAK BHARAT	11.667	7.176	524	560	384	285	1.012	2.770
16	HUMBANG HASUNDUTAN	48.684	24.445	1.445	1.561	835	887	3.815	8.363
17	SAMOSIR	31.428	12.632	1.177	1.090	553	490	2.583	5.819
18	SERDANG BEDAGAI	176.146	101.083	2.299	2.306	1.481	2.383	6.615	14.884
19	BATU BARA	112.592	66.123	3.140	2.365	2.710	1.881	5.143	15.229
20	PADANG LAWAS UTARA	53.231	32.531	1.843	1.443	1.291	932	3.654	8.132
21	PADANG LAWAS	66.044	41.830	2.257	3.069	2.188	1.022	4.901	14.437
22	LABUHANBATU SELATAN	70.944	45.358	2.066	2.073	1.582	1.632	3.929	11.337
23	LABUHANBATU UTARA	91.196	54.864	1.666	1.912	1.796	1.196	3.590	8.638
24	NIAS UTARA	29.991	18.488	3.498	2.917	1.251	1.029	3.117	11.859
25	NIAS BARAT	20.195	11.856	2.406	1.777	898	466	2.662	8.233
26	KOTA MEDAN	469.316	232.874	6.716	5.353	4.491	3.793	20.220	40.496
27	KOTA PEMATANG SIANTAR	66.494	31.981	872	781	554	473	3.837	6.517
28	KOTA SIBOLGA	21.192	11.697	1.041	900	584	599	3.131	6.265
29	KOTA TANJUNG BALAI	44.788	26.438	558	432	387	288	1.822	3.487
30	KOTA BINJAI	71.862	42.950	298	406	296	442	2.254	3.692
31	KOTA TEBING TINGGI	44.977	22.983	425	394	231	399	1.638	2.908
32	KOTA PADANG SIDEMPUAN	52.268	28.976	1.863	1.327	763	598	3.664	8.756
33	KOTA GUNUNGSITOLI	33.525	20.502	1.843	857	418	446	3.978	7.040
	TOTAL	3.006.048	1.826.704	84.777	78.738	57.239	57.385	207.152	485.887

Figure 2. Data on Stunting Sufferers in 2024

2. Literature Study

Literature Study at this stage the researcher uses several references from journals related to the research.

a. Stunting

Stunting (dwarfism) is a condition characterized by a low body length or height compared to age. This condition is measured by a body length or height greater than minus 2 standard deviations from the median of the World Health Organization (WHO) child development standard. Stunting in infants is a chronic nutritional problem caused by various factors, such as socioeconomic conditions, maternal nutrition during pregnancy, illness in stunting, and inadequate nutrient intake in stunting. If stunted, children will face difficulties in achieving maximum physical and cognitive growth in the future, are susceptible to disease, and are at risk of reduced productivity. Broadly speaking, stunting can limit economic development, increase poverty, and widen inequality.

Stunting is a nutritional problem that threatens the quality of life of the nation's future generations. Stunting is a process of chronic malnutrition that has short-term impacts in the form of stunted growth and long-term impacts in the form of low productivity in young adulthood and the risk of developing degenerative diseases.

PHP is a component of the PHP Hypertext Preprocessor. PHP is a type of scripting language used to build applications for the web and connect them to servers. PHP is a language that uses HTML add-ons to build applications that make maximum use of data and data.

3. Results and Discussion

The following are the challenges faced by the National Population and Family Planning Board (BKKBN) in determining or estimating the increase in stunting:

1. Stunting data is often non-linear and influenced by numerous economic, social, and environmental factors. This makes accurate predictions difficult.
2. The BKKBN still relies on classical statistical methods (such as regression), which lack flexibility in handling uncertain data patterns.
3. Stunting is influenced by various factors, such as maternal nutrition, parenting patterns, sanitation, and access to healthcare. These factors can fluctuate and are difficult to predict.
4. The data used is not always updated in real time, so predictions often do not reflect the most recent conditions.
5. The use of advanced technology for data analysis can still be challenging in some regions, including North Sumatra.

Obstacles faced by the BKKBN in predicting stunting include:

1. Data collected from various sources can have different recording methods, leading to inconsistencies in analysis.
2. Delays in Data Processing: Data from the regions often arrives late and is poorly integrated with the central system.
3. Lack of Utilization of AI or More Accurate Predictive Models: The use of more sophisticated methods such as Fuzzy Time Series or Machine Learning is still limited.
4. Social and Cultural Factors: Some regions may be less active in reporting data, or there may still be a stigma associated with reporting stunting cases.
5. Lack of Budget and Resources: Procurement of technology and training of experts for data analysis can be a barrier.

By implementing Fuzzy Time Series, estimates of the increase in stunting become more accurate because this method is able to capture data change patterns in a fuzzy manner (not rigid like linear regression). It is more accurate than older methods because it considers complex fluctuation patterns. It is flexible to changing conditions (e.g., the impact of government programs, changes in consumer consumption patterns). It can be applied to unstable data without losing accuracy. The mathematical form of the Fuzzy Time Series method is shown below:

Table 1. Stunting Data

No	Regency	Total In 2023	Total In 2024
1	Tapanuli Tengah	25686	21526
2	Tapanuli Utara	17331	13496
3	Tapanuli Selatan	23610	11075
4	Nias	14376	14190
5	Langkat	37908	28899
6	Karo	22467	18244
7	Deli Serdang	69296	42042
8	Simalungun	37407	24560
9	Asahan	28746	20783
10	Labuhanbatu	27240	20751
11	Dairi	17570	14510
12	Toba	9814	7012
13	Mandailing Natal	37654	30609
14	Nias Selatan	29915	28675
15	Pakpak Bharat	3516	2775
16	Humbang Hasundutan	10456	8363
17	Samosir	8832	5819
18	Serdang Bedagai	24003	14994
19	Batu Bara	19061	15229
20	Padang Lawas Utara	14099	9133
21	Padang Lawas	20124	14437
22	Labuhanbatu Selatan	16129	11307
23	Labuhanbatu Utara	19805	9618
24	Nias Utara	13338	11804

25	Nias Barat	8592	8203
26	Kota Medan	63450	40486
27	Kota Pematang Siantar	8641	6517
28	Kota Sibolga	7118	6265
29	Kota Tanjung Balai	5574	3487
30	Kota Binjai	6108	3692
31	Kota Tebing Tinggi	5329	2988
32	Kota Padang Sidempuan	12076	6756
33	Kota Gunungsitoli	10140	7642
	Max	69296	42042
	Min	3516	2775

Step 1: Determining the Universe of Discourse (U)
Universe U is determined based on the range of TOTAL 2023 and TOTAL 2024 data values, then calculated using the Sturgest formula:

Interval = 1+(3,322*LOG10(33))
= 6,044503308 dibulatkan menjadi 6

1. Nilai minimum (Min) = 2775
2. Nilai maksimum (Max) = 69296
3. interval (n) = 6

So, the interval size is calculated as follows:

Interval Size = (Max–Min)/Interval
= (69,296–2,775)/6
=11005

Step 2: Fuzzify 2023 & 2024 Data
Each value for 2023 and 2024 is grouped into a fuzzy set based on the universal interval U:

To create the interval, take the initial data with the smallest value, 2775, and then add it to the resulting Interval Size:

1. 2775+11005=13780
2. 13780+11005=24785
3. 24785+11005=35790
4. 35790+11005=46795
5. 46795+11005=57800
6. 57800+11005=68805

Tabel 2. Interval

Interval		Fuzzy Set	Keterangan
2775	13780	A1	Rentang 2775 hingga 13780 maka A1
13780	24785	A2	Rentang 13780 hingga 24785 maka A2
24785	35790	A3	Rentang 24785 hingga 35790 maka A3
35790	46795	A4	Rentang 35790 hingga 46795 maka A4
46795	57800	A5	Rentang 46795 hingga 57800 maka A5
57800	68805	A6	Rentang 57800 hingga 68805 maka A6

Then, fuzzify the TOTAL 2023 and TOTAL 2024 data:

In Central Tapanuli Regency, the total for 2023 was 25,686, so the data falls within the range of 24,785 to 35,790, or A3. The complete results are presented in Table 3.

Tabel 3. Fuzzifikasi (F)

No	Regency	Total In 2023	Total In 2024	F 2023	F 2024
1	Tapanuli Tengah	25686	21526	A3	A2
2	Tapanuli Utara	17331	13496	A2	A1

3	Tapanuli Selatan	23610	11075	A2	A1
4	Nias	14376	14190	A2	A2
5	Langkat	37908	28899	A4	A3
6	Karo	22467	18244	A2	A2
7	Deli Serdang	69296	42042	A6	A4
8	Simalungun	37407	24560	A4	A2
9	Asahan	28746	20783	A3	A2
10	Labuhanbatu	27240	20751	A3	A2
11	Dairi	17570	14510	A2	A2
12	Toba	9814	7012	A1	A1
13	Mandailing Natal	37654	30609	A4	A3
14	Nias Selatan	29915	28675	A3	A3
15	Pakpak Bharat	3516	2775	A1	A1
16	Humbang Hasundutan	10456	8363	A1	A1
17	Samosir	8832	5819	A1	A1
18	Serdang Bedagai	24003	14994	A2	A2
19	Batu Bara	19061	15229	A2	A2
20	Padang Lawas Utara	14099	9133	A2	A1
21	Padang Lawas	20124	14437	A2	A2
22	Labuhanbatu Selatan	16129	11307	A2	A1
23	Labuhanbatu Utara	19805	9618	A2	A1
24	Nias Utara	13338	11804	A1	A1
25	Nias Barat	8592	8203	A1	A1
26	Kota Medan	63450	40486	A6	A4
27	Kota Pematang Siantar	8641	6517	A1	A1
28	Kota Sibolga	7118	6265	A1	A1
29	Kota Tanjung Balai	5574	3487	A1	A1
30	Kota Binjai	6108	3692	A1	A1
31	Kota Tebing Tinggi	5329	2988	A1	A1
32	Kota Padang Sidempuan	12076	6756	A1	A1
33	Kota Gunungsitoli	10140	7642	A1	A1

B. Step 3: Determining Fuzzy Relations
The fuzzy relations are obtained from the transformation Fuzzy 2023 → Fuzzy 2024.

Tabel 4. Relasi *Fuzzy*

No	Regency	Total In 2023	Total In 2024	Fuzzy 2023	Fuzzy 2024	Relasi Fuzzy
1	Tapanuli Tengah	25686	21526	A3	A2	A3->A2
2	Tapanuli Utara	17331	13496	A2	A1	A2->A1
3	Tapanuli Selatan	23610	11075	A2	A1	A2->A1
4	Nias	14376	14190	A2	A2	A2->A2
5	Langkat	37908	28899	A4	A3	A4->A3
6	Karo	22467	18244	A2	A2	A2->A2
7	Deli Serdang	69296	42042	A6	A4	A6->A4
8	Simalungun	37407	24560	A4	A2	A4->A2
9	Asahan	28746	20783	A3	A2	A3->A2
10	Labuhanbatu	27240	20751	A3	A2	A3->A2
11	Dairi	17570	14510	A2	A2	A2->A2
12	Toba	9814	7012	A1	A1	A1->A1
13	Mandailing Natal	37654	30609	A4	A3	A4->A3
14	Nias Selatan	29915	28675	A3	A3	A3->A3
15	Pakpak Bharat	3516	2775	A1	A1	A1->A1

16	Humbang Hasundutan	10456	8363	A1	A1	A1->A1
17	Samosir	8832	5819	A1	A1	A1->A1
18	Serdang Bedagai	24003	14994	A2	A2	A2->A2
19	Batu Bara	19061	15229	A2	A2	A2->A2
20	Padang Lawas Utara	14099	9133	A2	A1	A2->A1
21	Padang Lawas	20124	14437	A2	A2	A2->A2
22	Labuhanbatu Selatan	16129	11307	A2	A1	A2->A1
23	Labuhanbatu Utara	19805	9618	A2	A1	A2->A1
24	Nias Utara	13338	11804	A1	A1	A1->A1
25	Nias Barat	8592	8203	A1	A1	A1->A1
26	Kota Medan	63450	40486	A6	A4	A6->A4
27	Kota Pematang Siantar	8641	6517	A1	A1	A1->A1
28	Kota Sibolga	7118	6265	A1	A1	A1->A1
29	Kota Tanjung Balai	5574	3487	A1	A1	A1->A1
30	Kota Binjai	6108	3692	A1	A1	A1->A1
31	Kota Tebing Tinggi	5329	2988	A1	A1	A1->A1
32	Kota Padang Sidempuan	12076	6756	A1	A1	A1->A1
33	Kota Gunungsitoli	10140	7642	A1	A1	A1->A1

C. Step 4: Defuzzification (2025 Prediction Calculation)
The prediction is calculated by taking the average interval of the target fuzzy set.

Tabel 5. Defuzzyfikasi

No	Regency	Relasi Fuzzy	Interval Results	*Fuzzy Time Series (Prediction Results For 2025)*	Data 2024	Estimation
1	Tapanuli Tengah	A3->A2	(13780+24785)/2	19283	21526	Turun
2	Tapanuli Utara	A2->A1	(2775+13780)/2	8278	13496	Turun
3	Tapanuli Selatan	A2->A1	(2775+13780)/2	8278	11075	Turun
4	Nias	A2->A2	(13780+24785)/2	19283	14190	Naik
5	Langkat	A4->A3	(24785+35790)/2	30288	28899	Naik
6	Karo	A2->A2	(13780+24785)/2	19283	18244	Naik
7	Deli Serdang	A6->A4	(35790+46795)/2	41293	42042	Turun
8	Simalungun	A4->A2	(13780+24785)/2	19283	24560	Turun
9	Asahan	A3->A2	(13780+24785)/2	19283	20783	Turun
10	Labuhanbatu	A3->A2	(13780+24785)/2	19283	20751	Turun
11	Dairi	A2->A2	(13780+24785)/2	19283	14510	Naik
12	Toba	A1->A1	(2775+13780)/2	8278	7012	Naik
13	Mandailing Natal	A4->A3	(24785+35790)/2	30288	30609	Turun
14	Nias Selatan	A3->A3	(24785+35790)/2	30288	28675	Naik
15	Pakpak Bharat	A1->A1	(2775+13780)/2	8278	2775	Naik
16	Humbang Hasundutan	A1->A1	(2775+13780)/2	8278	8363	Turun
17	Samosir	A1->A1	(2775+13780)/2	8278	5819	Naik
18	Serdang Bedagai	A2->A2	(13780+24785)/2	19283	14994	Naik
19	Batu Bara	A2->A2	(13780+24785)/2	19283	15229	Naik
20	Padang Lawas Utara	A2->A1	(2775+13780)/2	8278	9133	Turun
21	Padang Lawas	A2->A2	(13780+24785)/2	19283	14437	Naik
22	Labuhanbatu Selatan	A2->A1	(2775+13780)/2	8278	11307	Turun
23	Labuhanbatu Utara	A2->A1	(2775+13780)/2	8278	9618	Turun
24	Nias Utara	A1->A1	(2775+13780)/2	8278	11804	Turun
25	Nias Barat	A1->A1	(2775+13780)/2	8278	8203	Naik
26	Kota Medan	A6->A4	(35790+46795)/2	41293	40486	Naik

27	Kota Pematang Siantar	A1->A1	(2775+13780)/2	8278	6517	Naik
28	Kota Sibolga	A1->A1	(2775+13780)/2	8278	6265	Naik
29	Kota Tanjung Balai	A1->A1	(2775+13780)/2	8278	3487	Naik
30	Kota Binjai	A1->A1	(2775+13780)/2	8278	3692	Naik
31	Kota Tebing Tinggi	A1->A1	(2775+13780)/2	8278	2988	Naik
32	Kota Padang Sidempuan	A1->A1	(2775+13780)/2	8278	6756	Naik
33	Kota Gunungsitoli	A1->A1	(2775+13780)/2	8278	7642	Naik
					Naik	16
					Turun	17

Table 5 shows the estimated increase in stunting rates in 16 districts and a decrease in 17. Based on these estimates, the 16 districts experiencing increases must be able to anticipate stunting needs.

4. Conclusion

Based on the discussion in the previous chapters, this study concludes that the application of the Fuzzy Time Series (FTS) method enables the identification of trends in stunting cases across districts and cities in North Sumatra Province for the period 2023–2024, providing a clear overview of stunting developments within the region. By utilizing stunting data from two periods, the FTS steps and formulas can be systematically implemented to model and predict future stunting figures, demonstrating the method's potential for supporting data-driven decision-making. Furthermore, the development of a web-based application successfully integrates the FTS method as a practical tool for the North Sumatra BKKBN to estimate increases in stunting cases. For future research, it is recommended to include longer time-series data, compare multiple forecasting methods to improve prediction accuracy, and enhance the web application with real-time data integration and visualization features to support more comprehensive policy planning.

References

Adhyka, N., Yurizali, B., & Aisyiah, I. K. (2023). Peningkatan Pengetahuan Remaja akan Stunting dan Pola Konsumsi di SMAN 1 Kab Sijunjung. *Jurnal Pengabdian*, *1*(1), 32–38.

Aliana, D. S. N., Permanasari, Y., & Respitawulan. (2021). Prediksi Curah Hujan di Kota Bandung Menggunakan Model Logika Fuzzy Time Series. *Jurnal Riset Matematika*, *1*(1), 65–72. https://doi.org/10.29313/jrm.v1i1.220

Haganta, Z., Sembiring, I., Kelana Jaya, I., Rumapea, Y., & Rumahorbo, B. (2024). Methosisfo : Jurnal Ilmiah Sistem Informasi Prediksi Kebutuhan Keramik Di Cv. Asia Indah Anugerah Dengan Metode Single Exponential Smoothing (SES). *Methosisfo : Jurnal Ilmiah Sistem Informasi*, *4*(1), 17–25. https://ejurnal.methodist.ac.id/index.php/methosisfo

Hamdani, A. I., Agus Pranoto, Y., & Vendyansyah, N. (2020). Penerapan Metode Fuzzy Time Series Untuk Prediksi Penjualan Berbasis Web Pada Cv.AGVA Kota Pasuruan. *JATI (Jurnal Mahasiswa Teknik Informatika)*, *4*(1), 35–41. https://doi.org/10.36040/jati.v4i1.2433

Juan, K., & Budi, S. (2023). Pengembangan Menu Digital Menggunakan ReactJs Implementasi Hasil Belajar Studi Independen di Frontend Engineering Program Ruangguru CAMP (Career Acceleration Bootcamp). *Jurnal Strategi*, *5*(1), 130–142.

Kesuma, M. E.-K., Yunita, I., Fitra, J., Sholiha, N. A., & Oktaria, H. (2021). PENERAPAN SLiMS PADA LAYANAN SIRKULASI DI PERPUSTAKAAN PERGURUAN TINGGI. *AL Maktabah*, *6*(2), 103. https://doi.org/10.29300/mkt.v6i2.5148

Listyaning Pangestu, S., Rahmat, U., Program, S., Matematika, F., Matematika, D., Ilmu, P., Alam, U., Pamulang, T., & Selatan, I. (2024). Model Lee Metode Fuzzy Time Series Untuk Peramalan

Penjualan Obat Antibiotik. *Jurnal Matematika Dan Ilmu Pengetahuan Alam*, *4*(2).

Mubarak, R., Tursina, T., & Pratama, E. E. (2020). Prediksi Hasil Tangkapan Ikan Menggunakan Fuzzy Time Series. *Jurnal Sistem Dan Teknologi Informasi (Justin)*, *8*(3), 303. https://doi.org/10.26418/justin.v8i3.39831

Mukhlisin, Imrona, M., & Murdiansyah, D. T. (2019). Prediksi Harga Beras Premium dengan Metode Algoritma K-Nearest Neighbor. *E-Proceeding of Engineering*, *7*(1), 2714–2724.

Murni, I., Br pa, A. S., Lubis, B. R., & Ikhwan, A. (2023). Pengamanan Pesan Rahasia dengan Algoritma Vigenere Cipher Menggunakan PHP. *Journal on Education*, *5*(2), 3466–3476. https://doi.org/10.31004/joe.v5i2.1027

Noviaming, S., Takaeb, A. E. L., & Ndun, H. J. N. (2022). Persepsi Ibu Stunting Tentang Stunting Di Wilayah Puskesmas Tarus Kabupaten Kupang. *Media Kesehatan Masyarakat*, *4*(1), 44–54. https://doi.org/10.35508/mkmhttps://ejurnal.undana.ac.id/MKM

Nurliana Nasution, Feldiansyah Bakri Nasution, & Hasan, M. A. (2023). Pkm Pelatihan Pembuatan Web Berbasis Framework Codeigniter Untuk Siswa Smk. *J-COSCIS : Journal of Computer Science Community Service*, *3*(1), 10–19. https://doi.org/10.31849/jcoscis.v3i1.11001

Ramadhan, A., Baskara, D. R., Khairulloh, F. A., Komarudin, M. I., Daffa, M. A., Fadhillah Khairuddin, R., Fatimah, S., Sari, W., & Suryaningrat. (2023). Sosialisasi Pengenalan Website Berbasis HTML SMK Muhammadiyah 02 Tangerang Selatan. *Jurnal Pengabdian Kepada Masyarakat*, *1*(4), 294–298.

Saputra, A. A., Pakpahan, A. G. S., Kurtubi, A., Amiruddin, A., Fridaniarta, B., Wicaksono, E. Y., Saputra, H., Putra, M. Y. A., & Azahra, R. Y. (2023). Pelatihan Dan Pembuatan Website Menggunakan Html Dan Css. *Beujroh : Jurnal Pemberdayaan Dan Pengabdian Pada Masyarakat*, *1*(1), 119–125. https://doi.org/10.61579/beujroh.v1i1.41

Sari, I. K. (2021). Blended Learning sebagai Alternatif Model Pembelajaran Inovatif di Masa Post-Pandemi di Sekolah Dasar. *Jurnal Basicedu*, *5*(4), 2156–2163. https://doi.org/10.31004/basicedu.v5i4.1137

Wuryanto Endro Puspita Nella Valen, Ika, D. (2021). Model Average-based Fuzzy time series untuk prediksi perkembangan kasus terkonfirmasi positif COVID-19. *Jurnal Informatika Upgris*, *7*(2), 28–32. http://journal.upgris.ac.id/index.php/JIU/article/view/9559