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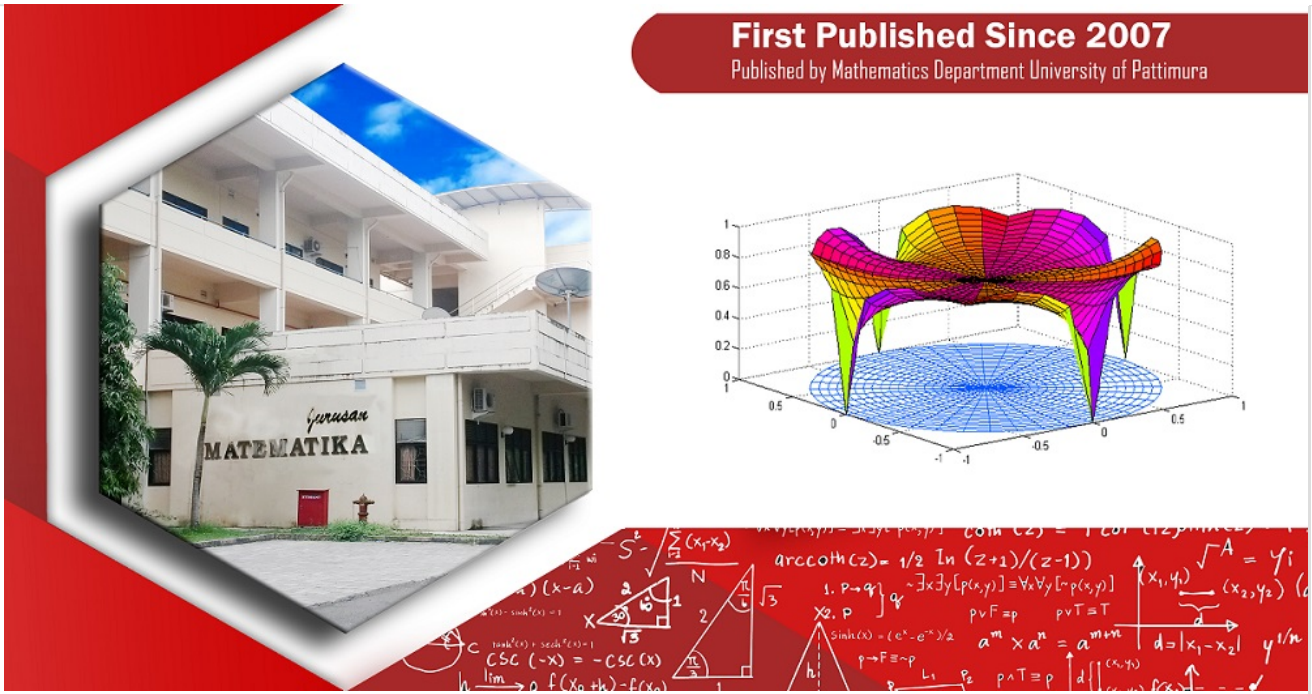

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We are delighted to announce that the Barekeng: Journal of Mathematics and Its Applications has been officially indexed in SCOPUS as of December 2024. The articles indexed are those published starting from Volume 14 (2020) up until the latest edition published during Scopus admission. More details can be viewed through the Scopus tracking system, Scopus website and, Scimagojr website.
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to the entire editorial team and peer reviewers for their dedication, hard work, and invaluable contributions to enhancing the quality of every manuscript published in BAREKENG: Journal of Mathematics and Its Applications.
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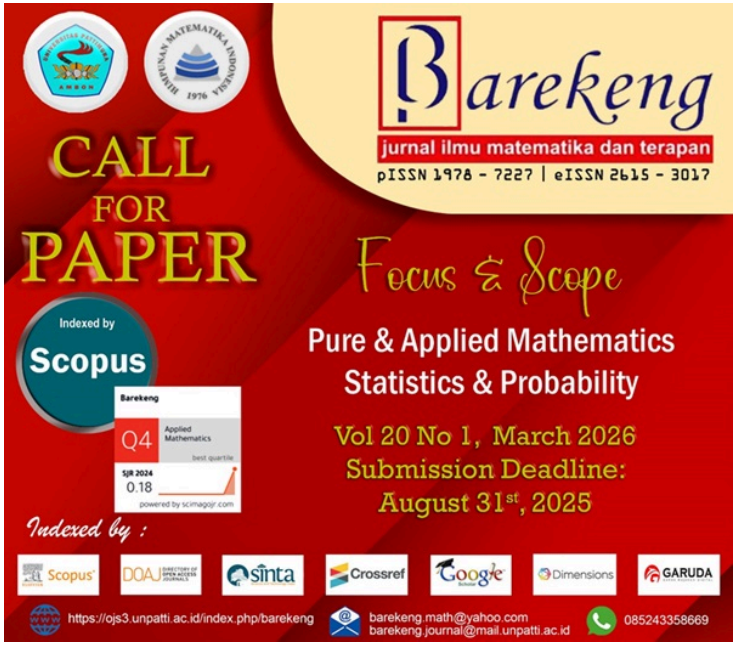

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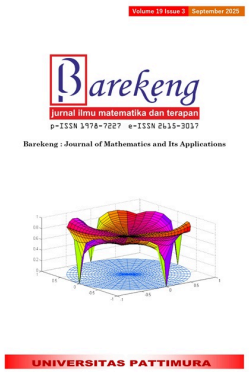

English. This volume is published four times a year in March, June, September, and December. All articles in this issue (60 research articles) include 242 authors from Indonesia, India, Malaysia, Nigeria, Oman, and Kuwait.

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Articles

PRICING OF THE ASIAN OPTION WITH THE KAMRAD-RITCHKEN'S TRINOMIAL MODEL

Jihan Nabila Wafa', Emy Siswanah

1457-1468

pdf

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GEOGRAPHICALLY WEIGHTED GENERALIZED POISSON REGRESSION AND GEOGRAPHICALLY WEIGHTED NEGATIVE BINOMIAL REGRESSION MODELING ON PROPERTY CRIME CASES IN CENTRAL JAVA

Prizka Rismawati Arum, Rahmad Putra Gautama, M. Al Haris

1469-1484

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347,236 190 46
11,149 176 46
7,042 165 45
3,065 145 41
1,641 143 39
975 141 37
921 135 37
896 129 37
824 128 35
817 118 35
775 101 34
741 99 34
698 95 31
557 92 29
556 91 29
553 88 26
525 84 26
452 83 24
448 83 22
434 81 19
432 79 18
354 71 18
313 66 18
301 64 18
298 63 17
266 62 17
260 60 17
242 59 17
238 57 16
237 54 16
233 52 14
224 50 13
216 49
195 47
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SENTIMENT ANALYSIS OF PRE-SERVICE MATHEMATICS TEACHER THROUGH NAÏVE BAYES CLASSIFIER: THE CASE OF MATHEMATICAL ABSTRACTION PROBLEM

Riki Andriatna, Dadan Dasari 1485-1498

pdf

Abstract views 0 | PDF downloads 0 |

COMBINING FUZZY ANP AND FUZZY ARAS METHODS FOR DETERMINING THE BEST LAND INVESTMENT LOCATION

Chasib Idris, Mila Kurniawaty, Sa`adatul Fitri 1499-1512

pdf

Abstract views 0 | PDF downloads 0 |

ANALYSIS OF THREE SERVERS CLOSED SERIES QUEUING NETWORK WITH DELAY TIME USING MAX-PLUS ALGEBRA

Marcellinus Andy Rudhito, Dewa Putu Wiadnyana Putra 1513-1524

pdf

Abstract views 0 | PDF downloads 0 |

MODELING GENDER DEVELOPMENT INDEX IN SOUTHEAST SULAWESI PROVINCE USING SEMIPARAMETRIC KERNEL REGRESSION

Andi Tenri Ampa, Lilis Laome, Muhammad Ridwan, Baharuddin Baharuddin, Makkulau Makkulau 1525-1536

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Baki Swita, Mulia Astuti, Fachri Faisal, Aang Nuryaman

1537-1552

pdf

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OPTIMIZING DEFINED BENEFIT PENSION PLAN FUNDING: COMBINING ENTRY AGE NORMAL METHOD AND SINGLE SALARY APPROACH

Wahyuni Ekasasmita, Nur Rahmi, Khaera Tunnisa, Muhammad Ikhlashul Amal

1553-1564

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DERIVATIONS OF PSEUDO BE-ALGEBRAS

Nessy Indryantika, Sri Gemawati, Kartini Kartini

1565-1574

pdf

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ANALYTICAL APPROACH OF GENERALIZED LINEAR MODELS FOR HANDLING OVERDISPERSION IN POVERTY DATA OF INDONESIA

Restu Arisanti, Resa Septiani Pontoh, Sri Winarni, Fellita Odelia Wibowo, Hanifah Khairunnisa, Raissheva Andika Pratama

1575-1586

pdf

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COMPARISON BETWEEN BAYESIAN QUANTILE REGRESSION AND BAYESIAN LASSO QUANTILE REGRESSION FOR MODELING POVERTY LINE WITH PRESENCE OF HETEROSCEDASTICITY IN WEST SUMATRA

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The articles for Volume 19 issue 2 June 2025 have been published, while for Volume 19 issue 3 September 2025 & Volume 19 issue 4 December 2025 are in progress. Currently, BAREKENG: Journal of Mathematics and Its Applications calls for papers for volume 20 issue 1, March 2026.

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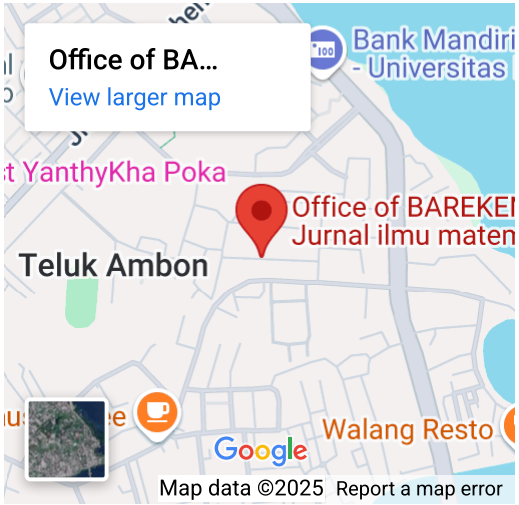

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MATHEMATICAL MODEL OF DENGUE HEMORRHAGIC FEVER SPREAD WITH DIFFERENT LEVELS OF TRANSMISSION RISK

Faishal Farrel Herdicho, Nabil Azizul Hakim, Fatmawati Fatmawati, Cicik Alfiniyah, John Olajide Akanni

1649-1666

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IMPLEMENTATION OF PLS-PM IN KNOWING THE FACTORS THAT INFLUENCE THE INCIDENCE OF TYPHOID FEVER IN PATIENTS IN ANUTAPURA PALU HOSPITAL

Virga Damayanti, Fadjryani Fadjryani, Iman Setiawan

1667-1680

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APPLICATION OF MAMDANI FUZZY LOGIC IN REFRIGERATOR SELECTION

Anisa Dwi Oktarina, Agus Maman Abadi, Syukrul Hamdi

1681-1698

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PREDICTION OF ECONOMIC GROWTH RATE OF TUBAN REGENCY WITH ADAPTIVE NEURO-FUZZY INFERENCE SYSTEM ALGORITHM

Maya Muaziza, Ahmad Zaenal Arifin, Suzatmo Putro

1699-1710

pdf

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FETAL HEALTH RISK STATUS IDENTIFICATION SYSTEM BASED ON CARDIOTOCOGRAPHY DATA USING EXTREME GRADIENT BOOSTING WITH ISOLATION FOREST AS OUTLIER DETECTION

Firda Yunita Sari, Dian Candra Rini Novitasari, Abdulloh Hamid, Dina Zatusiva Haq

1711-1724

pdf

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APPLICATION OF GPU-CUDA PARALLEL COMPUTING TO THE SMITH-WATERMAN ALGORITHM TO DETECT MUSIC PLAGIARISM

Alfredo Gormantara, Ferdianto Tangdililing, Sean Coonery Sumarta

1725-1736

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ESTIMATION OF BENEFIT RESERVES IN ENDOWMENT INSURANCE USING THE INDONESIAN MORTALITY TABLE IV AND ZILLMER METHOD

Wanda Hamidah Sadli, Devni Prima Sari

1737-1746

pdf

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APPLICATION OF THE FUZZY TOPSIS METHOD FOR LECTURER CERTIFICATION ASSESSMENT

Stephanie Marceline Raintung, Luther A. Latumakulita, Franky Paat, Irwan Karim, Steven Sentinuwo, Noorul Islam

1747-1764

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DETERMINING TEACHING SCHEDULE AT STATE SENIOR HIGH SCHOOL 1 DEPOK USING ASSIGNMENT THEORY WITH HUNGARIAN METHOD AND NEW IMPROVED ONES ASSIGNMENT METHOD ASSISTED BY PYTHON

Catherine Richelle Hindarto, Febi Sanjaya

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IMPLEMENTATION OF THE DBSCAN ALGORITHM FOR CLUSTERING STUNTING PREVALENCE TYPOLOGY IN WEST JAVA, CENTRAL JAVA, AND EAST JAVA REGIONS

Bagus Sumargo, Kadir Kadir, Dena Safariza, Munawar Asikin, Dania Siregar, Nilam Novita Sari, Danu Umbara, Rizky Hilmianto, Robert Kurniawan, Irman Firmansyah

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SPATIAL INTERPOLATION OF RAINFALL INTENSITY IN JAVA ISLAND USING ORDINARY KRIGING

Shabira A. Auliyazhafira, Fariza A. Putri, Theresia S. Nauli, Aulia R. Al Madani, I Gede Nyoman Mindra Jaya, Annisa N. Falah, Budi Nurani Ruchjana

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BEEF PRICE FORECASTING BASED ON TEMPORAL, SPATIAL AND SPACE-TIME PARAMETER INDICES

Syifa Nurul Fatimah, Ahmad Fuad Zainnuddin, Novi Mardiana, Utriweni - Mukhaiyar

pdf

Abstract views 0 | pdf downloads 0 |

NONLINEAR TRACKING CONTROL FOR PREY STABILIZATION IN PREDATOR-PREY MODEL USING BACKSTEPPING

Khozin Mu`tamar, Janson Naiborhu, Roberd Saragih, Dewi Handayani

1825-1840

pdf

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FUZZY GEOGRAPHICALLY WEIGHTED CLUSTERING WITH OPTIMIZATION ALGORITHMS FOR SOCIAL VULNERABILITY ANALYSIS IN JAVA ISLAND

Alwan Fadlurohman, Tiani Wahyu Utami, Setiawan Amrullah, Nila Ayu Nur Roosyidah, Oktaviana Rahma Dhani

1841-1852

pdf

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COMPARATIVE ANALYSIS OF MACHINE LEARNING METHODS IN CLASSIFYING THE QUALITY OF PALU SHALLOTS

Desy Lusiyanti, Selvy Musdalifah, Agusman Sahari, Iman Al Fajri

1853-1864

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ANALYSIS OF REAL RELATIVE ASYMMETRY IN URBAN TRANSPORTATION NETWORK PROBLEMS USING SPACE SYNTAX, REDS, AND MACHINE LEARNING CONCEPTS

Robiatul Adawiyah, Fitriyatul Mardiyah, Dafik Dafik, Ika Hesti Agustin, Excelsa Suli Wildhatul Jannah, Marsidi Marsidi

1865-1878

pdf

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STABILITY ANALYSIS OF GAMBLING BEHAVIOR MODEL WITH COGNITIVE BEHAVIORAL THERAPY TREATMENT

Fazat Asfa Niswah, Kartika Nugraheni, Irma Fitria, Retno Wahyu Dewanti

1879-1892

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A MODEL ON MARKET EQUILIBRIUM USING A DIFFERENTIAL EQUATION WITH TIME DELAYS

Jalina Widjaja, Naufal Zidan Putra Irawan, Yudi Soeharyadi, Dumaria R. Tampubolon

1893-1904

pdf

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PERFORMANCE COMPARISON OF SOME TYPES OF WAVELET TRANSFORMS FOR TOURISM DATA PATTERN APPROXIMATION

Syamsul Bahri, Lailia Awalushaumi, Bulqis Nebulla Syechah, Satriawan Pradana

1905-1922

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USING A MONOTONE SEQUENCE OF FUNCTIONS TO DETERMINE THE SHORTEST ARC LENGTH OF CIRCLES CONNECTED ANY TWO POINTS ON SPHERE

Muhammad Kabil Djafar, La Ode Safiuddin, Lilis Laome, Norma Muhtar, Herdi Budiman, Edi Cahyono, La. Gubu, Alfian Alfian, Indra Alamsyah, Askar Kohalsum

1923-1932

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ANALYSIS OF THE RELATIONSHIP BETWEEN WATER QUALITY AWARENESS AND DRINKING WATER CONSUMPTION BEHAVIOR (CASE STUDY: MAJENE CITY AND

CAMPALAGIAN VILLAGE, WEST SULAWESI)

Musafira Musafira, Nur Hilal A. Syahrir, Putri Indi Rahayu

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DYNAMIC ANALYSIS OF PREDATOR-PREY MODEL WITH CANNIBALISM INTERVENTION AND DISEASE INFECTION IN PREY USING HOLLING TYPE II RESPONSE FUNCTION

Fardinah Fardinah, Hikmah Hikmah, Rahmah Abubakar, Laila Qadrini, Haris Haris, Nadia Salsabilah

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APPLICATION OF THE SUPPORT VECTOR MACHINE, LIGHT GRADIENT BOOSTING MACHINE, ADAPTIVE BOOSTING, AND HYBRID ADABOOST-SVM MODEL ON CUSTOMERS CHURN DATA

Felice Elena, Robyn Irawan, Benny Yong

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A THREE-TERM CONJUGATE GRADIENT METHOD FOR LARGE-SCALE MINIMIZATION IN ARTIFICIAL NEURAL NETWORKS

Umar A Omesa, Muhammad Y. Waziri, Issam A. R. Moghrabi, Sulaiman M. Ibrahim, Gudu E B, Fakai S L, Rabiu Bashir Yunus, Elissa Nadia Madi

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SECURING INFORMATION CONFIDENTIALITY: A MATHEMATICAL APPROACH TO DETECTING CHEATING IN ASMUTH-BLOOM SECRET SHARING

Azhar Janjang Darmawan, Sugi Guritman, Jaharuddin Jaharuddin

1989-2002

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MATHEMATICAL MODELLING OF SMOKING BEHAVIOR: TREATMENT AND PREVENTION OPTIMAL CONTROL

Ananda Noersena, Fatmawati Fatmawati, Cicik Alfiniyah, Afeez Abidemi

2003-2016

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MODELING TOTAL FERTILITY RATE IN INDONESIA: A COMPARISON OF FOURIER SERIES REGRESSION AND ELASTIC NET REGRESSION

Fadhilah Fitri, Melin Wanike Ketrin, Mawanda Almuhayar

2017-2028

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PERFORMANCE LOSS QUANTIFICATION IN KERNEL DENSITY ESTIMATION FOR ACTUARIAL AND FINANCIAL ANALYSIS

Shafira Fauzia Untsa, Nanang Susyanto, Danang Teguh Qoiyyimi, Dwi Ertiningsih

2029-2038

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A COMPARATIVE ANALYSIS OF DBSCAN AND GAUSSIAN MIXTURE MODEL FOR CLUSTERING INDONESIAN PROVINCES BASED ON SOCIOECONOMIC WELFARE INDICATORS

NETWORK AS STOCK SELECTION METHOD

Emy Siswanah, Siti Maslihah, Agustina Anggraini, Muhammad Malik Hakim

2097-2110

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Abstract views 0 | PDF downloads 0 |

SURVIVAL ANALYSIS ON DATA OF STUDENTS NOT GRADUATING ON TIME USING WEIBULL REGRESSION, COX PROPORTIONAL HAZARDS REGRESSION, AND RANDOM SURVIVAL FOREST METHODS

Ramya Rachmawati, Nur Afandi, Muhammad Arib Alwansyah

2111-2126

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COX PROPORTIONAL HAZARD AND EXPONENTIAL SURVIVAL ANALYSIS IN PATIENTS WITH END-STAGE CHRONIC KIDNEY FAILURE AT BOJONEGORO

Nur Silviyah Rahmi, Achmad Rifai, M. Irfan Islami, Annisa Andra Azifa

2127-2140

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LEPROSY CASE MODELING IN EAST JAVA USING SPATIAL REGRESSION WITH QUEEN CONTIGUITY WEIGHTING

Toha Saifudin, Marisa Rifada, Karina Rubita Makhbubah, Devira Thania Ramadhanty

2141-2154

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2219-2228

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ANALYSIS OF FOOD SECURITY FACTORS WITH PATH MODELING SEGMENTATION TREE (PATHMOX) METHOD IN PARTIAL LEAST SQUARES IN WEST KALIMANTAN

Nabila Izza Harnanta, Hendra Perdana, Neva Satyahadewi

2229-2242

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COMPARISON OF EXPONENTIALLY WEIGHTED MOVING AVERAGE CONTROL CHART WITH HOMOGENEOUSLY WEIGHTED MOVING AVERAGE CONTROL CHARTS AND ITS APPLICATION

Erna Tri Herdiani, Mustabsyirah Mustabsyirah

2243-2262

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LEVEL SOFT GROUP AND ITS PROPERTIES

Saman Abdurrahman, Mochammad Idris, Faisal Faisal, Na'imah Hijriati, Threye Threye, Aprida Siska Lestia

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DETERMINING TEACHING SCHEDULE AT STATE SENIOR HIGH SCHOOL 1 DEPOK USING ASSIGNMENT THEORY WITH HUNGARIAN METHOD AND NEW IMPROVED ONES ASSIGNMENT METHOD ASSISTED BY PYTHON

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ABSTRACT

Every school has a lesson schedule that describes the allocation of teacher assignments to certain lesson hours in each class. The teaching schedule at State Senior High School 1 Depok is still made manually. Therefore, assignment theory using the Hungarian method and the New Improved Ones Assignment (NIOA) method assisted by Python is an alternative for automating the schedule creation process. The purpose of this research is to determine (1) the assignment model, (2) the application of the Hungarian method, (3) the application of the NIOA method, and (4) a comparison of the process and results using both methods from the teaching schedule at State Senior High School 1 Depok. The following research results were obtained. The assignment model can be arranged into assignment tables, which contain teacher codes in the rows, day and lesson hour codes in the columns, and the availability of teacher's teaching hours, which is filled in with entry 1 if the teacher can teach and 0 if the teacher cannot teach in the corresponding cells. Those tables are processed using Python according to Hungarian and NIOA assignment algorithms. The difference in the application of the two methods is only in the algorithm for finding the initial basic feasible solution. Overall, the two methods applied produce the same schedule results. Differences in results are obtained if two teachers can only teach at the same time.

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1. INTRODUCTION

Every school has a lesson schedule prepared for each class. The purpose of the lesson schedule is to ensure every student can receive learning experiences as much as possible within the existing schedule [1], [2], [3]. According to Chusna, Fatrianto, and Birbas [1], [4], a good lesson schedule should consider teacher placements and teaching hours.

Based on interviews with Curriculum Department Staff Teacher at State Senior High School 1 Depok, the school prepares the lesson schedule by considering several things, namely the type of teacher, Subject Teachers' Forum (MGMP), teacher's activities, student conditions, and course weight. However, the school still uses a manual method to create the schedule, which involves manually recording the time of teachers' teaching availability and entering this data into Excel for documentation. This manual approach completes the schedule in at least two weeks. If there is any revision on the schedule, the staff still have to check it manually, which can take a lot of time and effort. There is a possibility of human error in manual scheduling, such as putting the teacher in the time that the teacher can not teach, putting the teacher in the wrong class, or even accidentally putting two or more teachers in one class at the same time. Therefore, a solution is needed to create teaching schedules that are quicker and easier to check.

The scheduling process can be carried out in various ways, using mathematical methods and other approaches. Based on previous research, many school scheduling problems have been solved using genetic algorithms [5], [6], [7], [8]. Some have been addressed using the B/S method [9] and web-based approaches [4]. Additionally, they can also be solved mathematically using the integer linear model method and goal programming [10], [11], [12]. The assignment method for solving scheduling problems has not yet been found among these various methods.

Assignment theory is a special case of transportation theory [13]. The problem often resolved with transportation theory is the distribution of goods from several sources to several destinations. Therefore, the distribution process will be arranged so that each factory can get the goods it needs, each warehouse has sufficient supply, and shipping costs can be optimized. Allocation in transportation theory allows for multiple sources to be transported to a single destination or for a single source to be transported to multiple destinations. In contrast, assignment theory deals with assigning workers to specific tasks, with the condition that each worker performs only one task and only one worker performs each task.

The Hungarian method for optimizing assignment problems is the most common [14]. The principle of the Hungarian method is to select workers for jobs that produce optimum objective function value. The principles of the Hungarian method are (1) determining the initial feasible solution, (2) testing optimality, and (3) revising the table if there are any unassigned workers. A feasible solution can be obtained by subtracting each row and column with minimum and minimum columns. Optimality tests are carried out using horizontal and vertical lines that cover the assignment. The assignment occurred when the entry of a pair of workers and a job was 0. If the number of lines doesn't equal the number of rows or columns, the process continues to the revision stage. The revision stage is carried out by determining entries crossed by a line, not struck by a line, and closed by the intersection of two lines. Then, every entry that doesn't get crossed by a line is subtracted by the minimum of those entries (d_{ij}), and every entry whose position is in the intersection of two lines is added by d_{ij}. Even though the entries of the initial matrix change as a result of the operation, the assignment selection and optimization results remain the same.

Various methods have been developed to solve assignment problems [13], [15], [16], [17]. Khalid, Sultana, and Zaidi [18] developed a new assignment method called the New Improved One's Assignment (NIOA) Method. The algorithm consists of five steps. The first step is to calculate and write the sum of the elements in each row on the right side of the cost matrix. Then, determine the smallest sum among them. Divide each total of each row i of the matrix by the smallest sum. If $k_i < 2$ for all i, then proceed to step 3; otherwise continue on to the next step. The second step is to add or subtract any row by any number, until every $k_i < 2$. In the third step, the new matrix, find the smallest (or largest) entry of each row and each column. Then, divide each entry by the corresponding product of the smallest (or largest) entry on each row or column. In the next step, find each row's minimum (or maximum) entry in the new matrix and divide each entry by that minimum (or maximum) entry. The process of assigning the workers to their jobs is the same as in the Hungarian method but covers all entries with 1. If there are unassigned workers, revise. Select the minimum (or maximum) entry that does not lie on any of the lines. Then, divide every entry with uncovered lines by the minimum (or maximum) value.

However, Murugesan and Esakkiammal [15] discovered a problem that resulted in an optimal solution using the New Improved Ones Assignment Method. Their research concluded that some cases within assignment theory do not yield optimal results compared to the Hungarian method. If the results are not optimal, then the assignment may be different. In the case of a teaching schedule, as long as the teacher's time is available for a particular class, the results of the assignment will not be a problem. Optimal values are not considered in the case of teacher scheduling, creating a combination of assignments that schools can consider when choosing a schedule. Therefore, the NIOA method will not be a problem despite its weakness.

Assignment problems can be constructed and solved with the help of programming languages. Python is a programming language that is freely available and free to use, even for commercial purposes. Python is a programming language that is easy for users to understand [19], [20], [21]. Python also enables collaboration, making it one of the most widely used programming languages.

The Hungarian and New Improved One's Assignment methods will be implemented when creating teaching schedules. Python is used as a tool to assist in solving teacher scheduling problems. Python is an appropriate programming language for this research, as it allows for collaboration with schools.

2. RESEARCH METHODS

The research used applied research. Applied research is carried out to overcome problems and improve internal aspects of life by formulating alternative solutions based on scientific knowledge [22]. This research will apply assignment theory to the teacher's teaching schedule using the Hungarian and New Improved One's Assignment methods, which Python assists.

Definition 1. *Assignment theory is a special balanced case (equal number of rows and columns) of transportation theory, where the number of workers and tasks selected is equal to* 1 [14], [23]

Assignment theory consists of several workers and tasks to be paired, each having a certain weight (cost, time, earnings, and others). Each worker is paired with the task, providing minimal or maximal weight. The problem of assigning n workers to m tasks are expressed as follows.

Minimizing the objective function:

$$z = \sum_{i=1}^{n} \sum_{j=1}^{m} c_{ij} x_{ij} \tag{1}$$

Subject to (s.t.):

$$\sum_{i=1}^{m} x_{ij} = 1 \; ; j = 1,2,..,m \tag{2}$$

$$\sum_{j=1}^{m} x_{ij} = 1 \; ; i = 1,2,..,m \tag{3}$$

$x_{ij} = 1$, if worker i is assigned to job j or $x_{ij} = 0$, if worker i is not assigned to job j.

Description:

x_{ij}: assignment of worker i to job j

c_{ij}: weight (cost) of worker i on job j ($c_{ij} \in R$)

Table 1 represents **Definition 1**.

Table 1. Assignment Table as a Representation of the Assignment Matrix

		Job				
		1	2	3	...	n
Worker	1	c_{11}	c_{12}	c_{13}	...	c_{1n}
	2	c_{21}	c_{22}	c_{23}	...	c_{2n}
	⋮	⋮	⋮	⋮	⋱	⋮
	m	c_{m1}	c_{m2}	c_{m3}	...	c_{mn}

The research was carried out at State Senior High School 1 Depok, which is located at Babarsari Street, Tambak Bayan, Depok, Caturtunggal, Sleman, Special Region of Yogyakarta. The subject of this research is the lesson schedule at State Senior High School 1 Depok. Assignment Theory will be implemented in subjects to optimize the teaching schedule. The data used in this research is primary data. The required data are the number of subject teachers teaching in a particular class, the number of teaching hours for every teacher at every level, considerations to make lesson schedules, and lesson schedules applied at the school during the academic year 2023/2024.

Data is collected through interviews, observation, and documentation. Data is obtained by interviewing the Curriculum Department Staff who make the schedule. Data on teacher teaching schedules is obtained by observation and documentation. The research instrument needed is an interview guide. The interview guide contains information about how the school creates teaching schedules and what considerations the school takes into account when it makes a teaching schedule. Further information consists of teacher picket schedules, schedules of routine activities carried out by the school, the duration of the student's study at school, and other information received when conducting interviews. The data obtained will be analyzed in several sections. After obtaining the data on teachers and subjects taught by teachers, data are analyzed to form an assignment matrix according to the assumptions and considerations in making lesson schedules at school. The optimization of the assignment matrix is analyzed using different algorithms for each method in Python. The similarities and differences in the schedules formed to analyze the process and results of determining the teaching schedule.

The Python application used in this study is Google Colab, which utilizes the Pandas, NumPy, and Random libraries. Google Colab is connected to Google Drive using the mount feature during the process. The data file is stored in Google Drive as an Excel file. Subsequently, the Excel file is read using Pandas, producing input data as a data frame. After that, the data frame is converted into a list or array to facilitate executing the Hungarian and NIOA algorithms.

3. RESULTS AND DISCUSSION

Data was collected on April 1st, 2024, at State Senior High School 1 Depok on Babarsari Street, Tambak Bayan, Depok, Caturtunggal, Sleman, Special Region of Yogyakarta. The data was obtained through an interview with the Curriculum Department Staff Teacher, responsible for creating the class schedules at State Senior High School 1 Depok. The data collected includes a description of the teaching process for the 2023/2024 academic year, as well as information regarding the considerations and processes undertaken by the school in creating the class schedules.

The curriculum used by the school is the 2013 Curriculum for grades XI and XII and the Merdeka Curriculum for Phase E/Grade X. The school has 18 classes, consisting of six Phase E/Grade X classes, four grade XI MIPA classes, two grade XI IPS classes, four grade XII MIPA classes, and two grade XII IPS classes. Each grade follows 46 weekly lesson hours, consisting of 10 hours for Tuesday-Thursday and 8 hours for Monday and Friday. In the 2023/2024 academic year, State Senior High School 1 Depok has 42 teachers, comprising 31 Civil Servant Teachers and 11 Non-Permanent Teachers.

The teaching schedule at State Senior High School 1 Depok is arranged with several considerations, including the type of teacher, the schedule for Subject Teacher Conference, the personal considerations of the teachers, student conditions, and subject weights. State Senior High School 1 Depok has three types of teachers: Civil Servant Teachers (ASN) consisting of teachers who are part of the Civil Service and teachers who are Government Employees with Work Agreements, Religious Education and Character Education teachers, and Non-Permanent Teachers. Each subject teacher has a specific Subject Teacher Conference schedule, with one weekly meeting. Personal teacher considerations include health and condition, retirement age, individual and family matters, and other factors related to the teacher's activities outside of work. In addition to teacher considerations, the class schedule is also adjusted to student conditions and the subjects' weight. Subjects requiring high concentration, accuracy, and focus from students are preferably not placed at the end of the day. The school also provides options for placing subjects such as Informatics, Javanese Language, Cultural Arts, Music Arts, Religious Education, and Character Education at the end of the day. The first- and second-lesson hours on Monday should preferably be filled with subjects that have a minimum of four lesson hours, as the teacher briefing after the flag ceremony has the potential to cut the first lesson hour.

Based on those considerations, creating the schedule at the school begins by asking Non-Permanent Teachers and Religious Education and Character Education teachers who are not ASN about their availability to teach at the school. The next step is to review the Subject Teacher Conference (MGMP) schedule. Teachers with a Subject Teacher Conference (MGMP) schedule on a particular day can only teach until the 4th lesson hour. Next, the school considers the personal condition of each teacher. Teachers with health issues typically receive adjacent classes when scheduled to teach two or more classes in proximity. The class lasts two lesson hours per session, except for subjects with three two-lesson hours per week. The school will divide subjects with three two-lesson hours into two sessions: one session with two lesson hours and one session with one two-lesson hour. These two lesson hours will be scheduled on the same day as the other subjects and will have similar constraints. Subjects with at least three two lesson hours are scheduled on Monday during the first- and second-class periods. Physical Education (Penjasorkes) is preferably expected before the second break so that students do not exercise in the afternoon.

Assignment theory using the Hungarian method and the New Improved Ones Assignment (NIOA) method, with the assistance of Python, can be implemented to create the schedule. The scheduling is based on several assumptions:

1. The school has already assigned teachers to specific grades and subjects.
2. Non-Permanent Teachers have been manually scheduled to teach on certain days and class hours.
3. Supervisors for P5 activities are not scheduled.
4. Retirement time and personal considerations are not taken into account.

Based on the school's considerations in organizing the teaching schedule, a matrix is formed to model the teacher assignment at the school, as shown in **Table 2**.

Table 2. Teaching Assignments at State Senior High School 1 Depok 2023/2024 Academic Year

		Day_Lesson Hours Code				
		Monday_A	**Monday_B**	**Monday_C**	**…**	**Friday_D**
Teacher Code	1	c_{11}	c_{12}	c_{13}	…	c_{1m}
	2	c_{21}	c_{22}	c_{23}	…	c_{2m}
	3	c_{31}	c_{32}	c_{33}	…	c_{3m}
	⋮	⋮	⋮	⋮	⋱	⋮
	m	c_{m1}	c_{m2}	c_{m2}	…	c_{mm}

Minimizing the objective function:

$$z = \sum_{i=1}^{m} \sum_{j=1}^{m} c_{ij} x_{ij} \tag{9}$$

$c_{ij} = 1$, if the teacher can teach at the specific lesson hour

or

$c_{ij} = 0$, if the teacher can't teach at the specific lesson hour

Subject to (s.t.):

$$\sum_{i=1}^{m} x_{ij} = 1 \; ; j = 1,2,..,m \tag{10}$$

$$\sum_{j=1}^{m} x_{ij} = 1 \; ; i = 1,2,..,m \tag{11}$$

$x_{ij} = 1$, if teacher i is assigned to specific lesson hour j

or

$x_{ij} = 0$, if teacher i is not assigned to specific lesson hour j

Description:

x_{ij}: assignment of teacher i to lesson hour j

m is the number of lesson hours available in one week.

Phase E/Grade X has a value of $m = 17$, because they have P5 activities that take place at the last four lesson hours on Tuesday, Wednesday, and Thursday. Grades XI and XII have a value of $m = 20$ when the Religious Education and Character Education subject is conducted for 3 lesson hours at once in one day or $m = 21$ when the subject is divided into 1 and 2 lesson hours.

Classes XI and XII have two types of classes: the Mathematics and Natural Science (MIPA) primary class consists of four classes and the Social Sciences (IPS) major consists of two classes. The number of teachers in Class XI is 26, consisting of seven GTTs and three, including teachers of Religious Education and Character. Meanwhile, on Friday, the teachers who teach in Class XII have 24 teachers consisting of five GTTs and three of them are teachers of Religious Education and Character. Class XI MIPA 2 and XII MIPA 2 comprised Muslim and Christian students. Class XI MIPA 3 and XII MIPA 3 consist of Muslim and Catholic students. Class XI IPS 2 consists of Muslim, Christian, and Catholic students. Class XII IPS 2 consists of Muslim, Christian, Catholic, and Hindu students. Therefore, the time for assigning teachers to Religious Education and Character Education needs to be determined first.

The teacher constraint limits each teacher to teaching only one class at a specific time. The time constraint limits each class period to be taught by only one teacher. This study uses only entries where c_{ij} and x_{ij} have values of 1 and 0, so the optimization of the objective function will have the same value if there are other possible assignments. Those two numbers were chosen because the school does not have priority subjects, and all subjects are considered to be arranged equally. Therefore, this study uses assignment theory to assign teachers to teaching times.

The teacher code represents one meeting in a class for a specific teacher teaching a subject. The day and lesson hours codes are structured this way because each day has 8-10 lesson hours, and each session typically lasts for two lesson hours. Thus, class periods can be grouped in multiples of two, with the following breakdown: A for lesson hours 1-2, B for lesson hours 3-4, C for lesson hours 5-6, D for lesson hours 7-8, and E for lesson hour 9-10. However, certain conditions may prevent the lesson hour from being represented by code A. The teacher code for one meeting in a subject with three class periods will be combined with the meeting of a subject with similar constraints by assigning a new teacher code.

In this study, the assignment is still done manually using Google Sheets, as an automatic modeling method has not yet been found. When using Google Sheets, the first row of every sheet must be skipped because the Python code is designed to separate the Teachers and Day_Lesson Hours codes with an empty first row. **Table 3** is the assignment table for the initial data of class E1.

Table 3. Teaching Assignment Class E1

Teacher Code	E1_Monday_A	E1_Monday_B	E1_Monday_C	E1_Monday_D	E1_Tuesday_A	E1_Tuesday_B	E1_Tuesday_C	E1_Wednesday_A	E1_Wednesday_B	E1_Wednesday_C	E1_Thursday_A	E1_Thursday_B	E1_Thursday_C	E1_Friday_A	E1_Friday_B	E1_Friday_C	E1_Friday_D
36	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
29	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
28	1	1	1	1	1	0	0	1	1	1	1	1	1	1	1	1	1
27	1	1	1	1	1	1	1	1	1	1	1	0	0	1	1	1	1
27-28	1	1	1	1	1	0	0	1	1	1	1	0	0	1	1	1	1
32	1	1	1	1	1	0	0	1	1	1	1	1	1	1	1	1	0
3	1	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1
16	1	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1
25	1	1	1	1	1	1	1	1	0	0	1	1	1	1	1	1	1
40	1	1	1	1	1	1	1	1	0	0	1	1	1	1	1	1	1
3	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0
18	1	1	1	1	1	0	0	1	1	1	1	1	1	1	1	1	1
41	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
26	1	1	1	1	1	1	1	1	0	0	1	1	1	1	1	1	1
6	1	1	1	1	1	1	1	1	1	1	1	0	0	1	1	1	1
31	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11	1	1	1	1	1	1	1	1	1	1	1	0	0	1	1	1	1

After the table is completed, the file is downloaded in .csv format and processed using Python. Once the teacher assignment for class E1 is created, the modeling continues for class E2. In addition to the school's considerations, the modeling for class E2 depends on the assignment results in class E1. The same approach is applied to create the assignments for all classes, continuing with class E3, class E4, and so on until XII IPS 2. This ensures that a teacher already teaching in one class will not be scheduled to teach in another class simultaneously.

Data is processed according to each method's algorithm. The Hungarian and NIOA methods produce the same initial feasible matrix, so the result of the optimal matrix is also the same. The assignment results using both methods do not exhibit varying assignment combinations. The Python code has been designed to provide assignments to the leftmost entry that meets the assignment criteria in each row with the smallest Boolean value of 'True' [24]. Thus, the resulting assignment form from Python is obtained as follows in Figure 1.

```
['E1_Monday_A'] ----- ['27-28_E1']
['E1_Monday_B'] ----- ['36_E1']
['E1_Monday_C'] ----- ['31_E1']
['E1_Monday_D'] ----- ['27_E1']
['E1_Tuesday_A'] ----- ['25_E1']
['E1_Tuesday_B'] ----- ['40_E1']
['E1_Tuesday_C'] ----- ['41_E1']
['E1_Wednesday_A'] ----- ['3_E1']
['E1_Wednesday_B'] ----- ['6_E1']
['E1_Wednesday_C'] ----- ['11_E1']
['E1_Thursday_A'] ----- ['26_E1']
['E1_Thursday_B'] ----- ['28_E1']
['E1_Thursday_C'] ----- ['32_E1']
['E1_Friday_A'] ----- ['30_E1']
['E1_Friday_B'] ----- ['16_E1']
['E1_Friday_C'] ----- ['18_E1']
['E1_Friday_D'] ----- ['29_E1']
```

Figure 1. List of Teaching Assignments in Class E1 from Python

The meaning of Figure 1 above is as follows. For example, [‘E1_Friday_D’] ---- [‘29_E1’] means that the teacher for class E1 on Friday during lesson hours 7-8 (D) is a teacher with code 29. The assignment matrix for the next class is prepared and processed similarly using Python. Based on the results, there are some differences in the schedule for Grade XII. The main change is in Grade XII MIPA 1, as the subsequent classes follow the outcome of the class before. In the case of Grade XII MIPA 1, a difference in results was found between the Hungarian and NIOA methods, as shown in Table 4.

Table 4. Differences in Teacher Assignment Results in Class XII MIPA 1

Schedule	Teacher Code		Schedule	Teacher Code	
	Hungarian	NIOA		Hungarian	NIOA
Monday_A	38-1	14	Wednesday_E	2-1	8-1
Monday_B	23-1	20	Thursday_A	13-2	5-1
Monday_C	8-1	38-2	Thursday_B	15	23-1
Monday_D	34B	23-2	Thursday_C	19B-1	8-2
Tuesday_4-5	2-2	17	Thursday_D	14	19B-2
Tuesday_6-7	23-2	2-1	Thursday_E	20	19B-1
Wednesday_A	5-1	15	Friday_A	38-2	34B
Wednesday_B	13-1	24A	Friday _B	19B-2	13-2
Wednesday_C	8-2	38-1	Friday _C	24A	2-2
Wednesday_D	17	13-1	Friday _D	5-2	5-2

The results were different because two teachers could only teach simultaneously, as shown in Table 5. This issue causes the assignment matrix to be unable to find an optimal line equal to the number of rows or columns in the assignment matrix, leading to a revision stage. The results of the revision stage for both methods differ. The revision process in teacher assignments affects some teachers, leading to assignments that do not align with the considerations. If a similar situation occurs, it is necessary to recheck the matrix and also review the schedule once it is completed.

Table 5. Obstacles in the Class XII MIPA 1 Assignment Matrix

Taecher Code	XII MIPA 1 Monday_A	XII MIPA 1 Monday_B	XII MIPA 1 Monday_C	XII MIPA 1 Monday_D	XII MIPA 1 Tuesday_45	XII MIPA 1 Tuesday_67	XII MIPA 1 Wednesday_A	XII MIPA 1 Wednesday_B	XII MIPA 1 Wednesday_C	XII MIPA 1 Wednesday_D	XII MIPA 1 Wednesday_E	XII MIPA 1 Thursday_A	XII MIPA 1 Thursday_B	XII MIPA 1 Thursday_C	XII MIPA 1 Thursday_D	XII MIPA 1 Thursday_E	XII MIPA 1 Friday_A	XII MIPA 1 Friday_B	XII MIPA 1 Friday_C	XII MIPA 1 Friday_D
196-1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
196-2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
34B	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14	0	1	1	1	0	0	1	1	0	1	1	1	0	1	1	0	1	1	1	1
17	0	1	1	1	0	0	1	1	0	1	1	0	1	0	1	1	0	1	1	0
13-1	1	1	1	1	0	0	1	1	1	0	0	0	0	0	0	0	1	1	1	1
13-2	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
15	0	1	1	1	0	0	0	0	0	0	0	1	1	0	1	1	1	1	1	0
20	0	0	0	0	0	0	1	1	1	0	1	1	1	0	1	1	1	0	1	0
2-1	1	1	1	1	0	0	0	1	1	1	1	1	0	0	0	0	1	1	1	1
2-2	0	0	0	0	1	1	0	1	1	1	1	1	0	0	0	0	1	1	1	1
23-1	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	1
23-2	0	0	0	0	1	1	0	0	0	0	0	1	0	1	1	1	0	0	0	0
24A	1	1	1	1	1	1	1	0	0	0	1	1	1	1	1	1	1	1	0	0
38-1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
38-2	0	0	0	0	0	0	1	1	1	1	1	0	0	0	0	0	1	1	1	1
5-1	1	1	1	1	0	0	1	0	0	0	1	0	0	0	0	0	1	1	1	1
5-2	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
8-1	1	1	1	1	0	0	0	0	0	0	0	1	1	1	1	1	0	0	0	0
8-2	0	0	0	0	0	0	1	0	1	1	1	0	0	0	0	0	1	1	0	1

In the context of teacher scheduling, the optimization results are not heavily emphasized. Nevertheless, differences in results indicate another example of non-optimal assignments in the NIOA method, as noted in [15]. According to the opinions of these researchers, the Hungarian method is the most reliable so far, and future researchers should not rely solely on the NIOA method. In this case, the NIOA method offers opportunities to explore alternative variations in scheduling teacher assignments.

Overall, the scheduling process met the expectations of the Curriculum Department Staff Teacher, specifically the implementation of a blocking system from the start. The scheduling results using Python are produced more quickly than manual scheduling. Despite many assumptions, the scheduling results using Python can be reviewed in less than a week.

However, there are some weaknesses in the scheduling process using Python. Even though a blocking system has been created based on the school's considerations, there is still a possibility that the resulting schedule may not be suitable for teachers or students. For example, in Table 5 two teachers can teach for only one lesson hour. It would be a problem for Python since it will proceed to the revision stage of each method, resulting in an unsuitable schedule. The assignment matrix should be reviewed before it is processed in Python. If it does happen, manual checking is necessary to ensure that the schedule aligns with teachers' and students' capacities and abilities. This checking can be done using Excel with Conditional Formatting applied.

Another weakness is that no parallel assignment matrix form has been found for all classes within one school, so there are additional obstacles to viewing the assignment of teachers between one class and another. However, scheduling can still be done one by one between classes. Apart from that, the weighting in this study still uses the numbers 1 and 0. It will probably be much better if the entries are large enough for a subject-blocking system with a fixed time for its implementation.

Table 6 and Table 7 below are the results of teacher assignments to teach at State Senior High School 1 Depok in the 2023/2024 academic year. The school's lesson schedule format prepares the results.

Table 6. Teaching Schedule Using Hungarian Method

TIME		PHASE E / GRADE X						GRADE XI						GRADE XII					
DAY	JP	E1	E2	E3	E4	E5	E6	MIPA 1	MIPA 2	MIPA 3	MIPA 4	IPS 1	IPS 2	MIPA 1	MIPA 2	MIPA 3	MIPA 4	IPS 1	IPS 2
MONDAY	1	27	42	32	30	25	3	4	29/37	16	26	34B	35	38	23	7/10	6	40	19A
	2	28	42	32	30	25	3	4	29/37	16	26	34B	35	38	23	7/10	6	40	19A
	3	36A	31	27	3	11	6	4	29/37	16	21	35	34B	23	15	5	8	19A	24A
	BREAK																		
	4	36A	31	28	3	11	6	42	4	29/10	21	35	34B	23	15	5	8	19A	24A
	5	31	36	18	27	6	26	42	4	29/10	33	40	25	8	5	13	19B	9	24B
	BREAK																		
	6	31	36	18	28	6	26	35	4	29	33	40	25	8	5	13	19B	9	24B
	7	27	28	36	6	31	18	35	42	33	25	24B	40	34B	13	19B	23	7	17
	8	27	28	36	6	31	18	29	42	33	25	24B	40	34B	13	19B	23	7	17
TUESDAY	1	25	11	40	36	16	27	5	17	8	6	35	32B	4	13	34B	23	15	24B
	2	25	11	40	36	16	27	5	17	8	6	35	32B	4	13	34B	23	15	24B
	3	40	16	26	27	36	30	21	5	34B	9	25	20	4	7/37	23	24A	3	32B
	4	40	16	26	27	36	30	21	5	34B	9	25	20	2	4	23	24A	3	32B
	BREAK																		
	5	41	6	30	16	27	36	13	21	5	26	24B	9	2	4	20	7	40	34B
	6	41	6	30	16	27	36	13	21	5	26	24B	9	23	4	20	7	40	34B
	BREAK																		
	7							34B	25	21	20	40	24B	23	2	19B	6	9	3
	8							34B	25	21	20	40	24B	7	2	19B	6	9	3
	9			P5				23	13	26	34B	9	40	7	5	2	21	24B	20
	10							23	13	26	34B	9	40	7	5	2	21	24B	20
WEDNESDAY	1	3	27	28	11	30	41	23	35	25	15	32B	18	5	24A	4	21	38	40
	2	3	27	28	11	30	41	23	35	25	15	32B	18	5	24A	4	21	38	40
	3	6	32	3	28	41	16	35	5	15	8	18	9	13	14	4	34B	17	38
	4	6	32	3	28	41	16	35	5	15	8	18	9	13	14	7/10	34B	17	38
	BREAK																		
	5	11	30	41	18	3	28	5	21	6	14	17	34A	8	20	13	9	32B	15
	6	11	30	41	18	3	28	5	21	6	14	17	34A	8	20	13	9	32B	15
	BREAK																		
	7							21	13	5	35	34A	15	17	8	2	38	3	9
	8							21	13	5	35	34A	15	17	8	2	38	3	9
	9			P5				13	20	35	6	15	32B	2	38	8	17	14	3
	10							13	20	35	6	15	32B	2	38	8	17	14	3
THUR	1	26	29	27	25	28	11	17	35	6	4	34A	18	13	38	8	15	16	
	2	26	29	27	25	28	11	17	35	6	4	34A	18	13	38	8	15	16	7/37/10/22
	3	28	18	29	32	40	25	33	23	35	4	14	34A	15	17	38	19B	16	
	4	28	18	29	32	40	25	33	23	35	8	14	34A	15	17	38	19B	7	4
	BREAK																		
	5	32	25	16	7	18	31	36	15	17	8	20	24B	19B	23	14	38	34B	4
	6	32	25	16	7	18	31	36	15	17	29	20	24B	19B	23	14	38	34B	4

TIME		PHASE E / GRADE X						GRADE XI						GRADE XII					
DAY	JP	E1	E2	E3	E4	E5	E6	MI PA 1	MI PA 2	MI PA 3	MI PA 4	IPS 1	IPS 2	MI PA 1	MI PA 2	MIP A 3	MI PA 4	IPS 1	IPS 2
SDAY										BREAK									
	7							25	33	36	29	18	35	14	7/37	23	20	38	40
	8							25	33	36	29	18	35	14	7/37	23	20	38	40
	9				P5			29	36	26	35	32B	14	20	19 B	17	8	24A	38
	10							29	36	26	35	32B	14	20	19 B	17	8	24A	38
	1	30	27	25	40	32	7/10	33	42	21	17	29	4	38	19 B	5	16	24B	9
	2	30	28	25	40	32	45483	33	42	21	17	29	4	38	19 B	5	16	24B	9
	3	18	3	31	42	26	27	20	33	8	9	29	4	19 B	2	38	16	32B	14
FRIDAY	4	18	3	31	42	26	28	20	33	8	9	4	29/37 /10	19 B	2	38	7	32B	14
										BREAK									
	5	16	40	6	26	27	32	42	23	8	33	4	29/37 /10	24 A	34 B	15	9	20	19B
	6	16	40	6	26	28	32	42	23	8	33	4	29/37 /10	24 A	34 B	15	9	20	19B
										BREAK									
	7	29	26	11	31	7/37	40	15	34 B	20	21	9	17	5	8	24A	14	19A	32B
	8	29	26	11	31	7/37	40	15	34 B	20	21	9	17	5	8	24A	14	19A	32B

The assignment theory, particularly the Hungarian method, and NIOA can be utilized to schedule teacher assignments in various schools. If scheduling is to be implemented in other schools, adjustments to assumptions, considerations, and the modeling process will be needed. The teacher codes at a school can be adjusted according to the number of teachers and can be sorted by the subjects they teach. The teaching time codes can be adjusted based on class hours per day. Personal considerations can be related to the conditions of the teachers and students.

Table 7. Teaching Schedule Using NIOA Method

TIME		PHASE E / GRADE X						GRADE XI						GRADE XII					
DAY	JP	E1	E2	E3	E4	E5	E6	MI PA 1	MIPA 2	MI PA 3	MI PA 4	IPS 1	IPS 2	MI PA 1	MI PA 2	MI PA 3	MI PA 4	IPS 1	IPS 2
	1	27	42	32	30	25	3	4	29/37	16	26	34B	35	23	13	7/10	6	38	19A
	2	28	42	32	30	25	3	4	29/37	16	26	34B	35	23	13	7/10	6	38	19A
	3	36A	31	27	3	11	6	4	29/37	16	21	35	34B	38	8	13	9	19 A	40
										BREAK									
	4	36A	31	28	3	11	6	42	4	29/ 10	21	35	34B	38	8	13	9	19 A	40
	5	31	36	18	27	6	26	42	4	29/ 10	33	40	25	8	5	23	19 B	32B	24B
MONDAY										BREAK									
	6	31	36	18	28	6	26	35	4	29/ 10	33	40	25	8	5	23	19 B	32B	24B
	7	27	28	36	6	31	18	35	42	33	25	24B	40	34 B	15	19B	21	7	38
	8	27	28	36	6	31	18	29	42	33	25	24B	40	34 B	15	19B	21	7	38
TUES	1	25	11	40	36	16	27	5	17	8	6	35	32B	4	23	34B	38	9	14
	2	25	11	40	36	16	27	5	17	8	6	35	32B	4	23	34B	38	9	14
	3	40	16	26	27	36	30	21	5	34 B	9	25	20	4	7/37	24A	6	15	3

TIME		PHASE E / GRADE X						GRADE XI						GRADE XII					
DAY	JP	E1	E2	E3	E4	E5	E6	MIPA 1	MIPA 2	MIPA 3	MIPA 4	IPS 1	IPS 2	MIPA 1	MIPA 2	MIPA 3	MIPA 4	IPS 1	IPS 2
DAY	4	40	16	26	27	36	30	21	5	34 B	9	25	20	2	4	24A	6	15	3
										BREAK									
	5	41	6	30	16	27	36	13	21	5	26	24B	9	2	4	20	7	40	34B
	6	41	6	30	16	27	36	13	21	5	26	24B	9	23	4	20	7	40	34B
										BREAK									
	7							34 B	25	21	20	40	24B	23	13	5	9	3	32B
	8				P5			34 B	25	21	20	40	24B	7	13	5	9	3	32B
	9							23	13	26	34 B	9	40	7	5	2	21	24B	20
	10							23	13	26	34 B	9	40	7	5	2	21	24B	20
WEDNESDAY	1	3	27	28	11	30	41	23	35	25	15	32B	18	5	38	4	8	24B	17
	2	3	27	28	11	30	41	23	35	25	15	32B	18	5	38	4	8	24B	17
	3	6	32	3	28	41	16	35	5	15	8	18	9	13	20	4	34 B	17	38
	4	6	32	3	28	41	16	35	5	15	8	18	9	13	20	7/10	34 B	17	38
										BREAK									
	5	11	30	41	18	3	28	5	21	6	14	17	34A	2	8	38	20	9	32B
	6	11	30	41	18	3	28	5	21	6	14	17	34A	2	8	38	20	9	32B
										BREAK									
	7							21	13	5	35	34A	15	14	2	8	17	20	3
	8				P5			21	13	5	35	34A	15	14	2	8	17	20	3
	9							13	20	35	6	15	32B	38	17	5	14	3	9
	10							13	20	35	6	15	32B	38	17	5	14	3	9
THURSDAY	1	26	29	27	25	28	11	17	35	6	4	34A	18	13	2	8	38	16	7/37/10/22
	2	26	29	27	25	28	11	17	35	6	4	34A	18	13	2	8	38	16	
	3	28	18	29	32	40	25	33	23	35	4	14	34A	17	24A	15	19B	16	
	4	28	18	29	32	40	25	33	23	35	8	14	34A	17	24A	15	19B	7	4
										BREAK									
	5	32	25	16	7	18	31	36	15	17	8	20	24B	19 B	14	38	23	34B	4
	6	32	25	16	7	18	31	36	15	17	29	20	24B	19 B	14	38	23	34B	4
										BREAK									
	7							25	33	36	29	18	35	15	7/37	19B	8	32B	40
	8				P5			25	33	36	29	18	35	15	7/37	19B	8	32B	40
	9							29	36	26	35	32B	14	20	19 B	13	24 A	40	15
	10							29	36	26	35	32B	14	20	19 B	13	24 A	40	15
FRIDAY	1	30	27	25	40	32	7/10	33	42	21	17	29	4	8	19B	13	16	24A	9
	2	30	28	25	40	32	7/10	33	42	21	17	29	4	8	19B	13	16	24A	9
	3	18	3	31	42	26	27	20	33	8	9	29	4	19B	23	17	16	38	24A
	4	18	3	31	42	26	28	20	33	8	9	4	29/37/10	19B	23	17	7	38	24A
										BREAK									
	5	16	40	6	26	27	32	42	23	8	33	4	29/37/10	24A	34B	2	15	14	19A
	6	16	40	6	26	28	32	42	23	8	33	4	29/37/10	24A	34B	2	15	14	19A
										BREAK									
	7	29	26	11	31	7/37	40	15	34B	20	21	9	17	5	38	14	23	19A	24B
	8	29	26	11	31	7/37	40	15	34B	20	21	9	17	5	38	14	23	19A	24B

4. CONCLUSIONS

Based on the results and discussion, it can be concluded that:

a. The teaching assignment model at State Senior High School 1 Depok can be structured by assigning codes to all teachers, which will later correspond to the 'worker.' Next, codes are assigned to the days and lesson hours corresponding to the 'job'. The model-solving process is carried out sequentially, first solving the model for one class and then using the results from that class as constraints for solving the model for the next class.

b. Overall, the implementation process of the Hungarian method and New Improved Ones Assignment methods produces the same teaching assignment. The only difference lies in the part of the code in Python, which is adapted to each algorithm. Differences in results are obtained if there are two teachers who can only teach at the same lesson hour.

c. The limitation of this study is that the scheduling process can only be performed for one class at a time before proceeding to the next class. Future research can develop a teaching assignment model that enables scheduling for the entire school in parallel.

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