Patrol-Routing Management System for Prevention and Suppression Patrol in Eastern Economic Corridor

ระบบบริหารจัดการเส้นทางสายตรวจสำหรับงานป้องกันและปราบปราม ในเขตพัฒนาพิเศษภาคตะวันออก

Tuedpong Muangpan[1,*], Thanyaphat Muangpan[2] and Thitima Wonginta[3]

[1] Provincial Police Region 2, Royal Thai Police

[2,3] Faculty of Logistics, Burapha University

เทอดพงศ์ เมืองปัน[1,*], ธัญภัส เมืองปัน[2], และ ฐิติมา วงศ์อินตา[3]

[1] ตำรวจภูธรภาค 2 สำนักงานตำรวจแห่งชาติ

[2,3] คณะโลจิสติกส์ มหาวิทยาลัยบูรพา

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Abstract

This study aims to examine the current status of patrol-routing coordination and management. It analyzes and proposes management strategies for patrol routes and administrative systems. The focus is on developing and improving the efficiency of the Patrol-Routing Management System (PRMS) to enhance crime prevention and suppression efforts within Thailand's Eastern Economic Corridor (EEC). In response to the increasing demand for crime prevention, the Royal Thai Police have prioritized effectively managing patrol routes to mitigate criminal activities and improve response times. Through an in-depth analysis of patrol routes at key police stations in the EEC, specifically in Chonburi (Pattaya City Police Station), Rayong (Pae Police Station), and Chachoengsao (Mueang Chachoengsao Police Station). This study identifies improving patrol route planning, patrol time efficiency, and patrol management systems. The research applies the primary concept of the Traveling Salesman Problem (TSP) and Transport Management Systems (TMS) to develop an optimized patrol management system that enhances both patrol route and time efficiency while also increasing police visibility in high-crime areas. The findings indicate that effective patrol route planning contributes significantly to time management, resource allocation, and crime deterrence. The integration of advanced technologies facilitates dynamic and flexible routes, enabling law

* Corresponding author, email: 65810047@go.buu.ac.th

enforcement officers to access target areas more efficiently and respond promptly to emerging situations. Adapting patrol strategies to the specific characteristics of each area, supported by crime data, further improves crime control and resource utilization. Improved patrol routes not only support proactive crime prevention but also foster public confidence in law enforcement, contributing to sustainable community safety.

Keywords: motorcycle patrol routing, transportation management system, traveling salesman problem, patrol police officer, prevention and suppression patrol

บทคัดย่อ

งานวิจัยนี้มีวัตถุประสงค์เพื่อศึกษาข้อมูลปัจจุบันและวิเคราะห์การจัดการเส้นทางสายตรวจ เน้นพัฒนาและปรับปรุงระบบบริหารจัดการเส้นทางสายตรวจ(PRMS) เพื่อเสริมความสามารถในการป้องกันและปราบปรามอาชญากรรมในพื้นที่เขตพัฒนาพิเศษภาคตะวันออก(EEC) ของประเทศไทย สำนักงานตำรวจแห่งชาติให้ความสำคัญกับการบริหารเส้นทางสายตรวจอย่างมีประสิทธิภาพเพื่อลดปัญหาอาชญากรรมและพัฒนาการตอบสนองเหตุการณ์ โดยวิเคราะห์ข้อมูลและศึกษาการจัดการเส้นทางสายตรวจใน 3 จังหวัด ได้แก่ ชลบุรี (สถานีตำรวจเมืองพัทยา) ระยอง (สถานีตำรวจเพ) และฉะเชิงเทรา (สถานีตำรวจเมืองฉะเชิงเทรา) เพื่อเป็นแนวทางพัฒนาวางแผนเส้นทางสายตรวจและระบบบริหารจัดการอย่างเป็นระบบ งานวิจัยนี้นำแนวคิดปัญหาการเดินทางของพนักงานขาย(TSP) และระบบบริหารจัดการการขนส่ง(TMS) มาประยุกต์ใช้ในการพัฒนาระบบบริหารจัดการเส้นทางสายตรวจ มุ่งเพิ่มประสิทธิภาพเส้นทางและระยะเวลา รวมถึงการปรากฏตัวของเจ้าหน้าที่ตำรวจในพื้นที่ที่มีอาชญากรรมสูง ผลวิจัยชี้ว่าการวางแผนเส้นทางสายตรวจอย่างมีประสิทธิภาพส่งผลต่อการบริหารเวลา การจัดสรรทรัพยากร และการยับยั้งอาชญากรรมได้อย่างเป็นรูปธรรม การบูรณาการเทคโนโลยีทันสมัยช่วยให้การวางแผนและปรับเปลี่ยนเส้นทางดำเนินการได้รวดเร็วและยืดหยุ่น เจ้าหน้าที่เข้าถึงพื้นที่เป้าหมายได้อย่างมีประสิทธิภาพ พร้อมตอบสนองสถานการณ์เปลี่ยนแปลงได้ทันที อีกทั้งการปรับกลยุทธ์สายตรวจให้เหมาะกับลักษณะพื้นที่และใช้ข้อมูลอาชญากรรมในการวางแผนช่วยเพิ่มประสิทธิภาพควบคุมอาชญากรรมและจัดสรรทรัพยากรอย่างเหมาะสม เส้นทางที่ปรับปรุงแล้วส่งเสริมการป้องกันอาชญากรรม และสร้างความเชื่อมั่นระหว่างประชาชนกับตำรวจนำไปสู่ความปลอดภัยอย่างยั่งยืน

คำสำคัญ: เส้นทางสายตรวจรถจักรยานยนต์, ระบบบริหารจัดการการขนส่ง, ปัญหาการเดินทางของพนักงานขาย, เจ้าหน้าที่ตำรวจสายตรวจ, งานป้องกันและปราบปราม

INTRODUCTION

The world is changing rapidly across political, economic, and social dimensions. Societal shifts, such as demographic changes and continuous migration of people and labor, have significantly impacted security, crime, and disorder. These dynamics have heightened

societal and public demands for enhanced safety and security of life and property, which they expect from the state (International Organization for Migration, 2024).

To effectively overcome these challenges, the Royal Thai Police has employed a strategic management approach grounded in analyzing internal and external environments, encompassing strengths, weaknesses, opportunities, and threats (SWOT) (Royal Thai Police, 2023). As a primary agency responsible for public safety, the Royal Thai Police undertakes crime prevention and suppression as its core mission. These complemented administrative policies prioritizing public convenience and responsiveness to citizen needs.

A key and urgent policy initiative under the Royal Thai Police is to reduce public fear of crime. Crime prevention and suppression efforts focused on enhancing operational efficiency in tackling crimes that distress citizens and communities or have widespread social implications. The primary objectives are raising the standards for maintaining public order and improving crime prevention and suppression mechanisms (Royal Thai Police, 2024).

RESEARCH OBJECTIVES

1) To examine the current status of patrol-routing coordination and management for crime prevention and suppression within police stations in the Eastern Economic Corridor (EEC) of Thailand

2) To analyze and propose management strategies for patrol routes and administrative systems to enhance the effectiveness of crime prevention and suppression operations for police stations in Thailand's EEC.

SCOPE OF RESEARCH

This research develops and optimizes a patrol-routing management system (PRMS) to enhance crime prevention and suppression in Thailand's EEC, focusing on high-crime areas in three police stations: Pattaya City, Pae, and Mueang Chachoengsao. It evaluates patrol operations and proposes improved management strategies using qualitative and quantitative methods, including observations, interviews, and statistical analysis.

CONCEPTUAL FRAMEWORK

The conceptual framework of the Patrol-Routing Management System (PRMS) in the Eastern Economic Corridor (EEC) focuses on enhancing police operational efficiency and effectiveness. Utilizing advanced techniques like the Traveling Salesman Problem (TSP) and

Transportation Management Systems (TMS), it aims to optimize patrol routing, police resource management, and performance evaluation. The study examines the current status of patrol-routing coordination and management, proposes strategies for improving patrol operations, and increases police visibility in high-risk areas. The expected outcomes include improved public safety and reduced crime rates (as shown in Figure 1)

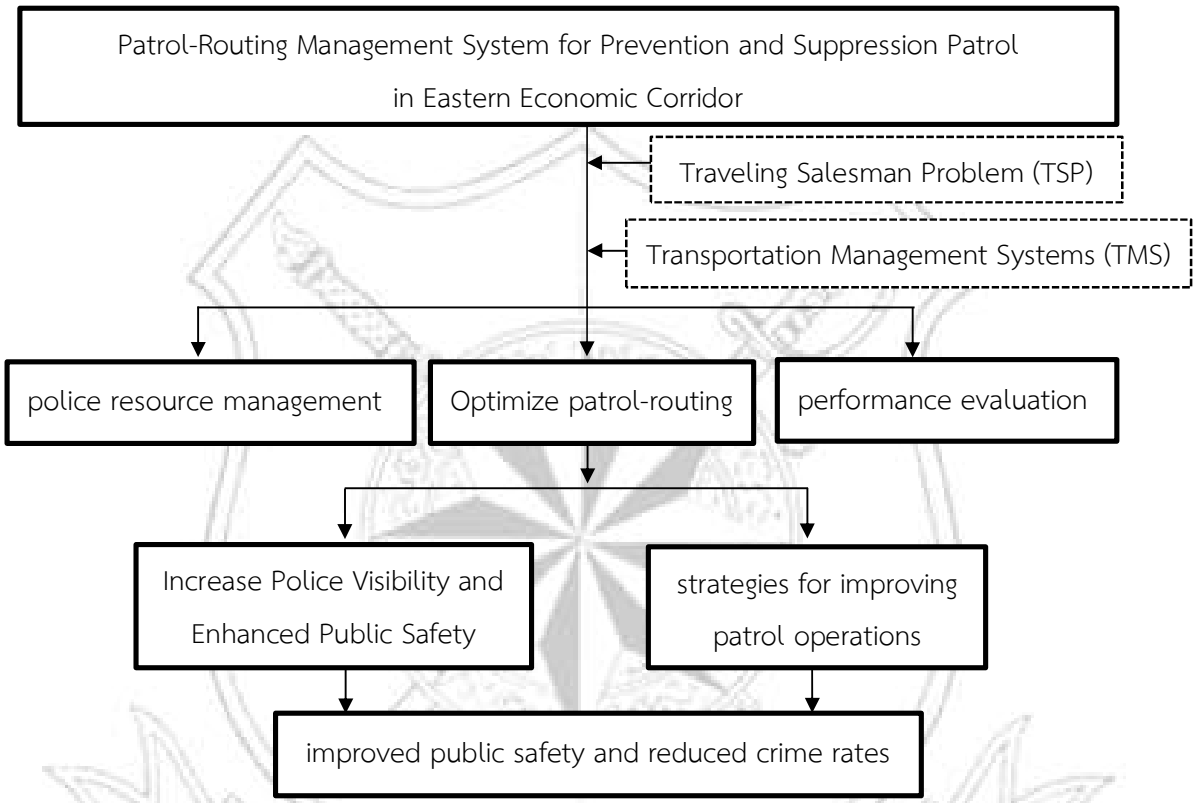

Figure 1 The conceptual framework

LITERATURE REVIEW

1) Transport Management Systems (TMS)

Transport Management Systems (TMS) are strategic tools to optimize transportation planning to achieve business goals like speed and cost-effectiveness. The Transportation Manager oversees critical processes, such as route optimization, vehicle and personnel utilization, and cost reduction. TMS software helps lower transportation costs (e.g., fuel and delivery time) and automates planning and tracking, improving operational efficiency (Kopytov, Gromov, & Abramov,2023).

Effective transportation management enhances logistics efficiency, reduces costs, and improves customer service, driving business growth. It impacts production, inventory, and customer service, requiring strategic decisions to prevent cost shifts across the supply chain.

Transportation decisions must consider their broader impact on the supply chain to avoid cost shifts that increase overall expenses.

Key elements of transportation management include network planning, route optimization, outsourcing decisions, vehicle dispatch, driver assignment, and maintenance. Efficient transportation connects procurement, production, and distribution, ensuring smooth supply chain operations. (Rodpailom, 2015).

TMS efficiency requires optimizing asset utilization by maximizing storage, reducing transportation distances, and leveraging resources effectively while aligning services with customer expectations and fostering satisfaction (Udompaijitkul, 2004).

2) Traveling Salesman Problem (TSP)

The Traveling Salesman Problem (TSP) seeks the shortest route through multiple destinations, visiting each once before returning. It optimizes time, fuel, and route management, with applications in logistics, tourism, and scheduling (Pithakasoso, 2013).

The primary objective of TSP is to identify a travel route that minimizes the total distance while ensuring that each city in a given set is visited once. Due to its complexity, TSP serves as a benchmark problem in optimization and operations research, with applications in logistics, transportation, and planning.

3) Crime Prevention and Suppression Concepts

Crime prevention and suppression involve eliminating root causes, reducing criminal intent, and minimizing opportunities. Effective strategies require cooperation between authorities, the private sector, and the public. Police play a key role in prevention, suppression, and offender management to deter crime. Approaches can be proactive (environmental/social measures) or reactive (investigation/suppression). Public collaboration is a vital component of crime prevention efforts, which can divide into two categories:

3.1 Preventive measures are classified into three types: Basic prevention and reduced crime opportunities through visible police patrols in high-risk areas, especially at night. Routine Prevention-Follows systematic guidelines for crime deterrence and continuous monitoring. Proactive Prevention-Targets high-risk individuals or groups with ongoing interventions to prevent crime before it occurs.

3.2 Suppressive Measures are divided into routine suppression (monitoring illegal arms, drug trafficking, and contraband) and proactive suppression (coordinated efforts addressing emerging crime trends and societal needs).

Theoretical Perspectives on Crime Prevention: Effective crime prevention requires a multi-theoretical approach. Key theories include: Law Enforcement Theory, Community Relations Theory, Community Policing Theory, Environmental Design Theory, Broken Windows Theory, and Community-Oriented Policing and Problem Solving (COPPS).

Effective crime prevention requires integrating theories and adapting to context. This study develops a patrol route management system for motorcycle patrols in Thailand's Eastern Economic Corridor, utilizing integrated theories to enhance safety and reduce crime.

METHODOLOGY

1) Research Design, Data Population, and Collection

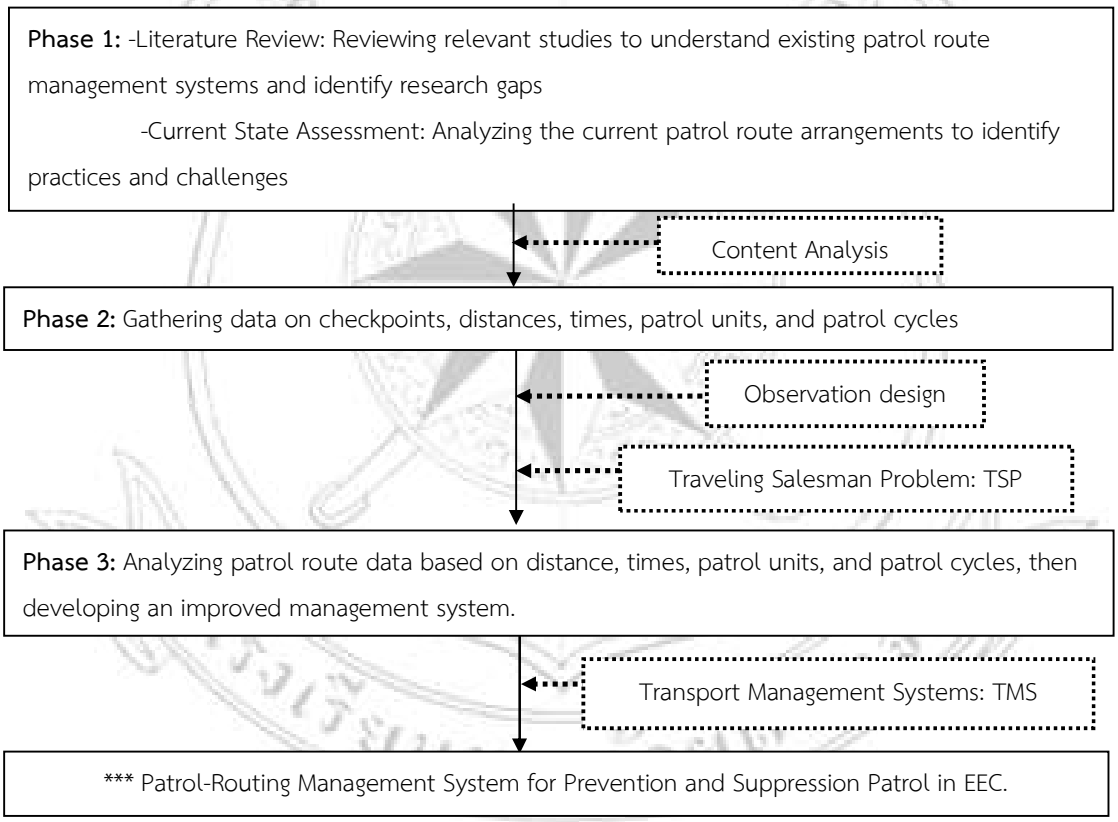

Figure 2 Research design

The research involves a Patrol-Routing Management System for Prevention and Suppression Patrol in the Eastern Economic Corridor is to study existing patrol routes and the problems encountered in their operation. The collected data is analyzed to identify the underlying structure of the problems, and this research process is used in three phases (as shown in Figure 2).

2) Data Analysis and Statistics Analysis

The first phase is qualitative analysis, examining concepts, theories, documents, and interviews to understand their structure, sequence, and scope (National Science and Technology Development Agency, 2017). This research applied the Traveling Salesman Problem (TSP) and Transport Management Systems (TMS) in the second and third phases. TSP aims to determine the optimal route that visits N cities or locations exactly once and returns to the starting point, minimizing the total distance (Pitakasos, 2013).

Statistics Analysis involves summarizing and presenting the collected data using tables, charts, graphs, and basic statistical measures (Wanitchabancha, 2008). The methods used include Frequency Distribution, which shows the frequency of data points, percentages, traveling salesman problem (TSP), and transport management systems (TMS) that are used to analyze travel paths to cover all locations with minimal distance, which impacts travel efficiency in terms of time, fuel consumption, and route management.

3) Descriptive Statistics of the Research Sample

The population included all patrol routes managed by police stations in urban areas and major tourist cities within Thailand's Eastern Economic Corridor (EEC), identified as high-crime areas. The study covered three provinces: Chonburi (Pattaya City Police Station), Rayong (Pae Police Station), and Chachoengsao (Mueang Chachoengsao Police Station)

The data collection tool was an observation form consisting of five components: checkpoints, distance, time, patrol units, and patrol cycles. This study used two data sources.

Literature reviewing studies on the current state of patrol route management in urban and the observations conducted in tourist areas to gather information on distances, time, and costs associated with patrol routes. This data is used to optimize patrol route management systems for police stations in the EEC.

The study of secondary data, including checkpoint databases, patrol units, and patrol cycles, was collected from police stations in the EEC, and the collected data was utilized to support the analysis and development of patrol route management systems for crime prevention and suppression. Content analysis and the Traveling Salesman Problem (TSP) were applied as the main analysis methods. Descriptive statistics were also employed to illustrate the characteristics of the collected data. These included the presentation of data and frequency distribution. Additionally, the TSP model was used to analyze patrol routes that must cover all designated points while minimizing the total distances. This method contributes to improved patrol efficiency, particularly in terms of time management, fuel consumption, and overall patrol route operations.

RESULTS

Patrol route information of prevention and suppression patrol

The data on checkpoint locations (red box) across three police stations revealed that Pattaya City Police Station has the highest number of checkpoints, totaling 87, followed by Mueang Chachoengsao Police Station with 73 checkpoints, and Pae Police Station with 26 checkpoints.

The patrol plan is divided into vehicle-motorcycle patrols and Police box patrols. There are three patrol formats: Format 1 consists of three shifts per day (00:01–08:00, 08:01–16:00, and 16:01–24:00), while Format 2 consists of two shifts per day (08:00–20:00 and 20:00–08:00 the following day), as part of vehicle and motorcycle patrol operations and Format 3 operates continuously for 24 hours, commencing at 08:01 and concluding at 08:00 the following day, as part of police box patrol operations.

Regarding patrol distance and duration for the three police stations, Pattaya City Police Station had the longest patrol distance, covering 42.35 km per round, with a patrol duration of 105.82 minutes per round in Zone 7. Pae Police Station's longest patrol distance was 17.73 km per round, with a duration of 81.28 minutes in Zone 1. Mueang Chachoengsao Police Station's longest patrol distance was 41.80 km per round at the Bang Phai guard post, with a patrol duration of 93.54 minutes per round in Zone 1.

The average patrol distance and duration data indicated that Pattaya City Police Station had the longest average patrol distance of 25.32 kilometers and the most extended average duration of 87.13 minutes per round, followed by Mueang Chachoengsao Police Station with 23.55 kilometers and 63.72 minutes, and Pae Police Station with 8.02 kilometers and 38.65 minutes. As shown in Table 1 Summary of Patrol Data for Police Stations below.

Analysis of patrol route management for prevention and suppression of patrol

This study aims to enhance patrol efficiency and coverage by utilizing current data and integrating the Traveling Salesman Problem (TSP) theory with a Traffic Management System (TMS) to optimize motorcycle patrol routes. Distance data between checkpoints in each patrol zone serves as the primary dataset. In the analytical process and proposed route improvements. The patrol zone is selected based on the longest route and patrol duration from each police station. The findings provide actionable insights for optimizing patrol route management and addressing the operational demands of police stations within the Eastern Economic Corridor. The details are as follows, see Table 2.

Table 1 Summary of Patrol Data for Police Stations

Police Station	Shift	Time (AM/PM)	Patrol Zone	Checkpoint (Red Box)	Distance (km)	Time (Minutes)
1. Pattaya City	1	00.01 –08.30	1	11	20.00	79.00
Police Station	2	08.01 –16.30	2	11	20.20	79.24
	3	16.01 –00.30	3	11	25.20	97.24
			4	10	19.10	79.88
			5	11	23.13	82.76
			6	11	24.05	83.86
			7	11	42.35	105.82
			8	11	28.50	89.20
			Averages		**25.32**	**87.13**
2. Pae	1	08:00 - 20:00	1	12	17.73	81.28
Police Station	2	20:00 - 08:00 (Next Day)				
	Police box	08:01 - 08:00 (Next Day)	Hin Khao police box	4	8.00	24.60
			ThaRuea Klaeng police box	5	4.91	25.89
			KohSamet police box	5	1.42	22.84

Table 1 Continues

Police Station	Shift	Time (AM/PM)	Patrol Zone	Checkpoint (Red Box)	Distance (km)	Time (Minutes)
			Averages		**8.02**	**38.65**
3.Mueang	1	00.01 –08.00	1	11	27.95	93.54
Chachoengsao	2	08.01 –16.00	2	11	19.45	73.34
Police Station	3	16.01 –00.00	3	11	22.85	82.42
			4	10	18.50	72.20
	Police box	08:01 - 08:00 (Next Day)	KhlongLuang Paeng police box	9	27.78	67.90
			NueangKhet police box	2	26.50	41.80
			WangTakian police box	5	26.30	56.56
			BangKwan police box	2	4.60	15.52
			Bang Phra police box	4	19.80	43.76
			Bang Phai police box	8	41.80	90.16
			Averages		**23.55**	**63.72**

Table 2 The distances between each checkpoint along the motorcycle patrol route in Pattaya City Police Station, Zone 7

From/To	0	1	2	3	4	5	6	7	8	9	10	11
0	0.00	6.50	1.20	8.20	2.60	5.40	6.60	4.60	5.50	5.00	7.10	6.30
1	6.50	0.00	7.00	4.20	2.30	1.20	2.10	3.20	2.20	1.80	1.90	1.60
2	1.20	7.00	0.00	7.10	5.50	6.10	6.80	4.40	5.30	4.80	6.60	6.60
3	8.20	4.20	7.10	0.00	4.70	3.30	4.10	3.90	4.60	4.10	3.90	4.20
4	2.60	2.30	5.50	4.70	0.00	2.10	1.70	1.20	0.70	0.70	2.20	1.40
5	5.40	1.20	6.10	3.30	2.10	0.00	0.70	2.70	1.60	2.20	0.70	0.90
6	6.60	2.10	6.80	4.10	1.70	0.70	0.00	2.80	1.50	2.30	0.65	0.70
7	4.60	3.20	4.40	3.90	1.20	2.70	2.80	0.00	1.00	0.50	2.50	1.80
8	5.50	2.20	5.30	4.60	0.70	1.60	1.50	1.00	0.00	0.85	2.00	1.20
9	5.00	1.80	4.80	4.10	0.70	2.20	2.30	0.50	0.85	0.00	2.10	1.50
10	7.10	1.90	6.60	3.90	2.20	0.70	0.65	2.50	2.00	2.10	0.00	1.20
11	6.30	1.60	6.60	4.20	1.40	0.90	0.70	1.80	1.20	1.50	1.20	0.00

The table 2 presents the solution to the motorcycle patrol routing problem in Zone 7 of Pattaya City Police Station, analyzed using the Traveling Salesman Problem (TSP) Framework and the Nearest Neighbour method. This approach selects the next destination based on proximity to the current location. The optimal route is 0-2-7-9-4-8-11-6-10-5-1-3, returning to 0, with a total distance of 24.35 kilometers. The total patrol time required to complete all checkpoints in one cycle is 84.22 minutes.

Table 3 The distances between checkpoints on the motorcycle patrol route of the Phe Police Station, Zone 1

From/To	0	1	2	3	4	5	6	7	8	9	10	11	12
0	0.00	1.00	2.50	3.50	1.00	0.60	0.35	0.22	0.75	2.30	3.50	4.00	0.60
1	1.00	0.00	6.30	8.10	4.80	4.30	3.60	4.00	4.50	6.00	7.30	7.80	4.30
2	2.50	6.30	0.00	7.10	2.70	3.10	4.20	3.90	3.00	2.40	1.10	1.60	3.90
3	3.50	8.10	7.10	0.00	4.40	4.00	3.20	3.60	4.10	5.70	6.90	7.40	3.50
4	1.00	4.80	2.70	4.40	0.00	0.45	1.50	1.10	0.30	1.20	2.50	3.00	1.30
4	1.00	4.80	2.70	4.40	0.00	0.45	1.50	1.10	0.30	1.20	2.50	3.00	1.30
5	0.60	4.30	3.10	4.00	0.45	0.00	1.10	0.65	0.17	1.70	2.90	3.50	0.85
6	0.35	3.60	4.20	3.20	1.50	1.10	0.00	0.60	1.10	2.60	3.90	4.40	1.00

7	0.22	4.00	3.90	3.60	1.10	0.65	0.60	0.00	0.50	2.00	3.30	3.80	0.70
8	0.75	4.50	3.00	4.10	0.30	0.17	1.10	0.50	0.00	1.60	2.80	3.30	1.00
9	2.30	6.00	2.40	5.70	1.20	1.70	2.60	2.00	1.60	0.00	1.30	1.80	4.10
10	3.50	7.30	1.10	6.90	2.50	2.90	3.90	3.30	2.80	1.30	0.00	0.50	2.80
11	4.00	7.80	1.60	7.40	3.00	3.50	4.40	3.80	3.30	1.80	0.50	0.00	2.50
12	0.60	4.30	3.90	3.50	1.30	0.85	1.00	0.70	1.00	4.10	2.80	2.50	0.00

The table 3 presents the solution to the motorcycle patrol routing problem in Zone 1 of Phe Police Station, analyzed using the Traveling Salesman Problem (TSP) Framework and the Nearest Neighbour method. This approach selects the next destination based on proximity to the current location. The optimal route is 0-8-9-11-12-1-2-3-5-10-7-4-6, returning to 0, with a total distance of 6.27 kilometers. The total patrol time required to complete all checkpoints in one cycle is 87.76 minutes.

Table 4 The distances between checkpoints on the motorcycle patrol route of the Mueang Chachoengsao Police Station, Zone 1

From/To	0	1	2	3	4	5	6	7	8	9	10	11	12
0	0.00	0.70	0.85	0.90	1.40	1.10	1.80	1.80	0.30	0.30	1.70	0.80	0.45
1	0.70	0.00	0.13	0.18	0.70	0.35	1.10	1.10	0.80	0.90	1.00	1.40	0.24
2	0.85	0.13	0.00	0.05	0.60	0.22	0.10	0.85	0.95	1.00	0.85	1.50	0.35
3	0.90	0.18	0.05	0.00	6.00	0.23	1.00	0.85	1.00	1.10	0.85	1.60	0.40
4	1.40	0.70	0.60	6.00	0.00	0.65	0.80	0.40	1.50	1.60	0.45	2.10	1.00
5	1.10	0.35	0.22	0.23	0.65	0.00	1.00	0.90	1.20	1.20	0.30	1.70	0.60
6	1.80	1.10	0.10	1.00	0.80	1.00	0.00	1.00	0.90	1.20	0.90	1.70	0.60
7	1.80	1.10	0.85	0.85	0.40	0.90	1.00	0.00	1.90	2.00	0.07	2.50	1.30
8	0.30	0.80	0.95	1.00	1.50	1.20	0.90	1.90	0.00	0.35	1.50	0.85	0.35
9	0.30	0.90	1.00	1.10	1.60	1.20	1.20	2.00	0.35	0.00	1.90	0.50	0.65
10	1.70	1.00	0.85	0.85	0.45	0.30	0.90	0.07	1.50	1.90	0.00	2.50	1.40
11	0.80	1.40	1.50	1.60	2.10	1.70	1.70	2.50	0.85	0.50	2.50	0.00	1.10
12	0.45	0.24	0.35	0.40	1.00	0.60	0.60	1.30	0.35	0.65	1.40	1.10	0.00

The table 4 presents the solution to the motorcycle patrol routing problem in Zone 1 of Mueang Chachoengsao Police Station, analyzed using the Traveling Salesman Problem (TSP) Framework and the Nearest Neighbour method. This approach selects the next destination based on proximity to the current location. The optimal route is 0-7-8-5-4-9-

10-11-2-12-6-3-1, returning to 0, with a total distance of 23.09 kilometers. The total patrol time required to complete all checkpoints in one cycle is 67.53 minutes.

The researcher analyzed and compared the distance and time of the current motorcycle patrol routes with the optimized routes developed using the TSP approach. The comparison reveals significant differences in distance and time between the two models, as summarized in Table 5

Table 5 Comparison of Distance and Time Between Current and Optimized Motorcycle Patrol Routes Based on TSP Analysis

Police Station	Distance (km)				Time (minutes)			
	current	using TSP	Difference	Percentage (%)	current	using TSP	Difference	Percentage (%)
Pattaya City Police Station	42.35	24.35	-18.00	42.50	105.82	84.22	-21.60	20.41
Phe Police Station	17.73	6.27	-11.46	64.64	81.28	67.53	-13.75	16.92
Mueang Chachoengsao Police Station	27.95	23.09	-4.86	17.39	93.54	87.76	-5.78	6.18

From the table 5 presents the results indicate the following: 1.) Pattaya City Police Station: A comparison of the patrol routes before and after optimization shows a reduction in the distance by 18 kilometers (42.50%) and a decrease in patrol time by 21.60 minutes (20.41%). 2.) Phe Police Station: The optimized patrol route demonstrates a distance reduction of 11.46 kilometers (64.64%) and a time reduction of 13.75 minutes (16.92%). And 3.) Mueang Chachoengsao Police Station: The distance was reduced by 4.86 kilometers (17.39%), and patrol time decreased by 5.78 minutes (6.18%).

Optimizing motorcycle patrol routes for the three police stations reduced the patrol times. Applying the Traveling Salesman Problem (TSP) enhanced efficiency between checkpoints, enabling shorter patrol cycles, increased frequency, and the flexibility to cover additional high-risk areas effectively.

This section analyzes patrol route management for crime prevention and suppression in the Eastern Economic Corridor (EEC) can support crime prevention and suppression concepts through the application of TSP (Transportation System Problem) and TMS (Transportation Management System). These applications can significantly impact

crime prevention and suppression by improving time efficiency, operational efficiency, and crime prevention through eliminating root causes, reducing criminal intent, and minimizing criminal opportunities. This analysis focuses on suggestions for improving crime prevention. Based on the analysis of current patrol route management systems, several suggestions are proposed to enhance effectiveness and efficiency. This section outlines key suggestions for improving patrol route management, including:

- Patrol Route Optimization: Implementing advanced algorithms, such as the Traveling Salesman
- Customized Patrol Plans: Customizing patrol plans based on each area's unique needs increases patrol frequency in high-crime areas and reallocates resources during peak crime periods to enhance deterrence and improve response times.
- Technology and Data-Driven Patrol Policing: Leveraging technologies like GPS and route management systems for real-time decision-making. This information allows for flexible resource allocation and more accurate, timely responses to emerging incidents.

Patrol-Routing Management System for prevention and suppression patrol

The Patrol-Routing Management System (PRMS) is a structured framework designed to enhance the effectiveness and efficiency of patrol operations. Unlike traditional approaches, PRMS integrates advanced methodologies, data analytics, and real-time technologies to address evolving crime prevention and suppression needs. It serves as a comprehensive tool that aligns patrol strategies with each area's unique requirements, ensuring optimal resource utilization and proactive law enforcement. PRMS consists of several key components, including:

1. Dynamic Patrol Route Optimization: Advanced algorithms, such as the Traveling Salesman Problem (TSP), minimize travel time and distance. This result ensures efficient patrol coverage of all critical checkpoints, reducing resource consumption while maximizing visibility in high-risk areas.

2. Flexible Patrol Plans: Patrol plans are customized to address specific regional needs, such as increasing patrol frequency in high-crime areas or reallocating resources during peak crime periods. This adaptability improves deterrence, response times, and resource allocation efficiency.

3. Smart Policing Technologies: Technologies like GPS and Transport Management Systems (TMS) apply to support real-time decision-making. These tools enable immediate

route adjustments, efficient resource management, and enhanced monitoring of patrol operations.

4. Operational Patrol Performance Evaluation: PRMS incorporates key performance indicators, including time efficiency, resource utilization, crime deterrence rates, and workload distribution, to continuously assess and refine patrol strategies.

5. Advancing Crime Prevention and Crime Suppression: By systematically covering high-risk areas and maintaining a strong police presence, PRMS enhances both crime prevention and suppression. Its adaptability to changing crime patterns enables proactive and responsive law enforcement, reducing crime rates and fostering public trust (as shown in Figure 3).

Key Components of PRMS

1. Dynamic Patrol Route Optimization	-Minimizes travel time and distance -Covers all critical checkpoints -Maximizes visibility in high-risk areas
2. Flexible Patrol Plans	-Adjusts to regional needs -Increases patrol frequency in high-crime areas -Reallocates resources efficiently
3. Smart Policing Technologies	-Utilizes GPS and TMS -Enables real-time decision-making -Enhances route adjustments
4. Operational Patrol Performance Evaluation	- Monitors time efficiency -Tracks resource utilization -Evaluates crime deterrence
5. Advancing Crime Prevention and Crime Suppression	-Reduces crime rates -Builds public trust -Adapts to changing crime patterns

Figure 3 Key Components of the Patrol-Routing Management System

DISCUSSION

This study underscores the critical role of optimizing patrol management systems in enhancing crime control within Thailand's Eastern Economic Corridor (EEC). The findings demonstrate that the efficient management and planning of patrol routes, along with the adaptation of TSP and TMS, significantly impact crime prevention and suppression by improving time efficiency, operational efficiency, and crime prevention. The study highlights the importance of tailoring patrol strategies to local crime trends. Areas with distinct crime profiles, such as urban centers and tourist destinations, require customized patrol plans to

address specific challenges. Utilizing data-driven adaptive policing, law enforcement can dynamically adjust patrol routes based on real-time crime patterns, ensuring a more targeted and effective response.

Furthermore, optimized patrol routing increases police visibility, enhances public safety, and improves strategies for patrol operations in high-crime areas, deterring criminal activity and fostering public trust. Strengthening this collaboration between law enforcement and the community is essential for sustainable crime reduction and long-term public safety.

CONCLUSION

This study emphasizes the critical role of an optimized patrol management system for police officers, particularly in the EEC. The findings highlight that optimizing patrol routes and integrating TSP and TMS probably significantly enhance crime prevention and suppression by improving time and operational efficiency. The PRMS incorporates advanced strategies, supporting efficient resource utilization, increasing police visibility in high-risk areas, and fostering public confidence.

Additionally, the study proposes actionable recommendations to further improve patrol efficiency, such as adopting customized strategies based on local crime trends and integrating real-time technologies like GPS and TMS. These tools enable flexible patrol routing and effective allocation of patrol resources. The study highlights the need for creative solutions in patrol management to address the dynamic requirements of modern policing and improve public safety and confidence.

RECOMMENDATIONS

This research result presents the development and optimization of a patrol-routing management system (PRMS) to enhance crime prevention and suppression operations for police stations in Thailand's Eastern Economic Corridor (EEC). The study shows optimizing motorcycle patrol routes for the three police stations reduced patrol distances and times. The recommendations for patrol management are patrol route optimization, customized patrol plans and technology, and data-driven patrol policing to improve crime prevention and suppression efficiency. However, community collaboration and engagement are important to help the police cooperate with people in the community to collect real-time crime data and build trust in police operations, which is essential for sustainable crime

reduction. Moreover, Police officer's training is advanced technologies and data-driven patrol strategies. Well-trained personnel are key to the successful implementation of the patrol system. Finally, patrol plans should improve to be regularly updated to adapt to emerging crime patterns.

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