Universiti Kebangsaan Malaysia
The National University of Malaysia

LESTARI
Universiti Kebangsaan Malaysia

MALAYSIA MADANI | TEKAD 57 IMAN ILMU AMAL | SUSTAINABLE DEVELOPMENT GOALS | 4 QUALITY EDUCATION | #130 QS World University Rankings | #7 Times Higher Education Impact Rankings

Buku Abstrak Lanjutan

KOLOKIUM SISWAZAH LESTARI

2026

Tema:

Membentuk Masa Depan: Keadilan, Daya Tahan dan Kelestarian Melangkaui 2030

"Shaping the Future: Justice, Resilience and Sustainability Beyond 2030"



IMAN • ILMU • AMAL

ISI KANDUNGAN

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KATA ALUAN | FOREWORD

Good morning to all the fellows, researchers and students,



PROF. ChM. DR. GOH CHOO TAA
FMIC FASc
Director
LESTARI UKM

The Institute for Environment and Development (LESTARI), established in 1994 at Universiti Kebangsaan Malaysia (UKM), functions as a premier multidisciplinary research institution focused on sustainable development. By bridging scientific inquiry, policy implementation, and societal needs, the institute actively addresses complex socio-economic and environmental challenges. LESTARI's research framework is fundamentally rooted in sustainability science and the advancement of the Sustainable Development Goals (SDGs), reflecting UKM's broader institutional commitment to ecological preservation and human prosperity.

The annual LESTARI Colloquium serves as a vital scholarly nexus, facilitating rigorous academic exchange among researchers and students. This platform is designed to disseminate empirical findings and foster critical dialogue on multifaceted sustainability paradigms. Beyond a conventional academic gathering, the colloquium cultivates an intellectual culture that champions inter and cross-disciplinary synthesis, integrating perspectives from the natural and social sciences, technological innovation, and public policy.

The designated theme for the 2026 LESTARI Colloquium, "Shaping the Future: Justice, Resilience, and Sustainability Beyond 2030," strategically mirrors the institute's core objectives. This theme challenges the scholarly community to collaborate in developing holistic approaches capable of mitigating contemporary sustainability crises. Through interdisciplinary integration, the colloquium seeks to inspire novel theoretical and practical insights that inform evidence-based policymaking, ultimately harmonizing human advancement with environmental conservation.

Finally, profound gratitude is extended to all participants, supervisors, evaluators, and the organizing committee for their commitment and dedication in making the 2026 LESTARI Colloquium a success. It is anticipated that this ongoing intellectual endeavour will continue to precipitate interdisciplinary partnerships and robust research networks, thereby advancing sustainable development on both national and global levels. Ultimately, these collective initiatives aim to consolidate LESTARI's prominent position in environmental governance and sustainability research across Malaysia and the broader region.

Thank you.

PRAKATA | PREFACE



DR. MINHAZ FARID AHMED
Chairman
LESTARI Colloquium 2026

LESTARI Colloquium 2026
Theme: Shaping the Future: Justice, Resilience, and Sustainability Beyond 2030

We extend our profound appreciation for the successful execution of the LESTARI Colloquium 2026, an annual academic event convened by the Institute for Environment and Development (LESTARI), Universiti Kebangsaan Malaysia. This colloquium functions to strengthen the scholarly and investigative culture among academics and postgraduate scholars, aligning intrinsically with LESTARI's strategic vision to sustain its vanguard position in sustainability science and governance at both domestic and global levels.

The colloquium serves as an essential nexus for researchers to disseminate empirical findings, exchange intellectual perspectives, and critically examine contemporary sustainability challenges through a multidisciplinary lens. Reflecting the overarching theme, " Shaping the Future: Justice, Resilience, and Sustainability Beyond 2030," the event promotes a comprehensive paradigm for conceptualizing the complex interactions among humanity, environmental systems, and developmental trajectories. This thematic focus underscores the imperative of harmonizing economic advancement, societal welfare, and ecological conservation to secure a sustainable future.

As the organizing entity, LESTARI continuously prioritizes the synthesis of knowledge and interdisciplinary synergism across its research endeavours. Consequently, the event cultivates scholarly networks among postgraduates, academic supervisors, and institutional peers, thereby reinforcing a robust and high-impact research ecosystem. Furthermore, the intellectual discourse generated during the event is anticipated to yield innovative paradigms and actionable policy directives that advance the national sustainable development framework.

In summation, profound gratitude is extended to the Director of LESTARI, the research fellows acting in evaluative and supervisory capacities, the organizing committee, and all attendees for their steadfast dedication. It is anticipated that this scholarly event will function as a catalyst for strategic institutional collaborations, further strengthening LESTARI's prominence as a premier institution dedicated to the proliferation of knowledge, innovation, and sustainable practices in Malaysia and beyond.

Thank you.

KOLOKIUM SISWAZAH LESTARI 2026

LESTARI POSTGRADUATE COLLOQUIUM 2026

21 – 22 OKTOBER 2026

21st – 22nd of OCTOBER 2026

BILIK KULIAH UTAMA LESTARI

MAIN LECTURE ROOM LESTARI

"Membentuk Masa Depan: Keadilan, Daya Tahan dan Kelestarian Melangkaui 2030"

"Shaping the Future: Justice, Resilience and Sustainability Beyond 2030"

HARI PERTAMA: 21 OKTOBER 2026 (RABU)

DAY 1 : 21st of OCTOBER 2026 (WEDNESDAY)

MASA / *TIME*		**AKTIVITI / AGENDA** *(ACTIVITY /AGENDA)*
0800 - 0830		Pendaftaran peserta & Kehadiran *Registration & Attendance*
0830 – 0845		Ucapan Aluan Pengarah LESTARI *Welcoming Remarks by the Director of LESTARI*
0845 - 0900		Taklimat Pengerusi Kolokium Siswazah LESTARI (KSL) *Briefing by the Chairman of LESTARI Graduate Colloquium 2026*
SESI 1 *SESSION 1*		**Moderator:** Dr. Aziemah Zulkifli **Penilai** / *Assessors:* 1. Prof. Dr. Muhammad Rizal Razman 2. Prof. Ts. Dr. Lee Khai Ern 3. Dr. Nor Diana Mohd Idris
P1	0900 - 0925	**Mohd. Aminur Faiz Bin Suis | P132214 | Doktor Falsafah (PhD)** *An Integrated Study of Mangrove Ecology and Coastal Community Perceptions in Sulaman Lake Forest Reserve, Sabah*
P2	0925 - 0950	**Nursyazwani Binti Aznan | P137186 | Doktor Falsafah (PhD)** Profil Keselamatan Makmal Di Institusi Pengajian Tinggi: Analisis Pengetahuan, Kesedaran, Amalan Dan Risiko Pendedahan Bahan Kimia
P3	0950 - 1015	**Guo Minjie | P137539 | Doktor Falsafah (PhD)** *Sustainability of Da Shuhua as an Intangible Cultural Heritage (ICH) in Yu County, China from a Local Memory Perspective*
P4	1015 - 1040	**Zhao Wenbo | P139464 | Doktor Falsafah (PhD)** *Visual Symbol-Based Ice and Snow Management for Sustainable Tourism in Harbin, China*
1040 – 1100		Rehat / Persediaan Sesi Dialog *Break / Dialogue Session Preparation*

SESI DIALOG BERSAMA PAKAR *DIALOGUE SESSION WITH EXPERTS* **1100 - 1230**		Moderator: Assoc. Prof. Dr. Sharina Abdul Halim Ahli panel / *Panelist:* 1. Emeritus Prof. Dato' ChM. Dr. Mazlin bin Mokhtar 2. YM Tengku Mohd Fauzi bin Tengku Abdul Hamid
1230 – 1415		Makan Tengah Hari & Rehat / Solat Zohor *Lunch Break & Zohor Prayer*
SESI 2 *SESSION 2*		**Moderator**: Prof. Madya Gs. Dr. Nuriah Abd Majid **Penilai /** *Assessors:* 1. Prof. Dr. Sarah Aziz Abdul Ghani Aziz 2. Prof. ChM. Dr. Tan Ling Ling 3. Gs. Dr. Nurfashareena Muhamad
P5	1415 - 1440	**Marhaini Binti Mat | P145884 | Doktor Falsafah (PhD)** Governans Kelestarian Bagi Pengurusan Kewangan Iklim di Negeri Selangor
P6	1440 - 1505	**Cui Sixun | P118443 | Doktor Falsafah (PhD)** *Evaluating Multi-Dimensional Rural Sustainability: A Livelihood-Oriented Indicator System for Anhui's Tea-Producing Villages*
P7	1505 - 1530	**Saiful Irwan Bin Rafar | P141360 | Doktor Falsafah (PhD)** *A Strategic ESG Integration Framework for Malaysia's Infrastructure Sector: Bridging Regulatory Standards, Industry Practices and Global Benchmarks*
P8	1530 - 1555	**Mohamad Farid Zaini | P145195 | Doktor Falsafah (PhD)** *Characterising UNESCO Global Geoparks In Indonesia: Identifying Structural Gaps and Governance Concerns*
1555 – 1630		Minum Petang & Bersurai *Refreshment & End of day 1*

HARI KEDUA: 22 OKTOBER 2026 (KHAMIS)
DAY 2: 22nd of OCTOBER 2026 (THURSDAY)

MASA */ TIME*		**AKTIVITI / AGENDA** *(ACTIVITY /AGENDA)*
0830 – 0900		Pendaftaran *Registration*
SESI 3 *SESSION 3*		**Moderator:** Dr. Mir Sujaul Islam **Penilai /** *Assessors:* 1. Prof. Dr. Joy Jacqueline Pereira 2. Prof. Dr. Ahmad Fariz Mohamed 3. Gs. Dr. Aida Soraya Shamsuddin
P9	0900 - 0925	**Nur Asmiza Binti Baharin | P159338 | Sarjana** ***/ Master*** Filem Polidopamina Tercetak Permukaan Untuk Pengecaman Elektrokimia Tanpa Label Gelatin Khinzir Bagi Pengesahan Halal
P10	0925 - 0950	**Mohamad Shardi Amin Bin Hapizi | P158339 | Sarjana** ***/ Master*** Persepsi Pengguna Terhadap Impak Sosial dan Ekonomi Perkhidmatan MRT Laluan Kajang, Lembah Klang
P11	0950 - 1015	**Abd. Rahim Bin Abd. Aziz | P154585 | Sarjana** ***/ Master*** Pengenalpastian Elemen Khusus Kesiapsiagaan Polis Diraja Malaysia dalam Menangani Ancaman Banjir Puing di Bentong, Pahang.
P12	1015 - 1040	**Mohamad Nazir Bin Ramlan | P149785 | Sarjana** ***/ Master*** Penilaian Pelaksanaan Governans Baik Dalam Proses Penilaian Impak Alam Sekitar *(EIA)* Di Malaysia Berdasarkan Lapan Prinsip *UNESCAP*
1040 – 1100		Rehat / Minum Pagi *Break / Refreshment*
SESI 4 *SESSION 4*		**Moderator:** Prof. Dr Nor Zalina Harun **Penilai** / Assessors: 1. Prof. ChM. Dr. Goh Choo Ta 2. Prof. Madya Dr. Saiful Arif Abdullah 3. Ts. Dr. Lim Chen Kim
P13	1100 - 1125	**Norazmin Adibah Binti Othman | P145991 | Doktor Falsafah (PhD)** Pertanian Bandar Sebagai Alat Intervensi Sosio-Spatial Dalam Membentuk Komuniti Bandar Berdaya Huni: Kajian Kes Penduduk Kuala Lumpur
P14	1125 - 1150	**Xu Ruiyin | P146846 | Doktor Falsafah (PhD)** *Bridging the Gap in Tea Culture: An Education-Based Study of Traditional and New-Style Tea in Hangzhou, China*
P15	1150 - 1215	**Nurakmar Hakim Bin Jasni | P152985 | Doktor Falsafah (PhD)** Pendekatan Geospasial dalam Integrasi Kerentanan Fizikal dan Sosial untuk Penilaian Risiko Tanah Runtuh di Lembangan Sungai Langat, Malaysia

P16	1215 - 1240	**Jeremy Jason Chin Chwan Chuong | P151497 | Doktor Falsafah (PhD)** *Label-Free Molecularly Imprinted Polydopamine Electrochemical Sensor for Non-Invasive Igf-1 Detection: Advancing Anti-Doping Screening Strategy*
1240 – 1340		**Sesi Perbincangan Persatuan Siswazah LESTARI** *LESTARI Graduate Association Discussion Session*
1340 – 1430		Makan Tengah Hari & Rehat / Solat Zohor *Lunch Break & Zohor Prayer*
1430 – 1600		**Majlis Penutup Kolokium Siswazah LESTARI 2026** *Closing Ceremony of LESTARI Graduate Colloquium* ● Rumusan Pelajar | *Summary from LESTARI Graduate Association Discussion Session* ● Rumusan Pengerusi KSL | *Concluding Summary by The Colloquium Chairman* ● Penyampaian Hadiah | Award Presentation ● Ucapan Penutup & Sesi Fotografi | *Closing Remarks & Photo Session*
1600		Minum Petang & Bersurai *Refreshment & Dismissal*

AN INTEGRATED STUDY OF MANGROVE ECOLOGY AND COASTAL COMMUNITY PERCEPTIONS IN SULAMAN LAKE FOREST RESERVE, SABAH

Mohd. Aminur Faiz bin Suis | P132214 | Doctor of Philosophy

Main supervisor: Associate Professor Dr. Ahmad Aldrie Amir (UKM)
Co-supervisors: Associate Professor Dr. Sharina Abdul Halim (UKM) and
Associate Professor Dr. Behara Satyanarayana (UMT)

1. INTRODUCTION

Mangrove forests are social-ecological systems in which ecological processes, human use, local livelihoods and governance interact across multiple scales (Zimmer et al. 2022). Studies on that system provide an integrated approach for understanding the linked dynamics between ecosystems and the human communities that depend on them (Folke 2006). All human activities are included under the social component, whilst the biosphere and its related natural processes are referred to as the ecological component. For any conservation initiative to be successful, the integration of multiple scales and knowledge types is necessary (Chaplin-Kramer et al. 2022).

The success of mangrove conservation projects depends on several factors, including stable financing, coastal community participation and adequate ecological knowledge (Damastuti et al. 2022; Ramli et al. 2023). Community-based forestry remains the best practice with the highest contribution to the expansion of mangrove cover, worldwide (Hagger et al. 2022). Inadequate knowledge prior to the formulation of conservation strategies on the other hand, has led to failed mangrove restoration projects in many countries (Kodikara et al. 2017). Since mangrove forests are closely linked to human populations, conservation measures should be designed with communities and other stakeholders (Zimmer et al. 2022). This clearly indicates that mangrove conservation should not be planned in isolation as it limits cooperation amongst relevant stakeholders.

Sulaman Lake Forest Reserve (SLFR) is a 2,555 ha Class V Mangrove Reserve in Tuaran, Sabah. Surrounded by coastal communities and growing development pressures, it provides an important setting for studying both ecological change and community perspectives on mangrove conservation.

2. PROBLEM STATEMENT AND LITERATURE REVIEW

SLFR currently does not have a comprehensive mangrove conservation plan that reflects its ecological condition and local community context. Such a plan should consider both ecological and social factors. However, limited information on the mangrove ecosystem and nearby communities has made this difficult. Therefore, this research project aims to support relevant stakeholders by combining ecological data with coastal community perceptions in SLFR.

Not much is known about how mangrove vegetation in Sabah has changed over time. Between 2018 and 2023, Sabah Forestry Department (SFD) established 22 permanent sample plots to study vegetation dynamics in Sandakan and Lahad Datu (SFD 2023; Tangah et al. 2018). Given Sabah's extensive mangrove cover, the existing permanent-plot network remains limited for monitoring vegetation dynamics at the state level.

In the context of environmental conservation, perception refers to the way an individual observes, understands, interprets, and evaluates a particular issue (Bennett 2016). Human behaviour can be directly shaped by perception, and indirectly influenced through several socioeconomic variables (Afonso et al. 2022). Understanding coastal communities' perceptions of mangrove threats is important because these perceptions can influence the success of conservation programmes (Owuor et al. 2019). However, there is a major knowledge gap regarding coastal communities' perceptions of mangrove ecosystem threats in Sabah.

An integrated and transdisciplinary research project enables a more nuanced understanding of how mangrove ecological conditions influence coastal community perceptions and how, in turn, these perceptions shape human behaviours and management outcomes. This project is consistent with the Sabah Mangrove Action Plan 2024-2033 (SFD 2024) and the National Policy on Biological Diversity 2022-2030 (Ministry of Natural Resources and Environmental Sustainability 2022), which emphasize holistic management and community participation in biodiversity conservation.

3. OBJECTIVES

The main objectives of this research project are: (1) To analyse the stand structure, species composition, tree biomass, and vegetation dynamics across the seaward, intermediate, and landward zones; (2) To understand the perceptions of coastal communities regarding threats to the mangrove ecosystem; and (3) To propose evidence-based conservation measures for the sustainable management of SLFR, tailored to the current mangrove ecological conditions and community perspectives. Together, these objectives link mangrove changes with community views to guide conservation measures that address both ecological and local concerns.

4. METHODOLOGY

To address the first objective, 27 permanent plots were established across the SLFR ecological zones, re-inventoried after 12 months, and subjected to standard statistical analysis. The zones were distinguished by their distance from the coast, mangrove species composition, and stand structure. For the second objective, 30 in-depth interviews were conducted to understand coastal communities' perceptions of threats to the mangrove forests. Data collection continued until thematic saturation was reached, and the interview data were analysed thematically. For the third objective, the ecological findings and community perspectives were integrated through Strengths, Weaknesses, Opportunities, and Threats (SWOT) and Threats, Opportunities, Weaknesses, and Strengths (TOWS) analyses, supported by focus group discussions and expert consultations, to develop evidence-based conservation measures.

5. RESULTS AND DISCUSSION

A total of 12 tree species were enumerated. This figure underestimates total floristic richness because non-woody species were excluded from the present inventory. Suis et al. (2025) also reported that the westernmost part of SLFR is home to at least 25 mangrove species. The seaward zone was dominated by smaller Ceriops tagal, while Rhizophora apiculata predominated in the intermediate and landward zones. The mean tree diameter was highest in the landward zone, followed by the intermediate, then seaward zones. These zones also exhibited differences in other ecological attributes such as structural, diversity, biomass, and carbon variables.

The statistical analyses provide quantitative support for clear zonal differentiation within SLFR. The Kruskal–Wallis tests showed significant differences among ecological zones for most measured structural, diversity, biomass, and carbon variables. The strongest contrast was generally observed between the seaward and landward zones, suggesting that mangrove forest characteristics change markedly along the seaward–landward gradient. The paired 2025–2026 census comparisons further indicate that short-term vegetation dynamics were not uniform across zones (Figure 1). The higher stem loss in the seaward zone may be linked to natural and human pressures, although these were not directly measured.

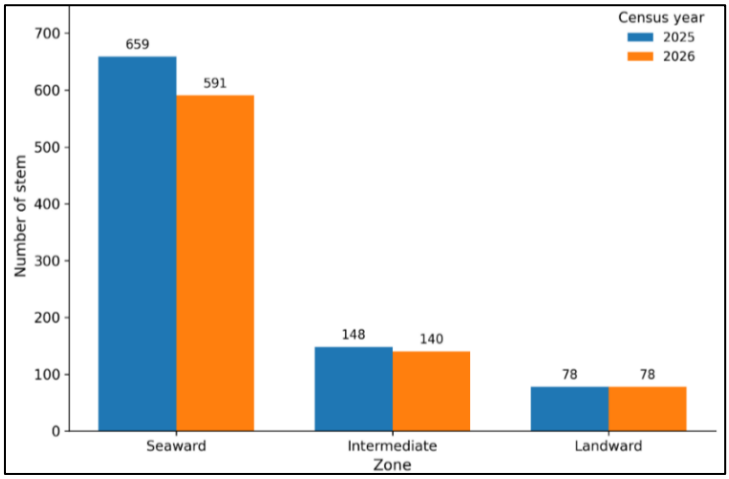


Figure 1: Stem abundance before and after the 12-month re-census.

Four overarching themes were developed: (1) perceptions of the ecological importance and benefits of mangroves, (2) perceptions of natural threats to the mangrove ecosystem, (3) perceptions of anthropogenic threats to the mangrove ecosystem, and (4) awareness gaps and misperceptions. Under the first theme, this study revealed a high level of awareness among respondents regarding the ecosystem services provided by the mangrove forests in SLFR. Awareness of ecosystem services also shaped how coastal communities interpreted both natural and anthropogenic threats. When communities fail to recognise the full range of benefits derived from mangrove ecosystem services, they are more likely to misperceive or underestimate threats to these intertidal forests. These misperceptions can make local conservation more difficult by reducing community support and participation, and by creating a gap between management priorities and the threats that local people consider important.

A total of 11 TOWS strategic outputs were generated through the integration of the four SWOT components. Overall, the proposed conservation measures were classified into three temporal categories: short-term (within two years), mid-term (three to five years), and long-term (beyond five years). In addition, this study spatially refined the 11 conservation measures to ensure that each measure can be implemented according to the ecological realities of the seaward, intermediate, and landward zones.

6. CONCLUSION

This project demonstrates that mangrove ecosystems in SLFR exhibit clear and significant variation in stand structure, species composition, and vegetation dynamics across the three ecological zones. From a social perspective, coastal communities possess strong awareness of

mangrove ecosystem services, yet their perceptions of threats varied across different socioeconomic contexts.

Future research should incorporate quantitative approaches to examine the relationship between ecological conditions and community perceptions more rigorously. Expanding the study to multiple sites would also allow for comparison across different social-ecological contexts. In addition, policymakers should adopt integrated conservation measures that consider both ecological conditions and community perspectives. This integrated study provides site-specific evidence to guide zone-based ecological monitoring, targeted community engagement and conservation planning in SLFR.

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PROFIL KESELAMATAN MAKMAL DI INSTITUSI PENGAJIAN TINGGI: ANALISIS PENGETAHUAN, KESEDARAN, AMALAN DAN RISIKO PENDEDAHAN BAHAN KIMIA

Nursyazwani Binti Aznan | P137186 | Doktor Falsafah

Penyelia utama: Prof. ChM. Dr. Goh Choo Ta
Penyelia bersama: Ts. Dr. Murnira Binti Othman dan Dr. Norafneeza Binti Norazahar

1. PENGENALAN

Makmal di institusi pengajian tinggi sering diangkat sebagai pusat pemacu inovasi dan intelek, namun di sebalik fungsi dinamik ini, ia merupakan tempat yang berisiko dan terdedah kepada pelbagai bahaya serta kemalangan berpotensi yang mengancam nyawa. Kajian yang dijalankan oleh (Bai et al. 2022) menunjukkan bahawa kelemahan dalam pengurusan bahan kimia merupakan punca utama insiden di makmal. Justeru, pengurusan keselamatan makmal yang berkesan hendaklah dibangunkan berteraskan kawalan serta tadbir urus bahan kimia berbahaya yang sistematik dan menyeluruh.

Di Malaysia, kerangka utama perundangan bagi pengurusan bahan kimia di tempat kerja adalah Peraturan-peraturan Keselamatan dan Kesihatan Pekerjaan (Penggunaan dan Standard Pendedahan Bahan Kimia Berbahaya kepada Kesihatan) 2000 (Peraturan USECHH 2000) (Yon 2022), yang mana mewajibkan perlaksanaan pentaksiran risiko kesihatan bahan kimia (CHRA) (Abdullah et al. 2023), namun tumpuannya lebih kepada risiko kesihatan akibat pendedahan kepada bahan kimia (DOSH 2018). Dari segi kawalan risiko kebakaran pula banyak merujuk kepada Undang-undang Kecil Bangunan Seragam 1984 (UBBL 1984) dan Akta Perkhidmatan Bomba 1988 (Akta 341) (Salleh et al. 2023), tetapi ianya tidak menilai secara terperinci hazad fizikal bahan kimia seperti letupan, mudah terbakar, swareaktif dan piroforik. Untuk melihat lebih teliti kepada hazad fizikal bahan kimia, kajian ini mencadangkan agar perlaksanaan pentaksiran risiko hazad fizikal bahan kimia dilaksanakan di makmal.

Justeru, kajian ini bertujuan untuk menilai profil keselamatan makmal melalui aspek pengetahuan, kesedaran, amalan, risiko pendedahan dan hazad fizikal bahan kimia serta membangunkan kerangka sistem penarafan pengurusan keselamatan makmal yang holistik.

2. PERMASALAHAN KAJIAN DAN SOROTON KAJIAN

Kegagalan majikan mematuhi keperluan perlaksanaan CHRA boleh menyebabkan tindakan penguatkuasaan, seperti penutupan operasi makmal. Situasi ini pernah berlaku di Pusat Penyelidikan Institut Ibnu Sina, Universiti Teknologi Malaysia (UTM) apabila Jabatan Keselamatan dan Kesihatan Pekerjaan (JKKP) Negeri Johor mengarahkan penutupan sementara makmal tersebut berikutan kegagalan menyediakan sistem kawalan kerja yang mencukupi, termasuk penilaian risiko kesihatan bahan kimia, sistem pengudaraan yang sesuai serta pemantauan penggunaan dan kawalan bahan kimia (Yusof 2019). Susulan tindakan penguatkuasaan tersebut, UTM telah melaksanakan CHRA secara menyeluruh pada tahun 2023 melibatkan 204 buah makmal dan stor bahan kimia. Walaubagaimanapun, pematuhan terhadap keperluan CHRA didapati masih belum mampu menghalang berlakunya insiden yang berpotensi mengganggu operasi makmal. Sebagai contoh, pada tahun 2024, Jabatan Bomba

dan Penyelamat Malaysia (JBPM) telah menjalankan operasi peneutralan dan pelupusan sebanyak 4.6 kg asid pikrik di UTM, iaitu sejenis bahan kimia yang diklasifikasikan sebagai bahan letupan Divisyen 1.1, kerana berpotensi menyebabkan letupan sekiranya tidak dikendalikan dengan betul (JBPM 2024).

Insiden ini jelas menunjukkan bahawa perlaksanaan CHRA sahaja tidak memadai kerana tumpuannya kepada risiko kesihatan idividu (DOSH 2018), tidak merangkumi risiko fizikal dan kerosakan aset akibat kebakaran atau letupan bahan kimia. Justeru, pendekatan yang lebih menyeluruh diperlukan dengan mengintegrasikan pelbagai dimensi risiko bagi membentuk profil keselamatan makmal yang seterusnya dapat menyokong pembangunan sistem penarafan pengurusan keselamatan makmal yang lebih komprehensif.

3. OBJEKTIF KAJIAN

Kajian ini mempunyai empat objektif, iaitu (i) untuk menilai tahap pengetahuan, kesedaran, dan amalan (KAP) staf berkaitan pengurusan keselamatan di makmal, (ii) menilai tahap risiko pendedahan pekerjaan terhadap bahan kimia kepada staf makmal, (iii) menilai risiko hazad fizikal bahan kimia di makmal menggunakan borang penilaian risiko api bahan kimia, dan (iv) membina kerangka sistem penarafan pengurusan keselamatan makmal di institusi pengajian tinggi. Namun hanya objektif (i) dan (ii) dibentangkan dalam kolokium kali ini.

4. KAEDAH KAJIAN

Kajian ini menggunakan pendekatan kuantitatif yang melibatkan dua komponen utama, iaitu edaran soal selidik KAP, serta pemantauan pendedahan bahan kimia.

Bagi objektif satu, soal selidik telah diedarkan secara keratan rentas selama enam bulan kepada 350 orang staf makmal skim C (Pegawai Sains, Penolong Pegawai Sains, dan Pembantu Makmal) dan skim J (Jurutera dan Penolong Jurutera) di UTM. Sebanyak 186 respons diterima, namun hanya 156 responden yang menggunakan bahan kimia dalam tugasan harian dipilih untuk analisis. Instrumen kajian terdiri daripada empat bahagian iaitu maklumat demografi, pengetahuan, kesedaran dan amalan berkaitan pengurusan keselamatan makmal. Data dianalisis menggunakan perisian Pakej Statistik untuk Sains Sosial (SPSS) melalui analisis deskriptif, ujian t-bebas, analisis varians (ANOVA), ujian t-sample berpasangan, korelasi Pearson serta regresi linear berganda.

Untuk objektif kedua, pemantauan pendedahan bahan kimia dijalankan dengan merujuk kepada Kaedah Analisis Manual NIOSH (NMAM) 1501 bagi bahan kimia heksana, dan NMAM 1501 bagi toluena. Sampel dianalisis menggunakan alat kromatografi gas - pengesan pengionan nyala (GC-FID). Hasil keputusan makmal kemudian digunakan untuk mengira Purata Wajaran Masa Lapan Jam (8 jam TWA), dan dibandingkan dengan had pendedahan yang dibenarkan (PEL) dalam Peraturan USECHH 2000. Penilaian tahap risiko bahan kimia tersebut ditentukan secara kuantitatif berpandukan manual CHRA.

5. KEPUTUSAN DAN PERBINCANGAN

Analisis deskriptif menunjukkan jurang yang ketara antara aspek kognitif dan tingkah laku responden, iaitu hanya 25% responden mempunyai tahap pengetahuan tinggi mengenai keselamatan bahan kimia, berbanding kesedaran (73.08%) dan amalan keselamatan (78.21%) yang tinggi. Ujian-t bebas dan ANOVA mengesahkan bahawa faktor demografi tidak menunjukkan perbezaan signifikan ($p>0.05$) terhadap tahap KAP.

Seterusnya, ujian-t sampel berpasangan mendedahkan bahawa skor pengetahuan terhadap bahaya fizikal adalah signifikan dan lebih tinggi ($p < 0.001$, $\mu = 3.49$) berbanding bahaya kesihatan. Namun, didapati bahawa tahap kesedaran dan amalan adalah seimbang bagi kedua-dua kategori. Analisis korelasi Pearson pula menunjukkan bahawa hubungan antara pengetahuan dan kesedaran adalah lemah ($r = 177$, $p = 0.027$), manakala hubungan antara pengetahuan dan amalan adalah tidak signifikan. Sebaliknya, wujud hubungan yang kuat dan signifikan ($r = 0.587$, $p < 0.001$) antara kesedaran dan amalan, yang menandakan bahawa peningkatan pengetahuan teori semata-mata tidak menjamin pembentukan amalan kerja yang selamat.

Dapatan ini diperkukuhkan lagi oleh analisis regresi linear berganda di mana gabungan pengetahuan dan kesedaran hanya menyumbang sebanyak 34.1% variasi terhadap amalan keselamatan makmal ($R2 = 0.341$), dengan kesedaran bertindak sebagai satu-satunya peramal yang signifikan. Implikasi keputusan ini menunjukkan bahawa sebahagian besar amalan keselamatan (65.9%) ditentukan oleh faktor-faktor kontekstual dan sistemik yang lain.

Bagi aspek pemantauan pendedahan bahan kimia, analisis kuantitatif menunjukkan semua bacaan 8 jam TWA bagi heksana dan toluena adalah jauh lebih rendah daripada PEL. Selaras dengan itu, kesemua enam lokasi persampelan mencatatkan Penarafan Pendedahan (ER) yang rendah, sekali gus menghasilkan Penarafan Risiko (RR) pada tahap rendah berdasarkan kaedah penilaian kuantitatif CHRA. Dapatan ini selari dengan tahap amalan keselamatan kakitangan makmal yang tinggi (78.21%) serta kesedaran yang kuat (73.08%) seperti yang dikenal pasti dalam analisis deskriptif soal selidik terdahulu.

6. KESIMPULAN

Secara keseluruhannya, kajian ini menunjukkan bahawa staf makmal mempunyai tahap kesedaran dan amalan keselamatan yang tinggi, namun masih terdapat jurang dalam pengetahuan berkaitan bahaya bahan kimia. Kesedaran didapati mempunyai hubungan yang kuat dengan amalan keselamatan, manakala pengetahuan sahaja tidak menunjukkan hubungan yang signifikan dengan amalan. Penilaian pendedahan pula menunjukkan risiko pekerjaan terhadap heksana dan toluena berada pada tahap rendah di semua lokasi persampelan. Dapatan ini menunjukkan bahawa pengurusan keselamatan makmal yang berkesan memerlukan penilaian yang melangkaui aspek tingkah laku dan pendedahan kesihatan, dengan turut mengambil kira risiko fizikal bahan kimia bagi menyokong pembangunan kerangka sistem penarafan yang lebih holistik.

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SUSTAINABILITY OF DA SHUHUA AS AN INTANGIBLE CULTURAL HERITAGE (ICH) IN YU COUNTY, CHINA, FROM A LOCAL MEMORY PERSPECTIVE

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1. INTRODUCTION

Target 11.4 of the Sustainable Development Goals (SDGs) asks states to treat cultural heritage as part of sustainable development. In practice, however, heritage governance has come to equate protection with being seen. China's ICH system has followed that logic — national inventories, accredited bearers, tourism tie-ins (Waterton et al., 2010). The problem is what this equation leaves behind. Ethnographic and policy work shows inscription repeatedly pulls rituals out of their home sites, flattens their calendars, and converts them into state-run spectacles rather than community ones (Vecco et al., 2010; Gentry et al., 2019). The shape still survives, but the memory behind it does not.

Therefore, the study needs a case whose memory is unusually tied to place and time — a ritual that can't be moved without losing what it carries. This is the case with Da Shuhua, which is why it anchors the study. In Yu County, China, blacksmiths previously flung molten iron at the city wall during the Spring Festival. The sparks are the point, but they also belong to a cosmology of warding off evil tied to the night that cannot simply be changed. A ritual so bound to where and when it happens should be the hardest test of the visibility-as-vitality swap the global framework assumes. But Da Shuhua listed in 2021 has been turned into year-round commercial shows. The spectacle stays but the workshops, the seasonal rhythm, and the local viewers who once held it together have fallen away (Gentry et al., 2019; Xie et al., 2018).

So far, no framework has explained this exact kind of break. Built on local memory theory (Nora, 1989; Assmann, 2011), the study proposes a four-dimensional model of memory discontinuity and asks how Da Shuhua might be carried forward as a living memory rather than a staged one.

2. PROBLEM STATEMENT

The conservation crisis in Da Shuhua comes down to three failures that feed each other. First, embodied transmission has collapsed. The craft is learned only under molten iron at about 1,649°C, so once the timing is missed, the apprentice is burned. If losing a season the workshop is ruined. Yet no apprenticeship system survives to take on that risk (Ingold, 2000; Ma & Liu, 2020). Second, the ritual's meaning has hollowed out. Crowds still come, but the cosmology the practice ever carried has dissolved into tourist itineraries and repeated performances, leaving a form with no belief attached (Nora, 1989; Yuan & Gu, 2019). Third, the generations have come apart. Elders treat the ritual as something to pass on, while younger people consider it as a show (Hafstein, 2004; Yuan & Gu, 2019). Listing raised the custom's profile while

quietly moving control of scheduling and meaning away from the people who sustained it, which is what Yuan et al. (2019) call the decoupling of form and function.

These failures point to one blind spot in how heritage is judged. The 2003 UNESCO Convention (UNESCO, 2003) and its periodic reporting (UNESCO, 2018) measure value by visibility, listing, and bearers not by the mnemonic infrastructure (sites, seasons, kinship, apprenticeship) that actually keeps a practice alive. Da Shuhua is listed, yet its transmission keeps collapsing. Local memory theory (Nora, 1989; Assmann, 2011) helps here because it reads transmission, meaning, and generation as one memory system rather than separate problems. With SDG 11.4 (United Nations, 2015), the study asks how Da Shuhua's memory is held across generations and what socio-material conditions drive its transmission breakdown — corresponding to RO1 and RO2 — and offers a diagnostic, not applied, framework for reading the break.

3. OBJECTIVE

The overall aim of the study is to explore the sustainability of Da Shuhua as an ICH from the perspective of Local Memory and in conjunction with SDG 11.4. This study proposes two core research objectives for this colloquium.

> **RO1**: To explore the symbolic, emotional, and discursive constructions of Da Shuhua as a vessel of local memory, with attention to generational variation in cultural perception, affective resonance, and identity attachment.
>
> **RO2**: To investigate the socio-material mechanisms that undermine the embodied transmission of Da Shuhua, focusing on physical vulnerability, demographic shifts, and disrupted ritual learning processes.

4. METHOD

The study takes a single embedded case study design (Yin, 2018) and works within a convergent parallel mixed-methods framework (Creswell & Plano Clark, 2011): the qualitative and quantitative strands run independently and meet at the interpretation stage where qualitative themes supply the dimensions and quantitative indicators populate the cells of a Memory Discontinuity Matrix. Each strand checks the other.

RO1 – Mapping intergenerational memory. Stratified purposive sampling covers five community-based stakeholder categories and three age cohorts (18–29, 30–54, 55+), yielding a 72–114 sample based on Guest et al.'s (2006) saturation rule across the 15 stratum cells. Recruitment stops at saturation — three consecutive interviews with no new code. Each interview is scored on a 5-point memory-attribution index (recall, transmission intent, ritual meaning) and coded in NVivo 12 Plus (Braun & Clarke, 2006) under Local Memory theory. Cohort means are compared by one-way ANOVA to anchor the qualitative gradient rather than stand in for it.

RO2 – Diagnosing structural and institutional drivers. The twelve experts were selected by purposive criterion sampling — 4 cultural officials, 5 scholars, and 3 organisers — drawn from the Yu County ICH Office roster and extended by snowball, each screened for direct involvement in the 2021 listing or its post-listing governance. Their interviews are content-analysed (Hsieh & Shannon, 2005) against annual SPSS trends of four indicators drawn from the ICH Office records and the county yearbook (2015–2025): ICH funding, tourism revenue,

commercial performance, bearer count. Both strands converge into a Memory Discontinuity Matrix, where the qualitative themes give the dimensions and the indicator trends give the cell-level evidence.

Reliability and validity. Credibility rests on saturation and a second-round member check. Dependability is based on inter-coder agreement targeted at $\kappa \geq 0.80$ with an NVivo audit trail. And transferability is on thick description of Yu County. The one-way ANOVA on the memory-attribution index gives the quantitative triangulation of the cohort gradient, while the expert and indicator strands triangulate the structural reading. Ethics approval and informed consent were obtained before fieldwork.

5. RESULTS AND DISCUSSION

As laid out above, the two strands meet in this section: interview themes are read next to the cohort means and the policy-indicator trends, and a finding only counts when both sides agree.

RO1 – Intergenerational perceptions. Three patterns came through the age cohorts. Elders (55+) placed Da Shuhua inside a full cosmological order in the lunar calendar, the city wall as a boundary, hereditary smithing, and fire as purification. That's what Assmann (2011) calls culturally encoded, temporally anchored memory. Middle-aged participants (30–54) felt something was missing but could not say what. Youth (18–29) met the custom on short-video apps as a local show, not a seasonal rite. The T-test on the memory attribution index produced the following results: means dropped from 4.31 (elders) to 3.02 (middle-aged) to 1.84 (youth), $F(2, 95) = 58.7$, $p < .001$, $\eta^2 = .55$. The interview gradient and the statistical gradient tell the same story, and the gap marks the middle-aged cohort as the last real bridge to living memory.

RO2 – Interruption of transmission. Five disruptors showed up where the expert accounts and the policy records overlapped. (1) Performance frequency: annual shows ran up tenfold from about 30 in 2021 to roughly 300 in 2025 (Yu County ICH Office records), yet the share still held during the Spring Festival fell from 100% before listing to 13% in 2025 (SPSS trend). (2) Workforce: hereditary smiths are now under 20% of performers but the rest are contract workers who know the moves but not the ritual (expert interviews). (3) Spatial dislocation: 78% of 2025 performances were staged in commercial plazas, not on the ancestral walls. (4) Governance: Cultural and Tourism Bureau officials now set nine of every ten performance decisions, against fewer than two in ten before listing. (5) Funding: The 2025 county budget put ¥0 into apprentice training and ¥2.6 million into performance infrastructure, a 0:1 split held across all five years. The testimony of marginalisation and the shape of the budget capture the same thing from two sides, backing Yuan et al. (2019)'s decoupling of form and function: visibility is up, yet the conditions for memory are gone.

6. CONCLUSION

The listing did not fail Da Shuhua but the listing regime did, by equating visibility with life. The intergenerational slide ($4.31 \rightarrow 3.02 \rightarrow 1.84$) and the five disruptors spell out what Yuan et al. (2019) call the decoupling of form and function. The study's mnemonic sustainability, set against visibility measures (listing, bearers), is a practice's hold on the spatial, temporal, and educational conditions that let memory pass between generations — four checkable dimensions carry it: sites, seasons, kinship, apprenticeship.

Three moves follow. Shift funding from performance infrastructure to apprenticeship and site upkeep. Give scheduling back to the hereditary households, with the Cultural and Tourism Bureau coordinating rather than directing. Add transmission indicators (apprentice numbers, on-site share) to the UNESCO and county metrics.

Two cautions. The RO2 expenditure figures come from unaudited county yearbooks, so the 0:1 ratio is indicative, not exact. Future work can close that gap: obtain the budget-execution ledgers from the county finance bureau, file freedom-of-information requests where they are withheld, and cross-check the totals against contractor payments, venue receipts, and bearer subsidies. The single case also bounds the claim —the four dimensions have yet to be run on other site-bound rituals. The study leaves a lens and an agenda for place-bound ICH.

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VISUAL SYMBOL-BASED ICE AND SNOW MANAGEMENT FOR SUSTAINABLE TOURISM IN HARBIN, CHINA

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1. INTRODUCTION

The United Nations Sustainable Development Goal 11 (SDG 11) provides a clear direction for the sustainable development of tourism cities (United Nations 2015), and ice and snow tourism, which integrates natural landscapes, local culture and visitor experiences, is closely aligned with this goal (UNWTO 2017). Harbin is a core ice and snow tourism city in China whose visual cultural symbols blend Chinese and Russian characteristics. However, rapid expansion has produced homogenised visual design, shallow cultural interpretation and insufficient immersive experiences, making it difficult to guide tourists towards sustainable behaviour (China Tourism Academy 2024). The root of this problem is theoretical: existing studies examine visual symbols in fragmented single dimensions rather than within an integrated perception framework, so the perception dimensions through which symbols operate cannot be validly measured, and consequently the complete pathway from symbol perception to tourist sustainable behaviour has never received empirical support as a chained process. To close this gap, and based on the Stimulus-Organism-Response (S-O-R) theory (Mehrabian & Russell 1974) and tourism semiotics (MacCannell 1976), this study builds a chain model of "visual symbol perception - tourism experience - satisfaction - sustainable behaviour intention". Unlike general destination image research, ice and snow visual symbols are characterised by ephemerality, multi-sensory embeddedness and cross-cultural condensation, which gives this context distinctive theoretical value. Theoretically, the study establishes a three-dimensional (aesthetic, cultural and emotional) symbol perception system for ice and snow tourism (Buckley 2012). Practically, it proposes an actionable symbol management plan for governments to optimise landscape design, preserve cross-border culture and promote eco-tourism, offering a reference for ice and snow cities implementing SDG 11.

2. PROBLEM STATEMENT

The application of the S-O-R framework to tourism is well established (Mehrabian & Russell, 1974; Bitner, 1992); the innovation of this study must therefore be located in the structure of the chain model and the uniqueness of the ice and snow context. By extending the traditional three-stage single chain into a multi-link chained mediation structure—ASA → CSA → PA → TS → SBI—with the EC moderator identifying boundary conditions, and by positioning ice and snow visual symbols as the core stimulus source (Mirzoeff, 1999; Rose, 2001), the study goes beyond the conventional destination image analytical framework. Ice and snow visual symbols differ from general destination images in their ephemerality, multi-sensory embeddedness, cultural condensation and semiotic self-sufficiency (Urry, 2002; Jenkins, 2003; Hunter, 2008), so the cognitive-affective framework of destination image research cannot fully capture them. The practical urgency is equally evident. Official statistics show that Harbin received about 87 million visitors and RMB 124.8 billion in tourism revenue during the 2023-

2024 ice and snow season, yet industry reports indicate that tourist engagement remains concentrated in short-term sightseeing: attractions relying on spectacle-like visual display achieve high footfall but low revisit intention, weak emotional attachment and little conversion to environmentally responsible behaviour (China Tourism Academy, 2024). Existing visual communication approaches emphasise visual novelty rather than cultural narrative, which explains their failure to trigger sustainable behaviour. The core research question is therefore reformulated as: through what mechanisms do perceptions of Harbin's ice and snow visual symbols shape tourists' experience and satisfaction, and thereby their sustainable behaviour intentions, and under what environmental conditions do these effects strengthen or weaken?

3. OBJECTIVE

The overall aim of this study is to adopt the S-O-R theory and tourism semiotics as the core analytical framework for examining how local government can optimise visual ice and snow symbol management in landscape design, preserve cross-border culture, and promote eco-tourism development in Harbin, China. Specifically, this study seeks to achieve the following two interrelated objectives:

Research Objective 1: Use qualitative research to classify the dimensions of Harbin ice and snow tourism visual symbols, explain the meaning of each symbol, and clarify the internal logical path of how visual symbol perception affects tourists' psychological experience.

Research Objective 2: Conduct quantitative empirical analysis based on the S-O-R model to test the serial mediating effect of tourists' psychological experience between visual symbol perception and tourists' sustainable tourism behaviour.

4. METHOD

This study adopts an exploratory sequential mixed methods design, in which qualitative coding in the first stage informs quantitative modelling in the second (Creswell & Creswell, 2017). The qualitative stage collects four types of materials: archived documents, official tourism articles, social media user-generated content and domestic and international academic papers; no survey data are involved at this stage. NVivo 12 is used to conduct three-level coding (open, axial and selective) on these materials, and triangulation across the four data sources verifies the credibility of the coding. The coding identifies three main dimensions of Harbin ice and snow visual symbols: aesthetic, cultural and emotional. The results show that aesthetic symbols appear most frequently but create only short-term visual attraction, while cultural and emotional symbols appear less often yet leave longer-lasting memories. Most scenic spots emphasise visual forms but lack cultural storylines, making the symbols shallow to visitors. These qualitative findings determine the measurement dimensions and item pool of the subsequent questionnaire. The quantitative stage is built on the revised S-O-R model. A total of 401 valid questionnaires were collected from five major ice and snow scenic spots in Harbin, a sample size meeting the standards for PLS-SEM analysis (Hair et al., 2019). SmartPLS 4.0 was used to test the reliability and validity of the measurement model and the path relationships of the structural model through PLS-SEM with 5,000 bootstrap resamples (Hair et al., 2022). This stage analyses how the three symbol perceptions drive tourist experience and satisfaction differently, confirms the "symbol perception - tourist experience - satisfaction" mechanism, and tests the moderating role of EC.

5. RESULTS AND DISCUSSION

This section reports the findings of RO1 and RO2 and discusses their theoretical and practical value. In Phase 1, three-level coding of the qualitative corpus confirmed the three-dimensional structure of Harbin ice and snow visual symbols: aesthetic symbols appeared most frequently but generated only short-term attraction, whereas cultural and emotional symbols appeared less often yet produced durable memories. This yields a standard three-dimensional symbol list that fills the classification gap in ice and snow tourism and provides qualitative grounding for the variables in Phase 2. Phase 2 went beyond descriptive statistics to full inferential testing. The measurement model showed satisfactory reliability and validity (composite reliability 0.83-0.91; AVE 0.57-0.68; all HTMT values below 0.85). In the structural model, all hypotheses were supported: aesthetic perception → experience ($\beta = 0.21$, $t = 3.42$, $p < 0.01$), cultural perception → experience ($\beta = 0.39$, $t = 7.86$, $p < 0.001$) and emotional perception → experience ($\beta = 0.36$, $t = 6.98$, $p < 0.001$); experience → satisfaction ($\beta = 0.58$, $t = 12.34$, $p < 0.001$) and satisfaction → sustainable behaviour intention ($\beta = 0.47$, $t = 9.15$, $p < 0.001$). The model explained 62% of the variance in satisfaction and 48% in sustainable behaviour intention, and the chained mediation from symbol perception through experience and satisfaction to sustainable behaviour intention was significant; EC negatively moderated the cultural perception → experience path ($\beta = -0.12$, $t = 2.31$, $p < 0.05$). These results confirm that cultural and emotional perceptions drive experience far more strongly than aesthetic perception: ice scenery alone cannot raise satisfaction, whereas symbols carrying local customs, regional history and immersive emotional resonance generate deeper experience and stronger sustainable behaviour intentions.

6. CONCLUSION

This study found that Harbin's ice and snow visual symbols operate through three perception dimensions, among which cultural and emotional perceptions exert far stronger effects on tourist experience and satisfaction than aesthetic perception; experience and satisfaction in turn significantly drive sustainable behaviour intention, with environmental characteristics acting as a boundary condition. These findings show that ice and snow scenery alone cannot generate sustainable tourist behaviour, and that symbols carrying local customs, regional history and immersive emotional resonance are the decisive stimuli. Theoretically, the verified three-dimensional perception framework and the "symbol perception - experience - satisfaction - sustainable behaviour intention" chain fill the empirical gap in ice and snow scenarios and extend the application of S-O-R theory, offering a replicable analytical tool for cross-destination research. Practically, the results support Harbin tourism authorities in upgrading landscape design and immersive cultural narratives: scenic spots should strengthen cultural and emotional symbol layouts and add interactive Sino-Russian cultural facilities to foster tourists' eco-friendly and heritage-protection behaviour, providing actionable guidance for ice and snow cities to realise SDG 11. Limitations remain: the sample covers five Harbin scenic spots without cross-city validation; group difference tests are excluded; and the data rely on self-reported intentions rather than actual behavioural records.

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GOVERNANS KELESTARIAN BAGI PENGURUSAN KEWANGAN IKLIM DI NEGERI SELANGOR

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1. PENGENALAN

Perubahan iklim merupakan ancaman global yang telah memberi kesan signifikan kepada negara di dunia terutamanya negara-negara membangun (Intergovernmental Panel on Climate Change 2023). Pelaksanaan pelan mitigasi dan adaptasi bagi menangani kesan perubahan iklim memerlukan sumber kewangan yang mencukupi. Perjanjian Paris dan Matlamat Pembangunan Lestari, Pertubuhan Bangsa-Bangsa Bersatu telah mengenal pasti kewangan iklim sebagai instrumen penting bagi membiayai tindakan tersebut (Kotchen 2020). Walau bagaimanapun, keberkesanan pengurusan kewangan iklim tidak hanya bergantung kepada ketersediaan dana, tetapi juga kepada amalan governans yang mengawal proses perancangan, penyelarasan, pelaksanaan dan pemantauan kewangan tersebut (Lubinga & Mazenda 2024). Di peringkat subnasional, governans yang berkesan penting dalam memastikan sumber kewangan iklim dapat diuruskan secara optimum bagi menyokong pelaksanaan tindakan iklim mengikut keperluan tempatan. Sebagai sebuah negeri yang aktif melaksanakan tindakan iklim dan mendapatkan kewangan daripada pelbagai sumber, Negeri Selangor memberikan konteks yang sesuai untuk mengkaji amalan governans kewangan iklim. Oleh itu, kajian ini dilaksanakan bagi mengenal pasti jenis governans kelestarian pengurusan kewangan iklim yang diamalkan di Negeri Selangor dengan memberi tumpuan kepada governans kelestarian jenis hierarki, pasaran dan rangkaian untuk mencapai pengurusan kewangan iklim yang berkesan dan lestari.

2. PERMASALAHAN KAJIAN DAN SOROTON KAJIAN

Pengurusan kewangan iklim merujuk kepada keupayaan untuk memperoleh, memperuntukkan, membelanjakan dan memantau sumber kewangan bagi menyokong inisiatif mitigasi dan adaptasi perubahan iklim. Sumber kewangan iklim merangkumi instrumen pembiayaan seperti geran, pinjaman, jaminan, bon hijau dan pertukaran hutang daripada pelbagai sumber domestik, antarabangsa, dana awam dan swasta serta kerjasama pelbagai hala dan dua hala (United Nations Development Programme 2023). Di peringkat subnasional, pengurusan kewangan iklim menghadapi pelbagai cabaran termasuk kekangan pentadbiran, kapasiti institusi yang terhad dan struktur governans yang tidak jelas (Gilder & Rumble 2020). Cabaran ini menjejaskan keberkesanan pengagihan, penyelarasan, pelaksanaan dan pemantauan kewangan iklim serta mengehadkan keupayaan kerajaan subnasional dalam mendapatkan sumber kewangan yang mencukupi (Doku et al. 2021). Governans merujuk kepada struktur, proses dan mekanisme yang mengawal pembuatan keputusan, pelaksanaan kuasa serta interaksi antara pihak berkepentingan bagi memastikan akauntabiliti dan ketelusan untuk mencapai matlamat bersama (Ansell 2023; Ansell & Torfing 2022; Lowndes & Skelcher 1998; Peters 1998). Kajian terdahulu mencadangkan tiga jenis governans kelestarian iaitu hierarki, pasaran dan rangkaian (Ansell 2023; Kooiman 2003; Powell & Bromley 2015; Ronfeldt 1998). Governans

jenis hierarki menekankan pendekatan atas ke bawah menerusi kawalan berpusat oleh kerajaan (Cvetković et al. 2019; Graham & Serdaru 2020). Governans jenis pasaran pula lazimnya didorong oleh mekanisme pasaran, insentif ekonomi dan penyertaan sektor swasta (Thompson et al. 1991; Vogel 2023). Manakala, governans jenis rangkaian menekankan kerjasama yang melibatkan pelbagai pihak berkepentingan, termasuk kerajaan, sektor swasta dan pertubuhan bukan kerajaan dalam proses membuat keputusan (Kawabata 2023; Klijn & Koppenjan 2012; Thorelli 2003). Kajian ini menggunakan Teori Institusi bagi menjelaskan bagaimana struktur institusi dan mekanisme interaksi mempengaruhi governans pengurusan kewangan iklim (Dimaggio 1998; Hoffman & Jennings 2015). Walaupun kajian berkaitan kewangan iklim di peringkat global dan Malaysia semakin berkembang, kebanyakannya memberi fokus kepada dasar perubahan iklim, institusi multilateral dan instrumen pembiayaan di peringkat antarabangsa dan nasional (Susskind et al. 2020), manakala kajian mengenai governans kewangan iklim di peringkat subnasional masih terhad. Dalam konteks Negeri Selangor, walaupun pelbagai tindakan perubahan iklim dan usaha mendapatkan sumber kewangan telah dilaksanakan, namun tidak diketahui jenis governans yang diamalkan oleh pihak berkepentingan dalam menguruskan kewangan iklim di negeri tersebut, sama ada menggunakan governans jenis hierarki, pasaran, rangkaian atau gabungan ketiga-tiganya. Ketidakjelasan ini mengehadkan pemahaman tentang bagaimana struktur institusi, peranan dan interaksi antara pihak berkepentingan yang diamalkan oleh pihak berkepentingan dalam pengurusan kewangan iklim di Negeri Selangor.

3. OBJEKTIF KAJIAN

Kajian ini bertujuan untuk mencapai empat objektif kajian. Bagi tujuan pembentangan kolokium, tumpuan diberikan kepada dua objektif yang telah dicapai setakat ini iaitu (i) untuk mengenalpasti pihak berkepentingan yang terlibat dalam pengurusan kewangan iklim di Negeri Selangor (ii) untuk menganalisis peranan dan penglibatan yang dimainkan oleh pihak berkepentingan dalam pengurusan kewangan iklim di Negeri Selangor berdasarkan kepada tiga jenis governans kelestarian iaitu hierarki, pasaran dan rangkaian.

4. KAEDAH KAJIAN

Kajian ini menggunakan pendekatan kualitatif berasaskan reka bentuk kajian kes dengan falsafah interpretivisme bagi meneroka amalan governans dalam pengurusan kewangan iklim di peringkat subnasional. Negeri Selangor dipilih sebagai kes kajian kerana terdedah kepada impak perubahan iklim, mempunyai komitmen terhadap agenda tindakan iklim dan merupakan negeri pertama yang memperkenalkan dasar perubahan iklim, selain aktif meneroka pelbagai mekanisme kewangan iklim domestik dan antarabangsa (Kementerian Sumber Asli dan Kelestarian Alam 2024; Unit Perancang Ekonomi Negeri Selangor 2024). Data kajian dikumpulkan melalui analisis dokumen dan temu bual separa berstruktur. Sebanyak lapan dokumen rasmi dianalisis, merangkumi dasar perubahan iklim (n=2), rancangan negeri (n=1), pelan tindakan (n=1), perancangan belanjawan (n=2) dan pelan pembangunan lima tahun negara (n=2). Analisis dokumen digunakan untuk mengenal pasti rangka kerja kawal selia, peranan institusi dan mekanisme kewangan berkaitan pengurusan kewangan iklim di Negeri Selangor. Bagi data primer, persampelan bertujuan digunakan untuk memilih informan berdasarkan kepakaran, peranan dan penglibatan secara langsung dalam pengurusan kewangan iklim. Seramai lapan informan ditemu bual yang terdiri daripada wakil kementerian persekutuan (n=3), agensi kerajaan negeri (n=2), sektor swasta (n=2) dan pertubuhan bukan

kerajaan (n=1). Protokol temu bual telah divalidasi oleh pakar dan mendapat kelulusan Jawatankuasa Etika Penyelidikan Universiti Kebangsaan Malaysia pada 27 Mei 2026 (No. Kelulusan: UKM/PPI/111/8). Data dianalisis menggunakan analisis tematik dengan bantuan perisian ATLAS.ti berdasarkan pendekatan Braun dan Clarke (2006) bagi mengenal pasti dan mentafsir amalan governans kelestarian hierarki, pasaran dan rangkaian. Triangulasi antara dapatan analisis dokumen dan temu bual digunakan bagi meningkatkan kredibiliti dan kebolehpercayaan dapatan kajian (Lim 2024).

5. KEPUTUSAN DAN PERBINCANGAN

Dapatan objektif pertama mengenal pasti pihak berkepentingan utama dalam pengurusan kewangan iklim di Negeri Selangor berdasarkan tiga peringkat. Di peringkat antarabangsa, United Nations Framework Convention on Climate Change, negara maju, agensi pelbagai hala seperti United Nations Development Programme dan dana iklim pelbagai hala seperti Green Climate Fund merupakan antara pihak berkepentingan utama yang membentuk kerangka, komitmen dan mekanisme kewangan iklim antarabangsa. Di peringkat Persekutuan, Kementerian Sumber Asli dan Kelestarian Alam, Kementerian Kewangan, Kementerian Ekonomi dan Bank Negara Malaysia berperanan dalam penggubalan dasar, penyelarasan, penetapan keutamaan pembangunan di peringkat nasional serta penyediaan dan pemudahcara sumber kewangan. Di peringkat negeri, Unit Perancang Ekonomi Negeri Selangor dan Pusat Adaptasi Perubahan Iklim Negeri Selangor berperanan dalam penetapan dasar, penyelarasan dan pelaksanaan tindakan iklim mengikut keperluan tempatan. Selain itu, sektor swasta seperti syarikat milik kerajaan negeri dan pertubuhan bukan kerajaan turut memainkan peranan dalam pengurusan kewangan iklim di Negeri Selangor melalui kerjasama awam-swasta dan perkongsian sumber serta pengetahuan. Bagi objektif kedua, analisis tematik mengenal pasti amalan governans hierarki (480 perenggan), pasaran (460 perenggan) dan rangkaian (458 perenggan). Dapatan ini menunjukkan perbezaan fungsi dan mekanisme interaksi antara pihak berkepentingan bagi setiap jenis governans. Governans hierarki menyediakan autoriti dan kawalan melalui penetapan dasar, peraturan, penyaluran peruntukan dan pematuhan terutamanya dalam hubungan menegak antara institusi di peringkat antarabangsa, Kerajaan Persekutuan dan Kerajaan Negeri. Governans pasaran yang melibatkan sektor swasta dan syarikat milik kerajaan negeri menyokong mobilisasi sumber, kecekapan, insentif dan mengutamakan pulangan pelaburan terutamanya dalam projek mitigasi. Manakala, governans rangkaian menggalakkan penglibatan, keterbukaan dan kolaborasi dalam hubungan mendatar antara agensi kerajaan, sektor swasta dan pertubuhan bukan kerajaan. Kategori kawalan merupakan kategori paling dominan dalam governans hierarki dengan frekuensi sebanyak 215 daripada 480 perenggan. Dapatan ini menunjukkan bahawa pengurusan kewangan iklim di Negeri Selangor didominasi oleh governans hierarki dan analisis substantif mendapati sebahagian keputusan dan akses kepada sumber kewangan bergantung pada mandat, prosedur dan mekanisme kelulusan yang ditetapkan pada peringkat lebih tinggi. Situasi ini mengehadkan autonomi kerajaan negeri dalam pengurusan kewangan iklim secara lebih fleksibel bagi memenuhi keperluan pembiayaan tempatan. Pada masa yang sama, sebanyak 310 perenggan menunjukkan pertindihan kod antara ketiga-tiga jenis governans. Ini menggambarkan bahawa pengurusan kewangan iklim di Negeri Selangor tidak bergantung kepada satu jenis governans kelestarian sahaja, sebaliknya mengamalkan gabungan tiga jenis governans kelestarian iaitu hierarki, pasaran dan rangkaian.

6. KESIMPULAN

Kajian ini telah mengenal pasti pihak berkepentingan utama serta menganalisis peranan dan penglibatan mereka dalam pengurusan kewangan iklim di Negeri Selangor berdasarkan governans hierarki, pasaran dan rangkaian. Kebergantungan antara ketiga-tiga jenis governans menunjukkan terdapat keperluan untuk mewujudkan pendekatan governans kelestarian secara hibrid bagi memperkukuh pengurusan kewangan iklim di peringkat subnasional. Dapatan ini seterusnya dijadikan sebagai asas bagi memenuhi objektif kajian berikutnya, iaitu membangunkan kerangka governans kelestarian pengurusan kewangan iklim yang inklusif dan praktikal, selaras dengan keperluan dan konteks Negeri Selangor.

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EVALUATING MULTI-DIMENSIONAL RURAL SUSTAINABILITY: A LIVELIHOOD-ORIENTED INDICATOR SYSTEM FOR ANHUI'S TEA-PRODUCING VILLAGES

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1. INTRODUCTION

Sustainable rural development is a global priority. The UN 2030 Agenda identifies rural areas as key settings for addressing poverty, decent work, and climate action. China had 477 million rural residents in 2023, with an urban-rural per capita disposable income gap of 2.39:1 (National Bureau of Statistics of China, 2024). In response, the Rural Revitalization Strategy was adopted in 2017, followed by the 2025 Comprehensive Rural Revitalization Plan (Central Committee of the CPC & State Council, 2018; Central Committee of the CPC & State Council, 2024). Yet progress varies across sectors and localities, requiring targeted measurement tools to guide policy.The tea industry exhibits this requirement. Tea planting includes economic output, ecological benefits, and cultural heritage as a perennial crop system with decades-long economic cycles. Anhui Province is world-renowned for its famous teas, such as Huangshan Maofeng, Lu'an Guapian, and Keemun Black Tea. By 2024, the province had stabilized its tea garden area at 3.2 million mu (approximately 213,000 hectares), with an annual output value of dried tea reaching 23.9 billion RMB and the total output value of the entire industry chain exceeding 90 billion RMB (Anhui Daily, 2025, citing the Department of Agriculture and Rural Affairs of Anhui Province). However, Anhui's tea-growing villages still face challenges such as an aging farming population, soil degradation, and the migration of young people whereas the issues that are difficult to fully capture within standard rural assessment frameworks.

Additionally, the existing frameworks fail to capture the interaction between livelihood assets and the economic, ecological and social sustainability outcomes of the tea-producing communities. Therefore, this study integrates the Sustainable Livelihoods Framework (SLF) and the Triple Bottom Line (TBL) theory to create an industry-sensitive, policy-linked evaluation indicator system for Anhui's tea-producing villages. The construction phase of the indicator system is covered in this paper.

2. PROBLEM STATEMENT

This study focuses on rural communities in Anhui Province involved in the tea industry. Although measures for rural revitalization and economic revitalization have already been implemented, questions remain regarding how these measures can be fully tailored to the needs of the tea industry and the regions where it is based.

Existing research on sustainable rural development evaluation falls into three categories: general multidimensional frameworks based on the triple bottom line (TBL) theory (Elkington, 1997; Liu, 2023; Mog, 2004); infrastructure and human settlement assessments (Wang, 2010; Li, 2020; Zhao, 2023); and agricultural sustainability assessments (Kanter et al., 2016; Wordofa, 2024), though tea-specific studies focus narrowly on economic output or production technology (Cai, 2021; Wang et al., 2023). Existing policy plans and evaluation frameworks

for rural revitalization are largely guided by food security, focusing on traditional agricultural indicators such as yield and cultivated area, and emphasizing the basic survival need of ensuring adequate food supply. However, tea is not a staple crop essential for survival; rather, it is a cash crop with distinct cultural value and diverse ecosystem services. Therefore, it requires a set of indicators specific to the tea industry.

To address these gaps, this study introduces the Sustainable Livelihoods Framework (SLF) as the theoretical foundation for analysing tea-producing villages. The SLF not only aligns more closely with the five major objectives of China's rural revitalization plan but also enables us to trace how external shocks affect farmers' capital allocation decisions, which in turn influence long-term sustainability. Therefore, this study combines the TBL and SLF to construct a sector-sensitive, policy-linked evaluation system for sustainable rural development in the tea industry. This system aims to provide a scientific basis for the government to implement targeted policies and optimize resource allocation, while also serving as a model evaluation tool for other tea-producing regions across the country.

3. RESEARCH OBJECTIVES

This study has three main objectives to develop and apply a livelihood-oriented indicator system for evaluating rural sustainability in tea-producing village in Anhui Province, China. It includes:

(1) To develop and validate a multidimensional, livelihood-oriented sustainability indicator system for tea-producing villages by integrating the Sustainable Livelihood Framework and the Triple Bottom Line theory.

(2) To assess the sustainable development levels of rural sustainability among selected tea-producing villages in Anhui Province using the validated indicators system.

(3) To formulate evidence-based policy recommendations for enhancing the sustainability development of tea-producing villages within the context of the China Rural Revitalization Policy. For the colloquium, the first objective will be prioritized: develop and validate a multidimensional sustainability indicator system for tea-production village.

4. RESEARCH METHODOLOGY

This study employs Delphi method to develop and validate a multidimensional sustainability indicator system for tea-producing villages. An initial pool of 24 indicators was developed through literature and policy document analysis by integrating the Sustainable Livelihoods Framework (SLF) and Triple Bottom Line (TBL). A purposely selected panel of 20 experts form academia, government, and the tea industry participated in the expert consultation. Indicators were assessed using a five Likert scale and screened based on a mean score of >3.5 and a coefficient of variation (CV) of <0.25. Descriptive statistics and Kendall' s coefficient of concordance were used to assess expert consensus. The institutional ethics review process is currently in progress.

We used SPSS 26.0 to calculate the mean, standard deviation, coefficient of variation, and Kendall's coefficient of concordance for each indicator.

5. RESULTS AND DISCUSSION

Based on the SLF conceptual framework and the Triple Bottom Line theory, this study conducted a systematic content analysis of academic literature and policy documents to preliminarily construct an initial indicator system comprising 3 dimensions, 8 element levels, and 24 specific indicators. The mean scores and coefficients of variation for each indicator are summarised in Table 1.

The Delphi method consultation revealed that most indicators exhibited a high degree of expert consensus (mean > 3.5, coefficient of variation < 0.25). However, experts from different fields differ in their ratings of various types of indicators. Production-related indicators, which are highly objective and quantifiable, consistently receive high scores. In contrast, there is significant disagreement regarding emerging ecological indicators: while the academic community rates them highly, the industry expresses concerns about data availability and practical feasibility. Indicators such as “tea export value and growth rate” and “number of Intangible Cultural Heritage bearers for tea culture” are close to the coefficient of variation threshold, revealing a fundamental challenge: China’s tea industry must simultaneously integrate into the global market and pursue economic growth while preserving local cultural characteristics and maintaining its traditional roots—a balance that is often difficult to achieve.

The integration of SLF and TBL provides a unified theoretical foundation for the indicator system, a view endorsed by experts. Human capital indicators and social capital indicators have garnered a high degree of consensus, validating the applicability of SLF in characterizing the dynamics of rural livelihoods in the tea industry; the high scores received by ecological indicators further reinforce the value of the environmental dimension of TBL.

In addition, only 6 of the 20 experts expressed a willingness to participate in subsequent Delphi rounds; this low retention rate is also a challenge faced in Delphi method research.

In summary, the results of the first round of the Delphi study indicate that experts have a high level of consensus on the core indicator system. Differences among various types of indicators and experts from different fields provide guidance for optimization. Additionally, practical issues such as data availability and maintaining expert participation still require attention.

Table 1. Mean scores and CV of first-round Delphi indicators

Dimension	Indicator	Mean	CV	Dimension	Indicator	Mean	CV	Dimension	Indicator	Mean	CV
Economic	1. Tea output value growth rate	4.65	0.16	Ecological	8. Eco-certified tea garden ratio	4.5	0.18	Social	16. Safe drinking water coverage	4.5	0.16
	2. Tea industry comprehensive	4.6	0.18		9. Green pest control coverage	4.75	0.12		17. 4G/5G network coverage	4.35	0.22
	3. Improved variety garden ratio	4.35	**0.28**		10. Soil organic matter content	4.5	0.16		18. Standardised clinic rate	4.05	0.24
	4. E-commerce sales ratio	4.15	0.24		11. Soil-water conservation rate	4.5	0.18		19. Village affairs satisfaction	4	0.24
	5. Deep-processing output ratio	4.65	0.16		12. Agri-waste utilisation rate	4.15	0.24		20. Tea culture inheritor count	4.25	**0.27**
	6. Public brand value index	4.4	0.21		13. Biodiversity index	4.45	0.18		21. Tea cultural events per year	4.3	0.22
	7. Export value & growth rate	4.2	**0.3**		14. Carbon sequestration value	4.2	0.24		22. Coop participation rate	4.2	0.22
					15. Water conservation	4.55	0.16		23. Youth return-to-village rate	4.4	0.2
									24. Policy awareness & satisfaction	4.35	0.18

6. CONCLUSION

Through the first round of Delphi expert consultations, this study preliminarily established an evaluation system for the sustainable development of rural tea industries comprising 24 indicators and reached expert consensus—22 indicators met the selection criteria (mean ≥ 3.5, coefficient of variation ≤ 0.25). The ecological dimension achieved the highest level of consensus (average CV = 0.16), reflecting experts' widespread recognition of the ecological service functions of the tea industry and directly addressing the "industry insensitivity" gap identified in this study.

In the upcoming second round of Delphi consultations, the AHP method will be used to determine the weights of the indicators. Once the indicator system is finalized, field research will be conducted in selected tea-producing villages in Anhui Province to empirically validate the indicator system.

At the theoretical level, this study demonstrates that the integration of SLF and TBL provides an effective conceptual foundation for the evaluation of specialty agriculture. At the practical level, this framework offers tea-producing regions a practical diagnostic tool and provides empirical evidence to optimize rural revitalization policies.

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A STRATEGIC ESG INTEGRATION FRAMEWORK FOR MALAYSIA'S INFRASTRUCTURE SECTOR: BRIDGING REGULATORY STANDARDS, INDUSTRY PRACTICES AND GLOBAL BENCHMARKS

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1. PENGENALAN / INTRODUCTION

1.1 Background of Research

The infrastructure sector encompasses the physical and organisational structures and facilities such as transportation, energy, water and telecommunications systems, that are necessary for the operation of a society and its economy (OECD 2017). Infrastructure development plays a critical role in driving economic growth; however, it also exerts profound and lasting impacts on environmental systems and social structures (World Bank 2020). This duality has intensified calls for embedding sustainability principles into the infrastructure sector, particularly as projects increasingly intersect with issues of environmental degradation, social inequality and governance deficiencies (UNEP 2021). Given the resource-intensive nature of infrastructure and its long project lifecycles, early and continuous integration of environmental and social assessments is imperative to avoid unintended adverse outcomes (ADB 2019). Equally, sound governance is essential to guide ethical decision-making, ensure accountability and align projects with societal aspirations (UNOPS 2020).

2. PROBLEM STATEMENT AND LITERATURE REVIEW

Existing Malaysian initiatives demonstrate substantial progress in ESG disclosure and governance, but they do not yet provide a single, sector-specific pathway showing how different requirements should be integrated throughout infrastructure decision-making. ESG expectations are distributed across corporate reporting, climate disclosure, governance, assurance and industrial policy. Although this strengthens transparency and accountability, overlapping standards and uneven organisational readiness can complicate implementation, particularly for smaller firms and firms with limited technical capability (Institute for Capital Market Research Malaysia 2023; Dasanayaka et al. 2022). Comparative research similarly shows that regulatory convergence may improve consistency while creating implementation difficulties when institutional coordination and organisational capacity do not develop at the same pace (Singhania & Saini 2023).

Accordingly, the specific problem addressed in this study is that, despite the expansion of ESG policies and reporting requirements, Malaysia's infrastructure sector still lacks a sufficiently integrated regulatory profile that clearly connects local requirements, industry implementation needs and global benchmarks. This gap is important because fragmented ESG expectations can lead to inconsistent application across the infrastructure project life cycle, where environmental, social, governance and financing decisions are closely interdependent (Qi et al. 2023).

Research Questions

i. What are the global and local ESG-related regulatory requirements and frameworks that influence Malaysia's infrastructure sector?

3. OBJEKTIF KAJIAN / OBJECTIVE

i. To identify global and local ESG-related regulatory requirements and frameworks relevant to Malaysia's infrastructure sector.

4. KAEDAH KAJIAN / METHOD

4.1 Methods for Objective 1 - To identify global and local ESG-related regulatory requirements and frameworks relevant to Malaysia's infrastructure sector

(i) Document Content Analysis

A systematic document content analysis will be conducted on global ESG frameworks (e.g., Global Reporting Initiative (GRI), Task Force on Climate-related Financial Disclosures (TCFD), Sustainability Accounting Standards Board (SASB), International Financial Reporting Standards (IFRS), IFRS S1, IFRS S2 and the Science-Based Targets initiative (SBTi), as well as Malaysia's national ESG-related policies and instruments (e.g., Bursa Malaysia Sustainability Reporting Guidelines, Malaysian Code on Corporate Governance (MCCG), National Energy Transition Roadmap (NETR)Green Technology Master Plan (GTMP) and National Sustainability Reporting Framework (NSRF). The analysis will use NVivo software, The analysis will identify regulatory drivers, disclosure obligations, governance expectations and sectoral mandates specific to the infrastructure sector. The findings will highlight both overlaps and gaps in the regulatory landscape, informing alignment needs between international best practices and Malaysia's policy environment.

5. RESULTS AND DISCUSSION

Objective 1 - To identify global and local ESG-related regulatory requirements and frameworks relevant to Malaysia's infrastructure sector

Theme	Evolution	Key Findings	Overall Trend
Governance	Leadership to Accountability	Board responsibility expanded from oversight to legal accountability, management structures formalised, ESG incentives introduced	Strong governance institutionalisation
Materiality	Flexible to Structured	Materiality evolved into evidence-based assessment incorporating stakeholder input, value chain impacts and climate scenarios	More strategic and forward-looking
Stakeholder Engagement	Consultation to Continuous Engagement	Stakeholders become active decision-makers influencing strategy, supported by structured engagement and response mechanisms	Greater stakeholder integration

Assurance	Voluntary to Mandatory	Assurance progresses from optional verification to mandatory GHG assurance under NSRF	Improved credibility and reliability
International Alignment	Local Guidance to Global Standards	Malaysia aligns progressively with TCFD, ISSB, GRI, SASB and TNFD	Enhanced global comparability

The findings show a clear regulatory trajectory. Governance and assurance moved toward stronger accountability, while materiality and stakeholder engagement became more structured and evidence-based. This pattern is consistent with international ESG regulatory convergence (Singhania & Saini 2023), systematic materiality assessment (Garst et al. 2022), structured stakeholder engagement (Stocker et al. 2020) and the role of assurance in strengthening disclosure credibility (Hazaea et al. 2022).

The results directly answer Objective 1 by showing that Malaysia's ESG regulatory environment is layered. Bursa Malaysia sets core disclosure and governance expectations, the NSRF strengthens ISSB-aligned reporting and assurance, and the i-ESG Framework provides industry transition direction. The overall trend is toward stronger national and global alignment, although formal alignment does not yet imply uniform implementation across firms because ESG readiness and internal capability remain uneven (Institute for Capital Market Research Malaysia 2023; Dasanayaka et al. 2022).

6. KESIMPULAN / CONCLUSION

The analysis indicates that Malaysia's sustainability reporting framework has evolved from a voluntary disclosure regime (2018) into a mandatory, governance-driven and internationally aligned ESG reporting system (2024 onwards). Across the five themes, there is a clear progression towards enhanced board accountability, structured materiality assessments, continuous stakeholder engagement, mandatory sustainability assurance and alignment with international standards, such as TCFD and ISSB. Collectively, these developments strengthen the transparency, credibility and comparability of corporate sustainability disclosures, while positioning Malaysia to meet global investor expectations. Nevertheless, the literature consistently identifies organisational capability, particularly among SMEs and mid-sized firms, as the principal implementation challenge, highlighting the need for continued capacity building, technical support and institutional development to ensure effective and consistent adoption of the evolving ESG reporting requirements.

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CHARACTERISING UNESCO GLOBAL GEOPARKS IN INDONESIA: IDENTIFYING STRUCTURAL GAPS AND GOVERNANCE CONCERNS

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Co Supervisor: Emeritus Professor Dato' Dr. Ibrahim Komoo

1. INTRODUCTION

Over the past 15 years, Indonesia has actively promoted the rapid development of UNESCO Global Geoparks (UGGp) as a strategic instrument for holistic and integrated sustainable regional development (Farsani et al. 2011, UNESCO 2016). However, the capacity of geoparks to fulfil this mandate depends critically on how governance is designed and practised across different levels and sectors. Existing studies largely address specific issues such as tourism development, community engagement, or environmental management in one or two geoparks (Farsani et al. 2011, Naibaho & Su 2025, Ristiawan et al. 2023, Wahyudin et al. 2023), but systematic understanding of how geopark governance itself is configured, who leads and shapes it, and how policy instruments operate in practice remains limited. This study addresses this gap by focusing on the systematic characterisation of geopark governance in Indonesia, using six revalidated UGGp (Batur, Gunung Sewu, Ciletuh Palabuhanratu, Rinjani-Lombok, Toba Caldera and Belitong) as comparative cases to reveal common patterns and context-specific variations.

2. PROBLEM STATEMENT AND LITERATURE REVIEW

The development of UNESCO Global Geoparks (UGGp) in Indonesia has accelerated significantly following Presidential Regulation No. 9 of 2019, which mandates a structured approach to national geopark management and development. However, despite this regulatory framework, the current governance landscape remains fragmented. Recent literature and UNESCO revalidation recommendations highlight significant disconnects in policy implementation and institutional coordination (Dwipati et al. 2025,; Hajar et al. 2025,; Utomo et al. 2024). Specifically, revalidation processes have exposed a mismatch between national mandates and local execution, leading to governance vulnerabilities that hinder long-term sustainability (Hajar et al. 2025, Salsabil et al. 2023). While the literature acknowledges these recurring challenges, there is a lack of systematic synthesis of the governance factors common across Indonesian UGGps. Consequently, this study addresses the knowledge gap by systematically analysing governance structures across six Indonesian UGGps to identify the common institutional and operational factors that create governance disconnects.

3. OBJECTIVE

The primary objective of this study is to characterise the governance profile of six Indonesian UGGps. Specifically, the study aims to:

- Map the existing governance arrangements, including, policy instruments, key actors, and decision-making structures.
- Identify and categorise the main governance concerns and persistent challenges highlighted by UNESCO revalidation findings.

- Develop a synthesis of governance factors that require urgent intervention to ensure sustainable regional development.

4. METHODOLOGY

This study employs a qualitative, multi-method approach comprising document analysis and semi-structured interviews. The research pathway is structured as follows:

1. **Document Analysis (DA):** To determine the initial governance landscape, a systematic DA was conducted on UNESCO revalidation reports and recommendations, national policy documents, and management plans. Techniques included thematic content analysis to extract key governance dimensions (e.g., actor interaction, policy alignment). This analysis generated a governance checklist identifying critical gaps, such as institutional mismatch and communication disconnects.
2. **Semi-Structured Interviews**: Guided by the DA-derived checklist, in-depth interviews were conducted with key stakeholders across the six UGGps. The interview protocol focused on probing the specific concerns identified in the DA, allowing for a deeper exploration of the "why" behind the documented governance issues.
3. **Triangulation and Integration**: The study integrates data by cross-referencing DA findings with interview insights to ensure validity. Governance dimensions were coded and characterised within each case, followed by a comparative analysis across the six UGGps to identify patterns in institutional performance. This triangulation ensures that the identified governance concerns are grounded in both official documentation and stakeholder reality.

5. RESULT AND DISCUSSION

The findings from semi-structured interviews and document analysis reveal a complex governance landscape characterised by a disparity between high-level regulatory mandates and operational implementation. The characterisation of governance in the six Indonesian UGGp reveals several convergent patterns:

Policy instruments and budgeting

At the local level, geopark development is constrained by the absence of clear national guidance on budgeting and financing mechanisms. Although Presidential Regulation No. 9 of 2019, ministerial regulations, local regulations, and selected development-planning documents recognise geopark development, they do not define dedicated budget lines, eligible expenditure categories, or procedures for integrating geopark activities into routine planning and budgeting processes. This regulatory ambiguity creates uncertainty among local government agencies and can position geopark expenditure as discretionary or secondary. Consequently, geopark management units experience persistent funding limitations, constraining their capacity to maintain operations, implement programmes, and support community participation. Clear policy instruments and stable, institutionalised financing are therefore essential to sustain geopark governance and advance sustainable regional development within geopark territories.

Key actors and political dynamics

Local governments, particularly regional secretaries and senior officials, are the principal actors in geopark governance, shaping strategic agendas, allocating resources, and representing geoparks in external forums. However, governance continuity is vulnerable to five-year

political cycles, as changes in leadership may alter priorities, reallocate funding, and interrupt ongoing programmes, thereby weakening institutional memory. Non-government stakeholders, including local communities and tourism actors, generally have limited influence over planning and decision-making and are frequently positioned as programme beneficiaries rather than equal governance partners. Nevertheless, the sustained contribution and persistence of local champions within geopark communities are critical to maintaining initiatives beyond political transitions and to supporting the long-term, sustainable development of geoparks and geosites.

Institutional arrangements

Institutional arrangements across the six UGGps are predominantly local government-led. Although each geopark has a formally established management unit, these units commonly operate as extensions of sectoral agencies or regional secretariats rather than as autonomous or semi-autonomous governance bodies. Their authority, resources, and operational capacity consequently depend heavily on local government priorities and political support, producing state-centric governance configurations that are vulnerable to five-year political cycles. None of the six geoparks has established an effective multi-stakeholder coordination forum to facilitate inclusive planning, joint decision-making, and accountability. As a result, geopark planning and development remain largely directed by local government actors, while coordination challenges persist both among local stakeholders and across levels of government.

The Document-Analysis confirms that recurring governance concerns in revalidation reports relate to policy implementation, stakeholder roles, and coordination arrangements. Semi-structured interviews further provide empirical evidence of the institutional bottlenecks experienced by local geopark managers. The findings identify three interrelated areas requiring attention: (1) weak cross-sectoral coordination, (2) insufficient integration of non-government stakeholders in decision-making, and (3) ambiguity in the application of policy instruments. Although formal institutional structures are in place, these systemic disconnects constrain their capacity to support coherent, inclusive, and sustained geopark governance.

6. CONCLUSION

This study establishes an empirical baseline for understanding governance challenges in Indonesian UGGps. This research identifies the policy instruments, structural, and operational factors that currently impede it, providing a foundation for future interventions. The study confirms that governance gaps in Indonesian UGGps are not isolated incidents but reflect systemic issues in policy coordination and implementation. The developed DA methodology, specifically the governance checklist used to triangulate revalidation reports with stakeholder feedback, serves as a transferable tool for other geoparks to identify and address their specific governance concerns, ultimately contributing to more robust and sustainable regional development models.

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FILEM POLIDOPAMINA TERCETAK PERMUKAAN UNTUK PENGECAMAN ELEKTROKIMIA TANPA LABEL GELATIN KHINZIR BAGI PENGESAHAN HALAL

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1. PENGENALAN

Gelatin merupakan biopolimer berasaskan protein yang terhasil daripada hidrolisis kolagen yang lazim diperoleh daripada kulit, tulang serta tisu penghubung haiwan seperti ikan, lembu dan khinzir (Elyasi, Rahimi & Sepahvend 2020). Secara global, pengeluaran gelatin dianggarkan mencecah 326,000 tan setahun dengan khinzir sebagai sumber utama diikuti oleh kulit lembu, tulang dan sumber-sumber lain (Demirhan, Ulca & Senyuva 2012; Uddin et al. 2021; Yilmaz et al. 2013). Pengeluaran terbesar gelatin yang bersumberkan khinzir menunjukkan kepelbagaian sifat dan fungsi yang baik termasuk keupayaan dalam pembentukan filem, pengemulsian dan pembuihan menjadikannya sesuai untuk diaplikasikan dalam industri makanan, farmaseutikal dan kosmetik (Ahmad et al. 2017). Di samping itu, penggunaan tisu khinzir juga disokong oleh kestabilannya yang tinggi dalam proses penstrukturan, pengegelan serta melibatkan kos rendah dan masa pengeluaran yang lebih singkat berbanding sumber lain (Anuar, Tukiran & Jamaludin 2023; Yang et al. 2022). Sejajar dengan perkembangan industri halal global, kajian ini mencadangkan pendekatan berasaskan elektro-pempolimeran dopamina untuk mengubah suai permukaan elektrod karbon tercetak skrin (SPCE) dengan biofilem pengesan polidopamina tercetak permukaan (SIPDA). Filem tercetak SIPDA mempunyai rongga pengecaman sintetik yang bersifat pelengkap dari segi konformasi dan komposisi kimia, dengan itu berkeafinan kimia tinggi dalam pengikatan terhadap sasaran gelatin khinzir bagi membolehkan pengikatan semula yang selektif melalui gabungan interaksi bukan kovalen pada tapak pengecaman permukaan buatan (Tretjakov et al. 2013).

2. PERNYATAAN MASALAH DAN ULASAN KEPUSTAKAAN

Penggunaan meluas gelatin bersumberkan khinzir dalam industri seperti makanan, farmaseutikal dan kosmetik didorong oleh faktor kos yang rendah telah menimbulkan kebimbangan serius terhadap status halal sesuatu produk (Anuar et al. 2023). Isu ini semakin meruncing seiring dengan peningkatan kesedaran pengguna Muslim serta individu yang mengamalkan diet tertentu terhadap ketulenan sumber sesuatu bahan (Yap & Gam 2019). Selain itu, sesetengah kaedah analisis yang diaplikasikan pada produk gelatin terproses atau dalam matriks bercampur menghadapi cabaran dari segi kepekaan dan kepilihan disebabkan oleh interaksi antara rantai protein gelatin dan komponen matriks sampel yang mengganggu pengecaman sumber gelatin dengan tepat. Walaupun kaedah fizikokimia seperti pemendakan kalsium fosfat dan analisis komposisi asid amino (PCA) mampu membezakan gelatin bovina dan khinzir pada sampel tulen, namun kaedah tersebut kurang tepat bagi matriks kompleks (Hidaka & Liu 2003; Nemati et al. 2004). Manakala teknik yang lebih spesifik seperti tindak

balas rantai polimerase (PCR) dan ujian imunoserapan berkaitan enzim (ELISA) memerlukan kos yang tinggi serta peralatan yang canggih (Doi et al. 2009; Tanabe et al. 2007). Namun demikian, analisis gelatin dalam produk siap menghadapi cabaran akibat hidrolisis asid atau alkali serta pengekstrakan bersuhu tinggi semasa pemprosesan komersial yang mendegradasi rantaian protein serta asid nukleik (Demirhan, Ulca & Senyuva 2012; Mikhailov 2023). Kesan kemerosotan ini mengakibatkan ketiadaan penanda biomolekul yang utuh sekali gus mengehadkan keberkesanan kaedah konvensional seperti kaedah kromatografi cecair berprestasi tinggi (HPLC) dan elektroforesis gel poliakrilamida natrium dodeksil sulfat (SDS-PAGE) (Sha et al. 2020; Tukiran et al. 2016). Bagi mengatasi had tersebut, beberapa kaedah terkini seperti Spektrometri Jisim Kromatografi Cecair Tandem (LC-MS/MS) bagi pengesanan peptida spesifik dan Drople Digital PCR (ddPCR) bagi kuantifikasi residu asid nukleik terdegradasi telah diperkenalkan (Darmawan et al. 2025; Salamah et al. 2019) dengan menawarkan kepekaan yang tinggi, namun teknologi ini terikat dengan penyediaan sampel yang rumit serta masa analisis yang panjang. Kekangan ini menyebabkan kaedah moden tersebut tidak praktikal untuk pengujian pantas dan saringan masa nyata secara langsung di lapangan.

3. OBJEKTIF KAJIAN

Kajian ini tertumpu kepada pembangunan biosensor elektrokimia berasaskan filem polidopamina tercetak permukaan (SIPDA) untuk pengesanan gelatin khinzir secara bebas label yang praktikal, sensitif dan berdaya kos. Objektif kajian yang akan dibincangkan dalam pembentangan kolokium adalah seperti berikut:

I. Menyediakan filem pengecaman SIPDA pada permukaan elektrod terpegun dengan nanozarah emas terubah suai sisteamina (sisAuNPs) melalui teknik pempolimeran elektrokimia, dan mengkaji sifat fizikal dan kimianya seperti kumpulan berfungsi, morfologi permukaan, saiz, komposisi unsur dan kesan pemindahan jisim pada elektrod tercetak SIPDA.

II. Menentukan keafinan kimia antara gelatin khinzir dan elektrod bercetak SIPDA bagi pengecaman elektrokimia tanpa label gelatin khinzir melalui kajian pemindahan elektron dan rintangan pemindahan cas pada antara muka elektrod-elektrolit sensor SIP.

4. METODOLOGI KAJIAN

Kajian ini membangunkan biosensor elektrokimia berasaskan SIP untuk pengesanan kuantitatif gelatin khinzir. Nanozarah sisAuNPs dihasilkan melalui kaedah kimia basah, diikuti oleh pencirian fizikal dan kimia menggunakan spektroskopi UV-vis untuk memantau jalur plasmon permukaan setempat dan perubahan ciri optik sebagai pengesahan pembentukan serta pengubahsuaian permukaan nanozarah emas tersebut. Seterusnya, permukaan elektrod SPCE diubahsuai secara elektrokimia dengan lapisan 4-karboksifenil melalui tindak balas diazonium, diikuti dengan pengaktifan kumpulan karboksil menggunakan tindak balas taut silang karbodiimida. Seterusnya, sisAuNPs disadurkan pada permukaan SPCE bagi membentuk lapisan nanozarah emas berfungsi, diikuti dengan pemegunan gelatin khinzir pada permukaan menggunakan agen taut silang ditiobis (sulfosuksinimidil propionat) (DTSSP) untuk menghasilkan lapisan biopengecaman terikat secara kovalen yang stabil. Sintesis membran polidopamina (PDA) secara elektrokimia dilakukan pada permukaan elektrod terpegun dengan gelatin khinzir bagi membentuk rangka polimer di sekeliling templat tersebut. Seterusnya, templat gelatin disingkirkan menggunakan larutan penjana semula seperti 0.1 M 2-

merkaptoetanol dalam etanol dan 0.1% SDS dalam 3 M NaCl untuk menghasilkan tapak pengikatan khusus gelatin khinzir pada membran polimer teracuan. Pencirian tindak balas biosensor SIP gelatin khinzir kemudiannya dijalankan menggunakan teknik voltametri kitaran (CV) dengan penunjuk redoks feri/ferosianida, $[Fe(CN)_6]^{3-/4-}$ bagi menentukan keafinan kimia antara gelatin dan permukaan elektrod.

5. HASIL DAN PERBINCANGAN KAJIAN

Pembentukan nanozarah emas distabilkan sisteamina dilihat berdasarkan perubahan fizikal hasil warna merah delima larutan sisAuNPs dengan analisis spektroskopi UV-vis menunjukkan panjang gelombang serapan maksimum pada 528 nm, adalah selaras dengan kajian Wai dan New (2019) dan Zheng et al. (2013) yang menggunakan sisAuNPs sebagai prob kolorimetrik dengan puncak jalur serapan resonans plasmon permukaan tempatan (LSPR) dalam julat 520 nm hingga 540 nm. Kajian elektrokimia CV elektrod diubah suai sisAuNPs pada kadar imbasan 50 mV s-1terhadap elektrod rujukan Ag/AgCl dalam julat keupayaan -0.6 V hingga 1.1 V menggunakan larutan elektrolit 3 mM feri/ferosianida dalam kehadiran 0.1 M KCl, menunjukkan arus redoks yang meningkat serta keupayaan pemisahan puncak (ΔEp) iaitu 0.38 V berbanding dengan elektrod karbon asal SPCE tanpa pengubahsuaian permukaan (ΔEp=0.65 V), sekali gus menunjukkan kinetik pemindahan elektron yang lebih pantas dan kebolehbalikan tindak balas redoks yang dipertingkatkan pada permukaan elektrod sisAuNPs. Seterusnya, kepekatan templat gelatin khinzir optimum bagi penjanaan rongga pengecaman biomimetik diperoleh pada 100 mg mL-1dan isipadu sebanyak 6 µL. Di samping itu, filem PDA tidak tercetak molekul (NIP) juga disintesis secara pempolimeran elektrokimia tanpa kehadiran templat bertindak sebagai kawalan. Secara umumnya, biofilem PDA mempunyai permukaan yang reaktif secara kimia disebabkan oleh kehadiran kumpulan berfungsi katekol, kuinon, amina, serta imina dan mudah mengalami penjerapan tidak spesifik serta pengotoran permukaan (fouling) yang boleh menjejaskan tindak balas pemindahan elektron (Liebscher 2019). Dalam kajian ini, penurunan arus redoks CV bagi lapisan PDA dalam larutan penimbal fosfat didapati lebih drastik bagi NIP berbanding SIP berikutan kesan fouling pada permukaan NIP, manakala struktur berongga elektrod SIP membantu pengekalan kadar pemindahan elektron di permukaan elektrod. Hasil ini turut disokong oleh CV menggunakan larutan feri/ferosianida, yang menunjukkan arus puncak redoks yang ketara bagi SIP berbanding NIP, selaras dengan laporan bahawa filem PDA boleh bertindak sebagai lapisan pengehad resapan bergantung kepada struktur dan ketebalan filem (Turco et al. 2017). Hasil prosedur pencucian elektrod SIP menggunakan larutan elusi menunjukkan peningkatan rangsangan redoks feri/ferosianida, mengesahkan penyingkiran molekul gelatin khinzir dan pembentukan rongga pengecaman pelengkap sasaran yang meningkatkan tindak balas pemindahan elektron di permukaan elektrod. Pengikatan semula molekul gelatin khinzir pada 10 mg mL 1turut dibuktikan melalui penurunan ketara rangsangan arus redoks akibat sifat insulatif molekul gelatin khinzir yang mengehadkan tindak balas pemindahan elektron di permukaan elektrod.

6. KESIMPULAN

Filem SIPDA telah dibangunkan melalui penghasilan rongga pengecaman biomimetik menggunakan gelatin khinzir sebagai templat. Hasil kajian elektrokimia menunjukkan bahawa elektrod SIPDA membenarkan pemindahan elektron yang lebih lancar dan kurang mengalami penjerapan molekul tidak spesifik berbanding elektrod NIP. Proses pencucian berjaya menyingkirkan molekul templat dan menghasilkan rongga pengecaman yang sepadan dan

disahkan keberkesanannya dengan penurunan arus redoks akibat daripada pengikatan semula gelatin khinzir. Oleh itu, sistem SIPDA yang dibangunkan berpotensi digunakan untuk pengecaman gelatin khinzir berdasarkan keafinan kimia dan interaksi spesifik antara analit dan rongga pengecaman permukaan elektrod. Berdasarkan potensi tersebut, teknologi ini boleh menyumbang kepada pembangunan kaedah pengesanan yang sensitif dan berdaya guna untuk diaplikasikan dalam industri halal. Pembangunan biosensor ini selaras dengan Matlamat Pembangunan Mampan (SDG) 9 melalui pengenalan inovasi teknologi penderia tempatan serta SDG 12 dengan menyediakan alat kawalan kualiti yang menjamin integriti dan ketelusan rantaian bekalan industri halal.

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PERSEPSI PENGGUNA TERHADAP IMPAK SOSIAL DAN EKONOMI PERKHIDMATAN MRT LALUAN KAJANG, LEMBAH KLANG

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1. PENGENALAN

Kawasan metropolitan memerlukan sistem pengangkutan awam yang cekap dan mampan bagi menangani peningkatan populasi, kesesakan lalu lintas, kerosakan infrastruktur, masalah alam sekitar, serta kebergantungan yang tinggi terhadap kenderaan persendirian (Borhan et al., 2019; Jabatan Perangkaan Malaysia, 2023; Laisak et al., 2021; Yazid et al., 2020). Walaupun rangkaian pengangkutan awam telah berkembang, majoriti masyarakat masih melebihkan penggunaan kenderaan persendirian berbanding pengangkutan awam disebabkan faktor keselesaan, kelajuan, dan fleksibiliti (Borhan et al., 2019; Irtema et al., 2018). Sehubungan itu, kerajaan membangunkan Mass Rapid Transit (MRT) sebagai pengangkutan utama bagi meningkatkan aksesibiliti, mobiliti, dan kelancaran pergerakan masyarakat di Lembah Klang (MRT Corporation, 2023). Namun demikian, keberkesanan dan tahap kebolehpercayaan pembangunan MRT bukan sahaja diukur daripada aspek fizikal, ketepatan masa, dan teknikal, malah bergantung kepada persepsi pengguna terhadap kualiti perkhidmatan yang mempengaruhi kepuasan pengguna di luar sana (Soza-Parra et al., 2019). Oleh itu, kajian ini menilai persepsi pengguna terhadap impak sosial pembangunan MRT Laluan Kajang, Lembah Klang.

2. PERMASALAHAN KAJIAN DAN SOROTAN KAJIAN

Walaupun pembangunan Mass Rapid Transit (MRT) Laluan Kajang telah meningkatkan aksesibiliti, mobiliti, dan kemudahan pergerakan harian di Lembah Klang, beberapa cabaran seperti isu perjalanan awal dan akhir pengguna, kekurangan kemudahan sokongan, serta ketidakseimbangan akses antara kawasan bandar dan pinggir bandar masih menjejaskan keberkesanan perkhidmatan kepada pengguna (Shaari et al., 2022; Rashidi et al., 2017; Dziauddin et al., 2024).Sorotan kajian terdahulu menunjukkan bahawa kebanyakan penyelidikan lebih tertumpu kepada aspek teknikal sistem rel, manakala kajian yang menilai persepsi pengguna terhadap impak sosial masih terhad (Ahmad et al., 2021; Muhammad Rijal Mohamad, 2022; Rosmiati Ahmad & Noordeyana Tambi, 2024). Jurang kajian ini kritikal kerana tanpa pemahaman mendalam tentang persepsi pengguna, perkhidmatan MRT berisiko terus beroperasi dengan ketidaksepadanan antara bekalan infrastruktur dan keperluan sebenar masyarakat. Kegagalan menyelaraskan perkhidmatan dengan keperluan pengguna bukan sahaja akan menyebabkan pembaziran pelaburan infrastruktur, malah boleh menyebabkan penurunan tahap penggunaan yang menghalang hasrat kerajaan dalam mengurangkan kebergantungan terhadap kenderaan persendirian. Justeru, kajian ini mengemukakan perspektif baharu dengan mengintegrasikan data lapangan terkini mengenai impak sosial MRT terhadap kualiti hidup, aksesibiliti, dan mobiliti pengguna secara holistik. Penilaian ini penting bagi menyediakan data empirikal yang mampu membantu pihak berkuasa merangka strategi penambahbaikan yang lebih berorientasikan pengguna serta memastikan pembangunan infrastruktur rel ini benar-benar inklusif dan menyokong mobiliti mampan di Lembah Klang.

3. OBJEKTIF KAJIAN

Objektif kajian yang akan dibincangkan semasa pembentangan kolokium Adalah seperti berikut:

1.Objektif utama kajian ini adalah untuk menilai persepsi pengguna terhadap impak sosial perkhidmatan MRT Laluan Kajang di Lembah Klang dari aspek aksesibiliti, mobiliti, dan kemudahan pergerakan harian. Penilaian ini dilaksanakan bagi mengukur tahap persepsi pengguna secara komprehensif, seterusnya mengenal pasti sejauh mana keberkesanan perkhidmatan tersebut dalam memenuhi keperluan mobiliti masyarakat di kawasan metropolitan

4. KAEDAH KAJIAN

Kajian ini menggunakan pendekatan kuantitatif berbentuk tinjauan deskriptif iaitu pengumpulan data numerik berstruktur untuk menggambarkan fenomena atau trend persepsi pengguna terhadap impak sosial berkaitan dengan MRT Laluan Kajang yang melibatkan seramai 382 responden. Jumlah penetapan saiz sampel ini ditentukan berdasarkan jadual Krejcie dan Morgan pada aras keyakinan 95% untuk populasi pengguna transit Lembah Klang yang besar, di mana responden dipilih melalui kombinasi teknik persampelan bertujuan dan persampelan mudah di kawasan lapangan. Pemilihan ini melibatkan beberapa stesen utama MRT Laluan Kajang, iaitu Stesen Kajang, Stesen Stadium Kajang, Stesen Taman Mutiara, Stesen Cochrane, Stesen Aeon Maluri, Stesen Bukit Bintang, Stesen Muzium Negara, serta beberapa stesen MRT yang terletak di kawasan Damansara. Kriteria pemilihan responden adalah terbuka tanpa mengira jantina bagi individu berumur 18 tahun dan ke atas. Data dikumpul secara hibrid iaitu secara bersemuka dan menggunakan kod QR ini hanya menghadkan kepada satu respons sahaja, bagi mengelakkan jawapan berulang). Tempoh pengumpulan data soal selidik mengambil masa selama sebulan menggunakan instrumen Skala Likert lima mata yang telah diuji kebolehpercayaannya melalui pekali Cronbach's Alpha. Akhir sekali, data dianalisis menggunakan perisian SPSS melalui statistik frekuensi dan deskriptif, terutamanya nilai min dan sisihan piawai di mana skor min dikategorikan kepada tahap rendah, sederhana, dan tinggi, bagi menilai senario serta trend persepsi pengguna terhadap aspek aksesibiliti, mobiliti, dan kemudahan pergerakan harian.

5. KEPUTUSAN DAN PERBINCANGAN

Analisis demografi menunjukkan majoriti responden ialah Perempuan sebanyak (59.9%, n=229), jumlah responden tertinggi Adalah berumur 18–24 tahun (49.2%, n=188), Status pekerjaan pula, bekerja di sektor swasta (42.7%, n=163) mencatat jumlah tertinggi, responden berpendapatan RM2,001–RM4,000 (35.1%, n=134) dan menetap di kawasan bandar (76.2%, n=291). Kekerapan menggunakan MRT, kebanyakannya pengguna menggunakan MRT secara jarang adalah (45.5%, n=174), manakala tujuan utama penggunaan MRT secara berasingan dicatatkan bagi tujuan bekerja seramai (34.6%, n=132) dan melancong (34.6%, n=132). Secara keseluruhannya, persepsi terhadap impak sosial MRT Laluan Kajang adalah positif. Bagi aksesibiliti, min antara 3.94 hingga 4.29 menunjukkan persepsi yang baik. Laluan ke stesen yang selamat dan mesra pengguna mencatatkan skor tertinggi (4.29), manakala jarak ke stesen terendah (3.94), berkemungkinan dipengaruhi oleh lokasi kediaman dan kemudahan perjalanan awal dan akhir. Dapatan ini selari dengan Mohamad (2022) yang menekankan kepentingan aksesibiliti dalam pengangkutan awam. Dimensi mobiliti mencatatkan min tertinggi, iaitu

antara 4.40 hingga 4.54. Keupayaan bergerak ke pelbagai destinasi memperoleh skor tertinggi (4.54), menunjukkan MRT berkesan meningkatkan pergerakan pengguna. Dapatan ini selari dengan Rosmiati Ahmad dan Noordeyana Tambi (2024) berkaitan peranan pengangkutan awam dalam meningkatkan mobiliti masyarakat bandar. Bagi kemudahan pergerakan harian, min antara 4.19 hingga 4.34 menunjukkan persepsi positif. Kelancaran dan perancangan perjalanan mencatatkan skor tertinggi (4.34), manakala peningkatan kualiti kehidupan terendah (4.19), yang berkemungkinan dipengaruhi faktor lain seperti kos dan masa perjalanan. Dapatan ini turut menyokong Rosmiati Ahmad dan Noordeyana Tambi (2024) yang mengaitkan pengangkutan awam dengan kesejahteraan harian.

6. KESIMPULAN

Secara keseluruhannya, dapatan kajian menunjukkan persepsi positif pengguna terhadap impak sosial MRT Laluan Kajang dari aspek aksesibiliti, mobiliti, dan kemudahan pergerakan harian. Bagi memperkasakan perkhidmatan ini, pihak pengendali dicadangkan untuk memperkemas rangkaian perjalanan pengguna dari peringkat awal ke akhir perjalanan, menaik taraf laluan pejalan kaki yang mesra OKU di sekitar stesen, serta mengoptimalkan kekerapan bas perantara. Penambahbaikan khusus ini diharap dapat membantu pihak berkuasa merealisasikan sistem pengangkutan awam Lembah Klang yang lebih cekap, mampan, dan berpusatkan keperluan pengguna.

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PENGENALPASTIAN ELEMEN KHUSUS KESIAPSIAGAAN POLIS DIRAJA MALAYSIA DALAM MENANGANI ANCAMAN BANJIR PUING DI BENTONG, PAHANG.

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1. PENGENALAN

Perubahan iklim yang semakin ekstrem dan tidak menentu telah meningkatkan intensiti serta kekerapan ancaman bencana semula jadi, sekali gus mengubah landskap pengurusan bencana daripada pendekatan yang bersifat reaktif kepada pengurusan risiko yang lebih proaktif (Trut & Kovacevic 2022). Peningkatan corak cuaca yang ekstrem akibat daripada perubahan iklim ini berisiko untuk meningkatkan kejadian banjir puing. Cuaca ektrem menghasilkan hujan berintensiti tinggi dan berpanjangan berpotensi meningkatkan hakisan dan ketidakstabilan cerun menggalakan pembentukan bencana geologi ini (Mariatul Kiftiah Ahmad Legiman et al. 2023; Turkington et al. 2016). Banjir puing berbeza dengan banjir biasa kerana lebih dikenali sebagai aliran hiperpekat membawa aliran puing dengan kandungan air yang banyak (Ilinca 2021). Ia adalah fenomena yang berlaku di kawasan tebing tanah tinggi melalui saluran yang curam dan berpotensi mengganggu dasar aliran cerun ke sungai (Baggio et al. 2024; Church and Jakob 2020; Xu & Wang 2025). Pergerakannya yang sangat dasyat boleh menyebabkan kehilangan nyawa, kerosakan infrastruktur dan harta benda, kerugian ekonomi serta alam sekitar yang besar dalam sekelip mata sahaja (Sati & Kumar 2022). Selaras dengan perkembangan tersebut, Kerangka Sendai bagi Pengurangan Risiko Bencana (Sendai Framework for Disaster Risk Reduction, SFDRR) yang diperkenalkan pada tahun 2015 telah menjadi rujukan utama dalam memperkukuh kesiapsiagaan dan kapasiti agensi tindak balas bencana di peringkat antarabangsa (Maly & Suppasri 2020). Di Malaysia, komitmen terhadap transformasi pengurusan bencana telah diterjemahkan melalui pewujudan Agensi Pengurusan Bencana Negara (NADMA) pada tahun 2015 sebagai agensi peneraju utama pengurusan bencana negara serta pengemaskinian mekanisme pengurusan bencana menerusi Arahan NADMA No. 1 pada 2024. Dalam konteks ini, Polis Diraja Malaysia (PDRM) merupakan antara agensi tindak balas utama yang memainkan peranan penting dalam operasi menyelamat, pemindahan mangsa, kawalan keselamatan dan penyelarasan di lapangan. Keperluan untuk meningkatkan kesiapsiagaan menjadi semakin kritikal apabila berhadapan dengan ancaman banjir puing Oleh itu, kesiapsiagaan PDRM perlu dinilai berdasarkan ciri-ciri khusus banjir puing bagi memastikan keberkesanan tindak balas kecemasan. Sehubungan dengan itu, kajian ini memberi tumpuan kepada tahap kesiapsiagaan PDRM dalam menangani ancaman banjir puing di Bentong, Pahang.

2. PERMASALAHAN KAJIAN DAN SOROTAN KAJIAN

Polis merupakan antara barisan hadapan yang memainkan peranan penting dalam pengurusan bencana, khususnya dalam melaksanakan operasi mencari dan menyelamat, memastikan keselamatan awam, ketenteraman awam, mengurus pemindahan mangsa serta menyokong penyelarasan operasi kecemasan (Blaustein et al. 2023; Luong 2021). Di Malaysia, PDRM merupakan antara agensi tindak balas utama yang melaksanakan fungsi-fungsi tersebut seperti

yang digariskan di bawah Arahan NADMA No.1. Selain sebagai penyelamat, PDRM juga dilantik sebagai Komander Operasi Bencana (KOB) untuk koordinasikan pelbagai agensi tindak balas bagi menyelaras operasi di lapangan semua kategori bencana (NADMA 2024). Kejadian banjir puing di Bentong Pahang pada tahun 2021 telah menyebabkan 12 nyawa terkorban yang mana 2 mangsa masih lagi belum ditemui sehingga hari ini. Kerosakan harta benda termasuk trauma penduduk turut menjadi impak kejadian ini. IbuPejabat Polis Daerah Bentong merekodkan sejumlah 5679 repot polis telah dibuat untuk kes banjir puing yang berlaku pada tahun 2021 (IPD Bentong 2021). Bencana geologi ini memberi cabaran besar kepada PDRM dari segi pengetahuan dan sumber yang sesuai. Kejadian banjir puing yang pantas menuntut tahap kesiapsiagaan PDRM yang lebih khusus berbanding banjir biasa. Ini kerana tindak balas terhadap bencana geologi seperti banjir puing ini lebih berisiko berbanding tindak balas terhadap banjir biasa. Oleh itu, tahap kesiapsiagaan PDRM menjadi faktor yang sangat kritikal dalam menentukan keberkesanan tindak balas di lapangan. Sebarang kesilapan yang berlaku sewaktu operasi bencana boleh menyebabkan nyawa mangsa dan mereka sendiri dalam bahaya (Noraini Omar Chong & Khairul Hisyam Kamarudin 2018). Situasi ini terjadi apabila mendapati PDRM tidak dapat bertindak balas dengan berkesan terhadap banjir puing kerana masih kurang panduan kesiapsiagaan yang jelas. Di sini terhasilnya satu garis halus yang berhubungan di antara proses tindak balas dengan kesiapsiagaan sekaligus mewujudkan jurang pengetahuan yang perlu diisi. Melihat kepada peranan dan tanggungjawab PDRM yang begitu besar ini, tahap kesiapsiagaan pasukan polis dalam menghadapi ancaman banjir puing perlulah dalam keadaan terbaik dan berfokus. Permasalahan utama yang dikenal pasti ialah ketidakjelasan mengenai elemen-elemen spesifik yang membentuk komponen kesiapsiagaan polis dalam menangani ancaman banjir puing. Kesiapsiagaan polis terhadap bencana juga terhad di dalam literatur dan penulisan akademik serta sebahagian besarnya diabaikan dan tidak diberi perhatian (Luong 2021; Parvez Hayat 2017). Keadaan ini mewujudkan satu jurang pengetahuan dalam penulisan akademik melibatkan institusi kepolisan termasuk PDRM dalam pengurusan bencana untuk meningkatkan kesiapsiagaan menghadapi bencana kompleks.

3. OBJEKTIF KAJIAN

1) Mengenal pasti elemen khusus kesiapsiagaan Polis Diraja Malaysia dalam menangani ancaman banjir puing di Bentong, Pahang.

4. KAEDAH KAJIAN

Lokasi kajian adalah di daerah Bentong, Pahang berdasarkan kajian kes banjir puing yang berlaku pada tahun 2021. Daerah Bentong, Pahang juga dipilih sebagai lokasi kajian kerana terletak di kawasan pergunungan yang mempunyai risiko berlakunya banjir puing pada masa hadapan (Henao Salgado, Alfonso & Vélez Upegui 2025); Pinos & Timbe, 2020). Metodologi kajian menggunakan kaedah kualitatif melalui pendekatan kajian kes (Othman Lebar 2023; Regmi 2024). Populasi kajian adalah terdiri daripada keanggotaan PDRM. Proses ini melibatkan 14 informan yang diambil daripada mereka yang bertugas di Ibu Pejabat Daerah Polis Bentong, Pahang. Pemilihan sampel ini menggunakan teknik sampel bertujuan daripada kalangan Pegawai Kanan Polis (PKP) dan Pegawai Rendah Polis (PRP). Kesemua sampel ini dipilih oleh IPD Bentong dari kalangan mereka yang berpengalaman dalam pengurusan dan operasi lapangan menangani banjir puing tahun 2021. Pengumpulan data kajian telah dijalankan dengan menggunapakai kaedah perbincangan kumpulan fokus (FGD) yang dibuat sebanyak dua (2) kali melibatkan tujuh (7) informan untuk satu kumpulan perbincangan. Proses

yang dilaksanakan melibatkan dua (2) kategori berbeza iaitu PKP dan PRP supaya data lebih jelas dengan mendapatkan pandangan silang di antara pengurusan dan anggota lapangan (Sim & Waterfield 2019). Perbincangan telah menggunakan soalan terbuka dan fleksibel supaya jawapan yang diperoleh lebih berfokus kepada objektif kajian (Othman Lebar 2023). Selesai pengumpulan data, rakaman perbincangan diterjemahkan ke dalam transkrip untuk tujuan analisis (Thompson 2022). Kemudian data-data diekstrak untuk mencungkil elemen-elemen yang dikenalpasti menggunakan perisian Nvivo 15. Kelulusan Jawatankuasa Etika Universiti (JEP-2025-1243) juga diperoleh sebelum ke lapangan. Persetujuan bertulis termasuk pengkodan kepada setiap informan telah diwujudkan untuk mewakili identiti sebenar (Elliott 2018).

5. KEPUTUSAN DAN PERBINCANGAN

Hasil kajian dihuraikan mengikut beberapa elemen yang telah dikenalpasti melalui analisis menggunakan perisian NVivo 15. Empat (4) elemen utama telah dikenal pasti dalam pengumpulan data yang dibuat untuk mempersiapkan PDRM ke arah kesiapsiagaan bagi menangani ancaman banjir puing iaitu pengetahuan risiko bencana, kemahiran sumber manusia, kesesuaian logistik dan kepentingan koordinasi antara agensi. Elemen pertama iaitu pengetahuan risiko bencana (93%) banjir puing merupakan salah satu komponen penting kepada kesiapsiagaan PDRM. Pengetahuan mengenai punca dan kesan bencana merupakan pengetahuan asas yang perlu ada dan mencerminkan kekuatan kognitif yang terdapat di kalangan majoriti informan. Elemen kedua berkenaan kemahiran sumber manusia (93%) pula mendedahkan bahawa terdapat beberapa kekurangan kritikal dalam latihan dan kursus terutamanya seperti penyelamatan di air deras, penggunaan peralatan menyelamat, komunikasi serta pengurusan bencana. Elemen ketiga yang diperoleh iaitu kesesuaian sumber logistik (85%) di lapangan seperti kenderaan lasak yang sesuai, peralatan menyelamat serta komunikasi menekankan bahawa keupayaan operasi PDRM bergantung pada sistem mobilisasi dan komunikasi yang berkesan. Manakala mesyuarat awal bersama, pembahagian tugas di lapangan serta mesyuarat strategik awal berfungsi sebagai kekuatan utama untuk koordinasi antara agensi (70%) yang merupakan elemen keempat yang dikenalpasti untuk kesiapsiagaan menangani banjir puing. Dimensi elemen yang saling berkaitan ini membentuk satu rangka kerja asas yang menyokong kesiapsiagaan PDRM serta meningkatkan keupayaan organisasi untuk pengurusan bencana yang lebih cekap dan berkesan. Kajian ini telah mengenal pasti beberapa elemen yang berasaskan data memberikan asas yang tersusun untuk membimbing kesiapsiagaan PDRM menangani kejadian banjir puing dalam pelbagai konteks. Walaupun terdapat sedikit perbezaan pandangan, namun perbincangan kedua FGD menunjukkan penekanan yang sama terhadap tema yang dibincangkan.

6. KESIMPULAN

Kesimpulannya, kesiapsiagaan PDRM dalam pengurusan bencana untuk menangani banjir puing tidak seharusnya dilihat hanya sebagai tindak balas selepas bencana berlaku tetapi lebih kepada proses yang sistematik bermula pada fasa sebelum bencana. Penemuan kajian ini yang mengenal pasti elemen khusus dalam empat komponen kesiapsiagaan mempunyai hubungan dan saling melengkapi antara satu sama lain. Secara asasnya kajian ini telah menemui bahawa peningkatan tahap kesiapsiagaan memerlukan perubahan yang lebih berstruktur melalui panduan operasi yang jelas dan tidak hanya bergantung pada tindakan semasa krisis semata. Ini memberi erti yang pengetahuan dan pengalaman operasi di lapangan boleh diterjemahkan

menjadi panduan yang boleh difahami dan dipraktikkan oleh semua peringkat keanggotaan PDRM. Tambahan lagi, penyelarasan yang cekap bagi mengelakkan kekeliruan serta pertindihan peranan dan aset juga merupakan faktor kepada kesiapsiagaan yang baik. Penemuan kajian ini wajar ditafsir sebagai salah satu instrumen untuk mengemas kini garis panduan operasi PDRM bagi menangani ancaman bencana banjir puing. Namun begitu, kajian kualitatif yang dicadangkan ini hanya melibatkan hasil awal yang dibina berdasarkan dapatan kajian melibatkan IPD Bentong sahaja. Kerangka ini masih memerlukan pengesahan kajian yang lebih lanjut melibatkan sampel, lokasi dan konteks yang lebih meluas. Cadangan penyelidik supaya kajian lanjutan dibuat secara lebih meluas selepas ini melibatkan PDRM di peringkat pusat dan negeri serta dibuat secara penyelidikan campur.

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PENILAIAN PELAKSANAAN GOVERNANS BAIK DALAM PROSES PENILAIAN IMPAK ALAM SEKITAR (*EIA*) DI MALAYSIA BERDASARKAN LAPAN PRINSIP *UNESCAP*

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1. PENGENALAN

Penilaian Impak Alam Sekitar (*Environmental Impact Assessment, EIA*) merupakan instrumen perancangan alam sekitar yang berperanan mengintegrasikan pertimbangan alam sekitar ke dalam proses membuat keputusan sesuatu projek pembangunan. Di Malaysia, *EIA* diwajibkan di bawah Seksyen 34A, Akta Kualiti Alam Sekeliling 1974 [Akta 127] dan Perintah Kualiti Alam Sekeliling (Aktiviti yang Ditetapkan) (Penilaian Kesan kepada Alam Sekeliling) 2015. Sejak diperkenalkan pada tahun 1987, pengurusan *EIA* telah melalui pelbagai penambahbaikan dari aspek perundangan, prosedur dan pentadbiran. Walau bagaimanapun, keberkesanan pengurusan *EIA* tidak wajar dinilai semata-mata berdasarkan pematuhan terhadap keperluan prosedur dan teknikal, sebaliknya perlu turut dilihat dari perspektif governans institusi yang mendasari proses membuat keputusan, penglibatan pihak berkepentingan dan pelaksanaan tanggungjawab kawal selia.

Kerangka lapan Prinsip Governans Baik yang diperkenalkan oleh *United Nations Economic and Social Commission for Asia and the Pacific (UNESCAP),* iaitu penyertaan, kedaulatan undang-undang, ketelusan, responsif, orientasi konsensus, kesaksamaan dan inklusiviti, keberkesanan dan kecekapan serta kebertanggungjawaban, sesuai digunakan untuk menilai pengurusan *EIA* kerana prinsip-prinsip tersebut merangkumi ciri asas proses pentadbiran dan pembuatan keputusan yang berkualiti. Dalam konteks *EIA*, prinsip tersebut dapat digunakan untuk meneliti bagaimana maklumat disediakan, pihak berkepentingan dilibatkan, keputusan dibuat berdasarkan peruntukan undang-undang, tanggungjawab institusi ditetapkan serta tindakan susulan dan pemantauan dilaksanakan (*UNESCAP* 2009). Justeru, kerangka ini menyediakan asas analisis yang sistematik untuk menilai pengurusan *EIA* dari perspektif governans institusi.

2. PERNYATAAN MASALAH DAN SOROTAN LITERATUR

Walaupun Malaysia mempunyai kerangka perundangan dan institusi yang mantap dalam pelaksanaan *EIA*, literatur terdahulu menunjukkan bahawa beberapa dimensi governans masih memerlukan perhatian, khususnya berkaitan penyertaan awam, ketelusan proses membuat keputusan, kebertanggungjawaban institusi, pemantauan pasca-kelulusan dan penyelarasan antara agensi. Sebagai contoh, Loh et al. (2023) meneliti isu penyertaan awam dalam undang-undang *EIA* di Malaysia. Perbincangan berkaitan governans alam sekitar pula menunjukkan kepentingan kualiti institusi dan governans terhadap pencapaian hasil alam sekitar (Azimi et al. 2023). Walau bagaimanapun, bukti tersebut masih belum memberikan gambaran yang menyeluruh tentang pelaksanaan kesemua lapan prinsip governans baik dalam pengurusan *EIA* oleh institusi pengawalseliaan.

Sorotan literatur juga menunjukkan kecenderungan kajian terdahulu untuk menilai dimensi governans tertentu secara berasingan, seperti ketelusan, penyertaan atau kebertanggungjawaban, serta memberi tumpuan kepada perspektif pihak berkepentingan luaran. Oleh itu, terdapat jurang dari segi penilaian yang mengintegrasikan kesemua lapan prinsip *UNESCAP* dalam satu kerangka analisis dan mengaplikasikannya secara khusus terhadap pengurusan *EIA* oleh Jabatan Alam Sekitar Malaysia sebagai institusi pengawalseliaan utama. Kajian ini berusaha mengisi jurang tersebut dengan menganalisis bagaimana elemen-elemen lapan prinsip tersebut diterjemahkan dalam dokumen perundangan, dasar dan pentadbiran yang membentuk pengurusan *EIA*.

3. OBJEKTIF KAJIAN

Objektif kajian yang dibentangkan dalam kolokium ini adalah untuk menentukan tahap pelaksanaan lapan Prinsip Governans Baik *UNESCAP* dalam pengurusan Penilaian Impak Alam Sekitar oleh Jabatan Alam Sekitar Malaysia.

4. KAEDAH PENYELIDIKAN

Kajian ini menggunakan pendekatan kualitatif melalui reka bentuk kajian kes dengan Ibu Pejabat Jabatan Alam Sekitar Malaysia di Putrajaya sebagai lokasi kajian. Bagi tujuan pembentangan kolokium ini, analisis difokuskan kepada analisis dokumen bagi mencapai objektif pertama. Dokumen yang dianalisis merangkumi Akta Kualiti Alam Sekeliling 1974, Perintah Kualiti Alam Sekeliling (Aktiviti Yang Ditetapkan) (Penilaian Kesan Kepada Alam Sekeliling) 2015, *Environmental Impact Assessment (EIA) Guidelines* in Malaysia 2016, *Guidelines on Pollution Prevention in Industrial Siting 2025,* Sistem pendaftaran dan pensijilan Certified Qualified *EIA* Consultant, Sistem Pemantauan *EIA (SPEIA), Environmental Mainstreaming Directive on Guided Self-Regulation (GSR)* dan Garis Panduan Kawasan Sensitif Alam Sekitar (KSAS). Pemilihan dokumen dibuat berdasarkan kerelevanan langsung terhadap fungsi pengawalseliaan *EIA* dan keupayaannya memberikan bukti mengenai pelaksanaan prinsip governans.

Analisis dokumen dilaksanakan secara tematik dan deduktif dengan menggunakan lapan Prinsip Governans Baik *UNESCAP* sebagai kategori analisis utama. Setiap dokumen diteliti bagi mengenal pasti peruntukan, prosedur, mekanisme dan tanggungjawab institusi yang menunjukkan elemen penyertaan, kedaulatan undang-undang, ketelusan, responsif, orientasi konsensus, kesaksamaan dan inklusiviti, keberkesanan dan kecekapan serta kebertanggungjawaban. Analisis perbandingan antara dokumen digunakan untuk mengenal pasti keselarasan dan jurang pelaksanaan. Temu bual separa berstruktur dengan lima orang pegawai daripada Bahagian Penilaian JAS merupakan komponen kajian keseluruhan, namun data temu bual tidak dibentangkan dalam abstrak ini kerana fokus kolokium adalah kepada dapatan analisis dokumen.

5. HASIL KAJIAN DAN PERBINCANGAN

Analisis dokumen menunjukkan bahawa kesemua lapan Prinsip Governans Baik *UNESCAP* mempunyai elemen yang dapat dikenal pasti dalam pengurusan *EIA* di JAS. Prinsip penyertaan dapat ditelusuri melalui peruntukan dan proses yang membuka ruang kepada penglibatan pihak berkepentingan dalam proses *EIA*. Prinsip kedaulatan undang-undang pula ditunjukkan melalui kebergantungan pengurusan *EIA* kepada peruntukan akta, peraturan, garis panduan dan prosedur yang menetapkan keperluan serta tanggungjawab kawal selia. Ketelusan dapat

dikaitkan dengan penyediaan maklumat, prosedur dan proses yang membolehkan pihak berkepentingan memahami keperluan serta keputusan berkaitan *EIA*.

Bagi prinsip responsif, dokumen menunjukkan kewujudan mekanisme dan prosedur bagi mempertimbangkan isu, komen serta keperluan berkaitan alam sekitar dalam proses pengurusan *EIA*. Orientasi konsensus pula dapat dilihat melalui proses pertimbangan terhadap pandangan dan kepentingan pihak berkepentingan dalam proses penilaian dan pembuatan keputusan. Prinsip kesaksamaan dan inklusiviti berkait dengan keperluan mengambil kira pihak yang terjejas serta kepentingan sosial dan alam sekitar dalam proses *EIA*. Sementara itu, keberkesanan dan kecekapan tercermin melalui struktur tanggungjawab, prosedur penilaian, proses pembuatan keputusan dan pengaturan pemantauan pasca-kelulusan. Kebertanggungjawaban pula ditunjukkan melalui penetapan peranan, tanggungjawab dan kawalan institusi terhadap pelaksanaan proses *EIA*.

Secara keseluruhannya, dapatan analisis dokumen menunjukkan bahawa lapan prinsip tersebut tidak berfungsi secara terasing, sebaliknya saling berkaitan dalam membentuk pengurusan *EIA* yang berasaskan governans. Dapatan ini menyokong pandangan *UNESCAP* (2009) bahawa prinsip governans baik merupakan ciri yang saling melengkapi dalam membentuk proses pentadbiran yang berkualiti. Dapatan ini juga selari dengan Loh et al. (2023) yang menekankan kepentingan penyertaan awam dalam konteks *EIA* di Malaysia, di samping memperluas perbincangan tersebut melalui analisis yang mengintegrasikan lapan prinsip governans dalam perspektif institusi pengawalseliaan.

Walau bagaimanapun, dapatan ini hendaklah ditafsirkan sebagai dapatan awal berdasarkan analisis dokumen. Analisis temu bual dalam kajian keseluruhan akan digunakan pada peringkat seterusnya untuk memperkukuh pemahaman tentang bagaimana prinsip-prinsip tersebut dilaksanakan dalam amalan. Oleh itu, abstrak ini tidak membuat kesimpulan muktamad tentang hubungan sebab-akibat antara pelaksanaan prinsip governans dengan keberkesanan pengurusan *EIA*.

6. KESIMPULAN

Analisis dokumen menunjukkan bahawa lapan Prinsip Governans Baik *UNESCAP* dapat digunakan sebagai kerangka bersepadu untuk menilai pelaksanaan governans dalam pengurusan *EIA* oleh Jabatan Alam Sekitar Malaysia. Elemen penyertaan, kedaulatan undang-undang, ketelusan, responsif, orientasi konsensus, kesaksamaan dan inklusiviti, keberkesanan dan kecekapan serta kebertanggungjawaban dapat dikenal pasti dalam peruntukan perundangan, dasar, garis panduan dan pengaturan pentadbiran *EIA*. Pendekatan ini memberikan perspektif yang lebih menyeluruh terhadap pengurusan *EIA* berbanding penilaian yang hanya berasaskan pematuhan prosedur.

Pada peringkat kajian semasa, dapatan adalah bersifat awal dan terhad kepada analisis dokumen. Kajian ini berpotensi menyumbang kepada bidang governans alam sekitar dengan memperlihatkan aplikasi kerangka *UNESCAP* secara bersepadu dalam konteks pengurusan *EIA* Malaysia. Dari perspektif dasar dan amalan, pendekatan ini berpotensi membantu mengenal pasti ruang penambahbaikan berkaitan ketelusan, penyertaan pihak berkepentingan, kebertanggungjawaban, penyelarasan antara agensi dan pemantauan pasca-kelulusan. Kajian ini khususnya berkaitan dengan SDG 16 (Keamanan, Keadilan dan Institusi yang Kukuh), yang menekankan institusi yang berkesan, bertanggungjawab dan inklusif, serta berpotensi

menyokong SDG 17 (Perkongsian untuk Matlamat) melalui pengukuhan kerjasama dan penyelarasan antara institusi dan pihak berkepentingan.

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PERTANIAN BANDAR SEBAGAI ALAT INTERVENSI SOSIO-SPATIAL DALAM MEMBENTUK KOMUNITI BANDAR BERDAYA HUNI: KAJIAN KES PENDUDUK KUALA LUMPUR

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1. PENGENALAN

Proses perbandaran yang pesat meningkatkan tekanan terhadap daya huni bandar melalui cabaran fizikal, alam sekitar, ekonomi, sosial dan tadbir urus yang saling berkaitan. Malaysia terus mengalami tahap perbandaran yang tinggi, dengan sebahagian besar penduduk tertumpu di kawasan bandar pada tahun 2025 (United Nations 2025). Dalam konteks nasional ini, Kuala Lumpur dianggarkan mempunyai 2.1 juta penduduk dan kekal sebagai wilayah paling padat di Malaysia, dengan kepadatan 8,546 orang bagi setiap kilometer persegi pada tahun 2025 (Jabatan Perangkaan Malaysia 2025). Konteks perbandaran yang padat ini mengukuhkan keperluan terhadap pendekatan perancangan yang melangkaui penyediaan infrastruktur dan pencapaian indeks makro dengan turut merangkumi pengalaman penduduk terhadap ruang kejiranan, hubungan sosial dan keupayaan kolektif membentuk persekitaran tempat tinggal (Leh et al. 2020; Mouratidis 2021). Pertanian bandar semakin diiktiraf sebagai intervensi pelbagai fungsi yang berpotensi mengaktifkan ruang, menyokong akses kepada makanan, meningkatkan kualiti persekitaran dan memperkukuh interaksi sosial (Murdad et al. 2022; Pradhan et al., 2024). Kajian ini memposisikan pertanian bandar berasaskan komuniti sebagai alat intervensi sosio-spatial yang menghubungkan pengaktifan ruang fizikal dengan proses sosial komuniti. Secara konseptual, Pertanian Bandar (PB) ialah alat intervensi sosio-spatial, Pemberdayaan Komuniti (PK) ialah mekanisme pengantara manakala Komuniti Bandar Berdaya Huni (KBBH) ialah hasil yang diteliti.

2. PERMASALAHAN KAJIAN DAN SOROTAN KAJIAN

Literatur menunjukkan bahawa pertanian bandar berpotensi menyumbang kepada kelestarian alam sekitar, keselamatan makanan, manfaat sosioekonomi dan kesejahteraan sosial komuniti (Ilieva et al., 2022; Pradhan et al., 2024). Namun, manfaat tersebut lazimnya dinilai secara berasingan, sedangkan mekanisme yang menerangkan bagaimana pertanian bandar menyumbang kepada pembentukan komuniti bandar berdaya huni masih kurang diuji secara empirikal dan bersepadu. Dalam konteks Kuala Lumpur, empat permasalahan yang saling berkaitan membentuk rasional kajian. Pertama, tekanan pembangunan dan persaingan guna tanah mengehadkan penyediaan, akses dan pengaktifan ruang hijau sebagai ruang sosial dan produktif komuniti (Dewan Bandaraya Kuala Lumpur, 2023; Ishak et al., 2022). Kedua, tekanan kos sara hidup dan kerentanan akses makanan mengukuhkan keperluan terhadap pendekatan yang menyokong keselamatan makanan dan manfaat sosioekonomi, dengan pertanian bandar sebagai pelengkap kepada sistem bekalan makanan bandar yang lebih luas (Murdad et al., 2022; Huq & Deacon, 2025). Ketiga, penyertaan dalam pertanian bandar tidak semestinya menghasilkan pemberdayaan secara automatik kerana hubungan antara penyertaan, modal sosial dan pemberdayaan bergantung pada bentuk penglibatan serta hubungan komuniti dengan institusi dan pihak berkepentingan (Nazuri et al., 2022, 2025). Keempat, keberkesanan

dan kesinambungan pertanian bandar dipengaruhi oleh akses kepada tanah dan sumber, pembiayaan, komitmen peserta, sokongan institusi, kejelasan peranan serta penyelarasan antara pihak berkepentingan (Ishak et al., 2022; Omar Chong et al., 2024). Kajian tempatan telah meneliti cabaran pelaksanaan, penyertaan, modal sosial dan pemberdayaan, namun bukti masih terhad dalam menjelaskan secara bersepadu hubungan PB, PK dan KBBH. Permasalahan teras kajian ini ialah kekurangan bukti empirikal yang menjelaskan bagaimana, melalui mekanisme apa dan dalam keadaan pelaksanaan yang bagaimana pertanian bandar dapat menyumbang kepada pembentukan komuniti bandar berdaya huni di Kuala Lumpur. Jurang mekanisme ini signifikan kerana kewujudan ruang kebun, penghasilan tanaman atau penyertaan dalam aktiviti tidak semestinya diterjemahkan kepada hasil daya huni tanpa pembentukan kapasiti, agensi, jaringan, akses kepada sumber dan tindakan kolektif komuniti. Oleh itu, kajian ini menguji hubungan PB–PK–KBBH berasaskan pengalaman penduduk Kuala Lumpur, manakala fasa kualitatif menjelaskan mekanisme dan keadaan pelaksanaan yang mendasari dapatan kuantitatif sebagai asas pembangunan dan pemurnian kerangka strategi.

3. OBJEKTIF KAJIAN

Kajian keseluruhan mempunyai empat objektif. Bagi kolokium ini, pelaporan memberi tumpuan kepada dapatan kuantitatif bagi tiga objektif pertama, iaitu: (i) mengenal pasti peranan PB dalam mengaktifkan ruang hijau sebagai ruang sosial dan produktif; (ii) menilai sumbangan PB terhadap keselamatan makanan dan manfaat sosioekonomi; dan (iii) menguji peranan PK sebagai pengantara dalam hubungan PB dengan KBBH. Dapatan bagi ketiga-tiga objektif ini seterusnya dijelaskan dan diperincikan melalui fasa kualitatif sebelum diintegrasikan sebagai asas kepada pembangunan dan pemurnian kerangka strategi bagi Objektif 4.

4. KAEDAH KAJIAN

Kajian ini menggunakan reka bentuk kaedah campuran berurutan penjelasan (explanatory sequential mixed methods) dengan fasa kuantitatif diikuti fasa kualitatif eksplanatori dan integrasi dapatan (Creswell & Plano Clark, 2018). Fasa kuantitatif menggunakan soal selidik berstruktur dan persampelan bertujuan berasaskan kriteria iaitu melibatkan penduduk dewasa berumur 18 tahun dan ke atas yang menetap di Kuala Lumpur serta terlibat secara langsung atau tidak langsung dengan pelaksanaan kebun atau aktiviti pertanian bandar berasaskan komuniti. Pembangunan instrumen merangkumi semakan kandungan oleh pakar, prapengujian kefahaman terhadap 20 penduduk dan kajian rintis melibatkan 100 responden. Set data akhir merangkumi 390 respons sah yang dikaitkan dengan 42 kebun atau projek pertanian bandar di kesemua 11 kawasan Parlimen Kuala Lumpur. Objektif 1 dan 2 dianalisis menggunakan statistik deskriptif berdasarkan purata dan sisihan piawai, manakala Objektif 3 dianalisis melalui Pemodelan Persamaan Berstruktur Kuasa Dua Terkecil Separa (PLS-SEM) menggunakan SmartPLS 4 untuk menilai model pengukuran, model struktur, saiz kesan, pengantaraan dan keupayaan ramalan. Pengujian inferensi menggunakan pensampelan semula (bootstrapping) sebanyak 10,000 subsampel, ujian dua hala, aras keertian 0.05 dan selang keyakinan 95% dengan pembetulan bias (Hair et al., 2022). Fasa kualitatif melibatkan 17 informan yang dipilih secara bertujuan berdasarkan kelayakan, pengalaman, kepakaran, penglibatan langsung dan peranan strategik; kecukupan sampel dipandu oleh prinsip kuasa maklumat (Malterud et al., 2016; Hennink & Kaiser, 2022). Dapatan bagi ketiga-tiga objektif ini seterusnya dijelaskan dan diperincikan melalui fasa kualitatif sebelum diintegrasikan

sebagai asas kepada pembangunan kerangka strategi yang dimurnikan melalui perbincangan kumpulan fokus bagi mencapai Objektif 4.

5. KEPUTUSAN DAN PERBINCANGAN

Model pengukuran akhir merangkumi 52 indikator (18 PB, 17 PK dan 17 KBBH) dan memenuhi kriteria kebolehpercayaan serta kesahan (alfa Cronbach = 0.945–0.966; rho_A = 0.949–0.967; kebolehpercayaan komposit = 0.951–0.969; AVE = 0.522–0.647; HTMT = 0.759–0.829), sekali gus mengesahkan bahawa ketiga-tiga konstruk dapat dibezakan secara empirikal. Bagi Objektif 1, PB berada pada tahap tinggi (purata = 3.902; sisihan piawai = 0.699). Dimensi Pengaktifan Ruang Sosial dan Produktif mencatatkan purata tertinggi (3.957), manakala Sokongan Institusi/Agensi terendah (3.846) namun kedua-duanya berada pada tahap tinggi. Dapatan ini menunjukkan bahawa penduduk menilai PB bukan sekadar sebagai aktiviti penanaman, tetapi sebagai pengaktifan ruang kejiranan yang menggabungkan fungsi sosial dan produktif, di samping menunjukkan ruang untuk memperkukuh sokongan institusi. Bagi Objektif 2, dimensi Sosioekonomi dan Keselamatan Makanan turut berada pada tahap tinggi (purata = 3.997; sisihan piawai = 0.801), dengan persepsi positif terhadap akses hasil tanaman, perkongsian sumber, pembelajaran kemahiran dan manfaat sosioekonomi. Kedudukannya yang relatif lebih rendah berbanding dimensi KBBH lain menunjukkan bahawa manfaat makanan dan sosioekonomi penting, tetapi bukan satu-satunya sumbangan PB terhadap daya huni. Bagi Objektif 3, analisis menunjukkan bahawa PK merupakan mekanisme pengantara penting dalam hubungan PB dengan KBBH. Semua hubungan langsung adalah positif dan signifikan. PB→PK merupakan laluan paling kuat ($\beta = 0.795$, $t = 22.052$, $p < 0.001$), diikuti PK→KBBH ($\beta = 0.559$, $t = 8.227$, $p < 0.001$) dan PB→KBBH ($\beta = 0.288$, $t = 4.310$, $p < 0.001$). PB menerangkan 63.2% varians PK ($R^2 = 0.632$), manakala PB bersama-sama PK menerangkan 65.2% varians KBBH ($R^2 = 0.652$). Saiz kesan PB→PK adalah besar ($f^2 = 1.715$), PK→KBBH sederhana ($f^2 = 0.331$) dan PB→KBBH kecil ($f^2 = 0.088$). Kesan tidak langsung PB→PK→KBBH juga positif dan signifikan ($\beta = 0.444$, $t = 9.068$, $p < 0.001$; 95% CI [0.345, 0.537]) serta lebih besar daripada kesan langsung PB→KBBH, dengan kesan keseluruhan $\beta = 0.733$. Nilai VAF sebanyak 60.6% menunjukkan pengantaraan separa komplementari oleh PK, iaitu bahagian substantif hubungan PB dengan KBBH diterangkan melalui PK sementara laluan langsung PB→KBBH kekal signifikan. Dengan itu, kesemua hipotesis hubungan langsung dan pengantaraan yang diuji adalah disokong. Prestasi ramalan turut menyokong model, dengan kesemua 34 indikator endogen mencatatkan Q^2predict positif antara 0.212 hingga 0.468, manakala PLS-SEM menghasilkan RMSE lebih rendah daripada model linear bagi 32 daripada 34 indikator. Secara substantif, PB berkait dengan KBBH bukan sahaja secara langsung, tetapi turut melalui pemberdayaan komuniti, khususnya kapasiti, agensi, jaringan, akses kepada sumber dan tindakan kolektif. Pola ini selari dengan kajian tempatan tentang penyertaan, modal sosial dan pemberdayaan komuniti pertanian bandar (Nazuri et al., 2022, 2025), serta memperluas pemahaman tersebut dengan menunjukkan secara empirikal peranan PK sebagai mekanisme pengantara antara PB dengan KBBH. Oleh sebab reka bentuk kuantitatif bersifat keratan rentas, hubungan ini tidak ditafsirkan sebagai bukti sebab-akibat.

6. KESIMPULAN

Berdasarkan dapatan kuantitatif bagi tiga objektif pertama, PB dinilai tinggi dalam mengaktifkan ruang sosial dan produktif, manakala sumbangan terhadap keselamatan makanan dan manfaat sosioekonomi turut berada pada tahap tinggi. Penemuan utama ialah PK

berperanan sebagai pengantara yang signifikan dalam hubungan PB dengan KBBH, menunjukkan bahawa hubungan PB dengan daya huni bukan sekadar bersifat langsung, tetapi turut beroperasi melalui mekanisme pemberdayaan komuniti. Secara konseptual, PB ialah alat intervensi sosio-spatial, PK ialah mekanisme pengantara dan KBBH ialah hasil yang diteliti. Secara praktikal, pelaksanaan PB perlu melangkaui penyediaan tapak dan input dengan menyokong pembangunan kapasiti, kepimpinan inklusif, jaringan, akses kepada sumber dan tindakan kolektif komuniti. Fasa kualitatif seterusnya memperincikan mekanisme dan keadaan pelaksanaan, sebelum dapatan kedua-dua fasa diintegrasikan untuk membangunkan dan memurnikan kerangka strategi bagi Objektif 4. Secara keseluruhan, kajian menyediakan asas empirikal bagi strategi pelaksanaan pertanian bandar berasaskan pemberdayaan komuniti yang lebih responsif terhadap pembentukan komuniti bandar berdaya huni di Kuala Lumpur.

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BRIDGING THE GAP IN TEA CULTURE: AN EDUCATION-BASED STUDY OF TRADITIONAL AND NEW-STYLE TEA IN HANGZHOU, CHINA

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1. INTRODUCTION

China's traditional tea-processing techniques and associated social practices were inscribed on UNESCO's Representative List of the Intangible Cultural Heritage of Humanity in 2022 (UNESCO 2022). Hangzhou, home to Longjing tea and a major centre of China's digital economy, makes the tension between heritage preservation and commercial adaptation especially visible (Hangzhou Municipal Bureau of Statistics & Hangzhou Survey Office of the National Bureau of Statistics 2025). Traditional practice passes on knowledge through terroir, processing, brewing ritual and intergenerational participation. By contrast, new-style tea brands such as CHAGEE, MIXUE and HEYTEA centre on convenience, product innovation and digital purchasing. Commercial adaptation can keep tea visible in everyday urban life but may weaken links between consumption and the knowledge and practices through which tea culture is transmitted. At the same time, new-style tea may also encourage consumers to explore tea origins and traditional practices (Zhang et al. 2024).

This study therefore examines how education can connect contemporary tea consumption with cultural transmission. Purchasing patterns show how and where young people encounter tea; education may determine whether those encounters develop into cultural understanding and participation, thereby mediating between preservation and commercial adaptation. The study asks how learning content, access and format might reconnect heritage knowledge with contemporary consumption, while using commercial innovation as a possible channel for heritage learning. A comparable process has been documented in Hangzhou's handicraft heritage, where intergenerational transmission involves adaptation rather than simple replication (Wang et al. 2024).

2. PROBLEM STATEMENT

Hangzhou's tea culture shows three interrelated gaps. The knowledge gap separates the specialised meanings of traditional tea from many younger consumers' limited heritage knowledge, while specialist language may also deter novices (Shen & Su 2022). The accessibility gap reflects that new-style tea is embedded in everyday commercial and digital settings, while traditional tea offers fewer routine points of contact (Yin & Fang 2024). The consumption-habit gap concerns time, expenditure and setting: traditional participation generally requires longer visits and familiarity with formal conventions. Research on ready-to-drink tea shows that product attributes and perceived benefits shape enjoyment (Wang & Yu 2016), suggesting that routine-compatible formats may influence choice. When novices find few places to learn and traditional practice does not fit their routines, limited familiarity can persist. This combination may make specialist settings feel more distant even when interest exists. The gaps are thus better understood as connected than separate.

Existing educational approaches leave several of these gaps unresolved. Tea knowledge is often transmitted through families and apprenticeships (UNESCO 2022), while lecture- and reading-based teaching may not engage tea's sensory and social dimensions (Xu & Nur Husna 2025). Nor does such teaching match the places and routines through which many younger consumers encounter tea. These gaps suggest that a future education-based framework should combine plain-language heritage content, wider physical and digital access, and short experiential activities compatible with everyday routines. Short explanations combined with sensory practice could make introductory learning more accessible. A 40-participant VR experiment on dian cha provides supporting evidence from a related educational setting: the interactive group showed better knowledge acquisition and learning motivation than the passive-browsing group (Li & Zheng 2025).

3. OBJECTIVE

This research comprises four overall objectives aimed at developing an education-based framework to bridge traditional and new-style tea culture in Hangzhou. For this colloquium presentation, however, focus is placed on the first two completed objectives:

Objective 1: To assess the knowledge, accessibility, and consumption-habit gaps between traditional tea culture and new-style tea consumption in Hangzhou.

Objective 2: To analyse patterns in consumers' perceptions of traditional and new-style tea and their choices between the two across demographic groups in Hangzhou.

4. METHOD

An explanatory sequential mixed-methods design was used: Phase 1 quantitative analysis preceded Phase 2 qualitative explanation (Creswell & Plano Clark 2018). Phase 1 comprised 320 valid consumer questionnaires collected through convenience sampling in Hangzhou's shopping malls, school precincts, office areas and cultural sites. For Objective 1, descriptive statistics profiled each gap through measures of traditional-tea knowledge, perceived accessibility, consumption frequency, delivery-platform use, expenditure, purchase duration and routine compatibility. Each measure was analysed separately. For Objective 2, SPSS group means, frequencies and cross-tabulations were used to conduct a descriptive analysis of consumers' perceptions and choices across age and educational-attainment groups.

Phase 1 findings guided the purposive selection of contrasting participant groups and sites and shaped the Phase 2 interview questions. Phase 2 comprised 18 semi-structured interviews and observations at six purposively selected sites. Participants included students, tea-culture educators, industry practitioners, traditional teahouse owners and new-style tea shop employees. For Objective 1, interview themes and observations examined how knowledge expectations, location, digital access, time, expenditure and social norms contributed to the measured gaps. For Objective 2, interviews helped contextualise the demographic patterns observed in consumers' perceptions and choices. Qualitative data were coded thematically in NVivo. During interpretation, themes and observation notes were linked to the corresponding quantitative findings for each objective.

5. RESULTS AND DISCUSSION

Objective 1: Knowledge, accessibility, and consumption-habit gaps. For the knowledge gap, 22.7% of younger respondents named all six tea categories, and 61.2% felt intimidated entering traditional teahouses because they lacked specialist knowledge. For the accessibility gap, new-style tea was available through delivery platforms, whereas none of observed traditional teahouses offered delivery. Interviews and observations linked new-style shops with study and casual socialising but traditional teahouses with formal occasions. For the consumption-habit gap, a new-style tea purchase averaged 7.2 minutes versus 52.4 minutes for a traditional teahouse visit; schedule fit was cited more often than lower price (84.4% versus 12.5%). The results identify specialist presentation as a possible entry barrier (Shen & Su 2022), support the importance of convenience (Yin & Fang 2024), and add a temporal explanation to research on ready-to-drink tea motivations (Wang & Yu 2016). Taken together, the findings identify specialist knowledge demands, fewer everyday access points and lower routine compatibility as three dimensions of the gap between young consumers and traditional tea settings.

Objective 2: Demographic patterns in perceptions and tea choices. Age showed the clearest descriptive contrast. Respondents aged 18-25 averaged 4.2/15 in traditional-tea knowledge, compared with 11.8/15 among those aged 45 and above. The younger group consumed new-style tea 4.2 times weekly and traditional tea 0.3 times; the older group showed the reverse pattern, consistent with age differences in innovative tea adoption (Yin & Fang 2024). Educational attainment showed a less marked descriptive contrast: postgraduate respondents still consumed new-style tea 2.9 times weekly, and 68.4% of high-knowledge respondents chose it in daily routines, reflecting perceptions of greater accessibility and routine fit. Across the mixed stakeholder sample, 13 of 18 interviewees expressed interest in learning about traditional tea but reported few approachable opportunities. Their accounts suggest that new-style tea shops could provide accessible settings for introductory tea-culture activities. A survey of 384 Sichuan youths likewise found high knowledge and positive attitudes but only moderate heritage practice, with knowledge differing by age and education (Hu & Shuhaida 2026). The survey and interviews both distinguish knowing about heritage from having a practical route into it. Knowledge-based teaching alone may therefore be insufficient unless opportunities fit daily life.

6. CONCLUSION

For Objective 1, interviewees described feeling uncertain in formal tea settings when they lacked specialist tea knowledge. Survey and observational findings also showed that traditional tea offered fewer everyday physical and digital access points, while longer sessions fitted poorly with young people's routines. The analysis for Objective 2 identified demographic patterns in consumers' perceptions and choices. Age produced the clearest descriptive contrast in traditional-tea knowledge and tea choice, whereas higher educational attainment or tea knowledge did not consistently correspond to traditional-tea consumption. Interviewees often explained their preference for new-style tea in terms of limited opportunities for heritage participation rather than rejection of tradition. These findings provide an empirical basis for a future education-based framework combining accessible heritage content, wider physical and digital access, and short experiential activities that fit everyday routines.

The findings suggest four stakeholder-specific practical recommendations. First, local cultural institutions should bring youth events and digital micro-content to university and commercial precincts. Second, tea-culture education institutions should provide short, beginner-level, experiential modules. Third, schools and curriculum developers should embed tea history, processing, sensory practice, and cultural meaning in modular formal and informal learning. Finally, traditional teahouses and new-style tea brands should integrate brief heritage activities into new-style venues and create pathways to deeper teahouse experiences. These actions respond directly to the knowledge, accessibility, and consumption-habit gaps identified under Objective 1.

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PENDEKATAN GEOSPASIAL DALAM INTEGRASI KERENTANAN FIZIKAL DAN SOSIAL UNTUK PENILAIAN RISIKO TANAH RUNTUH DI LEMBANGAN SUNGAI LANGAT, MALAYSIA

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1. PENGENALAN

Tanah runtuh merupakan antara bencana geologi yang kerap berlaku di Malaysia dan memberi impak yang besar terhadap keselamatan penduduk, infrastruktur, alam sekitar serta pembangunan sosioekonomi (Sim et al., 2023; Siti Hawa et al., 2021). Kedudukan Malaysia yang beriklim tropika dengan taburan hujan tahunan yang tinggi, di samping faktor topografi berbukit dan pembangunan pesat di kawasan cerun, telah meningkatkan kecenderungan berlakunya kejadian tanah runtuh di pelbagai kawasan (Sabri & Ash'aari, 2023; Zulkafli et al., 2023). Seiring dengan peningkatan aktiviti pembangunan dan perubahan guna tanah, penilaian risiko tanah runtuh menjadi semakin penting untuk menyokong usaha pengurangan risiko bencana serta perancangan pembangunan yang lebih mampan (Fan et al., 2020; Tengtrairat et al., 2021). Kemajuan teknologi geospatial, khususnya Sistem Maklumat Geografi (GIS), telah membuka ruang kepada pembangunan pelbagai pendekatan dalam pemetaan dan analisis risiko bencana. Melalui integrasi data fizikal dan data spasial, GIS membolehkan kawasan yang berpotensi mengalami tanah runtuh dikenal pasti dengan lebih sistematik, sekali gus membantu pihak berkepentingan merancang langkah mitigasi serta meningkatkan kesiapsiagaan komuniti (Demirel et al., 2025; Fernandez et al., 2016; Mafigiri et al., 2025). Pendekatan ini bukan sahaja menyokong pengurusan bencana secara lebih berkesan, malah turut menyumbang kepada pembangunan yang lebih tahan lama dan lestari. Lembangan Langat dipilih sebagai kawasan kajian kerana merupakan antara lembangan sungai utama di Semenanjung Malaysia yang mengalami pembangunan pesat, pertumbuhan penduduk yang tinggi serta mempunyai kawasan berbukit yang terdedah kepada kejadian tanah runtuh. Keadaan ini menjadikan Lembangan Langat sebagai kawasan yang sesuai untuk membangunkan satu kerangka penilaian risiko tanah runtuh secara spasial yang dapat menyokong proses perancangan, pengurusan dan pengurangan risiko bencana.

2. PERMASALAHAN KAJIAN DAN SOROTON KAJIAN

Kajian berkaitan tanah runtuh di Malaysia telah berkembang dengan pesat, khususnya dalam pembangunan peta kerentanan menggunakan Sistem Maklumat Geografi (GIS), penderiaan jauh serta teknik pemodelan statistik dan pembelajaran mesin (Rahman et al., 2022; Selamat et al., 2022; Wang et al., 2023). Antara kaedah yang digunakan termasuk *Frequency Ration (FR), Analytical Hierarchy Process (AHP), Logistic Regression, Random Forest dan Artificial Neural Network (ANN).* Kebanyakan kajian memberi tumpuan kepada faktor fizikal seperti kecerunan, ketinggian, geologi, guna tanah, taburan hujan dan jarak ke sungai dalam menentukan kerentanan tanah runtuh (Muhamad et al., 2015; Syams et al., 2025; Zulkafli et al., 2023). Walau bagaimanapun, penilaian kerentanan fizikal sahaja belum mencukupi untuk

menggambarkan risiko sebenar kerana impak bencana turut dipengaruhi oleh tahap kerentanan komuniti. Faktor demografi dan sosioekonomi boleh mempengaruhi keupayaan masyarakat untuk bersedia, bertindak balas dan pulih selepas bencana (Orlandini et al. 2024; Rahman et al., 2022; Ram & Gupta 2022). Konsep Kerentanan Sosial (Social Vulnerability) semakin mendapat perhatian kerana dapat menjelaskan bagaimana ciri-ciri penduduk mempengaruhi tahap risiko yang dihadapi (Cutter 2024; Derakhshan et al. 2022). Antara indikator yang lazim digunakan termasuk kepadatan penduduk, komposisi umur, pendapatan, kemiskinan dan pekerjaan. Walaupun pendekatan kerentanan sosial telah digunakan dalam pelbagai kajian, penggunaannya dalam penilaian risiko tanah runtuh di Malaysia masih terhad, khususnya dalam mengintegrasikan kerentanan sosial dan fizikal secara spatial. Di Lembangan Langat, kajian terdahulu turut banyak memberi tumpuan kepada faktor fizikal dalam pemodelan kerentanan tanah runtuh (Anuar & Alias, 2021; Islam et al., 2020; Selamat et al., 2024). Oleh itu, masih terdapat keperluan untuk menggabungkan dimensi fizikal dan sosial bagi menghasilkan penilaian yang lebih menyeluruh. Sehubungan itu, kajian ini mencadangkan kerangka penilaian risiko tanah runtuh yang mengintegrasikan model *Frequency Ration* (FR) dengan Indeks Kerentanan Sosial (SoVI) dalam persekitaran GIS. Pendekatan ini mengambil kira kedua-dua kebarangkalian kejadian tanah runtuh dan tahap kerentanan komuniti sebagai asas kepada penilaian risiko yang lebih komprehensif.

3. OBJEKTIF KAJIAN

Kajian ini bertujuan untuk:

(i) Membangunkan model kerentanan tanah runtuh menggunakan kaedah *Frequency Ration* (FR) berdasarkan faktor-faktor fizikal di Lembangan Langat;

(ii) Membangunkan Indeks Kerentanan Sosial *(Social Vulnerability Index, SoVI)* menggunakan indikator demografi dan sosioekonomi; dan

(iii) Menganalisis taburan ruang kerentanan fizikal dan sosial sebagai asas kepada pembangunan model penilaian risiko tanah runtuh di Lembangan Langat.

4. KAEDAH KAJIAN

Kajian ini dijalankan di Lembangan Langat, Malaysia, yang meliputi kawasan seluas kira-kira 2,700 km² dan merangkumi sebahagian negeri Selangor, Negeri Sembilan serta Wilayah Persekutuan Putrajaya. Pembangunan Indeks Kerentanan Sosial (Social Vulnerability Index, SoVI) menggunakan lapan indikator demografi dan sosioekonomi yang diperoleh daripada Jabatan Perangkaan Malaysia (DOSM), iaitu kepadatan penduduk, peratus penduduk warga emas, peratus kanak-kanak, peratus penduduk perempuan, pendapatan isi rumah median, kadar kemiskinan, pekali Gini dan kadar pekerjaan. Data disusun pada peringkat mukim bagi membolehkan perbandingan spatial antara kawasan kajian. Semua indikator dinormalkan menggunakan kaedah min-max normalization, manakala pendapatan isi rumah median diterbalikkan supaya arah hubungan dengan kerentanan adalah konsisten. Pemberat yang sama digunakan bagi semua indikator kerana bilangan unit spatial yang terhad (n = 14) mengehadkan keteguhan penggunaan kaedah pemberatan multivariat seperti *Principal Component Analysis (PCA) dan Analytical Hierarchy Process (AHP).* Nilai SoVI kemudiannya dikira melalui pengagregatan kesemua indikator dan dikelaskan kepada lima tahap kerentanan menggunakan kaedah Natural Breaks (Jenks). Bagi komponen kerentanan tanah runtuh, model *Frequency Ration (FR)* menggunakan enam faktor fizikal, iaitu ketinggian, kecerunan, aspek cerun,

geologi, guna tanah dan jarak ke sungai. Sebanyak 113 rekod inventori tanah runtuh diperoleh, dengan 110 lokasi yang mempunyai maklumat spatial lengkap digunakan dalam analisis, manakala 109 lokasi digunakan bagi analisis Receiver Operating Characteristic (ROC). Nilai FR bagi faktor-faktor tersebut digabungkan untuk menghasilkan Landslide Susceptibility Index (LSI), yang kemudiannya dikelaskan kepada lima kategori menggunakan kaedah Natural Breaks (Jenks). Prestasi model dinilai menggunakan analisis ROC dan Area Under the Curve (AUC). Seterusnya, lapisan SoVI dan LSI diintegrasikan dalam persekitaran Sistem Maklumat Geografi (GIS) melalui pendekatan raster overlay bagi menghasilkan Landslide Risk Index (LRI).

5. KEPUTUSAN DAN PERBINCANGAN

Model kerentanan tanah runtuh yang dibangunkan menggunakan kaedah *Frequency Ration* (FR) telah mengenal pasti taburan spatial kawasan yang berpotensi mengalami kejadian tanah runtuh di Lembangan Langat. Hasil analisis menunjukkan kawasan berkerentanan tinggi dan sangat tinggi tertumpu di bahagian hulu lembangan, khususnya kawasan berbukit dan bergunung yang mempunyai cerun lebih curam serta dipengaruhi oleh keadaan geologi dan guna tanah. Sebaliknya, kawasan tanah rendah di bahagian hilir lembangan menunjukkan tahap kerentanan yang lebih rendah. Nilai LSI yang dihasilkan adalah antara 56 hingga 1,830 dan dikelaskan kepada lima kategori menggunakan Natural Breaks (Jenks). Kelas Very Low merangkumi 46.61% kawasan kajian, manakala kelas Low, Moderate, High dan Very High masing-masing merangkumi 20.67%, 17.05%, 5.76% dan 0.38%. Model FR turut menunjukkan prestasi yang baik berdasarkan analisis ROC dengan nilai AUC sebanyak 0.800. Daripada 110 lokasi tanah runtuh yang digunakan untuk validasi, sebanyak 43 kejadian (39.09%) berada dalam kelas Moderate, 33 kejadian (30.00%) dalam kelas High dan 14 kejadian (12.73%) dalam kelas Very High. Secara keseluruhan, 81.82% kejadian tanah runtuh berada dalam tiga kelas tersebut walaupun kawasan berkenaan hanya merangkumi kira-kira satu pertiga daripada keseluruhan lembangan. Dapatan ini menunjukkan bahawa model FR berjaya membezakan kawasan dengan keadaan fizikal yang lebih stabil dan tidak stabil. Bagi kerentanan sosial, nilai SoVI menunjukkan variasi spatial yang ketara antara 14 mukim di Lembangan Langat. Lenggeng merekodkan nilai SoVI tertinggi iaitu 0.597, diikuti Nilai (0.586) dan Putrajaya (0.475), manakala Morib (0.202), Sungai Pelek (0.206) dan Sijangkang (0.216) mencatatkan nilai terendah. Perbezaan ini menunjukkan bahawa tahap kerentanan sosial tidak seragam walaupun komuniti berada dalam lembangan yang sama. Integrasi LSI dan SoVI melalui pendekatan raster overlay dalam GIS menghasilkan Landslide Risk Index (LRI) yang menggambarkan interaksi antara kerentanan fizikal dan sosial. Hasil menunjukkan bahawa 51.28% kawasan Lembangan Langat berada dalam kategori Very Low risk, 17.30% Low, 19.23% Moderate, 7.91% High dan 4.28% Very High. Oleh itu, kawasan High dan Very High secara keseluruhan merangkumi 12.19% daripada kawasan kajian dan mewakili kawasan keutamaan kerana keadaan fizikal yang lebih mudah mengalami tanah runtuh bertepatan dengan tahap kerentanan sosial yang lebih tinggi. Corak spatial risiko turut menunjukkan bahawa kawasan yang mempunyai kerentanan tanah runtuh tinggi tidak semestinya mempunyai tahap risiko yang tinggi apabila kerentanan sosial adalah rendah. Sebaliknya, kawasan dengan kerentanan fizikal sederhana boleh menunjukkan risiko yang lebih tinggi apabila komuniti yang lebih terdedah tertumpu di kawasan tersebut. Dapatan ini menunjukkan bahawa integrasi kerentanan fizikal dan sosial memberikan gambaran risiko yang lebih menyeluruh berbanding penggunaan peta kerentanan fizikal secara berasingan. Secara

keseluruhannya, hasil kajian menunjukkan bahawa pengintegrasian maklumat kerentanan fizikal dan sosial dapat membantu mengenal pasti kawasan yang memerlukan keutamaan dalam perancangan mitigasi, kesiapsiagaan bencana dan perancangan guna tanah di Lembangan Langat.

6. KESIMPULAN

Kajian ini telah membangunkan model kerentanan tanah runtuh menggunakan kaedah *Frequency Ration* (FR) serta Indeks Kerentanan Sosial (SoVI) bagi Lembangan Langat. Kedua-dua model menunjukkan bahawa faktor fizikal dan sosial memainkan peranan penting dalam memahami kerentanan sesuatu kawasan terhadap bencana tanah runtuh. Integrasi kedua-dua komponen melalui pendekatan GIS menghasilkan penilaian risiko yang lebih menyeluruh dengan mengenal pasti kawasan yang mempunyai kombinasi kerentanan fizikal dan sosial yang lebih tinggi. Dapatan kajian menunjukkan bahawa 12.19% kawasan kajian berada dalam kategori risiko tinggi hingga sangat tinggi, yang boleh dijadikan asas dalam penentuan kawasan keutamaan bagi pelaksanaan langkah mitigasi dan kesiapsiagaan bencana. Dapatan kajian menyediakan maklumat asas yang dapat membantu pihak berkepentingan dalam perancangan guna tanah, pengurusan risiko bencana dan penentuan kawasan keutamaan bagi pelaksanaan langkah mitigasi. Pada fasa penyelidikan seterusnya, pendekatan ini boleh dikembangkan melalui pengintegrasian faktor kebolehcapaian dan pendekatan kecerdasan buatan bagi menghasilkan model penilaian risiko tanah runtuh yang lebih komprehensif.

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LABEL-FREE MOLECULARLY IMPRINTED POLYDOPAMINE ELECTROCHEMICAL SENSOR FOR NON-INVASIVE IGF-1 DETECTION: ADVANCING ANTI-DOPING SCREENING STRATEGY

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1. INTRODUCTION

The integrity of professional sports relies heavily on rigorous anti-doping protocols, particularly for monitoring performance-enhancing drugs (PEDs), such as recombinant human growth hormone (GH) and its downstream biomarker insulin-like growth factor-1 (IGF-1) (Bailes & Soloviev 2021; Figueiredo et al. 2025). Monitoring the GH/IGF-1 axis is essential because circulating GH clears rapidly, with a half-life of less than 20 min (Baumann 2012), whereas circulating IGF-1 persists for 7–20 h (Juul 2003), providing a wider diagnostic window for detecting misuse.

However, a significant bottleneck exists in current testing methodologies: standard IGF-1 detection is highly challenging in non-invasive samples due to low physiological concentrations and severe matrix interference (WADA 2021; WADA 2025). Consequently, validated anti-doping monitoring remains primarily dependent on blood-based biomarkers, creating logistical burdens and motivating the development of simple electrochemical sensors for IGF-1 in complex non-invasive matrices, such as urine and saliva.

To address this challenge, this study reports the fabrication and multi-technique evaluation of a biomimetic molecularly imprinted polydopamine (MIPDA) sensor on screen-printed carbon electrodes (SPCEs) designed for non-invasive IGF-1 screening. This work examines the interfacial charge-transfer dynamics, surface morphology, and chemical transitions across the pre-template removal (pre-TR), post-template removal (post-TR), and target rebinding stages.

2. PROBLEM STATEMENT AND LITERATURE REVIEW

Malaysian anti-doping authorities (ADAMAS 2025) rely heavily on routine urine collection to screen for prohibited substances. However, this approach cannot effectively detect GH abuse, as approved testing for GH and its key biomarker, IGF-1, requires blood samples and centralised laboratory analysis (Erkmen et al. 2024; Wang et al. 2022).

The short physiological half-life of GH further limits detection, allowing strategically timed administration to evade testing (Holt & Ho 2019). In contrast, IGF-1 has a longer persistence and therefore provides a wider detection window, making it a more suitable biomarker for GH abuse. Nevertheless, conventional IGF-1 analysis remains invasive and laboratory

dependent, highlighting the need for decentralised detection approaches. This limitation has serious consequences, as demonstrated by a reported fatal GH overdose in an athlete who had never tested positive under routine anti-doping protocols (Erfanifar et al. 2022).

Decentralised electrochemical biosensors offer a promising solution, but conventional designs often rely on fragile and costly antibodies (Domsicova et al. 2024; Sequeira Antunes & Ferreira 2023). Molecularly imprinted polydopamine (MIPDA) provides a robust biomimetic alternative by forming stable synthetic recognition cavities for label-free protein detection (Córdoba-Aceituno et al. 2025; Lamaoui et al. 2023). Dopamine is also an affordable monomer that polymerises under mild aqueous conditions, while its catechol and amine groups enable multiple interactions with protein templates (Ozcelikay-Akyıldız et al. 2026). However, MIPDA-based electrochemical sensing for IGF-1 remains underexplored, warranting further development as a decentralised approach to detecting GH abuse.

3. RESEARCH OBJECTIVES

Motivated by the need for robust non-invasive anti-doping detection, the specific objectives addressed in this colloquium are:

I. To synthesise a biomimetic MIPDA sensing film with recognition cavities for IGF-1. II. To evaluate the physicochemical, morphological, and interfacial characteristics of the MIPDA biosensing film for IGF-1 recognition.

These objectives focus on the material fabrication and characterisation stages of the biosensor. Objective I establish the synthetic recognition sites, while Objective II evaluates their physical structure, chemical composition, and interfacial electrochemical behaviour to confirm successful sensor fabrication.

4. RESEARCH METHODOLOGY

MIPDA was fabricated on SPCEs through electropolymerisation of dopamine in the presence of IGF-1 as the template. The optimised fabrication involved 20 electropolymerisation cycles using 1 mg mL^{-1} dopamine and 20 µg mL^{-1} IGF-1. The resulting pre-TR film underwent template removal (TR) using 0.1 M NaOH for 1 h to generate accessible molecularly imprinted cavities, producing the post-TR MIPDA sensor. A non-imprinted polydopamine (NIPDA) control was prepared under identical conditions without IGF-1.

The MIPDA and NIPDA sensors were evaluated across three states: pre-TR, post-TR, and after IGF-1 rebinding. Electrochemical characterisation was performed using cyclic voltammetry (CV), electrochemical impedance spectroscopy (EIS), and differential pulse voltammetry (DPV) in a ferri/ferrocyanide redox probe. Surface morphology was examined using Field Emission Scanning Electron Microscopy (FESEM, 3 kV), while surface roughness (Sq) was evaluated using Atomic Force Microscopy (AFM, tapping mode).

Energy Dispersive X-ray Spectroscopy (EDX, 15 kV) assessed elemental composition, while Fourier Transform Infrared Spectroscopy (FTIR, 4000–650 cm^{-1}) evaluated functional group changes.

5. RESULTS AND DISCUSSION

MIPDA synthesis optimisation identified the selected electropolymerisation conditions as suitable for polymer and cavity formation, while excessive polymer growth hindered TR. CV showed that redox peak currents decreased from anodic peak current (ipa)=93.0/cathodic peak current (ipc)=−98.2 µA for bare SPCE to ipa=40.4/ipc=−39.0 µA after MIPDA formation, reflecting PDA deposition. Following TR, the currents recovered to ipa=53.7/ipc=−51.1 µA,

then decreased to ipa=47.1/ipc=−42.7 μA after IGF-1 rebinding, indicating cavity re-occupation. In contrast, NIPDA showed minimal change after rebinding (ipa=40.8/ipc=−36.1 to ipa=39.2/ipc=−33.7 μA), supporting preferential IGF-1 recognition by MIPDA. TR using 0.1 M NaOH effectively disrupted non-covalent interactions between IGF-1 and the PDA matrix, producing accessible recognition cavities (Khumsap et al. 2021).

EIS was used to evaluate interfacial charge-transfer resistance (Rct) at different fabrication stages. The bare SPCE exhibited an Rct of 5,361 Ω, which increased to 26,731 Ω for MIPDA and 31,425 Ω for NIPDA, confirming the formation of insulating polydopamine films. Following TR, Rct decreased markedly to 17,697 Ω for MIPDA, compared with 22,532 Ω for NIPDA. Although the post-TR Rct remained higher than that of bare SPCE (5,361 Ω), the decrease indicates that TR reopened accessible imprinted cavity pathways while retaining the underlying insulating PDA framework. The greater decrease observed for MIPDA provides electrochemical evidence of successful TR and the formation of accessible molecularly imprinted cavities (Agibayeva et al. 2025; Turan et al. 2025). DPV analysis further demonstrated IGF-1 rebinding, with MIPDA showing a current difference of approximately 6 μA compared with <2 μA for NIPDA. Potentially interfering proteins produced smaller responses close to NIPDA levels (~2 μA), indicating preferential recognition of IGF-1 by the imprinted cavities.

Physical characterisation further validated the formation and structural changes of the MIPDA film. FESEM revealed a conformal and relatively uniform PDA coating over the granular carbon microstructure, while maintaining the underlying surface features. The film thickness remained below 100 nm, indicating controlled electropolymerisation and avoiding excessive surface coverage (Rocha et al. 2023). AFM analysis showed that surface roughness (Sq) decreased from 293.13 nm for the bare SPCE to 281.33 nm in the pre-TR state and further to 225.80 nm after TR. The progressive decrease in roughness suggests that PDA deposition modified and smoothed the underlying carbon surface, while subsequent TR further altered the surface morphology through template and weakly associated material removal (Bogdan et al. 2022; Tong et al. 2025).

EDX analysis further supported the successful incorporation and removal of the IGF-1 template. The pre-TR MIPDA exhibited 1.46 at% nitrogen and 0.07 at% sulfur, consistent with the presence of protein-derived elements within the polymer matrix. Following TR, these values decreased to 1.23 at% nitrogen and 0.06 at% sulfur, supporting the removal of IGF-1 from the sensing film (Telli & Arabaci 2024; Yan et al. 2025). FTIR analysis supported PDA formation through characteristic O–H/N–H stretching and C=C stretching bands at approximately 3300 and 1500 cm^{-1}, respectively. The increased intensity of the ~3300 cm^{-1} band in pre-TR MIPDA was attributed to the contribution of IGF-1 functional groups, while its subsequent decrease after TR provided further evidence of template extraction without substantial alteration of the PDA matrix.

6. CONCLUSION

A biomimetic MIPDA sensing film was successfully fabricated on SPCEs for IGF-1 recognition. Electropolymerisation was optimised at 20 cycles using 1 mg mL^{-1} dopamine and 20 μg mL^{-1} IGF-1, while TR was achieved using 0.1 M NaOH for 1 h. EIS demonstrated a pronounced decrease in Rct following TR, supporting the formation of accessible molecularly imprinted cavities. DPV further demonstrated preferential IGF-1 recognition over potentially

interfering proteins. FESEM and AFM confirmed the formation of a uniform thin PDA film and corresponding surface changes, while EDX and FTIR provided further evidence of template incorporation and removal without substantial disruption of the PDA matrix. Overall, the developed MIPDA platform provides a promising biomimetic approach for non-invasive IGF-1 detection, with potential to support decentralised and more accessible screening as a complementary approach to conventional blood-based, centralised analysis.

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