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FPM SENTINEL: A DATA-DRIVEN FACILITY PERFORMANCE MANAGEMENT DASHBOARD FOR THE SRI LANKAN BUILT ENVIRONMENT

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ABSTRACT

Facility Performance Management (FPM) is an emerging sub-domain of facility management (FM) concerned with the systematic monitoring and optimisation of built-environment performance across multiple operational dimensions. Despite growing international recognition of its strategic value, Sri Lankan FM practice remains predominantly reactive, with no integrated, data-driven performance monitoring systems established. This paper presents the development and expert validation of FPM Sentinel; a web-based dashboard prototype designed to consolidate multi-dimensional facility performance data into a single, accessible visualisation tool tailored for Sri Lankan FM experts. The prototype is built upon a six-pillar FPM framework comprising Maintenance Management, Energy Management, Resource Utilisation, User and Occupant Comfort, Safety and Compliance, and Aesthetics, with each pillar underpinned by literature-justified Key Performance Indicators (KPIs). Developed using a Design Science Research (DSR) approach and demonstrated through a hypothetical case study facility (F001), the prototype was evaluated by seven Sri Lankan FM experts representing architecture, hospitality, commercial property management, and multi-property FM. Expert review confirmed the conceptual validity of the framework, the contextual relevance of the KPI set, and practical applicability to the local FM context. Evaluation feedback also informed framework refinements, including the addition of a Renewable Energy Utilisation KPI and adjustments to improve accessibility for non-FM users. The FPM Sentinel represents a proof-of-concept response to an identified gap in Sri Lankan FM practice, demonstrating the feasibility of data-driven, multi-dimensional performance monitoring pending validation with live operational data.

Keywords: *Dashboard Visualisation; Design Science Research; Facility Performance Management; Key Performance Indicators; Sri Lanka.*

1 INTRODUCTION

There has been a significant change in the management of built environment, which has evolved to become more data-oriented in terms of performance management as opposed to being more reactive in nature and more of maintenance work. Facility Performance

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Management (FPM) has now been perceived as a rational operation that monitors, quantifies, and empowers building performance on various operating facets, therefore, propelling facilities to add real value to occupants and organisations (Liu et al., 2026). With the growing complexity of building systems and the growth of the demands of stakeholders, the ability to centralize the performance information of differing sources to consistent and usable conclusions has become essential in the efficient management of facility management (FM) decision-making (Eckerson, 2012).

The FM practice is however, reactive and fragmented in Sri Lanka. There is a general trend of dispersing building performance data in disconnected systems, such as maintenance records, energy meters, and customer feedback mechanisms, with little to no connection to a unified system of evaluation (Dasandara et al., 2022). As a result, facility managers do not have the means to convert multidimensional performance data into transparent visuals to enable them to detect a trend, set priorities in interventions, as well as justify the strategic value of FM to the stakeholders of the organisation. This has made worse by reported shortcomings in competencies among the local FM workforce as well as lack of internationally-equivalent performance measurement systems adjusted to the Sri Lankan setting (Herath et al., 2019).

To address this gap, this study presents the design, development, and expert assessment of FPM Sentinel, a web-based Facility Performance Management dashboard prototype structured around a six pillar conceptual framework grounded in international FM literature and reviewed by seven locally and internationally experienced FM practitioners. The paper is structured as follows: Section 2 reviews theoretical foundations; Section 3 describes the research methodology; Section 4 presents the FPM Sentinel development; Section 5 reports expert validation findings; Section 6 presents the case study demonstration; Section 7 discusses implications; and Section 8 presents conclusions.

2 THEORITICAL BACKGROUND AND CONTEXTUAL GAP

2.1 FACILITY PERFORMANCE MANAGEMENT

Facility Performance Management (FPM) is a more specific sub-domain of Facilities Management (FM) that optimistically and in a formalized manner analyses and manages the performance of a facility, especially that of non-core areas of operation. This formal procedure involves monitoring, measuring, and optimising the facility performance to facilitate that buildings are appropriate to organisational goals such as operational efficiency, cost-effectiveness, safety, building occupant comfort, and environmental sustainability (Meng & Minogue, 2011). In FM, the measurement of performance touches upon such essential dimensions as energy efficiency, safety and health, occupant comfort, resources utilisation, and maintenance management, all of which are incorporated into unbiased, multi-dimensional evaluation frameworks (Shin et al., 2023).

The thorough literature review marks six pillars of FPM, including maintenance management, which comprises two categories of the building system maintenance planning and optimisation to prevent failure (Parida et al., 2015); energy management, which encompasses the active monitoring and optimisation of energy use (Fichera et al., 2020); resource utilisation, which concerns active monitoring and optimisation of water, space, and operational resources (Lam et al., 2008); user and occupant comfort encompassing thermal, visual, acoustic, and respiratory comfort dimensions (Wang et al., 2018); safety and compliance involving systematic management of building safety systems and regulatory adherence (Hassanain et al., 2022); and aesthetics capturing the influence of visual design quality and maintenance condition on occupant satisfaction (Whang et al., 2023).

2.2 PERFORMANCE DASHBOARD TECHNOLOGIES

The performance dashboards have become the traditional form of visualisation technology in real-time monitoring of key performance indicators (KPIs), which is a consolidated data-driven visualisation that forms the basis of evidence-based management decisions (Eckerson, 2012). It is known that successful dashboards are a combination of at-a-glance executive-level summary charts and drill-down diagnostic capabilities, thus, allowing both strategic control and targeted intervention (Yigitbasioglu & Velcu, 2012). According to Presthus and Bergum (2015), effective dashboard design consists of six key components: KPI selection, layout clarity, drilling capability, visual principles, technical functionality, and contextual information.

2.3 FPM IN THE SRI LANKAN CONTEXT

Facilities Management (FM) in the Sri Lankan construction industry encounters several unique challenges. Despite the diversity of building typologies across residential, commercial, institutional, and industrial sectors, structured approaches to managing building performance remain limited. Empirical data show that FM competence scores in the Sri Lankan market are significantly lower than in more developed FM markets, with notable discrepancies in technical, business management, and people management skills (Herath et al., 2019). This has resulted in decreased quality of FM services in the hotel, hospital, and commercial building sectors due to the absence of proper performance measurement systems (Dasandara et al., 2022). In turn, it has resulted in the evolution of an evident need for a comprehensive, multidimensional FPM and an effective visualisation instrument specific to the Sri Lankan context(Samarakkody & Perera, 2023).

3 RESEARCH METHODOLOGY

The research adopted a Design Science Research (DSR) methodology (Gledson et al., 2024; Lechner, 2024), following the seminal DSRM framework of Peffers et al. (2007) (see Table 1), which is most adequate in the context of development and testing of useful artefacts. The artefact, in this case, is the FPM Sentinel dashboard prototype that is aimed at managing the shortcomings of the professional practice identified earlier. DSR has an iterative cycle of problem identification and solution design and artefact development followed by evaluation and thus it can be suitable in applied research on facility management as the main contribution is a functional tool.

Table 1:Mapping of the study to the Peffers et al. (2007) Design Science Research Methodology (DSRM)

DSR Activity	Peffers et al. (2007) Description	Application in This Study	Study Phase
1. Problem Identification & Motivation	Define the specific research problem and justify the value of a solution	Identified the absence of an integrated, data-driven FPM system in Sri Lanka through a review of local FM practice and international literature. Justified the need for a multi-dimensional performance monitoring tool.	Phase 1
2. Define Objectives of a Solution	Infer objectives of a solution from the problem definition	Established the objectives of FPM Sentinel: to develop a six-pillar framework covering Maintenance, Energy, Resource Utilisation, Occupant Comfort, Safety & Compliance, and Aesthetics, each supported by literature-justified KPIs.	Phase 1
3. Design & Development	Create the artefact — construct, model, method, or instantiation	Developed the FPM Sentinel web-based dashboard prototype incorporating the six-pillar FPM framework and 13 KPIs. Built as a single-page web application hosted on Vercel with a four-layer architecture (Presentation, Application Logic, Data Integration, Data Storage).	Phase 2
4. Demonstration	Demonstrate use of the artefact to solve one or more instances of the problem	Demonstrated the potential functional capabilities of FPM Sentinel using a simulated illustrative dataset for hypothetical facility F001 (150,000 sq. ft., 25-storey commercial building), showcasing the Portfolio Performance Index (PPI), trend analysis, and performance status matrix.	Phase 3 & 4
5. Evaluation	Observe and measure how well the artefact supports solving the problem	Conducted semi-structured expert validation interviews with seven experienced Sri Lankan FM experts from architecture, hospitality, commercial property management, and multi-property FM. Validated the conceptual framework, KPI relevance, and dashboard usability. Incorporated expert-recommended refinements (e.g., Renewable Energy Utilisation KPI; non-FM user interface adjustments).	Phase 3

DSR Activity	Peffers et al. (2007) Description	Application in This Study	Study Phase
6. Communication	Communicate the problem, artefact, and its utility to researchers and practitioners	Findings communicated through this conference paper submitted to the 14th World Construction Symposium 2026, contributing to knowledge on data-driven FM practice in developing contexts.	Phase 4

The study occurred in four phases. Initially, a systematic literature review was undertaken to develop the six-pillar conceptual framework of FPM, from which two key performance indicators (KPIs) were derived for each pillar based on existing literature, with one additional KPI (Renewable Energy Utilisation) incorporated into the Energy Management pillar following expert validation, resulting in a total of 13 KPIs across the six pillars. Secondly, the prototype of the FPM Sentinel dashboard was deployed as an on-demand web app that is hosted on the Vercel platform, and its functionality was explored with a simulated illustrative dataset. Thirdly, semi-structured expert validation interviews were conducted with seven experienced facility management experts. Finally, the functionality of the dashboard was tested using a hypothetical case-study simulation based on a typical 150,000 sq. ft. commercial area (facility F001) consisting of 25 storeys.

Seven experts were sampled strategically so that they could represent different sectors as well as levels of experience in the field of facility management. Table 2 shows the panel of choice entailed:

Table 2: Expert profile

Expert	Designation	Years of experience
E1	Chartered Architect	40 years
E2	Head of Engineering	20 years
E3	Senior Property Manager	25 years
E4	Head of Facilities	07 years
E5	Facility Engineer	15 years
E6	Facility Manager	10 years
E7	Facility Manager	12 years

Simulated data used in this study is clearly admitted to be used as a pointer of the functionality of the dashboard, not as an indicator of empirical data of building performance.

4 THE FPM SENTINEL DASHBOARD

4.1 SYSTEM ARCHITECTURE

The FPM Sentinel has been designed as a custom single-page web app so that the control over interface design, data logic, and visualisation features can be achieved affordably. The dashboard follows a four-layer design: the Presentation Layer is the interactive user interface, the Application Logic Layer includes a JavaScript-based KPI normalisation and scoring server, the Data Integration Layer includes eight operational data sheets, fully structured and the Data Storage Layer contains a twelve-months' worth of past performance measurements. The overall Portfolio Performance Index (PPI) is calculated as an aggregated weighted station of six pillar scores where every KPI is normalised to a standardised 0-100 before being aggregated. The specific weight values (Maintenance Management 20%, Aesthetics 10%, and intermediate values for remaining pillars) were assigned based on the authors' interpretation of relative operational priority as reflected in the reviewed FM literature; it is acknowledged that this constitutes a limitation, and a formal weighting procedure such as the Analytical Hierarchy Process (AHP) (Vaidya & Kumar, 2006) should be employed in future iterations to derive weights more rigorously. The weight values reflect the relative operational prominence of each pillar as evidenced across the reviewed FM performance measurement literature. Lavy et al. (2010) establish that physical and operational dimensions encompassing maintenance condition, energy, and functional use consistently constitute the core of holistic FM performance assessment frameworks, which informed the higher weights assigned to Maintenance Management (20%), Energy Management (18%), and User and Occupant Comfort (18%) in this study. Aesthetics, while recognised as a valid FM dimension (Dasandara et al., 2022), is consistently positioned as a supplementary rather than primary operational indicator across the FM performance literature (Meng & Minogue, 2011; Lavy et al., 2010), supporting its lower weight of 10%. It is nonetheless acknowledged that differential weighting introduces an element of judgement, and a formal weighting procedure such as the Analytical Hierarchy Process (AHP) (Vaidya & Kumar, 2006) through pairwise comparison by domain experts should be employed in future iterations to derive weights with greater methodological rigour. The PPI is then overlayed onto a letter grade (A-F) and a maturity description of either Optimised, Established, Developing or Ad Hoc.

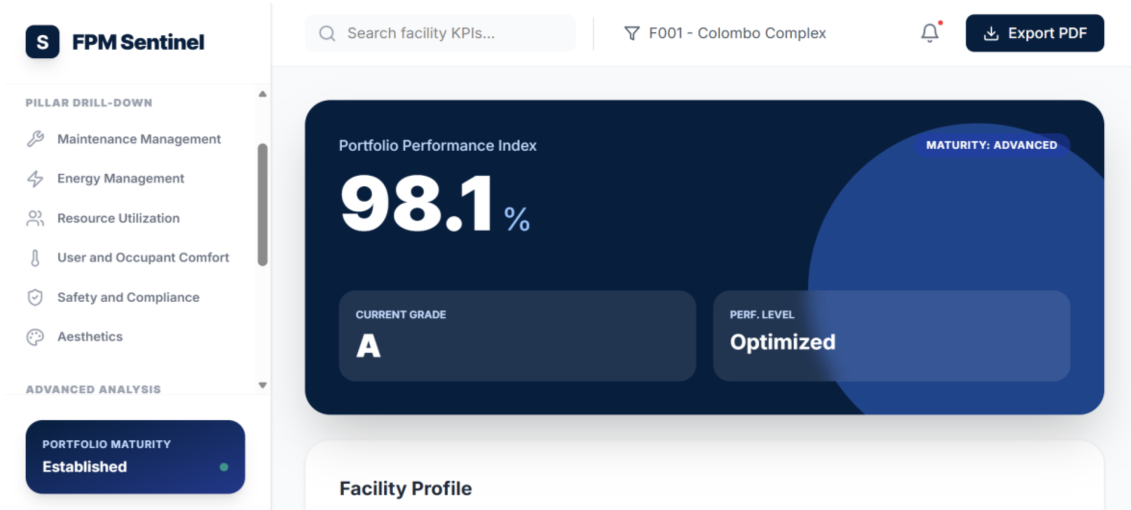

Figure 1: FPM sentinel landing page

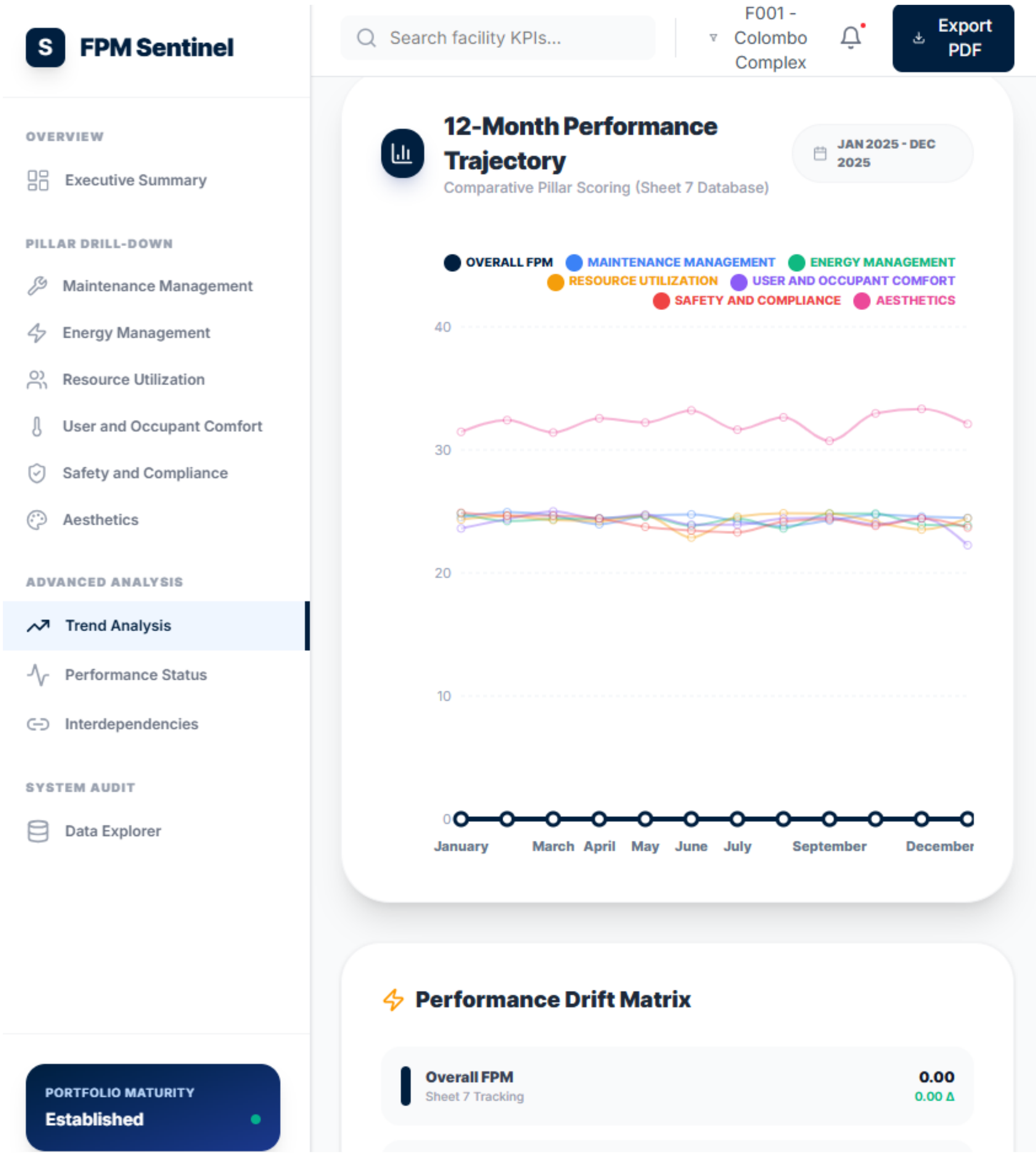

Figure 2: Advance analysis features

4.2 KPI FRAMEWORK

The KPIs used under each pillar were based on the measurability, availability of data, support in literature, and the dashboard presentation appropriateness. Table 3 presents the final KPI set with associated literature sources.

Table 3: FPM sentinel KPI framework

Pillar	KPI	Formula	Source
Maintenance (P01)	Planned Maintenance %	(Planned / Total Tasks) × 100	Lavy et al. (2014)
	WO Resolution Time	Total WO Time / No. Completed	Ioannidis et al. (2017)
Energy (P02)	Energy Use Intensity	Annual Energy (kWh) / GFA (m^2)	Chua et al. (2013)

Pillar	KPI	Formula	Source
	HVAC Energy %	(HVAC / Total Energy) × 100	Geekiyanage and Ramachandra (2018)
Resource (P03)	Space Utilisation Rate	Frequency (F) × Occupancy (O)	Abdullah et al. (2012)
	Water Consumption / m²	Annual Water (L) / GFA (m²)	Bertone et al. (2016)
Comfort (P04)	PMV / Thermal Comfort	ISO 7730 / ASHRAE 55	Fanger (1970)
	IAQ / CO_2 Concentration	CO_2 in ppm (<1000 benchmark)	Aziz et al. (2023)
Safety (P05)	Safety Audit Compliance Rate	(Completed / Required) × 100	Hassanain et al. (2022)
	Incident Rate	(Incidents / Total Staff) × 100	Expert Validation (this study)
Aesthetics (P06)	Occupant Aesthetic Satisfaction	Likert scale POE survey (1–5)	Asojo et al. (2021)
	Aesthetic Deficiency Rate	(Deficiencies / Areas) × 100	Preiser (2002)

4.3 INTERFACE AND NAVIGATION

The FPM Sentinel is arranged into three major navigation areas accessible through a fixed left-hand side bar. The Executive Summary shows the total PPI, grade, maturity classification, a hexagonal Pillar Performance Map showing all six pillars at the same time, a Critical Deviations panel indicating KPIs most divergent from to target, and a Facility Profile panel. All of the six individual Pillar Drill-Down pages provide KPI metric cards with current value and trend indicators, 12-month Performance Velocity area chart, a KPI Achievement Variance horizontal bar chart, and KPI Performance Audit panel with discrete KPI trend lines. An Advanced Analysis panel offers cross-pillar Trend Analysis, a Performance Status Matrix that shapes out all KPIs and labels them as On Target, Near Target and Critical At risk and a conceptual System Interdependencies view, which will be empirically developed at a later point. The reflection of System Data Explorer gives complete visibility of the underlying data pipeline over the eight tabbed data sheets.

5 KPI RELEVANCE AND CONTEXTUAL APPLICABILITY

The KPI set was found relevant and measurable by experts as shown in Table 4, in general in the context of Sri Lanka. Expert E1 supported the inclusion of Renewable Energy Utilisation into the Energy Management pillar with a reference to the increasing trend in implementing rooftop photovoltaic systems in commercial buildings in Sri Lanka; the suggestion was later implemented into the prototype. Expert E2 confirmed that HVAC energy consumption is the most pragmatic metric that is monitored in the hospitality industry, thus including it. The Safety Audit Compliance Rate was supported by Expert E3 as a substantive general compliance measure; and it is considered practical with regard to the Work Order management subsection. Experts E4 and E5 agreed on the suitability of the Safety and Compliance KPIs, with Incident Rate being an important outcome-based safety measure that would be relevant in the daily facility management operation.

Table 4: Expert to KPI mapping

Pillar	KPI 1	KPI 2/ Addition	Experts	Key Validation Finding
Maintenance Management	Planned Maintenance Execution Rate	WO Resolution Time	E2, E3, E4, E5	Both confirmed as most trackable; E3 recommended WO departmental filtering; E5 validated MTBF exclusion
Energy Management	Energy Use Intensity	HVAC System Energy %; Renewable Energy Utilisation	E1, E2, E6, E7	E1's Renewable Energy Utilisation recommendation incorporated; E6 & E7 flagged sector-specific HVAC benchmarks
Resource Utilisation	Space Utilisation Rate	Water Consumption Rate	E3, E6	Both confirmed; E6 suggested Manpower Utilisation as future addition
User & Occupant Comfort	PMV / Thermal Comfort	IAQ / CO_2 Index	E2, E3, E4	Confirmed as primary comfort KPIs; comfort complaints identified as leading FM escalation driver
Safety & Compliance	Safety Audit Compliance Rate	Incident Rate	E3, E4, E5	Incident Rate unanimously preferred over Training Completion Rate; SLA-based WO recommended by E7
Aesthetics	Occupant Aesthetic Satisfaction	Aesthetic Deficiency Rate	E1, E3	Both confirmed; critical for tenant satisfaction and lease renewal

5.1 USABILITY AND ACCESSIBILITY

E3 noted that, whilst the dashboard would be easily understood by facility management experts, some of the KPI definitions may be too difficult to understand by non-FM stakeholders, including property owners or top managers. Thus, E3 recommended that an icon tooltip be added next to every KPI in order to provide a plain-language explanation, which was listed among usability improvements of primary importance for the next development. E2 raised a concern regarding the target user hierarchy, thus highlighting the need to configure access levels in a production implementation, making it a potential development future.

5.2 COMMERCIAL VIABILITY

E3 clearly supported the fact that a process-based organisation should be happy to buy and implement the FPM Sentinel in order to streamline FM processes. E2 advised the use of the dashboard as an explanatory instrument that will warrant investment in qualified FM experts and, therefore, support the argument that FPM instruments can make FM a more central aspect of strategic management among Sri Lankan organisations (Dasandara et al., 2022). The E7 proposal in terms of client-definable weightages also adds to the strength of business viability by allowing the dashboard to adapt itself to unique strategic goals of different clients and construction typologies.

5.3 USABILITY, DESIGN, AND CUSTOMISATION

The most noticeable recurrent theme of four experts (E2, E3, E6, and E7) was the ease of use of dashboard by users with dissimilar degrees of FM technical skills. E3 repeated the suggestion of adding ‘i' icon tooltips next to every KPI to clarify it in plain language; it has been shown that this is prioritized in the usability enhancements. E7 highlighted the issue, indicating terminologies to be simplified in a manner that all people at any level of operation understand the dashboard without necessarily having to possess an understanding of the FM. E2 stressed the need to have user-access hierarchies configured towards a production deployment. A significant change in design suggested by E7 was the proposal to replace the immutable pillar and KPI weightages with permitting the framework to be set by the clients with their respective weightages as the organisational priorities and types of buildings. This suggestion, which is in line with the multi-criteria decision-analysis methods (Vaidya & Kumar, 2006), would significantly increase the flexibility of the dashboard to work in different deployment settings. Moreover, E7 supported the use of SLA-based work-order categorisation as opposed to department-based, citing the fact that SLAs are more related to FM service-delivery commitments, a substantive operational understanding on the basis of international FM operation.

6 CASE STUDY DEMONSTRATION

The FPM Sentinel was tested on a hypothetical building F001, a business complex with the size of 150000 sq. ft. spread on 25 floors with simulated illustrative data, meant to be representative of the typical performance benchmark in commercial buildings. Its dashboard showed an overall Performance Index (PPI) of 98.1%, which was depicted by grade A classification, an optimised level of performance as well as an advanced level of maturity. The performance map in the form of a hexagon indicated the broadly balanced performance across all six dimensions; the User and Occupant Comfort pillar had the lowest aggregate score of 90.5% in contrast to the 97% -100% score in the other five pillars. The Critical Deviations panel declared Lighting Quality Index (actual = 62.59, target = 80) and the Indoor Air Quality Index (actual = 72.1, target = 85) two critical performance indicators (KPIs) for which the target deviations were the highest, and they are both in the “WARNING” status.

Also, the Performance Status Matrix determined 10 of the 13 KPIs were On Target and 3 of the KPIs were also Critical At -Risk with the KPIs all being clustered in the User and Occupant Comfort pillar. The Trend Analysis page stated that User and Occupant Comfort had the highest negative drift over the last 12-months, whereas the Velocity Insights panel provided an automated narrative explanation of changes in performance momentum. Despite the Aesthetics pillar scoring a good aggregate score of 99.0%, the pillar indicated downward trend waves in all three KPIs in the latter half of the year, which illustrates the practical usefulness of the dashboard in alerting on imminent performance risks before the risk develops into a major problem. The case study illustration revealed that the FPM Sentinel can handle, visualise, and interpret multidimensional facility performance information, hence aiding evidence-based facilities management in decision-making.

7 DISCUSSION

The FPM Sentinel aims to address two related shortcomings, namely; the absence of an approved multi-dimensional FPM framework applicable to Sri Lanka and the absence of integrated visualisation tools that can turn building performance information into practical management information. The fact that the six-pillar framework received a unanimously positive score among seven experts in different industries and geographically diverse areas, i.e., in relation to Sri Lanka, the Gulf region and international FM practice, testifies to the fact that the framework is based on a real cross-contextual need that is not an exception in the literature (Dasandara et al., 2022; Herath et al., 2019).

The overlap of usability issues between four separate experts (E2, E3, E6, E7) of whom each can independently find it necessary to simplify the terminology provides a consistent indicator of a shared usability concern. When practitioners from different backgrounds independently converge on the same recommendation, this convergence lends indication of a substantive user need as opposed to a fortuitous notice. This intersection is the direct basis of the prioritisation of tooltip implementation as a high-priority development item of any future production version. The E7 suggestion of client weightages of KPI brings to bear a relevant architectural insight that goes not only as far as usability, but also as far as system design. The fact that, a fixed weighting scheme is informed by the literature, does not mean that it will suit the strategic priorities of individual organisations. What would be very beneficial is that a configurable system would go a long way in terms of flexibility and being commercially viable and this is the same kind of literature available on the multi-criteria decision analysis (Vaidya & Kumar, 2006). Similarly, the work-order suggestion of E7, which is based on SLA, is in line with the functional reality of international practice of FM service delivery, whereby the obligations of the contractual performance have more operational significance than the departmental classifications.

The case-study presentation shows how the FPM Sentinel converts disjointed data on KPI measures into a consistent narrative of performance, with User and Occupant Comfort being the least robust pillar, specific shortcomings in IAQ and Lighting Quality being highlighted, and a new aesthetic maintenance risk being noticed. Such diagnostic specificity can be attributed to the position of the literature that the impactful design of dashboards should be able to identify performance issues quickly and assist in making decisions based on evidence (Eckerson, 2012; Presthus & Bergum, 2015). It must be explicitly noted, however, that the reliance on simulated illustrative data constitutes a significant a significant limitation of this study. The hypothetical dataset was designed solely to demonstrate the functional capabilities of the dashboard and is not representative of actual building performance. This limits the generalisability of the results and the strength of validation claims; the framework and tool must be further tested using live operational data from real facilities before broader applicability can be asserted.

8 CONCLUSIONS

The research paper outlines how the FPM Sentinel was developed and assessed through expert review, addressing an identified gap in integrated, multi-dimensional FM performance monitoring within Sri Lankan practice. There are three major conclusions of this investigation.

To begin with, the 6-pillar FPM framework, including the Maintenance Management, Energy Management, Resource Utilisation, User and Occupant Comfort, Safety and Compliance, and Aesthetics, provides a structured multi-dimensional conceptual basis for assessing facility performance in the Sri Lankan context. The framework is grounded in international FM literature and assessed by seven experts across diverse industry sectors, demonstrating preliminary conceptual relevance and contextual applicability pending further empirical validation.

Secondly, this framework is brought into practice by the FPM Sentinel as a proof-of-concept dashboard prototype. Expert review indicated that an integrated, multi-dimensional FM performance tool in this nature addresses a recognised gap in the local FM market, with participating practitioners from diverse sectors affirming its practical relevance.

Thirdly, the professional checkpoint process, complemented with international insights provided by Gulf and globally experienced FM experts, produced substantive design recommendations, which entail client-configurable KPI weightages, work-order management via SLAs, simplified terminology, and increased findability of tool tips, and, in general, define and establish a roadmap of development. Future studies must focus on the validation of live-building in operational data, derivation of pillar weight through formal derivation based on AHP, the ability to implement client-configurable weighting to the framework, and apply the framework to the healthcare, education, and residential building domains.

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