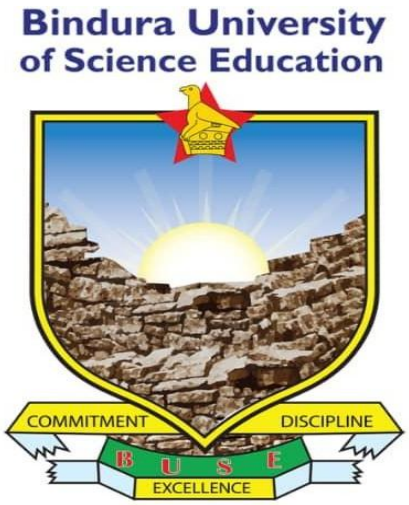


Design and evaluate a smart real estate ERP with predictive market intelligence and interpretable decision support in Zimbabwe.

By

Godfrey Tinotenda Major

B223667B

Supervisor: Mr Mhlanga

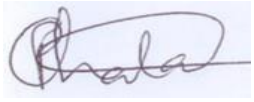
June 2026

A dissertation submitted in partial fulfilment of the requirements for the

Bachelor of Science Honours Degree in Software Engineering.

Approval Form

The undersigned certify that they have supervised **GODFREY TINOTENDA MAJOR's** dissertation, entitled "**Design and Evaluation of a Smart Real Estate ERP Framework with Predictive Market Intelligence, and Decision Support in Zimbabwe**," submitted in partial fulfilment of the requirements for the **Bachelor of Science Honours Degree in Software Engineering** at Bindura University of Science Education.

---GODFREY TINOTENDA MAJOR---------- **- -----STUDENT NAME**	**---05/06/2026----------** **---DATE**
-G. MHLANGA  **SUPERVISORS**	**----18/08/2026----------** **DATE**
--------  **---** **CHAKA----------** **-CHAIRPERSON**	**----18/06/2026----------** **- ---------- DATE** 
---------- **EXTERNAL EXAMINER**	**-------18/06/2026----------** **- ---------- DATE**

DEDICATION

This dissertation is dedicated to my family, whose encouragement sustained me throughout this programme, and to all who believe that disciplined software engineering can strengthen everyday practice in Zimbabwe.

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I thank the participating real estate organisations and their staff, who provided time, data access, and feedback in accordance with ethical and consent requirements. I also thank my family and friends for their moral support during the research and prototype development phases.

ABSTRACT

Many Zimbabwean real estate SMEs manage property, lease, tenant, and financial information across disconnected spreadsheets, paper records, informal communication channels, and accounting packages such as Sage and Palladium. This fragmentation increases reconciliation time, reduces transparency, and limits structured decision support. The study addresses this problem through Design Science Research (DSR) by designing, implementing, and evaluating the Property Management and Decision-support Application (PMPA), a Smart Real Estate ERP prototype for Zimbabwean real estate SMEs.

The research followed six iterative build–evaluate cycles. PMPA integrates property lifecycle management, financial functions (amortisation, invoicing, payments, lease revenue logic), a tenant-facing portal linked to the same relational data store as staff operations, dashboards, governed data ingestion, and bounded predictive market intelligence to support interpretable decision-making.

Evaluation used purposive sampling (three organisations; eleven participants). Baseline workflows (spreadsheet-led and accounting-ERP practice) were compared with the prototype using timed tasks, reconciliation step counts, financial discrepancy checks, and Likert-scale feedback aligned with hypotheses H1–H3. Directional findings within the sample showed reduced task times, fewer reconciliation steps, fewer financial discrepancies on sample items, and ratings above the neutral midpoint for the usefulness and clarity of analytics. Data-ingestion checks confirmed that governed ingestion is

feasible, but listing-derived indicators remain market signals rather than transaction-validated prices.

Limitations include a small sample size, a mix of live and synthetic data, non-production deployment, and partial listing coverage. The study concludes that PMPA provides context-aware Software Engineering design knowledge for integrated property–finance–tenant ERP practice within the constraints of Zimbabwean SMEs.

Keywords: Smart Real Estate ERP, Design Science Research, governed data ingestion, bounded predictive market intelligence, decision support, Zimbabwe, PropTech.

Abbreviations and Acronyms

AfDB African Development Bank

AI Artificial intelligence

API Application programming interface

CRM Customer relationship management

CSV Comma-separated values

DSR Design Science Research

DSS Decision Support System

EACZ Estate Agents Council of Zimbabwe

ERP Enterprise Resource Planning

ICT Information and communication technology

IFRS International Financial Reporting Standards

KPI Key performance indicator

ML Machine learning

MLOps Machine learning operations

PMPA Property Management and Decision-support Application

PropTech Property technology

RBZ Reserve Bank of Zimbabwe

REST Representational state transfer (API style)

RQ Research question

SME Small and medium enterprise

SUS System Usability Scale

ZIMSTAT Zimbabwe National Statistics Agency

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Chapter one

1.1 Introduction

1.1 Introduction

This dissertation presents the design, implementation, and evaluation of a Smart Real Estate ERP framework for Zimbabwean real estate SMEs. The working prototype, the Property Management and Decision-support Application (PMPA), was developed and assessed using Design Science Research (DSR). The chapter outlines the research background, problem statement, aim, objectives, questions, significance, assumptions, limitations, scope, key terms, and the organisation of the study.

In this work, "smart" refers to governed integration of internal property records with controlled external data, automation of defined financial logic, dashboards, and bounded predictive market intelligence for interpretable decision support.

1.2 Background to the Study

The real estate industry contributes materially to national investment and economic activity. In many developing countries, including Zimbabwe, the sector nevertheless struggles with weak data integration, manual processes, limited transparency, and decision-support tools that rarely integrate operational records and finance into a single system. Traditional property workflows often run alongside general-purpose accounting systems, with little interoperability among agencies, financiers, valuers, tenants, and developers.

Enterprise Resource Planning (ERP) approaches can centralise property data, standardise workflows, and strengthen financial control. When combined with transparent analytics and carefully bounded, interpretable decision-support functions, such systems can help practitioners work from a single view of properties, leases, and cash flows rather than from reconciled spreadsheets alone.

This research develops and evaluates PMPA as a DSR artefact: a modular web-based system that unifies property lifecycle management, finance, tenant-facing services, dashboards, and bounded predictive market intelligence, drawing on internal portfolio records, approved property-listing data, public macroeconomic indicators, and geospatial datasets. Development and evaluation follow six iterative DSR build-evaluate cycles within the academic programme timeline.

The problem has developed from uneven digitisation within Zimbabwean property practice. Although accounting packages such as Sage and Palladium are widely used for financial reporting, lease administration, tenant communication, portfolio tracking, and renewal management, they often still rely on Excel workbooks, WhatsApp, and paper-based records. Stakeholders affected include property managers, finance officers, estate agents, developers, tenants, and ICT staff in SMEs.

Zimbabwe's property market operates amid economic volatility, currency complexity, and shifting policy, all of which amplify the costs of fragmented records and delayed insights. Regional evidence highlights uneven digitisation and siloed processes across Sub-Saharan

Africa (AfDB, 2024). Integrated lifecycle–finance–tenant designs are scarce in the literature for resource-constrained SMEs.

Practice observations from Harare suggest that some medium-sized agencies maintain parallel Excel rent rolls that do not always reconcile line-by-line with Sage or Palladium general-ledger postings. Arrears ageing may be circulated as PDF exports or in informal WhatsApp threads, while formal demand letters can still be sent on paper. Renewal escalations and deposit schedules often appear to live in workbooks rather than in the accounting package. PMPA is motivated by this hybrid pattern and the need for a single auditable store that staff and tenants can query consistently.

1.3 Statement of the problem

The central problem is that many Zimbabwean real estate organisations manage property, lease, tenant, and finance information across disconnected spreadsheets, paper records, communication channels, and accounting packages. This results in reconciliation delays, calculation errors, weak transparency, and limited decision support. Although ERP systems support general business integration, there is limited empirically evaluated design knowledge for modular real estate ERP platforms that unify property operations, finance, tenant services, governed external data ingestion, and bounded predictive market intelligence within a single data model in resource-constrained settings.

1.4 Research aim

To produce and evaluate a working Smart Real Estate ERP prototype (PMPA) for Zimbabwean real estate SMEs through Design Science Research.

1.5 Research objectives

1.5.1 General objective

To design, implement, and evaluate a Smart Real Estate ERP framework (PMPA) for Zimbabwean real estate SMEs that integrates property lifecycle management, financial logic, tenant-facing services, governed external data ingestion, and bounded predictive market intelligence, using Design Science Research.

1.5.2 Specific objectives

i. To design a modular Smart Real Estate ERP architecture using a single relational data store.

ii. To implement financial functions, including amortisation, invoicing, payments and lease revenue logic.

iii. To develop a tenant-facing portal linked to the same data store as staff operations.

iv. To provide dashboards and bounded predictive market intelligence for structured decision support.

v. To develop a governed data-ingestion layer for listing, macroeconomic and geospatial data.

vi. To evaluate the prototype against spreadsheet-based and accounting-ERP baseline workflows.

1.6 Research questions

1.6.1 General research question

How can a Smart Real Estate ERP framework with governed data ingestion and bounded predictive market intelligence be designed, implemented, and evaluated to improve property–finance–tenant integration and structured decision support for Zimbabwean real estate SMEs?

1.6.2 Specific research questions

i. RQ1: Where do accounting-oriented ERPs and spreadsheet-based practices fall short in the Zimbabwean context for property lifecycle, tenant, loan, and lease-income work?
ii. RQ2: How can property, finance, and operations cohere in one modular design with clear interfaces and a consolidated data layer?
iii. RQ3: To what extent does automating loan and lease finance improve accuracy and reporting speed compared with manual spreadsheet workflows?

iv. RQ4: How does an integrated tenant portal affect workload, transparency, and consistency across staff and tenant perspectives?

v. RQ5: How do dashboards, listing-derived market indicators, macroeconomic context, geospatial datasets, and scoped analytics support faster, more structured real estate decision-making compared with baseline materials?

vi. RQ6: How does PMPA perform relative to baseline workflows on pre-defined efficiency, accuracy, and perceived-utility measures?

vii. RQ7: What constraints on data ingestion, governance, and access affect the development and evaluation of bounded predictive market intelligence in a Smart Real Estate ERP prototype in Zimbabwe?

1.7 Significance of the study

Significance to real estate SMEs. The study offers an implementable modular architecture with transparent financial logic, tenant channels tied to master data, and evaluation instruments linked to operational pain points (reconciliation, arrears, renewals) that are common in practice in Harare and Bulawayo.

Significance to software engineering practice. It contributes design knowledge for integrated property–finance–tenant systems under conditions of limited data availability, REST APIs, role-based access, governed ingestion pipelines, and proportionate analytics.

Significance to researchers. It provides a replicable DSR evaluation model—timed tasks, step and discrepancy counts, and Likert feedback—for similar African SME contexts, with honest reporting of implemented versus partial capability.

Significance for policy and data governance. It supports lawful use of listing and official macro/geospatial data through provenance logging and aggregation into indicative signals.

1.8 Assumptions

i. Two to three purposive organisations (and, within each, up to five to ten informants, where feasible) can be recruited in accordance with consent and ethics requirements.

ii. Participating organisations have basic ICT access sufficient for a web prototype in evaluation settings.

iii. Anonymised or synthetic property, lease, tenant, and payment data can be provided with consent where live extracts are incomplete.

iv. Authorised users enter or upload data in good faith; validation rules and sample reconciliation may still detect obvious errors.

v. Listing, macroeconomic, and geospatial data, where used, are obtained through governed ingestion from approved or official sources, with provenance recorded.

vi. Stakeholders engage voluntarily in evaluation tasks and feedback instruments.

vii. The prototype is used in non-production contexts during the study; no binding legal or financial decisions are made by the system.

1.9 Limitations

i. Small purposive samples limit statistical generalisation; findings aim for analytical transferability.

ii. Partial or anonymised exports may omit edge cases present only in live systems.

iii. Resource and connectivity constraints may affect session quality in some locations.

iv. Learning and Hawthorne effects may influence task times and ratings despite protocol mitigations.

v. Market-intelligence views depend on listing coverage and platform terms; they are indicative, not census-complete.

vi. Listing-derived indicators may include duplicates, stale prices, missing fields, and asking prices that differ from transaction prices.

vii. Bounded predictive market intelligence does not replicate industrial MLOps or national price-index construction.

viii. Manual data preparation is labour-intensive and must be quality-controlled.

ix. Ethics and privacy require ongoing attention to role-based access, minimisation of sensitive fields, and secure storage.

1.10 Scope and delimitation

Geographical scope. Zimbabwe, with an emphasis on urban centres such as Harare and Bulawayo.

Participant scope. Developers, agents, property managers, finance staff, and (where feasible) tenant representatives, recruited through non-probability purposive sampling from two to three organisations.

System scope. A modular ERP-style prototype covering the property lifecycle, finance, tenant experience, dashboards, governed data ingestion, and bounded predictive market intelligence, not a full commercial SaaS offering or a live bidirectional sync with every incumbent accounting package.

Data scope. Internal property, lease, tenant, payment, and maintenance records; approved listing data where lawful; macroeconomic data from ZIMSTAT, RBZ, and the World Bank; and geospatial data from ZimGeoportal. Unauthorised scraping and restricted datasets are excluded.

Evaluation scope. Formative checks occur each iteration; summative evaluation is measured in Chapter Four. Programme milestones: prototype, block 16 March–15 April 2026; summative evaluation, 16–30 April 2026; final submission, June 2026.

1.11 Definition of Key Terms

i. ERP (Enterprise Resource Planning): Integrated software for core business processes; in this study, extended beyond ledger-only use to property-specific workflows.

ii. Smart Real Estate ERP: An ERP extended with property modules, governed external data ingestion, automation of defined financial logic, dashboards, and bounded market-intelligence-based decision support, all within the scope defined in this chapter.

iii. PMPA: Property Management and Decision-support Application; the working prototype artefact evaluated in this study.

iv. DSR (Design Science Research): Construction and evaluation of IT artefacts to address identified problems (Hevner et al., 2004; Peffers et al., 2007).

v. DSS (Decision Support System): Computer-based systems that use data, models, and views to structure decisions (Turban, Sharda and Delen, 2020).

vi. Bounded predictive market intelligence: Interpretable insights from internal portfolio data, governed listing indicators, official macro series, and geospatial context, presented as trends and scenarios.

vii. Governed data ingestion: Import of external data only where lawful and permitted, with provenance and data-quality checks.

viii. PropTech: Digital technology applied to property marketing, management, and analytics (Baum, 2018; Buckley et al., 2019).

1.12 Organisation of the study

Chapter One introduces the problem, aim, objectives, questions, significance, and scope. Chapter Two reviews the literature on ERP, PropTech, DSS, and DSR, identifies the research gap, and presents the frameworks and hypotheses. Chapter Three describes the DSR methodology, system requirements, architecture, design, implementation tools, testing, and evaluation metrics. Chapter Four presents the results of implementation, testing, ingestion, and evaluation, with interpretation. Chapter Five concludes, makes recommendations, and outlines future work. References and appendices follow.

1.13 Chapter summary

This chapter established that Zimbabwean real estate SMEs often maintain fragmented property, financial, and tenant records. The study addresses that gap through PMPA, which is evaluated via DSR against spreadsheet and accounting-ERP baselines. Objectives, research questions, significance, assumptions, limitations, and scope were defined to guide subsequent chapters.

Chapter Two

2.0 Literature Review

2.1 Introduction

This chapter reviews the literature on ERP, PropTech, decision support, and Design Science Research as they relate to integrated property operations in Zimbabwe. Evidence is organised into a conceptual review, a theoretical review, an empirical review (covering global, African, and Zimbabwean studies), a research gap, conceptual and theoretical frameworks, and hypotheses.

2.2 Conceptual Review

Enterprise technology reviews commonly organise evidence into technical layers (integration, modules, analytics), implementation practices (phasing, governance, adoption), and outcomes (efficiency, agility, decision quality) (Chaffey & White, 2019; Turban, Sharda and Delen, 2020). For PMPA, the through-line is a single integrated real estate ERP framework for SMEs: a unified lifecycle data model that links property, finance, and tenant channels, with governed data ingestion and bounded predictive market intelligence.

Key concepts adopted in this study include Smart Real Estate ERP (property modules plus governed data ingestion and bounded analytics), governed data ingestion (lawful,

permitted, provenance-tracked imports), bounded predictive market intelligence (trends and scenarios, not national forecasts), ERP, PropTech, DSR, and DSS.

2.3 Theoretical Review

Turban, Sharda and Delen (2020) treat integrated data as a precondition for effective decision support, whereas Chaffey and White (2019) emphasise master-data discipline and process alignment as ERP success drivers. Ghobakhloo (2018) and AfDB (2024) show that these assumptions often fail in resource-constrained African SMEs. Hevner et al. (2004) and Peffers et al. (2007) provide the DSR foundation for artefact-centred knowledge in this study.

Critical contrasts include:

i. ERP and IS success literature (Chaffey & White, 2019; DeLone & McLean, 2003): privileges finance-led adoption. Ledger-centric models do not capture lease status, unit tenancy, or maintenance at the asset level—states that Zimbabwean firms still track outside the ERP (Estate Agents Council of Zimbabwe, 2023).

ii. PropTech literature (Baum, 2018; Buckley et al., 2019; Olanrewaju et al., 2020): emphasises digital channels and portfolio visibility, but often presents them as product categories rather than as a single, evaluated ERP spine tied to local accounting practice.

iii. Regional evidence (AfDB, 2024; Ministry of National Housing and Social Amenities, 2023; ZIMSTAT, 2024) documents uneven digitisation. External data must be governed—listing platforms as indicative signals and official statistics as macro context.

Regarding analytics, Zhang and Chen (2018) assume enterprise-scale AI pipelines, whereas Turban, Sharda and Delen (2020) require interpretable, auditable decision support—better aligned with amortisation and lease revenue in settings with limited data (Dwivedi et al., 2021). Industrial MLOps and national forecasting fall outside PMPA's scope.

2.4 Empirical Review

2.4.1 Global Studies

The PropTech scholarship treats digital innovation as reshaping property marketing, management, and analysis (Baum, 2018; Buckley et al., 2019). Baum (2018) distinguishes waves of property technology yet often assumes markets with reliable infrastructure and abundant listing data. Buckley et al. (2019) emphasise disintermediation and customer experience; Olanrewaju et al. (2020) show that barriers are organisational as much as technical.

Property-management literature (Park & Bae, 2015; Alaa & van der Schaar, 2018) presents predictive models for housing prices and market trends—valuable for valuation research but weak in integrated operations (e.g., invoicing, arrears, and tenant portals tied to a single store). PMPA therefore positions itself between generic ERP accounts and PropTech point solutions: a single relational model, interpretable financial logic, governed ingestion, and bounded market intelligence.

2.4.2 African Studies

Regional evidence converges on uneven digitisation and hybrid practice rather than full enterprise integration (AfDB, 2024). Compared with Park and Bae (2015), African settings require the governed use of listing, macro, and geospatial data, aggregated as indicative signals rather than as a complete market truth. Listing-derived asking prices, official series (ZIMSTAT, RBZ, World Bank), and geospatial layers can support bounded market intelligence only when provenance, permission, and data-quality rules are explicit.

2.4.3 Zimbabwean Studies

Sector sources (Estate Agents Council of Zimbabwe, 2023; Ministry of National Housing and Social Amenities, 2023) describe agencies that combine accounting packages with Excel, WhatsApp, and paper for leases and tenants—the hybrid pattern motivating RQ1. International AI-enabled ERP case studies are not treated as benchmarks; the relevant question is whether an integrated artefact can reduce reconciliation and support auditable finance under those constraints.

Synthesis across themes identifies four linked deficits in Zimbabwean SME practice: (1) lifecycle–finance disconnect; (2) tenant and staff data divergence; (3) analytics without governance; (4) evaluation gap—DSR requires explicit constructs (task time, discrepancies, Likert usefulness), not vendor adoption claims alone (Hevner et al., 2004; Venable et al., 2012).

2.5 Research Gap

The literature establishes three gaps:

1. ERP systems are typically finance-centred and do not fully support property lifecycle operations (Chaffey and White, 2019; Zhang and Chen, 2018)—a finding confirmed in Zimbabwean hybrid practice (Estate Agents Council of Zimbabwe, 2023; AfDB, 2024).

2. Property and PropTech systems often separate tenant channels, maintenance, finance, analytics, and governed external data ingestion, without a single evaluated spine aligned to local ledgers.

3. There is limited empirical evaluation of integrated real estate ERP prototypes that combine bounded predictive market intelligence with interpretable decision support in Zimbabwean or comparable SME contexts.

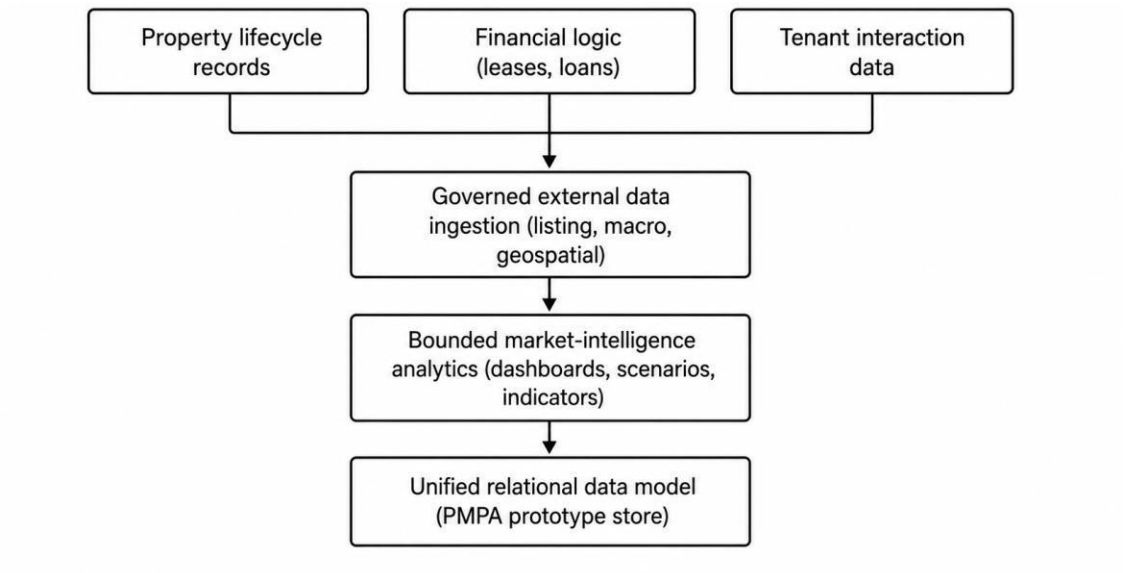
RQ7 notes that data ingestion, governance, and access constraints shape what market intelligence can be built and tested. This study addresses these gaps through PMPA and DSR evaluation.

2.6 Conceptual Framework

The usefulness of Smart Real Estate ERP depends on integrating five interconnected layers: property lifecycle records, financial logic, tenant interaction data, governed external data ingestion, and interpretable, bounded predictive market intelligence analytics. When

these layers share a single relational data model, users are expected to reduce reconciliation effort, improve financial accuracy, and access more structured decision support. This position links the literature to PMPA and aligns objectives i–vi with RQ1–RQ7. Figure 2.1 illustrates the relationships among these layers.

Figure 2.1: Conceptual Framework of Smart Real Estate ERP Usefulness



2.7 Theoretical Framework

Variables are measured as follows: workload (task minutes, reconciliation steps); financial accuracy (discrepancy counts, schedule generation time); usefulness/clarity/decision relevance (Likert scales); and ingestion quality (duplicate detection, provenance, asking-price handling). Relationships: integrated data and governed ingestion are expected to

reduce workload and improve accuracy; bounded market-intelligence views are expected to improve structured decision support, tested via H1–H3 in the summative evaluation.

2.8 Hypotheses

Summative evaluation tests three directional hypotheses:

i. H1: An integrated framework reduces administrative workload (e.g., report retrieval time and reconciliation steps) and improves transparency compared with spreadsheet-based baseline workflows.
ii. H2: Automated loan and lease finance logic produces fewer discrepancies and faster schedule or report generation than manual calculations for comparable sample items.
iii. H3: Dashboards and bounded market-intelligence views, based on listing-derived indicators, macroeconomic context, and geospatial data, reduce time spent on defined analytics tasks and receive ratings above the neutral midpoint for usefulness, clarity, and decision relevance compared with baseline analysis approaches.

2.9 Chapter Summary

This chapter defined key concepts, critically contrasted ERP, PropTech, DSS, and regional evidence, synthesised empirical themes into deficits for Zimbabwean SMEs, stated the research gap, and linked conceptual and theoretical frameworks to PMPA, RQs, and H1–H3.

CHAPTER THREE

3.0 RESEARCH METHODOLOGY

3.1 Introduction

This chapter outlines how the study constructs and evaluates PMPA using Design Science Research. PMPA is a working software prototype comprising a React/TypeScript frontend, a FastAPI backend, a PostgreSQL database, REST APIs, role-based access control, a governed data-ingestion layer, and an analytics layer for dashboards and bounded market intelligence. The chapter covers research design, the DSR approach, build–evaluate cycles, sampling, data collection, system requirements, architecture, detailed design, implementation tools, testing strategy, evaluation metrics, analysis procedures, ethics, and validity.

The contribution is a deployable artefact supported by evidence of utility within a bounded academic programme, rather than statistical generalisation to a national population.

3.2 Research Design

This study adopts a Design Science Research strategy with a mixed-methods evaluation (quantitative timed tasks and counts; qualitative themes). It is artefact-centred rather than a large-scale survey of ERP satisfaction. A purposive case-study orientation suits the evaluation of PMPA in real organisations under ethical and data constraints. The

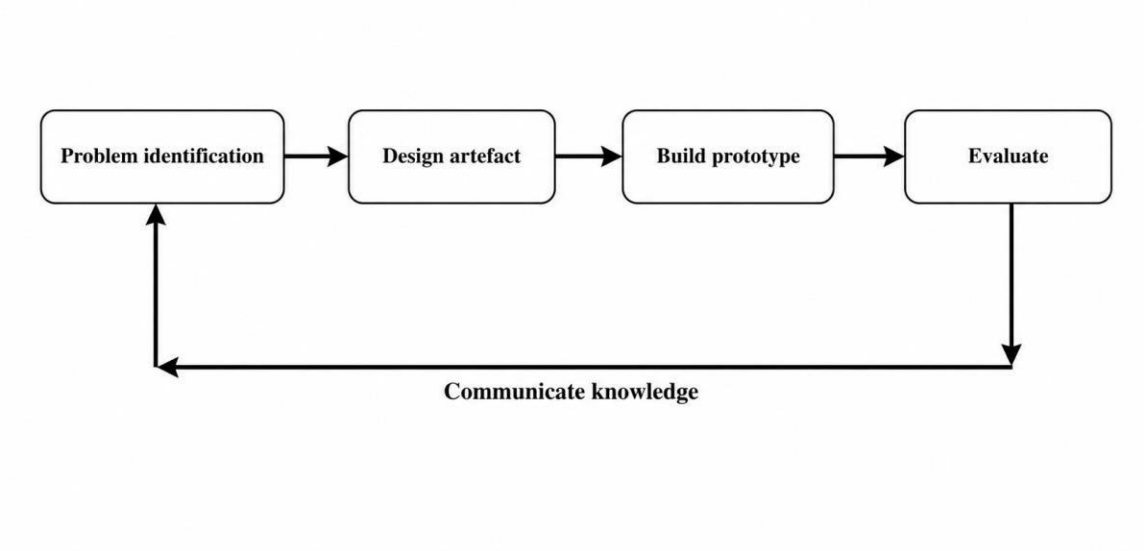
orientation is exploratory in examining how modules cohere around one store, and explanatory in relating observed differences in time, errors, and ratings to artefact features compared with accounting-ERP-plus-spreadsheet baselines.

3.3 Design Science Research Approach

DSR is appropriate because the research problem is addressed through a purpose-built IT artefact, whose fitness for purpose must be demonstrated through construction and evaluation (Hevner et al., 2004; Peffers et al., 2007). The central knowledge outcome is what works, for whom, and under which constraints when property, finance, tenant services, governed ingestion, and bounded market-intelligence analytics are unified within a single modular design.

DSR is preferred to alternatives because: (i) pure survey research would not produce the integrated prototype; (ii) a qualitative-only study would lack a falsifiable performance comparison; (iii) long-term ethnography does not align with the fixed build-and-evaluate window; (iv) action research implies sustained embedded intervention, whereas this study uses a non-production prototype and a controlled evaluation. Figure 3.4 summarises the build–evaluate cycle used in this study.

Figure 3.4: DSR Build–Evaluate Cycle



3.4 System Development Methodology

Development follows short, incremental iterations aligned with software engineering practice: requirements refinement, modular implementation, automated testing, formative checks, and summative user evaluation. Each iteration includes planning, design, implementation, and testing. Supervisory and practitioner feedback refines the scope to avoid creep beyond the defined data boundary. Modules remain separate at the interface level while sharing a single consolidated data layer.

3.5 Build–Evaluate Cycles

DSR is realised through six repeated build–evaluate cycles (Hevner et al., 2004; Peffers et al., 2007):

i. Iteration 1: Requirements refinement and modular architecture (property, finance, tenant, analytics, data strategy).

ii. Iteration 2: Property lifecycle and CRM (records, leases, leads, workflows).

iii. Iteration 3: Finance module—instalments, amortisation, invoicing, payments, lease-aligned revenue recognition.

iv. Iteration 4: Tenant-facing platform integrated with property and finance.

v. Iteration 5: Governed the data-ingestion layer, dashboards, KPIs, and macroeconomic and geospatial indicators.

vi. Iteration 6: Bounded predictive market intelligence, summative evaluation, refinement, and documentation.

Formative evaluation occurs at the end of each iteration. Summative evaluation (timed tasks, discrepancy counts, and Likert instruments) is concentrated in late Iteration 6 and during the evaluation window. Table 3.1 maps each iteration to its primary deliverable and study objectives.

Table 3.1: DSR Build–Evaluate Iterations and Objectives

Iteration	Primary deliverable	Objectives principally addressed
1	Modular architecture; data strategy	i

2	Property lifecycle and CRM	i
3	Finance (amortisation, lease revenue, payments)	i, ii
4	Tenant-facing platform	i, iii
5	Governed ingestion; dashboards; macro/geospatial context	iv, v
6	Bounded market intelligence; summative evaluation	iv, v, vi

Where full module maturity is not achieved by the evaluation window, implementation status is reported as implemented, partial, or conceptual-only.

3.6 Population and Sampling

Target population. Zimbabwean real estate organisations involved in development, leasing, property management, and related financial administration, with an emphasis on Harare and Bulawayo.

Sampling design. Non-probability purposive sampling targets two to three organisations that use accounting ERPs and spreadsheets extensively, consent to participate, and, where possible, offer portfolio diversity. Within each organisation, five to ten informants support context gathering, structured tasks, and feedback. The primary unit of analysis is the PMPA

artefact and its performance in selected workflow tasks. Findings aim for analytical transferability, not national statistical generalisation.

3.7 Data Collection Methods

Data sources include:

i. Internal organisational data—properties, leases, tenants, invoices, payments, arrears, maintenance, amortisation spreadsheets (anonymised or synthetic substitutes where needed).

ii. Approved property-listing data from sources such as Propertybook and selected developer or agency listings (e.g., Northgate Estates) was ingested only under governed access and aggregated into market indicators.

iii. Macroeconomic and demographic datasets from ZIMSTAT, RBZ, and the World Bank, with provenance.

iv. Geospatial datasets from ZimGeoportal/ZimGeospatial where lawful and permitted.

v. Documents, policies, forms, reports.

vi. Stakeholder input, semi-structured interviews about workflows and expectations. Table 3.2 summarises the external and internal data sources used by the prototype.

Table 3.2: Data Sources and Use in PMPA

Data source	Example fields	Use in PMPA	Risk/limitation
Internal records	leases, tenants, payments, arrears	finance, tenant, property dashboards	incomplete or anonymised
Propertybook / Northgate listings	asking price, location, property type	market indicators	stale/duplicate listings; asking ≠ transaction price
ZIMSTAT / RBZ / World Bank	inflation, exchange rate, population, GDP	macro context	different update frequencies
ZimGeoportal	location/spatial layers	geospatial context	coverage and format differences

Uncontrolled or unauthorised scraping, personal-data collection, and restricted datasets are not included. The table shows that PMPA combines internal records with external datasets. Internal data support operations and finances, while listing, macroeconomic, and geospatial sources provide limited market insights. These limitations are managed via provenance logging, data quality checks, and careful interpretation of external indicators.

3.8 Data Collection Instruments

i. Document review checklist for identifiers, lease terms, payment schedules, and loan parameters.

ii. CSV/Excel extraction templates with field definitions for loading the prototype database.

iii. Macro, listing, and geospatial provenance log (indicator, value, period, source, permission note).

iv. Semi-structured interview guide covering processes, pain points, data flows, and expectations.

v. Prototype evaluation form with Likert-scale items (1–5) for usability, usefulness, clarity, efficiency, and transparency, plus open comments.

3.9 System Requirements

3.9.1 Functional Requirements

Property lifecycle module

i. Create, read, update, and retire property and unit records.
ii. Manage leases, tenants, maintenance requests, and portfolio status.
iii. Support acquisition, leasing, maintenance, and disposition workflows.
iv. Finance module
v. Generate amortisation schedules for acquisition finance.
vi. Create invoices, record payments, and recognise lease revenue.
vii. Produce arrears, portfolio summary, and finance reports.

Tenant portal module

i. Allow tenants to view lease balances, payment history, and maintenance requests.
ii. Enforce role-based visibility consistent with staff master data.

Dashboard and reporting module

i. Display KPIs, portfolio summaries, and standard operational reports.
ii. Support export of evaluation-relevant outputs.

Governed data ingestion module

i. Import listing, macroeconomic, and geospatial data with provenance logging.
ii. Apply data-quality checks (duplicates, missing fields, stale prices, location normalisation).

Bounded market-intelligence module

i. Present listing-derived indicators, macro context, geospatial layers, and scenario views.
ii. Support defined analytics tasks without national price forecasting or opaque ML scoring.

Administration and security

i. User authentication, role-based authorisation, company-scoped data isolation, and audit logs.

3.9.2 Non-Functional Requirements

Table 3.4 lists the non-functional requirements applied to the PMPA prototype.

Table 3.4: Non-Functional Requirements for PMPA

Requirement	Description
Security	Authentication, authorisation, RBAC, data minimisation, audit trails, company-scoped isolation
Usability	Clear navigation for staff and tenant roles; evaluation tasks are completable within session time
Reliability	Consistent financial calculations; transactional integrity in PostgreSQL
Maintainability	Modular services (property, finance, tenant, analytics, ingestion) with REST APIs
Scalability	Architecture supports additional companies and modules without schema redesign
Performance	Report and dashboard retrieval within minutes for evaluation of portfolio sizes

Auditability	Provenance logs for external data; traceable amortisation and revenue outputs

3.10 System Architecture

PMPA is implemented as a layered web application comprising separate presentation, application, data, ingestion, and analytics tiers. The presentation tier delivers the staff dashboard and tenant portal. The application tier hosts modular FastAPI services. The data tier uses a single PostgreSQL database for all modules. The ingestion tier loads listing, macroeconomic, and geospatial data via governed REST pipelines. The analytics tier generates KPIs, indicators, and scenario views from the consolidated store. Role-based access control enforces company-scoped data isolation at the API and database query levels. Figure 3.1 shows the layered architecture.

Figure 3.1: Layered System Architecture of PMPA

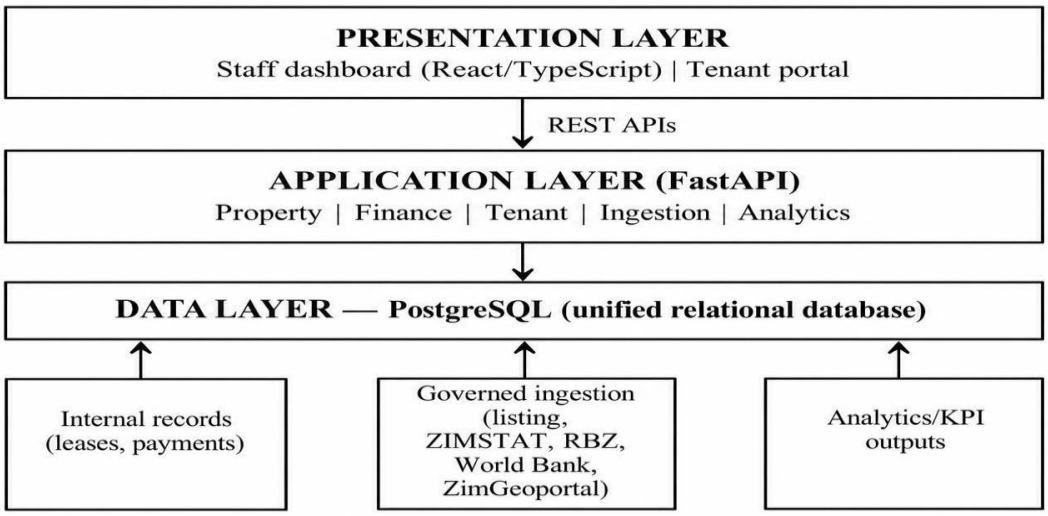
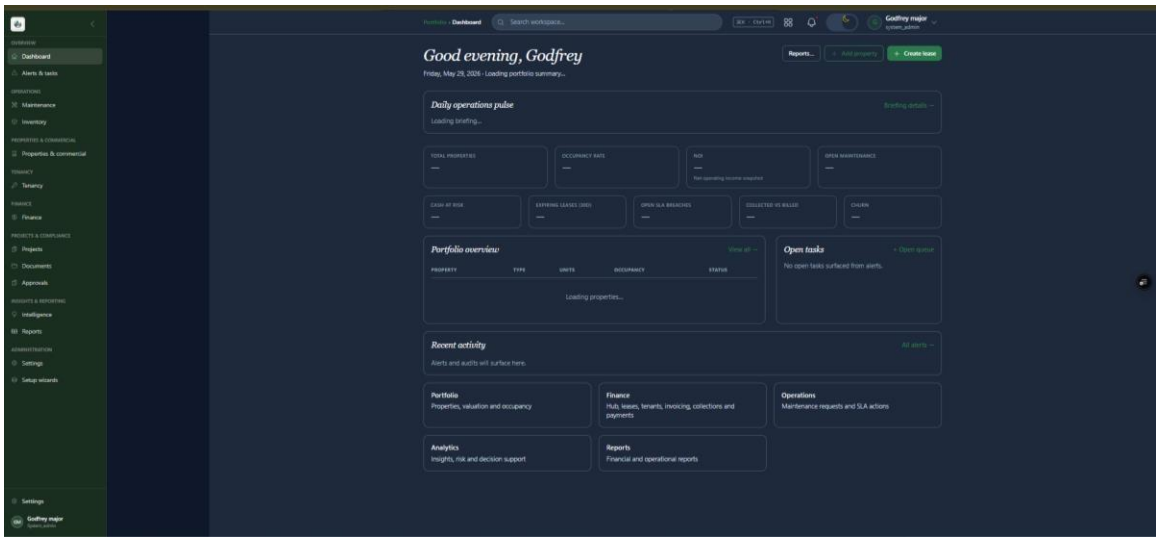


Figure 3.5: PMPA Staff Dashboard Interface



3.11 System Design

3.11.1 Use Case Design

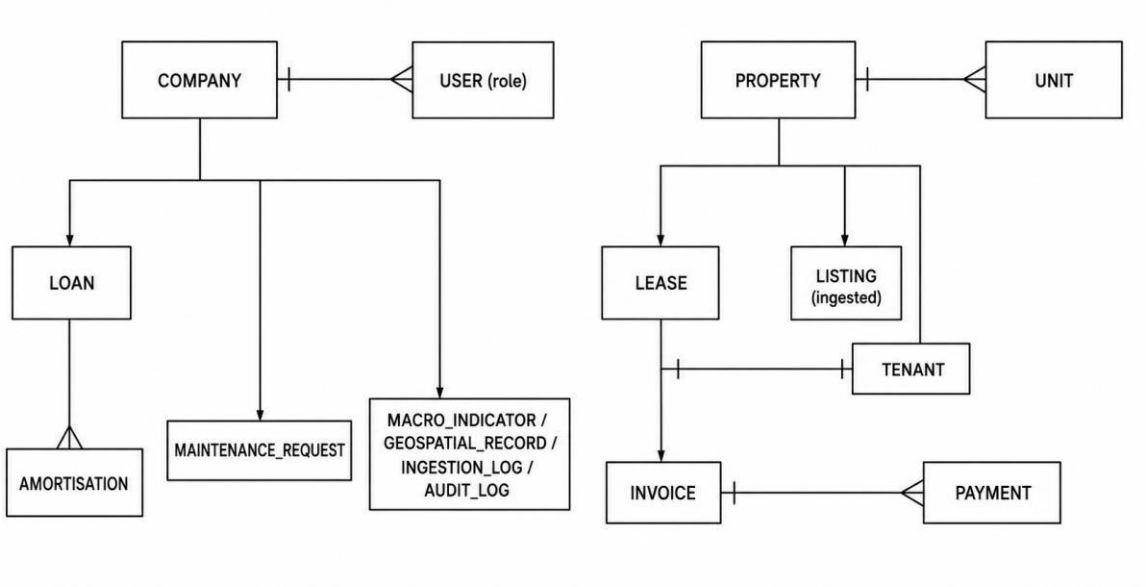
Primary actors include the property manager, finance officer, estate agent, tenant, system administrator, and data-ingestion operator. Core use cases include managing properties and leases, processing invoices and payments, generating amortisation schedules, viewing tenant balances, ingesting external datasets, and completing dashboard analytics tasks for H3 evaluation.

Illustrative scenario: A property manager produces a month-end arrears report. In the baseline workflow, this requires reconciling tenant lists and payment notes against spreadsheet ledgers and accounting ERP extracts across multiple files. In PMPA, the same insight is retrieved from the integrated store via dashboards or standard reports, with fewer cross-system steps (as measured by the fixed-task protocol).

3.11.2 Database Design

The consolidated relational schema includes entities for users, roles, companies, properties, units, tenants, leases, invoices, payments, loans, amortisation schedules, maintenance requests, listings, macro indicators, geospatial records, ingestion provenance, and audit logs. Foreign keys enforce relationships across the property, finance, and tenant domains, ensuring that staff and tenant views reference the same master data. Figure 3.3 presents the core entities and relationships.

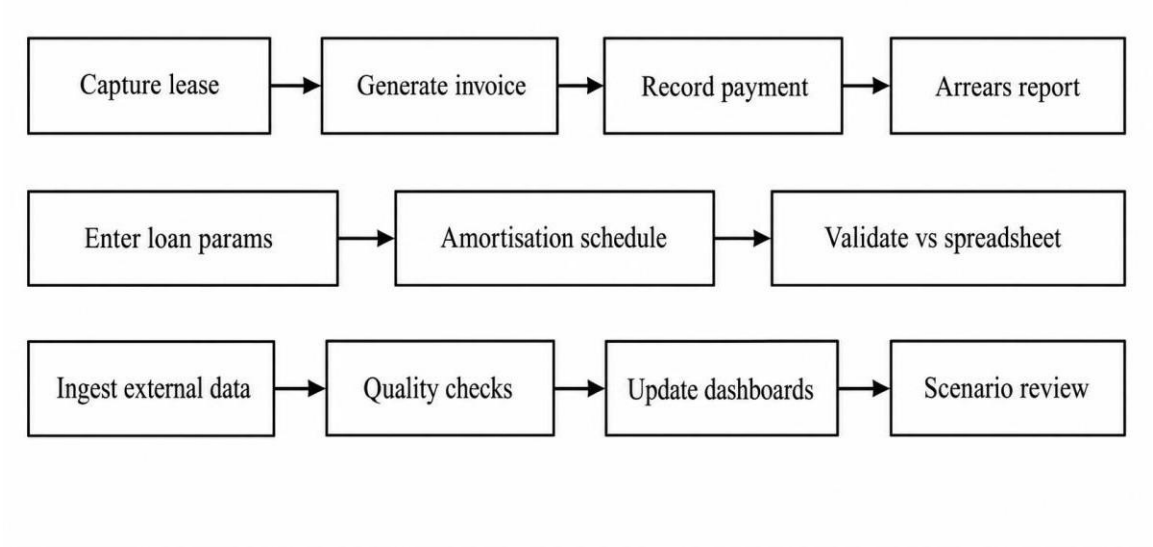
Figure 3.3: Database Entity Relationship Diagram (core entities)



3.11.3 Process Flow Design

Typical flows include lease capture → invoicing → payment recording → arrears reporting; loan parameter entry → amortisation schedule generation → validation against a reference spreadsheet; governed ingestion → data-quality checks → dashboard update → scenario review. Figure 3.2 outlines these process flows.

Figure 3.2: PMPA Process Flow Diagram



3.11.4 Module Design

i. Property lifecycle module—property CRUD, leases, maintenance, portfolio views.

ii. Finance module—amortisation, invoicing, payments, and lease revenue recognition.

iii. Tenant portal module—tenant-facing balances and requests linked to master data.

iv. Dashboard and reporting module—KPIs and operational reports.

v. Governed data-ingestion module—listing, macro, geospatial pipelines with provenance.

vi. Bounded market-intelligence module—indicators, trends, and scenarios for governed data.

Figure 3.6: Property Lifecycle Management

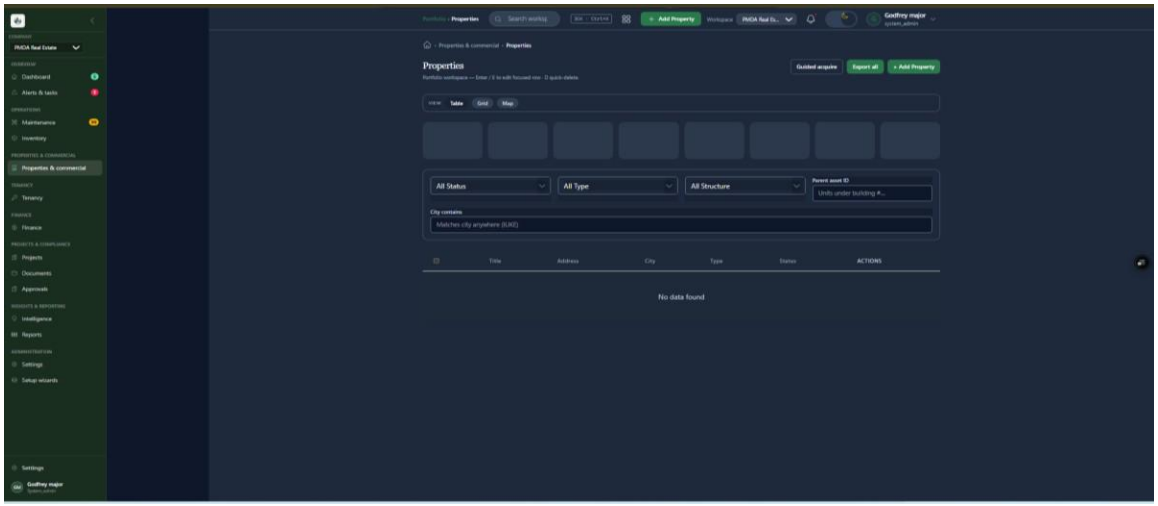


Figure 3.7: Lease and Invoicing Screen

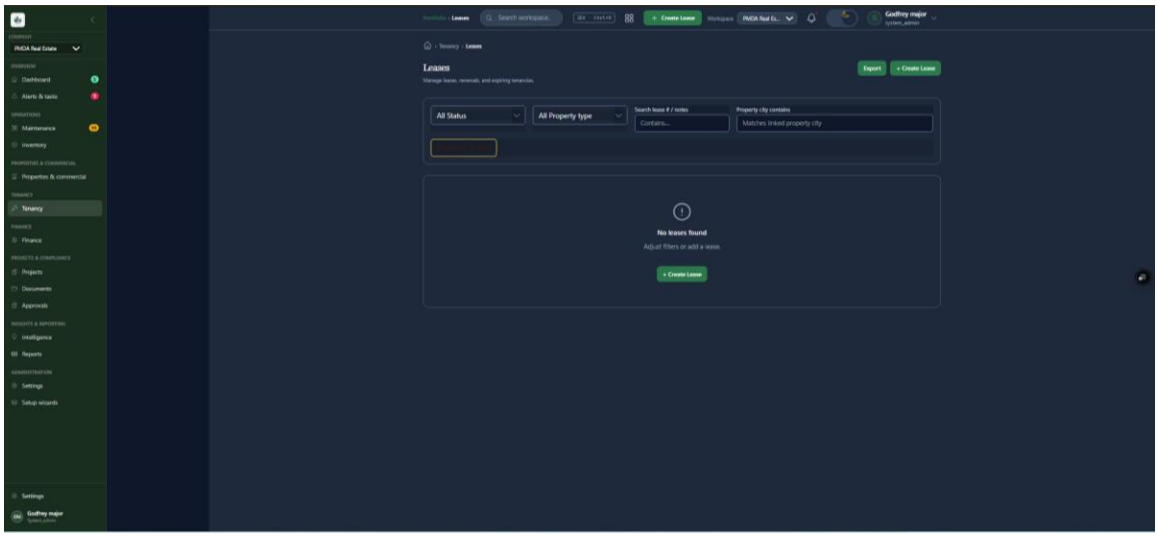


Figure 3.8: Tenant Portal Interface

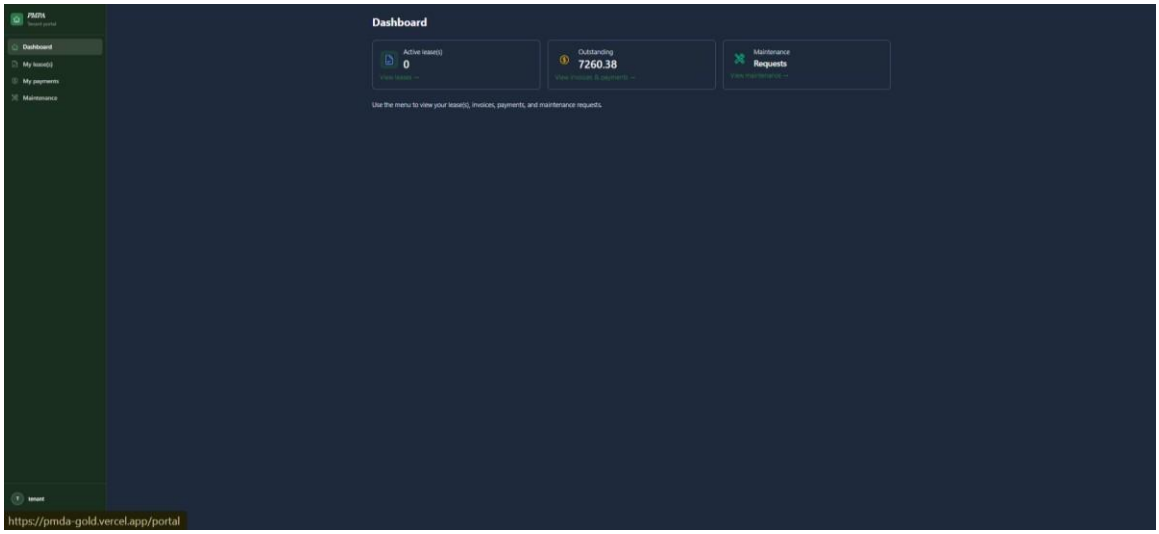
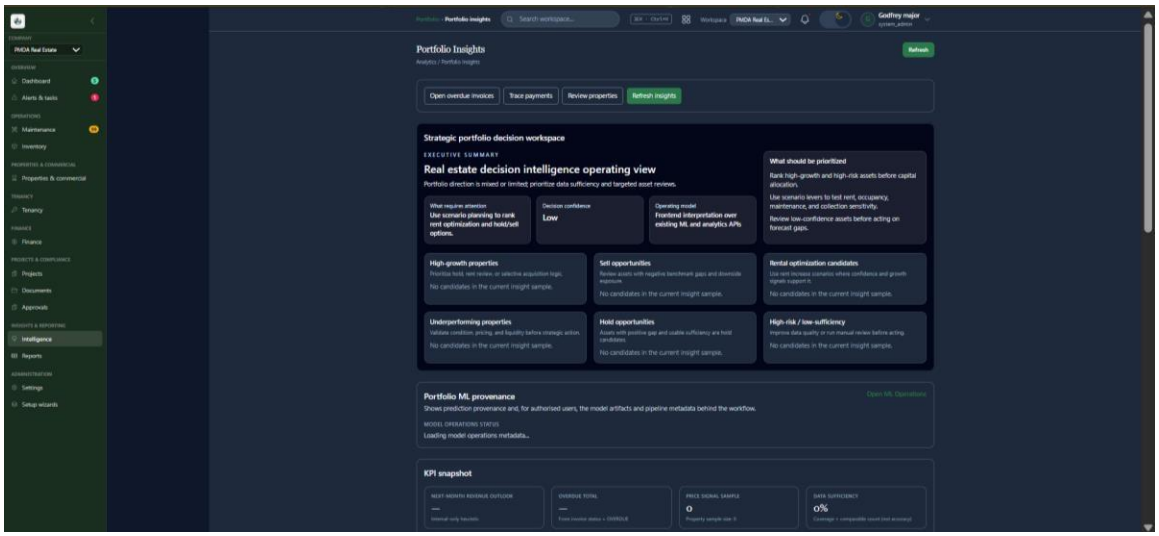


Figure 3.9: Market Intelligence Dashboard



3.12 Implementation Tools and Technologies

The prototype was implemented and version-controlled as a functional codebase. Table 3.5 lists the primary technologies.

Table 3.5: Implementation Tools and Technologies

Layer	Technology
Frontend	React, TypeScript
Backend	Python, FastAPI
Database	PostgreSQL
APIs	REST
Analytics scripts	Pandas (or equivalent) for transparent summaries
Version control	Git[https://github.com/godfr3y-ops/pmda/releases/tag/v1.0.0]

Exact version numbers belong in technical documentation; the research contribution is the framework and evaluation.

3.13 Testing Strategy

3.13.1 Unit Testing

Unit tests cover financial calculation functions (amortisation, lease revenue), validation rules, and ingestion parsers, using known inputs and expected outputs.

3.13.2 Integration Testing

Integration tests verify API endpoints, database transactions, role-based access controls, and ingestion pipeline writes, including provenance records.

3.13.3 System Testing

System tests exercise end-to-end workflows: lease-to-invoice-to-payment, tenant portal parity with staff views, dashboard generation, and cross-company isolation (zero cross-company rows in scripted queries).

3.13.4 User Acceptance Testing

User acceptance testing occurs during the summative evaluation window through structured tasks, Likert instruments, and short qualitative comments aligned with H1–H3.

3.14 Evaluation Metrics

Evaluation, scheduled in late Iteration 6, combines functional testing, structured tasks, and user judgment. Table 3.3 operationalises H1–H3.

Table 3.3: Hypotheses and Operational Measures

Hypothesis	Construct	Operational measures
H1	Workload; transparency; reconciliation burden	Report retrieval time (minutes); reconciliation step count; duplicate data-entry actions avoided where observable
H2	Accuracy; reporting speed	Discrepancy count vs reference spreadsheet on sample loans/leases; time to generate schedules (minutes)
H3	Analytics task time; perceived usefulness	Task time for defined questions; count of outputs completed; Likert means (1–5) for usefulness, clarity, decision relevance

Baseline. Participant's current practice: spreadsheets, accounting-ERP reports, and manual reconciliation. If only post hoc prototype timing is available, this limitation is documented.

Given purposive sampling and a small n, quantitative analysis is primarily descriptive (medians, means, counts, Likert summaries). Inferential tests may be reported only where assumptions are plausible; they indicate direction within the sample, not population inference.

3.15 Data Analysis Procedures

Analysis supports (i) prototype performance and usefulness and (ii) alignment with the research gap:

i. Descriptive statistics: task times, step counts, discrepancy counts.

ii. Comparative analysis: baseline versus prototype on standardised tasks.

iii. Dashboard/analytics review: relevance and clarity of KPIs and scenarios.

iv. Thematic coding: short comments grouped by usability, transparency, and decision support.

Tools include spreadsheets, SQL, and optional Python/Pandas for summaries.

3.16 Ethical Considerations

Voluntary informed consent is required for organisations and individuals. Personal and organisational data are handled in accordance with institutional ethical requirements: minimisation, restricted access, anonymisation, and secure storage. The prototype is used only in non-production settings. For external listing data, the study records source permissions, access method, collection date, and permitted use, and avoids reproducing protected content beyond aggregated indicators.

3.17 Validity, Reliability and Trustworthiness

i. Construct validity: Metrics map to objectives, RQs, and H1–H3.

ii. Internal validity: Triangulation among logs, timed tasks, discrepancy checks, Likert means, and qualitative themes.

iii. Reliability: Documented tasks, instruments, and analysis steps.

iv. Transferability: Rich description of modular design and constraints; no claim of statistical external validity.

Methodological limitations include small-n bias, gaps in anonymised export data, learning and Hawthorne effects, synthetic-data limitations, uneven listing coverage, and partial baseline–prototype comparisons, all of which are mitigated by transparent reporting.

3.18 Chapter Summary

This chapter specified DSR as the primary paradigm, six build–evaluate iterations, purposive sampling, governed data ingestion, functional and non-functional requirements, a layered architecture, module and database design, implementation tools, a testing strategy, and hypothesis-aligned evaluation metrics, together with ethics and validity considerations.

CHAPTER FOUR

4.0 DATA PRESENTATION, ANALYSIS AND INTERPRETATION

4.1 Introduction

This chapter presents findings from the implementation and evaluation of PMPA (Property Management and Decision-support Application), a Smart Real Estate ERP prototype developed for Zimbabwean real estate SMEs. The artefact was built to address fragmented property, finance, and tenant records typical of spreadsheet-led and accounting-ERP hybrid practice.

Analysis is based on four main indicators aligned with the study design: (i) system implementation and modular functionality; (ii) functional verification and system testing; (iii) baseline–prototype comparative performance on predefined tasks; and (iv) user acceptability, data-ingestion quality, and directional verification of hypotheses H1–H3. Findings are directional within the purposive sample (n = 11); percentage changes in the tables describe that sample only and do not claim national statistical generalisation.

4.2 Research context and participants

Three purposive organisations participated under anonymised labels. Org. A (Harare) combined property management and leasing, used Sage with extensive Excel rent rolls, and supplied anonymised CSV extracts with synthetic augmentation. Org. B (Bulawayo) was a smaller development firm on Palladium, contributing only synthetic portfolio data. Org. C (Harare) was a residential letting agency with partial live extracts (leases, invoices). Ethics clearance [details required: ethics approval reference number] and organisational consent were obtained prior to data handling. Table 4.1 profiles the participating organisations.

Table 4.1: Participant Profile (Organisations)

Organisation (label)	Role/sector emphasis	Location	Data mode for evaluation	Notes
Org. A	Property management and leasing	Harare	Anonymised CSV + synthetic augmentation	Mid-size portfolio; Sage + Excel baseline
Org. B	Real estate development	Bulawayo	Synthetic demo data	Palladium accounting; no live ERP feed
Org. C	Residential letting agency	Harare	Partial live extracts	Spreadsheet-led arrears and renewals

Interpretation. The three organisations represent a hybrid Sage/Palladium-plus-spreadsheet practice in Harare and Bulawayo, with varying data modes that influence how summative results are read.

Eleven participants completed structured tasks and instruments (n = 11). Sessions fell within 16–30 April 2026. Baseline and prototype task order was counterbalanced where logistics allowed. Table 4.2 shows participant roles.

Table 4.2: Participant Profile (Roles)

Role	n	Organisations represented
Property/portfolio management	3	A, B, C
Finance/accounts	3	A, C
Sales/agency	2	A, B
Tenant representative	2	A, C
IT / technical	1	A
Total	11	—

Interpretation. Role diversity supported task coverage across H1–H3. Results involving Org. B are treated as functional and usability evidence rather than live operational evidence.

4.3 System Implementation Results

PMPA was implemented successfully using an open-source stack suited to SME deployment: PostgreSQL as the unified relational store, FastAPI for modular business logic, and React with TypeScript for staff and tenant interfaces. REST APIs connect presentation, application, ingestion, and analytics layers. Table 4.3 reports implementation status against study objectives.

Table 4.3: System Implementation Status by Objective

Study objective	Status	Evidence

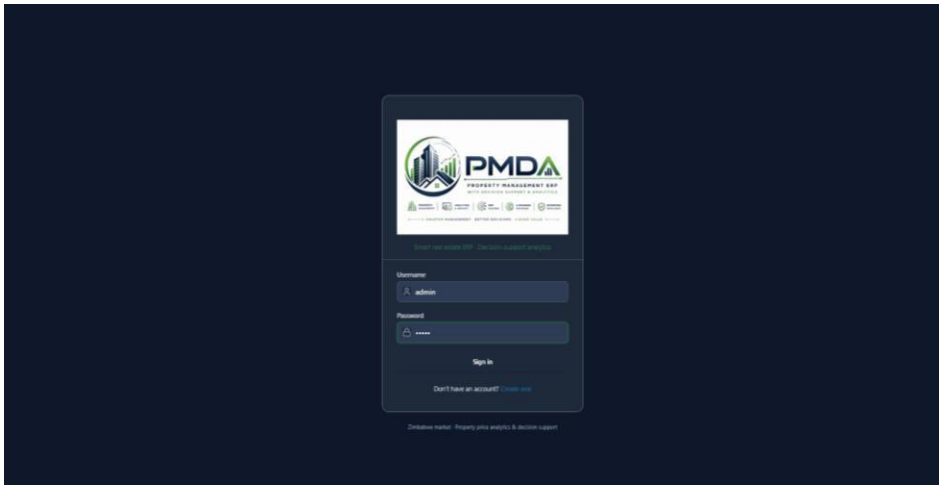
i Modular unified architecture	Implemented	Multi-module API; relational schema; Appendix F screenshots
ii Financial functions	Implemented	Amortisation and revenue services; sample validation logs
iii Tenant portal	Implemented	Tenant role; portal routes; staff–tenant parity checks
iv Dashboards and bounded market intelligence	Partial	KPI and indicator views; depth limited by listing coverage
v Governed data-ingestion layer	Implemented	Provenance logs, ingestion endpoints, access controls
vi Baseline versus prototype evaluation	Implemented	Timed protocols; evaluation matrices populated

Interpretation. Objectives i–iii, v, and vi reached Implemented status; objective iv was Partial because of listing coverage and thin organisational series. Conceptual-only components remain live bidirectional sync to Sage or Palladium and industrial-scale MLOps.

4.3.1 Authentication and role-based access control

Authentication employs secure session or token-based access, combined with role-based access control (RBAC) and data isolation within the company's scope. Roles such as staff, finance, tenant, and administrative restrict access to relevant modules and domains. Figure 4.1 illustrates the login interface used during the evaluation.

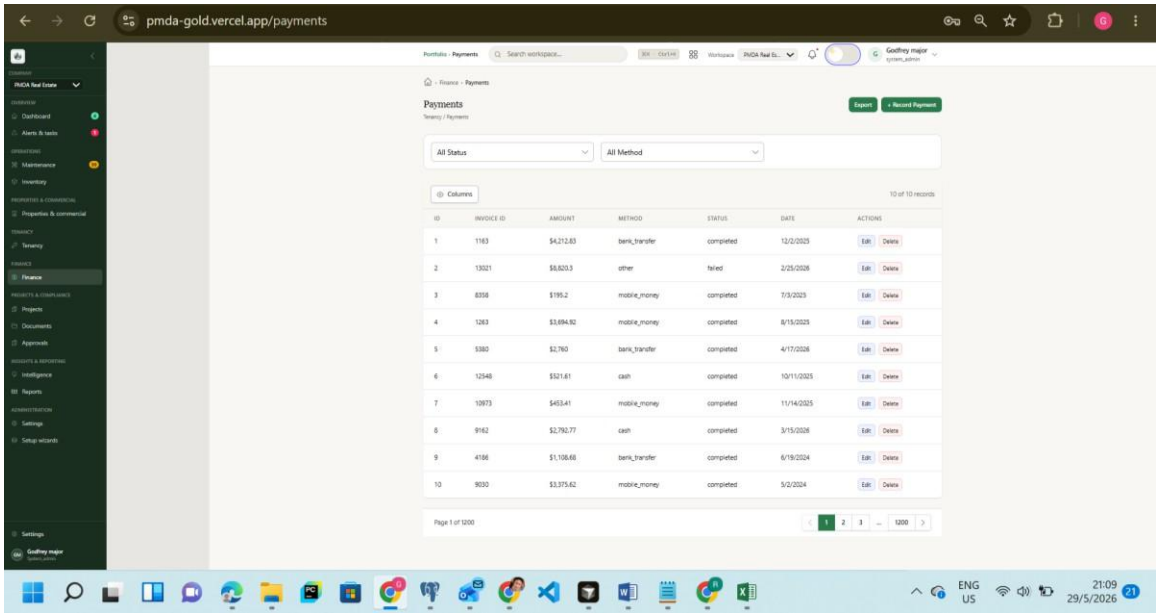
Figure 4.1: PMPA login and role-based access screen



4.3.2 Property Lifecycle and Finance Modules

The property lifecycle module supports property and unit records, leases, tenants, and maintenance workflows within the consolidated store. The finance module implements amortisation schedules, invoicing, payments, and lease revenue recognition, with outputs validated against spreadsheet references during testing.

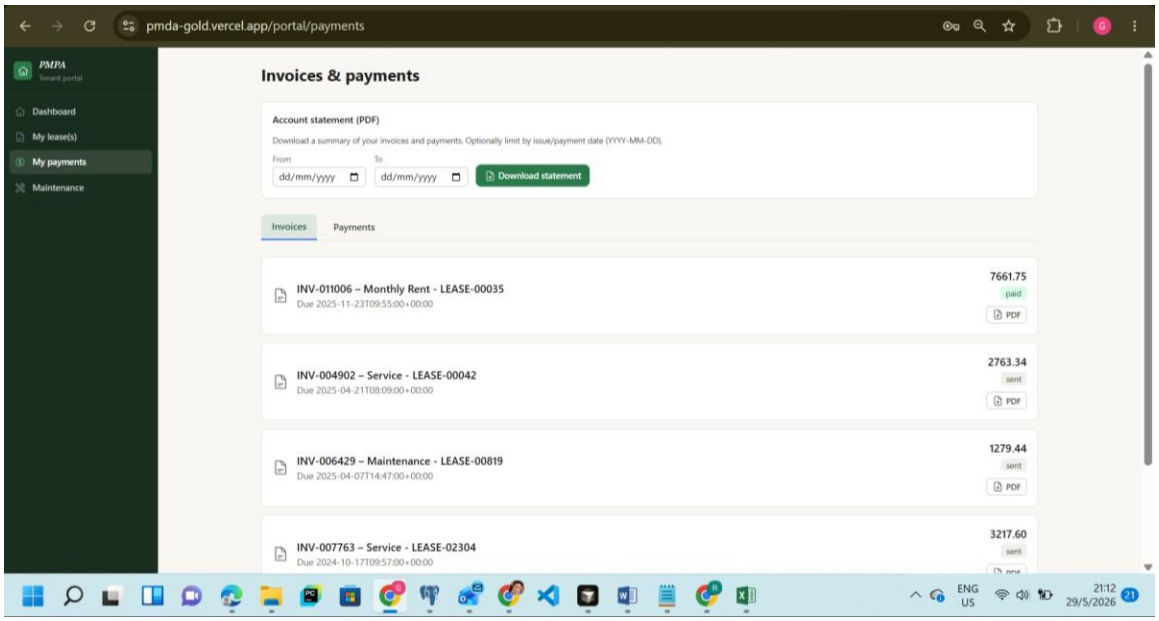
Figure 4.2: Property lifecycle and finance modules screen



4.3.3 Tenant Portal

The tenant portal allows tenants to view lease balances, payment history, and maintenance requests from the same PostgreSQL store used by staff, thereby supporting consistency between staff and tenant views, as evaluated in RQ4.

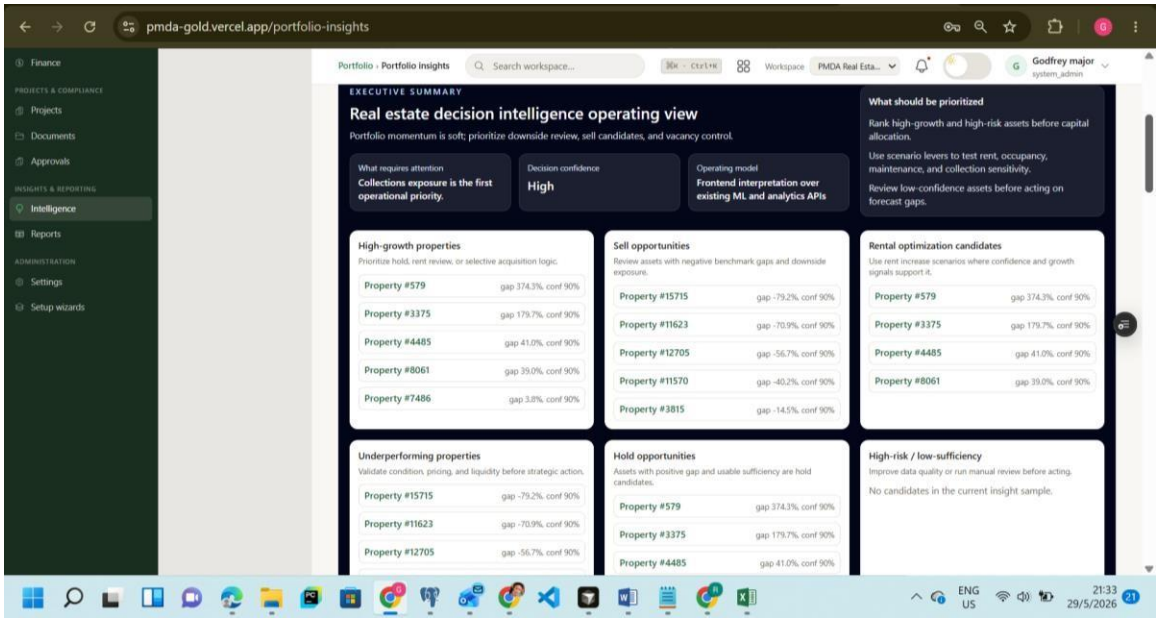
Figure 4.3: Tenant Portal/Payments/Invoices



4.3.4 Dashboards, Reporting, and Bounded Market Intelligence

The dashboard and reporting module provide portfolio summaries, arrears lists, and KPI views from the consolidated store. The bounded market-intelligence module presents listing-derived indicators, macroeconomic context, and scenario views for structured decision support, not for autonomous valuation or national price forecasting.

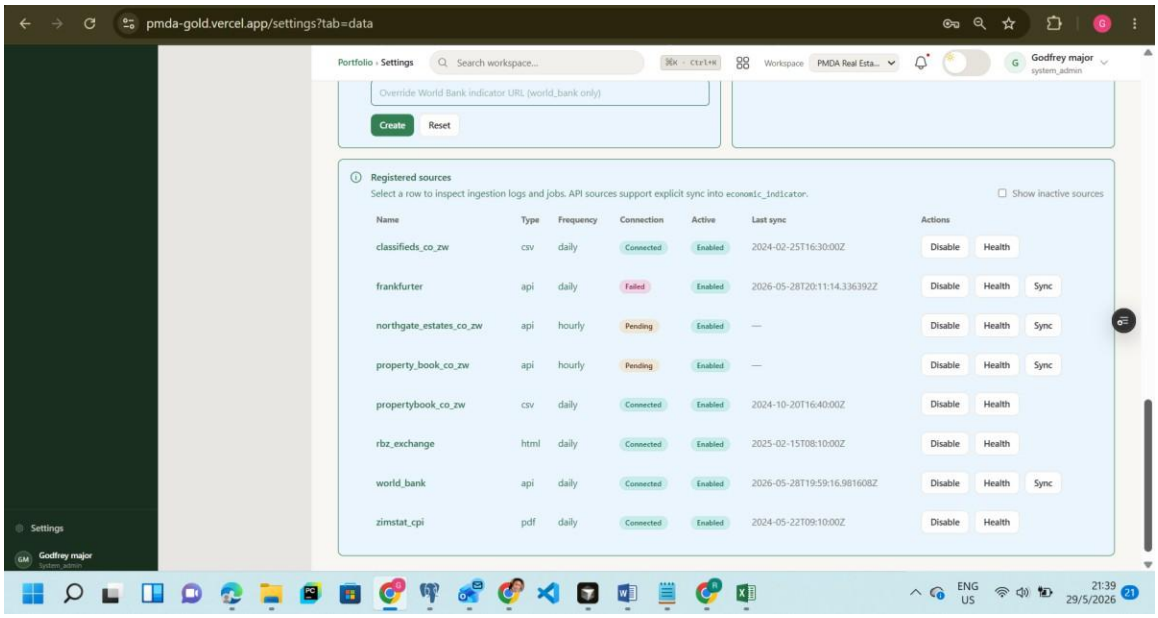
Figure 4.4: Dashboards, Reporting, and Bounded Market Intelligence



4.3.5 Governed Data-Ingestion Layer

The ingestion module loads listing, macroeconomic, and geospatial data via governed REST pipelines, with provenance logging, duplicate checks, and permission notes.

Figure 4.5: Governed Data-Ingestion Layer



4.4 System Testing and Usability Evaluation

Validation combined functional verification against Chapter Three requirements, unit and integration tests, formative system checks, and user acceptance testing during the summative window.

4.4.1 Results of Functional Verification

Functional testing covered core modules with inputs, expected outputs, and pass/fail criteria aligned to Section 3.9.

Table 4.4: Results of Functional Verification by Module

Module ID	Module name	Test condition	Expected result	Status
Mod-01	User access and RBAC	Valid/invalid credentials; unauthorised role access	Session authentication; role-limited access	Pass

Mod-02	Property lifecycle	CRUD property, lease, and tenant records	Records persist; relationships enforced	Pass
Mod-03	Finance (amortisation, revenue)	Sample loans/leases vs spreadsheet reference	Schedules match the agreed tolerance	Pass
Mod-04	Tenant portal	Tenant view vs staff master data	Balances and leases align for test tenants	Pass
Mod-05	Governed data ingestion	Ingest listing/macro sample with provenance	Provenance logged; quality checks applied	Pass
Mod-06	Dashboards and bounded market intelligence	Generate KPI and indicator views	Views render from consolidated store	Pass

Mod-07	Data isolation	Cross-company query under RBAC	Zero cross-company rows returned	Pass

Interpretation. All core modules passed functional verification before summative user tasks, supporting the credibility of H1–H3 evaluation results.

4.4.2 Unit and Integration Testing Results

Unit tests on amortisation and lease revenue functions passed against reference calculations. Payment amounts matched spreadsheet references to two decimal places on sample loans. API integration tests confirmed lease-to-invoice-to-payment flows, ingestion writes with provenance records, and role-based access enforcement.

4.4.3 System Testing Results

Formative system tests for Iterations 1–6 are shown in Table 4.5.

Table 4.5: Formative System Testing Results

Area	Check	Outcome
Amortisation	Sample loan vs spreadsheet	Pass: payment matches to two decimals
Lease revenue	Accrual totals vs reference	Pass within 0.05% tolerance
Tenant portal	Visibility vs staff view	Pass for five test tenants

Dashboards / analytics	KPIs from consolidated store	Pass; limited-data caveat for market-intelligence views
Data isolation	Cross-company query	Pass: zero rows

Interpretation. Core ERP paths passed prior to summative evaluation.

4.4.4 User Acceptance Testing Results

Eleven participants completed H1–H3 task protocols and Likert instruments during the summative window. No critical workflow failures blocked task completion on implemented modules. Connectivity interruptions briefly affected two sessions; tasks were resumed within the evaluation window.

4.5 Data-Ingestion and Data-Quality Results

Governed ingestion checks during Iterations 5–6 identified duplicate entries, incomplete location fields, stale advertised prices, and inconsistency between asking-price format and internal portfolio records. Provenance logs recorded the source platform, collection date, and permission notes for Propertybook and selected listings, which were then ingested. Macro series from ZIMSTAT, RBZ, and the World Bank, and geospatial layers from ZimGeoportal, were loaded with documented provenance where access was confirmed.

These findings support objective v and RQ7: ingestion is feasible under governance rules, but listing-derived indicators remain indicative market signals, not transaction-validated price evidence.

4.6 Baseline Comparative Analysis and Evaluation Results

Baseline workflows (spreadsheet-led and accounting-ERP practice) were compared with PMPA on standardised tasks defined in Chapter Three. Medians and Likert means summarise small-n directional change (n = 11).

4.6.1 H1: Administrative Workload and Transparency

Table 4.6 presents baseline versus prototype performance on administrative tasks linked to H1.

Table 4.6: H1 Baseline versus Prototype Task Performance

Task/output	Metric	Baseline (median, min)	Prototype (median, min)	Direction
Portfolio summary report	Minutes	25	4	−84% time
Arrears list	Minutes	18	3	−83% time
Month-end reconciliation	Step count	12	3	−75% steps
Lease renewal review	Minutes	20	5	−75% time

Interpretation. Within the purposive sample, large reductions in retrieval time and reconciliation steps provide directional evidence consistent with H1.

4.6.2 H2: Financial Accuracy and Reporting Efficiency

Table 4.7 reports the counts of financial discrepancies and schedule generation times for sample loans and leases (H2).

Table 4.7: H2 Financial Discrepancy and Time Results

Sample item	Discrepancies (baseline)	Discrepancies (prototype)	Time baseline (min)	Time prototype (min)
Loan 1 (USD 185k, 14.5%, 240 mo)	8	1	15	2
Loan 2 (USD 95k, 12%, 120 mo)	6	0	12	1.5
Loan 3 (USD 320k, 16%, 180 mo)	10	2	20	3
Lease 1 (USD 2 500 / mo, 12 mo)	5	1	10	1
Lease 2 (USD 4 200 / mo, 24 mo)	7	0	14	2

Interpretation. Automated schedules showed fewer discrepancies and faster generation on agreed sample items—directionally supporting H2.

4.6.3 H3: Dashboards and Bounded Market Intelligence

Table 4.8 summarises analytics task times and Likert ratings for bounded market-intelligence views (H3).

Table 4.8: H3 Analytics Task and Likert Results

Analytics task	Baseline (min)	Prototype (min)	Likert usefulness (mean / 5)	Likert clarity (mean / 5)
Rental price trend review	22	5	4.3	4.1
Vacancy stress scenario	30	7	4.0	3.8
Risk assessment review	25	6	4.2	4.0
Portfolio analytics report	28	4	4.5	4.3

Interpretation. Task-time reductions and Likert means above the neutral midpoint, in the direction of H3, support H3 as interpretable decision-support functions within the sample.

4.6.4 Analysis of comparative variance

Table 4.6 shows median portfolio summary retrieval time falling from 25 to 4 minutes and reconciliation steps from 12 to 3, consistent with reduced cross-file coordination when property, lease, and finance data share a single store. Table 4.7 shows fewer finance discrepancies and shorter schedule generation times for sample items. Table 4.8 shows analytics tasks completed faster, with favourable usefulness ratings. Together, these patterns provide directional support for H1–H3 within the purposive sample, subject to mixed data modes and small n.

4.7 User Evaluation and Feedback

Positive themes from evaluation forms and short comments included: consolidated navigation; reduced manual reconciliation across spreadsheets; trust after amortisation, with results matching familiar spreadsheets; clearer arrears and portfolio views; and the usefulness of bounded market-intelligence dashboards for structured review.

Challenges noted included intermittent connectivity outside central Harare, learning time on first use, and desire for richer listing coverage while acknowledging that indicators remain indicative signals only. Despite these constraints, acceptability among participants was generally favourable within the evaluation sessions.

4.8 Hypothesis Verification and Research Question Mapping

Directional evidence within the sample supports H1 (reduced workload and fewer reconciliation steps), H2 (fewer financial discrepancies and faster schedules for sample

items), and H3 (faster analytics tasks and Likert ratings above the neutral midpoint). These outcomes align with the bounded scope defined in Chapters One and Three.

Table 4.9 maps summative evidence to RQ1–RQ7.

Table 4.9: Mapping of Findings to Research Questions

RQ	Main evidence	Short answer
RQ1	Interviews; baseline task friction	Ledger-centric tools omit lease, loan, and arrears workflows common in practice
RQ2	Architecture; implementation status	PMPA delivers modular services on one relational store
RQ3	Formative and summative finance results	Within the sample, automated finance reduced discrepancies and sped schedule generation
RQ4	Portal checks; qualitative themes	Tenant views matched staff data; workload benefits reported

RQ5	Ingestion, dashboards, H3 results	Indicators and scenarios shortened analytics tasks within the sample
RQ6	H1–H3 tables	PMPA outperformed baselines on measured tasks within the sample
RQ7	Ingestion protocol	Governance constraints were manageable within the academic programme

4.9 Challenges Encountered During Evaluation

i. Mixed data modes across organisations (live, anonymised, synthetic) required careful interpretation of Org. B results.

ii. Connectivity interruptions affected two sessions, necessitating rescheduling.

iii. Listing data quality issues (duplicates, stale prices) limited the depth of bounded market intelligence.

iv. Non-production deployment precluded claims about long-term organisational adoption.

v. A small purposive sample (n = 11) limits statistical generalisation; findings remain analytically transferable only.

4.10 Summary of Findings

The main results from the implementation and evaluation were as follows for PMPA:

i. PMPA was implemented as a working modular Smart Real Estate ERP prototype on PostgreSQL, FastAPI, and React/TypeScript.

ii. Functional verification and system testing confirmed core module stability before summative tasks.

iii. Baseline–prototype comparison showed directional improvements in workload, finance accuracy, and analytics tasks within the sample.

iv. Governed data ingestion was feasible; listing indicators remain indicative signals.

v. User feedback was generally favourable, with connectivity and data-coverage constraints noted.

vi. H1–H3 and RQ1–RQ7 received directional support within purposive-sample limits.

Chapter Five draws conclusions and recommendations from these findings.

CHAPTER FIVE

5.0 CONCLUSIONS AND RECOMMENDATIONS

5.1 Introduction

This chapter wraps up the research on the design and assessment of a Smart Real Estate ERP framework for Zimbabwean real estate SMEs. It highlights the main findings related to the research goals, provides recommendations for practitioners and software developers, and suggests areas for future research.

The research aimed to design, implement, and evaluate PMPA (Property Management and Decision-support Application)—a modular Smart Real Estate ERP prototype that integrates property lifecycle management, financial logic, tenant services, governed data ingestion, and bounded predictive market intelligence to support structured decision-making. Using Design Science Research, PostgreSQL, FastAPI, React/TypeScript, and REST APIs, the study demonstrated how a software engineering artefact can address fragmented property–finance–tenant records in a resource-constrained SME context typical of practice in Harare and Bulawayo.

5.2 Conclusion

The research met its objectives of designing and evaluating a Smart Real Estate ERP framework for Zimbabwean real estate SMEs. Findings in Chapter Four showed that many firms manage property, lease, tenant, and financial data across disconnected spreadsheets, paper records, informal channels, and accounting packages such as Sage and Palladium. This fragmentation increases reconciliation time, weakens transparency, and limits structured decision support.

In response, PMPA was developed as a working prototype on a single relational data store, featuring role-based access, governed external data ingestion, and bounded market-intelligence views. Evaluation results provide directional evidence from the purposive sample (n = 11) that the prototype improves administrative workload, financial accuracy for sample items, and analytics task performance compared with baseline workflows. Core modules—including property lifecycle, finance, tenant portal, dashboards, and ingestion—passed functional verification and system testing. User feedback indicated general acceptability, subject to connectivity and data-coverage constraints.

Based on the above analysis, it can be concluded that an integrated, DSR-evaluated Smart Real Estate ERP offers a practical Software Engineering approach for Zimbabwean real estate SMEs. Claims remain bounded: findings are not nationally generalisable, listing-derived indicators are indicative rather than transaction-validated, and the system provides decision support rather than autonomous legal or financial decisions.

In terms of recommendations, real estate SMEs should adopt integrated property–finance data models, run PMPA-style systems in parallel with Sage or Palladium until reconciliation trust is established, and use listing-derived indicators only as market signals. Software developers should prioritise role-based access, audit logs, transparent financial logic, and governed ingestion with provenance rather than raw listing reproduction. Future researchers should replicate evaluations using larger purposive samples, conduct longitudinal adoption studies, and pursue API-first ingestion of official data where permitted.

5.3 Major Conclusions Drawn

i. The primary aim of designing, implementing, and evaluating a Smart Real Estate ERP framework (PMPA) for Zimbabwean real estate SMEs was achieved through six DSR build–evaluate cycles.

ii. The current approach used in many firms is inefficient because property, lease, tenant, and finance records remain fragmented across spreadsheets, accounting ERPs, and informal communication channels.

iii. A modular architecture on a single PostgreSQL relational store supported integrated property, finance, and tenant operations and reduced cross-file reconciliation during evaluation tasks.

iv. Automated amortisation, invoicing, payments, and lease revenue logic reduced financial discrepancies and schedule generation time on agreed sample items compared with manual spreadsheets.

v. The tenant portal, linked to the same master data store as staff operations, supported consistency and transparency between staff and tenant views.

vi. Dashboards and bounded predictive market-intelligence views shortened defined analytics tasks and received Likert ratings above the neutral midpoint within the purposive sample

vii. When provenance, permission, and data-quality rules were applied, governed data ingestion from listing, macroeconomic, and geospatial sources was feasible; listing data remains indicative market signals only.

viii. Functional verification, system testing, and baseline–prototype comparison provided directional support for hypotheses H1–H3 within the evaluation sample, not statistical generalisation to the national sector.

ix. The study demonstrated that software-led, integrated ERP design, rather than unconstrained AI or national price forecasting, can offer a viable path to property management decision support under Zimbabwean SME resource and governance constraints.

5.4 Areas for Further Study

i. Further studies could integrate live bidirectional connectors between PMPA-style modules and Sage or Palladium accounting systems.

ii. Researchers could examine API-first ingestion from ZIMSTAT, RBZ, the World Bank, and geospatial platforms to reduce manual macroeconomic transcription.

iii. Comparative studies could measure the cost-efficiency of integrated ERP prototypes versus spreadsheet-led and ledger-only workflows in Zimbabwean real estate SMEs.

iv. Longitudinal research could track organisational adoption, data quality, and staff trust after parallel deployment.

v. Future work could develop a mobile tenant portal with offline-tolerant synchronisation for areas with intermittent connectivity.

vi. Richer lawful listing ingestion and improved geospatial analytics could be studied under explicit data-governance and ethics protocols.

vii. Expanded evaluation cohorts across additional Zimbabwean cities would strengthen analytical transferability without claiming national census representativeness.

5.5 Chapter Summary

This chapter provided conclusions and recommendations emanating from the study on PMPA as a Smart Real Estate ERP framework for Zimbabwean real estate SMEs.

The chapter showed that the prototype was effective in reducing workload, improving financial accuracy on sample items, enhancing tenant–staff data consistency, and increasing structured analytics use within the purposive evaluation sample. Governed ingestion and bounded market intelligence were feasible but remain proportionate to available data. Recommendations for SMEs, developers, and researchers appear in Section 5.2; areas for further study are listed in Section 5.4.

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APPENDICES

Appendix A: Semi-Structured Interview Guide for Stakeholders

The purpose of the study was explained to each participant before the interview. Participants were informed that participation was voluntary, that their responses would be treated confidentially, and that anonymised labels would be used in the dissertation. Permission to take notes or record responses was requested where applicable.

1. Describe your role and typical weekly duties in property, leasing, or finance operations.
2. Explain how a new lease is captured from the offer stage to the first invoice. Which systems, files, or documents are used?
3. Where do Sage, Palladium, or other accounting tools end, and where do Excel, WhatsApp, email, or paper records begin?
4. How do you currently produce arrears reports, renewal reports, and portfolio summaries? Who uses these reports?
5. What reconciliation steps are normally done at month-end between property records and the accounting ledger?
6. What would a "single view" of property, lease, tenant, and finance records mean for your team?
7. What risks or concerns would you associate with using one integrated system?
8. What connectivity, skills, cost, or policy constraints affect software use in your organisation?
9. What reports, dashboards, or alerts would be useful for decision-making?
10. Is there anything else about your current workflow or system needs that has not been covered?

Appendix B: Prototype Evaluation Form

Participant ID: _____ Organisation Label: _____

Date: _____

Session Order: Baseline first / Prototype first

Participants rated the PMPA prototype using the following scale: 1 = Strongly disagree; 2 = Disagree; 3 = Neutral; 4 = Agree; 5 = Strongly agree.

No.	Statement	Rating
1	The prototype reduced time spent on assigned tasks.	5
2	The system was easy to navigate.	4
3	Property, lease, tenant, and finance information was easier to access.	4
4	The dashboards were clear and useful.	5
5	The market-intelligence views were relevant for decision-making.	3
6	I trust the amortisation and lease totals shown by the system.	5
7	The tenant-visible information was appropriate and not over-exposed.	5
8	The prototype could be useful for real estate SMEs in Zimbabwe.	4

Open comments:

What was most useful about the prototype?

_____

_____

What challenges did you experience?

_____

_____

What improvements would you recommend?

_____

_____

Appendix C: Informed Consent Summary

Organisations received a brief overview of the study, including the purpose of PMPA, the prototype's non-production status, anonymised reporting, secure data handling, and the right to withdraw.

Individual participants provided consent before participating in interviews, timed tasks, and prototype evaluations. Participant and organisation names were replaced with pseudonyms or labels such as Org. A, Org. B, Org. C, and Participant 1. No live legal, financial, or commercial commitments were executed via the prototype during the evaluation.

Participant Signature: _____ Date: _____

Researcher Signature: _____ Date: _____

Appendix D: Baseline versus Prototype Task Protocol

The following tasks were used to compare existing workflows with the PMPA prototype. Results were recorded using task completion time, step counts, discrepancy counts, and participant ratings.

Hypothesis	Task	Baseline Method	Prototype Method	Measure
H1	Produce portfolio summary	Existing files, spreadsheets, or ERP reports	PMPA dashboard or report	Minutes
H1	Produce arrears list for a fixed date	Excel, payment notes, or accounting reports	PMPA finance or dashboard module	Minutes and steps
H1	Count month-end reconciliation steps	Manual cross-checking	PMPA integrated records	Step count
H1	Review two lease renewals	Manual files or spreadsheets	PMPA lease records	Minutes
H2	Generate three loan schedules	Spreadsheet calculation	PMPA amortisation module	Minutes and discrepancies
H2	Generate two lease schedules	Manual or spreadsheet method	PMPA finance module	Minutes and discrepancies

H3	Complete four analytics questions	Baseline reports and manual notes	PMPA dashboards and scenarios	Minutes and Likert rating

Appendix E: Data Extraction Template

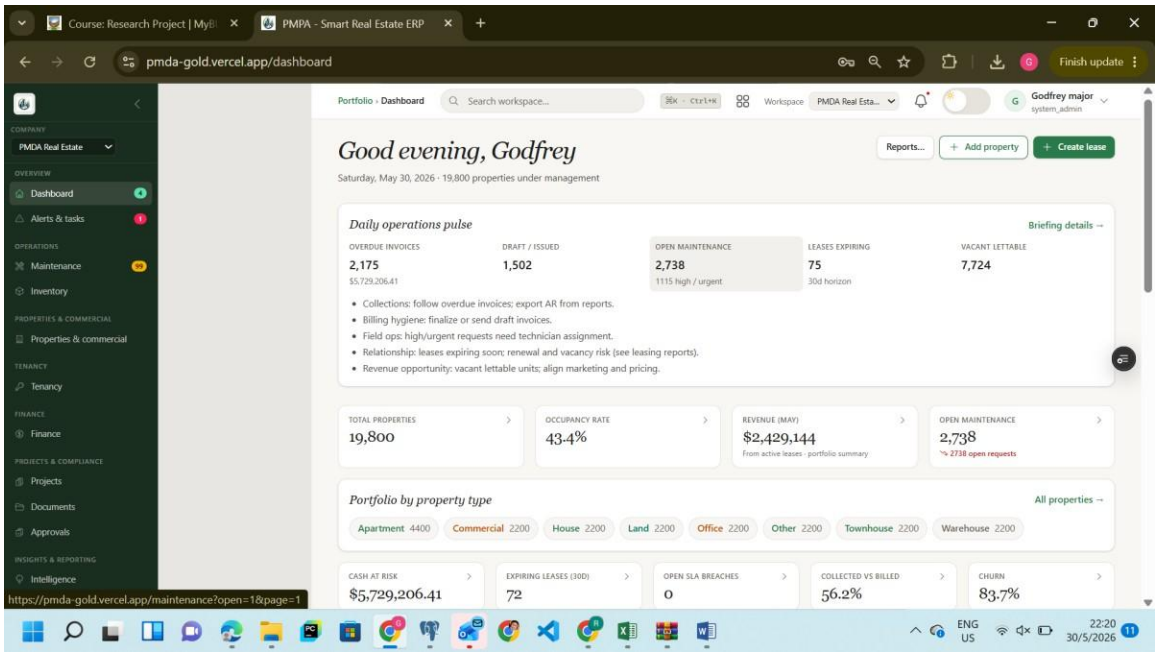
The following minimum set of fields was used to prepare anonymised or synthetic data for the PMPA prototype.

Data Category	Minimum Fields
Properties	property_id, address, city, type, units, status
Leases	lease_id, property_id, tenant_id, start_date, end_date, rent_amount, currency, escalation_rule
Tenants	tenant_id, name_pseudonym, contact_channel
Payments	payment_id, lease_id, payment_date, amount, method
Loans	loan_id, principal, annual_rate, term_months, payment_day
Macro indicators	indicator, period, value, source, accessed_date
Listings	listing_id, location, property_type, asking_price, source, accessed_date
Geospatial data	location_id, area_name, coordinates_or_layer, source, accessed_date

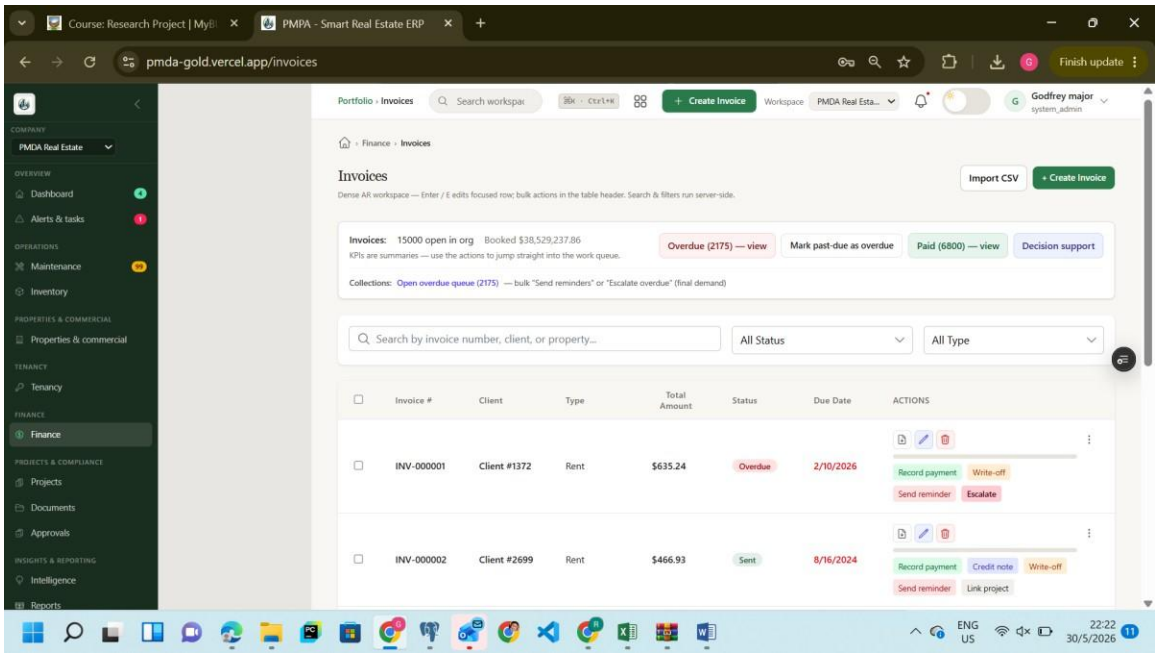
Appendix F: Prototype Screenshots Checklist

The following screenshots were included as visual evidence of the implemented PMPA prototype.

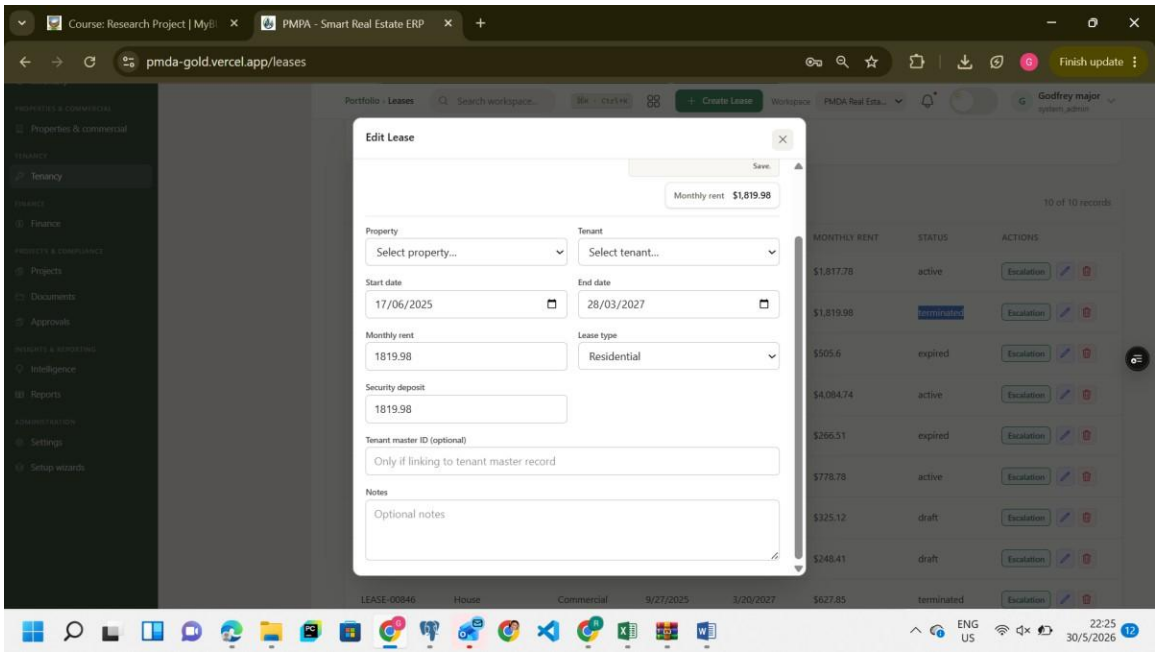
F3.6: Staff property dashboard



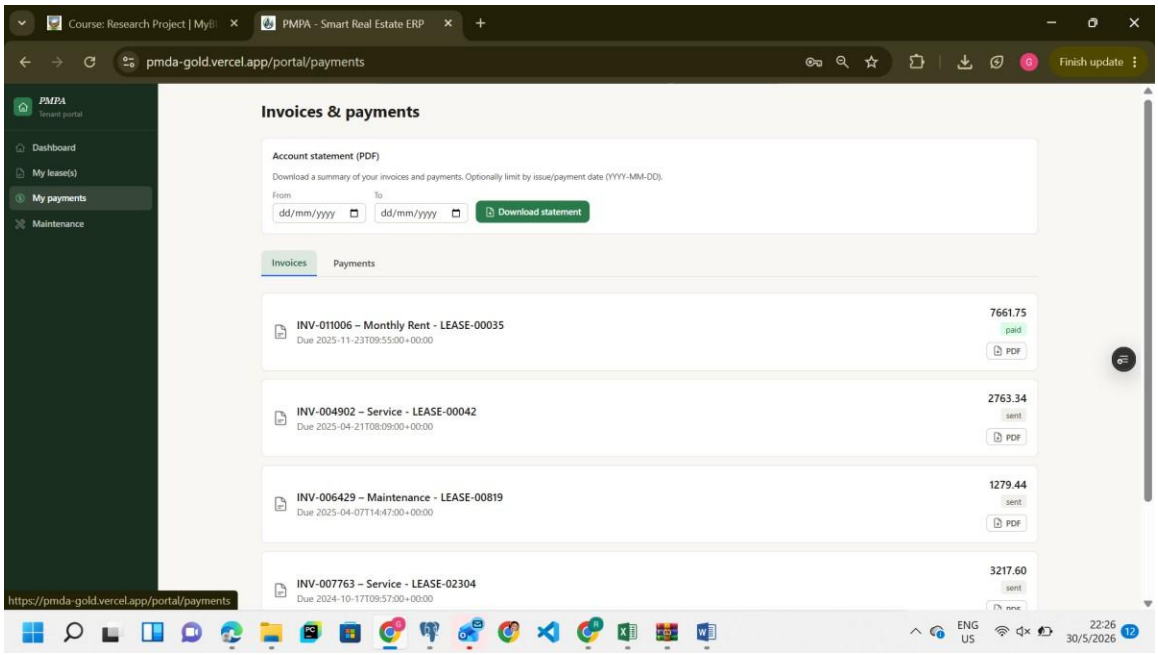
F3.7 Lease and invoicing screen



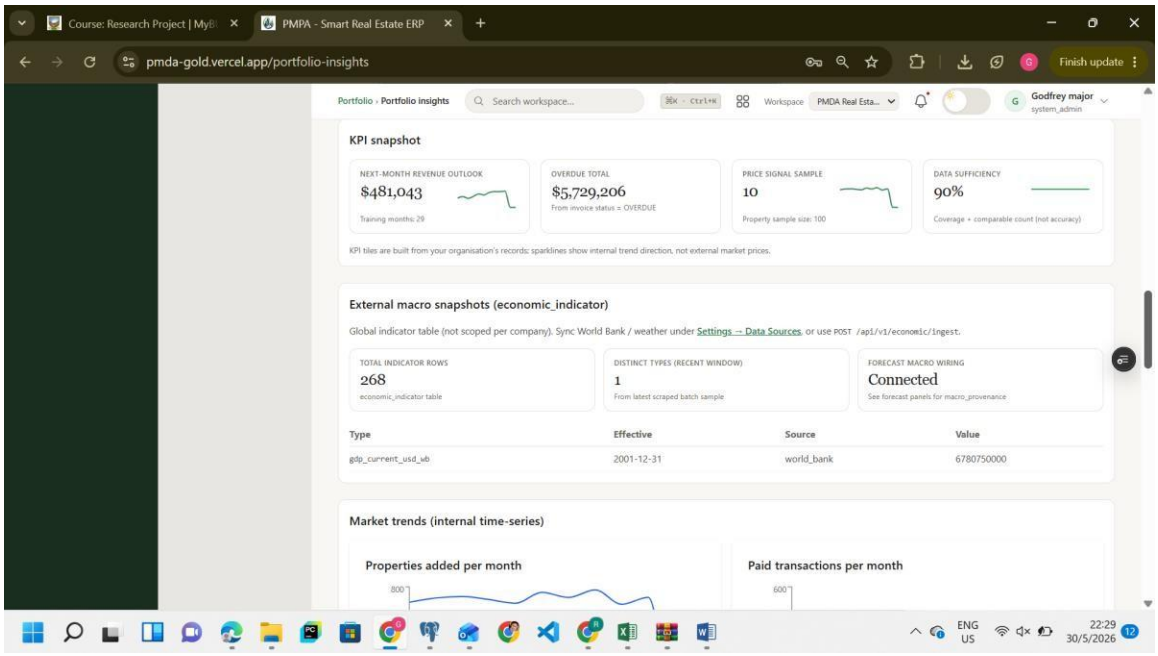
F.4.4 Amortisation schedule view



F.4.4.3 Tenant portal balances



F.4.5 Analytics or scenario screen used in H3 tasks



All screenshots were numbered consistently and cross-referenced with the List of Figures. Any tenant, financial, or organisational details shown in screenshots were anonymised before submission.

Appendix G: Filled Evaluation Results Summary

The following summary records the filled results used in Chapter Four. The values are directional within the purposive evaluation sample and are not presented as national statistics.

H1 Task/Output	Metric	Baseline	Prototype	Result
Portfolio summary report	Median minutes	25	4	Reduced by 84%
Arrears list	Median minutes	18	3	Reduced by 83%
Month-end reconciliation	Step count	12	3	Reduced by 75%
Lease renewal review	Median minutes	20	5	Reduced by 75%

H2 Sample Item	Baseline Discrepancies	Prototype Discrepancies	Baseline Time (min)	Prototype Time (min)
Loan 1: USD 185k, 14.5%, 240 months	8	1	15	2
Loan 2: USD 95k, 12%, 120 months	6	0	12	1.5
Loan 3: USD 320k, 16%, 180 months	10	2	20	3
Lease 1: USD 2,500/month, 12 months	5	1	10	1
Lease 2: USD 4,200/month, 24 months	7	0	14	2

H3 Analytics Task	Baseline Time (min)	Prototype Time (min)	Usefulness Mean / 5	Clarity Mean / 5
Rental price trend review	22	5	4.3	4.1
Vacancy stress scenario	30	7	4.0	3.8
Risk assessment review	25	6	4.2	4.0
Portfolio analytics report	28	4	4.5	4.3