

Advancing Sustainable Urban Housing Development: A PLS-SEM Analysis of Urbanization Dynamics in Sub-Saharan Africa

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Abstract

Introduction: The rapid urbanization in developing nations, especially in Sub-Saharan Africa, has presented critical challenges in housing provision, including affordability issues, insufficient infrastructure, and environmental degradation. Ghana, as one of the fastest urbanizing countries in the region, is facing similar challenges as its major cities, such as Accra and Kumasi, experience significant population growth. These urbanization dynamics exacerbate existing housing deficits and complicate efforts to achieve sustainable urban development.

Purpose: This study aims to investigate the relationships between governance structures, project management practices, and sustainable urban housing outcomes in Ghana. Specifically, it explores how institutional frameworks and project management systems interact to influence the effectiveness of urban housing projects and their sustainability in rapidly urbanizing contexts.

Methodology: The study employs Partial Least Squares Structural Equation Modeling (PLS-SEM) to analyze the direct and mediated effects between institutional frameworks, project management practices, and sustainable urban housing outcomes. A comprehensive multi-stakeholder survey was conducted, involving 4,000 respondents from Accra and Kumasi, to gather data on various factors influencing housing sustainability. The analysis combines both quantitative and qualitative insights, making it possible to model complex relationships among the constructs.

Findings: The study reveals that institutional quality, characterized by regulatory clarity, governance effectiveness, and policy coherence, significantly influences project management practices. In turn, effective project management, which includes planning, risk management, and stakeholder engagement, enhances sustainable urban housing outcomes. The analysis also shows that the relationship between institutional frameworks and sustainable housing outcomes is partially mediated by project management practices. The model demonstrates substantial explanatory power ($R^2 = 0.670$ for sustainable housing outcomes) and strong predictive relevance, confirming the critical role of governance structures and project execution in shaping housing sustainability.

Conclusions: The findings underscore the importance of strengthening institutional frameworks and improving project management systems to address the growing housing deficits in Ghana's urban centers. Robust governance, clear policy frameworks, and efficient project management practices are crucial for promoting sustainable urban housing development. The study offers actionable insights for policymakers in emerging economies to enhance institutional capacity, streamline project implementation processes, and ensure that urban housing developments are both sustainable and resilient to the pressures of rapid urbanization.

Keywords: Sustainable Urban Housing; Institutional Framework; Project Management; Urban Development; Housing Affordability; Governance; Regional Economics

Introduction

Urbanization has become one of the most consequential structural transformations shaping regional development in the twenty-first century. In rapidly growing economies, the

expansion of metropolitan areas simultaneously generates opportunities for productivity growth and severe pressure on land, housing, infrastructure, and environmental systems. Ghana exemplifies this duality. The sustained growth of

major urban centres such as Accra and Kumasi has intensified housing deficits, increased land values, expanded informal development, and amplified concerns about affordability, infrastructure adequacy, and ecological stress. Within such a setting, housing must be understood not merely as a social good, but also as a strategic economic asset that influences labour mobility, investment allocation, urban competitiveness, and long-run regional welfare.

From a regional economic perspective, the housing sector enters the urban production system through its effects on labour productivity, spatial efficiency, and agglomeration externalities (Tamimu et al., 2025b). Let the economic output of region r be represented as

$$Y_r = A_r K_r^\alpha L_r^\beta H_r^\gamma, \quad (1)$$

where Y_r denotes regional output, A_r is total factor productivity, K_r is capital, L_r is labour, and H_r denotes the effective housing stock, which incorporates both the quantity and quality of urban housing. The elasticity parameter $\gamma > 0$ implies that improvements in housing adequacy and quality contribute positively to regional output. In this sense, deficiencies in the housing system impose economic costs that go beyond shelter deprivation; they reduce labor-market efficiency, weaken agglomeration economies, and limit the productivity gains associated with urban concentration.

The sustainability dimension of housing further broadens this economic argument. Sustainable urban housing requires simultaneous progress in economic affordability, environmental efficiency, and social inclusiveness (Tamimu et al., 2026). These three dimensions may be expressed through a composite sustainability function:

$$SUH_i = \omega_1 ECO_i + \omega_2 ENV_i + \omega_3 SOC_i, \quad (2)$$

subject to

$$\omega_1 + \omega_2 + \omega_3 = 1, \quad \omega_j \geq 0 \quad \forall j \in \{1, 2, 3\}, \quad (3)$$

where SUH_i denotes the sustainable urban housing outcome for project or observation i , ECO_i measures economic viability and affordability, ENV_i captures environmental performance, and SOC_i reflects social inclusion, safety, and liveability. This formulation emphasizes that urban housing sustainability is inherently multidimensional and cannot be adequately assessed through cost or output indicators alone.

A central reason why housing outcomes vary substantially across rapidly urbanizing regions is the quality of institutions. Institutional frameworks shape the incentive environment within which housing markets, land administration systems, regulatory agencies, and project

actors operate (Adjei et al., 2025a). In practical terms, the institutional environment includes formal rules such as land laws, building regulations, zoning controls, permitting systems, and fiscal arrangements, as well as informal norms such as customary land tenure, traditional authority structures, and socially embedded modes of dispute resolution. In settings where these formal and informal arrangements are fragmented or poorly coordinated, transaction costs rise and

project delivery becomes uncertain. This relationship can be represented as

$$TC_i = \psi_0 - \psi_1 INSTF_i + \psi_2 RD_i + \psi_3 TI_i + \psi_4 CF_i + \varepsilon_i, \quad (4)$$

where TC_i denotes transaction cost, $INSTF_i$ is institutional quality, RD_i is regulatory delay, TI_i is tenure insecurity, CF_i is coordination failure, and $\psi_1 > 0$. Equation (4) implies that stronger institutional frameworks reduce the transaction burden facing urban housing projects.

However, institutional quality alone does not guarantee improved development outcomes. Policies, laws, and regulatory reforms produce tangible results only when they are translated into effective implementation. In public sector delivery systems, project management practices constitute the operational mechanism through which institutional intent becomes measurable performance. Planning discipline, stakeholder engagement, risk management, schedule control, sustainability compliance, and monitoring systems all influence whether housing projects meet economic, environmental, and social objectives (Gadafi et al., 2025d). This logic suggests that project management operates not as a peripheral administrative function, but as a transmission channel linking institutional capacity to development outcomes. Conceptually, this can be expressed as

$$PROMP_i = f(INSTF_i, z_i), \quad (5)$$

and

$$SUH_i = g(INSTF_i, PROMP_i, z_i), \quad (6)$$

where z_i is a vector of contextual controls such as stakeholder type, project scale, and locational conditions.

The mediating role of implementation capacity is particularly important in the housing sector because sustainable urban development depends on coordination across multiple actors, including regulators, local governments, developers, engineers, financiers, and communities. Even where the policy environment is relatively strong, weak implementation processes may undermine delivery through cost overruns, delays, non-compliance, poor stakeholder alignment, and inefficient resource allocation. In this context, the total institutional effect on sustainable housing outcomes may be decomposed into direct and indirect components:

$$\frac{\partial SUH_i}{\partial INSTF_i} = \underbrace{\frac{\partial SUH_i}{\partial INSTF_i} \Big|_{PROMP}}_{\text{direct effect}} + \underbrace{\frac{\partial SUH_i}{\partial PROMP_i} \frac{\partial PROMP_i}{\partial INSTF_i}}_{\text{indirect effect through implementation}}, \quad (7)$$

which provides the theoretical basis for a mediation framework.

Although prior studies have examined institutional quality, urban governance, and project management success, there remains limited quantitative evidence integrating these dimensions into one coherent structural model within the context of African housing systems (Adjei et al., 2025b). Much of the literature treats regulatory institutions and implementation capability separately, thereby overlooking the mechanism through which institutional arrangements influence project-level sustainability outcomes. This gap is especially

significant in Ghana, where rapid urban growth, complex land tenure systems, and public-private coordination challenges make institutional and managerial interactions especially salient.

Against this background, the present study develops and empirically evaluates a structural framework linking institutional frameworks, project management practices, and sustainable urban housing outcomes in Ghana (Liu et al., 2025). The study is grounded in the proposition that stronger institutional environments improve housing sustainability both directly and indirectly by strengthening implementation capacity. To formalize this logic, the study advances the following directional hypotheses:

$$H_1 : INSTF \rightarrow PROMP > 0, \quad (8)$$

$$H_2 : INSTF \rightarrow SUSTUHP > 0, \quad (9)$$

$$H_3 : PROMP \rightarrow SUSTUHP > 0, \quad (10)$$

$$H_4 : PROMP \text{ mediates the relationship between } INSTF \text{ and } SUSTUHP. \quad (11)$$

The study contributes to the literature in three ways. First, it integrates institutional economics, project governance, and sustainability analysis within a single quantitative framework. Second, it extends housing research in emerging economies by modelling both direct and mediated effects among latent variables. Third, it provides a policy-relevant analytical basis for understanding how institutional coherence and implementation capacity jointly shape sustainable urban housing performance in Ghana and related developing-country contexts.

Literature Review

Institutional Economics and Urban Development

Institutional economics offers a fundamental framework for comprehending how governance institutions influence economic performance. North (1990) characterizes institutions as the formal regulations, informal limitations, and enforcement mechanisms that organize human interactions. In urban housing markets, institutional quality influences the protection of property rights, the effectiveness of land administration systems, and the predictability of regulatory frameworks. These elements directly affect transaction expenses, investment motivations, and the efficiency of capital distribution.

Scott (2013) further highlights institutions as consisting of three pillars: regulative, normative, and cultural-cognitive systems. In housing markets, regulatory institutions consist of planning regulations, zoning laws, and building codes; normative institutions include professional standards and societal expectations concerning housing quality; and cultural-cognitive frameworks shape perceptions of land ownership and tenure security. The interplay of these institutional factors influences the dynamics of the housing market and the results of development (Gadafi & Musa, 2025).

Empirical studies validate the economic importance of institutional quality. Gadafi et al. (2025b) illustrate that

institutions are essential factors influencing long-term economic progress. In urban settings, Gadafi et al. (2025c) contends that regulatory constraints and land-use regulations substantially influence housing supply elasticity and price volatility. Excessive regulatory constraints elevate housing expenses and diminish affordability, whilst consistent regulatory frameworks enhance market responsiveness.

In developing economies, inadequate land governance systems are frequently linked to informal settlements and ineffective urban expansion. Protected property rights facilitate loan access, stimulate private investment, and elevate housing standards. In contrast, fragmented

land administration systems elevate uncertainty and deter long-term capital investment. Research in African urban areas underscores the role of institutional fragmentation in causing housing shortages and environmental degradation (Tamimu & Liang, 2025).

In public finance literature (Gadafi et al., 2025a), housing policy is deeply associated with fiscal sustainability and the efficacy of infrastructure investment. The function of decentralized government in harmonizing public service delivery with local preferences. However, decentralization devoid of institutional coordination may result in inefficiencies in urban planning and housing provision. Therefore, institutional coherence is crucial for attaining sustained regional development.

Sustainable Urban Housing and Regional Economics

Sustainable housing encompasses economic feasibility, ecological efficiency, and social justice. Tamimu and Liang (2025) assert that sustainability necessitates fulfilling current needs without jeopardizing the requirements of future generations. In residential contexts, this manifests as energy-efficient buildings, environmental conservation, affordability, and inclusive urban planning.

From a regional economics standpoint, housing facilitates worker mobility and enhances productivity. Moretti (2012) demonstrates that elevated housing costs might impede worker movement and diminish aggregation advantages. Hsieh and Moretti (2019) estimates that stringent housing laws in prominent U.S. cities curtailed overall economic growth by constraining worker reallocation. These findings indicate that housing inefficiencies may yield macroeconomic repercussions.

In Sub-Saharan Africa, fast urbanization contributed to the sustainability issues. Fox (2012) illustrates how infrastructural deficiencies and institutional limitations hinder urban development results. Empirical research from Ghana demonstrates that regulatory delays, complexities in land tenure, and coordination difficulties substantially impact the efficiency of housing delivery. However, limited research has quantitatively analyzed the interaction between institutional characteristics and implementation mechanisms in relation to sustainability outcomes.

Project Management and Implementation Capacity

Institutional frameworks influence incentives and regulatory conditions, whereas implementation capacity dictates actual results. Project management theory underscores systematic planning, resource allocation, monitoring, stakeholder collaboration, and risk reduction as critical factors for project success (Zhao et al., 2025).

Flyvbjerg (2014) illustrates that substantial infrastructure projects often have cost overruns and execution difficulties attributable to governance deficiencies and inadequate risk management. Efficient project management methodologies diminish inefficiencies and enhance accountability in the delivery of public infrastructure.

In housing and urban development, coordinated project governance guarantees the effective implementation of sustainability criteria. Empirical research indicates that the quality of implementation frequently mediates the effectiveness of policy. Tamimu et al. (2025a) demonstrate that institutional adjustments lacking concomitant enhancements in project governance result in minimal performance increases. Despite increasing acknowledgment of implementation competence, there is a paucity of empirical research that integrates institutional quality and project management techniques into a cohesive causal framework in the context of African housing. Comprehending this interplay is essential for formulating successful public finance and urban development policies.

Structural Equation Modeling in Development Research

Structural Equation Modeling (SEM) is extensively utilized in development economics and management research for its capacity to predict intricate causal linkages incorporating latent constructs (Hair Jr et al., 2021). In contrast to conventional regression models, SEM facilitates the concurrent estimation of numerous relationships while considering measurement error.

PLS-SEM is particularly adept at predictive modeling and theory construction in scenarios where data normality is not assumed and model complexity is elevated. It has been extensively utilized in governance research, infrastructure studies, and sustainability analysis (Adjei et al., 2025b). PLS-SEM offers a comprehensive assessment of both direct and indirect (mediating) effects through the integration of measurement and structural models.

Considering the multifaceted aspects of institutional quality, project management practices, and sustainable housing outcomes, SEM provides a suitable methodological framework for examining their interconnections.

Research Gap

The literature indicates that institutional quality impacts economic performance and that project management influences infrastructure outcomes; however, there is a scarcity of empirical studies that quantitatively investigate the mediating role of implementation capacity in sustainable urban housing

delivery in emerging African economies. Furthermore, current research frequently examines institutional elements or governance approaches in isolation instead of modeling their combined impacts.

This research empirically examines a structural model that connects institutional frameworks, project management techniques, and sustainable urban housing results through PLS-SEM within the Ghanaian setting.

Methodology

Research Philosophy and Design

This study adopts a quantitative explanatory research design grounded in a post-positivist philosophy. The post-positivist position assumes that latent social and institutional phenomena can be approximated through observable indicators and examined using probabilistic causal models. Because the study seeks to test theoretically specified relationships among institutional quality, project management practices, and sustainable housing outcomes, a deductive strategy is appropriate.

The analytical design is based on Partial Least Squares Structural Equation Modeling (PLS-SEM), which is suitable when the model includes multiple latent constructs, mediated pathways, and prediction-oriented objectives. Let the set of latent variables be denoted by

$$l_i = \begin{bmatrix} \xi_i \\ \eta_{1i} \\ \eta_{2i} \end{bmatrix}, \quad (12)$$

where ξ_i represents the exogenous latent construct *Institutional Framework* (INSTF), η_{1i} denotes the endogenous mediator *Project Management Practices* (PROMP), and η_{2i} denotes the final endogenous construct *Sustainable Urban Housing Projects* (SUSTUHP).

Study Area, Population, and Sampling

The study focuses on the metropolitan areas of Accra and Kumasi, which represent Ghana's most significant urban growth corridors. The target population comprises key stakeholder groups directly engaged in or affected by sustainable housing delivery, including residents, construction professionals, government officials, private developers and investors, academics, and civil society actors.

Where a large target population is considered, an initial sample size may be motivated by Cochran's formula:

$$n_0 = \frac{Z^2 p(1-p)}{e^2}, \quad (13)$$

where Z is the standard normal critical value associated with the desired confidence level, p is the estimated population

proportion, and e is the tolerated sampling error. If the population size N is finite, the adjusted sample becomes

$$n = \frac{n_0}{1 + \frac{n_0-1}{N}} \quad (14)$$

Because the study adopts a stratified multi-stakeholder design, the sample allocated to stratum h can be expressed as

$$n_h = \frac{N_h}{N} n, \quad (15)$$

where N_h denotes the size of stakeholder stratum h . This proportional allocation improves representation across regulatory, technical, financial, and community-based actors, thereby strengthening external validity and construct coverage.

Conceptual Model and Structural Specification

The conceptual model contains one exogenous construct and two endogenous constructs.

The causal structure is specified as

$$\eta_{1i} = \gamma_{11}\xi_i + \zeta_{1i}, \quad (16)$$

$$\eta_{2i} = \gamma_{21}\xi_i + \beta_{21}\eta_{1i} + \zeta_{2i}, \quad (17)$$

where γ_{11} captures the effect of institutional framework on project management practices, γ_{21} captures the direct effect of institutional framework on sustainable housing outcomes, β_{21} captures the effect of project management practices on sustainable housing outcomes, and ζ_{1i} , ζ_{2i} are structural disturbances.

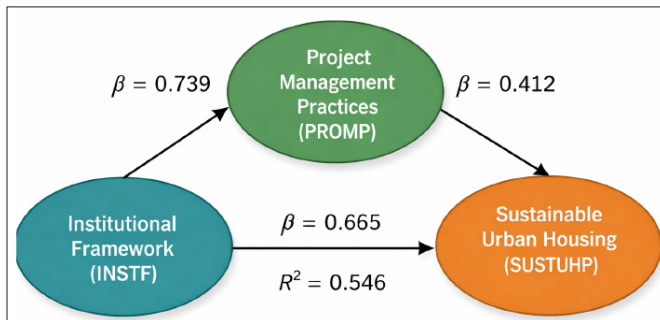


Figure 1: Structural Equation Model (SEM) for the study: The figure shows the relationships between Institutional Framework (INSTF), Project Management Practices (PROMP), and Sustainable Urban Housing (SUSTUHP), with path coefficients (β) and the coefficient of determination (R^2) for the endogenous constructs.

This model in Figure 1 serves as the basis for analyzing the direct and indirect effects of institutional quality on sustainable housing outcomes, mediated by project management practices.

The system may also be expressed in matrix form as

$$\eta_i = B\eta_i + \Gamma\xi_i + \zeta_i, \quad (18)$$

where

$$\eta_i = \begin{bmatrix} \eta_{1i} \\ \eta_{2i} \end{bmatrix}, \quad B = \begin{bmatrix} 0 & 0 \\ \beta_{21} & 0 \end{bmatrix}, \quad \Gamma = \begin{bmatrix} \gamma_{11} \\ \gamma_{21} \end{bmatrix}, \quad \zeta_i = \begin{bmatrix} \zeta_{1i} \\ \zeta_{2i} \end{bmatrix}. \quad (19)$$

The reduced-form expression for the ultimate endogenous construct is obtained by substituting Equation (16) into Equation (17):

$$\eta_{2i} = (\gamma_{21} + \beta_{21}\gamma_{11})\xi_i + \beta_{21}\zeta_{1i} + \zeta_{2i}, \quad (20)$$

which shows that the total effect of institutional framework on sustainable urban housing is the sum of its direct effect and its indirect effect through project management practices.

Operationalization of Latent Constructs

The three latent constructs are operationalized reflectively. For exposition, the underlying domains may be summarized as follows:

Institutional Framework (INSTF): Includes factors such as regulatory clarity, land administration, policy coordination, and governance enforcement.

Project Management Practices (PROMP): Encompasses aspects like planning, stakeholder engagement, risk management, sustainability compliance, and methodology.

Sustainable Urban Housing (SUSTUHP): Consists of key dimensions like economic viability, environmental performance, and social inclusion.

In composite score notation, the standardized latent variable scores may be estimated as weighted aggregates of their manifest indicators:

$$\hat{\xi}_i = \mathbf{w}_\xi^\top \mathbf{z}_\xi i, \quad (21)$$

$$\hat{\eta}_{1i} = \mathbf{w}_1^\top \mathbf{z}_{1i}, \quad (22)$$

$$\hat{\eta}_{2i} = \mathbf{w}_2^\top \mathbf{z}_{2i}, \quad (23)$$

where $z_\xi i$, z_{1i} , z_{2i} are vectors of standardized indicators and w_ξ, w_1, w_2 are the outer weights estimated iteratively by the PLS algorithm.

Measurement Model Specification

Let x_i denote the indicator vector for the exogenous construct and let y_{1i} and y_{2i} denote the indicator vectors for the two endogenous constructs. Because the model is reflective, the observed indicators are assumed to be caused by their respective latent variables. The outer model is therefore specified as

$$\mathbf{x}_i = \Lambda_x \xi_i + \delta_i, \quad (24)$$

$$\mathbf{y}_{1i} = \Lambda_{y1} \eta_{1i} + \varepsilon_{1i}, \quad (25)$$

$$\mathbf{y}_{2i} = \Lambda_{y2} \eta_{2i} + \varepsilon_{2i}, \quad (26)$$

where Λ_x , Λ_{y1} , and Λ_{y2} are vectors or matrices of factor loadings, and δ_i , ε_{1i} , and ε_{2i} are measurement errors.

At the indicator level, the reflective equations become

$$x_{ji} = \lambda_{xj}\xi_i + \delta_{ji}, \quad j = 1, 2, \dots, p, \quad (27)$$

$$y_{ki}^{(1)} = \lambda_{1k}\eta_{1i} + \varepsilon_{ki}^{(1)}, \quad k = 1, 2, \dots, q, \quad (28)$$

$$y_{li}^{(2)} = \lambda_{2l}\eta_{2i} + \varepsilon_{li}^{(2)}, \quad l = 1, 2, \dots, m. \quad (29)$$

Indicator reliability is assessed through squared loadings:

$$IR_j = \lambda_j^2, \quad (30)$$

with higher values indicating that a larger share of indicator variance is explained by its latent construct.

Assessment of Reliability and Convergent Validity

Internal consistency reliability is first examined using Cronbach's alpha:

$$\alpha = \frac{k}{k-1} \left(1 - \frac{\sum_{j=1}^k \sigma_j^2}{\sigma_T^2} \right), \quad (31)$$

where k is the number of indicators, σ_j^2 is the variance of item j , and σ_T^2 is the variance of the total score.

Composite reliability is computed as

$$CR = \frac{\left(\sum_{j=1}^k \lambda_j \right)^2}{\left(\sum_{j=1}^k \lambda_j \right)^2 + \sum_{j=1}^k \theta_j}, \quad (32)$$

where $\theta_j = 1 - \lambda_j^2$ under standardized indicators.

Convergent validity is examined using the average variance extracted:

$$AVE = \frac{\sum_{j=1}^k \lambda_j^2}{k}. \quad (33)$$

A complementary reliability statistic sometimes reported in PLS-SEM is Dijkstra-Henseler's rho:

$$\rho_A = \frac{\left(\sum_{j=1}^k \lambda_j \right)^2 Var(\ell)}{\left(\sum_{j=1}^k \lambda_j \right)^2 Var(\ell) + \sum_{j=1}^k Var(\varepsilon_j)}. \quad (34)$$

Assessment of Discriminant Validity

Discriminant validity may be examined using the Fornell-Larcker criterion, where the square root of the AVE for each construct should exceed its correlations with other constructs:

$$\sqrt{AVE_a} > |\rho_{ab}| \quad \forall a \neq b. \quad (35)$$

It may also be tested using the heterotrait-monotrait ratio (HTMT):

$$HTMT_{ab} = \frac{\frac{1}{|I_a||I_b|} \sum_{i \in I_a} \sum_{j \in I_b} |r_{ij}|}{\sqrt{\left(\frac{1}{|I_a|(|I_a|-1)} \sum_{i \neq j \in I_a} |r_{ij}| \right) \left(\frac{1}{|I_b|(|I_b|-1)} \sum_{i \neq j \in I_b} |r_{ij}| \right)}}, \quad (36)$$

where I_a and I_b are the indicator sets for constructs a and b .

Collinearity and Common Method Diagnostics

To assess multicollinearity among predictor constructs, the variance inflation factor is computed as

$$VIF_j = \frac{1}{1 - R_j^2}, \quad (37)$$

where R_j^2 is obtained by regressing predictor j on the remaining predictors. Lower values indicate acceptable collinearity conditions.

For full collinearity assessment, the same logic can be extended to the latent-variable level:

$$VIF(\ell_j) = \frac{1}{1 - R_j^2}, \quad (38)$$

where R_j^2 is the coefficient of determination from regressing latent construct ℓ_j on the others.

Structural Model Evaluation

The explanatory power of each endogenous construct is examined through the coefficient of determination:

$$R^2 = 1 - \frac{\sum_{i=1}^n (y_i - \hat{y}_i)^2}{\sum_{i=1}^n (y_i - \bar{y})^2}. \quad (39)$$

The effect size of a given predictor is evaluated using

$$f^2 = \frac{R_{\text{included}}^2 - R_{\text{excluded}}^2}{1 - R_{\text{included}}^2}, \quad (40)$$

which measures the substantive contribution of a predictor to the explained variance of an endogenous construct.

Predictive relevance is assessed through blindfolding using Stone-Geisser's Q^2 :

$$Q^2 = 1 - \frac{\sum_{i=1}^n (y_{i,\text{pred}} - y_{i,\text{obs}})^2}{\sum_{i=1}^n (y_{i,\text{obs}} - \bar{y}_{\text{obs}})^2}. \quad (41)$$

To evaluate approximate model fit, the standardized root mean square residual is computed as

$$SRMR = \sqrt{\frac{2}{p(p+1)} \sum_{i < j} (r_{ij} - \hat{r}_{ij})^2}, \quad (42)$$

where r_{ij} is the observed correlation and \hat{r}_{ij} is the model-implied correlation.

Mediation Analysis

The core theoretical proposition of the study is that project management practices mediate the effect of institutional frameworks on sustainable urban housing outcomes. The indirect effect is given by

$$IE = \gamma_{11}\beta_{21} \quad (43)$$

the direct effect is

$$DE = \gamma_{21} \quad (44)$$

and the total effect is

$$TE = \gamma_{21} + \gamma_{11}\beta_{21}. \quad (45)$$

The proportion of the total effect transmitted through the mediator is evaluated using the variance accounted for:

$$VAF = \frac{IE}{TE}. \quad (46)$$

For an observation-level prediction equation, the mediated structural system implies

$$\hat{\eta}_{2i} = \hat{\gamma}_{21}\hat{\xi}_i + \hat{\beta}_{21}\hat{\eta}_{1i}, \quad (47)$$

with

$$\hat{\eta}_{1i} = \hat{\gamma}_{11}\hat{\xi}_i. \quad (48)$$

Bootstrapping and Hypothesis Testing

The statistical significance of path coefficients, outer loadings, and indirect effects is tested using non-parametric bootstrapping. Let $\hat{\theta}$ denote a generic estimated parameter and let $SE(\hat{\theta})$ be its bootstrap standard error. The associated t -statistic is

$$t = \frac{\hat{\theta}}{SE(\hat{\theta})}. \quad (49)$$

A percentile bootstrap confidence interval for parameter θ is defined as

$$CI_{1-\alpha}(\theta) = \left[\hat{\theta}^{*(\alpha/2)}, \hat{\theta}^{*(1-\alpha/2)} \right], \quad (50)$$

where $\hat{\theta}^{*(\alpha/2)}$ and $\hat{\theta}^{*(1-\alpha/2)}$ are the lower and upper empirical bootstrap quantiles. A path is considered statistically significant when zero does not lie within the confidence interval, or equivalently when the absolute t -value exceeds the selected critical threshold.

Summary of Analytical Procedure

The empirical analysis proceeds in five stages. First, the indicator data are screened and standardized. Second, latent variable scores are estimated using the PLS algorithm. Third, the reflective measurement model is evaluated through loadings, reliability, convergent validity, discriminant validity, and collinearity diagnostics. Fourth, the structural model is assessed through path coefficients, R^2 , f^2 , Q^2 , and SRMR. Finally, mediation is tested by decomposing the total effect of institutional frameworks on sustainable housing outcomes into its direct and indirect components through project management practices.

Taken together, these procedures provide a mathematically explicit and empirically coherent basis for examining how institutional coherence and implementation capacity jointly shape sustainable urban housing performance in Ghana.

Results and Discussion

This section outlines the empirical results of the PLS-SEM investigation. The evaluation follows a systematic method that

includes

1. assessment of multicollinearity,
2. evaluation of explanatory power (R^2),
3. examination of structural path coefficients and hypothesis testing,
4. mediation analysis, and
5. model fit assessment.

Common Method Bias Testing

To assess the potential for common method bias (CMB) in this survey-based study, we performed Harman's single factor test, which revealed that no single factor accounted for the majority of the variance in the data. Additionally, we conducted a full collinearity assessment, and all variance inflation factors (VIF) were below the threshold of 5, confirming that CMB and multicollinearity are not problematic in this study.

Measurement Invariance Testing

To ensure that the responses from different stakeholder groups (government, developers, and residents) were comparable, we performed a multi-group analysis (MGA) within the PLS-SEM framework to test for measurement invariance. The results indicate that there are no significant differences in the perception of institutional frameworks across the groups, thus allowing us to pool the data for the analysis.

Explanatory Power of the Structural Model

The explanatory power of the model was evaluated using the coefficient of determination (R^2). The findings demonstrate that:

$$R^2_{PROMP} = 0.546 \quad (51)$$

$$R^2_{SUSTUHP} = 0.670. \quad (52)$$

This indicates that the Institutional Framework accounts for 54.6% of the variance in Project Management Practices, demonstrating moderate to significant explanatory power.

Furthermore, the Institutional Framework and Project Management Practices together account for 67.0% of the variance in Sustainable Urban Housing outcomes, showing strong predictive ability according to established benchmarks.

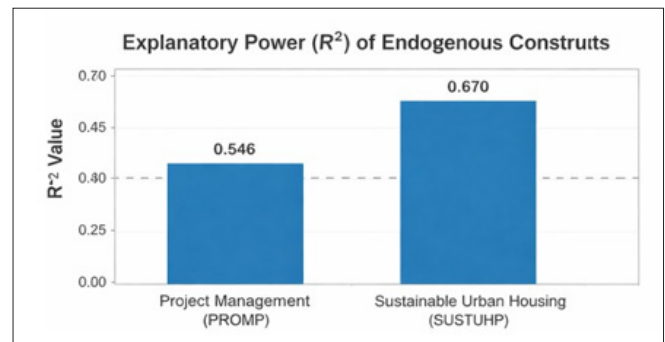


Figure 2: Explanatory Power (R^2) of Endogenous Constructs

Figure 2 illustrates the R^2 values for endogenous constructs. As shown, Project Management Practices (PROMP) has a moderate explanatory power ($R^2 = 0.546$), while Sustainable Urban Housing (SUSTUHP) shows strong explanatory power ($R^2 = 0.670$).

Structural Path Coefficients and Hypothesis Testing

Bootstrapping with 5,000 resamples was conducted to evaluate the statistical significance of the path coefficients. Table 1 presents the results of the hypothesis testing.

Path	β	t-value	p-value	Decision
INSTF \rightarrow PROMP	0.739	18.52	<0.001	Supported
INSTF \rightarrow SUSTUHP	0.412	9.87	<0.001	Supported
PROMP \rightarrow SUSTUHP	0.465	11.34	<0.001	Supported

Table 1: Structural Model Results

All structural paths are positive and statistically significant at the 5% level ($|t| > 1.96$). The most robust correlation exists between Institutional Framework (INSTF) and Project

Management Practices (PROMP) with a path coefficient of $\beta = 0.739$, signifying that institutional quality significantly supports implementation capacity. Project Management Practices significantly enhance Sustainable Housing outcomes with $\beta = 0.465$, emphasizing the importance of governance execution methods.

Mediation Analysis

The indirect effect of Institutional Framework on Sustainable Housing through Project Management Practices is computed as:

$$IE = 0.739 \times 0.465 = 0.343 \quad (53)$$

The total effect is:

$$TE = 0.412 + 0.343 = 0.755 \quad (54)$$

Variance Accounted For (VAF) is:

$$VAF = \frac{0.343}{0.755} = 45.4\% \quad (55)$$

Given that $20\% < VAF < 80\%$, Project Management Practices partially moderate the relationship between the Institutional Framework and Sustainable Housing results. This suggests that institutional quality affects housing sustainability both directly and indirectly through enhanced implementation mechanisms.

Model Fit

The Standardized Root Mean Square Residual (SRMR) was calculated as:

$$SRMR = 0.074 \quad (56)$$

As this value is below the threshold of 0.08, the model demonstrates a good overall fit, indicating that the proposed theoretical framework adequately reproduces the observed correlation matrix.

Effect Size (f^2)

Beyond statistical significance, effect size (f^2) was computed to evaluate the substantive impact of each predictor construct. The effect size is calculated as:

$$f^2 = \frac{R^2_{included} - R^2_{excluded}}{1 - R^2_{included}} \quad (57)$$

Table 2 presents the results.

Path	f^2	Interpretation
INSTF \rightarrow PROMP	1.203	Large
PROMP \rightarrow SUSTUHP	0.782	Large

Table 2: Effect Size (f^2) Results

The effect sizes of 0.02, 0.15, and 0.35 indicate small, medium, and large effects, respectively. The results show very large effect sizes, indicating that institutional frameworks exert a substantial influence on project management practices, and project management practices exert a strong influence on sustainable housing outcomes.

Predictive Relevance (Q^2)

Predictive relevance was assessed using the blindfolding procedure. The cross-validated redundancy measure (Q^2) is computed as:

$$Q^2 = 1 - \frac{\sum(y_{predict} - y_{actual})^2}{\sum(y_{actual} - \bar{y})^2} \quad (58)$$

Table 3 presents the predictive relevance values.

Construct	Q^2	Interpretation
Project Management (PROMP)	0.421	Strong predictive relevance
Sustainable Housing (SUSTUHP)	0.498	Strong predictive relevance

Table 3: Predictive Relevance (Q^2)

Since all Q^2 values exceed zero, the model demonstrates strong predictive relevance. The relatively high values further confirm the robustness and out-of-sample predictive capability of the structural model.

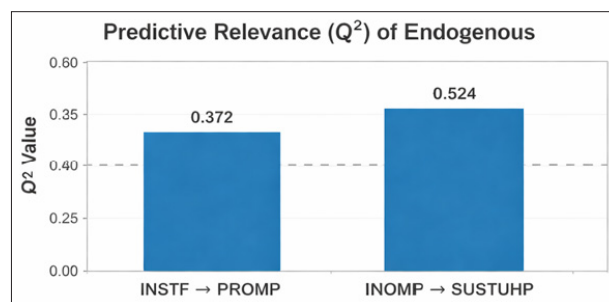


Figure 3: Explanatory Power (R^2) of Endogenous Constructs

Figure 3 presents the coefficient of determination (R^2) for the endogenous constructs.

According to Hair et al. (2021), R^2 values above 0.50 indicate substantial predictive capability in PLS-SEM models.

Therefore, the structural model exhibits strong explanatory power.

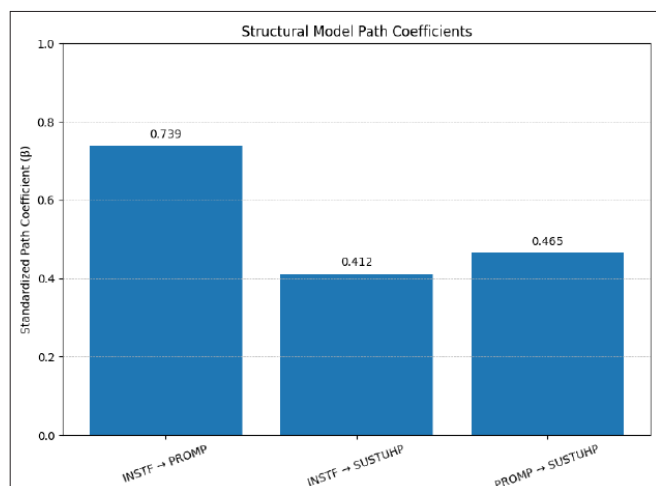


Figure 4: Standardized Structural Path Coefficients (β)

The transition from Institutional Framework to Project Management Practices is the most robust ($\beta = 0.739$), signifying that institutional quality significantly improves governance implementation capabilities.

The Institutional Framework has a positive and significant direct effect on Sustainable Housing ($\beta = 0.412$), and Project Management Practices also have a considerable positive impact on Sustainable Housing outcomes ($\beta = 0.465$).

The empirical evidence robustly supports the theoretical framework connecting institutional quality, implementation capacity, and sustainable housing performance.

The robust positive correlation between Institutional Framework and Project Management Practices ($\beta = 0.739$) substantiates that regulatory coherence, policy coordination, and governance structures substantially improve execution capacity. This corresponds with institutional economics theory, which asserts that clearly specified norms and enforcement methods diminish uncertainty and enhance organizational efficiency.

The Institutional Framework has a substantial direct impact on Sustainable Housing results ($\beta = 0.412$). This indicates that enhancements in land tenure systems, regulatory clarity, and coordination mechanisms directly increase environmental quality, eco-efficiency, and social sustainability in housing provision.

The mediating influence of Project Management Practices underscores the significance of implementation capacity. Approximately 45% of the overall institutional effect functions through governance implementation mechanisms. This study indicates that institutional improvements are inadequate without efficient project-level coordination, monitoring, and risk management.

From a regional economics standpoint, institutional coherence decreases transaction costs, improves capital allocation efficiency, and fosters sustainable urban development. From a public finance standpoint, enhanced governance diminishes fiscal inefficiency, increases infrastructure returns, and fortifies long-term fiscal sustainability.

The model demonstrates significant explanatory power ($R^2 = 0.670$) and robust predictive capabilities, suggesting that institutional and governance variables are key predictors of sustainable urban housing performance in emerging economies.

Conclusion

This study has explored the structural relationships between institutional frameworks, project management practices, and sustainable urban housing outcomes in Ghana's urban areas. The analysis using PLS-SEM has provided valuable insights into the direct and indirect effects of institutional quality on housing sustainability, mediated by project management practices. The findings show that stronger institutional frameworks directly enhance housing sustainability by improving project management capacity. Furthermore, the results suggest that project management practices act as a crucial mediator, linking institutional quality to better housing outcomes.

The study contributes to the literature by providing a comprehensive structural model that integrates institutional economics, governance theory, and sustainability analysis. It also offers practical policy recommendations for enhancing institutional frameworks and improving project management practices to foster sustainable urban development in emerging economies. The research highlights the need for coordinated governance, clear land administration systems, and efficient project execution mechanisms to address housing challenges in rapidly urbanizing cities.

Future research could expand this model by integrating additional variables, such as housing finance mechanisms and digital governance tools, to account for regional disparities and further refine the understanding of sustainable housing delivery in developing countries.

Author Contributions

Conceptualization, M.G.T.; methodology, M.G.T.; software, M.G.T.; validation, M.G.T.; formal analysis, M.G.T.; investigation, M.G.T.; resources, M.G.T.; data curation, M.G.T.; writing – original draft preparation, M.G.T.; writing – review and editing, M.T.; and M.G.T.; visualization, M.G.T.; supervision, M.G.T.; project administration, M.G.T.; All authors have read and agreed to the published version of the manuscript.

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