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Designing an Optimal Model for the Symbiosis of Artificial Intelligence and Human Capital in the Provision of Urban Services

Allah Bakhsh Khashi[1], **VAhid Pourshahabi**[2]

1- Ph.D. Candidate, Department of Management, ZAH.C., Islamic Azad University, Zahedan, Iran
2- Department of Management, Zahedan Branch, Islamic Azad University, Zahedan, Iran

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Abstract

The aim of this study was to design an optimization model for the coexistence of artificial intelligence and human capital in the provision of urban services in the municipalities of Sistan and Baluchestan Province. This research was conducted in two phases: qualitative and quantitative. In the qualitative phase, document analysis, interviews, and the Delphi technique were employed with the assistance of 20 experts to identify key dimensions and develop the initial model. The software used in this phase was MAXQDA. In the quantitative phase, data were collected from 300 employees of the municipalities of the province through a researcher-made questionnaire, the validity and reliability of which were tested and confirmed, and the data were analyzed through Structural Equation Modeling (SEM).

The findings indicated that the final research model demonstrated a satisfactory fit and comprised six main constructs, including contextual factors, artificial intelligence components, human capital components, mediating factors, coexistence strategies, and desirable outcomes. The strongest relationship in the model was observed between contextual factors and artificial intelligence components, with a path coefficient of 0.98. This study provides an indigenous model for optimizing the collaboration between humans and artificial intelligence in the municipalities of underprivileged regions.

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Corresponding Author: VAhid Pourshahabi | **Email:** v.pourshahabi@iauzah.ac.ir

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Extended Abstract

Introduction

The rapid growth of artificial intelligence in the public sector has created unprecedented opportunities to improve the delivery of urban services. However, the successful implementation of artificial intelligence is not merely a technical challenge; rather, it represents a profound organizational transformation that critically depends on effective interaction with human capital (Wilson & Daugherty, 2018; Wirtz et al., 2019). In many developing regions, this challenge is intensified by infrastructural deficiencies, skill gaps, and unique socio-cultural contexts.

Municipalities in Sistan and Baluchestan Province of Iran face specific difficulties, including dispersed populations, severe financial constraints, a shortage of digitally skilled personnel, and inadequate communication infrastructure (Jafarinia et al., 2021; Deputy for Management Development and Resources of the Governorship of Sistan and Baluchestan Province, 2022). Preliminary observations indicate that although there is willingness to adopt artificial intelligence, employees often fear job displacement, and the existing level of digital literacy is significantly lower than the national average (Planning and Budget Organization of Sistan and Baluchestan Province, 2023). Moreover, general artificial intelligence models developed for metropolitan areas are often unable to account for local knowledge, cultural nuances, and geographical dispersion.

Despite the growing body of literature on artificial intelligence in smart cities (Sun & Medaglia, 2019; Singh & Shah, 2025), most studies assume the presence of strong infrastructure and well-prepared human capital, leaving a significant gap regarding context-dependent and resource-constrained environments. Therefore, the necessity of the present research lies in developing a localized model that promotes a symbiotic (co-evolutionary) relationship, rather than a substitutive one, between artificial intelligence and human employees. The main objective is to design an optimal coexistence model that enables municipalities in a less-developed province to benefit from artificial intelligence while simultaneously empowering their existing workforce.

Theoretical Framework

In this study, three complementary theoretical frameworks are integrated. First, Becker's Human Capital Theory (Becker, 1964) posits that knowledge, skills, and experience are productive assets that generate economic and organizational returns. In urban management, human capital—including technical skills, creativity, organizational commitment, and awareness of local culture—constitutes a prerequisite for successful digital transformation (Pahlavani Rad, 202).

Second, the Unified Theory of Acceptance and Use of Technology (UTAUT) (Venkatesh et al., 2003) explain technology adoption through the constructs of performance expectancy, effort expectancy, social influence, and facilitating conditions—factors highly relevant to the adoption of artificial intelligence in public services.

Third, the framework of Collaborative Intelligence proposed by Wilson and Daugherty (2018) moves beyond the notion of substitution toward coexistence, where artificial intelligence performs data-driven tasks while human beings contribute ethical judgment, creativity, and contextual understanding. Recent empirical research confirms that trust, transparency, and algorithmic explainability are essential for such collaboration (Glikson & Woolley, 2020; Raftopoulos & Hamari, 20).

Taken together, these theories provide the foundation for a model composed of contextual factors, artificial intelligence components, human capital dimensions, mediating factors, coexistence strategies, and desirable outcomes.

Research Methodology

This study employed an exploratory sequential mixed-methods design. In the qualitative phase, following a systematic literature review, semi-structured interviews were conducted with 15 participants (senior managers, IT specialists, and AI experts) from the municipalities of Sistan and Baluchestan Province, selected through snowball sampling until theoretical saturation was reached. Subsequently, a three-round Delphi technique involving 20 experts was employed to reach a consensus on the model's components. Thematic analysis by MAXQDA software led to the extraction of 127 primary codes, 6 main themes, and 18 sub-themes.

In the quantitative phase, a researcher-made questionnaire (using a five-point Likert scale) was administered to a simple random sample of 300 municipal employees (drawn from a population of approximately 1,200). The validity of the instrument was confirmed through content validity, convergent validity (AVE > 0.5), and discriminant validity (Fornell-Larcker criterion). Reliability was also verified by Cronbach's alpha and composite reliability (CR > 0.7). Data were analyzed by SPSS software for descriptive statistics and Smart-PLS software for Structural Equation Modeling (SEM), including bootstrapping to test the significance of path coefficients.

Research Findings

The structural model demonstrated that all hypothesized paths were statistically significant ($p < 0.05$), confirming the multidimensional nature of human–AI coexistence in this context. The strongest relationship was observed between contextual factors—including hardware and software infrastructure, managerial support, adequate budget, and ethical considerations—and AI components (decision-making accuracy, reliability, and explainability), with a path coefficient of 0.986. This finding aligns with recent international studies emphasizing that foundational infrastructure and ethical governance are indispensable pillars for AI adoption in smart cities (Ben Dhaou et al., 2024; Thomas et al., 2025). Notably, without managerial commitment and sufficient funding, even well-designed AI systems are likely to fail.

Human capital components—particularly awareness of local culture (0.937), technology acceptance (0.797), and problem-solving skills (0.923)—had strong direct effects on mediating factors (trust in system accuracy, equitable distribution of benefits, and a clear managerial vision) as well as on desirable outcomes. These results confirm previous domestic studies (Nikfarjam & Soleimani, 2023; Karimi & Naderi, 2023) while extending them by quantifying the relative importance of local knowledge, a factor often overlooked in general AI models. In underdeveloped regions, employees' familiarity with geographical and cultural characteristics becomes a strategic asset that AI cannot easily replicate.

Furthermore, coexistence strategies—including intelligent task division, continuous training, and the use of decision-support systems—significantly improved outcomes such as service quality (0.873), citizen trust (0.894), crisis resilience (0.881), and reduced operational costs (0.877). These findings strongly support the collaborative intelligence model (Wilson & Daugherty, 2018) and recent empirical evidence from South Korea and Singapore (Yang & Lee, 2025; Singh & Shah, 2025), where human-in-the-loop designs have enhanced both efficiency and public acceptance. However, this study uniquely demonstrates that in

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resource-constrained environments, continuous training and intelligent task allocation are not optional enhancements but core drivers of effective coexistence.

Compared with earlier international studies that focused primarily on leading smart cities such as Barcelona and Singapore, this model reveals that contextual factors play a disproportionately larger role in less developed regions. While Ferreira dos Santos et al. (2025) identified inclusiveness and trust as key drivers, the present study adds that budget limitations and deficiencies in basic infrastructure can completely hinder AI initiatives unless they are explicitly addressed. Similarly, although ethical concerns (such as privacy and algorithmic bias) are global issues (Engstrom et al., 2020), in Sistan and Baluchestan Province, the absence of any formal ethical framework emerged as a primary concern raised by experts.

From a theoretical perspective, this study proposes a third model beyond the dominant views of "AI as replacement" or "AI as complement." It provides empirical evidence for coexistence as a distinct, context-dependent relationship in which AI and human capital co-evolve through mutual adaptation. From a practical perspective, the final model—comprising six components and 21 indicators—offers an operational roadmap for municipalities facing similar structural and resource constraints.

Conclusion

Using a mixed-methods approach, this study designed and empirically tested a localized coexistence model for artificial intelligence and human capital in the municipalities of Sistan and Baluchestan Province, Iran. The final structural model demonstrated a good fit (SRMR = 0.07, NFI = 0.91) and confirmed that contextual factors, AI components, human capital, mediating factors, and coexistence strategies collectively generate desirable outcomes. The strongest effects were found, respectively, in the relationship between contextual factors and AI components, and between human capital and coexistence strategies. Accordingly, the model provides a practical and evidence-based framework for optimizing human–AI collaboration in under-resourced urban service environments.

The findings showed that achieving an optimal coexistence between artificial intelligence and human capital in the municipalities of Sistan and Baluchestan requires simultaneous attention to technical infrastructure, capable human capital, and cultural–organizational strategies. Domestic studies such as Zamani et al. (2024) and Naseri & Ahmadi (2023) emphasized the role of AI in improving the quality of urban services, including waste management and transportation. Consistent with those studies, the present research found that AI components—namely decision-making accuracy, reliability, and algorithmic transparency—have a direct effect on desirable outcomes. Likewise, the results are aligned with the studies of Nikfarjam & Soleimani (2023) and Karimi & Naderi (2023), which identified training, skills, and employees' psychological readiness as prerequisites for successful digital transformation. In the present model, human capital, represented by indicators such as awareness of local culture and problem-solving skills, played a central role in technology acceptance.

At the international level, the findings are also consistent with Ferreira dos Santos et al. (2025), who identified inclusiveness and trust as major drivers of smart-city system adoption. Similarly, in the present model, trust in system accuracy and the perceived fair distribution of benefits emerged as key mediating factors. Furthermore, the results correspond with the findings of Singh & Shah (2025) and John et al. (2025) regarding the importance of collaborative and trust-based approaches to digital governance.