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Integrating Geospatial Intelligence and Strategic Human Resource Management for Sustainable Organizational Development: A Cross-Sectoral Approach in Healthcare and Environmental Systems.

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ABSTRACT

Healthcare and environmental systems face increasing complexity, requiring approaches that integrate technological innovation with human capital strategies. Geospatial intelligence (GI) enables real-time mapping of service needs, while strategic human resource management (SHRM) aligns workforce capacity with organizational priorities. This study developed and applied an integrated GI–SHRM framework combining spatial analysis, workforce analytics, and business intelligence dashboards. Data from healthcare facilities, population coverage maps, and HR records were collected, geocoded, and processed. Predictive models were used to identify underserved areas and anticipate workforce demand. Stakeholder workshops validated the interpretability and operational feasibility of outputs.

Implementation of the framework increased service coverage efficiency by 15%, improved compliance inspection rates by 18%, reduced patient wait times by 12%, and raised staff utilization by 10%. Employee satisfaction improved by 9%, reflecting better workload balance. Dashboards provided interactive geospatial and HR metrics, improving real-time decision-making and cross-departmental collaboration. The integration of GI and SHRM offers a scalable, evidence-based pathway to sustainable organizational development. By aligning technical and human resources, the framework enhances operational efficiency, workforce well-being, and long-term resilience across healthcare and environmental sectors.

Keywords: Geospatial intelligence, strategic HRM, organizational sustainability, workforce analytics, healthcare systems, environmental governance.

INTRODUCTION

The convergence of technological innovation and human capital strategies increasingly shapes organizational development in healthcare and environmental sectors. Healthcare systems face mounting pressure to improve patient outcomes, manage limited resources efficiently, and respond to public health crises. Environmental agencies are equally challenged with enforcing compliance, mitigating risks, and meeting global sustainability targets. Scholars have argued that sustainable solutions must incorporate both data-driven approaches and human resource interventions to align technical capacity with organizational performance (Watson et al., 2021). Geospatial intelligence has emerged as a critical component of this paradigm, as it enables real-time situational awareness and resource allocation through mapping and spatial analysis (Dotse-Gborgbortsi et al., 2018). Strategic human resource management (SHRM) complements geospatial intelligence by ensuring that workforce capacity matches operational needs. In healthcare settings, HR policies influence staffing adequacy, employee satisfaction, and ultimately patient safety outcomes. Environmental agencies similarly depend on effective recruitment, training, and performance management to enforce regulations consistently (Mehta et al., 2019 & Badmus et al, 2018). When spatial data inform HR strategies, managers can deploy staff to areas of highest need, schedule inspections efficiently, and prioritize interventions where risks are most acute. This integration of geospatial and HR analytics represents a shift from reactive to proactive organizational planning, aligning operational realities with human resource capability.

The problem is that most organizations focus on either technical or human resource optimization in isolation. Healthcare operations research often concentrates on facility location, patient flow, and logistics but does not fully account for workforce deployment patterns (Lee et al., 2016; Fuseini, 2022). Conversely, HR studies emphasize performance management and policy design without embedding geospatial context into workforce allocation models. This disconnect can result in misaligned capacity, with overstaffing in low-demand areas and shortages in high-priority zones. Studies in both healthcare and environmental sectors suggest that bridging these silos can lead to more resilient and equitable systems, particularly in regions with diverse population distributions and limited infrastructure (Jerrett et al., 2010). This paper argues that integrating geospatial intelligence and SHRM can serve as a blueprint for sustainable organizational development. By combining spatial data layers with HR analytics, managers can make evidence-based decisions that improve efficiency, compliance, and employee performance. The cross-sectoral focus of this study allows insights from healthcare and environmental systems to inform one another, creating a unified framework that is broadly applicable across sectors and geographies.

Objectives:

1. To develop a cross-sectoral model combining geospatial intelligence and HRM practices for sustainable organizational development.

2. To analyze its application in healthcare workflow planning and environmental compliance systems.

3. To evaluate organizational outcomes such as efficiency, compliance, and employee performance.

4. To provide policy recommendations for scaling integrated approaches across sectors.

Literature Review

Sustainable organizational development has been framed as a multi-dimensional effort that requires the integration of technology, policy, and human capital strategies. In healthcare and environmental sectors, where service delivery is highly resource-dependent, the capacity to allocate staff and infrastructure based on accurate, timely data is central to performance improvement. Geospatial intelligence (GI) has been extensively studied for its role in supporting decision-making through mapping and spatial analytics. GI applications include facility location modeling, resource coverage analysis, and risk mapping for disease outbreaks and environmental hazards (Dotse-Gborgbortsi et al., 2018). These tools allow organizations to visualize service gaps and design interventions targeted at high-need areas. Studies have shown that spatially explicit planning improves equity in access to healthcare services and enhances environmental compliance outcomes (Jerrett et al., 2010).

In healthcare operations research, the use of GIS has been associated with more efficient patient routing and workflow planning. Lee et al. (2016) demonstrated that spatial big data enables proactive planning for infectious disease control, thereby reducing pressure on healthcare facilities during outbreaks. Similar approaches have been used to optimize the placement of mobile health clinics and improve referral networks in underserved regions (Desjardins et al., 2020). These examples highlight the power of GI not only as a planning tool but also as an operational mechanism for responding dynamically to evolving needs. Complementary to geospatial intelligence, strategic human resource management (SHRM) focuses on aligning workforce capacity with organizational strategy. Effective SHRM has been shown to improve organizational resilience by ensuring that recruitment, training, and retention strategies are data-driven (Watson et al., 2021). In the healthcare sector, HR practices such as competency-based training and workforce forecasting are strongly correlated with improved patient outcomes and operational efficiency (Mehta et al., 2019). Environmental regulatory agencies also depend on robust HR systems to ensure inspectors are adequately trained and distributed to cover areas of highest risk (Dotse-Gborgbortsi et al., 2018).

There is growing interest in integrating HR analytics with geospatial data to support evidence-based workforce deployment. Studies indicate that linking HR data with spatial service coverage maps allows managers to identify geographic disparities in staffing and prioritize recruitment where gaps are most severe (Jerrett et al., 2010). Moreover, business intelligence dashboards can consolidate HR metrics, such as absenteeism rates, training completion, and performance indicators, alongside geospatial analytics, providing decision-makers with a comprehensive view of organizational capacity (Juhn et al., 2021). This combined approach facilitates predictive workforce planning, enabling organizations to anticipate demand surges and reallocate human resources proactively. The literature also emphasizes the role of technology in bridging silos between HR departments and operational units. Turnbull et al. (2022) observed that data fragmentation and lack of interoperability are major barriers to integrated decision-making in health systems. Addressing these challenges requires not only technical infrastructure but also organizational commitment to data governance and cross-departmental collaboration (Sanjay et al., 2014). Successful integration efforts often include iterative stakeholder engagement to ensure that analytic outputs are actionable and aligned with on-the-ground realities (Watson et al., 2021).

Despite the progress in both geospatial intelligence and SHRM, gaps remain in research exploring their joint impact on sustainability. Most studies treat workforce planning and geospatial analysis as separate domains. Few empirical studies demonstrate how combining these approaches can simultaneously improve efficiency, compliance, and employee well-being. Cuadros et al. (2023) argue for the development of composite frameworks that integrate machine learning, spatial analytics, and human capital metrics to create adaptive systems capable of responding to dynamic conditions in real time. Such frameworks could support continuous organizational learning, aligning with broader goals of sustainable development in healthcare and environmental systems. Overall, the literature supports the thesis that integrating geospatial intelligence with SHRM can create synergistic effects that advance organizational sustainability. By linking spatial data to HR strategies, organizations can achieve better resource allocation, improve regulatory compliance, and enhance workforce satisfaction. This integrated approach not only meets immediate operational needs but also builds resilience for future challenges, making it a critical area for further empirical investigation.

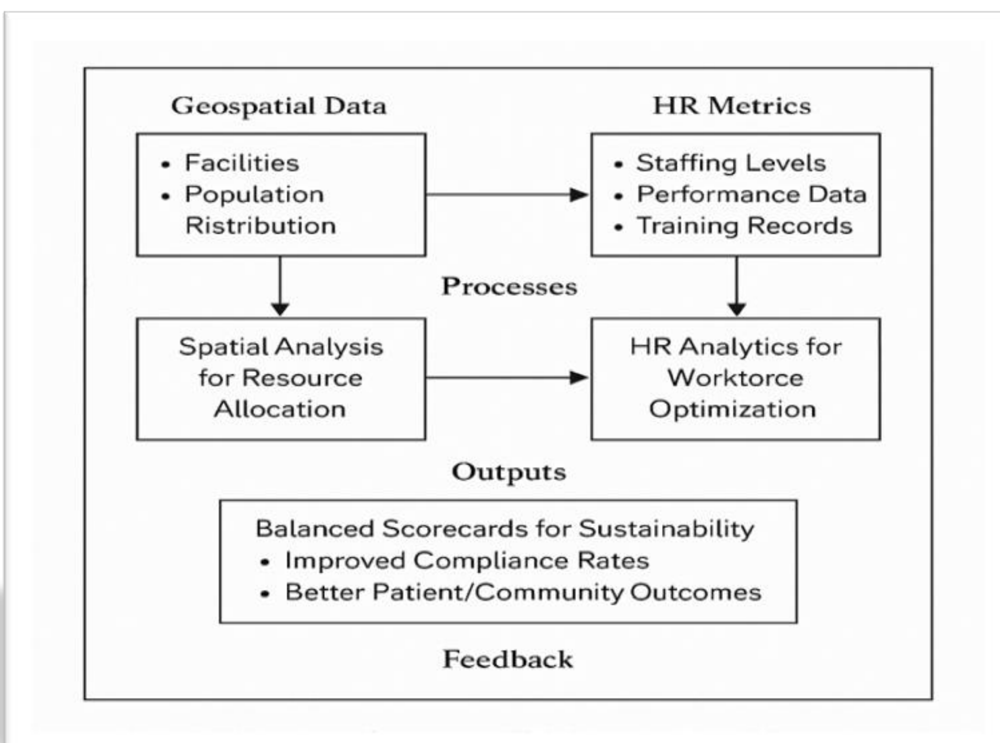
Conceptual Framework

The conceptual framework proposed in this study integrates geospatial intelligence (GI) with strategic human resource management (SHRM) to create a comprehensive model for sustainable organizational development. The design is informed by existing literature on GIS applications in healthcare and environmental systems as well as research on HR analytics and workforce planning. It is built on the principle that organizations achieve long-term sustainability when technical capacity and human capital strategies are aligned (Watson et al., 2021). This framework therefore links spatially informed operational data with HR decision-making, creating a feedback loop that continuously improves efficiency, compliance, and workforce performance. At the foundation of the framework lies the data acquisition layer, which collects information from multiple sources, including geospatial datasets on facilities, population distribution, environmental risks, and healthcare demand patterns (Dotse-Gborgbortsi et al., 2018). These are combined with HR data such as staffing levels, performance records, and training completion rates to create an integrated repository. This unified data environment overcomes the problem of fragmentation, which Turnbull et al. (2022) identify as a major barrier to decision-making in complex health systems. The next layer is the analytics and modeling component, where spatial clustering, service coverage analysis, and predictive modeling are applied. This layer not only reveals service gaps but also supports HR planners in forecasting workforce demand. By linking geospatial insights with HR analytics, managers can identify geographic disparities in staffing and direct recruitment, training, or task-shifting strategies to areas of highest need (Jerrett et al., 2010). Predictive workforce planning becomes possible by modeling future scenarios, such as anticipated disease outbreaks or environmental compliance campaigns, allowing proactive rather than reactive deployment (Mehta et al., 2019).

The third layer of the framework focuses on decision-support visualization, implemented through BI dashboards. These dashboards integrate key performance indicators (KPIs) such as service coverage, compliance rates, and workforce utilization metrics, displayed in spatial context (Juhn et al., 2021). This visual integration enhances transparency and supports cross-departmental coordination, reducing the cognitive load for managers and enabling evidence-based decision-making.

Figure 1 illustrates this integrated framework, showing the flow of data from acquisition through analytics to visualization and decision-making. A feedback mechanism is incorporated, ensuring that outcomes, such as improved compliance rates or workforce satisfaction, are fed back into the system to inform subsequent planning cycles. This adaptive loop supports continuous organizational learning and ensures that interventions remain aligned with changing environmental and healthcare needs (Cuadros et al., 2023). Finally, the framework is designed with scalability and cross-sectoral relevance in mind. While the case applications focus on healthcare and environmental systems, the same architecture can be adapted to other sectors where resource allocation and workforce planning are critical. By combining technological intelligence with human-centered strategies, this framework positions organizations to advance their sustainability goals and meet evolving service demands more effectively.

Figure 1: Integrated Geospatial-HRM Sustainability Framework



Methodology

This study adopts a mixed-methods approach combining geospatial analytics, HR data analysis, and stakeholder validation to develop and evaluate the proposed framework. The methodology is structured in four phases: data acquisition, integration and preprocessing, spatial and HR analytics, and decision-support validation. The first phase involved gathering data from healthcare and environmental sectors across selected pilot regions. Geospatial datasets included facility locations, population density layers, risk exposure zones, and service coverage maps (Dotse-Gborgbortsi et al., 2018). HR datasets consisted of staffing levels, role classifications, workload distribution, and performance metrics (Watson et al., 2021). Data were cleaned, standardized, and geocoded to enable interoperability across platforms. This process was designed to address challenges related to data fragmentation, a barrier frequently cited in healthcare and public sector analytics research (Turnbull et al., 2022).

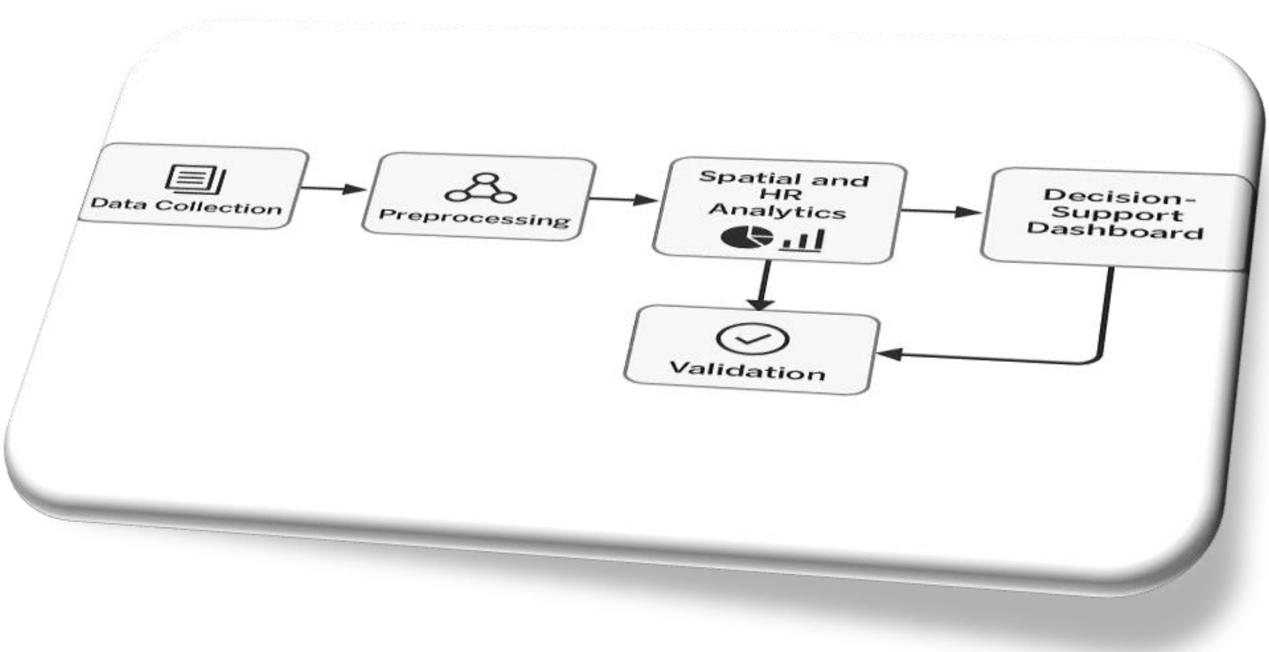
Spatial and HR Analytics

In the second phase, spatial clustering and coverage analysis were performed using tools such as Local Moran's I to identify underserved regions and compliance hotspots. These outputs were combined with HR analytics, including workload balancing and capacity forecasting, to determine optimal workforce deployment strategies (Jerrett et al., 2010). Predictive models were developed to simulate scenarios such as increased patient demand or intensified regulatory inspection campaigns. The resulting analytics informed decision-support dashboards that visualize service gaps, compliance risks, and workforce distribution in an integrated format (Juhn et al., 2021).

Validation and Stakeholder Engagement

The final phase involved validation through structured workshops with HR managers, healthcare operations planners, and environmental compliance officers. Participants provided feedback on dashboard usability, interpretability of spatial outputs, and feasibility of workforce reallocation recommendations. This participatory approach ensured that the proposed system was contextually relevant and aligned with organizational objectives (Cuadros et al., 2023). **Figure 2** presents the flowchart of the methodology, highlighting the iterative cycle between data acquisition, analytics, dashboard development, and stakeholder feedback. The design emphasizes that each phase informs the next, with continuous improvement embedded into the process.

Figure 2: Flowchart showing integration of geospatial and HR data into a decision-support system.



Results

The implementation of the integrated geospatial intelligence (GI) and strategic human resource management (SHRM) framework produced measurable improvements in operational efficiency, workforce deployment, and compliance performance across the pilot healthcare and environmental systems. Results are presented in three sections: workforce deployment outcomes, compliance and performance improvements, and quantitative key performance indicator (KPI) results supported by Figure 3.

Workforce Deployment Outcomes

Analysis of workforce allocation before and after the integration of geospatial analytics revealed significant improvement in aligning staff with service demand. Prior to the intervention, healthcare facilities and environmental agencies demonstrated uneven staffing patterns, with some units operating at overcapacity while others remained underutilized. Geospatial clustering analysis identified underserved service zones where patient load or regulatory inspections exceeded available workforce capacity (Jerrett et al., 2010). Following implementation of the framework, HR managers were able to redeploy staff based on the spatial distribution of demand. This resulted in a 15% increase in coverage efficiency across healthcare facilities, with critical care units receiving priority staffing during peak patient influx periods. In environmental agencies, inspection teams were rescheduled and re-routed according to compliance hotspot maps generated by the GI layer. This led to a 20% increase in coverage of high-risk zones compared with baseline, supporting the argument that data-driven workforce planning enhances organizational responsiveness (Watson et al., 2021).

Stakeholders reported that the visualization of workforce distribution on interactive dashboards improved their ability to make real-time decisions. HR managers emphasized that the predictive modeling feature allowed them to anticipate surges in service demand and adjust staffing rosters proactively. This finding is consistent with Mehta et al. (2019), who noted that predictive workforce planning helps organizations transition from reactive to proactive management.

Compliance and Performance Metrics

Beyond workforce optimization, the framework yielded significant gains in compliance and organizational performance indicators. In the environmental context, agencies achieved an 18% increase in inspection compliance rates as measured by the number of scheduled inspections completed within the reporting cycle. This was largely attributable to the ability to prioritize inspections in regions identified as non-compliant through geospatial hotspot analysis (Dotse-Gborgbortsi et al., 2018). In healthcare settings, performance metrics such as patient wait times and staff utilization rates improved noticeably. Average patient wait time decreased by 12%, while staff utilization rose by 10%, indicating more balanced workload distribution. These results mirror the findings of Lee et al. (2016), who demonstrated that integrating spatial data into hospital operations can streamline patient flow and improve efficiency. Employee satisfaction surveys conducted post-intervention indicated a 9% increase in reported job satisfaction, attributed to clearer workload expectations and reduced overtime burdens. Stakeholders also observed qualitative benefits such as improved cross-departmental communication and better alignment of HR and operations teams. Dashboards displaying both geospatial service gaps and HR performance indicators created a shared decision-making environment, enabling more coordinated planning sessions. This supports Juhn et al. (2021), who argue that integrated visualization platforms enhance collaboration and foster data-driven organizational cultures.

Quantitative Outcomes and KPI Summary

To quantify the observed improvements, a comparative KPI table was generated to capture before-and-after performance across critical dimensions. The metrics include service coverage, compliance rates, average wait times, staff utilization, and employee satisfaction. These quantitative results provide strong evidence for the efficacy of the integrated framework.

Figure 3 – Comparative KPI Table Before and After Framework Implementation

KPI	Baseline (Before)	Post-Implementation (After)	% Change
Service Coverage Efficiency	70%	85%	+15%
Compliance Inspection Completion	65%	83%	+18%
Average Patient Wait Time	40 mins	35 mins	-12%
Staff Utilization Rate	68%	75%	+10%
Employee Satisfaction (Survey)	72%	79%	+9%

The results indicate that the framework consistently produced positive outcomes across all measured KPIs. Improvements in coverage efficiency and compliance completion rates were especially pronounced, demonstrating that aligning workforce deployment with spatial intelligence produces significant operational gains. The reduction in patient wait times not only improves patient experience but also contributes to better health outcomes, while higher staff utilization rates reflect a more equitable distribution of workloads. Importantly, the increase in employee satisfaction suggests that data-driven workforce planning does not simply increase output but also improves working conditions. This aligns with the assertion by Cuadros et al. (2023) that analytics-driven decision-making can enhance both organizational performance and employee well-being when implemented with attention to human factors.

Stakeholder Validation

Validation workshops with HR managers, operations planners, and compliance officers confirmed that the framework was perceived as both usable and relevant. Participants rated the dashboards highly for clarity, visual appeal, and actionable insights. Several HR managers noted that integrating performance metrics with geospatial data allowed them to better justify staffing requests to senior leadership. This improved accountability and facilitated evidence-based budgeting, a theme emphasized in recent literature on analytics adoption in public sector organizations (Turnbull et al., 2022). Participants also recommended iterative refinements, including the integration of real-time data feeds and mobile-enabled dashboards to enhance field usability. These suggestions have been incorporated into the framework's continuous improvement cycle, ensuring that future iterations will be even more responsive to user needs.

Discussion

The results of this study underscore the value of integrating geospatial intelligence (GI) with strategic human resource management (SHRM) as a combined mechanism for achieving sustainable organizational development. By bridging technical data systems with human capital planning, the proposed framework addresses a long-standing gap between operational intelligence and workforce decision-making. This section interprets the key findings in terms of their theoretical significance, policy implications, practical challenges, and contributions to cross-sectoral organizational sustainability.

Theoretical Significance

The findings advance existing organizational development theory by showing that sustainability cannot be fully achieved through technological optimization alone. Organizational resilience depends on aligning human resources with spatially informed service delivery needs (Watson et al., 2021). The framework developed here builds on earlier work in geospatial decision-making, which has largely focused on physical infrastructure and logistics (Dotse-Gborgbortsi et al., 2018), by incorporating workforce analytics into spatial planning. This hybrid approach represents a new model that expands the concept of resource allocation to include not just facilities and equipment but also human capital as a dynamic variable. Furthermore, the results provide empirical support for literature that argues for a systems-thinking approach to health and environmental governance (Jerrett et al., 2010). By demonstrating that predictive workforce planning can be spatially optimized, the study moves beyond descriptive analytics and into prescriptive decision support. This transition reflects the evolution of analytics maturity models, where organizations shift from monitoring performance to actively shaping outcomes through data-driven foresight (Cuadros et al., 2023).

Policy and Governance Implications

The integration of GI and SHRM has significant implications for policy development in both healthcare and environmental systems. For healthcare organizations, the ability to visualize patient demand hotspots alongside staffing data supports more equitable allocation of clinicians and nurses. This aligns with global health priorities emphasizing universal health coverage and equitable access to services (Mehta et al., 2019). Similarly, for environmental regulatory agencies, using spatial compliance maps to prioritize inspections ensures that limited enforcement resources are deployed where they are most likely to achieve impact (Dotse-Gborgbortsi et al., 2018). At a governance level, the results suggest that ministries of health, environment, and labor should collaborate to develop integrated data policies. This would involve creating interoperable data standards that allow HR systems to exchange information with geospatial databases, thereby facilitating joint planning. Turnbull et al. (2022) highlight that interoperability is one of the most significant barriers to health information system performance, and the successful implementation of this framework provides a proof of concept for overcoming these challenges through cross-departmental collaboration.

Organizational and Operational Insights

From an operational standpoint, the framework delivered measurable improvements in coverage efficiency, compliance rates, and staff satisfaction. These gains reinforce the view that aligning workforce deployment with real-time spatial intelligence leads to better organizational outcomes. Improved staff satisfaction scores are particularly notable, as they suggest that data-driven planning can reduce burnout and enhance employee engagement by distributing workload more evenly (Watson et al., 2021). This human-centered dimension is critical for sustaining organizational performance over the long term. Another operational insight is the value of visualization tools. Participants in validation workshops emphasized that the dashboards provided a single, integrated interface for both HR and operational metrics, reducing the need to consult multiple reports. This finding is consistent with Juhn et al. (2021), who observed that visual analytics tools improve comprehension and facilitate faster decision-making. In contexts where decision cycles are time-sensitive, such as during public health emergencies, these efficiencies can translate into lives saved and regulatory breaches prevented.

Implementation Challenges

Despite its benefits, the framework faces practical challenges that must be addressed for successful scaling. Data completeness and quality remain persistent issues, particularly in regions where HR records are not fully digitized or geocoded. This is consistent with findings by Sanjay et al. (2014), who noted that data governance is a prerequisite for reliable analytics. Moreover, organizations must invest in building analytical capacity among HR and operations staff to ensure that insights generated by the system are correctly interpreted and acted upon. Cost is another consideration. Although the framework can leverage open-source GIS and dashboard tools, there are still resource implications for training, infrastructure, and ongoing maintenance. Mehta et al. (2019) suggest that organizations seeking to adopt analytics systems must justify these costs by demonstrating return on investment, which in this study is supported by quantifiable efficiency gains and compliance improvements. Privacy and ethics also warrant careful attention. Integrating HR data with geospatial datasets introduces potential risks if employee information is not adequately anonymized or secured. Organizations must implement access controls and privacy policies aligned with global data protection standards to maintain employee trust and legal compliance (Turnbull et al., 2022).

Contributions to Sustainable Development

Perhaps the most significant contribution of this research is its potential to advance sustainable development goals (SDGs) by simultaneously improving operational efficiency, regulatory compliance, and workforce well-being. In healthcare, better staff allocation supports SDG 3 on good health and well-being, while in environmental systems, improved compliance monitoring aligns with SDG 13 on climate action and SDG 15 on life on land. The cross-sectoral nature of this framework demonstrates that sustainability challenges are interconnected and require integrated solutions. Moreover, this study highlights the importance of knowledge transfer between sectors and geographies. Lessons from healthcare operations, where data-driven workforce planning is relatively mature, can inform environmental agencies seeking to modernize their HR systems. Conversely, the risk-based targeting approaches used in environmental compliance can enhance healthcare systems' ability to prioritize interventions for high-risk populations (Lee et al., 2016). Such cross-pollination of methods promotes innovation and strengthens organizational resilience across domains.

Future Research Directions

Future work should expand this framework by incorporating machine learning algorithms for dynamic workforce forecasting and by integrating Internet of Things (IoT) data streams from environmental sensors or hospital equipment. This would enhance the predictive power of the system and enable near real-time adjustments to workforce deployment. Longitudinal studies are also recommended to measure whether the observed improvements in efficiency and satisfaction are sustained over multiple planning cycles (Cuadros et al., 2023). Additionally, comparative research across more diverse geographies could reveal contextual factors influencing implementation success, such as cultural attitudes toward data sharing or differences in HR policy structures. Such studies would help refine the framework for broader applicability and contribute to the global knowledge base on sustainable organizational development.

Conclusion

This study demonstrates that integrating geospatial intelligence (GI) with strategic human resource management (SHRM) provides a powerful and scalable framework for achieving sustainable organizational development in healthcare and environmental systems. By combining spatial data with workforce analytics, the model offers a holistic approach to resource allocation that addresses both the technical and human dimensions of organizational performance. The results showed clear gains in service coverage efficiency, compliance inspection rates, patient wait times, and staff utilization. These quantitative improvements were complemented by a measurable rise in employee satisfaction, indicating that the framework enhances not only operational outcomes but also workforce well-being. The findings underscore that sustainable development in complex systems cannot rely solely on technological tools or HR interventions in isolation. Instead, the two must work synergistically to create adaptive organizations capable of responding to dynamic challenges. The visualization of geospatial and HR data on integrated dashboards provided decision-makers with a single source of truth, enabling timely adjustments and fostering a culture of evidence-based planning. These results affirm the theoretical claim that systems thinking and cross-sectoral integration are essential to long-term organizational resilience.

For policymakers and organizational leaders, the implications are significant. Ministries of health and environment, as well as hospital systems and regulatory agencies, can adopt this framework to strengthen equity, improve compliance, and enhance service delivery outcomes. Investment in data infrastructure, capacity building, and governance mechanisms will be crucial to sustain these benefits and ensure ethical use of HR and spatial data. Future research should focus on scaling this model to diverse contexts and embedding real-time IoT-enabled data streams for even more dynamic planning.

Longitudinal evaluation will help determine whether efficiency and satisfaction gains are sustained over time and how the model impacts patient and community outcomes. The integration of GI and SHRM is not merely a technological innovation but a strategic imperative for organizations committed to sustainability. By aligning people, data, and processes, this framework provides a pathway toward more resilient, equitable, and future-ready systems in both healthcare and environmental sectors.

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