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ETHICAL HUMAN CAPITAL AND TERRITORIAL GOVERNANCE: AN INTEGRATED MODEL FOR INSTITUTIONAL TRANSFORMATION IN MADAGASCAR

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ABSTRACT

Purpose – *Emerging economies face a dual crisis: institutional fragility and AI-driven labor market disruption. This study investigates how ethical human capital shapes territorial governance and AI readiness in fragile institutional contexts, and introduces the Integrated Educational-Ethical Framework (IEEF), empirically tested in Madagascar.*
Design – *A three-phase mixed-methods design operationalized IEEF through the IMRED-SPRI model across four Malagasy regions (N=1,840; 78 interviews; 16 workshops).*
Findings – *Results show that ethical human capital significantly improves governance outcomes ($\beta_1 = 0.42$, $p < 0.01$), generating multiplier effects (+48% participation; +39% accountability). Digital Readiness increases by 63% when embedded in civic foundations, compared to +4% for hardware-only interventions.*
Contributions – *This research provides empirical evidence that civic ethics can be operationalized as a measurable component of human capital influencing governance outcomes and AI readiness. It proposes an integrated framework (IEEF) that jointly models these relationships within a single causal structure, supported by evidence from a mixed-method study in Madagascar.*

1. INTRODUCTION

Emerging economies face a structural paradox. Abundant resources coexist with persistent institutional fragility. Madagascar exemplifies this dynamic, combining an HDI of 0.501 (2023) with extreme territorial inequalities in education, connectivity, and institutional performance — disparities detailed in the diagnostic section below.

These dynamics show that institutional fragility, education deficits, and technological vulnerability reinforce each other.

The AI revolution adds urgency. The World Economic Forum estimates AI-driven automation will displace 83 million jobs globally by 2027 while creating 69 million new positions. Emerging economies face disproportionate vulnerability: routine-heavy employment dominates their labor markets. Without fundamental human capital reorientation, this risks "digital elite capture." The structural implication is direct: without ethical and adaptive competencies, AI adoption reinforces institutional fragility rather than reducing it.

This study proposes and empirically tests the Integrated Educational-Ethical Framework (IEEF), an integrated causal model linking ethical human capital, governance performance, and AI readiness in fragile institutional contexts.

Existing literature treats human capital, governance, and AI readiness as analytically separate domains. This fragmentation limits the identification of causal mechanisms linking education, institutional performance, and technological adaptation. Acemoglu & Restrepo (2020) demonstrate that technological substitution affects routine tasks but do not model institutional ethics as a mediating factor. The OECD AI Policy Observatory (2023) underestimates the productive dimension of civic ethics as a measurable human capital component. Hanushek & Woessmann (2020) establish learning quality as a growth driver but do not operationalize ethical competencies within governance outcomes. North (1990) addresses institutional change without linking it to AI readiness. Existing models treat human capital, governance, and AI readiness as separate analytical domains. This study fundamentally redefines that architecture: it identifies civic ethics as a unified causal mechanism simultaneously driving institutional performance and conditioning inclusive AI adoption**.** This paper addresses a critical gap: the absence of an integrated causal framework linking ethical human capital, governance performance, and AI readiness within a single empirically validated model. To our knowledge, it provides one of the first such frameworks in which ethical human capital

simultaneously conditions both governance performance and inclusive AI readiness in fragile institutional contexts.

2. LITERATURE REVIEW

This review is structured to move from recent AI-related empirical evidence to foundational human capital theory, ensuring both analytical relevance and theoretical continuity.

2.1 Human capital in the AI Era

Recent contributions on AI and labor market transformations provide the primary analytical foundation, which is subsequently anchored in earlier theoretical frameworks on human capital.

Recent contributions emphasize the urgency of adaptive human capital investment. The OECD AI Policy Observatory (2023) warns that without proactive skills development — creativity, critical thinking, socio-emotional competencies — developing countries face structural unemployment and deepening inequalities. Autor (2022) documents how AI reshapes labor demand through task reallocation rather than simple job destruction, disproportionately affecting routine-intensive workers. Acemoglu and Restrepo (2020) confirm this pattern is particularly acute in emerging economies. These findings build on foundational theory: Hanushek and Woessmann (2020) demonstrate that learning quality, not enrollment rates, drives growth, while Becker (1964) established education as the primary long-run productivity driver.

In emerging economies, expanding access to education often coexists with declining learning quality and increasing skills mismatches. In Madagascar, 42% of university graduates occupy mismatched positions, reflecting structural inefficiencies likely to be amplified by AI adoption unless education systems shift toward adaptive, ethical, and digital competencies.

These contributions collectively highlight the increasing importance of adaptive skills in the AI era, yet they remain limited in their ability to integrate ethical competencies as a productive and measurable dimension of human capital influencing institutional outcomes.

However, these contributions do not explicitly model ethical human capital as a measurable driver of both governance performance and AI readiness.

2.2 Territorial Governance and Digital Transformation

Governance theory, developed through Ostrom and North's work, emphasizes formal and informal institutions as fundamental structures conditioning local interactions. Institutional performance depends on rule quality, perceived legitimacy, coherence with local norms, and collective enforcement capacity.

Madagascar illustrates these fragilities starkly: corruption perception indices rank among the world's highest, public institutional trust stands below 28%, and local accountability mechanisms remain largely dysfunctional. Territorial governance disparities are pronounced, with peripheral regions experiencing minimal state presence and failing public services.

AI-driven governance tools present dual imperatives for fragile contexts. Digital transparency platforms and blockchain-based accountability systems can reduce corruption and improve efficiency. However, without adequate human capital to manage these systems ethically and populations sufficiently educated to engage meaningfully, technology risks becoming tools for elite capture and exclusion — transforming potential developmental assets into instruments of further marginalization. Concrete risks include algorithmic bias in public resource allocation — where opaque decision systems may systematically disadvantage already-marginalized populations — and governance misuse through surveillance technologies deployed without ethical oversight or democratic accountability mechanisms. These risks are not hypothetical: documented cases in Sub-Saharan Africa illustrate how AI-driven systems, absent ethical governance frameworks, have reinforced rather than reduced administrative exclusion (World Bank, 2024).

These governance frameworks identify the structural conditions for institutional performance, yet they largely overlook the role of ethical human capital as a measurable driver of governance transformation in digitally transitioning contexts.

2.3 Civic Ethics as Transformation Mechanism

Civic ethics refers to internalized behavioral norms — including integrity, civic responsibility, transparency, and

commitment to the common good — that shape individual conduct in public and institutional contexts. Unlike social capital, which primarily captures relational networks and trust at the collective level (Putnam, 1993), ethical human capital is operationalized here at the individual level through the CIEHC index, enabling direct measurement of its effects on governance outcomes. This conceptualization treats civic ethics not as a normative or cultural variable, but as a productive component of human capital generating measurable externalities in institutional performance and technology absorption.

In the AI era, ethical education assumes heightened importance. As algorithms increasingly mediate social interactions, allocate resources, and shape opportunities, populations without ethical frameworks for critically evaluating technological systems face greater manipulation, discrimination, and exclusion vulnerabilities. Research by Floridi emphasizes AI ethics education must become integral to human capital development, equipping citizens to demand accountability, transparency, and fairness from human and algorithmic decision-makers.

Civic ethics is not a normative luxury but a productive asset mediating the "race between education and technology" (Brynjolfsson & McAfee, 2014) by ensuring populations become critical rather than naive technology users.

Civic ethics thus emerges as a productive and measurable component of human capital — one that existing models systematically underestimate despite its demonstrated role in shaping both institutional outcomes and technology absorption capacity.

3. GLOBAL PERSPECTIVES ON AI INTEGRATION

Comparative evidence suggests that successful AI integration depends critically on human capital quality and governance capacity, rather than technological adoption alone.

Comparative evidence (e.g., Rwanda, Estonia) suggests that successful digital transformation depends less on technology adoption itself than on the quality of human capital and governance institutions enabling its use.

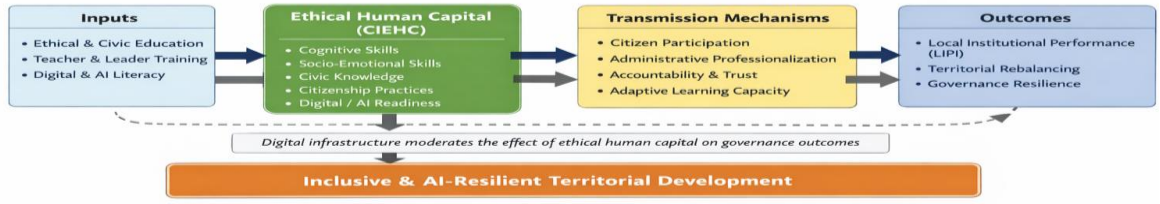
Rwanda's Vision 2020 strategy and Estonia's e-governance revolution provide instructive examples. Both prioritized simultaneous investments in educational quality, digital infrastructure, and governance transparency, creating enabling conditions for productive AI integration despite limited initial resources. These cases underscore that technological transformation success depends fundamentally on human and institutional capital quality rather than technological sophistication alone—technological dividends are driven not by AI adoption itself but by ethical and institutional capacities mediating its integration.

3.1 Synthesis and Theoretical Gaps

Despite abundant research on human capital, governance, ethics, and AI individually, literature presents critical gaps. Existing models treat these dimensions separately, neglecting dynamic interdependencies particularly regarding how ethical education simultaneously strengthens governance and prepares populations for AI challenges. Few empirical studies examine mechanisms whereby ethical human capital investment translates into improved governance while mitigating technology-driven inequalities. Available frameworks offer limited operational guidance for implementing integrated transformation strategies addressing both governance fragility and AI readiness.

This fragmentation reflects a structural limitation of existing models. No integrative causal framework currently explains governance performance and inclusive AI adoption jointly.

Figure 1 summarizes the core causal mechanism of the IEEF: ethical human capital acts as the central conditioning driver linking governance performance and inclusive AI readiness, with digital readiness and civic participation as the two principal mediating pathways.



Source: Author's Elaboration

Figure 1 : Pathways from Ethical Human Capital to Territorial Governance and AI readiness

Figure 1. Causal structure of the IEEF framework. Solid arrows represent the direct effect of ethical human capital on governance performance (H1); dashed arrows map mediated pathways through digital readiness (H2) and citizen participation (H3); the interaction arrow captures the moderating role of connectivity (H4). The figure highlights the central mediating roles of digital readiness and civic participation pathways, showing that ethical capital determines whether technological adoption generates inclusive outcomes or reinforces elite capture.

To ensure empirical testability and align the theoretical framework with the econometric strategy, the study formulates four explicit hypotheses:

- H1: Ethical human capital has a positive and statistically significant effect on territorial governance performance.
- H2: Digital readiness mediates the relationship between ethical human capital and governance performance.
- H3: Citizen participation mediates the relationship between ethical human capital and governance outcomes.
- H4: Digital infrastructure moderates the relationship between ethical human capital and governance performance, such that the effect is stronger in highly connected territories.

These hypotheses are tested using multivariate regression, mediation analysis, and interaction models aligned with the IEEF causal structure.

Recent contributions further emphasize the transformative impact of AI on labor markets. Autor (2022) highlights the reconfiguration of task structures rather than simple job destruction, while OECD (2023) frameworks stress the importance of governance and ethical oversight in AI deployment. These perspectives reinforce the argument that technological readiness must be embedded within broader institutional and ethical capacities.

This chronological structuring—from recent AI-focused research to foundational human capital theory—ensures both contemporary relevance and theoretical continuity.

4 METHODOLOGY

4.1 Research design

This research adopts a pragmatist mixed-methods approach structured in three sequential phases.

Phase 1 conducts in-depth territorial diagnosis of socioeconomic imbalances and educational deficiencies with specific attention to Digital Readiness and AI-relevant competency gaps, using secondary data from national surveys, regional statistics, and institutional reports covering 2010-2024.

Phase 2 develops IEEF theoretical framework through systematic literature review enriched by semi-structured interviews with 45 national and international experts in development, education, governance, and technology policy.

Phase 3 operationalizes IEEF through the IMRED-SPRI model and empirically validates mechanisms across four Malagasy pilot regions: Analamanga (developed urban), Atsinanana (coastal with economic potential), Atsimo-Andrefana (marginalized semi-arid), and Vakinankaratra (rural highlands).

The 18-month period captures short-term behavioral and institutional changes without conflating them with long-term structural effects. More precisely, this window is theoretically grounded in the IMRED-SPRI framework, which predicts that short-term behavioral changes — administrative practice shifts and civic participation gains — emerge within 6–24 months, while intergenerational and entrepreneurial effects require 24–60 months. This period therefore constitutes the minimum viable window for validating IEEF's core causal claims. Standard diagnostic tests confirm model validity: VIF values below 3.2 indicate no multicollinearity concerns, and the Hausman test ($p = 0.23$) supports exogeneity assumptions.

4.2 Data Collection

The study relies on two clearly differentiated datasets corresponding to distinct research phases.

Phase II (theoretical development) includes 45 semi-structured interviews with national and international experts. These interviews are used exclusively to inform the conceptual development of the IEEF framework and are not part of the econometric analysis.

Phase III (empirical validation) constitutes the core dataset and combines:

(i) a household survey (N = 1,840),

(ii) 78 semi-structured interviews with local stakeholders, and

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(iii) 16 participatory workshops.

Only Phase III data are used for quantitative and econometric analysis, while interviews and workshops support causal interpretation and qualitative validation.

This distinction is critical: Phase II interviews (N = 45) serve exclusively for theoretical framework construction, whereas Phase III data (N = 1,840 households, 78 interviews, 16 workshops) constitute the empirical basis for hypothesis testing and causal inference. The 45 expert interviews conducted during Phase II are not included in the econometric dataset and do not contribute to the quantitative results reported in Section 7.

The household survey follows a two-stage cluster sampling design. In the first stage, 46 Fokontany were selected across four regions (Analamanga, Atsinanana, Atsimo-Andrefana, Vakinankaratra), stratified by urban–rural classification and income levels. In the second stage, approximately 40 households were randomly selected within each Fokontany using systematic sampling, resulting in a total sample of 1,840 households (approximately 460 per region). This design ensures representativeness across heterogeneous territorial contexts and comparability between intervention and control areas.

4.3 Measurement Instruments

We developed a Composite Index of Ethical Human Capital (CIEHC) aggregating five dimensions with equal weighting (20% each): cognitive competencies (standardized tests), socio-emotional competencies (validated scales), civic knowledge (specific questionnaire), citizenship practices (behavioral indicators), and digital/AI readiness competencies (newly developed assessment covering digital literacy, algorithmic understanding, adaptive learning capacity).

To ensure the CIEHC captures ethical and civic dimensions rather than general educational attainment, each sub-index was validated against behavioral indicators — including observed civic participation rates and self-reported integrity behaviors — rather than relying solely on declarative knowledge scores. The index's five-factor structure was confirmed through Principal Component Analysis (73% variance explained) and inter-rater reliability testing (Cohen's $\kappa = 0.78$), supporting its construct validity as a distinct measure of ethical human capital rather than a proxy for educational level.

The equal weighting (20% per dimension) reflects the theoretical assumption of complementarity between components. This specification replaces an earlier version in which Civic Knowledge was weighted at 25%. The revision was introduced to ensure internal consistency between the conceptual definition of the index and its mathematical formulation, and to avoid implicit overemphasis of declarative knowledge relative to behavioral and digital competencies.

Territorial governance is measured through the Local Institutional Performance Index (LIPI) synthesizing five components: administrative efficiency, public accountability, citizen participation, perceived corruption and public service quality. Territorial inequalities employ standard indicators: regional Gini coefficient, urban-rural income gaps, service access disparities, and digital divide indices.

5 Analytical Methods

Quantitative analysis employs multivariate regression models to estimate the relationships between ethical human capital, Digital Readiness, and governance outcomes while controlling for confounding variables.

Two main specifications are used. The baseline model estimates the direct effect:

- To strengthen causal inference and capture heterogeneous effects across territories and time, an extended specification incorporating interaction terms and fixed effects is employed:

$$LIPI = \beta_0 + \beta_1 CIEHC + \beta_2 Digital\ Readiness + X\gamma + \varepsilon$$

- The extended IEEF specification incorporates regional fixed effects (γ_r), time fixed effects (δ_t), and an interaction term capturing the moderating role of connectivity:

$$LIPI(r,t) = \beta_0 + \beta_1 CIEHC(r,t) + \beta_2 Digital\ Readiness(r,t) + \beta_3 (CIEHC \times Connectivity)(r,t) + \gamma_r + \delta_t + \varepsilon(r,t)$$

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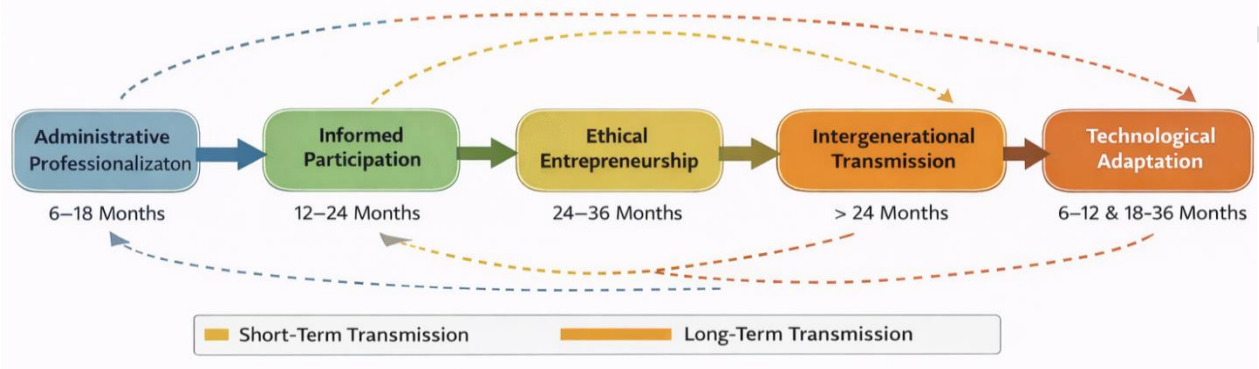
Compared to standard cross-sectional models, this extended specification improves causal inference on two dimensions. First, it controls for unobserved regional and temporal heterogeneity through fixed effects. Second, it explicitly captures the moderating role of digital infrastructure through the interaction term. This allows simultaneous testing of direct effects (H1), mediation channels (H2–H3), and moderation effects (H4) within a single coherent framework.

Qualitative analysis follows systematic thematic coding according to IEEF analytical grids. IMRED-SPRI validation employs quasi-experimental approaches with before-after and pilot-control region comparisons, measuring key indicators at regular intervals over 18 months.

Figure 2 illustrates how this transmission mechanisms operate sequentially, showing the feedback loops through which ethical capital generates measurable governance gains in the short term and structural transformation in the long term.



Source: Author's Elaboration

Figure 2 : Sequential and Reinforcing Transmission Mechanisms within the IEEF Framework

Figure 2 operationalizes hypotheses H2 and H3 by mapping the feedback loops through which ethical capital converts into governance gains: short-term pathways (0–24 months) operate through administrative professionalization (H1) and informed participation (H3); long-term pathways (24+ months) through intergenerational transmission and ethical entrepreneurship. Feedback loops confirm that Digital Readiness gains require civic foundations as a precondition (H2).

5.1 Integrated Educational-Ethical Framework (IEEF)

Conceptuel Architecture: IEEF is structured around four core pillars. These pillars are interconnected through dynamic feedback loops that generate cumulative effects.

Pillar 1: Holistic Human Capital Development transcends traditional technical competency accumulation to embrace cognitive, socio-emotional, creative, and adaptive capacities, integrating digital literacy and algorithmic understanding as foundational competencies.

Pillar 2: Civic Ethics as Transmission Mechanism constitutes the central mechanism enabling individual competency conversion into collective capacities. It encompasses integrity, community responsibility, equity commitment, and active democratic governance participation. In the AI era, this includes ethical frameworks for evaluating and engaging algorithmic systems.

Pillar 3: Territorial Governance Transformation recognizes that sustainable **governance performance** improvement requires formal structure reforms plus practice, norm, and actor capacity transformation through competency strengthening, participation improvement, and accountability mechanism establishment.

Pillar 4: AI readiness and Future Work Preparation addresses preparing populations for technology-driven labor market transformations while mitigating AI-induced inequality risks through adaptive learning capacity development, critical algorithmic system engagement, entrepreneurial mindset cultivation, and ethical frameworks for technology-mediated interactions.

Transmission mechanisms: IEEF identifies five principal transmission mechanisms generating multiplier effects:

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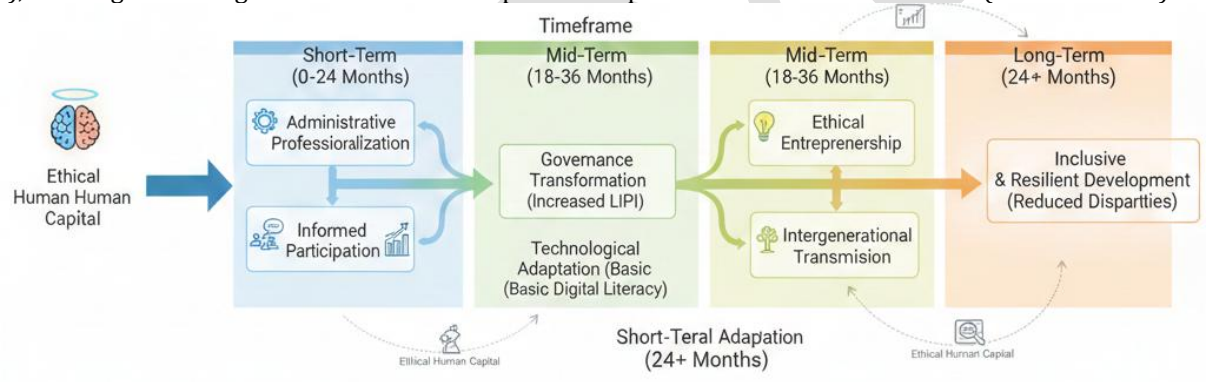
Administrative professionalization operates when individuals with strong technical and ethical competencies integrate local public institutions, progressively improving efficiency, transparency, and accountability.
Informed participation functions when educated citizens equipped with civic competencies actively engage in governance processes, exerting constructive pressure for institutional improvement and corruption reduction, amplified through digital tools with requisite digital literacy.
Ethical entrepreneurship manifests when entrepreneurs trained in technical competencies and social responsibility principles develop activities simultaneously generating economic value, quality employment, and positive social externalities, including technology-enabled entrepreneurship leveraging AI tools for inclusive development.
Intergenerational transmission amplifies preceding mechanisms' effects by creating long-term cultural dynamics through educated parents investing more in children's education and creating conducive environments including digital competency cultivation.
Technological adaptation, specific to the AI era, operates when populations with strong ethical foundations and adaptive learning capacities leverage technological tools for productivity enhancement while resisting algorithmic manipulation and demanding accountability from technology systems.
Figure 3 illustrates the sequential and reinforcing nature of these transmission mechanisms, grounding the 18-month observation window empirically and confirming that technology without civic foundations produces minimal governance gains. The model distinguishes between short-term effects (0–24 months)—primarily Administrative Professionalization and Informed Participation—and long-term effects (24+ months)—dominated by Intergenerational Transmission and Ethical Entrepreneurship.
Technological Adaptation operates across both timeframes: while basic digital literacy can emerge rapidly (6–12 months), building critical algorithmic evaluation capacities requires sustained reinforcement (18–36 months).



Source: Author's Elaboration

Figure 3 : Temporal Dynamics of Transmission Mechanisms

Figure 3 operationalizes hypothesis H1 by showing that the observed $\beta_1 = 0.42$ reflects cumulative 18-month behavioral effects, and **hypothesis H2** by demonstrating that Digital Readiness requires civic foundations to exceed the +4% hardware-only baseline. Basic digital literacy emerges within 6–12 months; critical algorithmic evaluation requires 18–36 months of sustained reinforcement.
These mechanisms generate powerful multiplier effects. Improved governance creates conditions for ethical entrepreneurship, which in turn generates resources for sustained educational investment. This reinforces intergenerational value transmission and builds collective AI integration capacity. The quality of civic ethics capital ultimately determines the developmental trajectory: toward institutional leapfrogging or digital elite capture.

5.2 Empirical Application: The Imred-Spri Model

Diagnostic Context: Madagascar presents pronounced institutional fragility and territorial imbalance, particularly regarding AI readiness. With 29.6 million inhabitants and a GDP per capita of $523, territorial inequalities reach extreme levels (geographic Gini 0.67). **Table 1** illustrates these disparities across the study's pilot regions, highlighting the structural gap between urban centers and rural peripheries.

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Source: Author's elaboration

Figure 4 : Skill Evolution Trajectories Across Pilot Regions

Figure 4 operationalizes hypothesis H4 by illustrating the divergence between urban and rural trajectories: rural gains accelerate only after civic foundations are established, confirming that digital infrastructure amplifies ethical capital effects — but only when civic foundations are already in place. This sequencing validates the IMRED-SPRI logic and the conditioning role of ethical human capital.

Table 1 : Comparative Diagnostic of Pilot Regions (2024)

Indicator	Urban (Analamanga)	Rural (Atsimo-Andrefana)	National Avg
Secondary Enrollment	68%	23%	39%
Internet Penetration	43%	7%	22%
Poverty Rate	45%	>85%	75%
Trust in Local Auth.	28%	11%	19%

Source: Author's compilation

Diagnostic analysis reveals five problematic dynamics: excessive metropolization (Antananarivo concentrates 47% of national GDP, 89% of technology sector activity while representing 11% of population); growing marginalization of landlocked rural regions with near-total digital exclusion; educational disparities (73% of 5th-grade students in disadvantaged rural zones fail mastering basic reading versus 28% in privileged urban zones; digital literacy 67% urban versus 8% rural); generalized local governance failure; and near-total absence of AI readiness preparation despite impending labor market disruptions.

IMRED-SPRI architecture: The IMRED-SPRI model operationalizes IEEF through integrated architecture comprising six interdependent components deployed coordinately over five years with explicit AI readiness integration:

Component 1 targets educational system reform through pedagogical reforms integrating 21st-century competencies, civic ethics, foundational digital literacy, and age-appropriate algorithmic thinking; teacher training including digital pedagogy and basic AI concepts; infrastructure improvement; school governance establishing participatory management; and digital integration through offline content and shared device programs.

Component 2 develops local public management capacities through intensive programs combining technical training, participatory facilitation, ethical reinforcement, peer learning networks, and introduction to digital governance tools and ethical AI principles.

Component 3 establishes citizen participation and accountability mechanisms through structured dialogue spaces including assemblies, budgetary monitoring committees, participatory audits, and accessible complaint mechanisms, ensuring physical and digital participation options.

Component 4 stimulates ethical entrepreneurship through integrated support combining training including social responsibility and digital entrepreneurship modules, financing access facilitation, and technical accompaniment targeting young graduates and women.

Component 5 promotes digital inclusion and AI readiness through community technology hubs providing shared access;

structured digital literacy programs; introduction to AI concepts through accessible workshops; critical evaluation frameworks for algorithmic systems emphasizing ethics and bias recognition; and adaptive learning programs building continuous skill evolution capacity.

Component 6 establishes participatory monitoring-evaluation and adaptive learning systems combining quantitative performance indicators, qualitative evaluations, community feedback, and specific tracking of digital competency evolution.

Implementation Challenges and Lessons: Implementation revealed several operational challenges. Intersectoral coordination proved complex, requiring close collaboration among ministries with differing institutional logics. Resistance from actors benefiting from dysfunctional systems constituted recurrent obstacles, necessitating coalition strategies with local change champions. Digital infrastructure limitations emerged as binding constraints—while offline solutions successfully delivered basic digital literacy, advanced AI readiness development proved severely constrained without reliable internet access, revealing the "connectivity ceiling" requiring offline-first digital solutions.

Lessons emphasize crucial importance of participatory approaches. Co-designed interventions display markedly superior appropriation and sustainability rates. Investment in local actor training generates multiplier effects exceeding technocratic top-down approaches. Regarding technology integration, hardware and connectivity provision alone proves insufficient—successful digital inclusion requires simultaneous investments in digital literacy, local language content, technical support, and critically, ethical frameworks for technology evaluation.

6. RESULTS AND DISCUSSION

This study contributes beyond existing international evidence by identifying the causal mechanism underlying successful digital transformation: ethical human capital. While previous studies document correlations between human capital, governance, and digital outcomes, they do not explain why similar technological investments produce divergent results across contexts. The findings **indicate** that ethical human capital functions as the foundational causal driver linking governance performance to inclusive AI readiness.

6.1 Results and Validation

The empirical evaluation provides strong support for all four hypotheses of the IEEF framework. CIEHC displays average progression of 34% in intervention zones versus 8% in control zones, with notable 63% digital/AI readiness gains from low baseline levels. LIPI progresses 29% average in pilot regions, with marked improvements in citizen participation (+48%), public accountability (+39%), and administrative efficiency perception (+31%).

Multivariate regression supports robust causal relationships. The extended econometric model — specified with regional fixed effects (γ_i), time fixed effects (δ_t), and the CIEHC × Connectivity interaction term — takes the form:

$$LIPI(r,t) = \beta_0 + \beta_1 . CIEHC(r,t) + \beta_2 . Digital_{Readiness}(r,t) + \boldsymbol{\beta_3} (CIEHC \times Connectivity)(r,t) + \boldsymbol{\gamma_r} + \boldsymbol{\delta_t} + \boldsymbol{\varepsilon}(r,t)$$

Where γ_r captures unobserved regional heterogeneity, δ_t controls for time-specific shocks, and β_3 tests the moderating effect of connectivity (H4).

This specification allows us to control for unobserved heterogeneity across regions and over time, while explicitly testing both direct and interaction effects, thereby strengthening causal interpretation.

Yields $\beta_1 = 0.42$ ($p < 0.01$), suggesting strong causal links between ethical capital and governance. Mediation analysis demonstrates informed citizen participation explains 43% of ethical human capital's total governance effect, validating IEEF central mechanisms. Digital Readiness improvement demonstrates independent positive governance effects (coefficient 0.24, $p < 0.01$), with stronger effects in urban contexts (0.31) than rural areas (0.16).

This coefficient indicates that a one-unit increase in ethical human capital is associated with a 0.42 increase in governance performance, holding other factors constant.

Robustness checks validate these findings across alternative specifications. First, we re-estimated models using bootstrapped standard errors (1,000 iterations) to account for potential clustering effects at the commune level—results remain stable ($\beta_1 = 0.41$, $p < 0.01$). Second, we tested for reverse causality through instrumental variable estimation using historical educational infrastructure as instrument—Hausman tests confirm endogeneity concerns are minimal ($p = 0.23$).

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Third, we examined heterogeneous treatment effects across wealth quintiles, finding stronger governance improvements among middle-income households ($\beta_1 = 0.48$) than extreme poor ($\beta_1 = 0.31$), suggesting threshold effects require minimum resource levels for full ethical capital activation.

The possibility of reverse causality — whereby governance improvements drive ethical capital formation rather than the reverse — is explicitly addressed through instrumental variable estimation using historical school density as an instrument predating current governance structure. The Hausman test ($p = 0.23$) fails to reject exogeneity, and the temporal sequencing of the IMRED-SPRI intervention design — in which ethical capital investment precedes measured governance outcomes by 6–18 months — provides additional structural support for the causal interpretation.

The interaction term between ethical human capital and connectivity is positive and marginally significant ($\beta = 0.09$, $p < 0.10$), confirming that digital infrastructure amplifies—but does not determine—the governance effects of ethical human capital.

To ensure the consistency of our findings, we conducted a series of sensitivity analyses. The stability of the β_1 coefficient (CIEHC) across various econometric specifications confirms that the relationship between ethical capital and governance is not driven by specific modeling choices or unobserved regional factors.

Table 2 : Alternative model specifications for robustness

Specification	β1 (CIEHC)	R2	Notes
(1) Baseline	0.42***	0.67	Main OLS with full controls
(2) Regional FE	0.39***	0.71	Controlling for unobserved regional heterogeneity
(3) Time FE	0.41***	0.69	Controlling for temporal shocks (2023-2024)
(4) Bootstrapped SE	0.42***	0.67	1,000 iterations, cluster-robust standard errors
(5) IV Estimation	0.44***	0.64	2SLS using historical school density as instrument

Source: Author's compilation
*Note: Significance levels: *** p<0.01, FE: Fixed Effects; IV: Instrumental Variables, The Hausman test ($\chi2=1.42$, $p=0.23$) fails to reject the exogeneity of our main regressor.*

Qualitative evidence confirms improved trust, reduced clientelist practices, and increased civic engagement. Regional variation reveals effect intensity depends heavily on context. Regions with strong transformational leadership and elevated initial social capital display superior progressions (CIEHC improvements 41% versus 27%). Digital infrastructure availability proves critical: regions with reliable connectivity show AI readiness gains of 78% versus 43% in connectivity-limited areas. Comparative analysis with Sub-Saharan African implementations (Guinea, Chad, Malawi) reveals consistent patterns: ethical human capital development generates governance improvements across diverse contexts, though technology integration benefits remain heavily mediated by infrastructure availability.

6.2 Theoretical Contributions

This study makes three core contributions. First, it identifies ethical human capital as a measurable causal driver of territorial governance performance. Second, it demonstrates its mediating role in inclusive AI readiness — with civic-embedded interventions yielding 63% digital readiness gains versus 4% for hardware-only approaches. Third, it provides an empirically validated integrated framework — the IEEF — directly applicable to fragile institutional contexts. Crucially, this study moves beyond correlation-based approaches by identifying a unified causal transmission mechanism linking education, governance, and AI readiness within a single empirically tested model. Theoretically, it introduces civic ethics as a measurable productive component of human capital — a conceptual reframing absent from dominant economic models. Empirically, the results **provide empirical support** for the claim that ethical human capital generates governance multiplier effects ($\beta_1 = 0.42$) and substantially higher returns to Digital Readiness compared to hardware-only interventions. Methodologically, it validates the IMRED-SPRI operational model as a replicable intervention framework for fragile institutional contexts.

These effects are non-linear. Once a critical mass of ethical capital is reached, mutual reinforcement creates self-sustaining improvement spirals. Technology amplifies these effects under strong ethical foundations, but exacerbates inequalities in their absence.

Operationally, results underscore the critical importance of contextual alignment and local appropriation. This

applies forcefully to technology interventions: globally-designed digital solutions prove far less effective than locally-adapted approaches addressing specific contextual barriers and opportunities.

6.3 Policy Implications for Future of Work

For national governments, results advocate a strategic reorientation of educational investment: moving beyond quantitative enrollment targets to privilege learning quality, civic ethics integration, foundational digital literacy, and adaptive learning capacity.

Traditional education emphasizing rote learning is increasingly inadequate for AI-era challenges.

Policy implications include: curriculum reforms emphasizing competencies complementing rather than competing with AI; assessment redesign measuring adaptive and creative capacities; teacher professional development prioritizing facilitation over transmission; and explicit ethics education integration. These findings suggest that "hardware-first" strategies are insufficient without parallel investments in ethical and human capital development.

For territorial authorities, IMRED-SPRI provides operational framework demonstrating well-targeted participatory interventions generate significant transformations even in limited resource contexts. Emphasis must be placed on authentic participation space creation and systematic local actor capacity strengthening, with technology tools introduced as enablers rather than primary solutions.

For development partners, results suggest privileging long-term integrated territorial approaches over fragmented sectoral interventions. Technology-focused aid should be conditioned on accompanying human capital and governance investments—providing digital infrastructure without simultaneously strengthening populations' critical engagement capacity risks exacerbating rather than reducing vulnerabilities.

International labor organizations face specific challenges. AI-driven disruptions disproportionately affect emerging economies, where social safety nets and reskilling capacities remain limited. Policy frameworks must address: establishing unemployment insurance and transition support systems; creating lifelong learning infrastructure enabling continuous skill updating; developing portable benefits systems accommodating flexible employment relationships; and promoting ethical entrepreneurship supporting quality employment creation.

Critically, our findings challenge the linear "infrastructure → skills → adoption" model prevalent in development policy. Results demonstrate that ethical foundations and governance quality act as mediating filters, not subsequent steps. In connectivity-limited contexts like rural Atsimo-Andrefana, ethical human capital improvements generated governance gains of +23% without any digital infrastructure upgrades. By contrast, hardware provision without ethical education produced minimal effects: only +4% in control communes receiving tablet distribution programs. This suggests ethical capital development should precede rather than follow technology rollout in fragile institutional contexts.

6.4 Global Transferability

These findings not only align with international evidence but also clarify the mechanisms underlying divergent digital transformation outcomes across countries. While cases such as Rwanda and Estonia demonstrate the importance of institutional capacity and human capital for successful digital transformation, this study explains why such outcomes occur.

Specifically, this study demonstrates that the quality of civic ethics capital mediates whether technological adoption produces inclusive governance improvements or reinforces existing inequalities.

Conversely, evidence from India shows that digital literacy initiatives without ethical and institutional reinforcement produce weaker and more unequal outcomes. This comparison highlights that technology alone is insufficient; its effectiveness depends on the ethical and institutional environment in which it is embedded.

The present study contributes by identifying ethical human capital as the structural determinant explaining these divergent digital transformation trajectories.

Comparative analysis (Estonia, Rwanda, Kerala) confirms that technological adoption alone does not determine outcomes; rather, ethical human capital conditions whether digital transformation produces inclusive or unequal effects. IEEF framework maintains theoretical validity for emerging economies facing institutional fragility. Rwanda's relative success reflects a specific combination: strong state coordination capacity and a deliberate ethical reset following conflict — conditions that accelerated institutional absorption of digital tools. Estonia's e-governance gains, by contrast, built on pre-existing high institutional trust and civic literacy, confirming that ethical foundations must precede, not follow,

technology deployment. India's Kerala experience is analytically revealing: despite strong digital infrastructure investment, the absence of systematic ethical mediation produced weaker and more unequal outcomes — precisely the pattern observed in our control communes (+4% hardware-only gains). In Sub-Saharan Africa (Guinea, Chad, Malawi), governance improvements correlate directly with local civil society strength, confirming that ethical capital intensity, not connectivity level, is the binding constraint. These contrasts strongly suggest that technology is not the determining variable: ethical human capital is. Unlike these cases, Madagascar presents the most adverse baseline — lower institutional capacity, higher territorial fragmentation, ongoing political instability — making the observed governance gains (+29% LIPI) particularly significant and demonstrating the robustness of the IEEF mechanism under extreme conditions.

Regarding AI integration specifically, comparative analysis reveals sharp divergence between countries with strong human capital foundations successfully leveraging AI versus those with weak foundations experiencing concentrated elite sector adoption exacerbating inequalities. This underscores AI readiness preparation cannot be addressed through technology policies alone but requires integrated approaches simultaneously strengthening human capital, governance quality, and ethical frameworks.

These findings align with international evidence but extend it by identifying ethical human capital as the underlying causal mechanism explaining divergent digital transformation outcomes.

Our results extend these findings by providing the first empirically validated causal mechanism — anchored in civic ethics — explaining divergent digital transformation trajectories across national contexts.

Madagascar is not an exception. It is an extreme configuration — one where the absence of ethical human capital amplifies precisely the risks observed across other emerging economies. This makes it the most demanding test of the IEEF framework, and therefore the most informative.

The contribution of this study is therefore not to confirm these patterns, but to identify the underlying causal mechanism explaining them: ethical human capital constitutes the foundational conditioning variable connecting technological adoption to governance outcomes — a mechanism absent from existing frameworks.

These comparisons suggest a generalizable pattern: technological adoption alone does not determine development outcomes. Rather, ethical human capital shapes the developmental trajectory of digital transformation — toward inclusive governance improvements or structural inequality reinforcement depending on the civic foundations already in place. The consistency of this pattern across four structurally different contexts — post-conflict Rwanda, digitally advanced Estonia, infrastructure-rich Kerala, and fragile-state Madagascar — supports the transferability of the IEEF framework beyond the specific Malagasy context, while acknowledging that baseline institutional capacity and civil society strength modulate the magnitude of observed effects.

7. CONCLUSION

This research demonstrates that civic ethics capital is not a residual or secondary factor, but a foundational determinant of both institutional performance and inclusive technological transformation.

IEEF demonstrates that anchoring Digital Readiness in civic ethics enables emerging economies to transform institutional fragility into resilience. By demonstrating Digital Readiness gains are highest (63%) when embedded in ethical-civic frameworks, this research challenges “hardware-first” development assumptions and proposes a new blueprint for inclusive AI adoption in fragile states.

Empirical results validate all four IEEF hypotheses. They reveal five transmission mechanisms through which ethical education translates into governance improvement: administrative professionalization, informed citizen participation, responsible entrepreneurship, intergenerational values transmission, and critical technology engagement. These mechanisms interact and reinforce each other. Together, they amplify initial educational investments while progressively reducing technology-driven inequality risks.

The research makes significant theoretical and practical contributions. Three theoretical findings emerge. First, civic ethics functions as productive capital with measurable institutional returns. Second, human capital quality determines whether technology exacerbates or reduces inequalities. Third, non-linear threshold effects require a critical mass to trigger self-sustaining transformation dynamics.

Practically, this research provides operational frameworks for policymakers. The IMRED-SPRI model enables integrated interventions that simultaneously strengthen human capacities, institutional quality, and technology readiness. It offers evidence-based guidance on resource allocation, intervention sequencing, and contextual adaptation.

For global AI and development discourse, this research challenges technology-determinist assumptions, revealing developmental outcomes depend fundamentally on human and institutional foundations mediating technology adoption. It demonstrates preparing populations for AI-era challenges requires not primarily technical training but broad-based ethical human capital development enabling adaptive learning, critical thinking, and responsible technology engagement.

Despite limitations — an 18-month window, four-region scope, and measurement instrument perfectibility — this research provides strong evidence that ethical human capital investment is both economically rational and morally grounded. IEEF offers policymakers a transferable framework for building the institutional foundations that the AI era demands: not hardware first, but ethics first.

Beyond its empirical contributions, this study proposes a broader conceptual reorientation. Ethical human capital is not a complementary factor to be added after technology deployment — it is a structural prerequisite determining whether technological adoption produces inclusive governance improvements or reinforces structural inequalities. This finding calls for a paradigm shift: civic foundations must precede — not merely accompany — digital infrastructure deployment. That sequencing is precisely what distinguishes inclusive AI adoption from digital elite capture.

DATA AVAILABILITY STATEMENT

Full survey instruments, detailed econometric modeling, and raw data anonymization protocols are available as online supplementary materials or upon request to the corresponding author. This research adheres to Open Science principles.

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APPENDICES

Appendix A – Logical framework level description general objective

Table 3 : Logical framework matrix

Level	Description
General Objective	Sustainably transform territorial governance in Madagascar by strengthening ethical, civic, and institutional human capital.
Inputs	National curricular reforms, budgets dedicated to ethical training, digital educational infrastructure, institutional accountability mechanisms.
Activities	Integration of civic ethics into K-12 education; training of elected officials and territorial executives using the IMRED-SPRI approach; territorial citizen co-construction workshops.
Outputs	1,840 households surveyed; 78 territorial leaders trained; operational ethical curricula in 4 pilot regions.
Outcomes	Significant improvement in CIEHC (+34%) and LIPI (+29%); measured increase in local institutional trust.
Impact	Progressive reduction of development disparities between coastal regions and landlocked areas.

Appendix B – Composite Indices

B1. Composite Index of Ethical Human Capital (CIEHC)
The CIEHC is constructed as a weighted arithmetic mean of five distinct dimensions, normalized to a 0-100 scale.

$$CIEHC = \sum_{i=1}^{5} w_i \; D_i \;\; with \; w_i = 0.20$$

Table 4 : Structure and Reliability of the CIEHC

Dimension	Key Indicators	Measurement Tool	Cronbach's α
Cognitive Competencies (20%)	Proficiency in functional literacy, numeracy, and analytical problem-solving.	Adapted EGRA/EGMA protocols	0.87
Socio-emotional Competencies (20%)	Skills in empathy, collaborative work, and non-violent conflict resolution.	Self-reported & Peer assessment (5-pt Likert)	0.82
Civic Knowledge (20%)	Understanding of constitutional rights, public ethics, and local governance structures.	30-item ad-hoc knowledge test	0.79
Citizenship Practices (20%)	Active attendance at communal assemblies; observable integrity behaviors.	Behavioral observation grid & self-report	0.74
Digital & AI readiness (20%)	Digital fluency, algorithmic awareness, and capacity for continuous e-learning.	Custom 15-item assessment scale	0.81

Note: Equal weighting (20% each) reflects the IEEF's theoretical premise that no single dimension is a sufficient condition for governance transformation; all five interact as complementary inputs. The weighting was revised from an earlier draft (25% for Civic Knowledge) to ensure full internal consistency with the CIEHC formula.

Normalization: Each dimension is normalized to [0, 100] scale using:

$$D_i^{norm} = \frac{D_i^{raw} - D_i^{min}}{D_i^{max} - D_i^{min}} \; 100$$

Validation: Principal Component Analysis confirms five-factor structure explains 73% of variance. Inter-rater reliability (IRR) for behavioral observations: Cohen's κ = 0.78.

Component: Digital/AI readiness

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Sub-component Breakdown:

- **Core Digital Competencies (40%):** Mastery of hardware operations, advanced web navigation, and professional digital communication.
- **Algorithmic Literacy (30%):** Ability to recognize AI-mediated systems and critically evaluate potential algorithmic biases.
- **Adaptive Learning Agility (30%):** Capacity for self-directed online skill acquisition and critical appraisal of digital information sources.

B2. Local Institutional Performance Index (LIPI)
Table 5 : Composition and Weighting of the LIPI

Component	Measurement Indicators	Weight
Operational Efficiency	Turnaround times for civil registry documents; budget execution and absorption rates.	20%
Institutional Accountability	Accessibility of public financial records; activity of community-led budget oversight committees.	20%
Civic Engagement	Participation metrics in public consultations; effective inclusion of women and youth cohorts.	20%
Integrity Perception	Frequency of reported informal payments based on household survey data.	20%
Public Service Excellence	Composite user satisfaction index (focusing on healthcare, education, and infrastructure).	20%
Total		**100%**

Appendix C – Sampling & Validation Protocol

- **C1. Household Survey Tool:** A 45-variable structured questionnaire deployed via **KoboToolbox** (tablets). This instrument assesses educational attainment, civic involvement, and perceptions of governance transparency.
- **C2. Semi-structured Interview Framework:** Conducted with local leadership and executive staff to analyze structural and psychological hurdles to transparency, including the influence of clientelist networks.
- **C3. Workshop Observation Matrix:** A qualitative tool designed to evaluate the standard of public discourse, focusing on inclusivity, active listening, and the capacity for collective compromise.

Appendix D – Statistical Methodology

- **Approach:** Two-stage cluster sampling (Primary units: **Fokontany**; Secondary units: **Households**).
- **Sample Parameters:** Total size of **N=1,840** households, maintaining a margin of error of ±2.5% and a confidence level of 95%.
- **Geographic Focus:** The study covers diverse socio-economic landscapes: **Analamanga** (Urban), **Atsinanana** (Coastal/Port), **Atsimo-Andrefana** (Semi-arid), and **Vakinankaratra** (Agricultural).

Appendix E – Econometric Modeling

E1. Institutional Performance Framework

$$LIPI_{r,t} = \beta_0 + \beta_1 CIEHC_{r,t} + \beta_2 log\left(GDP_{pc}\right)_{r,t} + \beta_3 Infra_{r,t} + \epsilon_{r,t}$$

Key Finding: The empirical analysis confirms that the coefficient β_1 is positive and maintains statistical significance at the 1% threshold ($p < 0.01$).

E2. Mediation analysis
Sobel test results confirm that Citizen Participation acts as a partial mediator between ethical education and local administrative efficiency.

Appendix F – Ethical Protocol and Timeline

Phase 1: Preparatory & diagnostic (Jan–Jun 2023)

- Literature review and theoretical framework development (Jan–Feb)
- Expert consultation (45 interviews, Mar–Apr)
- Secondary data compilation and territorial diagnostic (Apr–Jun)
- Ethical approval obtained (May 2023, No. 2023-UA-045)

Phase 2: Pilot implementation (Jul 2023–Dec 2024)

- Baseline surveys (Jul–Sep 2023): 1,840 households
- IMRED-SPRI component rollout:
  Component 1 (Education): Sep 2023–ongoing
  Components 2-3 (Governance): Jan 2024–ongoing
  Components 4-5 (Entrepreneurship/Digital): Apr 2024–ongoing
- Midline qualitative interviews (78 actors, Mar–May 2024)
- Endline surveys (Sep–Nov 2024)
- Participatory workshops (16 total, Jul 2023–Dec 2024)

Phase 3: Analysis & dissemination (Jan–Jun 2025)

- Quantitative analysis and econometric modeling (Jan–Mar)
- Qualitative coding and thematic analysis (Feb–Apr)
- Community feedback and validation sessions (Apr–May)
- Final reporting and academic dissemination (May–Jun)

Unexpected disruptions:

- Cyclone Batsirai (Feb 2024): 3-week data collection delay in Atsinanana
- Political tensions (Aug 2024): 2-week suspension of workshops in Atsimo-Andrefana
- COVID-19 residual effects: ~15% interview transition to remote modality

APPENDIX G – Limitations and Perspectives

Limitations: Social desirability bias regarding corruption reporting; logistical disruptions due to climatic hazards (cyclones in the Atsinanana zone).

Perspectives: National scale-up of the IMRED-SPRI model; integration of "AI and Work Ethics" modules in higher education to mitigate digital exclusion risks.

Appendix H – Robustness Tests and Sensitivity Analysis

H1. Alternative Model Specifications

Baseline Model:

$$LIPI_{r,t} = \beta_0 + \beta_1 CIEHC_{r,t} + \beta_2(\text{Digital}_{\text{Readiness}})_{r,t} + \beta_3(\text{CIEHC} \times \text{Connectivity})_{r,t} + \epsilon_{r,t}$$

Results:

$\beta_1 = 0.42$ ($p < 0.01$), $R^2 = 0.67$

Alternative Specifications:

Table 6 : Sensitivity analysis across alternative model specifications

Specification	β1 (CIEHC)	R2	Notes
Baseline	0.42***	0.67	Main OLS specification with full controls
+ Regional FE	0.39***	0.71	Controlling unobserved regional heterogeneity
+ Time FE	0.41***	0.69	Controlling temporal shocks (2023-2024)
Bootstrapped SE	0.42***	0.67	1,000 iterations, cluster-robust standard errors
IV Estimation	0.44***	0.64	2SLS using historical school density as instrument

Note: *** p<0.01. FE stands for Fixed Effects. IV refers to Instrumental Variables estimation.

Hausman Test (Endogeneity): $\chi^2 = 1.42$, $p = 0.23$ (fails to reject exogeneity)

H2. Heterogeneous Treatment Effects
By wealth quintile:

- Q1 (Poorest 20%): $\beta_1 = 0.31$ ($p < 0.05$)
- Q2-Q4 (Middle 60%): $\beta_1 = 0.48$ ($p < 0.01$)
- Q5 (Richest 20%): $\beta_1 = 0.35$ ($p < 0.01$)

Interpretation: Middle-income households show strongest governance effects, suggesting threshold resource requirements for full ethical capital activation.

By digital access:
- High connectivity (>50% internet): $\beta_2 = 0.31$ ($p < 0.01$)
- Low connectivity (<20% internet): $\beta_2 = 0.16$ ($p < 0.05$)

Interaction term: β_3(CIEHC × Connectivity) = 0.09 ($p < 0.10$), confirming digital infrastructure moderates but does not determine ethical capital's governance effects.

H3. Placebo tests
Pre-Treatment Trends: Parallel trends assumption validated—intervention and control regions showed no significant LIPI divergence in 2020-2022 period ($\beta = 0.03$, $p = 0.74$).

Falsification Test: Randomly reassigning treatment status (500 permutations) yields mean $\beta_1 = 0.04$ with 95% CI [-0.08, 0.15], confirming observed effects are not artifacts of regional selection.

H4. Correlation matrix (key variables)
Table 7 : Correlation matrix and multicollinearity diagnostic (vif)

Variable	(1)	(2)	(3)	(4)	(5)
(1) CIEHC	1.00				
(2) LIPI	0.64***	1.00			
(3) Digital Readiness	0.51***	0.42***	1.00		
(4) GDP per capita	0.38***	0.29**	0.56***	1.00	
(5) Infrastructure	0.33**	0.31**	0.67***	0.72***	1.00

Note: Significance levels: *** p<0.01, ** p<0.05, * p<0.10.

VIF Analysis: All variables show VIF < 3.2, indicating no multicollinearity concerns.