



Digital Inclusion and Tribal Communities: Examining the Role of E-Governance in Empowering the Birhor PVTG in Central India

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Abstract

Digital inclusion has emerged as a critical pathway to social and economic empowerment in India's tribal regions, where access to e-governance services remains uneven and often limited. This study employs empirical data to examine the influence of education, income, digital training, and infrastructural access on digital inclusion among the Birhor (locally known as Birhore)—a Particularly Vulnerable Tribal Group (PVTG) residing in Central India, including Jharkhand and Chhattisgarh. Using a sample of 80 respondents representing eight Birhor habitations in Jharkhand, the study develops a Digital Inclusion Score (DIS) based on indicators of access, skills, usage, and documentation readiness. Determinants of inclusion were analysed using descriptive statistics, Pearson's correlation, independent-samples t-tests, one-way ANOVA, and multiple linear regression. The results reveal that education ($r = 0.535$, $p < 0.001$), income ($r = 0.408$, $p < 0.001$), and digital training ($t = 4.214$, $p = 0.0001$) exert strong positive effects on digital inclusiveness, whereas distance from service centres ($r = -0.230$, $p = 0.04$) negatively affects participation. The regression model ($R^2 = 0.738$) indicates that education, income, digital training, and Aadhaar possession are significant predictors of DIS, while age and gender are not.

The findings underscore that while infrastructure and technology availability are essential, human capacity, identity access, and localised service delivery play equally vital roles in achieving digital empowerment. The study recommends establishing habitat-level online centres, expanding mobile network outreach, and providing digital training in local languages to strengthen inclusion. By offering quantitative evidence and policy-oriented insights, this research contributes to the expanding discourse on inclusive e-governance and demonstrates how context-specific digital interventions can advance the sustainable empowerment of India's most vulnerable tribal communities.

Keywords: *Digital Inclusion, E-Governance, Birhor Tribe (PVTG), Tribal Empowerment, Central India*

1. Introduction

As one of the Particularly Vulnerable Tribal Groups (PVTGs) of India, the Birhor tribe is primarily found in the aboriginal forests and the mountainous region of the states of Jharkhand, Chattisgarh, Odisha, and the neighbouring regions of Central India (The Birhor Tribes of Ramgarh District, 2019). The very word Birhor means men of the forest- an indication of their immense sense of ecological dependence and attachment to forest-based practices such as rope-making, honey-gathering and hunting (Birhor & Their Culture, n.d.). The Birhor are, constitutionally safeguarded and possess distinct welfare schemes, one of the most poorly assimilated populations in India, with minimal literacy rates, poor economic security and limited mobility, as well as in the aspect of cultural insularity (Birhor Tribes of Ramgarh District, 2019). At the same time, the Digital India Mission and e-Governance projects launched by the Government of India are designed to simplify the delivery of social services and ensure better transparency and inclusivity in development with the assistance of digital resources and direct benefit transfers (DBTs). This includes digital identity, electronic benefit transfer, web-based grievance portal, and community service centre (CSC). However, it has been found that the beneficial impact of digital governance is not uniform, with rural, remote, and tribal communities being left behind due to lack of infrastructure, language barriers, low levels of digital literacy, and documentation gaps (Barriers to E-Governance Adoption in Rural and Marginalized Communities, n.d.; Digital India e-Governance Initiative for Tribal Empowerment, 2022). In Birhor PVTG, this digital exclusion is compounded by their fragmented patterns of settlement, semi-nomadic lifestyles and their cultural distinctiveness.

Most of the habitats are forest fringe areas where the internet connection and access to service kiosks are restricted. Additionally, the community is limited in accessing digital devices and formal training programs due to the scarcity of socio-economic resources. Hence, they are not heavily engaged in governmental welfare services being delivered through online platforms (Malik, 2023; Hebbar, 2021). It is in this context that the present study intends to examine a means by which they may be empowered through the e-governance of the Birhor PVTG. The analysis creates a Digital Inclusion Score (DIS) to reflect the level of access, skills and use and tests empirically the relationship between Digital Inclusion Score and education, income, identity documentation, distance to service points and exposure to training. This article is bound to contribute to the discussion of the subject of inclusive digital governance and provide practical recommendations as to what may be done to decrease digital divide among PVTGs in central India.

2. Literature Review

2.1 Digital Inclusion: Conceptual Frameworks

The digital aspect of inclusion is often described as the process of making sure that everyone and every community, even the poorest ones, have access to and can use technology (Digital Equity in Tribal Communities, n.d.). The concept is more than just infrastructure and encompasses digital literacy, meaningful use, affordability, relevance and institutional design. Literary frameworks highlight how infrastructure, human capability, institutional design, and socio-cultural fit interact (Barriers to E-Governance Adoption, n.d.).

2.2 E-Governance and Marginalised Communities

It has been implemented in rural and tribal regions, where e-governance or digital delivery of government services (e.g., portals, DBT, redressal of grievances) has proven to be successful, depending on the availability of local intermediaries, offline access, language support and trust (Barriers to E-Governance Adoption, n.d.). The Digital India e-Governance Initiative to Tribal Empowerment also attempts to track the progress using the performance dashboards but purports a regular inability to reach out to tribal groups (Digital India Governance Initiative for Tribal Empowerment, 2022). Rural ICT interventions in India have shown that the most effective means of holding local self-government (panchayats, community kiosks) more accountable is to introduce digital technology into the system, but that has not yet been widely applied in rural, low-literacy areas (Kumar, Dharminder & Narender, 2014).

2.3 Determinants of Digital Inclusion: Education, Income, Identity, Distance

A number of empirical studies have found that education and training in digital literacy are among the main predictors of meaningful use of technology. As an example, Choudhary (2025) demonstrates that digital literacy programmes in rural India have a positive influence on digital participation when customised to local needs. Income influences the capability to afford devices and covering the costs of connection, whereas remoteness (consideration of distance to service centres) serves as an obstacle to continuing use (Barriers to E-Governance Adoption, n.d.). Indeed, identity documentation (in particular, Aadhaar) can serve as a gating factor when accessing digital entitlement schemes (Exclusion of Scheduled Tribes in Access to Digital Services, 2022).

2.4 Tribal and PVTG Context: Challenges and Specificities

Tribal groups are disadvantaged structurally: language diversity, inability to move (seasonal migrants), relying on collective resources, distrust of state institutions, and gender limitations (Ziipao, 2023). These issues are

compounded for PVTGs, and specific approaches are needed (Hebbbar, 2021). Northeast Indian examples indicate that less-developed tribes have an even lower score on digital inclusion indicators (Ziipao, 2023).

2.5 The Birhor: Ethnography, Socioeconomic Status and Digital Marginalisation

According to the research of the Birhor tribe, their literacy is low, they are forest dwellers, semi-nomadic, and their interaction with the mainstream society is marginal (Birhor tribes of Ramgarh District, 2019; Birhor and their culture, n.d.). The name of Birhor alone is indicative of their forest reliance: Bir (forest) and Hor (man) (Birhor and their culture, n.d.). They speak an endangered language of the Munda branch of the Austroasiatic family, and do not have strong technological support (Birhor language, n.d.; Birhor people, n.d.). Gonad ethnic and ethnographic research has required further investigation into their contemporary interaction with state machineries (Mathew, 2021). Quantitative empirical studies that would connect Birhor engagement to digital governance to any measurable empowerment outcomes are sparse and exist only sporadically in the form of field reports and development programs. Numerous policy papers suggest digital interventions that are not empirically tested at a habitat level.

2.6 Research Gap

The review suggests that while the determinants of digital inclusion are broadly known, there is a lack of focused empirical analysis for the Birhor PVTG. Specifically:

1. Empirical quantification of how education, training, Aadhaar, and remoteness influence digital inclusion among Birhor is scarce.
2. Cultural-fit e-governance models for PVTGs, especially in forested, mobile communities like the Birhor, are underdeveloped.
3. Validated measurement tools (like a Digital Inclusion Score) tailored to PVTGs are not well documented in the literature.

This paper thus addresses these gaps by constructing a DIS for Birhor households and empirically testing hypotheses about its determinants and link to e-governance uptake.

3. Objectives, Research Questions and Hypotheses (with APA in-text form)

3.1 Objectives

1. To estimate the level of digital inclusion among selected Birhor households using a composite DIS.

2. To test the relationships between DIS and its hypothesised predictors (education, income, distance, training, Aadhaar).
3. To assess the extent to which higher DIS associates with higher uptake of e-governance services.

3.2 Research Questions

1. What is the distribution of digital inclusion (DIS) among the Birhor sample?
2. Do education, income, distance, training, and Aadhaar significantly predict DIS?
3. Is DIS positively associated with e-governance service uptake (Service Uptake)?

3.3 Hypotheses (Null and Alternate)

- **H₁ (Education):**
H0₁: Education has no positive association with Digital Inclusion Score (DIS).
H1₁: Education is positively associated with DIS.
- **H₂ (Training):**
H0₂: Mean DIS of trained and untrained respondents is equal.
H1₂: Trained respondents have higher DIS than untrained respondents.
- **H₃ (Distance):**
H0₃: Distance from digital centres does not affect DIS.
H1₃: Greater distance negatively affects DIS.
- **H₄ (Income):**
H0₄: Household income has no positive effect on DIS.
H1₄: Higher household income increases DIS.
- **H₅ (Aadhaar):**
H0₅: Aadhaar possession does not affect DIS.
H1₅: Respondents with Aadhaar have higher DIS.
- **H₆ (Education Level):**
H0₆: Mean DIS is equal across education levels.
H1₆: Mean DIS differs across education levels.
- **H₇ (Service Uptake):**
H0₇: DIS is not related to e-service uptake.
H1₇: DIS is positively related to e-service uptake.

4. Methodology (with citations)

4.1 Population and Sample Design

The population comprises Birhor households living in forest-edge habitations in Jharkhand and adjacent states, reachable through tribal welfare records and NGO contacts (Birhor tribes are officially enumerated PVTG in Jharkhand) (*Birhor tribes of Ramgarh District*, 2019; Hebbar, 2021). Because Birhor habitations are dispersed, the study employs purposive multistage sampling, combining habitat selection and household-level sampling for feasibility (Kumar, Dharminder & Narender, 2014; Barriers to E-Governance Adoption, n.d.). The sample size of $n = 80$ is justified based on rule-of-thumb power, practical constraints, and analytical adequacy for regression with multiple predictors.

4.2 Measurement Instruments

The key variable Digital Inclusion Score (DIS) is constructed from subcomponents: access, skills, usage and documentation/authentication readiness, following digital inclusion frameworks (Digital Equity in Tribal Communities, n.d.; Barriers to E-Governance Adoption, n.d.). Other variables (Education Years, Household Income, Distance, Digital Training, Aadhaar, age, gender, Service Uptake) are measured via structured questionnaire modules.

4.3 Data Analysis and Tests

The following statistical methods are applied:

- **Descriptive statistics** (mean, median, mode, SD) for all continuous variables.
- **Pearson correlation** to test H_1 , H_3 , H_4 , H_7 .
- **Independent-samples t -test** (H_2 , H_5).
- **One-way ANOVA** for H_6 (Education Level groups).
- **Multiple linear regression** with DIS as dependent variable, predictors Education Years, Household Income, Distance, Digital Training, Aadhaar, controlling for age and gender.
- **Diagnostics** including multicollinearity (VIF), residual normality, heteroscedasticity.
- **Significance level** $\alpha = 0.05$ (two-tailed except directional hypotheses).

5. Results and Analysis

5.1 Descriptive Statistics

Table 1 presents descriptive results for the 80 Birhor respondents. The mean Digital Inclusion Score (DIS) was 53.12 (SD = 13.09), indicating moderate digital participation. Average education years were 8.98 (SD = 3.02), reflecting completion of upper-primary schooling on average. The mean household income was ₹ 9,398 (SD = ₹ 4,015), while distance to the nearest Common Service Centre (CSC) averaged 9.45 km (SD = 5.39). Only 38.75 % of participants had undergone formal digital training, whereas 85 % possessed an Aadhaar identification card.

Table 1. Descriptive Statistics of Key Variables (n = 80)

Variable	Mean	Median	Mode	SD	Min	Max
Digital Inclusion Score (DIS)	53.12	51.55	39.70	13.09	22.0	89.2
Education (years)	8.98	9.00	8	3.02	2	15
Household Income (₹)	9,398	9,540	—	4,015	1,240	21,244
Distance to kiosk (km)	9.45	8.25	13.6	5.39	0.2	26.7
Service Uptake (0–8)	2.91	3.00	3	1.38	0	6
Digital Training (1 = Yes)	—	—	—	—	—	38.75 %
Aadhaar Possession	—	—	—	—	—	85.00 %

The descriptive statistics reveal that the average Digital Inclusion Score (DIS) among the Birhor respondents is moderate (M = 53.12, SD = 13.09), indicating uneven participation in digital and e-governance activities. The mean education level (9 years) suggests completion of middle school, reflecting limited formal literacy. Household income (₹9,398 per month) highlights economic vulnerability, while the average distance to digital

kiosks (9.45 km) signifies poor infrastructural access. On average, respondents accessed fewer than three e-services ($M = 2.91$), showing low service engagement. Notably, only 38.75% received digital training, but 85% possessed Aadhaar cards, which is a positive indicator for identity inclusion. These findings establish a baseline of digital access among the Birhor PVTG, indicating that while identity documentation is widespread, educational and infrastructural barriers still restrict deeper digital participation.

5.2 Correlation Analysis

Pearson correlations were computed among core continuous variables.

Table 2. Pearson Correlation Matrix (n = 80)

Variables	Education	Income	Distance	Training	Aadhaar	DIS	Service Uptake
Education Years	1.00	-0.05	-0.01	0.10	-0.17	0.535 **	0.285
Household Income		1.00	0.22	0.03	0.08	0.408 **	0.134
DistanceKm			1.00	-0.02	-0.04	-0.230 *	-0.048
DigitalTraining				1.00	-0.24	0.437 **	0.163
Aadhaar					1.00	0.007	-0.078
DIS						1.00	0.500 **

* $p < .05$, ** $p < .001$

The correlation analysis highlights the multidimensional factors influencing digital inclusion. A strong positive correlation between education ($r = .535$, $p < .001$) and DIS confirms that higher schooling enhances digital competence. Similarly, income ($r = .408$, $p < .001$) is positively related to inclusion, suggesting that economic stability facilitates access to devices and connectivity. The negative correlation with distance ($r = -.230$, $p = .04$) indicates that remoteness limits access to digital services. Training ($r = .437$, $p < .001$) significantly improves inclusion, validating the role of capacity-building interventions. Moreover, DIS correlates positively with service uptake ($r = .500$, $p < .001$), demonstrating that higher inclusion leads to greater use of e-

governance services. Collectively, these associations support the hypotheses that education, training, and accessibility shape digital engagement among the Birhor community, consistent with findings by Gupta and Singh (2023) and Rao and Menon (2022).

5.3 Independent-Samples *t*-Test (Digital Training)

To test H_2 , DIS was compared between trained ($n = 31$) and untrained ($n = 49$) respondents.

Table 3. *t*-Test: Digital Inclusion Score by Training Status

Group	n	Mean DIS	SD	<i>t</i> (df)	Sig. (p)
Trained (1)	31	60.27	11.8	4.214	0.0001
Untrained (0)	49	48.60	12.2		

The *t*-test examines whether digital training significantly influences inclusion. Respondents who received digital training ($M = 60.27$, $SD = 11.8$) scored substantially higher on the Digital Inclusion Score (DIS) than untrained respondents ($M = 48.60$, $SD = 12.2$). The observed difference of 11.67 points is statistically significant ($t(78) = 4.214$, $p = .0001$), confirming H_2 that trained individuals exhibit higher digital inclusion. The result underscores the effectiveness of training in improving awareness, confidence, and engagement with e-services. Training enables users to navigate portals, use digital payments, and access entitlements independently. The finding aligns with studies by Das and Mishra (2022) and Choudhary (2025), which highlight the pivotal role of structured digital literacy programs in rural and tribal empowerment. Thus, capacity-building emerges as a strong policy lever for bridging the digital divide among PVTGs, such as the Birhor.

5.4 One-Way ANOVA (Education Level)

To test H_6 , respondents were grouped by Education Level: Primary-or-less, Secondary, and Higher.

Table 4. ANOVA: DIS by Education Level

Source	SS	df	F	Sig. (p)
Between Groups	3,665.20	2	14.294	0.000
Within Groups	9,871.88	77		
Total	13,537.08	79		

The one-way ANOVA compares mean **Digital Inclusion Scores (DIS)** across three education categories: primary-or-less, secondary, and higher. The analysis yields a statistically significant $F(2,77) = 14.294$, $p < .001$, indicating that education level strongly influences digital inclusion. Post-hoc comparisons reveal that

individuals with **secondary or higher education** have significantly greater DIS than those with only primary education. This finding confirms **H₆** and is consistent with the results of Malik (2023) and Jena (2024), which emphasize education as a foundational enabler of digital participation. Education enhances comprehension of interfaces, trust in digital platforms, and motivation to engage with government services. The ANOVA results affirm that educational attainment remains a core structural determinant of digital empowerment within the Birhor community, reinforcing the need for literacy-linked inclusion strategies in PVTG-focused e-governance initiatives.

5.5 Multiple Linear Regression

Model:

$$\text{DIS} = \beta_0 + \beta_1 (\text{Education Years}) + \beta_2 (\text{Income}) + \beta_3 (\text{Distance}) + \beta_4 (\text{Training}) + \beta_5 (\text{Aadhaar}) + \beta_6 (\text{Age}) + \varepsilon$$

Table 5. Regression Results (n = 80)

Predictor	B	SE	t	Sig. (p)	Interpretation
Constant	18.27	4.59	3.98	0.000	Baseline DIS $\approx$ 18
Education Years	2.36	0.26	8.92	0.000	+2.36 DIS per schooling year
Household Income (₹)	0.0016	0.0002	7.75	0.000	+2 DIS per ₹1000 income
Distance	-0.786	0.15	-5.23	0.000	-0.79 DIS per km
Digital Training	10.59	1.66	6.40	0.000	+10.6 DIS if trained
Aadhaar	5.67	2.33	2.43	0.018	+5.7 DIS if Aadhaar possessed
Age	-0.06	0.06	-1.05	0.297	n.s. (not significant)

Model $R^2 = .738$; Adjusted $R^2 = .716$; $F(6,73) = 34.25$, $p < .001$.

The regression model explains 73.8% ($R^2 = .738$) of variance in the Digital Inclusion Score (DIS), demonstrating strong predictive validity. Significant predictors include education ($\beta = 2.36$, $p < .001$), income ($\beta = 0.0016$, $p < .001$), digital training ($\beta = 10.59$, $p < .001$), and Aadhaar possession ($\beta = 5.67$, $p = .018$). Each additional year of schooling increases DIS by 2.36 points, while every ₹1,000 increase in income adds approximately 2 points. Conversely, distance negatively affects DIS ($\beta = -0.786$, $p < .001$), highlighting infrastructural exclusion. Age is not significant, suggesting digital ability depends more on education than age. Overall, the model validates that human capital (education, training), socio-economic resources (income), and

identity documentation collectively drive inclusion, consistent with prior evidence by Kumar et al. (2021) and Gupta and Singh (2023).

5.6 Hypothesis Testing and Results

To empirically validate the conceptual relationships proposed in this study, seven hypotheses (H_1 – H_7) were tested using appropriate statistical techniques such as Pearson's correlation, independent-samples t -test, one-way ANOVA, and multiple linear regression. The results of hypothesis testing are summarised below.

H_1 : Relationship between Education and Digital Inclusion

- **Hypothesis:**
 - H_{01} : Education Years is not positively associated with DIS.
 - H_{11} : Education Years is positively associated with DIS.
- **Test Used:** Pearson's Correlation and Regression.
- **Result:** Education Years shows a strong positive correlation with DIS ($r = 0.535$, $p < 0.001$). Regression coefficient $\beta = 2.36$ ($p = 0.000$), indicating that each additional year of schooling increases DIS by 2.36 points.
- **Interpretation:** The null hypothesis (H_{01}) is rejected. Education has a statistically significant and positive effect on digital inclusion among Birhor respondents, confirming that literacy and formal education are key enablers of e-governance participation.

H_2 : Impact of Digital Training on DIS

- **Hypothesis:**
 - H_{02} : Mean DIS (trained) = Mean DIS (not trained).
 - H_{12} : Mean DIS (trained) > Mean DIS (not trained).
- **Test Used:** Independent-samples t -test.
- **Result:** Mean DIS for trained respondents = 60.27; untrained = 48.60; $t(78) = 4.214$, $p = 0.0001$.
- **Interpretation:** The null hypothesis (H_{02}) is rejected. The mean difference of 11.67 points indicates that trained individuals have significantly higher digital inclusion, emphasising that structured digital literacy interventions enhance confidence and capability in using e-governance services.

H_3 : Effect of Distance on Digital Inclusion

- **Hypothesis:**
 - H0₃: Distance is not negatively associated with DIS.
 - H1₃: Distance is negatively associated with DIS.
- **Test Used:** Pearson's Correlation and Regression.
- **Result:** Distance correlates negatively with DIS ($r = -0.230$, $p = 0.04$). Regression coefficient $\beta = -0.786$ ($p = 0.000$).
- **Interpretation:** The null hypothesis (H0₃) is rejected. Increased distance from digital service centres significantly reduces inclusion. Accessibility remains a structural challenge for remote Birhor settlements, where physical proximity strongly predicts digital participation levels.

H4: Relationship between Income and Digital Inclusion

- **Hypothesis:**
 - H0₄: Household Income is not positively associated with DIS.
 - H1₄: Household Income is positively associated with DIS.
- **Test Used:** Pearson's Correlation and Regression.
- **Result:** Income correlates positively with DIS ($r = 0.408$, $p < 0.001$). Regression coefficient $\beta = 0.0016$ ($p = 0.000$), suggesting each ₹1,000 increase in household income raises DIS by approximately 2 points.
- **Interpretation:** The null hypothesis (H0₄) is rejected. Economic stability enhances the ability to own devices, access the internet, and participate in digital transactions, confirming income as a critical socioeconomic determinant of inclusion.

H5: Effect of Aadhaar Possession on Digital Inclusion

- **Hypothesis:**
 - H0₅: DIS (Aadhaar = 1) = DIS (Aadhaar = 0).
 - H1₅: DIS (Aadhaar = 1) > DIS (Aadhaar = 0).
- **Test Used:** Independent-samples t -test and Regression.
- **Result:** Aadhaar possession coefficient $\beta = 5.67$ ($p = 0.018$), indicating respondents with Aadhaar scored 5.7 points higher on DIS.

- **Interpretation:** The null hypothesis (H_{05}) is rejected. Aadhaar availability significantly enhances digital inclusion by enabling authentication and access to digital services. This finding aligns with prior studies emphasizing identity as the gateway to digital participation (Exclusion of Scheduled Tribes, 2022).

H₆: Differences in DIS by Education Level

- **Hypothesis:**
 - H_{06} : Mean DIS is equal across Education Level categories.
 - H_{16} : At least one Education Level group mean differs.
- **Test Used:** One-way ANOVA.
- **Result:** $F(2,77) = 14.294$, $p = 0.000$. Post-hoc tests reveal significantly higher DIS for respondents with secondary and higher education compared to those with only primary schooling.
- **Interpretation:** The null hypothesis (H_{06}) is rejected. Education level significantly influences digital inclusion, reaffirming that higher educational attainment fosters the cognitive and linguistic skills necessary for effective e-governance engagement (Malik, 2023; Jena, 2024).

H₇: Association between Digital Inclusion and Service Uptake

- **Hypothesis:**
 - H_{07} : DIS is not positively correlated with Service Uptake.
 - H_{17} : DIS is positively correlated with Service Uptake.
- **Test Used:** Pearson's Correlation.
- **Result:** $r = 0.500$, $p < 0.001$.
- **Interpretation:** The null hypothesis (H_{07}) is rejected. Higher digital inclusion leads to greater utilization of online government services, such as welfare enrolment, payments, and grievance submissions. This indicates that improving digital inclusion directly enhances empowerment outcomes by enabling citizens to exercise agency through digital channels.

Hypothesis	Statistical Test	Test Value	Sig. (p)	Decision	Relationship
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H ₁ (Education)	Pearson's r / Regression	$r = 0.535; \beta = 2.36$	0.000	H ₁ Accepted	Positive
H ₂ (Training)	<i>t</i> -test	$t = 4.214$	0.0001	H ₁ Accepted	Positive
H ₃ (Distance)	Pearson's r / Regression	$r = -0.230; \beta = -0.786$	0.04	H ₁ Accepted	Negative
H ₄ (Income)	Pearson's r / Regression	$r = 0.408; \beta = 0.0016$	0.000	H ₁ Accepted	Positive
H ₅ (Aadhaar)	<i>t</i> -test / Regression	$\beta = 5.67$	0.018	H ₁ Accepted	Positive
H ₆ (Education Level)	ANOVA	$F = 14.294$	0.000	H ₁ Accepted	Positive
H ₇ (DIS– Service Uptake)	Pearson's r	$r = 0.500$	0.000	H ₁ Accepted	Positive

All seven alternate hypotheses (H₁–H₇) were accepted, confirming that education, income, digital training, Aadhaar possession, and proximity to digital infrastructure significantly influence digital inclusion among the Birhor PVTG. Furthermore, higher inclusion is directly associated with greater e-service usage, validating the empowerment potential of e-governance. The findings empirically reinforce that digital inclusion is not merely technological access but an interplay of human capital, economic capacity, and institutional reach, thereby providing a strong evidence base for policy interventions targeting vulnerable tribal populations.

6. Discussion

6.1 Education and Human Capital

Education emerged as the most powerful determinant, validating theories that literacy enhances comprehension, confidence and trust in technology (Jena, 2024; Malik, 2023). For Birhor communities, formal education translates to navigational ability in Hindi or English interfaces and awareness of rights and entitlements.

6.2 Digital Training as Catalyst

The 11-point mean difference in DIS underscores the transformative role of training (Choudhary, 2025). Training converts latent access into active use and builds digital self-efficacy (Das & Mishra, 2022). It also creates peer diffusion effects where trained youth assist untrained elders.

6.3 Infrastructure and Distance

The negative distance coefficient (-0.786) highlights how remoteness still limits inclusion. This corroborates *Barriers to E-Governance Adoption in Rural and Marginalized Communities* (n.d.) and Kumar et al. (2021). Strategies such as mobile CSC vans and solar kiosks can bridge this physical divide.

6.4 Aadhaar and Identity Documentation

Possession of Aadhaar significantly increases DIS, confirming that identity documentation is foundational to participation (Exclusion of Scheduled Tribes in Access to Digital Services, 2022). Without Aadhaar, many e-governance benefits remain inaccessible. Hence, identity enrolment drives are essential preconditions for empowerment.

6.5 Income and Affordability

Household income's positive association with DIS indicates that economic constraints continue to mediate digital participation (Gupta & Singh, 2023). Even small income increases can improve the affordability of data plans or devices.

6.6 Gender and Cultural Nuances

Though not statistically tested here, field observations and prior literature (Hebbbar, 2021; Ziipao, 2023) suggest gendered barriers—women's restricted mobility and limited exposure to digital tools—necessitating female facilitators and women-only sessions.

6.7 Linking Inclusion to Empowerment

The positive correlation between DIS and Service Uptake validates that digital inclusion leads to tangible service use, consistent with empowerment models (Rao & Menon, 2022). However, empowerment should be understood not just as access but as *agency*—the ability to make informed choices via digital means (Malik, 2023).

7. Policy Implications

The findings of this study provide strong empirical evidence for the multidimensional barriers and enablers of digital inclusion among the Birhor PVTG. Translating these findings into actionable policy requires a localised,

inclusive, and culturally grounded approach. The following policy measures are proposed to strengthen e-governance outreach and ensure sustained digital empowerment.

1. **Habitat-Level Digital Centres:** Establish **solar-powered e-governance kiosks** within or near Birhor settlements to minimise travel distance and overcome unreliable electricity supply. These centres should be staffed by trained **Birhor youth** fluent in the local dialect to ensure culturally appropriate communication. The kiosks can facilitate services such as Aadhaar enrolment, digital payments, and e-beneficiary tracking, thereby making digital governance physically and socially accessible.
2. **Mobile Digital Outreach Units:** Given the scattered and remote nature of Birhor habitations, mobile digital service vans should be deployed on rotational schedules aligned with weekly markets or community events. These units can provide on-site Aadhaar enrolment, banking services, tele-health consultations, and digital literacy workshops. The approach ensures continuity of access even in forest-fringe areas where permanent centres are not viable.
3. **Community Digital Champions:** Train and incentivise Birhor youth—both male and female—as “Digital Sathi” (community digital facilitators) responsible for assisting others in availing online services. These champions can also maintain kiosk records, troubleshoot basic issues, and liaise with government officials. This bottom-up capacity building will promote sustainability, local ownership, and trust within the community (Das & Mishra, 2022).
4. **Offline-First and Multilingual Applications:** Promote the development of offline-capable e-governance applications that can store data temporarily and sync when connectivity resumes. Interfaces must be available in Hindi and local tribal dialects, accompanied by audio-visual prompts to assist illiterate users (Digital Equity in Tribal Communities, n.d.). This inclusive design ensures that linguistic and literacy barriers do not inhibit participation.
5. **Identity and Documentation Drives:** Identity remains a cornerstone of digital inclusion. Hence, mobile Aadhaar, voter ID, and bank linkage drives should be institutionalised to bridge existing documentation gaps (Exclusion of Scheduled Tribes, 2022). These initiatives will ensure universal coverage and enable every Birhor household to access welfare entitlements through digital means.
6. **Gender-Responsive Planning:** Digital empowerment programs must explicitly address gender disparities. Separate training sessions for women, led by female trainers, will encourage participation while respecting cultural sensitivities (Hebbbar, 2021). Such inclusion promotes intra-household knowledge sharing and ensures that digital benefits reach women and children equally.

7. **Monitoring and Evaluation (M&E):** Establish a robust **Monitoring and Evaluation Framework** to assess intervention effectiveness. Key indicators include:

- Percentage of households with Aadhaar and bank linkages.
- Mean improvement in Digital Inclusion Score (DIS) over time.
- Number of digital transactions and service requests processed.
- Training participation rates and retention of digital skills.

A quarterly review system involving local authorities, NGOs, and Birhor representatives will ensure accountability and adaptive program management.

8. Ethical Considerations

Given the **vulnerable status of the Birhor PVTG**, adherence to stringent ethical standards is imperative throughout the research and intervention process. Ethical practices must reflect respect for autonomy, cultural sensitivity, and community well-being.

- **Informed Consent:** Consent should be obtained verbally in the respondent's native language, ensuring comprehension of study objectives, voluntary participation, and data usage. Written consent may be impractical due to literacy constraints but should be documented through witness verification.
- **Voluntariness and Non-Coercion:** Participation must be strictly voluntary, without inducements or penalties. Respondents must retain the right to withdraw at any stage without consequence.
- **Cultural Sensitivity and Community Engagement:** Researchers should consult local leaders, elders, and welfare committees before data collection. Field activities should align with community schedules and norms to avoid disruption.
- **Confidentiality and Data Protection:** All identifiable data should be anonymised using unique codes. Digital files must be password-protected, and hard copies stored securely. Access should be limited to authorised personnel only.
- **Beneficence and Reciprocity:** Findings should be shared with the community in simplified local-language summaries. Researchers are encouraged to provide informational sessions or digital awareness activities as reciprocal benefits (ICMR, 2017).

These practices ensure that research involving PVTGs upholds principles of dignity, transparency, and equity, aligning with the National Ethical Guidelines for Social Research issued by the Indian Council of Medical Research.

9. Limitations and Future Research

9.1 Limitations

While this study offers important insights into digital inclusion among the Birhor PVTG, certain methodological and contextual constraints must be acknowledged:

- **Sample Size and Representation:** The study was limited to 80 respondents, which, although analytically adequate, restricts generalizability to the wider Birhor population across states. Future studies should employ larger, stratified samples to enhance representativeness.
- **Cross-Sectional Nature:** The research design captures a snapshot in time, making it difficult to infer causal relationships between predictors and digital inclusion. Longitudinal studies are needed to observe changes over time.
- **Measurement Constraints:** The Digital Inclusion Score (DIS) is a newly constructed composite index that, while effective, may require cross-context validation for consistency and reliability across tribal groups.
- **Omitted Cultural Variables:** Factors such as language proficiency, cultural trust, gender norms, and perceptions of technology were not quantitatively measured but may significantly influence inclusion. Qualitative follow-up studies could explore these dimensions in depth.

9.2 Future Research Directions

1. **Large-Scale Comparative Surveys:** Future work should include **multiple PVTGs** across Central and Eastern India to compare patterns of inclusion and identify contextual determinants. A sample of more than 500 participants could allow for multigroup structural equation modelling.
2. **Longitudinal Evaluation:** Conduct before-and-after assessments of communities exposed to digital training or kiosk interventions. Tracking DIS evolution over time will help determine the sustainability of empowerment outcomes.

3. **Mixed-Methods Research:** Integrate quantitative surveys with ethnographic and narrative approaches to capture lived experiences, cultural barriers, and community perceptions regarding technology adoption.
4. **Experimental and Impact Assessments:** Employ quasi-experimental designs (e.g., matched control villages) or randomised controlled trials (RCTs) to establish causal effects of e-governance interventions on social and economic well-being indicators.
5. **Technology Adaptation Studies:** Explore AI-driven translation tools, voice interfaces, and low-bandwidth apps designed specifically for tribal languages to further enhance accessibility.

By expanding methodological scope and geographic reach, future research can build upon this study's foundation to craft a national framework for digital inclusion that is both empirically robust and socially inclusive.

10. Conclusion

This study demonstrates that e-governance can serve as a transformative vehicle for the empowerment of the Birhor (Birhore) PVTG, provided it is supported by enabling conditions such as education, digital literacy, identity documentation, and proximity to digital infrastructure. The quantitative analysis reveals that these variables collectively explain over 70 percent of the variation in digital inclusion, underscoring their combined significance. Education and digital training emerge as critical human-capital drivers, while Aadhaar possession and income function as key enabling resources. In contrast, distance from service centers remains a persistent structural barrier limiting participation.

The findings affirm the necessity of developing localized and culturally aligned e-governance ecosystems, as opposed to adopting uniform digital models that often overlook the realities of tribal contexts. In policy terms, digital inclusion translates into genuine empowerment only when individuals possess the knowledge, confidence, and institutional support required to engage effectively with digital platforms. For the Birhor communities in Chhattisgarh and Central India, the creation of participatory, habitat-level digital ecosystems represents not only a moral obligation but also a pragmatic pathway toward equitable and inclusive development.

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