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Interlinkages among Localized Sustainable Development Goals in Gram Panchayats of Odisha: A Statistical Model-Based Logistic Regression Analysis

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Abstract: ***The localization of Sustainable Development Goals (SDGs) through the Panchayat Advancement Index (PAI) provides a framework for assessing multidimensional rural development at the Gram Panchayat (GP) level in India (Ministry of Panchayati Raj (MoPR), 2023, 2024). This study examines the interrelationships among nine Localized Sustainable Development Goal (LSDG) themes using data from 6,794 Gram Panchayats (GPs) in Odisha for 2022–23 and 2023–24. Improvement in each LSDG theme was measured by comparing scores across the two years and classifying GPs into improved and non-improved categories. Binary logistic regression models were employed to assess how progress in one development dimension influences improvement in others. The results indicate substantial variation in developmental progress across themes. Socially Secured Panchayat (94.77%), Self-Sufficient Panchayat (89.23%), and Clean and Green Panchayat (84.12%) recorded the highest proportions of improved Gram Panchayats. All logistic regression models were statistically significant ($p < 0.001$), with Good Governance Panchayat exhibiting the highest likelihood ratio statistic ($LR \chi^2 = 1173.69$). The Self-Sufficient Panchayat model demonstrated the highest explanatory power (Pseudo $R^2 = 0.2253$), while the Socially Secured Panchayat model achieved the strongest predictive performance (AUC = 0.8330). The analysis further revealed strong interdependencies among LSDGs, particularly between social security and poverty reduction (OR = 9.911), and between good governance and self-sufficiency (OR = 6.371). The findings underscore the importance of integrated and convergent development strategies for achieving sustainable rural transformation and strengthening localized development planning in Odisha.***

Keywords: Localized Sustainable Development Goals, Gram Panchayat, Logistic Regression, Rural Development, Governance, Odisha.

1. Introduction

The SDGs provide a globally accepted framework for advancing social welfare, economic prosperity, environmental sustainability, and institutional effectiveness (United Nations, 2015). In India, increasing emphasis has been placed on localizing these goals so that national development priorities can be translated into measurable outcomes at the grassroots level. GPs, as constitutionally recognized institutions of local self-government, play a crucial role in planning, implementing, and monitoring rural development initiatives (Mathew, 2018; Singh, 2021).

Recognizing the importance of local-level monitoring, the MoPR introduced the PAI, which operationalizes LSDGs through nine thematic dimensions covering poverty reduction, health, child welfare, water security, environmental sustainability, livelihoods, social protection, governance, and women's empowerment (MoPR, 2022, 2024). These themes collectively provide a framework for assessing the developmental performance of Gram Panchayats.

Development processes are inherently interconnected. Progress in one sector frequently influences outcomes in other sectors. For example, improvements in governance can strengthen service delivery, while social protection measures may contribute to poverty reduction and improved human development outcomes (Sachs, 2015; World Bank, 2022). Similarly, gender-inclusive governance has been associated with better health, education, and welfare indicators (Chattopadhyay & Duflo, 2004).

Although numerous studies have examined individual dimensions of rural development, empirical evidence on the interactions among multiple LSDG themes remains limited. Understanding these interrelationships is essential for designing integrated and convergence-based development strategies. Against this backdrop, the present study examines the linkages among nine LSDG dimensions in Odisha using binary logistic regression models and evaluates the predictive performance of these relationships through multiple model assessment criteria.

2. Review of Literature

Theoretical and empirical literature increasingly recognizes that sustainable development outcomes are multidimensional and interconnected. The 2030 Agenda for Sustainable Development emphasizes that economic growth, social inclusion, environmental protection, and effective institutions should be pursued simultaneously rather than independently (United Nations, 2015).

The capability approach proposed by Sen (1999) argues that development should be understood as the expansion of human freedoms and opportunities. Building on this perspective, Sachs (2015) highlights the importance of integrated policy

interventions for achieving sustainable development objectives. These approaches suggest that improvements in one domain of development often generate positive spill over effects in other domains.

Studies on decentralized governance in India indicate that Panchayati Raj Institutions (PRIs) contribute significantly to improving public service delivery, community participation, and local accountability (Mathew, 2018; Reddy, 2019). Research has further demonstrated that effective local governance is associated with better management of public resources and improved development outcomes (Panda, 2020).

Gender-sensitive governance has also received considerable attention in the literature. Chattopadhyay and Duflo (2004) found that women's participation in local decision-making positively influences priorities related to education, health, and social welfare. Likewise, social protection programmes have been identified as important mechanisms for reducing poverty and enhancing livelihood security among vulnerable populations (World Bank, 2020, 2022).

Recent policy reports published by NITI Aayog and the MoPR emphasize the growing importance of SDG localization and decentralized development monitoring in India (NITI Aayog, 2023; MoPR, 2024). However, most existing studies focus on specific sectors or individual indicators. Comprehensive empirical investigations examining the interactions among multiple localized development dimensions remain relatively scarce. The present study seeks to address this gap by analysing the statistical relationships among all nine LSDG themes in Odisha.

3. Objectives of the Study

The study aims to:

1) Examine the interrelationships among 9 themes as Localized Sustainable Development Goals for Odisha Context.
2) Identify key Themes influencing each other of LSDGs
3) Finding out the predictive performance of logistic regression models

4. Data and Methodology

The study is based on GP-level data for Odisha covering all 6,794 GPs. The data were obtained from the PAI portal, maintained by the MoPR, Government of India, and are publicly available through the PAI platform. The analysis utilized data from PAI 1.0 (2022–23) and PAI 2.0 (2023–24), which assess the performance of GPs across nine LSDG themes: Poverty Free Gram Panchayat (T1), Healthy Gram Panchayat (T2), Child Friendly Panchayat (T3), Water Sufficient Panchayat (T4), Clean and Green Panchayat (T5), Self-Sufficient Panchayat (T6), Socially Secured Panchayat (T7), Good Governance Panchayat (T8), and Women Friendly Panchayat (T9).

To examine development progress over time, the scores of each LSDG indicator for the year 2022–23 were compared with those of 2023–24. The difference between the two years was calculated for each GP and each LSDG indicator. A positive difference indicated improvement in the respective LSDG dimension, whereas a zero or negative difference indicated no improvement or deterioration. Based on this criterion, a binary outcome variable was created for each LSDG, where a value of 1 represented improvement and a value of 0 represented no improvement.

Subsequently, Binary Logistic Regression was employed to investigate the interrelationships among the nine LSDG dimensions. Separate logistic regression models were estimated by treating each LSDG indicator as the dependent variable in turn, while the remaining LSDG indicators were included as explanatory variables. This approach enabled the assessment of how improvements in one development dimension influence the likelihood of improvement in other dimensions, thereby revealing the interconnected nature of localized sustainable development at the Gram Panchayat level. The analysis is carried out through Stata software and MS Excel.

4.1 Logistic Regression Model

Binary logistic regression models were estimated for each LSDG indicator. The general model is expressed as:

$$\ln\left(\frac{p}{1-p}\right) = \beta_0 + \beta_1 T_1 + \beta_2 T_2 + \beta_3 T_3 + \beta_4 T_4 + \beta_5 T_5 + \beta_6 T_6 + \beta_7 T_7 + \beta_8 T_8 + \beta_9 T_9$$

where:

- T_1 , T_2 ……T_9 are LSDGs as defined above.
- (p) = probability of improvement in the dependent LSDG indicator,
- $\frac{p}{1-p}$ = odds of improvement
- $\ln\left(\frac{p}{1-p}\right)$ =log odds (logit)
- β_0 = Intercept
- β_1 to β_9= regression coefficients.

4.2 Conceptual Clarification of Regression Coefficients in Logistic Regression

Regression coefficients constitute the core parameters of a logistic regression model and describe the relationship between explanatory variables and the probability of a binary outcome occurring (Hosmer, Lemeshow, & Sturdivant, 2013; Agresti, 2018). In this regression, the dependent variable is expressed in terms of the logarithm of the odds of an event, allowing researchers to examine how predictor variables influence the likelihood of a particular outcome. In the present study, the coefficients indicate how improvement in one LSDG dimension affects the probability of improvement in another LSDG dimension while holding all other factors constant.

Unlike ordinary least squares regression, where coefficients represent direct changes in the dependent variable, logistic regression coefficients reflect changes in the log-odds of the outcome associated with a one-unit change in the predictor variable (Gujarati & Porter, 2021). A positive coefficient suggests that the predictor increases the likelihood of the outcome, whereas a negative coefficient implies a decrease in the likelihood of occurrence. The absolute magnitude of the

coefficient indicates the relative strength of the association between the explanatory and response variables.

Because log-odds are often difficult to interpret substantively, coefficients are commonly transformed into odds ratios by exponentiation (Hosmer et al., 2013). An odds ratio greater than one indicates a positive association, implying that the odds of the outcome increase as the predictor variable increases. Conversely, an odds ratio less than one indicates a negative association, while an odds ratio equal to one suggests no meaningful relationship between the variables (Agresti, 2018).

In this study, odds ratios are used to evaluate the interconnections among the nine LSDG themes. For instance, a large positive odds ratio for Socially Secured Panchayat in the Poverty Free Gram Panchayat model indicates that improvements in social security substantially increase the likelihood of poverty reduction. Similarly, significant positive odds ratios associated with Good Governance Panchayat in the Self-Sufficient Panchayat model suggest that governance improvements contribute to enhancing local economic resilience and self-reliance. Therefore, regression coefficients provide an empirical basis for identifying the development dimensions that act as catalysts for broader progress across multiple LSDG themes. The direction, magnitude, and statistical significance of these coefficients collectively help explain the pathways through which governance, social protection, environmental sustainability, health, and gender empowerment contribute to sustainable rural development.

4.3 Model Evaluation

The adequacy and predictive performance of the logistic regression models were evaluated using several complementary statistical measures, including the Likelihood Ratio (LR) Chi-square statistic, Pseudo R^2, Log Likelihood, Akaike Information Criterion (AIC), Bayesian Information Criterion (BIC), and the Area Under the Receiver Operating Characteristic Curve (AUC) (Hosmer, Lemeshow, & Sturdivant, 2013; Menard, 2010). These indicators provide information on model significance, explanatory capacity, goodness-of-fit, parsimony, and predictive accuracy.

The Likelihood Ratio (LR) Chi-square test was used to assess the overall significance of each logistic regression model by comparing the fitted model with a null model containing only the intercept term. A statistically significant LR Chi-square statistic indicates that the explanatory variables jointly contribute to predicting the outcome variable and improve model fit relative to the null model (Agresti, 2018). The Log Likelihood statistic was also examined as a measure of model fit, with larger values (i.e., values closer to zero) indicating a better correspondence between the predicted and observed outcomes (Hosmer et al., 2013).

To assess explanatory power, Pseudo R^2 statistics were considered. Although Pseudo R^2 does not have the same interpretation as the coefficient of determination in linear regression, it provides an indication of the extent to which the predictors contribute to explaining variation in the outcome variable (Menard, 2010). Model comparison was further conducted using the Akaike Information Criterion (AIC) and Bayesian Information Criterion (BIC), both of which balance model fit against model complexity. Lower values of AIC and BIC indicate a more parsimonious model with superior explanatory performance (Akaike, 1974; Schwarz, 1978).

The discriminative ability of each model was evaluated using the Area Under the Receiver Operating Characteristic Curve (AUC). The AUC measures the capacity of a model to correctly distinguish between positive and negative outcomes across different classification thresholds. According to Hosmer et al. (2013), AUC values above 0.70 indicate acceptable discrimination, values above 0.80 indicate good discrimination, and values above 0.90 indicate excellent predictive performance. Taken together, these measures provide a comprehensive framework for assessing the statistical adequacy, explanatory strength, and predictive capability of the logistic regression models used in this study.

5. Results and Discussion

5.1 Descriptive Analysis

Table 1 summarizes the improvement status of 6,794 GPs across the nine LSDG themes in Odisha between 2022–23 and 2023–24. The results indicate substantial variation in the extent of improvement achieved across different development dimensions.

Among the nine LSDG themes, Socially Secured Panchayat (T7) recorded the highest level of improvement, with 94.77 percent of Gram Panchayats showing positive progress. This was followed by Self-Sufficient Panchayat (T6) and Clean and Green Panchayat (T5), where 89.23 percent and 84.12 percent of Gram Panchayats, respectively, demonstrated improvement. Poverty Free Gram Panchayat (T1) also exhibited a high improvement rate of 80.97 percent, indicating widespread progress in this dimension.

Moderate levels of improvement were observed in Good Governance Panchayat (T8) and Water Sufficient Panchayat (T4), with 66.79 percent and 59.98 percent of Gram Panchayats reporting improvement, respectively. In both cases, the proportion of improved Gram Panchayats exceeded that of non-improved GPs.

Conversely, lower levels of improvement were found in Women Friendly Panchayat (T9), Child Friendly Panchayat (T3), and Healthy Gram Panchayat (T2). Improvement was recorded in only 34.28 percent, 28.88 percent, and 24.40 percent of Gram Panchayats, respectively. Overall, the descriptive findings reveal uneven progress across LSDG dimensions, highlighting substantial achievements in social security, self-sufficiency, and environmental sustainability, while indicating relatively slower advancement in health, child welfare, and women-focused development outcomes.

Table 1: Distribution of Gram Panchayats by Improvement Status across Localized Sustainable Development Goal (LSDG) Indicators in Odisha

LSDG Indicator	Not Improved (0) n (%)	Improved (1) n (%)	Total
T1: Poverty Free Gram Panchayat	1,293 (19.03)	5,501 (80.97)	6,794
T2: Healthy Gram Panchayat	5,136 (75.60)	1,658 (24.40)	6,794
T3: Child Friendly Panchayat	4,832 (71.12)	1,962 (28.88)	6,794
T4: Water Sufficient Panchayat	2,719 (40.02)	4,075 (59.98)	6,794
T5: Clean and Green Panchayat	1,079 (15.88)	5,715 (84.12)	6,794
T6: Self-Sufficient Panchayat	732 (10.77)	6,062 (89.23)	6,794
T7: Socially Secured Panchayat	355 (5.23)	6,439 (94.77)	6,794
T8: Good Governance Panchayat	2,256 (33.21)	4,538 (66.79)	6,794
T9: Women Friendly Panchayat	4,465 (65.72)	2,329 (34.28)	6,794

5.2 Comparative Model Performance

All nine logistic regression models were statistically significant ($p < 0.001$), indicating that the explanatory variables jointly contributed to predicting development outcomes. The Good Governance Panchayat model (T8) recorded the highest LR Chi-square value (1173.69), suggesting substantial explanatory strength. Similarly, Self-Sufficient Panchayat (T6) and Poverty Free Gram Panchayat (T1) demonstrated strong model performance. The highest pseudo R^2 was observed for Self-Sufficient Panchayat (22.53%), followed by Socially Secured Panchayat (20.17%). These results indicate that the selected predictors explain a considerable proportion of variation in these outcomes. The Socially Secured Panchayat model exhibited the lowest AIC (2242.68) and highest AUC (0.833), indicating excellent predictive performance. The Water Sufficient Panchayat model showed comparatively lower explanatory power with an AUC of 0.671. Overall, Self-Sufficient Panchayat and Socially Secured Panchayat emerged as the best-performing models.

Table 2: Comparative Model Fit Statistics for Logistic Regression Models of Localized Sustainable Development Goals (LSDGs)

Dependent Variable (LSDG)	No. of Observations	LR Chi-square	Prob > Chi-square	Log Likelihood	Pseudo R^2	AIC	BIC	Area under ROC (AUC)
Poverty Free Gram Panchayat (T1)	6,794	1006.44	0.000	-2803.28	0.1522	5624.559	5685.973	0.7507
Healthy Gram Panchayat (T2)	6,794	772.02	0.000	-3389.36	0.1022	6796.711	6858.125	0.7191
Child Friendly Panchayat (T3)	6,794	812.06	0.000	-3677.57	0.0994	7373.134	7434.548	0.712
Water Sufficient Panchayat (T4)	6,794	699.57	0.000	-4223.22	0.0765	8464.444	8525.858	0.6705
Clean and Green Panchayat (T5)	6,794	589.09	0.000	-2679.2	0.099	5376.407	5437.821	0.7175
Self-Sufficient Panchayat (T6)	6,794	1046.08	0.000	-1798.94	0.2253	3615.869	3677.283	0.8303
Socially Secured Panchayat (T7)	6,794	562.13	0.000	-1112.34	0.2017	2242.681	2304.095	0.833
Good Governance Panchayat (T8)	6,794	1173.69	0.000	-3731.6	0.1359	7481.204	7542.618	0.7321
Women Friendly Panchayat (T9)	6,794	917.81	0.000	-3908.8	0.1051	7835.605	7897.02	0.7118

5.3 Interrelationships among Localized Sustainable Development Goal (LSDG) Dimensions

The logistic regression results presented in Table 3 provide strong evidence that the nine LSDG dimensions are closely interconnected and mutually reinforcing. The predictors are mentioned in column and the dependent variable are in a row. The findings indicate that improvements achieved in one development dimension substantially increase the likelihood of progress in several other dimensions, highlighting the multidimensional nature of rural development. For the Poverty Free Gram Panchayat (T1) model, Socially Secured Panchayat (T7) emerged as the most influential predictor with an odds ratio of 9.911 (95% CI: 7.718–12.727). This implies that Gram Panchayats demonstrating improvements in social security were nearly ten times more likely to achieve improvements in poverty reduction than those without such progress. Similarly, Self-Sufficient Panchayat (T6) significantly influenced poverty reduction (OR = 2.506; 95% CI: 2.077–3.024), indicating that improvements in local economic self-reliance increased the likelihood of poverty reduction by approximately 2.5 times. These findings suggest that poverty alleviation is strongly associated with social protection and economic empowerment initiatives, consistent with the broader literature on multidimensional development and capability enhancement (Sen, 1999; Sachs, 2015).

The Healthy Gram Panchayat (T2) model further revealed important interconnections between economic, social, and gender dimensions of development. Poverty Free Gram Panchayat emerged as the strongest predictor of health improvement (OR = 3.218; 95% CI: 2.576–4.021), indicating that poverty reduction made health improvement approximately 3.2 times more likely. Likewise, Self-Sufficient Panchayat (OR = 2.883; 95% CI: 2.141–3.882) and Women Friendly Panchayat (OR = 2.048; 95% CI: 1.811–2.317) significantly enhanced the likelihood of health-related improvements. These results imply that improvements in livelihoods, economic opportunities, and gender inclusion contribute positively to health outcomes. For Child Friendly Panchayat (T3), Women Friendly Panchayat emerged as the strongest determinant (OR = 2.745; 95% CI: 2.446–3.079), followed by Socially Secured Panchayat (OR = 2.058; 95% CI: 1.445–2.931) and Good Governance Panchayat (OR = 1.957; 95% CI: 1.703–2.248). This suggests that child welfare outcomes are closely linked with gender empowerment, social protection mechanisms, and effective local governance structures. These findings support previous studies emphasizing the importance of women's empowerment and

institutional effectiveness in improving social development outcomes (Chattopadhyay & Duflo, 2004; United Nations, 2015).

Strong interrelationships were also observed among environmental sustainability, natural resource management, and economic development dimensions. In the Water Sufficient Panchayat (T4) model, Clean and Green Panchayat (T5) emerged as the strongest predictor (OR = 2.590; 95% CI: 2.245–2.987), indicating that environmentally sustainable Panchayats were approximately 2.6 times more likely to improve water sufficiency. Self-Sufficient Panchayat (OR = 1.949; 95% CI: 1.629–2.332) and Good Governance Panchayat (OR = 1.617; 95% CI: 1.442–1.814) also contributed significantly to water-related improvements. Conversely, Water Sufficient Panchayat strongly influenced Clean and Green Panchayat (OR = 2.589; 95% CI: 2.245–2.986), demonstrating a reciprocal relationship between environmental management and water resource sustainability. These results indicate that ecological sustainability and resource management are mutually reinforcing dimensions that require coordinated policy attention.

The Self-Sufficient Panchayat (T6) model exhibited one of the strongest relationships observed in the analysis. Good Governance Panchayat (T8) emerged as the dominant predictor with an odds ratio of 6.371 (95% CI: 5.259–7.719), suggesting that GPs with improved governance were more than six times as likely to achieve economic self-sufficiency. Healthy Gram Panchayat (OR = 2.883), Poverty Free Gram Panchayat (OR = 2.506), Clean and Green Panchayat (OR = 1.989), and Water Sufficient Panchayat (OR = 1.926) also significantly contributed to self-sufficiency outcomes. These findings indicate that economic self-reliance is not determined by a single factor but rather emerges through simultaneous progress in governance, health, environmental sustainability, and poverty reduction. Such results align with decentralized development frameworks that emphasize the integrated nature of local development processes (NITI Aayog, 2023; OECD, 2023).

The remaining models further highlight the pivotal role of governance, social inclusion, and gender empowerment in localized sustainable development. For Socially Secured Panchayat (T7), Poverty Free Gram Panchayat was the strongest predictor (OR = 9.837; 95% CI: 7.658–12.637), indicating an exceptionally strong association between poverty reduction and social security. In the Good Governance Panchayat (T8) model, Self-Sufficient Panchayat exhibited the strongest influence (OR = 6.335; 95% CI: 5.231–7.671), followed by Child Friendly Panchayat (OR = 1.957), Women Friendly Panchayat (OR = 1.919), and Water Sufficient Panchayat (OR = 1.613). Finally, Women Friendly Panchayat (T9) was most strongly associated with Child Friendly Panchayat (OR = 2.743), Socially Secured Panchayat (OR = 2.107), and Good Governance Panchayat (OR = 1.907). Collectively, these findings demonstrate that governance quality, social security, gender empowerment, environmental sustainability, and economic self-reliance function as mutually reinforcing pillars of sustainable rural development. The evidence strongly supports the adoption of integrated and convergence-based planning approaches for achieving localized Sustainable Development Goals at the Gram Panchayat level (United Nations, 2015; Ministry of Panchayati Raj, 2024).

Table 3: Odds Ratios (OR) and 95% Confidence Intervals Showing Interrelationships among Localized Sustainable Development Goals (LSDGs)

Predictor Variable	T1 Poverty Free GP	T2 Healthy GP	T3 Child Friendly GP	T4 Water Sufficient GP	T5 Clean & Green GP	T6 Self-Sufficient GP	T7 Socially Secured GP	T8 Good Governance GP	T9 Women Friendly GP
T1 Poverty Free GP	—	3.218*** (2.576–4.021)	1.018 (0.862–1.201)	1.291*** (1.124–1.484)	1.510*** (1.278–1.785)	2.519*** (2.086–3.042)	9.837*** (7.658–12.637)	1.310*** (1.130–1.518)	1.478*** (1.257–1.736)
T2 Healthy GP	3.268*** (2.614–4.085)	—	1.914*** (1.687–2.171)	1.484*** (1.304–1.689)	1.411*** (1.165–1.709)	2.992*** (2.221–4.032)	1.505* (1.006–2.252)	0.768*** (0.669–0.881)	2.040*** (1.804–2.308)
T3 Child Friendly GP	1.035 (0.878–1.221)	1.913*** (1.686–2.171)	—	1.280*** (1.133–1.447)	0.918 (0.776–1.086)	1.212* (0.965–1.524)	2.067*** (1.453–2.940)	1.966*** (1.711–2.259)	2.743*** (2.444–3.077)
T4 Water Sufficient GP	1.307*** (1.138–1.502)	1.476*** (1.297–1.681)	1.274*** (1.127–1.439)	—	2.590*** (2.245–2.987)	1.949*** (1.629–2.332)	0.994 (0.783–1.262)	1.617*** (1.442–1.814)	1.241*** (1.104–1.394)
T5 Clean & Green GP	1.507*** (1.275–1.782)	1.404*** (1.159–1.701)	0.898 (0.759–1.062)	2.589*** (2.245–2.986)	—	1.975*** (1.632–2.389)	1.121 (0.848–1.482)	1.797*** (1.547–2.087)	1.125 (0.956–1.323)
T6 Self-Sufficient GP	2.506*** (2.077–3.024)	2.883*** (2.141–3.882)	1.112 (0.889–1.392)	1.926*** (1.611–2.302)	1.989*** (1.647–2.402)	—	0.874 (0.638–1.195)	6.371*** (5.259–7.719)	0.819* (0.668–1.004)
T7 Socially Secured GP	9.911*** (7.718–12.727)	1.483* (0.991–2.218)	2.058*** (1.445–2.931)	0.979 (0.771–1.244)	1.145 (0.869–1.509)	0.869 (0.634–1.191)	—	1.413*** (1.101–1.813)	2.107*** (1.503–2.955)
T8 Good Governance GP	1.318*** (1.137–1.527)	0.757*** (0.659–0.870)	1.957*** (1.703–2.248)	1.613*** (1.439–1.809)	1.788*** (1.539–2.076)	6.335*** (5.231–7.671)	1.442*** (1.125–1.849)	—	1.907*** (1.674–2.172)

T9 Women Friendly GP	1.480*** (1.260–1.739)	2.048*** (1.811–2.317)	2.745*** (2.446–3.079)	1.246*** (1.109–1.400)	1.136 (0.966–1.337)	0.841* (0.684–1.035)	2.073*** (1.475–2.915)	1.919*** (1.685–2.186)	—

Significance level: *** p < 0.01, ** p < 0.05, * p < 0.10.

6. Conclusion

This study examined the interrelationships among the nine LSDG dimensions using Gram Panchayat-level data from 6,794 GPs in Odisha. The descriptive findings revealed substantial variation in development progress across the LSDG themes. Socially Secured Panchayat, Self-Sufficient Panchayat, Clean and Green Panchayat, and Poverty Free Gram Panchayat recorded relatively high levels of improvement, whereas Healthy Gram Panchayat, Child Friendly Panchayat, and Women Friendly Panchayat showed comparatively lower levels of progress.

The logistic regression results indicate that the LSDG dimensions are strongly interconnected and mutually reinforcing. Improvements in social security, governance, self-sufficiency, and women-friendly development significantly increased the likelihood of progress in several other development dimensions. In particular, Socially Secured Panchayat emerged as a strong predictor of Poverty Free Gram Panchayat, while Good Governance Panchayat demonstrated substantial influence on Self-Sufficient Panchayat and multiple development outcomes. These findings support the view that sustainable development outcomes are multidimensional and closely linked through institutional, social, economic, and environmental processes (Sen, 1999; Sachs, 2015).

The model evaluation statistics further confirmed the adequacy of the estimated logistic regression models. The significant Likelihood Ratio Chi-square statistics and satisfactory AUC values suggest that the selected predictors possess reasonable explanatory and predictive power (Hosmer et al., 2013). The findings are also consistent with the growing emphasis on SDG localization and integrated local governance frameworks advocated by the MoPR (2024), NITI Aayog (2023), and the United Nations (2015).

Overall, the study provides empirical evidence that sustainable rural development at the GP level cannot be achieved through isolated sectoral interventions. Instead, progress in governance, social protection, economic self-reliance, environmental sustainability, and gender empowerment tends to reinforce one another. Therefore, convergence-based planning and integrated policy implementation should be prioritized to accelerate the achievement of localized sustainable development goals. Future research may incorporate spatial econometric techniques, district-level heterogeneity, and longitudinal approaches to further explore the dynamics of localized sustainable development (OECD, 2023; United Nations Development Programme, 2024).

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