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Female Voter Turnout and Victory Margins in Sarawak Elections: A Linear Regression Analysis (2006–2021)

Penyertaan Pengundi Wanita Dan Margin Kemenangan Dalam Pilihan Raya Sarawak: Analisis Regresi Linear (2006–2021)

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ABSTRACT

In Malaysia, women constitute roughly half the electorate, yet the influence of female turnout on State Legislative Assemble (DUN) electoral outcomes is poorly documented, especially in Sarawak. This study quantifies the effect of female turnout on victory margins in Sarawak's state elections (2006, 2011, 2016, 2021) using linear regression on constituency-level data (registered female voters, winning vote counts). The analysis reveals a strong positive association between female turnout and winning margins in 2006–2016 (R^2 = 0.677–0.879), indicating that constituencies with higher female engagement yielded more decisive victories. In 2021, however, this predictive power dropped sharply (R^2 = 0.322), signaling evolving voter dynamics. The findings suggest female voters have been pivotal in past elections, underscoring the need for gender-responsive strategies. Conversely, the attenuated effect in 2021 implies new factors including an expanded youth electorate (with turnout exceeding 75 % in recent polls) and intensified digital campaigning are reshaping electoral contests. This analysis provides novel empirical evidence on gendered voting dynamics at the Malaysian State Legislative Assemble (DUN) level, contributing to debates on electoral competitiveness and inclusive democracy by showing that women's turnout continues to matter, albeit in a shifting political landscape.

Keywords: electoral outcomes; female voter participation; gender-inclusive policy; linear regression analysis; Sarawak state elections

ABSTRAK

Di Malaysia, wanita merangkumi kira-kira separuh daripada keseluruhan pengundi, namun pengaruh kadar keluar mengundi wanita terhadap keputusan pilihan raya di peringkat negeri masih kurang didokumentasikan, khususnya di Sarawak. Kajian ini mengukur kesan penyertaan pengundi wanita terhadap margin kemenangan dalam pilihan raya negeri Sarawak (2006, 2011, 2016, 2021) dengan menggunakan analisis regresi linear berasaskan data peringkat kawasan pilihan raya (jumlah pengundi wanita berdaftar dan jumlah undi kemenangan). Analisis menunjukkan hubungan positif yang kukuh antara penyertaan pengundi wanita dan margin kemenangan bagi tempoh 2006–2016 (R^2 = 0.677–0.879), yang menandakan bahawa kawasan pilihan raya dengan tahap penglibatan wanita yang lebih tinggi menghasilkan kemenangan yang lebih meyakinkan. Walau bagaimanapun, pada tahun 2021, keupayaan ramalan ini menurun dengan ketara (R^2 = 0.322), mencerminkan perubahan dalam dinamik tingkah laku pengundi. Dapatan kajian mencadangkan bahawa pengundi wanita memainkan peranan penting dalam pilihan raya terdahulu, sekali gus menekankan keperluan strategi yang responsif gender. Sebaliknya, pengurangan kekuatan hubungan pada tahun 2021 menunjukkan kemunculan factor baharu, termasuk pertambahan pengundi muda (dengan kadar keluar mengundi melebihi 75% dalam pilihan raya terkini) serta peningkatan kempen digital, yang sedang membentuk semula persaingan pilihan raya. Analisis ini menyediakan bukti empirikal baharu mengenai dinamika pengundian berasaskan gender di peringkat subnasional Malaysia, serta menyumbang kepada perbahasan berkaitan daya saing pilihan raya dan demokrasi inklusif dengan menunjukkan bahawa penyertaan wanita masih signifikan, walaupun dalam landskap politik yang semakin berubah.

Kata kunci: analisis regresi linear; dasar inklusif gender; keputusan pilihan raya; penyertaan pengundi wanita; pilihan raya negeri Sarawak

INTRODUCTION

Women's political participation is essential for inclusive democracy, yet scholars note it remains uneven, especially at State Legislative Assemble (DUN) levels (Cornwall & Goetz, 2005). Women account for roughly half of the electorate globally, but gaps in turnout and influence persist (Kittilson, 2016; Paxton et al., 2007). Formal franchise rights do not guarantee equal power: where women lack strong collective organizations, they "face considerable difficulties in overcoming cultural obstacles to substantive inclusion" (Cornwall & Goetz, 2005). Recent large-scale analyses underline this complexity. For example, comprehensive voter-registration data in the United States reveal that gender often fails to predict turnout in patterns expected by earlier surveys (Ansolabehere & Hersh, 2013). These insights underscore the need for detailed empirical study of women's turnout using rich data and rigorous methods. Sarawak provides a unique context for this study. The state's population is ethnically diverse about half indigenous Dayak (primarily Iban and Bidayuh) plus significant Malay, Chinese, and other minorities (Badaruddin et al., 2005; Mersat, 2018). Many Dayak-majority constituencies retain traditional longhouse governance and land-tenure systems, unlike Malay-majority areas (Mersat, 2018). Moreover, Sarawak has special autonomy under the 1963 Malaysia Agreement, controlling land rights, native titles, and immigration (Mersat, 2018). These powers shape development and identities in ways not seen in peninsular Malaysia. Sarawak also has stark urban–rural divides: cities like Kuching, Sibu, and Miri contrast sharply with isolated riverine villages. Spatial inequality often depresses turnout in remote areas (Fiorino et al., 2021; Frank & Martínez i Coma, 2023). In sum, ethnic diversity, semi-autonomous governance, and geographic isolation combine to create an electoral environment where women's voting patterns may differ from national or urban norms.

Despite Malaysia's rich election studies, gendered turnout at the state level remains under-investigated. Most research addresses federal elections or aggregate turnout (Baskaran et al., 2018; Jin, 2010), overlooking constituency-level gender dynamics. Official returns list registered female voters per constituency but not how those votes are cast, so no prior study has directly linked female turnout rates to victory margins in Sarawak. Analyses of Malaysian elections rarely disaggregate turnout by gender (Bhalotra et al., 2016; Crook, 2021), and richer data often overturn conventional turnout models (Ansolabehere & Hersh, 2013). Existing literature on Sarawak (Akobiarek & Puyok, 2024; Bhalotra et al., 2016; Crook, 2021) lacks the granularity needed for gender-based turnout analysis. This constitutes a clear data gap: we lack fine-grained evidence on women's electoral influence at the constituency level in Sarawak's plural society. We address these challenges with an ecological linear regression approach. In the absence of individual voting records, we exploit constituency returns by regressing the winning margin on female turnout (proxied by registered voters and vote totals). Ecological regression is appropriate when individual data are unavailable (Bhalotra et al., 2016). This method is novel in Sarawak's context, as few studies have applied quantitative models (e.g., regression or GIS) to gendered turnout across multiple elections (Bhalotra et al., 2016). By using gender-specific voter counts and outcomes, our analysis directly infers the impact of female mobilization on electoral margins.

This analysis makes two key contributions. First, by quantifying the turnout–margin relationship across Sarawak's state elections (2006-2021), we show how women's participation translates into electoral competitiveness. We find that higher female turnout strongly predicted larger victory margins in 2006-2016, though the effect attenuated in 2021 reflecting evolving dynamics such as an expanding young electorate and intensified digital campaigning. Second, we situate Sarawak's case in broader theories of inclusivity and representation. High social diversity

can fragment party systems (Flick Witzig & Vatter, 2018), and truly inclusive elections must address gendered barriers (Schneider & Carroll, 2020). If women's turnout influences outcomes, parties may need gender-responsive strategies to mobilize this constituency (Safarpour et al., 2022). In sum, our regression-based design provides rigorous evidence of women's electoral power in Sarawak and informs comparative debates on mobilizing underrepresented groups (Cornwall & Goetz, 2005).

LITERATURE REVIEW

GENDER AND VOTER TURNOUT

Recent empirical work highlights that gender gaps in turnout depend on context rather than a universal bias. Chattha & Lakhtakia (2025) show that in Pakistan's 2018 election, introducing women-only polling stations actually reduced women's turnout (by about 2 percentage points). Likewise, Murshed (2025) finds that in rural Bangladesh women outvote men: younger and married women turned out at higher rates, while even educated women were less likely to vote than men. These counterintuitive findings indicate that institutional interventions and socio-demographics can reverse expected patterns. They underscore that one cannot assume women's turnout is inherently lower everywhere instead, gendered turnout differences must be tested with local data in Sarawak's diverse setting (Chattha & Lakhtakia, 2025; Murshed, 2025).

YOUTH AND ETHNIC TURNOUT

Subnational analyses in Malaysia reveal turnout varies by age and ethnic community. In Johor state, Zhang & Hutchinson (2022) find that high-turnout districts overwhelmingly favored Malay-majority ruling parties, whereas lower-turnout areas favored the opposition. They also report that newly enfranchised 18–20-year-olds did not turn out more than older voters, although 21–29-year-olds showed modestly higher turnout (Zhang & Hutchinson, 2022). In Sarawak, a Kuching survey after lowering the voting age finds only about 65.5% of young respondents are ready to vote; political knowledge and peer influence were the strongest predictors of turnout intention (Yi et al., 2023). These studies emphasize that turnout correlates with demographic factors – ethnic composition, age cohort, education – and that constituency-level data can reveal such patterns (Yi et al., 2023; Zhang & Hutchinson, 2022). They underscore the need to consider Sarawak's ethnic and youth subgroups when analyzing turnout.

SUBNATIONAL ELECTORAL TRENDS

State-level studies illustrate local voting dynamics. Puyok (2024) examines Sarawak's 2021 election and shows Dayak-majority rural seats swinging back to the ruling Gabungan Parti Sarawak (GPS) on the basis of inclusive development appeals. This suggests that pragmatic local issues such as infrastructure and services drove turnout and preferences more than purely ethnic appeals. Similarly, the Johor analysis by Zhang & Hutchinson (2022) uses polling-district results to uncover turnout and party correlations. These works reflect a trend toward constituency-level analysis of Malaysian state elections (Puyok, 2024; Zhang & Hutchinson, 2022). Notably, none of these studies link outcomes to gender-disaggregated turnout. Our regression approach directly addresses this gap by quantifying how women's turnout affects victory margins, thereby

complementing the State Legislative Assemble (DUN) literature on electoral trends (Puyok, 2024; Zhang & Hutchinson, 2022).

COMPARATIVE PERSPECTIVES

Studies in other multi-ethnic democracies highlight that turnout is shaped by multiple interacting factors. In Pakistan and Bangladesh, reforms or demographics can flip expected gender gaps (Chattha & Lakhtakia, 2020; Murshed, 2025). For example, a Pakistani polling-station experiment shows a gender-equity reform backfired (Chattha & Lakhtakia, 2020). Spatial analyses elsewhere find that remote or unequal areas often have depressed turnout (Fiorino et al., 2021; Frank & Martínez i Coma, 2023), suggesting Sarawak's geographic isolation may similarly suppress participation. Fossati (2025) multi-country experiments in Southeast Asia indicate that candidate traits and local issues including women candidates or community interests and significantly shift turnout in plural societies. Together, these findings imply that in Sarawak (with its ethnic federalism, uneven development, and expanding youth electorate) turnout likely reflects the interaction of gender with age, ethnicity, and local context. In summary, no single factor uniformly predicts participation (Chattha & Lakhtakia, 2020; Fiorino et al., 2021; Fossati, 2025; Frank & Martínez i Coma, 2023). This review underscores the need to analyze Sarawak's voter data directly to uncover any gender-specific turnout effects.

METHODOLOGY

DATA

This section details the data sources used in the analysis and the preprocessing steps undertaken to ensure data quality and suitability for Linear Regression (LR) modeling. The primary data source for this study is the Election Commission of Malaysia (EC). The EC publishes detailed results for each constituency in each election, including the total number of votes cast, the number of votes received by each candidate, and the breakdown of voters by gender. For this study, data on the total number of female voters and the total votes obtained by the winning candidate in each constituency for the 2006, 2011, 2016, and 2021 Sarawak DUN elections have been extracted. We used constituency-level data (n=71 in 2006 and 2011), (n=82 in 2016 and 2021), extracting total female registered voters and votes for the winning candidate from the Election Commission's results. The victory margin (dependent variable) was operationalized as the winning candidate's total votes, and the independent variable was the number of female voters.

To maintain data integrity, cleaning procedures include verifying consistency across years and constituencies, identifying missing values, and applying imputation techniques where necessary. Specifically, mean imputation is used for continuous variables when data is missing at random, while regression imputation estimates missing values based on patterns within the dataset (Afifi et al., 2007). Outlier detection is performed using visualization tools such as box plots and scatter plots to identify extreme values that could unduly influence regression outcomes. If outliers are detected, further examination and, if necessary, transformations such as logarithmic adjustments are applied to ensure data normality and homoscedasticity (Gelman et al., 2001). The cleaned and preprocessed dataset is then used for subsequent regression analysis.

LINEAR REGRESSION (LR)

The study employs a Linear Regression (LR) model to assess the relationship between female voter turnout and the number of votes required to secure victory in an election. The dependent variable is the total number of votes received by the winning candidate in each constituency, representing the minimum threshold for electoral success (Flick Witzig & Vatter, 2018). The independent variable is the total number of female voters, serving as a measure of female voter participation.

Ordinary Least Squares (OLS) regression is used to estimate the model parameters, ensuring an unbiased and efficient estimation of the relationship between these variables (Gelman et al., 2001). Before conducting the regression analysis, the fundamental assumptions of linear regression are tested:

Linearity: The assumption is assessed through scatter plots and residual plots to ensure that the relationship between the independent and dependent variables is appropriately modeled (Higgle et al., 1997).

Independence of Residuals: The Durbin-Watson test is applied to detect the presence of autocorrelation among errors (Afifi et al., 2007).

Homoscedasticity: The assumption that the variance of residuals remains constant across different levels of the independent variable is evaluated using the Breusch-Pagan test and residual plots (Gelman et al., 2001).

Normality of Residuals: Histograms and Q-Q plots are used to confirm whether residuals follow a normal distribution. If any assumptions are violated, corrective measures such as data transformations or alternative modeling approaches are considered (Flick Witzig & Vatter, 2018).

"Linear regression is a straightforward way to quantify how changes in female turnout are associated with vote margins. Its coefficient (β) yields the estimated increase in votes per additional female voter, and R^2 indicates the proportion of variance explained. This interpretability and quantitative precision make LR suitable for testing our hypotheses about gendered voting." (Fossati, 2025; IBM, 2024)

RESULTS

LINEAR REGRESSION (LR) ANALYSIS OF FEMALE VOTES WITH WINNING VOTES IN 2006

In the 2006 Sarawak state election (71 constituencies), the mean constituency had approximately 6,232 female voters (SD = 2,659.9) and a winning vote count of 5,060 (SD = 2,117) (TABLE 1 and FIGURE 1). The Pearson correlation between the number of registered female voters and the votes received by the winning candidate was very strong ($r = 0.851$, $p < 0.001$). Correspondingly, the ordinary least squares regression of female voter count on winning votes yielded $R = 0.851$ and $R^2 = 0.724$ (adjusted $R^2 = 0.720$). The model's standard error of estimate (SEE) was 1,408.42. The estimated regression line had an intercept of about 825.3 and a slope of $B \approx 1.069$, implying that each additional vote for the winning candidate corresponded to roughly one additional registered female voter in the constituency. This regression was highly significant ($F(1,69) \approx 181$, $p < 0.001$), and diagnostic checks indicated that the assumptions of normality and homoscedasticity of residuals were reasonably met. In practical terms, the 2006 model explains about 72.4% of the variance in female voter counts across constituencies. The nearly one-to-one slope and high R^2 indicate that constituencies with larger female electorates tended to have larger

winning vote totals. At the same time, the sizeable SEE and scatter around the fitted line suggest there remained constituency-specific variation (due to factors like urban–rural differences or local political dynamics) beyond what the simple model captured.

TABLE 1. 2006 Model Summary Linear Regression Analysis between Total Female Voters and Winning Votes in the 2006 Sarawak State Legislative Assemble

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.851[a]	.724	.720	1408.421

Note: Predictors: (Constant), Total Votes for Victory
Dependent Variable: Total Female Voters
(Source: Election Commission of Malaysia, n.d.)

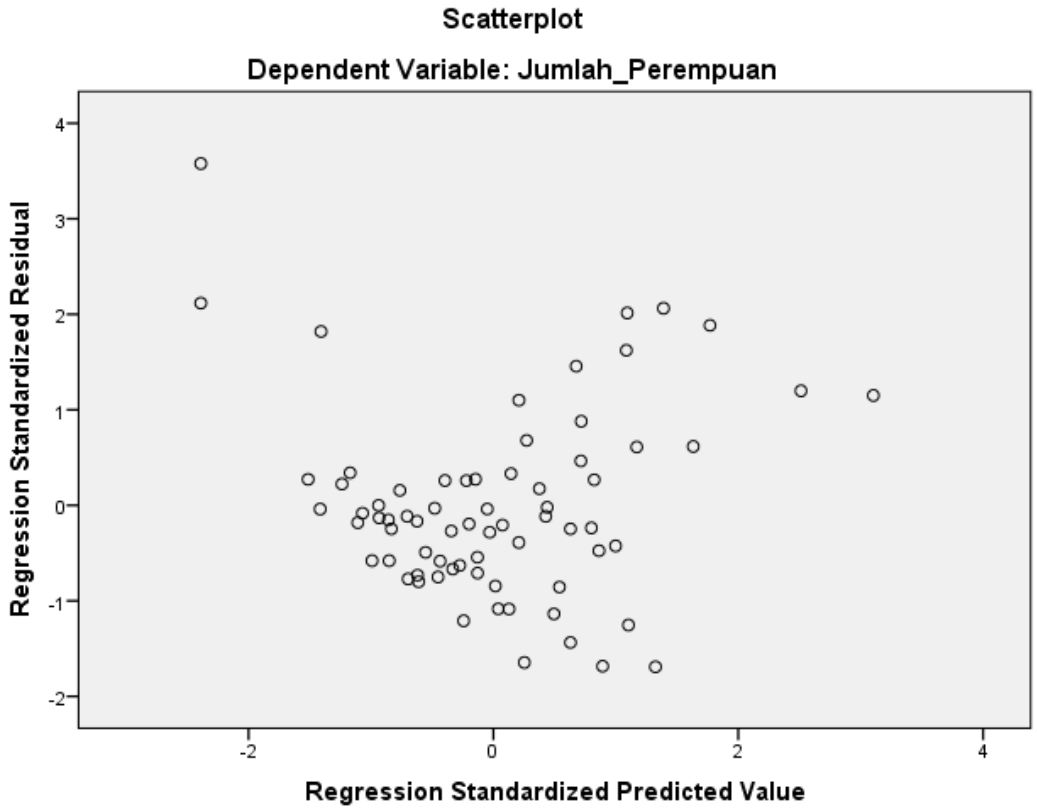

FIGURE 1. Scatterplot 2006 Model Summary Linear Regression Analysis between Total Female Voters and Winning Votes in the 2006 Sarawak State Legislative Assemble

LINEAR REGRESSION (LR) ANALYSIS OF FEMALE VOTES WITH WINNING VOTES IN 2011

The 2011 election (71 constituencies) produced an even stronger turnout–victory link. On average, constituencies had about 6,908 female voters (SD = 3,096) and a winning vote total of 6,201 (SD = 2,873). The Pearson correlation between female voter count and winning votes was extremely high ($r = 0.937$, $p < 0.001$), indicating an almost perfectly linear association. The linear regression yielded $R = 0.937$ and $R^2 = 0.879$ (adjusted $R^2 = 0.877$), meaning that roughly 87.9% of the variance in female turnout was explained by the winning vote totals. The SEE was 1,086.05. The

regression coefficients were an intercept of about 647.8 and a slope of B ≈ 1.010; thus, each additional vote for the winner corresponds to approximately one additional registered female voter. This model was also highly significant ($F(1,69) \approx 499.995$, $p < 0.001$), and residual diagnostics showed no serious departures from the regression assumptions. In sum, the 2011 regression indicates a very tight, positive relationship: constituencies with more registered women almost uniformly saw higher winning vote counts. The extremely high R^2 (87.9%) and near-one slope reflect that female voter enrollment was an exceptionally strong predictor of victory margins in 2011. Nevertheless, about 12% of the variance remained unexplained, implying that factors not included in the model (such as local mobilization efforts or constituency demographics) also played a role (TABLE 2 and FIGURE 2).

TABLE 2. 2011 Model Summary Linear Regression Analysis between Total Female Voters and Winning Votes in the 2011 Sarawak State Legislative Assemble

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.937[a]	.879	.877	1086.045

Note: Predictors: (Constant), Total Votes for Victory
Dependent Variable: Total Female Voters
(Source: Election Commission of Malaysia, n.d.)

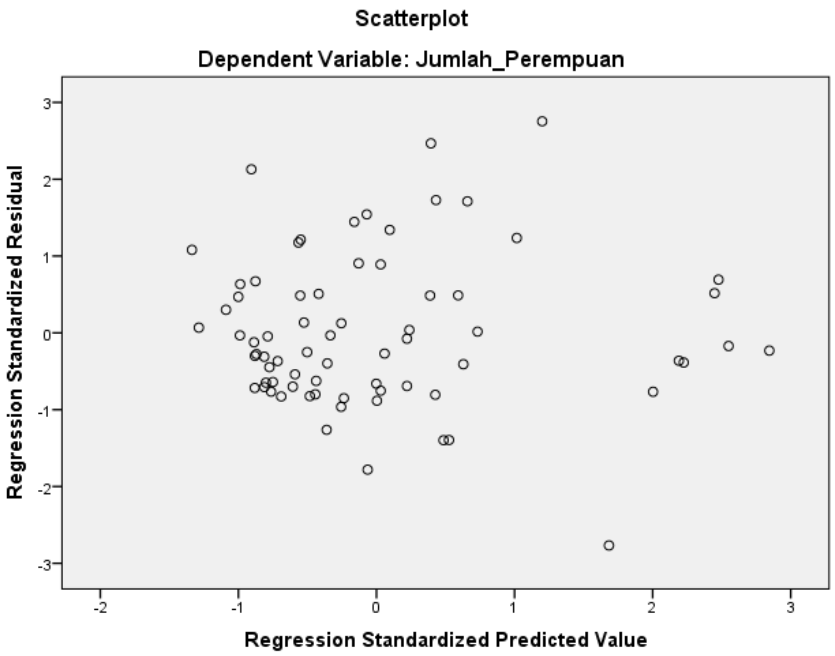

FIGURE 2. Scatterplot 2011 Model Summary Linear Regression Analysis between Total Female Voters and Winning Votes in the 2011 Sarawak State Legislative Assemble

LINEAR REGRESSION (LR) ANALYSIS OF FEMALE VOTES WITH WINNING VOTES IN 2016

In the 2016 election (82 constituencies), the positive association persisted but with greater dispersion. The mean constituency had about 6,957 female voters (SD = 3,147) and the winning candidate's average vote count was 6,184 (SD = 2,612). The Pearson correlation was r = 0.823 (p

< 0.001), indicating a strong but weaker association than in 2011. Regression analysis gave R = 0.823 and $R^2 = 0.677$ (adjusted $R^2 = 0.673$), so that approximately 67.7% of the variance in female voter counts was explained by winning votes. The SEE increased to 1,800.63, reflecting a larger average prediction error. The fitted line had an intercept of about 828.5 and a slope of B = 0.991 – again very close to one female voter per additional vote for the winner. The model remained statistically significant ($F(1,80) = 167.429$, $p < 0.001$), and diagnostic checks (not shown) indicated no obvious violations of regression assumptions. Compared to earlier years, the 2016 results show more scatter: the slope remains positive (≈0.99) but the R^2 is notably lower. In substantive terms, larger female electorates generally coincided with higher victory margins, but 32.3% of variation in female turnout was unexplained by the model. This suggests that constituency heterogeneity (e.g. rural vs. urban composition or local political factors) introduced more "noise" in 2016. Overall, the 2016 model reaffirms a clear positive turnout–victory relationship, but with a weaker fit and higher residual variance than in 2006–2011 (TABLE 3 and FIGURE 3).

TABLE 3. 2016 Model Summary Linear Regression Analysis between Total Female Voters and Winning Votes in the 2016 Sarawak State Legislative Assemble

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.823[a]	.677	.673	1800.627

Note: Predictors: (Constant), Total Votes for Victory
Dependent Variable: Total Female Voters
(Source: Election Commission of Malaysia, n.d.)

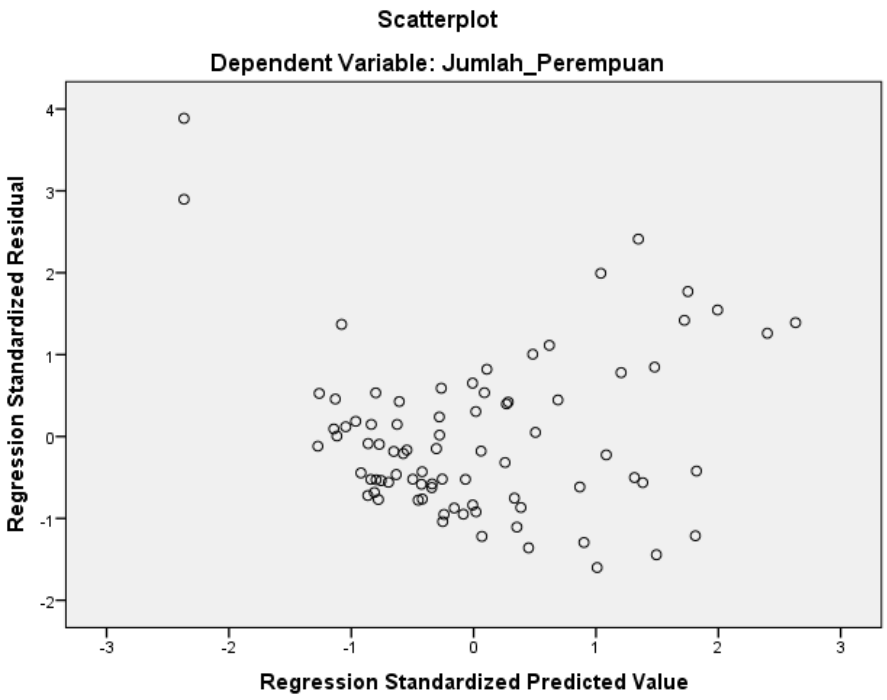

FIGURE 3. Scatterplot 2016 Model Summary Linear Regression Analysis between Total Female Voters and Winning Votes in the 2016 Sarawak State Legislative Assemble

By 2021 (82 constituencies), the turnout–victory link remained positive but was substantially attenuated. Constituencies averaged about 7,710 registered women (SD = 3,523) and winning vote totals of 5,634 (SD = 2,148). The Pearson correlation fell to r = 0.568 ($p < 0.001$), a moderate association. The regression produced R = 0.568 and $R^2 = 0.322$ (adjusted $R^2 = 0.314$), meaning only 32.2% of the variance in female voter counts was explained by the winning vote totals. The SEE grew to 2,919.23, indicating a much larger typical error. The estimated line had an intercept of about 2,466 and a slope B = 0.931, still roughly one female voter per vote won. The model was statistically significant ($F(1,80) = 38.028$, $p < 0.001$), but the lower R^2 and F-value reflect a much weaker predictive power. Diagnostic plots (not shown) did not reveal major assumption violations, but the residuals were widely dispersed (range roughly –2,778 to +11,065). In practical terms, the 2021 regression indicates that female turnout was still positively related to victory margins, but the simple model captured only about one-third of the variation. This suggests that other factors (such as demographic shifts, youth turnout, or new party dynamics) increasingly influenced outcomes. Overall, the 2021 results underscore that although higher female registration tended to accompany larger victory vote counts, female turnout had become a less dominant predictor by 2021 (TABLE 4 and FIGURE 4).

TABLE 4. 2021 Model Summary Linear Regression Analysis between Total Female Voters and Winning Votes in the 2021 Sarawak State Legislative Assemble

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.568[a]	.322	.314	2919.228

Note: Predictors: (Constant), Total Votes for Victory
Dependent Variable: Total Female Voters
(Source: Election Commission of Malaysia, n.d.)

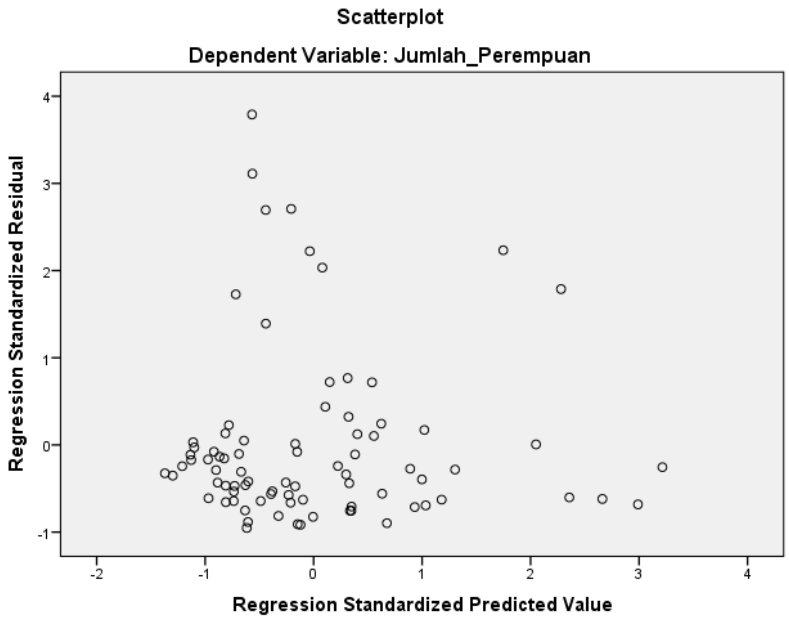

FIGURE 4. Scatterplot 2021 Model Summary Linear Regression Analysis between Total Female Voters and Winning Votes in the 2021 Sarawak State Legislative Assemble

DISCUSSION

2006 SARAWAK STATE ELECTION

In the 2006 Sarawak state election, women's turnout strongly predicted victory margins. The regression of winning votes on female turnout yielded $r \approx 0.85$ ($p < .001$) and $R^2 \approx 0.72$, with a slope (≈1.07) implying roughly one extra female voter per additional vote won. Residuals were roughly normal and homoscedastic, suggesting OLS assumptions held (Kimball & Kropf, 2005; Stratmann, 1974). Constituencies with higher female turnout thus tended to produce larger margins. Roughly 28% of the variance was unexplained, reflecting omitted factors. Socio-economic or geographic variables (age, income, urban–rural) were not modeled (Bauer, 2020; Coffé & Bolzendahl, 2010; Hua et al., 2021). Local constituency traits or campaign strategies could also deviate from the trend (Jin, 2010; Mersat, 2018). In sum, the 2006 findings highlight a strong, statistically significant gender–turnout effect, but also underscore the need to consider additional factors (Bucchianeri, 2018; Giné & Mansuri, 2018).

2011 SARAWAK STATE ELECTION

The 2011 election produced an exceptionally tight turnout–margin relationship. The regression explained about 87.9% of the variance ($r \approx 0.94$, $p < .001$) with a slope of about 1.01. The standard error (~1,086) was small, reflecting a very close fit. Nearly all constituency variation in female turnout was accounted for by the winning vote totals. This outcome echoes research showing that surges in women's participation can decisively influence electoral outcomes (Ansolabehere & Hersh, 2013; Cascio & Shenhav, 2020; Hansen, 1997). 12% of variance remained unexplained, indicating other dynamics. Unmeasured influences – such as economic development, education, or media exposure, could account for this gap. Sarawak's socio-spatial heterogeneity persisted: turnout and vote totals varied widely across districts (Jin, 2010; Mersat, 2018). Some constituencies with many women may have benefited from targeted mobilization or higher civic engagement not captured by the model (Paxton et al., 2007; Schneider & Carroll, 2020). In summary, the 2011 results provide strong evidence that women's turnout was instrumental in electoral success, but they also underscore the need to incorporate additional predictors (Desposato & Petrocik, 2003; Ghitza & Gelman, 2013; Trangucci et al., 2018).

2016 SARAWAK STATE ELECTION

In 2016, the gender–turnout effect remained strong but was somewhat weaker. Female turnout and winning votes correlated at $r \approx 0.82$ ($p < .001$), with $R^2 \approx 0.677$. The slope (~0.99) again implies roughly one female voter per vote won, and the model's ANOVA was highly significant ($F \approx 167$, $p < .001$), confirming robustness (Bucchianeri, 2018; Ditonto et al., 2014; Golder et al., 2017). The standard error increased (~1,800), reflecting more scatter around the fit. Substantively, constituencies with larger female electorates tended to have higher victory margins, consistent with enduring gender dynamics. This pattern may reflect broader factors such as rising women's education or empowerment and continued outreach to female voters (Setzler & Yanus, 2018; Stauffer & Fraga, 2022). Nonetheless, the 2016 model's simplicity is a limitation. It omitted demographic factors (income, ethnicity, media exposure) that likely matter (Ansolabehere & Hersh, 2013; Cascio & Shenhav, 2020). Any institutional changes or campaign innovations since 2011 were not captured. The assumption of linearity could mask threshold or saturation effects

(for example, turnout ceilings). These issues suggest future models should include additional socio-economic predictors and possibly use multivariate or longitudinal approaches (Cornwall & Goetz, 2005; Schneider & Carroll, 2020). Despite these caveats, the 2016 results reaffirm that female voters continued to play an important role in Sarawak elections.

2021 SARAWAK STATE ELECTION

In 2021, female turnout continued to correlate positively with victory margins, consistent with prior evidence on gendered turnout – but to a far weaker degree (Giné & Mansuri, 2018; Hansen, 1997). The correlation was $r \approx 0.568$ ($p < .001$) and the regression explained only ~32.2% of the variance ($R^2 \approx 0.322$). The slope (~0.93) indicates each additional vote won corresponded to roughly 0.93 more female voters, but the standard error was very large (~2,919) and residuals were widely dispersed. Thus, while higher female registration still tended to accompany larger victory counts, by 2021 the simple model captured only about one-third of turnout variation. Several contextual changes likely underlie this decline. A major shift was lowering the voting age to 18 (Undi18), which added a large cohort of new young voters and diluted the gender–turnout link (Cascio & Shenhav, 2020; Frank & Martínez i Coma, 2023; Ondercin, 2021). Campaign dynamics also changed: the 2021 campaign was highly media-driven and nationalized, with social media and pandemic issues dominating, potentially overriding local gender effects (Cascio & Shenhav, 2020; Melusky et al., 2020). Economic and health concerns during the pandemic may have further altered turnout. Spatial differences remained: rural or ethnic constituencies could exhibit distinct turnout behaviors (Rasmussen, 1983; Safarpour et al., 2022). The modest R^2 and large residuals highlight that many factors (education, income, partisan context) were omitted (Irvani et al., 2021; Olsen, 1972; Plutzer, 2002; Trangucci et al., 2018). In sum, the 2021 results show that while women's turnout continued to matter, electoral success was influenced by a broader set of social and institutional factors (Cascio & Shenhav, 2020; Frank & Martínez i Coma, 2023; Plutzer, 2002; Safarpour et al., 2022; Trangucci et al., 2018).

COMPARATIVE ANALYSIS ACROSS ELECTION YEARS (2006–2021)

Across the four elections, the female-turnout–victory relationship remained positive but its strength varied sharply. In 2006 the model was already strong ($R^2 \approx 0.72$) and it tightened dramatically in 2011 ($R^2 \approx 0.88$), nearly all constituency variation in female turnout was explained by winning votes. By 2016 the association had weakened ($R^2 \approx 0.68$) and by 2021 it was much weaker ($R^2 \approx 0.32$). Early-year residuals were relatively small and homoscedastic, whereas scatter increased in 2016 and by 2021 residuals became very wide. In short, the model's explanatory power peaked around 2011 and then declined by 2021 only about one-third of turnout variance was tied to victory totals. These trends likely reflect broader shifts in Sarawak's electoral context. The tight fits in 2006–2011 suggest intensive female mobilization; indeed, studies find that surges in women's turnout can decisively affect outcomes (Cascio & Shenhav, 2020; Giné & Mansuri, 2018). For example, Giné & Mansuri (2018) show that targeted voter education can substantially raise women's turnout and alter winners' vote shares. By 2016 the gender effect remained strong but more diffuse, perhaps indicating that parties had refined their outreach and women's empowerment had risen. In contrast, 2021 saw major institutional and demographic changes. Lowering the voting age (Frank & Martínez i Coma, 2023) injected a large cohort of young electors, diluting the gender effect, and the campaign was highly nationalized and media-driven,

which likely overrode simple local gender patterns (Cascio & Shenhav, 2020; Melusky et al., 2020). At the same time, Sarawak's enduring regional cleavages continued to matter: Mersat (2018) documents volatile shifts in Dayak-majority constituencies, indicating that local socio-economic issues and demographic shifts added noise to the turnout–margin pattern.

These comparative observations also highlight model limitations. The earlier regressions were robust (with normal, homoscedastic residuals), but they omitted key predictors. Economic development, education, ethnicity, and media exposure were uncontrolled (Coffé & Bolzendahl, 2010; Irvani et al., 2021), so even high R^2 values leave room for unobserved heterogeneity. By 2021 the univariate model's assumptions were most strained: the low R^2 and large standard error show that gender turnout alone cannot fully capture electoral dynamics. Although the positive slope (≈1) signals a persistent correlation each year, varying intercepts and error spreads suggest non-linearities or saturation effects may exist. In short, the linear relationships confirm a significant gendered turnout effect, but their changing fit indicates that additional variables (campaign strategies, socio-economic context, voting reforms) are crucial to fully explain election results (Cascio & Shenhav, 2020; Trangucci et al., 2018). Together, the evidence suggests evolving gendered electoral behavior. In 2006–2011, Sarawak women's votes were a strong and reliable source of winning margins, consistent with broader studies of expanding female participation (Cascio & Shenhav, 2020; Hansen, 1997). After 2016 that connection weakened: by 2021 female turnout remained correlated with victory margins, but far more weakly. This evolution implies that the bases of women's electoral influence have changed. It may reflect diminishing returns to gender-focused mobilization, other demographics (youth, urban voters) may now sway races more or that political engagement has become more evenly distributed by gender. In any case, the attenuating relationship underscores that gender is one of many interacting factors shaping Sarawak's elections (Cascio & Shenhav, 2020; Coffé & Bolzendahl, 2010; Mersat, 2018).

CONCLUSION

This study's constituency-level analysis (2006–2021) reveals a strong positive link between women's turnout and victory margins in Sarawak. In the 2006–2016 elections, higher female turnout consistently predicted much larger victory margins. Our models explained about 68–88% of the variation, suggesting almost an extra vote in the margin for each additional female voter. This implies women's turnout substantially boosted candidates' success in that period. By 2021, the effect remained significant but weaker (with the model's R^2 dropping to ~32%), indicating women's turnout had a diminishing influence on margins as other factors (such as higher youth turnout or digital campaigning) became more important. The analysis has important limitations. We used aggregated constituency data, which risks inferring individual behavior from group totals. We also omitted factors like voter age, ethnicity, income, and urban–rural context that could affect victory margins. The simple linear regression may oversimplify dynamic electoral processes. These issues (aggregation bias, omitted variable bias, and simplifying assumptions) mean the turnout–margin link should be interpreted with caution.

These results have significant theoretical and practical implications. Theoretically, they demonstrate a clear gendered turnout effect even in a multi-ethnic setting: higher female turnout correlates with larger victory margins across Sarawak's diverse constituencies. Practically, this suggests mobilizing women voters can be decisive in elections. Political parties, campaign groups, and civil society organizations thus have strong incentives to invest in women's voter education

and outreach. Recognizing this turnout–margin relationship underscores the need for gender-responsive electoral strategies: actively engaging women voters can strengthen democratic competition and inclusion. Future research should address these gaps and deepen our understanding of the gender-turnout link. Incorporating additional demographic and socio-economic variables in panel or multilevel models could reveal how different factors interact with turnout. Spatial analyses might identify local turnout "hotspots" and contextual patterns that aggregate models miss (Ahmad et al., 2024, 2025; Ariffin et al., 2024; Bismelah et al., 2024; Jubit et al., 2023; Masron et al., 2024; Mohd Ali et al., 2025; Zakaria et al., 2025). Nonlinear methods or machine learning techniques could capture complex relationships beyond linear trends. Finally, combining aggregate analysis with micro-level data (such as voter surveys) would validate and enrich these findings.

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