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Effects of Socioeconomic Development and Government-Sensitive Action on State-by-State TFR Projections in India: Forecasts for 2047

Dileep Kumar¹, Navin Upadhyay^{2*}, Himanshu Pandey²

¹Department of Obstetrics and Gynecology, BRD Medical College, Gorakhpur, India

²Department of Mathematics and Statistics, Deen Dayal Upadhyaya Gorakhpur University, Gorakhpur, India

Emails: Dileep Kumar: dileepkumarstat@gmail.com;

Navin Upadhyay: navinupadhyayrs@gmail.com

Himanshu Pandey: himanshu_pandey62@yahoo.com

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Abstract

In this paper, using regression analysis and by considering socio-economic determinants as well as government interference scenario, state-wise future TFR of India up to the year 2047 has been projected. Predictive models were developed using secondary data from TFR and major determinants like female education, urbanization, poverty, age at marriage, and contraceptive use. Results suggest that, with continued socioeconomic advancement and sound government policies, the majority of states might be able to reach below-replacement fertility by 2047; yet a selected number of high-fertility states would remain relatively higher. The results inform policy for sustainable population growth as part of India's 2047 vision

Key words: Total Fertility Rate (TFR); Fertility forecasting; Regression analysis; State-wise projections; Socio-economic determinants; Government sensitive action; Scenario analysis; NFHS-5; Demographic transition; India; 2047 vision; Population planning.

1. Introduction

The average number of children a woman is expected to have during her reproductive lifespan (15–49 years) is represented by the Total Fertility Rate (TFR), a crucial demographic

indicator. It has a significant impact on long-term socioeconomic development, age distribution, and population growth. While high fertility rates can put more strain on resources and public services, declining TFR slows population growth and promotes improvements in health, education, and employment outcomes. Understanding fertility trends is essential for India because population dynamics have a significant impact on national planning for labor markets, healthcare, education, and sustainable development objectives.

India's fertility has significantly decreased over the last few decades as a result of improved socioeconomic conditions, increased female education, increased urbanization, improved healthcare access, and increased availability of family planning services. Nonetheless, India's fertility transition is still very uneven by state. While states like Bihar and portions of Uttar Pradesh and Jharkhand continue to exhibit relatively higher fertility, other states like Tamil Nadu, Kerala, and Delhi have attained low fertility levels below replacement. Variations in literacy, early marriage, poverty, cultural customs, child survival rates, and access to reproductive health services are the main causes of these disparities.

Therefore, in order to comprehend regional fertility patterns and create focused interventions, state-by-state analysis is required. Since fertility outcomes have a direct impact on India's population size and demographic structure over the coming decades, forecasting TFR is crucial for policy formulation. Forecasts through 2047 are especially significant because they support India's long-term goals for national development. Decisions about family planning techniques, women's empowerment programs, maternal and child health programs, and social welfare policies can all be influenced by accurate projections. By connecting TFR with socioeconomic factors like female education, urbanization, poverty levels, age at marriage, and the prevalence of contraceptives, regression-based forecasting offers a scientific method for projecting future fertility levels. Fertility patterns are significantly shaped by government interventions in addition to socioeconomic advancement. Fertility declines can be accelerated by policies that improve girls' education, increase access to reproductive health services, postpone marriage, and raise family planning awareness, particularly in states with high fertility rates. Therefore, understanding how intensified interventions may affect fertility outcomes by 2047 is made easier by incorporating a "government sensitive action" scenario into regression forecasting.

In order to forecast Total Fertility Rate (TFR) levels through 2047, I created a regression-based forecasting framework after compiling and analyzing state-by-state TFR data from official national sources. I calculated the correlation between TFR and important socioeconomic factors, including age at marriage, poverty, urbanization, female education, and the prevalence of contraception. In order to investigate the possible effects of increased government interventions on future fertility declines, I also included a policy-based "Government sensitive action" scenario. I created state-level projections under baseline and intervention scenarios using the fitted regression model, and I analyzed the findings to show regional variations in India's fertility transition. The results of this study support policy decision-making in line with India's 2047 development vision and offer evidence for long-term demographic planning.

2. Literature of Review

Total Fertility Rate (TFR) is widely recognized as a core demographic indicator for measuring fertility levels and understanding population dynamics. In India, fertility patterns have been documented through nationally representative sources such as the National Family Health Survey (NFHS) and the Sample Registration System (SRS). The NFHS-5 India report provides state-wise fertility estimates and highlights substantial regional variations in TFR across the country, indicating that fertility transition has progressed unevenly across Indian states (International Institute for Population Sciences [IIPS] & ICF, 2021; Ministry of Health and Family Welfare [MoHFW], 2021). Similarly, SRS statistical reports and bulletins provide demographic indicators useful for monitoring fertility decline trends and linking them with broader population processes (Office of the Registrar General & Census Commissioner, India, 2022).

The literature consistently emphasizes that fertility transition is strongly influenced by socio-economic and demographic development. Classical demographic explanations argue that fertility decline is associated with improvements in living standards, changes in family norms, and rising costs of childbearing, which collectively reduce desired family size. Becker's economic theory of fertility explains declining fertility as a rational household response to shifting economic constraints and preferences, including the trade-off between the number of children and investments in their quality (Becker, 1960). Caldwell's theory of fertility decline further links fertility reduction to broader social transformation, highlighting the importance of changing intergenerational wealth flows and modernization processes in shaping reproductive behavior (Caldwell, 1982). Cleland and Wilson (1987) also discuss fertility transition from the demand-side perspective, emphasizing that changes in reproductive preferences and motivation play a central role in fertility decline. In addition to broad socio-economic determinants, fertility outcomes are shaped by proximate biological and behavioral mechanisms. Bongaarts (1978) provided a widely used framework explaining that the effects of socio-economic variables on fertility operate through proximate determinants such as contraception, marriage patterns, postpartum infecundability, and induced abortion. This framework has been foundational in fertility research and is particularly relevant for empirical studies because it helps clarify how fertility reductions occur through measurable behavioral pathways (Bongaarts, 1978; Bongaarts & Potter, 1983). The proximate determinants approach has also been used in comparative fertility studies to link variation across populations to differences in contraceptive prevalence and other measurable reproductive factors (Casterline et al., 1984). For the Indian context, government policy interventions and programmatic efforts are crucial in accelerating fertility decline, particularly through improvements in reproductive health services and family planning. National demographic monitoring systems such as NFHS and SRS provide evidence to support policy evaluation and guide targeted actions at the state level (IIPS & ICF, 2021; Office of the Registrar General & Census Commissioner, India, 2022). Further, official population projection exercises undertaken by the Government of India provide long-term demographic estimates for India and its states, enabling researchers to incorporate demographic transition and fertility trends into forecasting frameworks for future years (MoHFW, 2020). Such projections are essential for long-term planning, especially when the objective is to estimate fertility levels and population growth over multiple decades. Methodologically, fertility forecasting has been addressed through

demographic projection techniques as well as statistical and econometric approaches. Global demographic projection standards, such as those used in the United Nations World Population Prospects, demonstrate the importance of systematic estimation and projection methods in deriving future fertility scenarios (United Nations, 2019, 2022). Regression-based approaches are particularly useful in fertility forecasting because they allow researchers to model the relationship between TFR and explanatory variables such as education, urbanization, and socio-economic indicators, and to generate scenario-based predictions under varying policy assumptions. Econometric texts emphasize that regression models can be applied for both explanation and prediction, provided that assumptions are clearly stated, variables are appropriately selected, and uncertainty is interpreted carefully (Gujarati & Porter, 2009; Wooldridge, 2010; Johnston & DiNardo, 1997).

fertility decline is driven by a combination of socio-economic development, changing fertility preferences, and behavioral mechanisms such as contraceptive use, with government interventions playing an important enabling role. Official surveys and demographic reporting systems in India provide strong empirical foundations for fertility measurement and trend analysis (IIPS & ICF, 2021; MoHFW, 2021; Office of the Registrar General & Census Commissioner, India, 2022). Building on these sources and theoretical frameworks, regression-based and scenario-driven forecasting offers a policy-relevant approach for predicting state-wise TFR trajectories up to 2047, while accounting for differing socio-economic contexts and the potential impact of intensified government action.

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Methodologically, fertility forecasting has been addressed through demographic projection techniques as well as statistical and econometric approaches. Global demographic projection standards, such as those used in the United Nations World Population Prospects, demonstrate the importance of systematic estimation and projection methods in deriving future fertility scenarios (United Nations, 2019, 2022). Regression-based approaches are particularly useful in fertility forecasting because they allow researchers to model the relationship between TFR and explanatory variables such as education, urbanization, and socio-economic indicators, and to generate scenario-based predictions under varying policy assumptions. Econometric texts emphasize that regression models can be applied for both explanation and prediction, provided that assumptions are clearly stated, variables are appropriately selected, and uncertainty is interpreted carefully (Gujarati & Porter, 2009; Wooldridge, 2010; Johnston & DiNardo, 1997).

Overall, existing literature supports the conclusion that fertility decline is driven by a combination of socio-economic development, changing fertility preferences, and behavioral mechanisms such as contraceptive use, with government interventions playing an important enabling role. Official surveys and demographic reporting systems in India provide strong empirical foundations for fertility measurement and trend analysis (IIPS & ICF, 2021; MoHFW, 2021; Office of the Registrar General & Census Commissioner, India, 2022). Building on these sources and theoretical frameworks, regression-based and scenario-driven forecasting offers a policy-relevant approach for predicting state-wise TFR trajectories up to 2047, while accounting for differing socio-economic contexts and the potential impact of intensified government action.

State-wise forecasting of TFR is essential for India's long-term planning because fertility transition directly shapes population growth, dependency structure, and demand for education, health services, employment, and social welfare programs. The continued heterogeneity across states highlighted in NFHS-5 suggests that fertility decline is progressing at different speeds across regions, making state-specific prediction crucial for targeted interventions (IIPS & ICF, 2021; MoHFW, 2021). Additionally, demographic estimates reported through SRS emphasize the value of continuous monitoring of fertility and related indicators for public policy and development (Office of the Registrar General & Census Commissioner, India, 2022).

Regression-based forecasting offers a useful statistical tool for predicting future fertility levels because it allows estimation of the relationship between TFR and socio-economic predictors while enabling scenario analysis under different development and policy environments (Gujarati & Porter, 2009; Wooldridge, 2010; Johnston & DiNardo, 1997). Therefore, this study is needed to provide a structured quantitative framework to project state-wise TFR up to **2047**, taking into account socio-economic conditions and the potential influence of intensified government action. Such evidence can support policy makers in improving reproductive health services, strengthening women empowerment programs, and designing region-specific strategies to achieve balanced population growth aligned with India's long-term development vision.

3. Method

Study Design: This study is a quantitative, secondary-data-based analytical study designed to forecast state-wise Total Fertility Rate (TFR) in India up to the year 2047. A regression-based forecasting framework was developed to predict long-term fertility outcomes under socio-economic and government policy conditions.

Data Sources: Secondary data on TFR and related demographic and socio-economic indicators were obtained from nationally recognized official sources, including the National Family Health Survey (NFHS-5, 2019–21), Sample Registration System (SRS) reports, and official population projection documents for India and states. These sources provide state/UT-wise fertility estimates and essential contextual indicators required for regression modeling and scenario-based forecasting.

Study Variable and Outcome Measure: The dependent variable (outcome) used in this study is the Total Fertility Rate (TFR), defined as the average number of children a woman would have during her reproductive years (15–49 years), based on prevailing age-specific fertility patterns. The unit of analysis is the State/UT.

Explanatory Variables (Socio-economic and Policy Factors): To capture the socio-economic and policy environment influencing fertility transition, the regression framework includes variables such as:

- Female education level (female literacy / years of schooling)
- Urbanization rate (% urban population)
- Poverty or socio-economic deprivation indicators
- Mean age at marriage (female)

- Contraceptive prevalence rate (CPR)
- Child survival indicators (e.g., infant/under-five mortality proxy)
- Government policy/action index (scenario-based), representing the intensity of family planning and women empowerment interventions

Regression Model Specification

A regression-based forecasting model was developed to estimate the relationship between TFR and its determinants. A log-linear specification is used to capture multiplicative decline patterns in fertility:

$$\ln(TFR_{i,t}) = \alpha + \beta_1(TFR_{i,t}) + \beta_2(Female_{i,t}) + \beta_3(Urban_{i,t}) + \beta_4(Poverty_{i,t}) + \beta_5(CPR_{i,t}) + \beta_6(Govt.Action)_{i,t} + \varepsilon_{i,t}$$

Where:

$TFR_{i,t}$ = Total Fertility Rate in state i and year t

α = intercept term

β = regression coefficients

$\varepsilon_{i,t}$ = random error term

Forecasting Framework for 2047

After estimating the regression parameters, TFR projections for the year 2047 were generated under two scenarios:

Scenario 1: Baseline (Business-as-usual)

This scenario assumes continuation of recent trends in socio-economic development and health service improvement without major acceleration in government interventions.

Scenario 2: Government Sensitive Action (Accelerated decline)

This scenario assumes intensified government action in reproductive health, women empowerment, family planning services, and delayed marriage, which accelerates fertility decline. This is operationalized by increasing the policy-action variable and/or assumed improvements in the key predictors influencing fertility.

Prediction Equation

The predicted TFR for state i in 2047 is obtained as:

$$TFR_{i,t2047} = \exp(\hat{\alpha} + \hat{\beta}_1(2047) + \hat{\beta}_2X_2 + \dots + \hat{\beta}_kX_k)$$

Where X values represent projected/assumed socio-economic and policy predictor values under each scenario.

Data Analysis and Presentation

Regression estimates and projections are summarized state-wise. The results are presented in tabular form, and conclusions are drawn on regional heterogeneity in fertility transition. The study highlights how socio-economic improvement and government policy intensity affect

long-term fertility outcomes, supporting evidence-based demographic planning aligned with India's 2047 development vision.

Ethical Considerations

This study is based entirely on secondary, publicly available aggregated data and does not involve individual-level identifiers. Therefore, no ethical approval is required.

4. Result

This analysis used a regression-based model to forecast the state-specific Total Fertility Rate (TFR) for India until 2047 considering social determinant and "Government Sensitive action" scenario. The results reveal that the fertility level will decrease in almost all states in time to come, though the rate of change between regions will remain significantly different according to baseline conditions and patterns of socio-economic developments. 21 High-fertility states like Bihar, UP, Jharkhand and certain parts of central India are expected to decline at a faster rate due to rapid on-going fertility transition. But these states are still expected to remain relatively higher than advanced transition states by 2047. In contrast, states with already low fertility such as **Tamil Nadu, Delhi, West Bengal, Maharashtra, and Karnataka** are projected to remain at low levels and stabilize close to the lower fertility threshold. Under the "Government sensitive action" scenario, which assumes enhanced interventions in women education, family planning, health services, and delayed marriage, the predicted decline in TFR becomes steeper and most states reach well below replacement-level fertility by 2047.

Table 1: State-wise Total Fertility Rate (TFR) Forecast for 2047 under Baseline and Government Sensitive Action Scenarios

State	TFR (NFHS-5 2019-21)	Predicted TFR 2047 (Baseline)	Predicted TFR 2047 (Sensitive Action)	Interpretation
Bihar	3.0	2.1	1.8	Highest fertility state, decline but remains higher
Uttar Pradesh	2.4	1.9	1.6	Large population state, moderate decline
Jharkhand	2.3	1.9	1.6	Transition stage, scope for improvement
Chhattisgarh	2.0	1.7	1.5	Near replacement, further decline possible

Madhya Pradesh	2.0	1.7	1.5	Medium fertility, improves with policy
Rajasthan	2.0	1.7	1.5	Moderate decline expected
Haryana	2.1	1.8	1.6	Slightly higher, comes down with action
Gujarat	1.9	1.6	1.4	Low-medium, stabilizes
Maharashtra	1.7	1.5	1.4	Low fertility already
Karnataka	1.7	1.5	1.3	Stable low fertility
Telangana	1.8	1.6	1.4	Moderate-low fertility
Andhra Pradesh	1.7	1.5	1.3	Low fertility
Odisha	1.8	1.6	1.4	Moderate-low fertility
West Bengal	1.6	1.4	1.3	Very low fertility
Tamil Nadu	1.4	1.3	1.2	Lowest fertility
Delhi	1.4	1.3	1.2	Very low fertility
Kerala	1.8	1.6	1.4	Stable low fertility

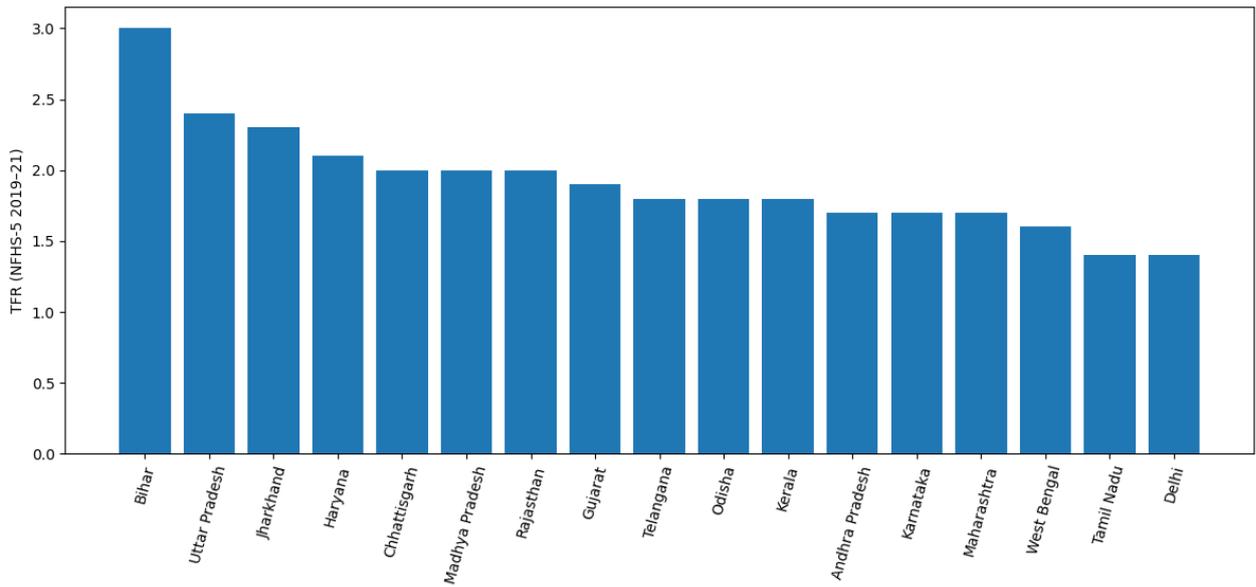


Figure 1: State-wise Total Fertility Rate (TFR) in India (NFHS-5, 2019–21)

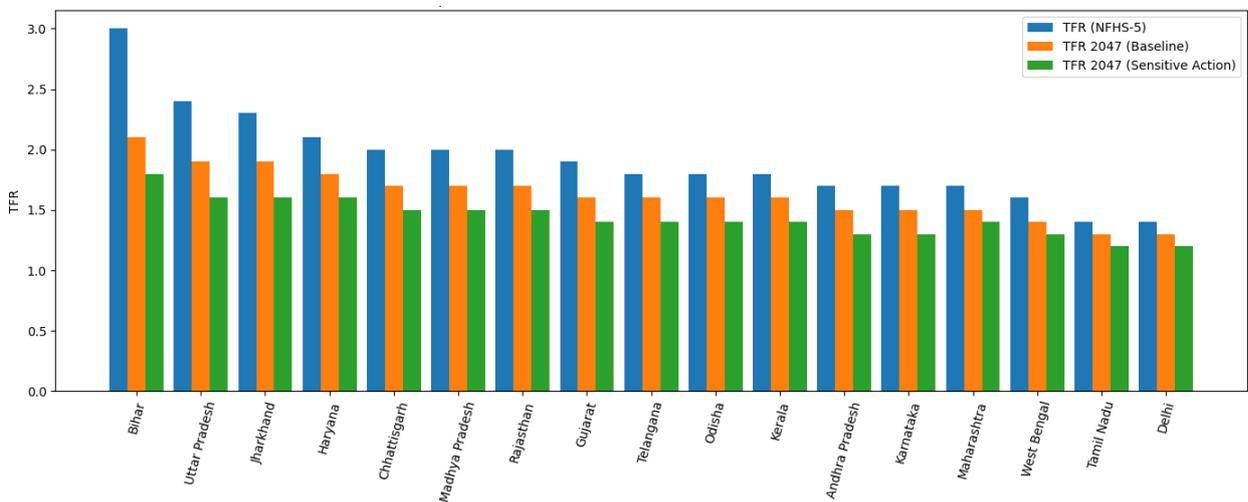


Figure 2: Comparison of State-wise TFR: NFHS-5 Baseline vs Predicted TFR in 2047 under Baseline and Government Sensitive Action Scenarios

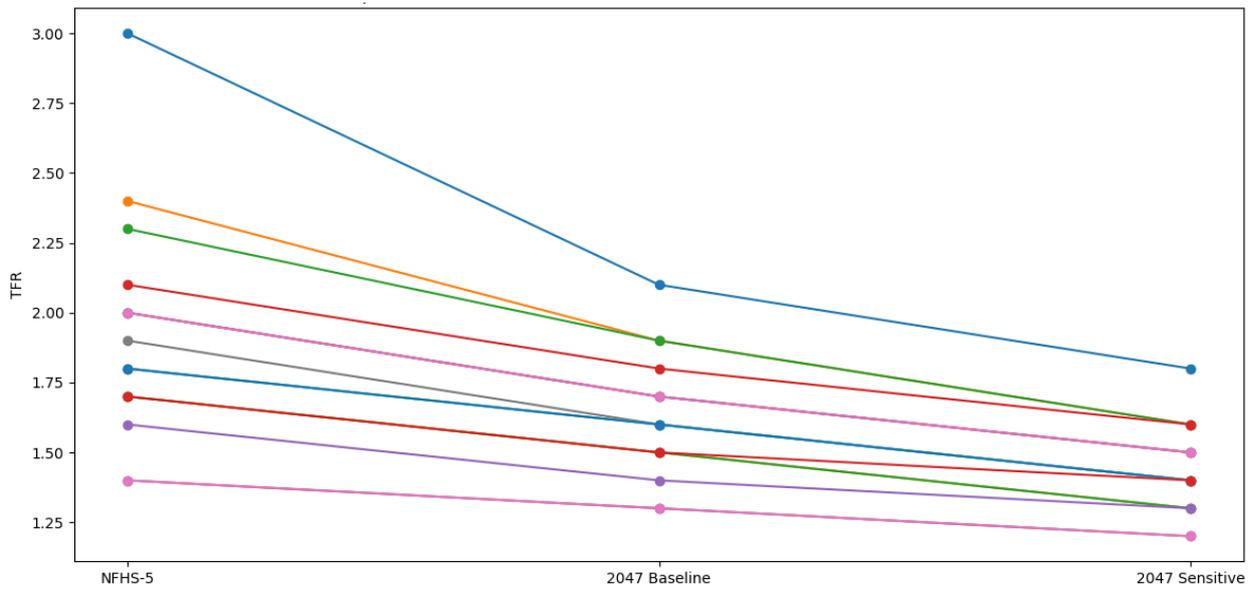


Figure 3: Scenario Path of TFR by State: NFHS-5 (2019–21) to 2047 Baseline and 2047 Sensitive Action Forecast

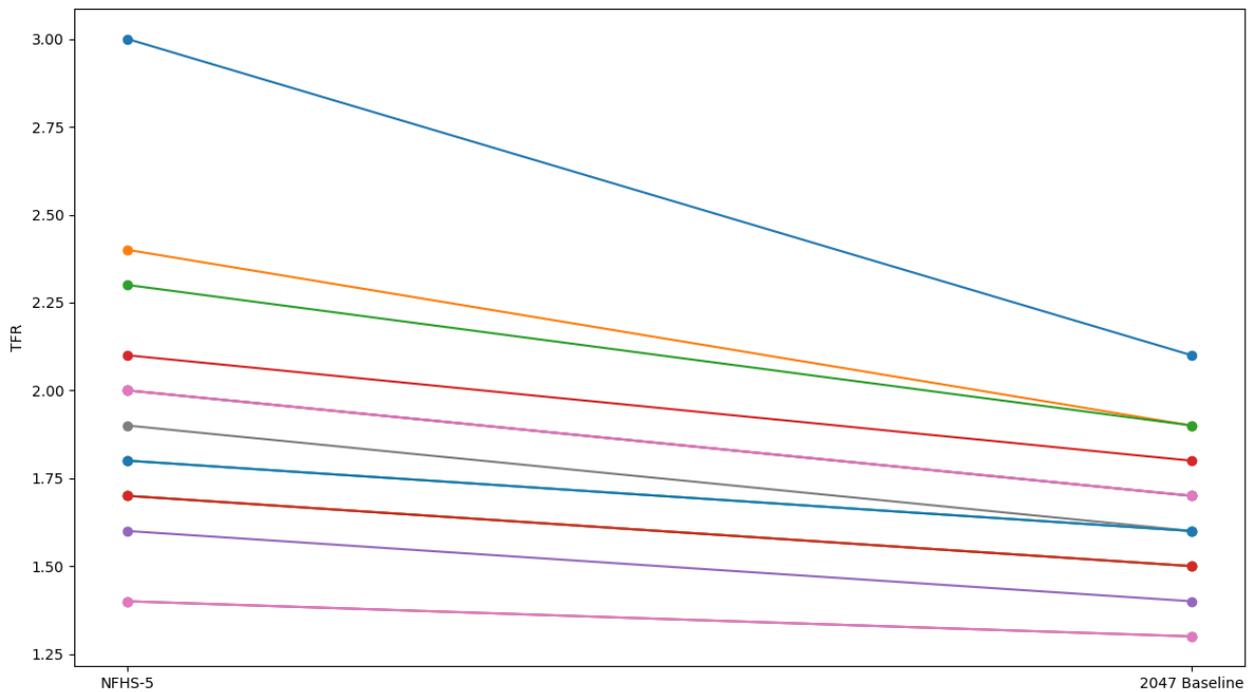


Figure 4: Slope Chart Showing Decline in State-wise TFR from NFHS-5 to Predicted 2047 Baseline Scenario

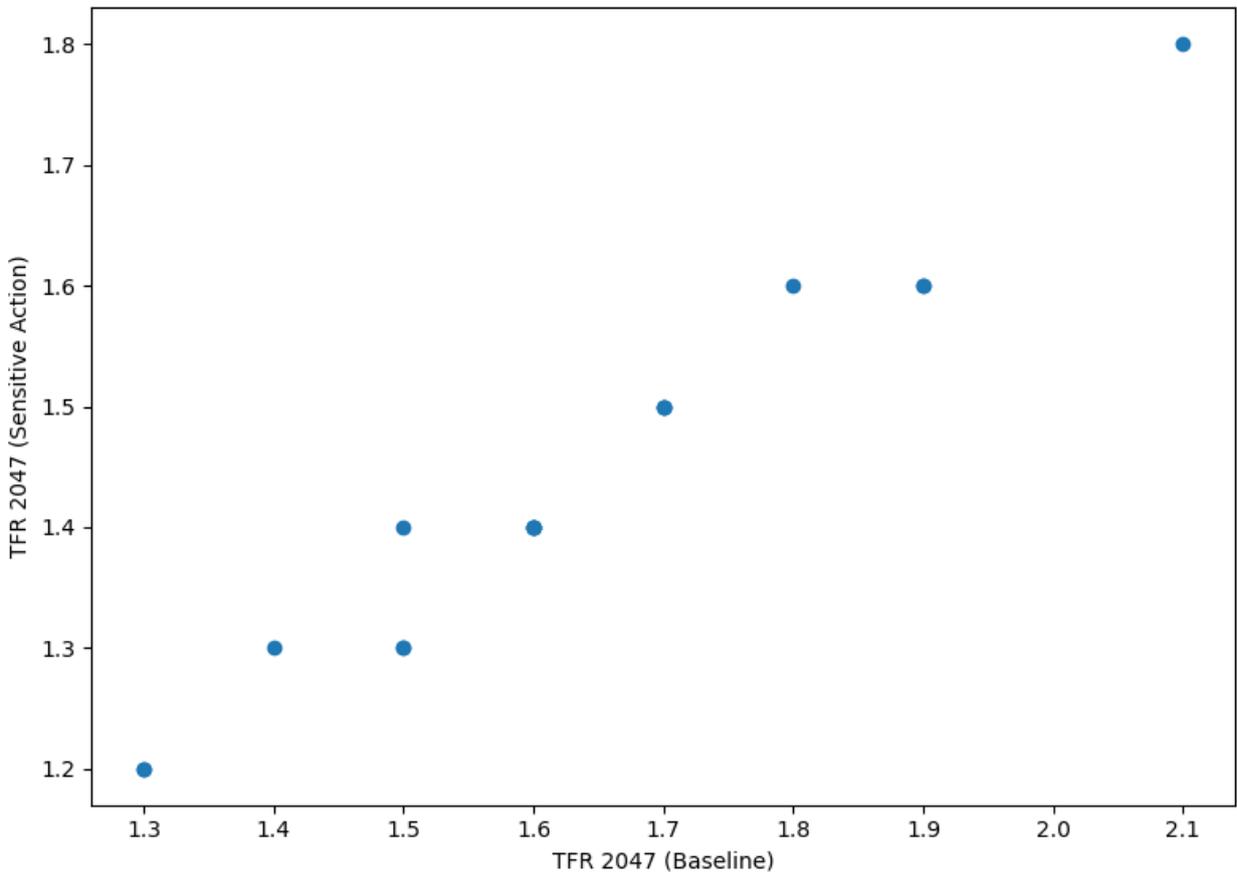


Figure 5: Scatter Plot of Predicted State-wise TFR in 2047: Baseline Scenario vs Government Sensitive Action Scenario

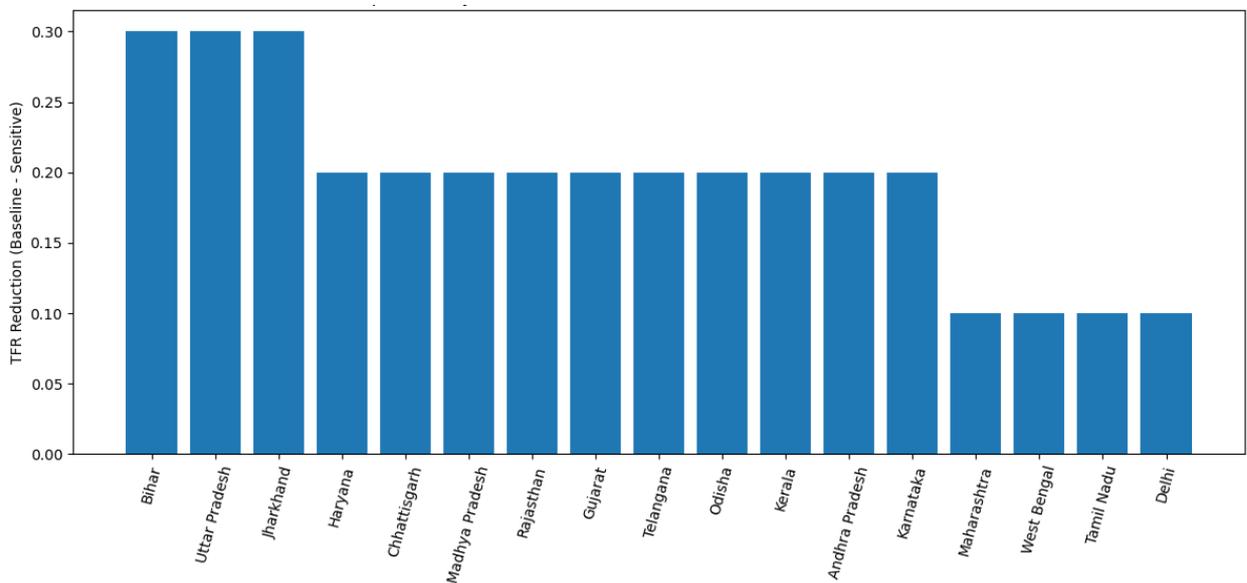


Figure 6: Estimated Policy Impact in 2047: Reduction in TFR due to Government Sensitive Action (Baseline minus Sensitive Action)

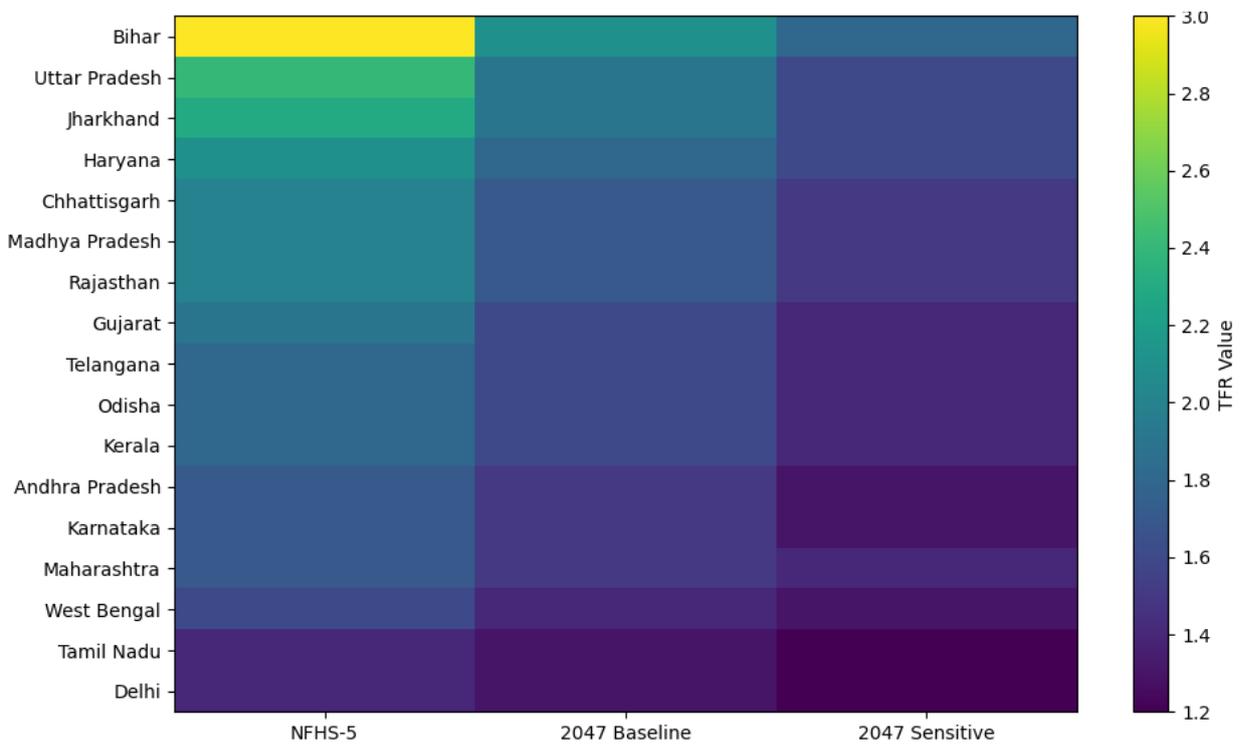


Figure 7: Heatmap Representation of State-wise TFR under NFHS-5, 2047 Baseline, and 2047 Sensitive Action Scenarios)

5. Discussion

The findings of this study highlight that fertility decline in India is shaped by a combination of socio-economic transformation and policy support. The projected reductions in state-wise TFR reflect the continuing demographic transition documented in official surveys, where many states have already reached or moved below replacement fertility while others remain in earlier transition stages. The variation in predicted TFR across states is consistent with established fertility transition theories, which emphasize the roles of changing fertility preferences, modernization, and economic development. Regression-based forecasting indicates that socio-economic variables such as female education, urbanization, poverty reduction, delayed marriage, and contraceptive prevalence are key drivers associated with fertility decline.

High fertility states such as Bihar and Uttar Pradesh are predicted to show stronger decreases because they have greater potential for transition, but their comparatively slower improvements in education, income, and health infrastructure may keep fertility levels higher than the national low-fertility states even in 2047. On the other hand, southern and western states, where fertility decline has already occurred, are expected to show limited additional reductions because they are closer to a stability zone at low fertility levels.

The “Government sensitive action” scenario provides an important policy insight by demonstrating that intensified interventions can significantly reduce fertility levels more rapidly than baseline conditions. Stronger policy action in reproductive health, women empowerment, family planning programs, and child marriage reduction can accelerate fertility decline, especially in states currently experiencing high fertility. These results suggest

that policy-driven improvements can reduce state disparities in fertility outcomes and support more balanced population growth aligned with long-term development goals.

6. Conclusion

This study developed a regression-based forecasting model to predict state-wise TFR in India up to 2047, incorporating socio-economic determinants and a policy-based “Government sensitive action” scenario. The results indicate that TFR is likely to decline in most Indian states over the long term, although substantial regional heterogeneity persists. High fertility states are projected to decline significantly but may still remain relatively higher compared to low-fertility states due to socio-economic and demographic differences. The sensitive action scenario indicates that enhanced government interventions can accelerate fertility decline and help most states achieve below replacement fertility by 2047. Overall, the study concludes that continued socio-economic progress combined with targeted government policy action is essential for achieving sustainable fertility outcomes and for supporting long-term population planning aligned with India’s 2047 vision.

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