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Prediction of fertility parameters in Ilam city in five-year intervals up to the horizon of 2051

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A B S T R A C T

Introduction: Population dynamics are central to policymaking and future planning, commanding perpetual governmental attention across economic, social, and cultural domains. This study focuses on forecasting fertility indicators in Ilam city, projecting trends in five-year intervals up to 2051.

Materials & Methods: The "secondary document analysis" method was employed, utilizing data from the country's population censuses (1976-2016), birth events, and population statistics reported by Iran's National Organization for Civil Registration. The urban area of Ilam served as the study's location. A mixed-method approach to population forecasting, involving the use of Spectrum, Mortpak, and Excel, was employed for fertility status prediction and analysis.

Results: The research outcomes indicate that under two scenarios with fixed and minimal thresholds (fertility rates of 1.8 and 1.5, respectively), the net reproduction rate (NRR) would fall below one girl.

Conclusion: Based on these scenarios, it is evident that girls cannot replace their mothers in bearing children, contributing to the observed decline in fertility and, consequently, the population of Ilam city.

Keywords: Fertility indicators, Population, Ilam city

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Introduction

The fluctuation in fertility rates emerges as a paramount demographic concern in recent years in Iran, leading to the formulation of population policies that assign roles to organizations addressing this pivotal issue (1). Fertility dynamics in Iran prompt national policies influenced by cultural, normative, religious, and educational factors (2). The provincial assessment of fertility rates in Iran indicates a trend toward sub-replacement rates since the early 1990s. In 1997, four provinces (Guilan, Tehran, Semnan, and Isfahan) recorded sub-replacement fertility rates (3). The 1999 report from the Statistical Center of Iran stated a national rate of 2.06 (1.88 and 2.39 for urban and rural areas, respectively). From 1996-2000, five out of 28 provinces had sub-replacement fertility rates, while 20 provinces had rates of 2-3, two provinces had rates of 3-4, and Sistan and Baluchistan had a rate of 5. In 2012, South Khorasan, Sistan and Baluchistan, Kohkiloyeh and Boyer Ahmad, and Kurdistan experienced the highest fertility rates, while the rest of the provinces had rates below 2. The lowest fertility rates were in Tehran, Isfahan, Mazandaran, and Merkazi. Despite an increasing population of women of reproductive age, births decreased from 2.2 million in 1986 to 1.35 million in 2011. Changes in the age pyramid cannot justify the fertility decrease, necessitating exploration of other reasons (4). Nasiri et al. (5) investigated the effects of economic factors on the fertility rate in Iran, concluding that total annual household expenses did not significantly impact the fertility rate. Another index, gross domestic product (GDP) per capita, indicated that pure economic indicators were not as significant as sociocultural variables, particularly women's employment status, in determining fertility.

Naderi Nabi et al. (1) (2020) examined fertility changes in Iran based on live birth sequences from 2006-2016. The study analyzed data on the birth rate of 15-49-year-old married women, comprising 2% of the sample population (983,000 people) from the 2006-2016 census. The live birth sequence ratio from no child to one child (85%) and from one child to two children (76%) remained almost constant, but it decreased from three to four children (75% to 61%). Cumulative fertility in Iran increased from 3.2 in 2006 to 5.2 in 2016, indicating acceptable fertility among married women. Population policies targeting economic and welfare infrastructures, inflation reduction, job creation, and improved housing conditions aim to promote marriage and ultimately enhance fertility.

Ahmadian & Mehrabani (2) (2013) assessed the impact of economic factors and women's education level on the fertility rate in Tehran, noting substantial negative effects from both women's and men's education, with the former having a more prominent impact.

In another study, Dreze & Morthi (6) (2001) analyzed data from 14 important states of India, representing 96% of the country's population, and found strong negative impacts of women's literacy on the fertility rate and neonatal mortality during 1981-91.

Bahat et al. (7) (2002) observed in India that women's literacy level had a strong negative effect on fertility

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during the initial stages of demographic transition. However, as the transition progressed, this effect weakened and was replaced by other factors.

Osili & Long (8) (2008) investigated the universal primary education program in Nigeria using econometric tools and concluded that women's higher education would decrease fertility, with each year of higher education corresponding to a decrease of 0.26 in fertility.

Becker, Sinirella, and Wossman (9) (1973) analyzed data from over 330 counties in Germany to explore the relationship between education and fertility, reporting that education (i.e., enrollment in primary schools) had a negative impact on fertility (i.e., the ratio of the number of 5-year-old or younger children to the number of 15-45-year-old women).

According to the latest population and housing census in Iran in 2016, Ilam province had a population of 580,158, residing in 25 urban and 676 rural places. The total urban and rural population of Ilam province was 395,263 and 184,444, respectively, with 451 non-residents. This means that 68.13% of the province's population lives in urban areas, 31.79% in rural areas, and 0.08% are nomads. The trend of urbanization in Ilam province increased from 19.75% in 1976 to 68.13% in 2016, signifying a rapid transformation from a completely rural context to urbanization. The turning point occurred between 1986 and 1996 when the urban population exceeded the rural population, reaching 53.23% in 1996.

The trend of urbanization in Iran from 1976 to 2016 reveals a constant increase in the country's urban population, rising from 15,854,680 in 1976 to 59,146,847 in 2016 (3.73 times). The average growth of the country's urban population from 1976-2016 was estimated at 3.35%. The rate of urbanization varied across census periods, with the largest absolute increase observed between 1996 and 2006, standing at 11,442,175. The country's urbanization index showed an ascending trend in the urbanization rate, increasing from 47.03% in 1976 to 74.0% in 2016 (National Statistics Research Organization).

Comparing Ilam province's urban population developments with the whole country reveals similarities and differences. The province experienced a similar increase in urban population during 1976-2016, with the largest growth occurring between 1976 and 1986 (compared with 1996-2006 in the country). The growth rate of the urban population in Ilam province was higher than the national average during 1976-2016 (5.38% versus 3.35%). However, between 1996 and 2006, the country's urban population experienced a larger growth compared to its prior decade (1986-75), which was not observed in the urban population of Ilam province. In 2016, the urbanization rate in Ilam province was lower than the national average (68.13% versus 74.0%). Despite rapid changes in the rate of urbanization in Ilam province, the country's rate of urbanization has consistently been higher.

Given the above, it is necessary to analyze the trend of the fertility rate in Ilam city to prevent the ramifications of population shrinkage in the future.

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In this research, our aim is to estimate the fertility index in Ilam city up to the 2051 horizon and scrutinize possible scenarios and their outcomes.

Materials and Methods

The study employed the "secondary document analysis" method to conduct its research. Secondary analysis, also known as secondary data analysis, involves examining the study's objectives based on existing data collected by statistical centers, such as Iran's Statistics Center. The primary sources for this study comprised data from population censuses conducted in Iran between 1976 and 2016, along with data on birth events and population statistics reported by Iran's National Organization for Civil Registration.

The research focused on the city complex of Ilam in 2017. A combined method of population forecasting was utilized to predict and analyze the future population of Ilam. Using the population data of Ilam city in 2016 as a baseline, and guided by a series of hypotheses and scenarios, projections were made for the horizon of 2051. Descriptive parameters and population models were employed to analyze the data, and population forecasting indicators were generated with the assistance of population software, including Spectrum, Mortpak, and Excel.

Results

Table 1 illustrates the forecasted results for two fertility parameters, namely Total Fertility Rate (TFR) and Net Reproduction Rate (NRR), in Ilam city across four designated scenarios at five-year intervals from 2016 to 2051. The TFR for the year 2051 was determined for each scenario, with each corresponding to the assumed fertility rate.

In the upper-limit scenario, assuming a fertility rate of 2.5, the TFR in Ilam city for 2051 is projected to be 2.5 children. The middle-limit scenario, aiming for replacement level (2.1 children), predicts a TFR of 2.1 children in 2051. The fixed-limit scenario, characterized by a constant fertility rate of 1.8 from 2016 to 2051, forecasts a TFR of 1.8 children in 2051. Lastly, the lower-limit scenario, with a fertility rate of 1.5 children, anticipates a TFR of 1.5 children in Ilam city for 2051.

For the NRR in 2051, the upper-limit scenario (fertility rate of 2.5) predicts an NRR of 21 girls in Ilam city. The middle-limit scenario (fertility rate at replacement level, 2.1 children) anticipates an NRR of 1.01 girls. The fixed-limit scenario, with a constant fertility rate of 1.8 from 2016 to 2051, projects an NRR of 0.88 girls in Ilam city in 2051. Finally, the lower-limit scenario (fertility rate of 1.5 children) foresees an NRR of 0.73 girls in 2051.

Table 1. Prediction of Fertility Indicators in Ilam City (2016-2051) Across Four Scenarios for Fertility Rate

Years	Ascending fertility with a steep slope (2.5 children)	Ascending fertility up to the replacement threshold (2.1	Stable fertility (1.8 children)	Descending fertility (1.5 children)

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			children)					
	TFR	NRR	TFR	NRR	TFR	NRR	TFR	NRR
2016	1.8	0.88	1.8	0.88	1.8	0.88	1.8	0.88
2021	1.9	0.90	1.84	0.88	1.8	0.88	1.76	0.86
2026	2.0	0.95	1.89	0.90	1.8	0.88	1.71	0.84
2031	2.1	1.00	1.93	0.92	1.8	0.88	1.67	0.82
2036	2.2	1.05	1.97	0.95	1.8	0.88	1.63	0.79
2041	2.3	1.10	2.01	0.97	1.8	0.88	1.59	0.77
2046	2.4	1.15	2.06	0.99	1.8	0.88	1.54	0.75
2051	2.5	20.1	2.1	1.01	1.8	0.88	1.50	0.73

TFR: Total Fertility Rate, NRR: Net Reproduction Rate

As indicated in Table 1, in the fixed-limit and lower-limit fertility scenarios, featuring total fertility rates of 1.8 and 1.5, the Net Reproduction Rate (NRR) drops below one daughter. This implies that, in these scenarios, girls cannot replace their mothers in bearing children. This phenomenon is a contributing factor to the decline in fertility and, consequently, the population in Ilam city.

Table 2. Prediction of Average Maternal Age and Children-to-Women Ratio in Ilam City (2016-2051) Across Four Scenarios for Fertility Rate

Years	Ascending fertility with a steep slope (2.5 children)		Ascending fertility up to the replacement threshold (2.1 children)		Stable fertility (1.8 children)		Descending fertility (1.5 children)	
	AMA	CWR	AMA	CWR	AMA	CWR	AMA	CWR
2016	27.4	0.27	27.4	0.27	27.4	0.27	27.4	0.27
2021	27.4	0.29	27.4	0.29	27.4	0.29	27.4	0.28
2026	27.4	0.25	27.4	0.25	27.4	0.24	27.4	0.23
2031	27.6	0.25	27.4	0.23	27.4	0.21	27.4	0.20
2036	27.8	0.27	27.4	0.24	27.4	0.22	27.4	0.20
2041	27.9	0.32	27.4	0.28	27.4	0.25	27.4	0.23
2046	28.1	0.36	27.5	0.31	27.4	0.28	27.4	0.24
2051	28.3	0.39	27.6	0.31	27.4	0.27	27.4	0.23

AMA: Average Maternal Age, CWR: Children to Women Ratio

Table 2 illustrates the predictions for two additional fertility indicators, namely average maternal age and child-to-woman ratio (CWR), in Ilam city over five-year intervals under four assumed fertility scenarios from 2016 to 2051.

In the upper-limit scenario, characterized by a fertility rate of 2.5, the average maternal age is projected to increase from 27.4 years in 2016 to 28.3 years in 2051. In the middle-limit

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scenario, where the fertility rate aligns with the replacement level (2.1 children), the average maternal age is expected to rise by 0.2 years, reaching 27.6 in 2051. The fixed-limit scenario, assuming a constant fertility rate of 1.8 from 2016 to 2051, indicates no change in the average maternal age, maintaining it at 27.4 years throughout. Similarly, in the lower-limit scenario (fertility rate of 1.5 children), the average maternal age is projected to remain constant at 27.4 years until 2051.

Child-to-woman ratio (CWR), as a fertility indicator, is presented in Table 2. Under the upper-limit scenario (fertility rate of 2.5), the CWR in Ilam city is forecasted to increase from 0.27 in 2016 to 0.39 in 2051. This implies that by 2051, for every 100 women of reproductive age (15-49 years) in Ilam city, there will be 39 children aged 0-4 years. In the middle-limit scenario (fertility rate equal to the replacement level, 2.1 children), the CWR in Ilam city in 2051 is projected to be 0.31 (31 up to 4-year-old children for every 100 women of reproductive age). In the fixed-limit scenario (fertility rate of 1.8 during 2016-2051), the CWR in Ilam city in 2051 remains constant at 0.27, indicating no change from 2016 due to the consistent fertility rate. Finally, under the lower-limit scenario (fertility rate of 1.5), the CWR in Ilam city in 2051 is anticipated to be 0.23.

Discussion

The period from the 1370s to 1380s witnessed a shift in population policies in Ilam, specifically, and Iran, generally, focusing on population growth reduction. However, contemporary population policies should adopt a multidimensional approach. Acknowledging the population transition status, these policies need to be dynamic and adaptable to new conditions. It is crucial to integrate current and future population dynamics into regional and national development plans, along with budget allocations. Developing effective population policies and laws necessitates awareness among legislators and policymakers regarding the prevailing population trends. Coordination among policymaking organizations, executive sectors, and educational institutes is vital for informed decision-making, facilitating the enactment of appropriate laws and allocation of necessary resources to address population-related challenges.

In a study by Afshari (2014) (4), the impact of major economic instability on fertility rates in Iranian women was explored. The findings suggested a negative relationship between provincial development levels and fertility rates. Economic development, leading to increased women's higher education and delayed marriage, negatively impacted fertility rates, aligning with Leibenstein's modernization theory. However, some studies indicated positive responses of fertility to increased women's participation rates and per capita income growth, consistent with the Pennsylvania doctrine predicting pro-cyclical fertility behavior.

Fetros et al. (2017) (10) investigated the relationship between women's employment rates and fertility rates in Iran. Their findings suggested negative correlations between marriage age, urbanization rate, per capita income, and fertility rate, while the employment rate showed a positive relationship. Increased employment rates and financial security were

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associated with higher fertility desires among Iranian women.

Manzouri et al. (2012) (11) examined the parameters of the healthy fertility program in Isfahan province, emphasizing the importance of counseling to reduce unwanted pregnancies and increase awareness about the correct use of contraceptives.

Sifori Togharjardi et al. (2019) (12) conducted a meta-analysis study on fertility determinants, identifying 45 variables impacting fertility rates significantly. Seven variables, including women's power in the family, women's education in economic transition, old age at marriage, women's physical fitness, risk of abortion, men's child care training, and women's education level, were highlighted for their substantial impact.

Azizi et al. (2015) (13) assessed the prevalence of underlying causes of high-risk pregnancies in Sanghar city, Iran. Urinary infection, history of abortion, and age $>$ 35 years or $<$ 18 years were identified as significant risk factors.

Addressing fertility and childbearing issues in Ilam city is imperative, considering the substantial changes observed since the mid-1980s. Despite the total fertility rate falling below replacement levels in the 2000s, the recent decade has witnessed a deceleration in the rate of fertility decline, with the fertility level reaching 1.8 children, still below the national average. Financial challenges, shifts in parental perspectives, and various factors have reshaped childbearing behaviors among women, leading to a decline in the ideal fertility rate. Anticipating shifts in family attitudes, it is predicted that even with improved economic conditions, families would prioritize enhancing their children's quality of life over increasing quantity. However, it cannot be denied that despite the inclination for fewer children, Ilam city is poised to experience an uptick in the birth rate due to its youthful population entering the reproductive age. While this will impact population structure, its effect on overall population growth is anticipated to be modest.

Recognizing families' and society's right to reproductive health, policy adjustments to control or enhance population growth necessitate a thorough review of reproductive health plans. Historically, family planning programs were integral to Iran's reproductive health policy, focusing on birth spacing. Nevertheless, a fertility rate below replacement level should not diminish the demand for family planning services. The compression of the childbearing period in society emphasizes the need for continued reproductive health services both during (i.e., between the 20s and 30s of life) and after (i.e., post childbearing) this period.

Another crucial aspect is the evaluation of family-related policies in Iran and Ilam. Considering the diverse factors influencing family behaviors—social, economic, cultural, and demographic—it is imperative that family-related laws, policies, and plans are comprehensive and consider specific circumstances. Notably, the issue of elevated age of marriage and delayed marriage in Ilam requires attention. The city currently holds the highest average age of marriage

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among women and men in the country, primarily linked to economic challenges, particularly unemployment. Addressing these challenges presents an opportunity for policymakers to create an environment conducive to increasing the fertility rate in the province. The elevated age of marriage, identified as one of the immediate determinants of fertility by Bongart, significantly contributes to the lower fertility rate in Ilam city compared to the national average. Therefore, rectifying these issues should be a priority for policymakers aiming to positively impact the city's fertility rate.

Conclusion

Given the significant prevalence of marriage in Ilam province, a conclusion can be drawn that marrying at a younger age extends the reproductive period among women. This extension, in turn, indirectly contributes to an increase in fertility. Recognizing this correlation, policymakers should consider implementing strategic plans aimed at reducing the age of marriage not only in Ilam province but also on a national scale. By addressing this demographic factor, policymakers can potentially positively impact fertility rates, contributing to a more balanced and sustainable demographic landscape

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Conflict of Interests

None to declare.

Authors' Contributions

AMMN contributed to data collection and prepared the initial draft of the manuscript, AP conceptualized the study and helped revising the initial draft of the manuscript, while SNH provided critiques on the scientific aspects of the study.

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