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Spatio-temporal Trends and Patterns of Synthetic Fertility Index Across African Countries: A Comprehensive Analysis from 1950 to 2023

Mouhamadou Djima Baranon^{1, 2*}, Ambroise Tchando Nahini², Chérif Ayena², Achille Mahuna Soglo² & Tina Confort Kollie¹

¹ Pan African University Institute for Basic Sciences, Technology, and Innovation, P. O. Box 147 Arusha, Tanzania.

² Université de Parakou, BP 123. Parakou · Bénin.

*Author for Correspondence ORCID ID: <https://orcid.org/0009-0005-7783-653X>; Email: djima.mouhamadou@gmail.com

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*Fertility dynamics,
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(SFI),
African Countries,
Spatio-Temporal Analysis,
Demographic Transitions.*

This paper examines the spatiotemporal trends and patterns of the Synthetic Fertility Index (SFI) in African countries from 1950 to 2023. The study used data from the Demographic and Health Surveys (DHS) program and Atlasocio.com to analyse the evolution of fertility rates in Africa. The findings reveal a significant decline in fertility rates over the past decades, with many countries experiencing a shift from high SFI exceeding 6 children per woman in the mid-20th century to levels below 3 children per woman by 2023. However, regional disparities persist, with North African countries and South Africa consistently demonstrating lower SFIs compared to their counterparts in West Africa, Central Africa, and East Africa. The study emphasizes the importance of addressing persistent regional disparities in fertility rates through targeted policies and interventions aimed at improving access to education and healthcare, promoting gender equality, and addressing cultural norms and practices that perpetuate high fertility rates. Overall, the study provides valuable insights into the demographic transition taking place in Africa and highlights the need for continued research and policy action to promote socio-economic development in the continent.

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INTRODUCTION

The dynamics of fertility rates in African countries have been a subject of significant interest and concern due to their profound implications for population growth, development trajectories, and societal well-being [1, 2]. Its exploration stands at the intersection of demographic, socio-economic, and public health research, offering a rich tapestry of insights into the complex interplay of factors shaping population trends over time. The spatio-temporal trends and patterns of synthetic fertility indices across the diverse landscape of African nations from 1950 to 2023 represent a compelling narrative of demographic evolution, reflecting not only the demographic transitions but also the broader implications for development, health, and societal well-being.

The intricate relationship between fertility rates and socio-economic development, revealing deviations from the traditional negative correlation, has been extensively studied. Recent research has highlighted shifts towards a positive relationship between fertility and economic development, challenging the long-standing negative association [3]. Studies have explored factors such as changes in family policies, spatial economic organization, and migration processes that contribute to this reversal. Additionally, the emergence of a positive fertility-development relationship has been observed in some countries, indicating a complex interplay between socioeconomic variables and fertility patterns [4]. The emergence of new paradigms challenges established notions, particularly the nuanced dynamics observed at very high levels of development, prompting a re-evaluation of the underlying drivers of fertility in developing economies. By meticulously analysing the synthetic fertility index over more than seven decades, this comprehensive analysis aims to

unravel the multifaceted layers of fertility dynamics in African countries.

Moreover, the impact of health systems, environmental factors, and cultural norms on fertility rates cannot be overstated. The spatial heterogeneity of fertility indices across Africa, influenced by factors such as access to healthcare, environmental sustainability, and sociocultural practices, underscores the need for a holistic approach to understanding fertility dynamics [5]. By delving into the spatio-temporal trends and patterns of synthetic fertility indices, this study endeavours to provide a panoramic view of the diverse factors shaping fertility outcomes in African countries. This holistic perspective not only illuminates the demographic landscape but also lays the foundation for evidence-based strategies to address demographic challenges and foster sustainable development.

In the context of evolving fertility rates and the imperative to achieve demographic equilibrium, this analysis seeks to offer a comprehensive exploration of the synthetic fertility index across African countries. By providing a nuanced perspective on the intricate relationship between development, health, and population dynamics, this study aims to inform policy formulation, health interventions, and development strategies tailored to the unique demographic context of Africa.

Through a meticulous examination of spatio-temporal trends and patterns of fertility indices, this analysis endeavours to serve as a guiding beacon for stakeholders, policymakers, and researchers navigating the complex terrain of demographic transitions in Africa, paving the way for informed decisions and sustainable solutions for the future.

LITERATURE REVIEW

Fertility Trends in Africa: A Historical Perspective

The study of fertility patterns in African countries has been a topic of significant interest for demographers, policymakers, and researchers alike. Over the past several decades, Africa has experienced dynamic changes in population dynamics, with fertility rates playing a central role. Early studies by Caldwell and Caldwell (1987) [6] emphasized the high fertility levels prevalent in sub-Saharan Africa, often referred to as the “African fertility puzzle.” These scholars highlighted the persistence of high total fertility rates (TFRs) despite improvements in education, urbanization, and healthcare infrastructure.

A common explanation for high fertility in Africa is the widespread desire for large families. This poses a challenge for family planning programs, which aim to assist women in achieving their reproductive goals [7, 8]. However, recent studies challenge the assumption that family planning programs have limited effects on desired family size. Bongaarts (2020) [8] found that both women’s education and family planning programs significantly contribute to fertility decline [9]. Surprisingly, family planning programs can reduce wanted fertility, suggesting their impact may be larger than conventionally assumed. Notably, in some economically disadvantaged countries like Ethiopia, Malawi, and Rwanda, high-quality family planning programs have led to substantial declines in wanted fertility [10].

The Demographic Transition Theory and African Context

The Demographic Transition Theory (DTT) has been widely applied to European and Asian contexts. However, its applicability to Africa remains debated [11]. Many authors argued that contextual factors unique to Africa—such as cultural norms, economic disparities, and political instability—significantly influence fertility patterns [12, 13].

Education, Urbanization, Family Planning Programs, and Fertility in Africa

Urbanization is associated with declining fertility rates globally. In African cities, the relationship is complex. Scholars highlighted that while urban areas generally experience lower total fertility rates (TFRs) compared to rural regions, substantial variations exist within cities [14]. Factors like slum conditions, access to family planning services, and migration patterns contribute to divergent fertility outcomes [15, 16].

DATA AND METHODOLOGY

This section outlines the data sources and methodological approach employed in analysing spatio-temporal trends and patterns of the Synthetic Fertility Index (SFI) across African countries from 1950 to 2023.

Data

In this research, we used the Synthetic Fertility Index (SFI) of all the 54 African countries recorded or estimated in 1950, 1960, 1970, 1980, 1990, 2000, 2010, 2020, and 2023. Those data were obtained from Atlasocio.com, a platform gathering data on various topics including population, demography, health, and economics. Atlasocio.com compiles data from various sources. For SFI, the data compiled are from the Demographic and Health Surveys (DHS) program for African countries. It’s important to note that Atlasocio.com may include estimates for some years and countries. Furthermore, the DHS program conducts nationally representative surveys in various countries, including African nations. These surveys collect data on fertility, including birth histories, which can be used to calculate SFI. Country-specific DHS data can be accessed through the following link [DHS Program Data](#).

Methodology

This study employed a mixed-methods approach that combined quantitative and spatial analysis techniques to examine the SFI trends across the 54 African countries.

Synthetic Fertility Index (SFI)

The main indicator for this study is the SFI. Then it is important to give an overview of its meaning and calculation approach.

The Synthetic Fertility Index (SFI) for a particular year represents the average number of children each woman would theoretically have if she lived through her entire reproductive period and bore children according to the current age-specific fertility rates. It is calculated by summing the age-specific fertility rates for women within a specified range of reproductive ages. Here's the formula to calculate the SFI:

$$SFI = \sum_{i=15}^{49} ASFR_i \quad [1]$$

where $ASFR_i$ represents the age-specific fertility rate for each age group ranging from 15 to

49 years.

$$ASFR_i = \frac{\text{Number of births to women in age group } i}{\text{Mid-year population of women in age group } i} \times 1000 \quad [2]$$

with $i \in [15,50]$

Quantitative Analysis

Our methodology encompassed the application of time series analysis techniques to uncover trends in SFI throughout the extensive study period spanning from 1950 to 2023. By systematically examining the trajectory of synthetic fertility rates over time, we gained valuable insights into the evolving dynamics of population growth and reproductive patterns across Africa, identifying significant fluctuations and long-term patterns that shape demographic trends. Furthermore, our research embraced a comparative framework to elucidate variations in SFI levels and trends among different African countries and sub-regions. Through meticulous grouping based on geographical proximity, we conducted rigorous comparative analyses to discern disparities and similarities in fertility dynamics. Graphics have been used to showcase the trends of SFI by country and sub-region (Northern African, Southern Africa, Central Africa, Western Africa, and Eastern Africa)

Spatial Analysis

In our research endeavours, we have utilized geographic visualization techniques, particularly choropleth maps, to shed light on the intricate spatial distribution of the Synthetic Fertility Index (SFI) across the African continent. Through these methods, we've delved into the rich tapestry of fertility dynamics, uncovering geographical clusters and patterns that offer invaluable insights into the continent's demographic landscape.

Central to our mapping efforts has been the utilization of QGIS Software, a versatile Geographic Information System (GIS) tool renowned for its flexibility and robust features. With QGIS, we've been able to integrate diverse datasets and craft highly detailed choropleth maps that vividly portray the variegated levels of SFI across Africa's diverse regions over time. By combining these data sources and methodological approaches, this study provided a comprehensive analysis of spatio-temporal trends and patterns of SFI in African countries.

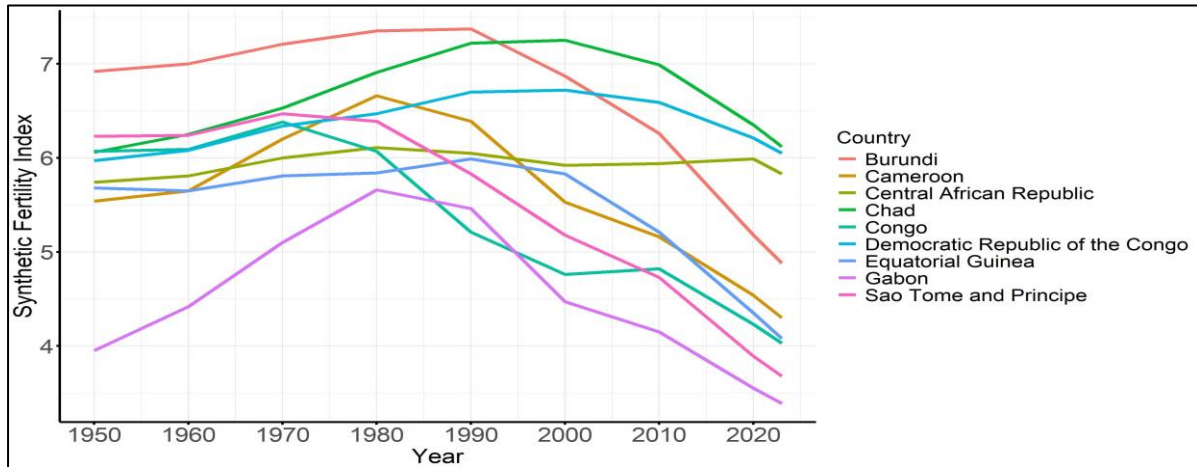
RESULTS AND DISCUSSION

Progression of Synthetic Fertility Index Across Central African Countries

Figure 1 illustrates the varied and diverse trends in the Synthetic Fertility Index (SFI) among the Central African countries. From 1950 to 1970, all these nations witnessed an upward trend in their SFIs. However, from 1980 onwards, some countries, such as Congo and Sao Tome and Principe, started to exhibit a decline in their SFIs. Furthermore, countries like Burundi and Chad experienced an increase in their SFIs until 1990. Since the 2000s, all Central African countries, with the exception of the Central African Republic and the Democratic Republic of Congo, have been experiencing a continuous and irreversible decline in their SFIs. This decline is particularly noteworthy in Gabon and Sao Tome and Principe, where the SFIs are less than 4 children per woman in 2023. In the same year, Cameroon, Equatorial Guinea, and Congo recorded relatively moderate SFIs, ranging between 4 and 4.5 children per woman. Conversely, countries like the Central African

Republic, Chad, and the Democratic Republic of Congo have not yet experienced a significant decrease in their SFIs, with values still hovering around 6 children per woman.

Figure 1: Central African countries' synthetic fertility index (SFI) trends

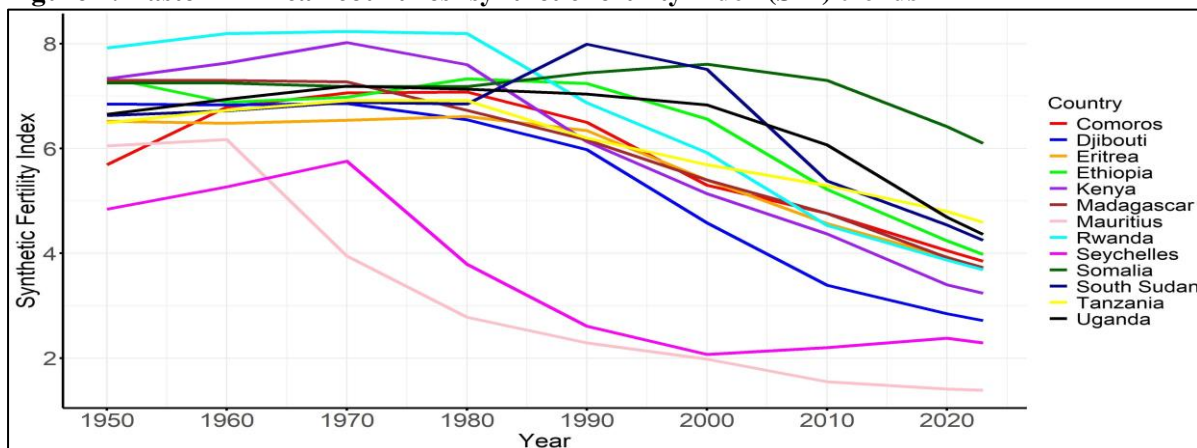


Progression of Synthetic Fertility Index Across Eastern African Countries

Figure 2 reveals a significant and noteworthy downward trend in the Total Fertility Index (SFI) for Mauritius and Seychelles over the past decades. This shift is particularly pronounced in Mauritius, where the SFI dropped below 2 children per woman by 2023, a stark contrast to the approximate SFI of 6 recorded in 1950. Similarly, Djibouti has experienced a substantial reduction in its SFI, declining from over 6 in 1950 to less than 3 in 2023. This decline signifies a considerable transformation in reproductive behaviour and societal dynamics within these nations. In contrast, other countries in the South African region have undergone a more moderate and gradual decline in their SFI compared to

Mauritius, Seychelles, and Djibouti. Among these nations, Rwanda stands out as a remarkable case of demographic transition. The country has achieved substantial progress in reducing its SFI from around 8 children per woman in 1950 to less than 4 in 2023. This significant decrease in fertility rates reflects notable advancements in healthcare, education, and family planning initiatives in Rwanda. However, Somalia's demographic trajectory presents a more intricate and complex picture. Despite a general trend of declining fertility rates worldwide, Somalia's SFI has shown fluctuation and inconsistency. Between 1950 and 2023, the country experienced only a marginal 1-point decrease in its SFI, with occasional increases observed in recent years.

Figure 2: Eastern African countries' synthetic fertility index (SFI) trends

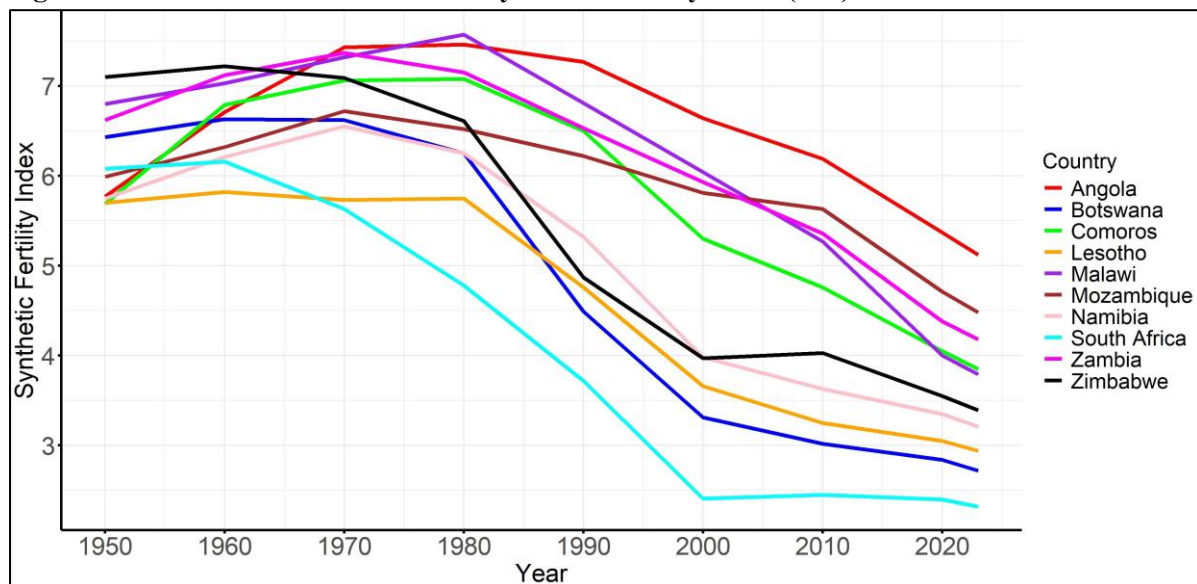


Progression of Synthetic Fertility Index Across Southern African Countries

Figure 3 illustrates a notable and consistent decline in fertility rates among Southern African countries. Specifically, South Africa, Lesotho, Botswana, and Namibia have demonstrated a significantly steep decrease in their Synthetic Fertility Indices (SFIs). In contrast, the pace of decline appears comparatively gradual in countries such as Zambia, Angola, Mozambique, Comoros, and Malawi. For all countries in the sub-region, an irreversible decrease in the SFI has been observed since 1990. South Africa, in particular, has exhibited a remarkable downward trend, which began after 1960 with an SFI of over

6 children per woman. The drop in this SFI was dramatic, reaching just under 2 children per woman in 2000, a value that has remained relatively stable until 2023. Botswana and Lesotho have also experienced significant declines in their SFIs, although the trend is relatively weaker compared to South Africa. In 2023, these two countries have SFIs of 2 and 3 children per woman, respectively. Zimbabwe follows a similar trend, with an SFI of around 3.5 in 2023. Moreover, countries like Malawi, Comoros, Zambia, and Mozambique have been characterized by a relatively slow decline, with SFIs ranging between 4.8 and 5.5 in 2023.

Figure 3: Southern African countries' synthetic fertility index (SFI) trends



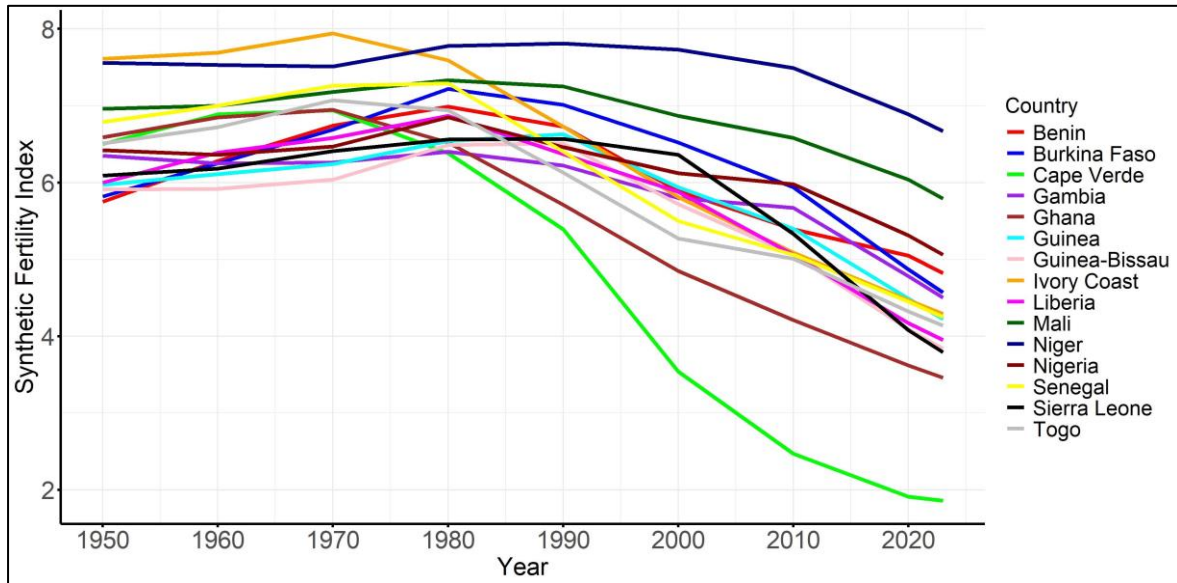
Progression of Synthetic Fertility Index Across Western African Countries

Figure 4 highlights Cape Verde as a notable example of demographic transformation, particularly in the context of declining Synthetic Fertility Index (SFI) trends over recent decades. This island nation has undergone a significant evolution, experiencing a substantial decrease from a fertility rate exceeding 6 children per woman in 1950 to less than 2 children per woman by 2023. Similarly, Nigeria, while exhibiting a less pronounced decline compared to Cape Verde, has demonstrated a noteworthy downward trajectory in its Synthetic Fertility Index (SFI). Despite a less steep decline, Nigeria has made

substantial strides, with the SFI falling to below 4 children per woman in 2023. It is important to note that with the exception of Niger, most West African countries have observed a noticeable decline in their SFIs from 1950 to 2023. This trend indicates a broader demographic transition unfolding across the region, influenced by shifts in societal norms, improved access to reproductive healthcare, and economic advancements. Despite these overarching patterns, certain countries like Mali and Ghana continue to contend with relatively high SFI values, exceeding 5 children per woman in 2023. Additionally, nations such as Benin, Ivory Coast, Burkina Faso, Gambia, Senegal, Guinea, and

Guinea-Bissau have achieved SFIs ranging degrees of progress in efforts to reduce fertility between 4 and 5 in 2023, showcasing varying rates.

Figure 4: Western African countries’ synthetic fertility index (SFI) trends

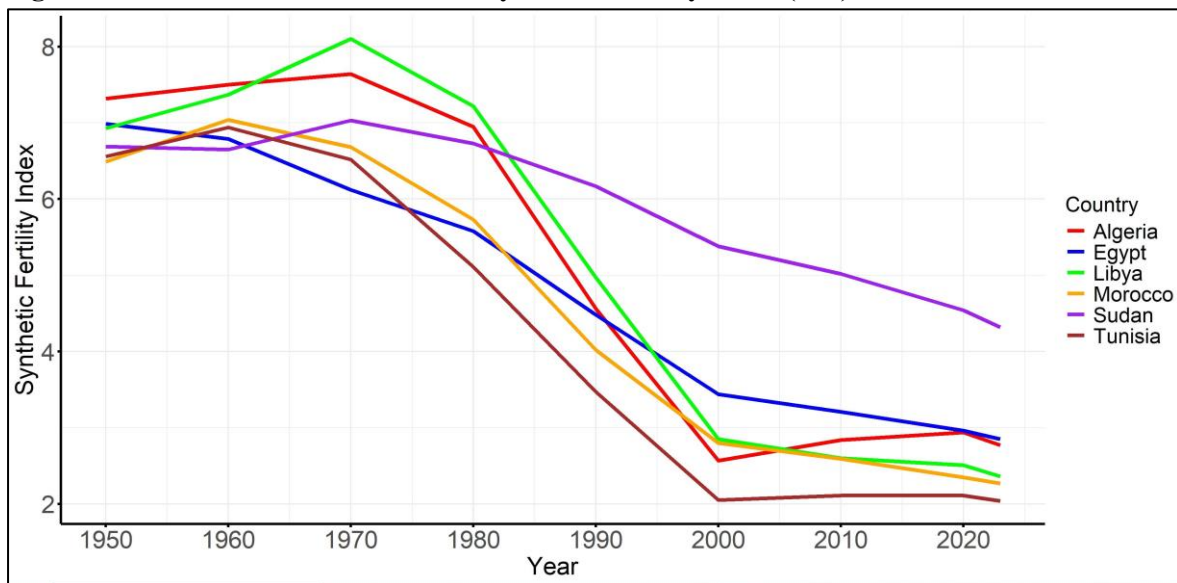


Progression of Synthetic Fertility Index Across Northern African Countries

Figure 5 reveals a clear downward trend in fertility rates across Northern African countries over time. Specifically, countries such as Tunisia, Morocco, and Libya have demonstrated a significant decline in fertility rates from 1970 to 2023. Egypt, while experiencing a decline in its Synthetic Fertility Index (SFI) since 1950, has shown a slower rate of reduction compared to those mentioned above. Algeria, in particular, has

experienced a globally decreasing SFI over time, although recent years (2000 to 2023) have shown a slight increase in its SFI. Among the countries of North Africa, Sudan has experienced a relatively modest decline in its SFI. However, its SFI is less than approximately 4 children per woman, while other countries display SFIs equal to or below 3 children per woman in 2023. Despite these variations, the overall trend suggests a shift towards lower fertility rates in Northern Africa.

Figure 5: Northern African countries’ synthetic fertility index (SFI) trends



Spatial Distribution of Synthetic Fertility Index (SFI)

Spatial Distribution of Synthetic Fertility Index (SFI) in 1950

Figure 6 provides a detailed analysis of the Synthetic Fertility Indices (SFIs) of African countries in 1950. As shown in the figure, the SFIs for African countries during this period were significantly high, with the majority of the countries having more than 6 children per woman. The highest SFI was recorded in Rwanda, with an average of 7.92 children per woman, followed closely by Ivory Coast and Niger, with SFIs of 7.61 and 7.56, respectively. Interestingly, the SFIs were not confined to any particular sub-region but were distributed across all sub-regions. For instance, Ethiopia and Kenya, which are located in the Eastern Africa sub-region, had SFIs of 7.35 and 7.3, respectively, while Algeria, which is in the Northern Africa sub-region, had an SFI of 7.3. Similarly, Madagascar and Somalia, which are located in the Southern and Eastern Africa sub-regions, respectively, had SFIs of 7.33 and 7.25, respectively. On the other hand, the lowest SFIs were recorded in Gabon and Seychelles, with 3.95 and 4.84 children per woman, respectively. These countries are located in the Central and Southern Africa sub-regions, respectively. However, it is important to note that even the countries with the lowest SFIs had relatively high indices compared to global standards during this period.

In summary, the SFIs of African countries in 1950 were generally high, with the majority having more than 6 children per woman. The SFIs were not confined to any specific sub-region but were distributed across all sub-regions. This suggests that the high fertility rates in African countries during this period were a common phenomenon, and not limited to any particular region or country.

Spatial Distribution of Synthetic Fertility Index (SFI) in 1960

Figure 7 shows that in 1960, the Synthetic Fertility Indices (SFIs) for African countries continued to reflect high fertility rates, with over 6 children per woman being the norm for the majority of nations. Notably, Gabon and

Seychelles maintained the lowest SFIs during this period, with 4.42 and 5.27 children per woman, respectively. Additionally, countries such as Cameroon, Equatorial Guinea, the Central African Republic, Lesotho, and Guinea-Bissau also recorded SFIs below 6 children per woman, ranging from 5.65 to 5.92, indicating a slight deviation from the prevalent high fertility trend. Conversely, countries like Rwanda, Ivory Coast, Kenya, Niger, Algeria, Libya, Madagascar, Somalia, Zimbabwe, and Zambia stood out with the highest SFIs in 1960. Rwanda led with an SFI of 8.19, followed closely by Ivory Coast, Kenya, and Niger with SFIs of 7.69, 7.63, and 7.53, respectively. Other notable countries with high fertility rates included Algeria (7.5), Libya (7.37), Madagascar (7.3), Somalia (7.25), Zimbabwe (7.22), and Zambia (7.12). Interestingly, similar to the pattern observed in 1950, the distribution of high and low SFIs in 1960 did not align with specific sub-regions. Instead, the highest and lowest rates were dispersed across various sub-regions, indicating a widespread prevalence of high fertility rates across the continent during this period. This lack of regional clustering suggests that the factors influencing fertility rates in African countries in 1960 were diverse and not confined to any particular geographical area.

Spatial Distribution of Synthetic Fertility Index (SFI) in 1970

The Synthetic Fertility Indices (SFIs) for African countries in 1970, as depicted in Figure 8, demonstrate that the majority of nations, except six countries, had indices ranging between 6 and 8.23 children per woman. Among these six countries, Mauritius and Gabon stood out with SFIs significantly lower than 5.5 children per woman, with values of 3.95 and 5.1, respectively. On the other hand, countries like Rwanda, Libya, Kenya, Ivory Coast, Algeria, Niger, Angola, Malawi, Madagascar, Senegal, Burundi, Uganda, Somalia, and Mali exhibited the highest SFIs during this period. Rwanda led with an SFI of 8.23, followed closely by Libya (8.1), Kenya (8.02), Ivory Coast (7.94), Algeria (7.64), Niger (7.51), Angola (7.43), Malawi (7.32), Madagascar (7.27), Senegal (7.26), Burundi (7.21), Uganda

(7.19), Somalia (7.18), and Mali (7.18). Furthermore, while high SFIs were still prevalent in the majority of African countries in 1970, the distribution of the highest and lowest rates across sub-regions showed some notable patterns. Countries in West Africa, North Africa, and East

Africa predominantly had the highest SFIs, while Central African countries and those in Southern Africa generally had relatively lower rates, albeit still significantly high compared to global standards.

Figure 6: Spatial distribution of synthetic fertility index by country in 1950

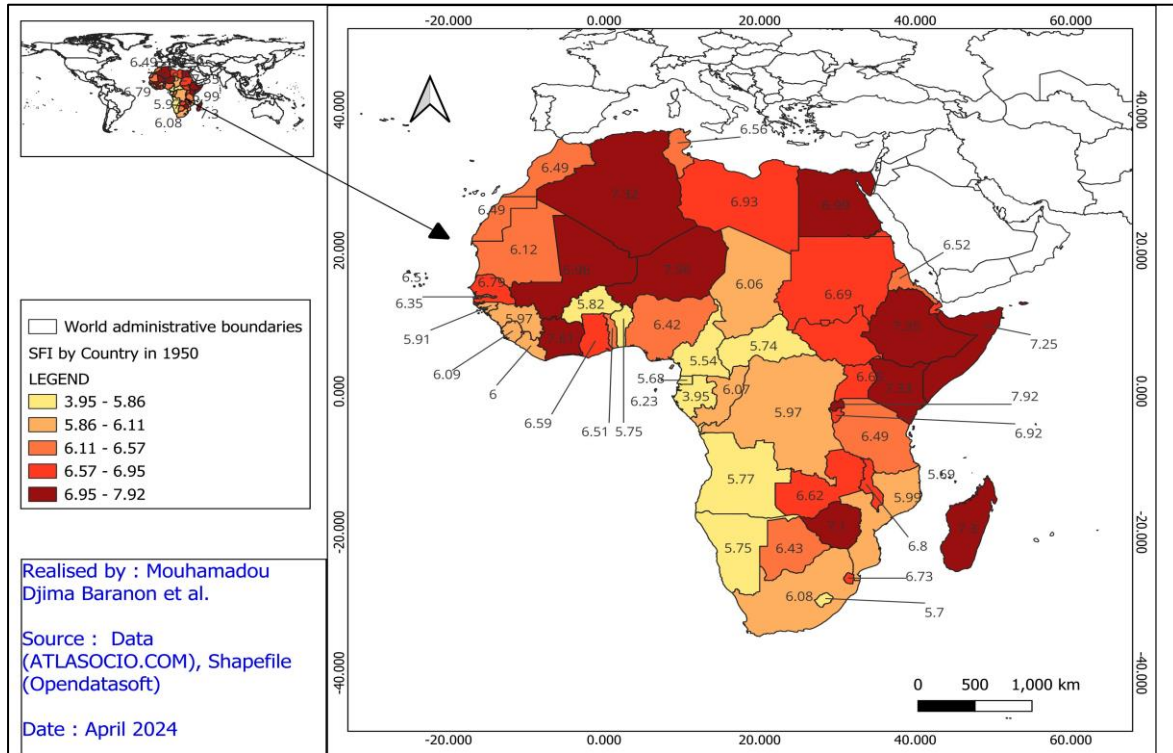


Figure 7: Spatial distribution of synthetic fertility index by country in 1960

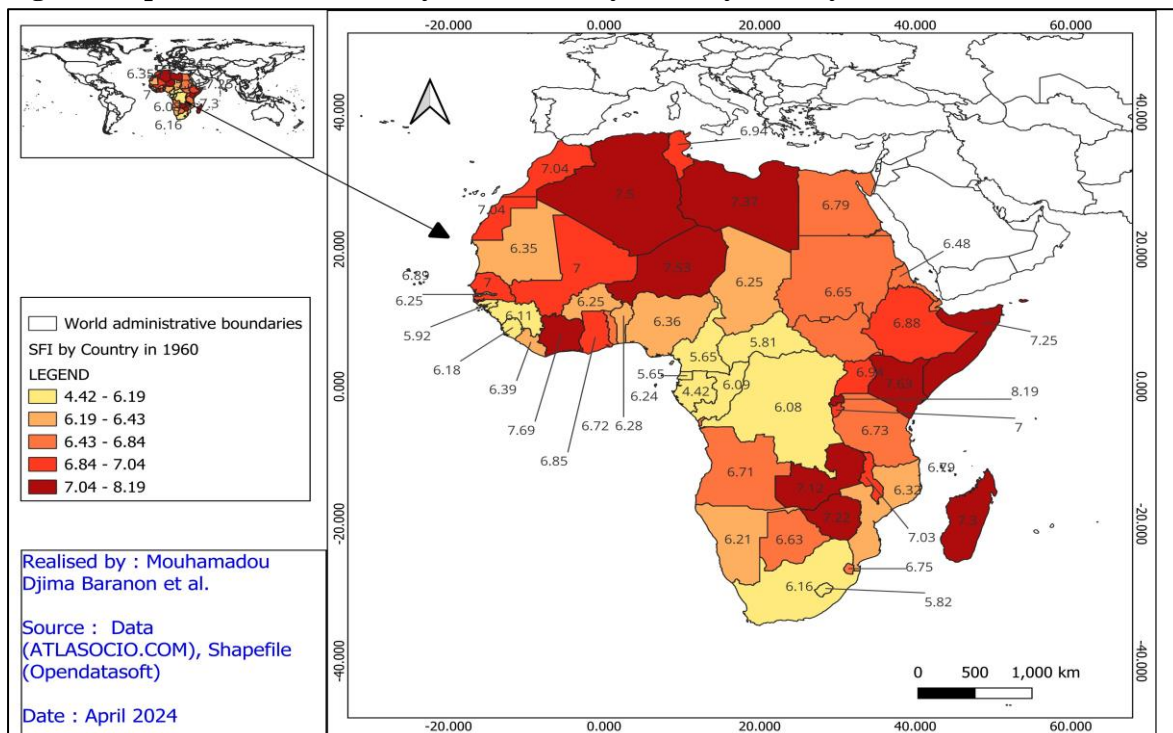
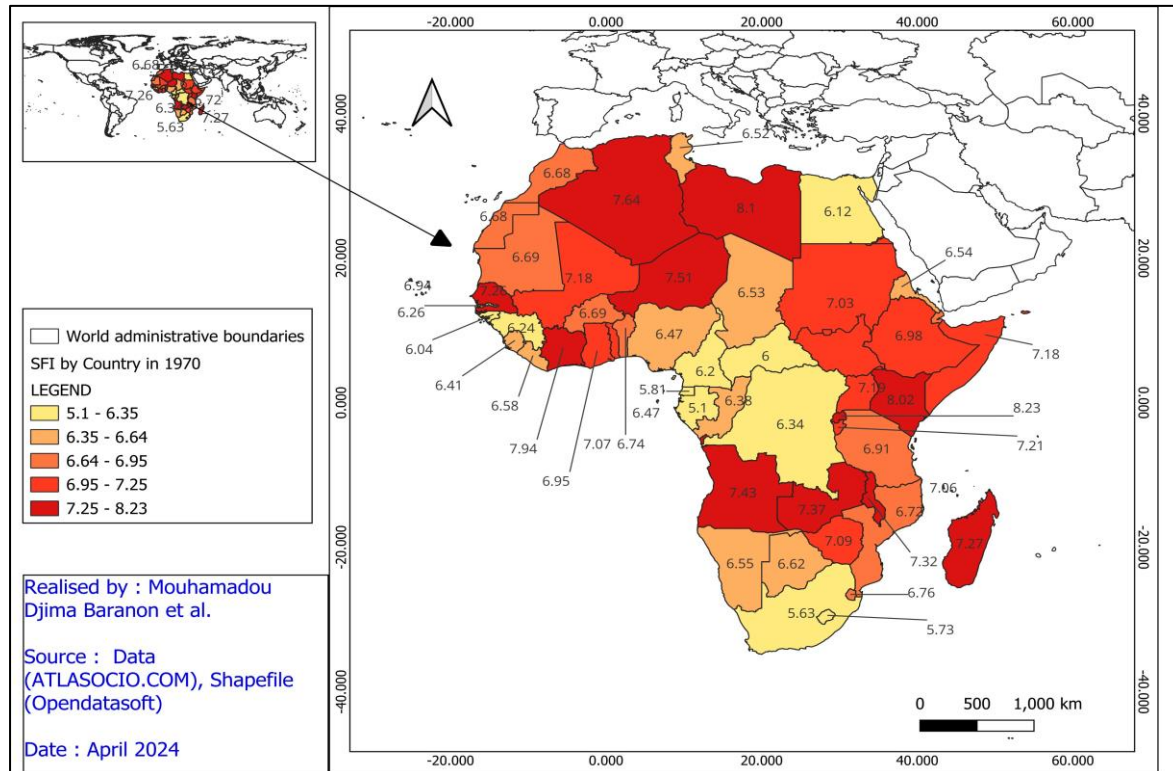


Figure 8: Spatial distribution of synthetic fertility index by country in 1970



Spatial Distribution of Synthetic Fertility Index (SFI) in 1980

In 1980, the Synthetic Fertility Indices (SFIs) for African countries exhibited a diverse range of values, as shown in *Figure 9*. Mauritius continued to display a remarkably low SFI of less than 3 children per woman, specifically 2.78, while Seychelles and South Africa had similar indices, with 3.79 and 4.78, respectively. Five countries presented relatively higher SFIs but less than 6 children per woman, including Tunisia (5.11), Egypt (5.58), Gabon (5.66), Morocco (5.73), Lesotho (5.75), and Equatorial Guinea (5.84). For all other countries, the SFI was equal to or greater than 6 children per woman. The countries with the highest rates in 1980 were Rwanda (8.19), Niger (7.78), Kenya (7.6), Ivory Coast (7.59), Malawi (7.57), Angola (7.46), Burundi (7.35), Mali (7.33), Ethiopia (7.33), Senegal (7.29), Libya (7.22), Burkina Faso (7.22), Somalia (7.18), Zambia (7.15), Uganda (7.13), Comoros (7.08), Benin (6.99), and Algeria (6.95). Notably, for most West African and East African countries, SFIs were the highest compared to others. However, some North African countries had rates below 6, indicating a lower degree of fertility in

these regions. Southern African countries and those in the centre had similar patterns, with countries displaying rates either below 6 or slightly above 6.

Spatial Distribution of Synthetic Fertility Index (SFI) in 1990

Figure 10 shows that in 1990, the Synthetic Fertility Indices (SFIs) for African countries continued to reflect a landscape where the majority of nations had SFIs equal to or greater than 6 children per woman, with only 20 countries recording rates below this threshold. Notably, countries like South Sudan (7.99), Niger (7.81), Somalia (7.44), Burundi (7.37), Angola (7.27), Mali (7.25), Ethiopia (7.24), Uganda (7.04), Burkina Faso (7.01), Rwanda (6.87), Malawi (6.81), Ivory coast (6.73), Benin (6.73), and the Democratic Republic of the Congo (6.7) stood out with the highest SFIs during this period. Conversely, Mauritius and Seychelles maintained exceptionally low SFIs below 3 children per woman, specifically 2.29 and 2.61, respectively. Tunisia and South Africa had relatively close rates, at 3.47 and 3.72, respectively. Other countries such as Morocco, Egypt, Botswana,

Algeria, Lesotho, Zimbabwe, and Libya also had rates below 5, ranging between 4.2 and 4.97. Therefore, in 1990, a noticeable trend emerged where North African countries and those in Southern Africa had the lowest SFIs compared to

countries in West Africa and East Africa, which exhibited the highest SFIs. Central African countries fell in between, showcasing intermediate SFIs.

Figure 9: Spatial distribution of synthetic fertility index in 1980

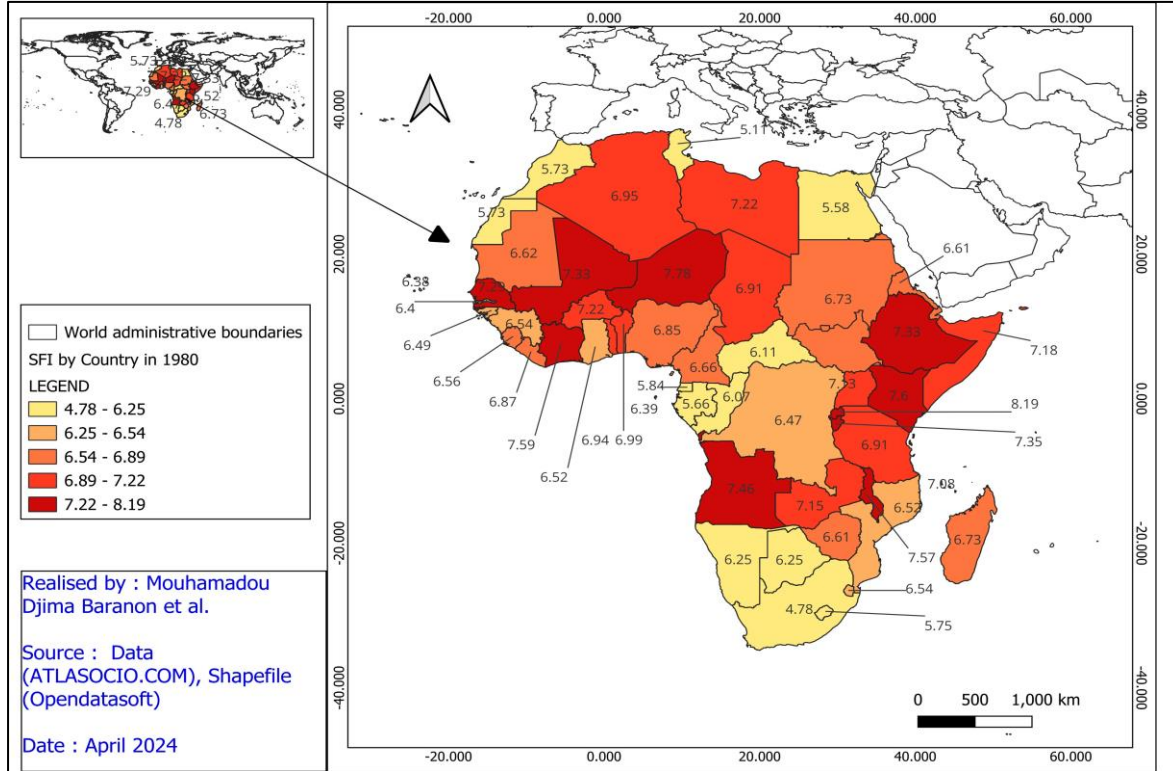
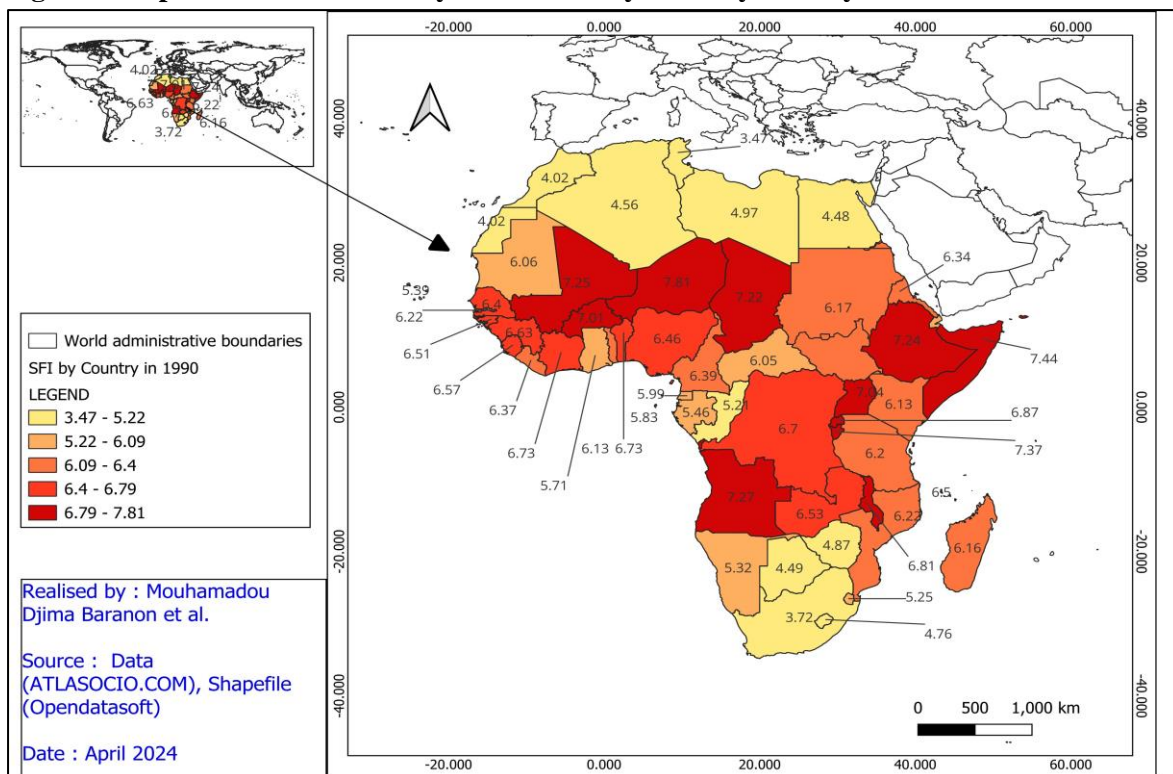


Figure 10: Spatial distribution of synthetic fertility index by country in 1990

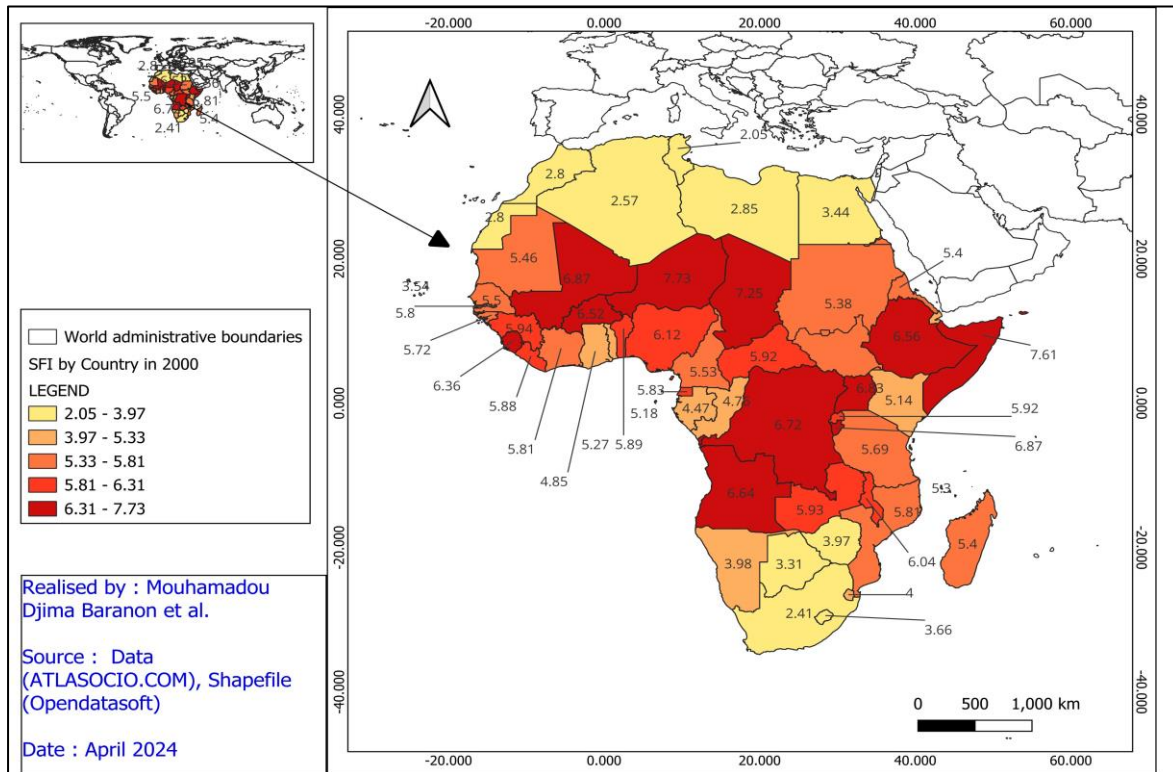


Spatial Distribution of Synthetic Fertility Index (SFI) in 2000

In 2000 (Figure 11), the Synthetic Fertility Indices (SFIs) for African countries continued to exhibit a diverse range of values, with 13 countries recording SFIs lower than 4 children per woman. Mauritius had an exceptionally low SFI of 1.98, while Tunisia and Seychelles had slightly over 2 children per woman as SFIs, with values of 2.05 and 2.07, respectively. South Africa, Algeria, Morocco, and Libya also had low SFIs, ranging between 2.41 and 2.83. Botswana, Egypt, Cape Verde, Lesotho, Zimbabwe, and Namibia also had

SFIs ranging between 3.31 and 3.98. On the other hand, a total of 14 countries had SFIs greater than 6, including Niger (7.73), Somalia (7.61), South Sudan (7.51), Chad (7.25), Burundi (6.87), Mali (6.87), Uganda (6.83), Democratic Republic of Congo (7.2), Angola (6.64), Ethiopia (6.56), Burkina Faso (6.52), Sierra Leone (6.36), Nigeria (6.12), and Malawi (6.04). Moreover, some countries had SFIs close to 6, ranging between 5.5 and 5.94, including Guinea, Zambia, Rwanda, Central African Republic, Benin, Liberia, Equatorial Guinea, Ivory Coast, Mozambique, Gambia, Guinea-Bissau, Tanzania, Cameroon, and Senegal.

Figure 11: Spatial distribution of synthetic fertility index by country in 2000



Globally, the lowest fertility rates in 2000 were recorded in North African countries, with most having fewer than 3 children per woman. A similar observation was made for countries in Southern Africa, which generally displayed fertility rates lower than 4 children per woman. In contrast, countries in West Africa, East Africa, and Central Africa had the highest fertility rates, reaching over 7 children per woman in some countries like Niger, Somalia, and Chad.

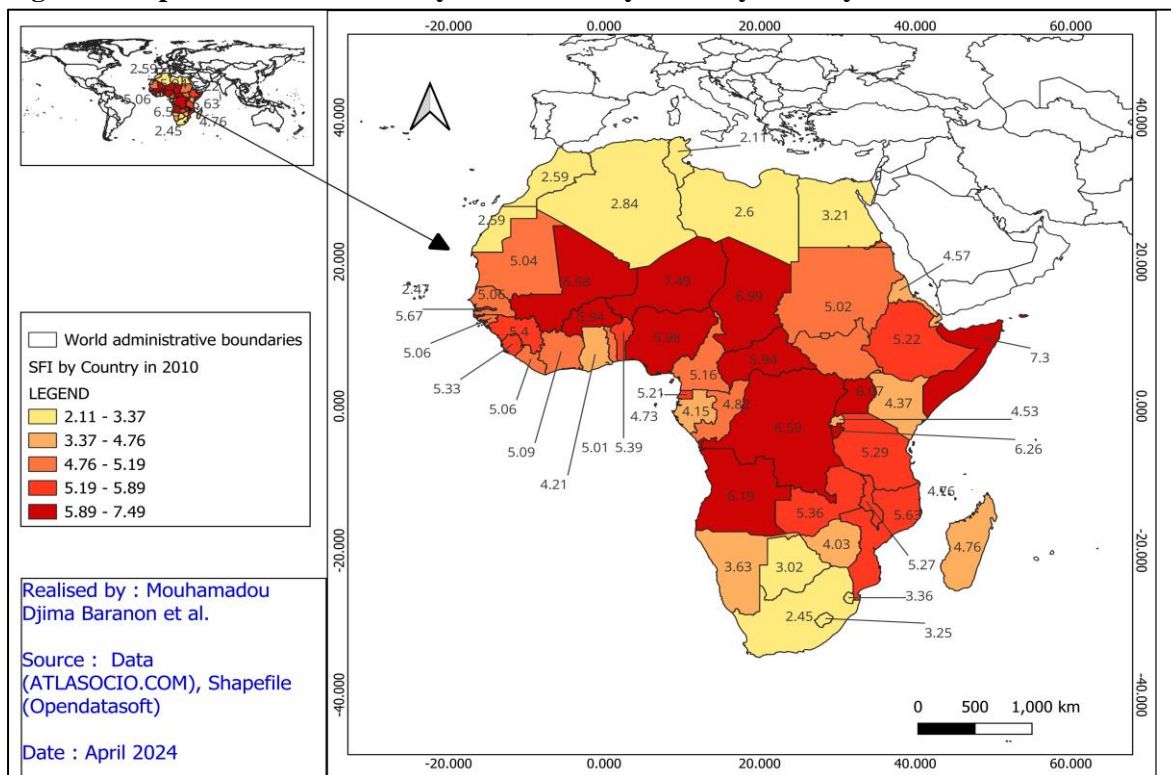
Spatial Distribution of Synthetic Fertility Index (SFI) in 2010

In 2010, the Synthetic Fertility Indices (SFIs) for African countries continued to showcase a diverse range of values, with only 8 countries having SFIs higher than 6, specifically ranging between 6.07 and 7.49 (see Figure 12). Niger led with the highest SFI of 7.49, followed by Somalia (7.3), Chad (6.99), Democratic Republic of Congo (6.59), Mali (6.58), Burundi (6.26), Angola (6.19), and Uganda (6.07). Additionally, some

countries had rates relatively close to 6, ranging between 5.63 and 5.98, including Nigeria, Burkina Faso, Central African Republic, Gambia, and Mozambique. On the other hand, 14 countries stood out with SFIs lower than 4 children per woman. Countries like Namibia, Djibouti, Eswatini, Lesotho, Egypt, and Botswana had SFIs ranging between 3.02 and 3.63. Algeria, Libya, Morocco, Cape Verde, South Africa, Seychelles, and Tunisia had SFIs ranging between 2.11 and 2.84, thus lower than 3 children per woman. Mauritius, in particular, had a very low SFI of 1.55 children per woman.

In 2010, most North African countries displayed rates lower than 3 children per woman, indicating a significant decline in fertility rates in this region. Countries in Southern Africa mostly had SFIs lower than 4 children per woman, following a similar trend. However, West Africa, Central Africa, and East Africa generally displayed the highest fertility rates, reaching over 7 children per woman in some countries like Niger, and Somalia. However, some countries among these regions showed relatively low rates, such as Ghana (4.21), Gabon (4.15), Kenya (4.37), Rwanda (4.53), and Eritrea (4.47).

Figure 12: Spatial distribution of synthetic fertility index by country in 2010

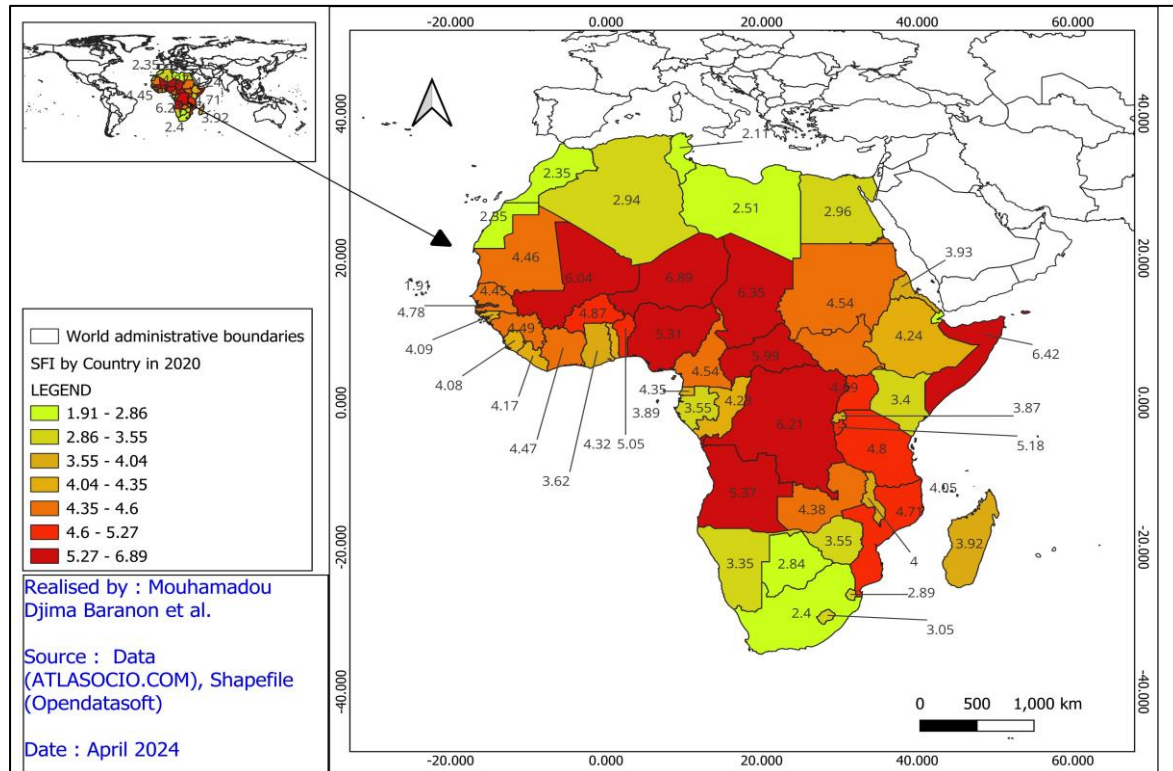


Spatial Distribution of Synthetic Fertility Index (SFI) in 2020

Figure 13 shows that in 2020, the Synthetic Fertility Indices (SFIs) for African countries continued to exhibit a diverse range of values, with 4 countries standing out with significantly higher SFIs surpassing 6 children per woman. These countries were Niger (6.89), Somalia (6.42), Chad (6.34), and the Democratic Republic of Congo (6.21). Following closely were 5 other nations with relatively lower SFIs ranging from 5.18 to 6.04: Mali (6.04), Central African

Republic (5.99), Angola (5.37), Nigeria (5.31), and Burundi (5.18). Moreover, 22 countries had SFIs lower than 4 children per woman, with the lowest rates recorded in Mauritius (1.41), Cape Verde (1.91), Tunisia (2.11), Morocco (2.35), Seychelles (2.38), South Africa (2.4), and Libya (2.51). Among the remaining 15 countries out of the 22, SFIs ranged between 2.84 and 3.93, including Djibouti, Eswatini, Algeria, Egypt, Lesotho, Namibia, Kenya, Zimbabwe, Gabon, Ghana, Rwanda, Sao Tome and Principe, Madagascar, and Eritrea.

Figure 13: Spatial distribution of synthetic fertility index by country in 2020



Overall, North African countries, except for Sudan, displayed SFIs lower than 3 children per woman, indicating a significant decline in fertility rates in this region. Similarly, countries in Southern Africa showed a very similar trend, with some countries also having SFIs below 3, and others slightly above 3. In contrast, the highest rates were particularly observed in West African and Central African countries. East Africa, on the other hand, exhibited relatively lower rates compared to those in West and Central Africa. Furthermore, some countries like Ghana, Cape Verde, Gambia, Togo, Gabon, Congo, Rwanda, Kenya, Eritrea, and Djibouti had rates close to those of countries in Southern Africa.

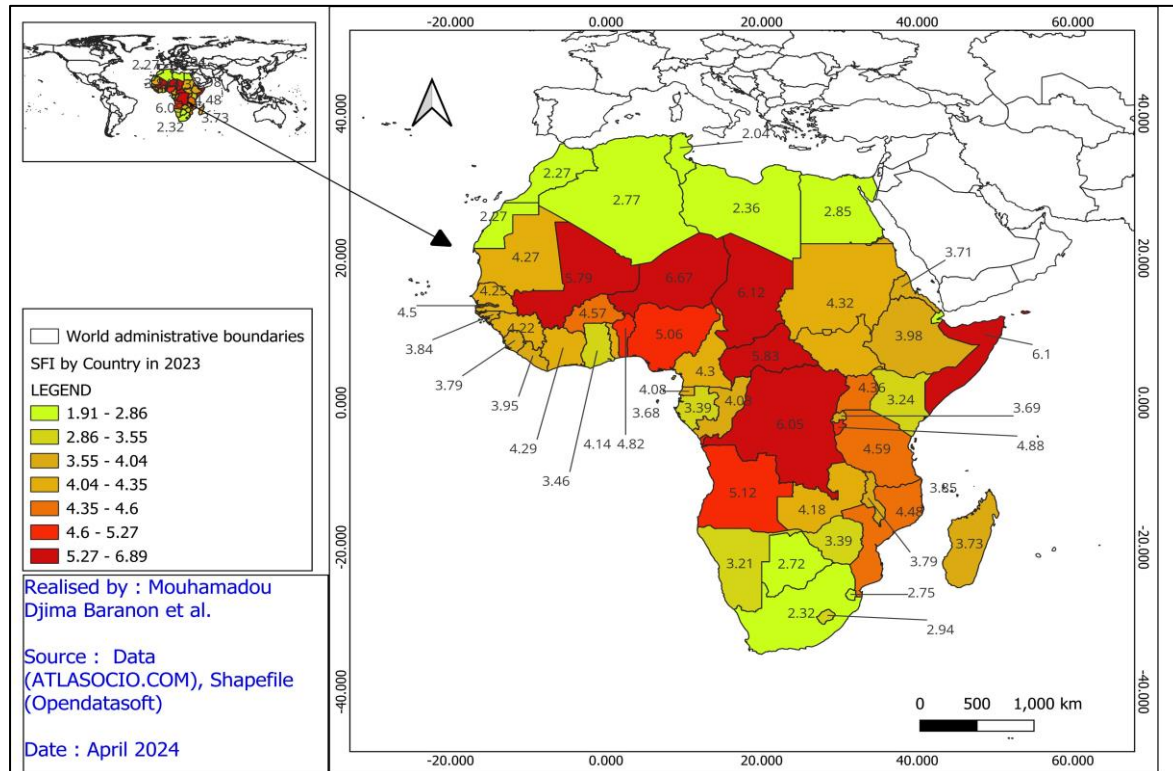
Spatial Distribution of Synthetic Fertility Index (SFI) in 2023

In 2023 (Figure 14), the Synthetic Fertility Indices (SFIs) for African countries continue to exhibit a diverse range of values. A total of 13 countries has SFIs below 3 children per woman, reflecting a significant decline in fertility rates in

these nations. Mauritius and Cape Verde stand out with particularly low rates, below 2 children per woman, at 1.39 and 1.86, respectively. Tunisia, Morocco, Seychelles, South Africa, and Libya also have SFIs below 2.4, ranging between 2.04 and 2.36. These countries are followed by 6 nations with SFIs close to 3, including Botswana (2.72), Djibouti (2.72), Eswatini (2.75), Algeria (2.77), Egypt (2.85), and Lesotho (2.94).

On the other hand, Niger continues to have the highest rate, at 6.67 children per woman, indicating a significantly higher fertility rate compared to other African countries. It is followed by Chad, Somalia, the Democratic Republic of the Congo, the Central African Republic, and Mali, with rates close to 6. Regionally, the lowest SFIs are observed in North African countries, where fertility rates are generally below 3 children per woman, and in South Africa, where SFIs are consistently low, generally below 3. Countries in West Africa and East Africa show a mix, with a trend of SFIs generally below 4.5 children per woman.

Figure 14: Spatial distribution of synthetic fertility index by country in 2023



CONCLUSION

The examination of Synthetic Fertility Indices (SFIs) across African nations offers a multifaceted portrayal of demographic dynamics and regional nuances. Across the decades, a discernible decline in fertility rates has been observed, marking a significant departure from the consistently high SFIs exceeding 6 children per woman prevalent in the mid-20th century to levels below 3 children per woman by 2023 in many countries. Nevertheless, within this overarching trend, regional variations in fertility rates persist. North African countries and South Africa consistently exhibit lower SFIs compared to their counterparts in West Africa, Central Africa, and East Africa.

Despite the valuable insights gained from the analysis of Synthetic Fertility Index (SFI) trends across African countries, the reliance on retrospective data, particularly birth histories collected through surveys, introduces potential biases and inaccuracies. Improvements in data collection techniques, such as the integration of digital health records and real-time monitoring systems, could enhance the accuracy and reliability of fertility data.

Another significant challenge pertains to the limited availability of longitudinal data spanning extended periods. While the analysis covered a considerable time frame from 1950 to 2023, there remains a need for more extensive longitudinal studies to capture nuanced changes in fertility patterns over time. Longitudinal studies would enable researchers to better understand the underlying drivers of fertility dynamics and assess the long-term impacts of socioeconomic and policy interventions.

Additionally, the analysis primarily focused on aggregate-level fertility trends at the national level, overlooking sub-national variations and disparities. Future research should explore intra-country differences in fertility rates, considering factors such as urbanization, regional development disparities, and cultural diversity. Such granular analyses would provide valuable insights for targeted interventions and policy formulation at sub-national levels.

Moreover, while the analysis identified declining fertility rates across African countries, the underlying determinants of these trends remain inadequately explored. Future research should

delve deeper into the socioeconomic, cultural, and environmental factors influencing reproductive behaviours, utilizing interdisciplinary approaches to elucidate complex causal pathways.

Furthermore, it's important to note that the Demographic and Health Surveys (DHS) program, while providing invaluable data for this analysis, does not organize surveys uniformly across all countries in every survey round. As a result, data availability may vary both temporally and spatially, leading to gaps in the longitudinal dataset and the need for estimations for certain years and countries where DHS surveys were not conducted. These estimations introduce inherent uncertainties and may not fully capture the nuances of fertility dynamics during those periods. Consequently, the analysis for such years and countries should be interpreted with caution, considering the limitations associated with extrapolating from neighbouring or similar contexts. Future research should strive to address these data gaps by enhancing survey coverage and consistency across all African countries, ensuring a more comprehensive and robust understanding of fertility trends in the region.

DECLARATION

We affirm that this paper is original and is not currently under consideration by any other publication.

Data Availability

The data can be obtained from this link:

<https://atlasocio.com/classements/demographie/fecondite/classement-etats-par-indice-de-fecondite-afrique.php>

Conflict of Interest

The authors have no conflicts of interest to disclose.

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