Education Expansion, Urbanization and Fertility Change in Sub-Saharan Africa: A Decomposition Approach

Working Paper

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Introduction

Changes in the population distribution across subgroups in specific domains, such as education and place of residence, can substantially impact overall trends in a particular phenomenon. In Sub-Saharan Africa, contemporary population trends display a highly dynamic scenario. While the region has one of the highest proportions of rural and non-educated populations, education progress and urbanization are advancing rapidly (B. Schoumaker & D. Tabutin, 2020). The region is simultaneously experiencing a decline in fertility and an increase in the proportion of urban and more educated populations, raising essential questions about the interactions between urbanization, education, and the demographic transition.

Sub-Saharan Africa's fertility transition began later and progresses more slowly than in other regions in development (United Nations, 2024; B. Schoumaker, D. Tabutin, 2020). Overall fertility in the region averages 4.6 children per woman, well above other developing areas (UN, 2024). Fertility is shaped by intertwined determinants such as contraceptive use, age at marriage, and postpartum insusceptibility (Bongaarts, 2015), along with broader social factors, such as education and place of residence.

In this study, two indicators will be considered to analyze structural changes in fertility in Sub-Saharan Africa: urbanization and education progress. Both have been previously examined, jointly and separately, to study fertility differentials and trends (Caldwell, 1980; Bongaarts, 2010; Schoumaker & Sanchez Paez, 2020; Adhikari et al., 2024). However, the relationship between fertility and these two phenomena has largely been analyzed at the aggregate level, without fully accounting for the effects of shifting demographic weights and population composition. While some have examined compositional effects of education (Cleland, 2002; Schoumaker, 2024), to my knowledge, no study has explicitly decomposed national fertility change to describe the separate contributions of both education progress and urbanization.

The dynamics of contemporary Sub-saharan African populations, such as urbanization and progress in education, vary widely between and within countries. However, general patterns have been identified. The urbanization process in Sub-Saharan Africa has shown a distinctive evolution compared to other regions, with a later onset (around the 1950s), a marked acceleration between the 1960s and late 1970s, and an earlier deceleration beginning in the 1980s (Bocquier, 2004). Today, however, the region's urbanization has a higher pace compared to other regions of the world. The urban population continues to grow, with projections of over 700 million new urban residents by 2050 (UN, 2024). Nonetheless, 57% of the population remains rural overall (UN, 2024). Rural populations, undergoing social and structural transformations, continue to shape regional fertility trends (Fox, 2015).

Concerning education, while important progress has been observed (Tabutin & Schoumaker, 2020), Sub-saharan Africa has the highest rates in education exclusion in the world. Over one-fifth of children between the ages of 6 and

11 are out of school and this population is, in fact, increasing. Structural disparities in access and completion remain a significant source of demographic inequality (Unesco, 2022, 2024).

Education, Urbanization and Fertility

Education is considered a key determinant of human development (Lutz et al., 2014) and one of the very important of demographic behaviour (Cleland, 2002). Research has consistently shown a negative relationship between education and fertility (Cleland, 2002; Bongaarts, 2010; Adhikari et al., 2024; Schoumaker & Sanchez-Paez, 2024). Early findings in Nigeria, found that mothers' years of schooling were a better predictor of fertility levels than economic outcomes (Caldwell, 1979). The main explanations for this relationship are: (1) women with higher levels of education tend to have higher contraceptive prevalence due to increased acceptability and availability; and (2) extended education tends to postpone childbearing by delaying the onset of reproductive life (Cleland, 2002).

On the other hand, urbanization offers increased opportunities for socio-economic mobility through the growth of non-agricultural jobs and higher levels of education. This, in turn, raises the opportunity costs associated with parenthood and encourages more limited reproductive behaviors. Cities facilitate the spread of new reproductive behaviors and the legitimization of modern birth control, thereby accelerating the adoption of restrictive reproductive practices through exposure to a diversity of ideas and practices in urban environments (Montgomery et Casterline, 1996; Lerch, 2019).

While effects of schooling and urbanization are highly context specific and explained through variable, intertwined mechanisms (Jejeebhoy, 1995), education and rural-urban fertility differentials, follow a similar theoretical model of fertility decline forming an inversed "U" shape. After an initial convergence at higher levels, urban and higher educated are the first populations to exhibit the fertility decline. Rural and lower educated would follow the decline to reconverge with their counterparts (Rodriguez, 1996; Shapiro et Tambashe, 2000; Cleland, 2002; Garenne & Joseph, 2002; Schoumaker & Sanchez, 2020, 2024; Lerch, 2019; Adhikari et al, 2024).

In this case, both urbanization and education can influence overall fertility change through two main mechanisms: first, through changes in fertility levels within specific population groups, known as rate effects; and second, through the redistribution of the population across these groups as a result of urbanization and education progress, known as composition effects (Cleland, 2002; Schoumaker et Sanchez-Paez, 2024). This aggregate-level perspective has been commonly used to estimate the contribution of educational composition, with findings suggesting significant but variable effects across countries (Cleland, 2002; Schoumaker et Sanchez-Paez, 2024). For example, Schoumaker´and Sanchez-Paez (2024), using the Kitagawa method, evaluated fertility change by years of schooling to estimate the contribution of each educational group, particularly in the context of fertility stalls. Shapiro and Tenikue (2017), applying an Oaxaca decomposition, analyzed fertility changes in the region by women's education and child mortality. To the best of my knowledge, no study has yet explicitly decomposed national fertility change to isolate the separate contributions of education progress and urbanization within both rural and urban contexts.

After an assessment of the general trends, in this study, adapting the Kitagawa method (Schoumaker & Sanchez Paez, 2024; Canudas Romo 2002; Kitagawa, 1955), we provide a descriptive interpretation of the effects of urbanization and educational change on national fertility trends, distinguishing the composition effects attributable to education progress within rural and urban contexts, as well as those due to urbanization itself.

Data and Methods

This study relies on Demographic and Health Surveys (DHS) conducted in 18 Sub-Saharan African countries. Fertility trends were reconstructed using birth histories, focusing on the standard indicator of Total Fertility Rate (TFR) over the three years preceding each survey. For smoother results, TFR values were also calculated retrospectively across multiple survey rounds when overlapping reference periods were available within the previous 10 years. In the case of the decomposition analysis, the first and the last available surveys in each country were used as reference points. While the time intervals differ across countries, all countries maintain a minimum temporal range of approximately 20 years between 1987 and 2023.

The decomposition of the change in fertility (ΔTFR) between the two time points is conducted using the Kitagawa method. This technique allows the total change to be expressed as the sum of:

- **Rate effects:** changes in subgroup fertility levels.
- **Composition effects:** changes in the population distribution across subgroups.

Three decomposition models were applied:

1. Rural–Urban Decomposition (Model 1)

The first model considers only two population groups : urban and rural. In this case, the composition effect captures the impact of urbanization, i.e., changes in the proportion of the population living in urban vs. rural areas.

Total TFR Change

$$\begin{aligned}\Delta TFR &= TFR_2 - TFR_1 \\ &= (TFR_{\text{Urban2}} - TFR_{\text{Urban1}}) \cdot \frac{\%Pop_{\text{Urban2}} + \%Pop_{\text{Urban1}}}{2} \\ &\quad + (TFR_{\text{Rural2}} - TFR_{\text{Rural1}}) \cdot \frac{\%Pop_{\text{Rural2}} + \%Pop_{\text{Rural1}}}{2} \\ &\quad + \text{Composition}_{\text{Model 1}} + \text{Residual}_{\text{Model 1}}\end{aligned}$$

Composition Effect

$$\begin{aligned}\text{Composition}_{\text{Model 1}} &= (\%Pop_{\text{Urban2}} - \%Pop_{\text{Urban1}}) \cdot \frac{TFR_{\text{Urban2}} + TFR_{\text{Urban1}}}{2} \\ &\quad + (\%Pop_{\text{Rural2}} - \%Pop_{\text{Rural1}}) \cdot \frac{TFR_{\text{Rural2}} + TFR_{\text{Rural1}}}{2}\end{aligned}$$

Residual (Model 1)

$$\text{Residual}_{\text{Model 1}} = \Delta TFR - \text{Rate}_{\text{Model 1}} - \text{Composition}_{\text{Model 1}}$$

2. Combined Residence and Education Decomposition (Model 2)

Residence-education combined decomposition: The second model includes more detailed subgroups defined by the intersection of place of residence and educational attainment, including the categories of *None*, *Primary* and *Secondary+* (e.g., ”urban – primary”, ”rural – secondary+”). This approach allows for a more dynamic assessment of fertility and structural changes but does not isolate the independent contributions of compositions in education or residence.

$$\begin{aligned}
\Delta TFR &= TFR_2 - TFR_1 \\
&= \sum_{i=1}^{6}(TFR_{i2} - TFR_{i1}) \cdot \frac{PopShare_{i2} + PopShare_{i1}}{2} \quad \text{(Rate effect)} \\
&\quad + \sum_{i=1}^{6}(PopShare_{i2} - PopShare_{i1}) \cdot \frac{TFR_{i2} + TFR_{i1}}{2} \quad \text{(Composition effect)} \\
&\quad + \text{Residual}
\end{aligned}$$

Where: 2

- $i = 1$: Urban None
- $i = 2$: Urban Primary
- $i = 3$: Urban Secondary+
- $i = 4$: Rural None
- $i = 5$: Rural Primary
- $i = 6$: Rural Secondary+

3. Three-Stage Decomposition by Education in Rural and Urban (Model 3)

Finally, a strategy was applied to distinguish between educational change within each residential context and changes due to urbanization. First, separate decompositions were conducted within the urban and rural populations by educational level. Then, the resulting rate effects, composition effects and residuals from each context were aggregated into a national-level decomposit, weighting the values by the average population share of urban and rural areas. This approach enables the identification of compositional effects driven by educational change within urban and rural environments separately, while also isolating the contribution of urbanization, since the final residual matches the composition and residual terms of Model 1.

Step 1: Decompose Urban and Rural Separately

Urban:

$$\begin{aligned}
\Delta TFR_{\text{Urban}} = &\sum_{j=1}^{3}(TFR_{uj2} - TFR_{uj1}) \cdot \frac{EduShare_{uj2} + EduShare_{uj1}}{2} \\
&+ \sum_{j=1}^{3}(EduShare_{uj2} - EduShare_{uj1}) \cdot \frac{TFR_{uj2} + TFR_{uj1}}{2} \\
&+ \text{Residual}_{\text{Urban}}
\end{aligned}$$

Rural:

$$\begin{aligned}\Delta TFR_{\text{Rural}} = &\sum_{j=1}^{3}(TFR_{rj2} - TFR_{rj1}) \cdot \frac{EduShare_{rj2} + EduShare_{rj1}}{2} \\ &+ \sum_{j=1}^{3}(EduShare_{rj2} - EduShare_{rj1}) \cdot \frac{TFR_{rj2} + TFR_{rj1}}{2} \\ &+ \text{Residual}_{\text{Rural}}\end{aligned}$$

Where:

- $j = 1$: None
- $j = 2$: Primary
- $j = 3$: Secondary+

Step 2: Combine Using Normalized Weights

Let w_{Urban} and w_{Rural} be the average population shares across the two surveys:

$$\begin{aligned}\text{Rate}_{\text{Model 3}} &= w_{\text{Urban}} \cdot \text{Rate}_{\text{Edu-Urban}} + w_{\text{Rural}} \cdot \text{Rate}_{\text{Edu-Rural}} \\ \text{Composition}_{\text{W.Urban}} &= w_{\text{Urban}} \cdot \text{Composition}_{\text{Urban}} \\ \text{Composition}_{\text{W.Rural}} &= w_{\text{Rural}} \cdot \text{Composition}_{\text{Rural}} \\ \text{Residual}_{\text{W.Model 3}} &= w_{\text{Urban}} \cdot \text{Residual}_{\text{Urban}} + w_{\text{Rural}} \cdot \text{Residual}_{\text{Rural}} \\ \Delta TFR &= \text{Rate}_{\text{Model 3}} + \text{Composition}_{\text{W.Urban}} + \text{Composition}_{\text{W. Rural}} + \text{Residual}_{\text{W.Model 3}} \\ &\quad + \text{Residual}\end{aligned}$$

Step 3: Isolating Rural–Urban Composition and Distinguishing Composition Effects

In this case **Residual** captures other structural effects and interactions not explained by education within urban or rural areas, in this case, primarily urbanization.

To isolate the contribution of **urbanization**, we define:

$$\text{Residual} = \text{Composition}_{\text{Model 1}} + \text{Residual}_{\text{Model 1}}$$

Where

$$\text{Composition}_{\text{Urbanization}} = \text{Composition}_{\text{Model 1}}$$

Then:

$$\text{Composition}_{\text{Urbanization}} = \text{Residual} - \text{Residual}_{\text{Model 1}}$$

Then, in Model 3, the composition effects are clearly separated:

- **education progress in urban areas:** $\text{Composition}_{\text{Urban}}$
- **education progress in rural areas:** $\text{Composition}_{\text{Rural}}$
- **Rural-Urban Redistribution:** $\text{Composition}_{\text{Urbanization}}$

Results

Trends in Fertility and Population Composition

While trends vary widely across countries, rural–urban fertility differentials are consistently observed, with urban areas displaying lower fertility levels throughout the period (Figure 1), in line with existing literature. These disparities are further confirmed in Figures 2 and 3. In nearly all countries, rural women with no formal education exhibit the highest fertility levels, whereas urban women with at least secondary education show the lowest.

Although levels vary across contexts, two main patterns can be distinguished. The first shows an educational gradient across both rural and urban settings. In countries such as Benin, Rwanda, Nigeria, Ghana, and Kenya, fertility levels decline progressively with higher education, and rural women with higher education exhibit lower fertility than urban women with no schooling and sometimes than those with primary education. The second pattern, more commonly observed, reveals the dominant role of place of residence. In Côte d'Ivoire, Tanzania, Uganda, Cameroon, Burkina Faso, Niger, and especially Zimbabwe, fertility remains significantly higher in rural areas, particularly in the 'None' and 'Primary' groups. Regarding the trends, most countries show modest tendencies toward convergence across subgroups. In a few cases, such as Rwanda, a more pronounced convergence is observed, with a narrowing of fertility differences over time.

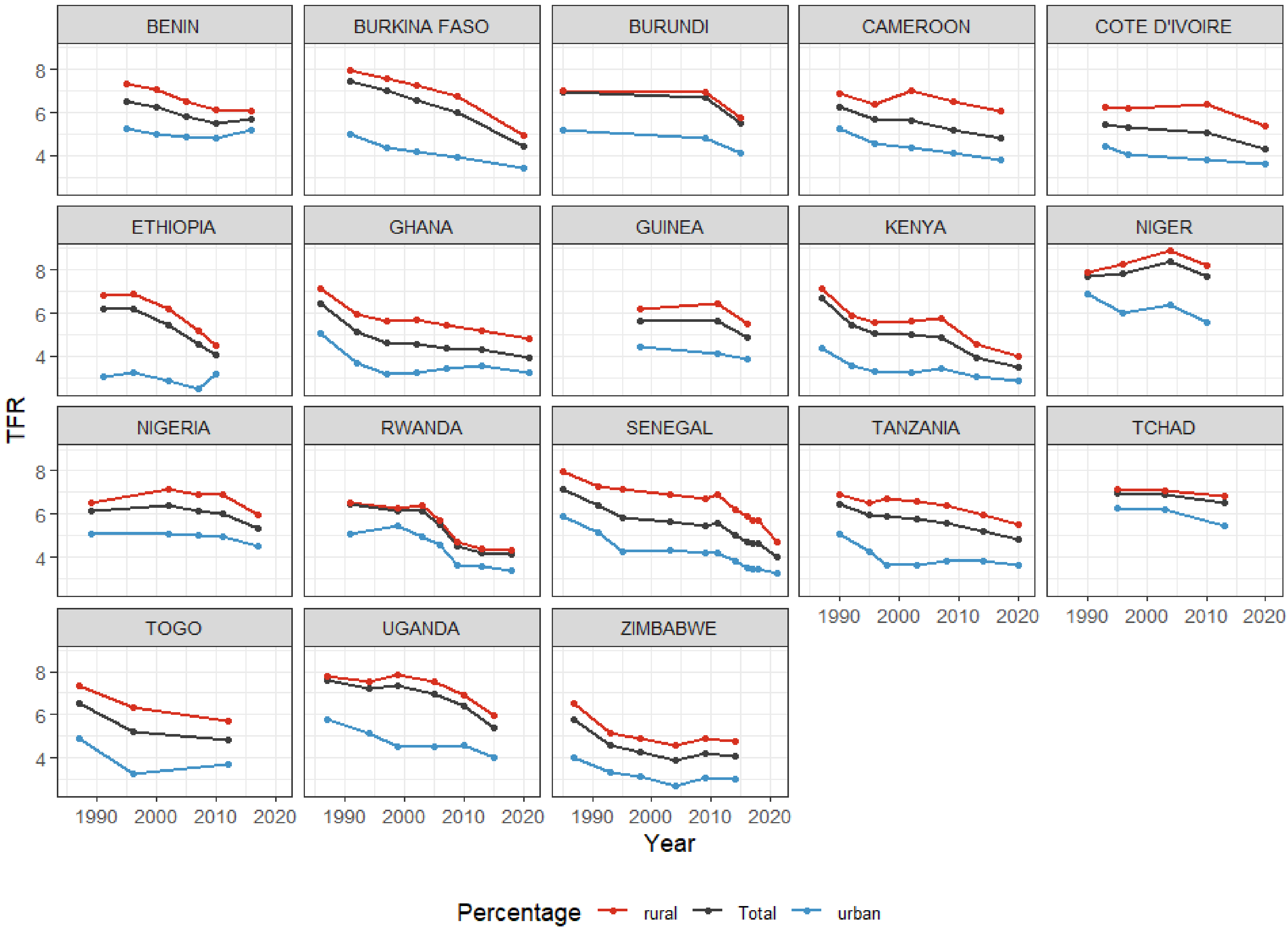
Caution is warranted when interpreting trends for certain subgroups, particularly rural women with secondary education and urban women with no education, as their sample sizes are very small in specific periods and countries (Figure 4 & 5).

An analysis of Figures 4 and 5 reveals that, across all 18 countries studied, urban population shares increased over time and were generally accompanied by improvements in educational attainment. However, the pace and intensity of these transitions vary substantially, allowing the identification of several broad typologies.

- First, Burundi, Rwanda, Zimbabwe, and Uganda illustrate a pattern of limited urbanization combined with substantial education progress. For instance, in Rwanda, the proportion of the population in the rural-secondary+ category rose from 5.4% to 21.0%, while the share of rural-none fell markedly from 34.3% to 8.5%, indicating a significant transformation in rural educational profiles. Burundi's rural-none share decreased from 79.1% to 34.8%.
- Second, Kenya and Ghana represent countries that experienced both early and rapid progress. In Ghana, the share of individuals in the urban-secondary+ group increased from 6.5% in the earliest survey to 45.3% in the most recent, becoming the dominant educational-residential group. Similarly, in Kenya, the rural-secondary+ population more than doubled (from 15.4% to 28.6%), accompanied by a sharp decline in the rural-none group (from 18.8% to 4.1%).
- Third, Burkina Faso and Senegal exhibit a trajectory of significant but delayed education progress. For example, in Burkina Faso, the share of rural-secondary+ individuals increased from 0.9% to 11.7%, despite only moderate urbanization growth.
- Fourth, countries such as Cameroon, Côte d'Ivoire, Tanzania, and Nigeria present a more balanced evolution in both urbanization and educational attainment. In Côte d'Ivoire, the urban-secondary+ group expanded from 10.6% to 26.1%, while rural-none declined by more than 14 percentage points, reflecting parallel shifts across both dimensions.
- Finally, countries like Niger, Guinea, and Tchad show limited structural change, with persistently high levels of educational exclusion in rural areas. For instance, in Niger, the rural-none group decreased from 76.0% to 71.3%, and the urban-secondary+ category grew by 2.6 percentage points (from 3.4% to 6.0%) over two decades.

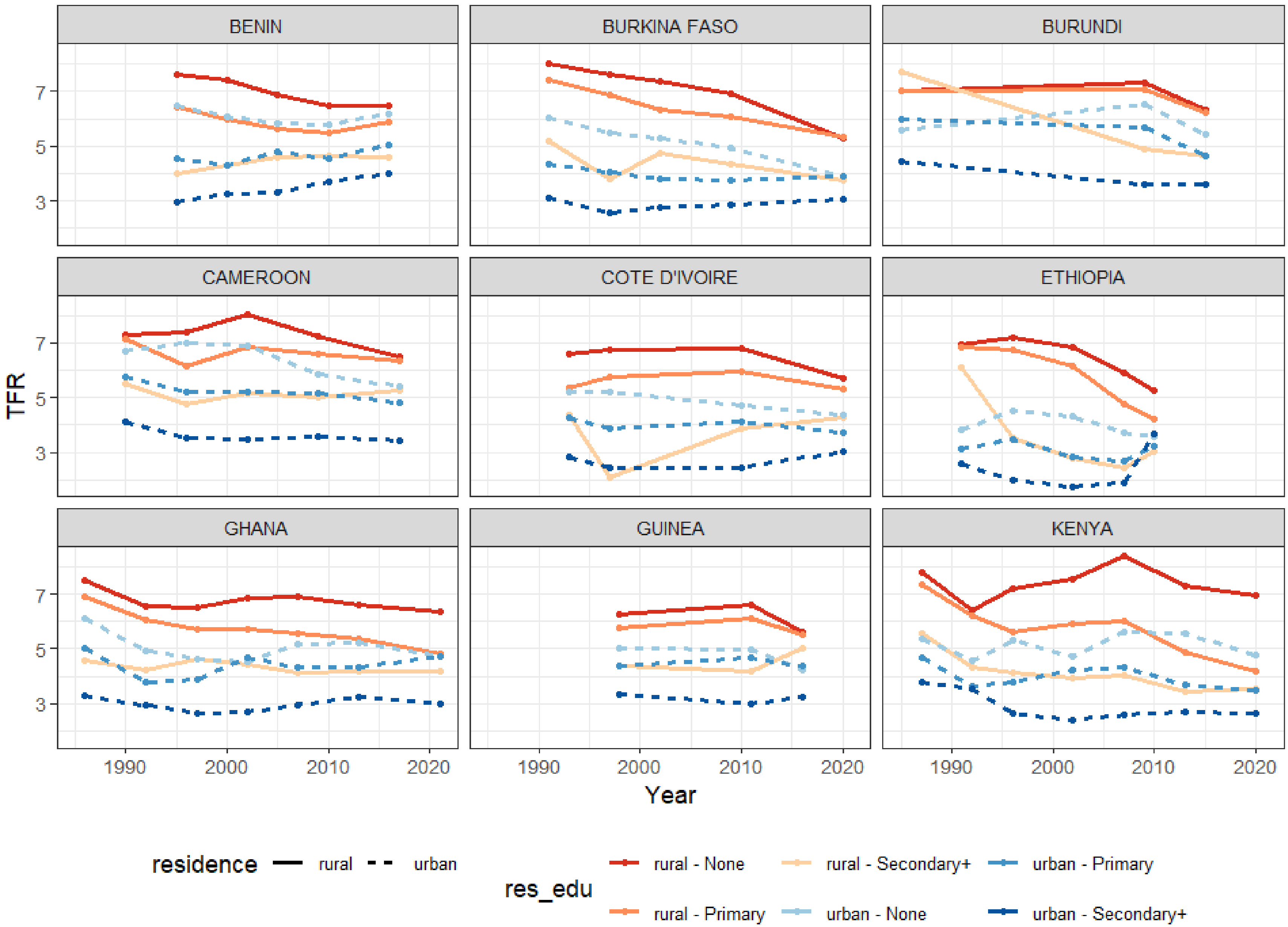
These patterns highlight substantial heterogeneity in demographic structural change across Sub-Saharan Africa, reflecting varying historical, political, and socioeconomic conditions that have shaped the pace of urban and educational transitions.

Figure 1: **Trends in TFR by Place of Residence**



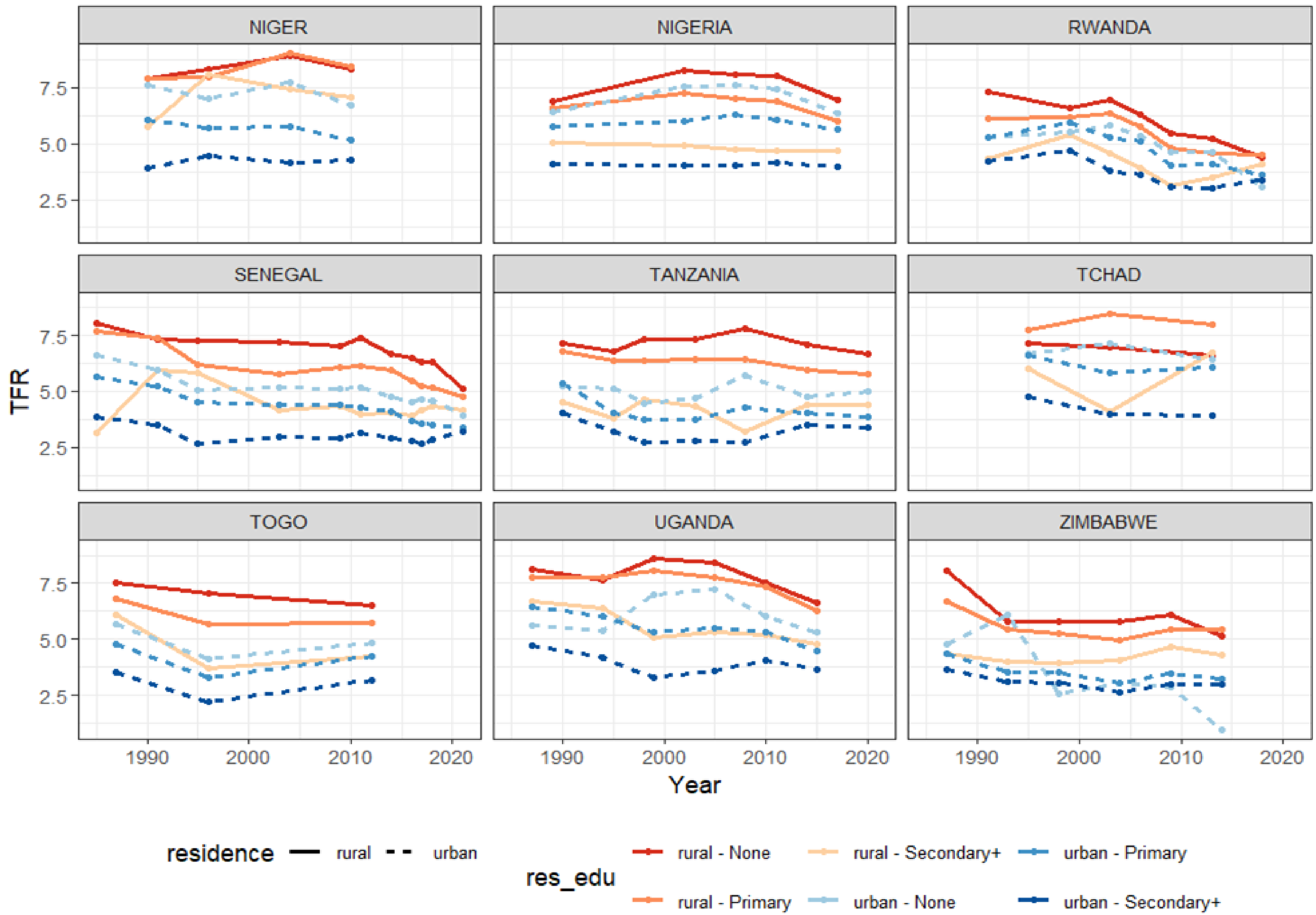
Source: Demographic and Health Surveys

Figure 2: **Trends in TFR by Educational Attainment and Place of Residence**



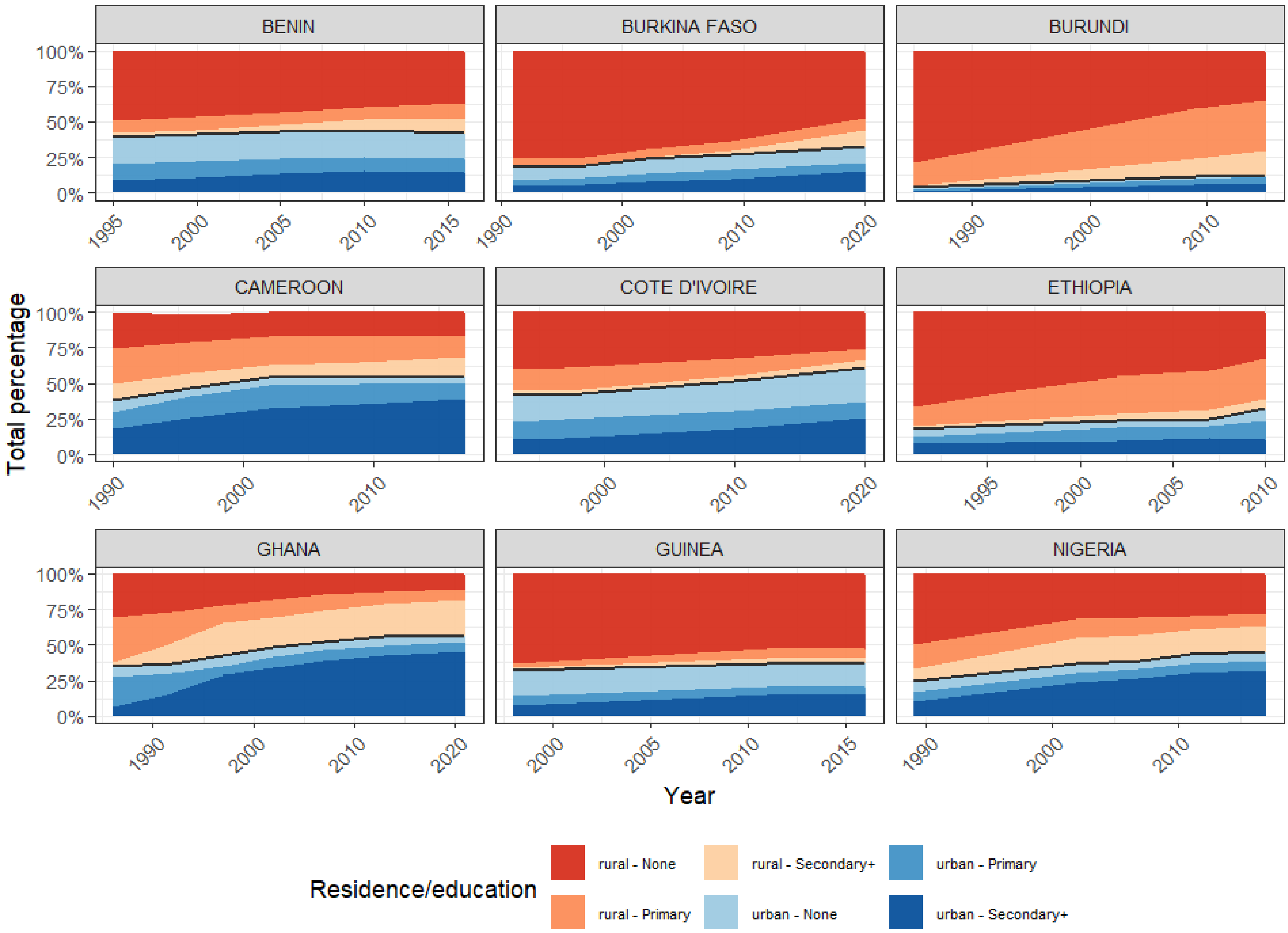
Source: Demographic and Health Surveys

Figure 3: **Trends in TFR by Educational Attainment and Place of Residence (Continued)**



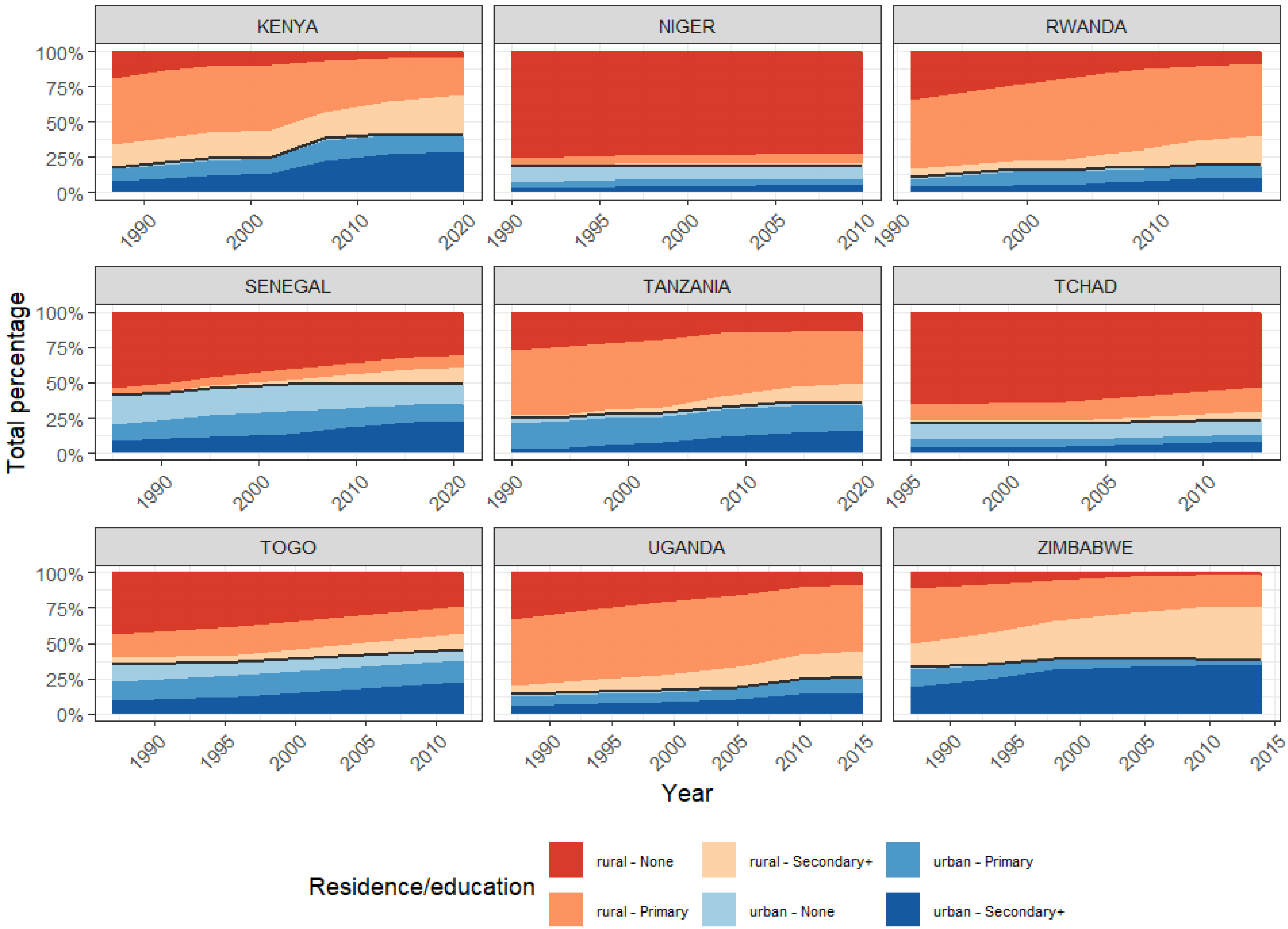
Source: Demographic and Health Surveys

Figure 4: **Evolution of Population Shares by Educational Attainment and Place of Residence**



Source: Demographic and Health Surveys

Figure 5: **Evolution of Population Shares by Educational Attainment and Place of Residence (Continued)**



Source: Demographic and Health Surveys

Decomposition of Fertility Change

Figure 6 presents the **Model 1** of decomposition of changes in the Total Fertility Rate (TFR) between the first and most recent surveys, based solely on place of residence (urban and rural). This decomposition distinguishes between rate effects, which refer to fertility changes within each residential group, and composition effects, which reflect shifts in the population distribution between urban and rural areas, expressed in this case as the urbanization effect.

In most countries, fertility decline is primarily driven by reductions in fertility rates within rural areas. This is especially pronounced in Burkina Faso and Kenya, where rural rate effects account for more than two children per woman of the overall TFR reduction. Cameroon stands out as a notable exception, being the only country where the urban component contributes more than the rural one. Alongside Cameroon, more urbanized countries such as Ghana and Senegal also show a greater influence of fertility change of urban women.

Although composition effects are generally smaller in magnitude, they play a non-negligible role in contexts of rapid urbanization. Nigeria, in particular, demonstrates a relatively higher contribution of compositional change to the overall fertility decline. In contrast, in countries such as Zimbabwe and Rwanda, the compositional effect is nearly null, suggesting that changes in the urban-rural distribution have not significantly influenced national fertility declines. Niger presents overall effects close to zero. Although a modest decline in urban fertility is observed, its national impact remains marginal due to the predominance of the rural population, which has shown limited fertility change.

The decomposition presented in **Model 2** (Figure 7) introduces the educational dimension to the analysis of changes in TFR. Overall, rural women remain the primary contributors to fertility decline. However, this model allows for a more detailed understanding by distinguishing which combinations of educational attainment and place of residence are driving the change. Moreover, several important differences emerge in comparison to Model 1.

The contribution of different educational groups varies by country. Among rural women, women with no education are the main contributors to the fertility decline, particularly in Burkina Faso, Benin, Ethiopia, and Chad. In Burkina Faso, the rural-none component alone accounts for more than one child per woman of the total reduction. In contrast, in countries like Kenya, Uganda, and Rwanda, where rural education levels are higher, the decline is primarily driven by women with primary education, with a significant contribution from those with secondary education as well. Senegal stands out for the strong contribution of non-educated women across both rural and urban.

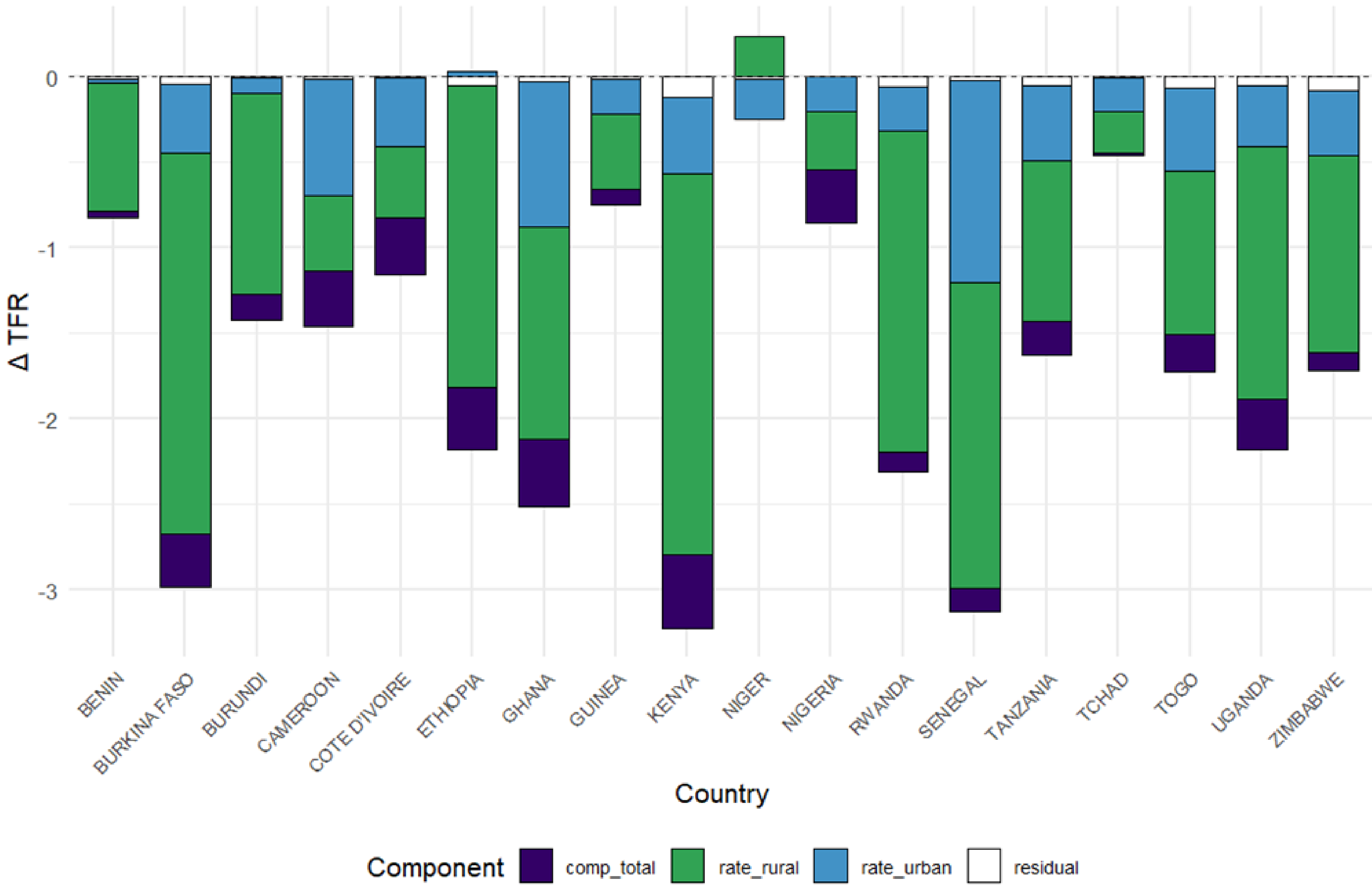
The composition effect in Model 2 reflects the demographic redistribution across both residence and educational groups. This component becomes substantially more influential than in Model 1, emphasizing the role of education progress in fertility decline. In Ghana and Nigeria, for instance, the composition effect, capturing both urbanization and education progress, accounts for the majority of the observed fertility reduction. The compositional effect is also a major component of change in Tanzania, Togo, Zimbabwe, Cameroon, and Côte d'Ivoire. Finally, the residual component remains small across countries, although it tends to be noticeably larger than in Model 1, likely due to the increased complexity of the decomposition.

Figure 8 presents **Model 3**, whose results are virtually the same to those of Model 2. However, this model allows a further analytical refinement by distinguishing compositional effects related to education progress *within urban and rural areas* from those derived from *urbanization* itself. This separation allows a more nuanced understanding of how different structural changes, educational improvements within residence contexts and shifts in the urban-rural population distribution, have contributed to the observed fertility declines.

The most relevant distinctions emerge in the composition effect. In several countries, such as Uganda, Côte d'Ivoire, Ethiopia, Cameroon, and Nigeria, urbanization played a considerable, and sometimes dominant, role within the total compositional change. In Ghana, which exhibited the strongest compositional effect in Model 2, education progress within both urban and rural areas contributes almost equally, though the urbanization component remains substantial.

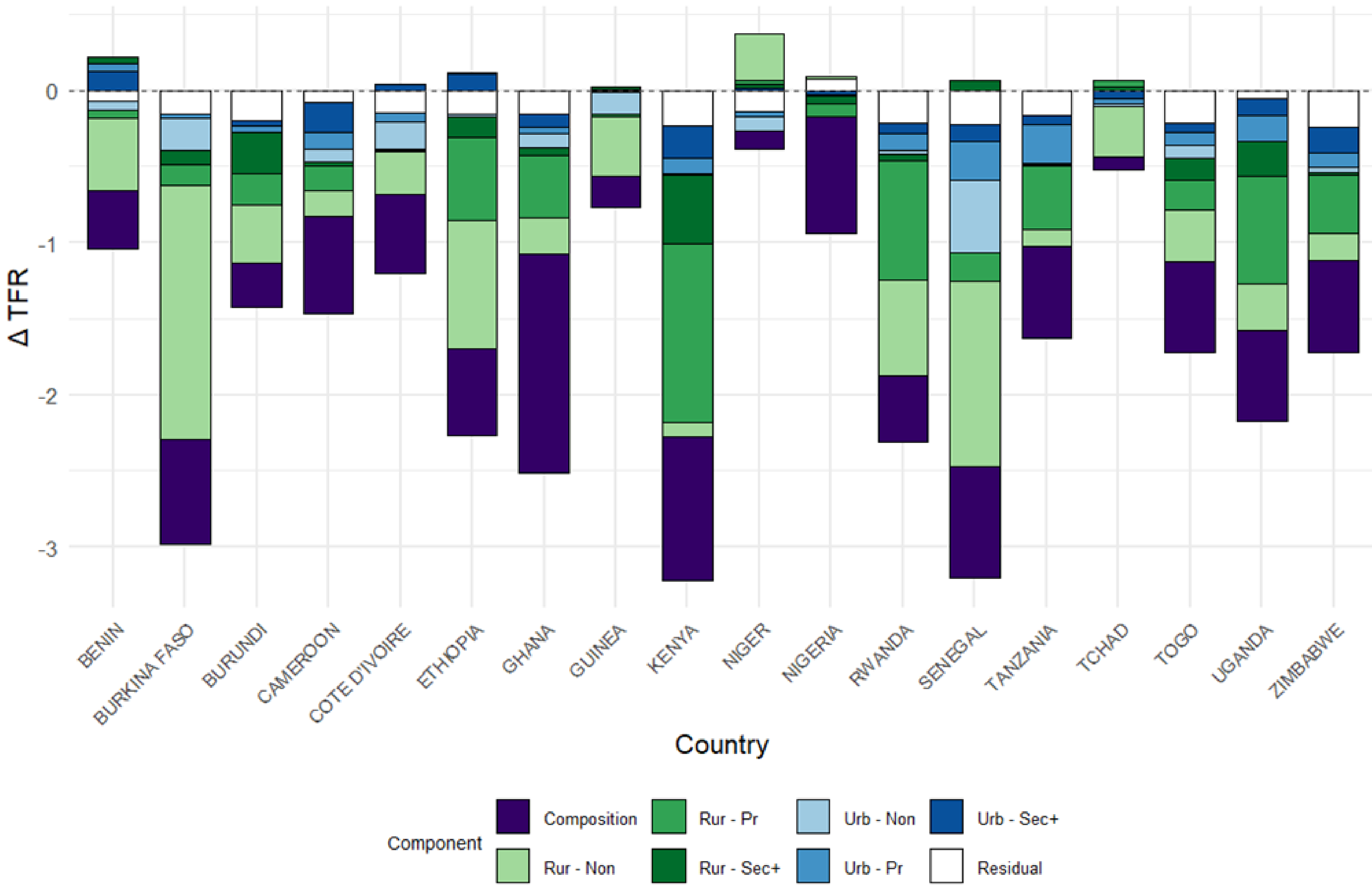
In contrast, with the exception of predominantly rural or demographically stagnant countries such as Guinea, Niger, and Chad, the educational composition effect within rural areas surpasses that of urban areas. Suggesting the role that rural education progress can play in driving fertility transitions, especially in settings where the majority of the population still resides in rural areas.

Figure 6: **Model 1 - Decomposition of changes in the TFR by place of residence between first and last survey**



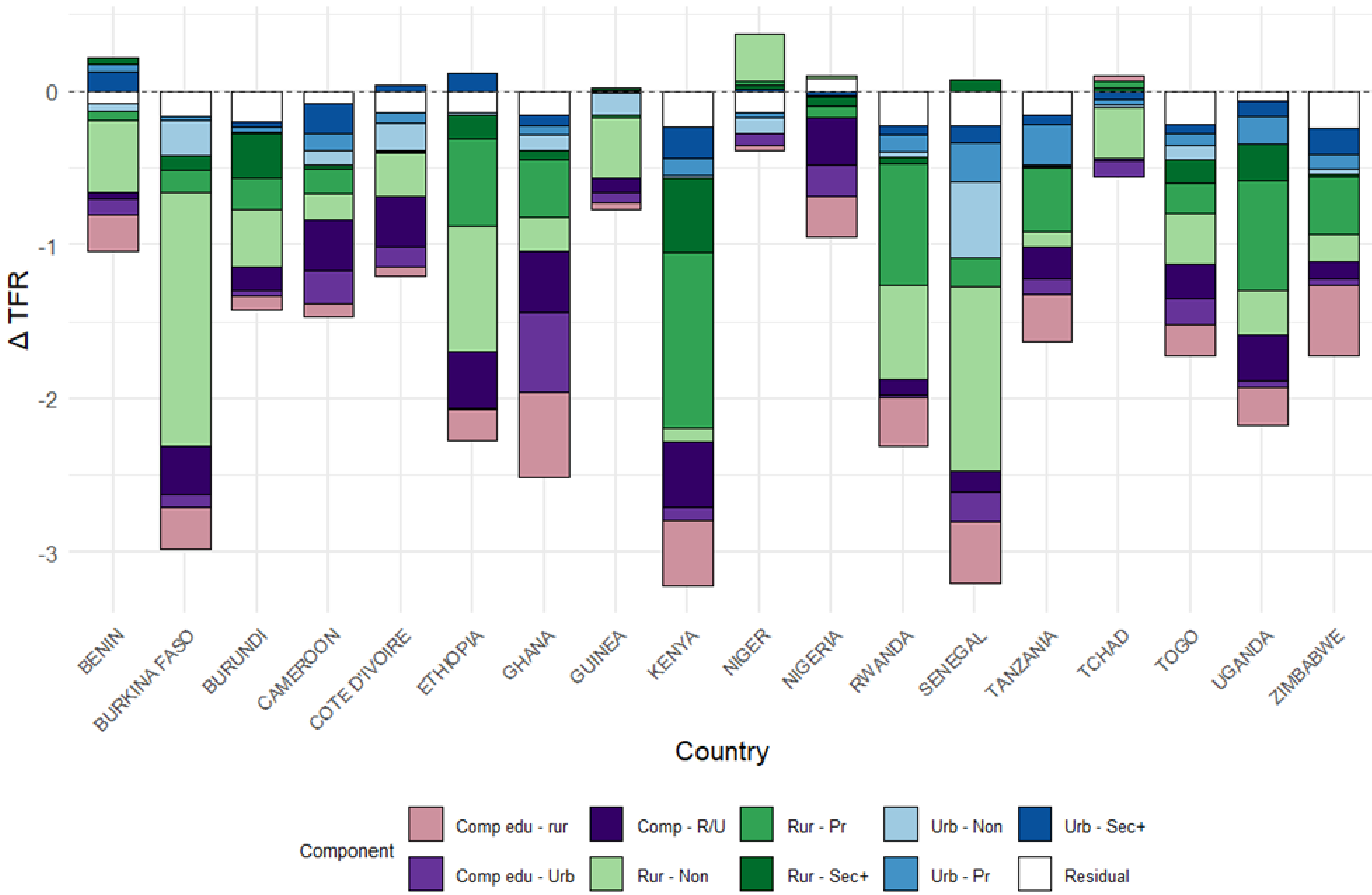
Source: Demographic and Health Surveys

Figure 7: **Model 2 - Decomposition of changes in the TFR by place of residence and educational attainment between first and last survey**



Source: Demographic and Health Surveys

Figure 8: **Model 3 - Decomposition of changes in the TFR by place of residence and educational attainment between first and last survey**



Source: Demographic and Health Surveys

Discussion and Conclusion

As highlighted by the trends (Figures 1–5), contemporary fertility changes in Sub-Saharan Africa tend to confirm the literature, showing a general inclination toward convergence across subgroups. However, rural women and those with low educational attainment consistently maintain substantially higher fertility. Considerable cross-country variation persists, with some contexts showing only timid change and incipient convergence, in contrast to cases such as Rwanda, where convergence is much more pronounced. These differences partly reflect underlying demographic dynamics, in this study proxied by rural–urban residence and educational attainment. Once again, heterogeneity is evident: while countries experiencing rapid urbanization or educational expansion tend to display earlier fertility transitions, the strength and timing of these relationships vary substantially.

The decomposition results underline the central role of rural women in explaining fertility change. Despite rapid urbanization, the demographic weight of rural populations continues to drive overall trends, while fertility decline in urban areas has often stalled. Over the past three decades, fertility change in most countries has been largely explained by rural declines (Figure 6). Nevertheless, as urban populations continue to increase , the relative importance of rural fertility decline in shaping fertility change is likely to diminish.

Each decomposition model highlights different aspects. Model 1 shows that fertility decline is primarily driven by rural changes, with urbanization itself playing a modest but non-negligible role. Model 2 adds the educational dimension, showing that women with no schooling or only primary education are often the main contributors to national fertility decline. Model 3 refines this further by isolating compositional effects of education within rural and urban contexts, while also distinguishing the contribution of urbanization itself. This stepwise approach illustrates how education progress within rural and urban areas, together with urbanization, both shape overall fertility decline, though their relative contributions vary across countries.

The educational composition effect emerges as a major driver of fertility change. However, compositional effects more generally require cautious interpretation. By definition, they capture changes in population structure, in this case, the increasing weight of low-fertility groups and the declining share of high-fertility groups, rather than direct behavioral change. This distinction raises important questions about how to interpret composition as a proxy for deeper demographic or developmental transformations.

Several limitations should be acknowledged. First, the analysis focuses on education and urbanization, leaving aside other important determinants of fertility change, such as contraceptive use, marriage patterns, or cultural factors (Bongaarts, 2015). Second, the decomposition relies on only two time points for each country, which does not allow for a dynamic assessment of the timing of changes or possible reversals. Third, the measurement of education and urbanization presents important challenges: educational attainment is analyzed without considering women's age, which may influence both fertility and access to schooling, also, education systems vary across countries, the same level of education may correspond to different numbers of years of schooling between different countries; urbanization is based on national definitions, while they tend to reflect functional urban realities, this complicates international comparison. Finally, data limitations in specific subgroups (e.g., rural women with secondary education, or urban women with no schooling) imply some caution in interpreting results for these categories.

Overall, this study highlights the persistent importance of rural fertility decline in shaping Sub-Saharan Africa's demographic transition, while also showing the growing contribution of educational expansion and urbanization. Together, these processes provide valuable insights into the heterogeneity and complexity of fertility change across the region.

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