Fertility in Sub Saharan Africa:

What Can We Learn from INDEPTH Sites?

Clémentine Rossier

Institute of Demographic and Life Course Studies, University of Geneva

and Institut National d'Etudes Démographiques, Paris

Clementine.Rossier@unige.ch

Valérie Delaunay

Institut de Recherché pour le Développent, Dakar

valerie.delaunay@ird.fr

Jacques Emina

INDEPTH, Accra

jacques.emina@indepth-network.org

Pauline Adamapoulos

Institute of Demographic and Life Course Studies, University of Geneva

Pauline.Adamopoulos@unige.ch

Martin Bangha

INDEPTH, Accra

martin.bangha@indepth-network.org

April 3, 2015

Paper presented at the *Annual Meeting of the Population Association of America*, 30 April- 2 May 2015, San Diego. This paper was written thanks to the support of INDEPTH and to grant PP00P1-144717/1 of the Swiss National Sciences Foundation.

Introduction

Scholars agree that the fertility decline decades in Sub Saharan Africa has been slow in the last two compared to other developing regions (Bongaarts and Casterline 2013, Tabutin and Masquelier 2013). In the mid-2000s, data from the Demographic and Health Surveys (DHS) indicated that the fertility decline had come to a halt in certain African countries, an occurrence which has been rarely observed in other contexts (Bongaarts 2006). An important debate followed, as to exactly which African country experienced a fertility stall and when (Bongaarts 2008, Shapiro 2008, Garenne 2008, Ezeh et al. 2009, Schoumaker 2009, Sneeringer 2009, Machiyama 2010, Garenne 2011). Part of the disagreement between these studies arose from the definitions and tools used to measure stalls; but the greatest point of divergence pertained to the detection and treatment of biases in the DHS fertility data. Schoumaker (2009) found part of the fluctuations in rates to be due to variations in sampling from one survey to the next; he also detected an important problem with births displacement: in certain surveys, interviewers tended to displace births which occurred less than five years prior to the survey to an earlier date, so as to avoid filling in lengthy parts of the questionnaire. After correcting for these biases and others, the number of identified stalls diminished and at the end, only Kenya seemed to have experienced a stall in the early 2000s (Machiyama 2010).

The debate on the African fertility stalls attracts attention to the quality of the data collected in the Demographic and Health Surveys. These surveys are today the principal source to monitor fertility trends and their determinants in Sub Saharan Africa. They contain extensive information on fertility, its proximate determinants and the socio-economic status of women and couples; these data are collected with a standard and supervised methodology, are nationally representative and internationally comparable, exist for many low-income countries, provide time trends for the last few decades, are free for users (funded by US Aid) and easily available (on the web). While this source of data is incredibly useful and generally reliable, the debate on the African fertility stalls shows that there is a need to restlessly question and validate these data, and where, pertinent, to identify analytical strategies to minimize their biases. For example, a recent comparison between vital statistical systems and population-based surveys in Mongolia has shown that fertility was off by up to one child in surveys due to the undercount of non-married women (Spoorenberg 2014).

Moreover, the DHS surveys, by design, because of their need for comparability in time and across all developing countries, are limited in their capacity for innovation to study fertility and its proximate determinants, and in their adaptability to the specificities of the African fertility transition. They certainly do pick up that the Sub-Saharan region has the highest fertility rates in the world, the lowest contraceptive prevalence, and the highest level of unmet need. But the continent is unique in other aspects. For example, induced abortion is very frequent in the region, especially among younger couples (Shah and Ahman 2012); most of these abortions are unsafe and contribute to the maternal morbidity and mortality burden. Women and couples also often rely on traditional methods of contraception to avoid pregnancies, at least in West and Central Africa (Osei et al. 2014, Bertrand et al. 2014, Rossier et al. 2014), and seem to lengthen their birth intervals to deal with the raising costs of children, especially in Southern and Eastern Africa (Townriss 2014). Fertility intentions seem ambivalent for a large share of the population (Speizer 2006), a population torn between strategies of diversification (and desires for large family) and strategies of human capital investments in children (and desires for small families). Some of these issues (like birth spacing) can be tackled with DHS data, but other (like induced abortion or fertility intentions) require the use of ad-hoc data

collection instruments, which have in some cases been developed and tested in specific settings, but could now be applied more systematically across the continent.

In addition, the DHS are cross-sectional surveys of individuals (which include data on retrospective events), which precludes them to study some important current topics related to the fertility transition. In particular, understanding and addressing contraceptive discontinuation, an important issue of concern in the area of family planning (Ali et al. 2013), would benefit from prospective data; studies of fertility intentions, another key driver of fertility behaviours, also are best served by longitudinal designs. Moreover, with its focus on individual outcomes (like contraceptive prevalence and unmet need), the DHS are ill equipped to study improvements in the quality of contraceptive provision, the next target for family planning programs around the world, likely to be crystallized in the coming Sustainable Development Goals. Evaluations of the functioning of existing family planning programs in health facilities, and the development and testing of new interventions will be key to improve the process of contraceptive provision as well as its outcomes. Finally, one last draw-back of the DHS has been their periodicity (every 5 year or so). In the new era of the data revolution, faster and more continuous data will be needed, also to monitor and promote reproductive change.

With their local grounding, continuous monitoring systems, and capacities for innovative, longitudinal and multi-site research, the Health and Demographic Surveillance Systems (HDSSs), grouped in the INDEPTH network (Sankoh and Byass 2012), seem uniquely positioned to constitute in the future an alternative source of evidence on fertility change and family planning in African countries. In Sub-Saharan Africa where vital statistics systems remain weak, Health and Demographic Surveillance systems are what more closely resemble them (Ye et al. 2012); they have a key role to play in efforts to triangulate and supplement survey sources. 37 HDSS are now implemented in 14 countries in Western, Eastern and Southern Africa, mainly in coastal East and coastal West Africa. They each monitor demographic trends in one single area inhabited by a population of 8,000 to 260,000 individuals (average for African INDEPTH sites= 83,000 individuals). These sites have been systematically collecting data on births; quite a few sites have been monitoring fertility now for ten years or more. INDEPTH has been working on rendering its existing data on fertility more readily available; since July 1st, 2013, vital rates can be computed for participating African sites in the INDEPTHStats tool offered on the INDEPTH website. As of July 2014, fertility data were available for 22 sites, from the year when the site started until 2012.

Using the data published via INDEPTHstats, and restricting our attention to African HDSS sites with at least five years of data, this paper will compare the fertility estimates from the HDSS to those from the DHS, zooming on the region containing the HDSS. The paper will then analyse the literature produced by INDEPTH sites on fertility and its main determinants (fertility intentions, sexual abstinence and initiation, contraception, induced abortion). The goal of our paper is to contribute to the debate on the quality of the fertility data collected in the African INDEPTH sites, but also to reflect on what the study of fertility trends in small, localized yet comparable areas can contribute to scientific knowledge, in complement to the usual analyses performed at the national level. Altogether, the purpose of this paper is to show the unique potential of INDEPTH sites for the study of fertility change and for the promotion and upgrading of family programs in low income countries, in order to encourage future scientific investments in these areas.

Data and methods

In this paper, we will focus on nine countries (three countries in Western Africa: the Gambia, Ghana, Senegal; and six countries in Eastern and Southern Africa: Ethiopia, Kenya, Malawi, Mozambique, South Africa, Tanzania,) hosting altogether 17 INDEPTH sites with at least five years of data (Table 1). All these sites participated to INDEPTHStats by July 1st 2014. Most of the nine countries are covered by three or four DHS surveys since the late 1980s or early 1990s, except for South Africa (only two DHS in 1998 and 2003, and the second one is not publically accessible), and the Gambia (no DHS). Half of the countries included in this analysis (Gambia, Malawi, Mozambique, Senegal and Tanzania) are at the early stages of the fertility transition, with TFRs between 5 and 6 children per woman. At the other end of the spectrum, one country has finished its transition: South Africa. Three other countries (Ethiopia, Ghana and Kenya) are in the middle of the transition, with TFRs between 3.9 and 4.6 children per woman.

Table 1: African HDSS participating to INDEPTHStats with at least five years of data and available DHS data for their region

Country	National TFR 2010-2015*	HDSS	From	To	DHS region	From	To
Ethiopia	4.6	Gilgel Gibe	2006	2011	Oromiya	2000	2011
Gambia	5.8	Farafenni	1993	2011	-	-	-
Ghana	3.9	Dodowa	2006	2011	Greater Accra	1988	2008
		Kintampo	2005	2011	Brong Ahafo	1988	2008
		Navrongo	1996	2011	Upper East	1993**	2008
Kenya	4.4	Kilifi	2004	2011	Coast	1989	2008/9
		Kisumu	2003	2011	Nyanza	1989	2008/9
		Nairobi	2002	2011	Nairobi Area	1989	2008/9
Malawi	5.4	Karonga	2003	2011	Northern	1992	2010
Mozambique	5.6	Manhica	2000	2010	Manhica	1997	2011
Senegal	5.0	Mlomp	1990	2011	Ziguinchor	1999	2011
		Niakhar	1990	2011	Fatick	2005**	2010/11
South Africa	2.4	Africa Centre	2000	2011	KwaZulu Natal	1998	1998
		Agincourt	1993	2011	Mpumalanga	1998	1998
Tanzania	5.0	Ifakara	1997	2011	Eastern	1992	2010
		Magu	1994	2011	Lake	1992	2010
		Rufiji	1999	2011	Eastern	1992	2010

* World Fertility patterns 2013, UN Population Division ** These regions are defined differently in earlier DHS

We undertook a graphic description of the evolution of annual TFRs for these 17 African sites. We displayed on the same graph the DHS data for the region containing the HDSS, for all years with a survey, using data from Statcompiler (correcting for 2 years as in Garenne 2011). Note that the definition of regions as varied across DHS surveys in two countries (Table 1). In Ethiopia, the comparison summons only one recent DHS (containing the region of interest) and just a five years of HDSS data (new sites). In other countries, long DHS trends can be compared with just a few years of HDSS data (new HDSS sites in Ghana, Kenya). In the same and other countries, long time series are available both from a long series of DHS and older HDSS sites (Ghana, Kenya, Malawi, Mozambique, Senegal, Tanzania). Finally, in the Gambia and South Africa, long times trends from HDSS sites cannot be compared with DHS data, or just with one survey. We used the HDSS profiles available on the

INDEPTH website[1] to inform the context of the sites and explain differences in fertility rates between the two sources of data.

To complete this analysis, we compiled the INDEPTH list of publications for years 1998 and 2013, as provided by the organization. The sites published 66 articles in 1998 and 493 in 2013[2]. We singled out all publications dealing with reproductive health conducted in a social sciences or public health approach (we excluded a few purely biomedical studies). Having retrieved the abstracts for all these studies, we further classified them according to their main theme into four categories: 1) HIV/Aids and other STIs, 2) safe motherhood, 3) fertility and its proximate determinants, and 4) other. Occasionally, articles treated two themes at once (ex: use of hormonal contraception and risk of HIV infection); in those cases, we decided on a predominant theme. We also analysed the methodological design of these studies, making a note of longitudinal and cohort studies, health interventions trials or developments, and qualitative or modelling approaches. Studies were often characterized by several of these methodological traits at once.

Results

Comparing fertility levels and trends in 17 HDSS and the DHS for their region

The comparison between regional DHS and HDSS fertility levels and trends shows a good match in seven of the 17 sites (see Figures 1 to 17 in Appendix 1). A case in point is Niakhar in the Fatick region of Senegal (see also Garenne 1994). The conclusion is similar when looking at the Dodowa fertility levels which match well with the trends indicated by the DHS in the Greater Accra region in Ghana. Similarly, in Kenya, the fertility levels measured in the Kilifi site are in line with fertility levels measured for the Coast region by the DHS. The same can be said of the Karonga site (Northern region in Malawi), and of the Kintampo site in the Brong Ahafo region in Ghana (except for the year when data collection started in this site). Finally, one of the sites in South Africa, Agincourt, seems to have its fertility rates closely aligned with the DHS rate for its region (Mpumalanga), although we have only on DHS data point to make the comparison. Kisumu in Nyanza region in Kenya is another site which has comparable rates to those measured by the DHS, although the site's fertility decline in recent years will need to be verified against the next DHS.

In five cases, the fertility levels are lower in HDSS sites compared to what could have been expected from the regional DHS measure. This is the case first for the Navrango site in Northern rural Ghana. Navrango was the site of a maternal and child health / family planning experiment starting in 1995, where contraceptives where made available through a community-based distribution scheme adapted to the local cultural context (Phillips et al. 2012). This experiment remains one of the rare family planning success stories available for the rural African context. Another case of lower than expected fertility rate is the site of Manhica in Mozambique. The site is located in the more urban part of the region, which could explain the fertility difference, lower by about 1.5 child on average

[1] [1](http://www.indepth-network.org/index.php?option=com_content&task=view&id=1306&Itemid=1070)

[2] Note that the lists contain a non-negligible number of double-counts (especially for multi-site publications), and a number of works which were conducted outside of INDEPTH sites (by INDEPTH researchers). We did not eliminate these articles from the general list, but did not select them in our subset of reproductive health articles.

per woman compared to the region as a whole. This is true also for Mlomp, a site located in the more developed and urban (coastal and touristic) part of the Ziguinchor region in Senegal. Similarly, Magu, in the Lake region in Tanzania, is located near the lake and its resources, and Gilgel Gibe in the Oromiya region in Ethiopia is located near a hydroelectric dam. The effect of urbanization /local development level on HDSS fertility levels is also clear in the case of Farafenni, which sees its fertility rate drop from a high and stable rate to a lower (and also stable) rate in 2002, the year when this site extended its coverage area to include the nearby town.

Finally, in three cases, the fertility rates are higher compared to the regional average as measured in the DHS. Fertility rates are somewhat higher in the Nairobi HDSS site compared to the DHS average for the region as whole, which is as expected since the HDSS site follows two impoverished slum neighbourhoods. Fertility rates are also higher in the Ifakara and the Rufiji sites, both located in the Eastern region of Tanzania, compared to the DHS measure for the region as a whole; these two sites seem to be implemented in poorer / more rural parts of the region.

Another interesting result emerges from the comparison between HDSS and DHS fertility rates. About half of the HDSS sites show important variations in fertility rates from one year to the next. These yearly variations can be as large as one child more or one child less, see for example the case of Farafenni in the Gambia, or the site of Niakhar especially before the years 2000. The sites with the most yearly variations are also are those with higher fertility rates. Sites with lower fertility rates (see for example the two sites in South Africa or Nairobi) have much smoother fertility curves. Strong yearly fertility variations in rural, high fertility contexts have been explained by variations in marriage and migration patterns, both strongly related to economic resources and agricultural crises (Hertrich and Delaunay, 1998).

Publications on fertility and its proximate determinants in INDEPTH sites in 1998 and 2013

Our comparison with the DHS show that HDSS sites have collected a mass of data on births, and that their count seem at least of equivalent quality compared to the DHS. How do researchers involved in INDEPTH sites use or elaborate on these data, and how has the situation evolved between 1998 and 2013? In general and in both years, the publications of INDEPTH sites lie in the field of public health and medical research, and focus on the health topics promoted by the Millennium Development Goals: nutrition (MDG 1), child health (MDG 4), maternal health (MDG 5), and HIV/ malaria other infectious disease (MFG 6), with some works also reflecting a concern with the chronic / injury /mental disease burden.

Out of the 66 articles published in 1998, 36% (24) were public health / social science articles on a reproductive health topic. These articles addressed almost equally the three main reproductive health issues: 8 articles were on STIs and HIV, 7 on fertility and its proximate determinants, 6 on safe motherhood; 3 additional articles focused on female genital mutilations and violence against women. In 2013, we found 95 publications (19% of total publications) to be social science / public health publications on reproductive health topics. 54 (57% of reproductive health publications) were related to HIV/AIDS and other STIs, 29 (31%) to safe motherhood and only 8 (8%) to fertility and its proximate determinants; 5 studies were on other sexual and reproductive health topics: sexual coercion, menstrual management, gender inequity and about RH in general. Altogether 1.4% of the

publications by INDEPTH sites in 2103 pertain to fertility and its proximate determinants, compared to 10.6% in 1998.

In methodological terms, most studies published used longitudinal data, in the form of cohorts of patients or through the analysis of surveillance data generated over many years, and the tendency is stronger in 2013 compared to 1998. The results show the power of longitudinal designs to inform causal mechanisms. For example, one recent study showed that the use of hormonal contraception did not increase the risk of HIV infection in sero-discordant couples, against preconceived ideas (Lutalo et al. 2013). The studies conducted and published by INDEPTH sites researchers also often revolve around health interventions or the refinements of existing ones, both in 1998 and in 2013. For example, Bor et al. (2013) described the impressive increase in life expectancy gained from the scale-up of ART in the Kwa Zulu Natal site. Numerous other studies in this site described the complex process of bringing HIV positive individual to use ART and unexpected consequences and challenges. Finally, many of these studies can be deemed to be innovative, although the methods to get there are varied. Some studies used statistical models (based on INDEPTH site data) to make projections or help weight different explanations or used qualitative techniques or quantitative cross-sections to gain better understanding of emerging topics. For example, Shenk et al. 2013 used Matlab data show that economic explanations of fertility declines receive more empirical support. Other studies used HDSS data to show lacks in common survey or conceptual approaches to problems. For example, a match between HDSS and a survey on the survival of siblings showed that many women who die in maternal death do not have any surviving sibling to report on them (Helleringer et al. 2013). Other studies use qualitative enquires to explore new topics. In sum, the studies on reproductive health published so far by INDEPTH sites researchers are overwhelmingly longitudinal, usually close to the development and evaluation of health interventions, and constitute fertile grounds for innovation. Not that multi-sites studies, almost inexistent in 1998, are becoming increasingly common in 2013.

Discussion and conclusions

Our comparison points to certain weaknesses of the fertility rates produced with DHS data: the comparison with the Kintampo and Navrango sites in Ghana confirm the existence of data quality issue with the DHS series identified for the year 2000s for rural Ghana (Schoumaker 2009, Machiyama 2010). Also, strong yearly variations are hidden by DHS trends, at least when linking the Statcompiler TFR produced from one survey to the next. These real-life yearly variations call attention to the limitation of the TFRs estimates from Statcompiler (computed with the last three years of births): calculations averaging 6 or 10 years of DHS preceding births data give a more useful estimate. Note that annual rates over the last 10 years with DHS data show plenty of year to year variations (Machiyama 2010).

Overall, fertility data from HDSSs would appear to be of greater quality than DHS data (except arguably in the first year or two, when the system is not yet performing at its full speed). Indeed, interviewers collect data in every household of the study sites at regular intervals (every 4 months, 6 months or at the most every year). Since data collection is on-going, displacement or recall biases of births are limited. In addition, births are registered at each round through direct interview, but also thanks to pregnancies registered at previous round. Sampling errors are not an issue either in HDSSs,

since data is collected on all reproductive age women living in the area covered. Finally, in HDSS sites, even women who end up dying are counted in the denominator and contribute births.

The shortcomings of HDSS fertility data are not linked to the estimation of the period total fertility rate but emerge rather when attempting to analyse fertility in a longitudinal perspective. Births are registered for women during their period of residency in the site only. To date only a few HDSSs collect the past birth histories of women who enter (or re-enter) the surveillance system. Parity (the rank of the birth) is typically not a piece of information collected in HDSS sites so far. This weakness is especially limiting since an important research advantage of HDSSs is their longitudinal dimension. For example, some sites collect information on the planned status of births, which could be linked to ulterior information on children health, survival and education. Birth spacing practices and their consequences on child outcomes could also be studied in every site. Sites with data on union formation can tackle the topic of premarital fertility and of the timing of the first births and their consequences later in life on women's and children's well-being. But such analyses cannot make the economy of data on parity and on women's prior birth history.

Our comparison of fertility trends in African HDSS sites with the DHS average for their region shows in almost half of the cases a good concordance; in the other cases, the differences are explained by varying levels of urbanization / development within regions and by the localization of the site. The extreme variability of fertility rates at the local level is in itself a subject of study, and new spatial approaches that map fertility rates across the continent using DHS data show a clear link between the advances of cities, the size of these cities, and spots of lower fertility (Corker 2015). More work could be done with HDSS data to explain between-sites fertility variations; ad-hoc contextual data could be collected in each site to quantify or qualify with greater precision the level of economic development / urbanization, as well as the shape and strength of local family planning programs. An important weakness of HDSS data for comparative analyses of fertility rates, however, is that the range of individual socio-demographic variables collected in sites remains limited, and that these variables are only starting to be standardized across sites. Moreover, few sites collect data on the proximate determinants of fertility, an important part of the explanation. While data on the factors which influence fertility are scant in INDEPTH sites, we underlined that these sites are great places to experiment and innovate. This void could be an opportunity to tackle new approaches in the field.

Finally, most of the research conducted at INDEPTH sites are related to intervention development, program evaluation, clinical trials or their scaling-up. The coming Sustainable Development Goals will promote efforts in the area of contraceptive provision (quality, accessibility, availability, acceptability) rather than simply aiming at increasing contraceptive prevalence and decreasing unmet need, as was the case in the Millennium Development Goals. With renewed attention to the *process* of contraceptive provision, evaluations and interventions of family planning programs will again become central to the reproductive health field. While up to 10% of the scientific production at INDEPTH concerned itself with fertility and fertility regulation in the late 1990s, this number did not reach 2% in 2013. With these new international aspirations, its proved capacities to produce robust data on fertility and it familiarity with health intervention work, INDEPTH may become again soon a hot spot for family planning experimentation.

References

Ali, M., Seuc, A., Rahimi, A., Festin, M., & Temmerman, M. (2014). A global research agenda for family planning: results of an exercise for setting research priorities. *Bulletin of the World Health Organization*, *92*(2), 93-98.

Bertrand, J. T., Sullivan, T. M., Knowles, E. A., Zeeshan, M. F., & Shelton, J. D. (2014). Contraceptive Method Skew and Shifts in Method Mix In Low-and Middle-Income Countries. *International perspectives on sexual and reproductive health*, *40*(3), 144-153.

Bongaarts, J. 2006. The Causes of Stalling Fertility Transitions. *Studies in Family Planning* 37(1): 1-16.

Bongaarts, J. 2008. Fertility Transitions in Developing Countries: Progress or Stagnation? *Studies in Family Planning* 39(2): 105-110.

Bongaarts, J., & Casterline, J. (2013). Fertility Transition: Is sub-Saharan Africa Different? *Population and Development review*, *38*(s1), 153-168.

Bor, Jacob et al. "Increases in Adult Life Expectancy in Rural South Africa: Valuing the Scale-up of HIV Treatment." *Science (New York, N.Y.)* 339.6122 (2013): 961–965. *NCBI PubMed*. Web.

Ezeh, A.C., B.U. Mberu, and J.O. Emina. 2009. Stall in Fertility Decline in Eastern African Countries: Regional Analysis of Patterns, Determinants and Implications. *Philosophical Transactions of the Royal Society B: Biological Science* 27(364): 2991-3007.

Garenne, M., & van Ginneken, J. (1994). Comparison of retrospective surveys with a longitudinal follow-up in Senegal: SFS, DHS and Niakhar. *European Journal of Population/Revue européenne de Démographie*, *10*(3), 203-221.

Garenne, M. 2008. *Fertility Changes in Sub-Saharan Africa.* DHS Comparative Reports No. 18. Calverton, Maryland: Macro International Inc.

Garenne, M. L. (2011). Testing for fertility stalls in demographic and health surveys. *Population health metrics*, *1*(7), 18.

Helleringer, Stéphane et al. "Misclassification of Pregnancy-Related Deaths in Adult Mortality Surveys: Case Study in Senegal." *Tropical medicine & international health: TM & IH* 18.1 (2013): 27–34.

Hertrich Véronique, Delaunay, Valérie, 1998. – "Les adaptations matrimoniales face à la crise agricole : le rôle de la pluviométrie dans deux populations du sahel", in, Francis Gendreau éd., Crises, pauvreté et changements démographiques dans les pays du Sud, ESTEM, Paris, p. 249-265.)

Lutalo, Tom et al. "Effects of Hormonal Contraceptive Use on HIV Acquisition and Transmission among HIV-Discordant Couples." *AIDS (London, England)* 27 Suppl 1 (2013): S27–34

Machiyama Kazuyo. 2010. *A Re-examination of Recent Fertility Declines in Sub-Saharan Africa.* DHS Working Papers No. 68. Calverton, Maryland, USA: ICF Macro.

Osei, I. F., Mayhew, S. H., Biekro, L., Collumbien, M., & ECAF Team. (2014). Fertility Decisions and Contraceptive Use at Different Stages of Relationships: Windows of Risk Among Men And Women in Accra. *International perspectives on sexual and reproductive health*, *40*(3), 135-143.

Phillips, J. F., Jackson, E. F., Bawah, A. A., MacLeod, B., Adongo, P., Baynes, C., & Williams, J. (2012). The Long-Term Fertility Impact of the Navrongo Project in Northern Ghana. *Studies in family planning*, *43*(3), 175-190.

Rossier, C., Senderowicz, L., & Soura, A. (2014). Do natural methods count? Underreporting of natural contraception in urban Burkina Faso. *Studies in family planning*, *45*(2), 171-182.

Sankoh, O., & Byass, P. (2012). The INDEPTH Network: filling vital gaps in global epidemiology. *International journal of epidemiology*, *41*(3), 579-588.

Schoumaker, B. 2009. Stalls and Reversals in Fertility Transitions in Sub-Saharan Africa: Real or Spurious? Document de travail SPED. Louvain-la-Neuve: Université catholique de Louvain.

Shah, I. H., & Åhman, E. (2012). Unsafe abortion differentials in 2008 by age and developing country region: high burden among young women. *Reproductive Health Matters*, *20*(39), 169-173.

Shapiro, D. and T. Gebreselassie. 2008. *Falling and Stalling Fertility in Sub-Saharan Africa.* International Union for the Scientific Study of Population International Seminar on Human Fertility in Africa. Cape Coast, Ghana.

Shenk, Mary K., Mary C. Towner, et al. "A Model Comparison Approach Shows Stronger Support for Economic Models of Fertility Decline." *Proceedings of the National Academy of Sciences of the United States of America* 110.20 (2013): 8045–8050.

Sneeringer, S.E. 2009. *Fertility Transition in Sub-Saharan Africa: A Comparative Analysis of Cohort Trends in 30 Countries.* DHS Comparative Reports No. 23. Calverton, Maryland: ICF Macro.

Speizer I. 2006. "Using strength of fertility motivations to identify family planning program Strategies", *International Family Planning Perspectives*, 32(4): 185-191.

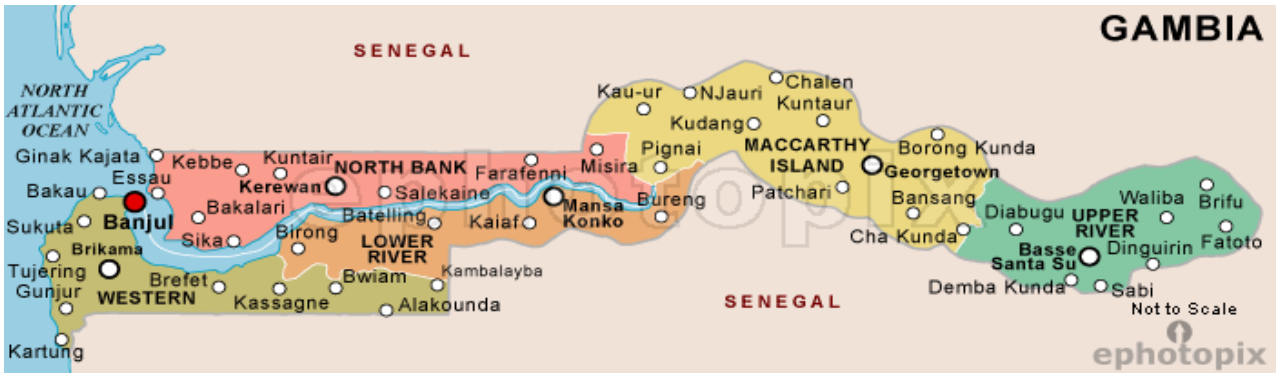
Spoorenberg, T. (2014). Reconciling discrepancies between registration-based and survey-based estimates of fertility in Mongolia. *Population studies*, *68*(3), 375-382.

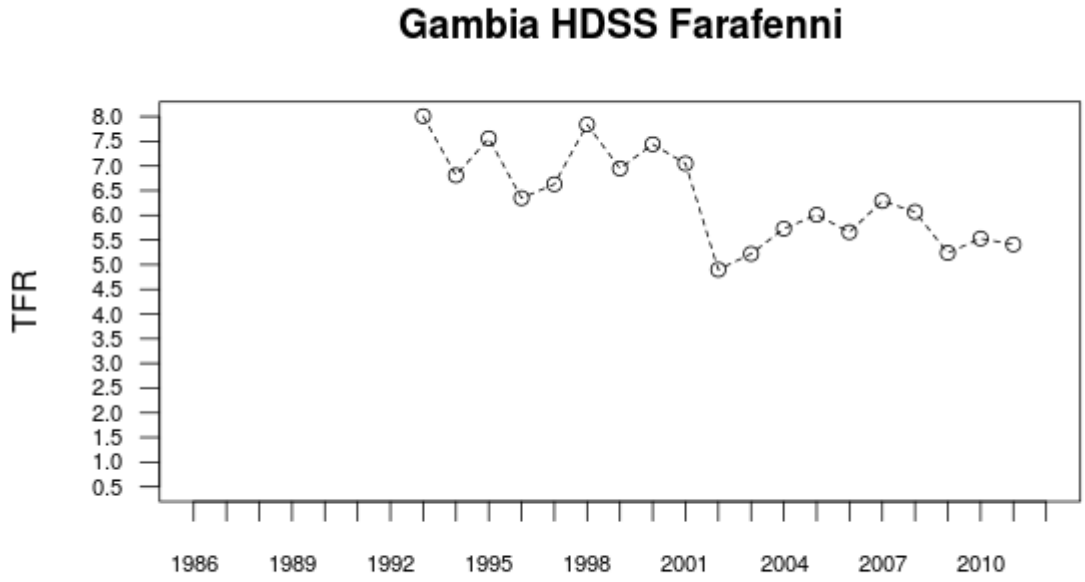
Tabutin D. et Masquelier B. (eds.), (2013), Ralentissements, résistances et ruptures dans les transitions démographiques, Actes de la Chaire Quetelet *2010*, Presses universitaires de Louvain, 298 pp.

Towriss, C. A. (2014). *Birth Intervals and Reproductive Intentions in Eastern Africa: Insights from Urban Fertility Transitions* (Doctoral dissertation, London School of Hygiene and Tropical Medicine (University of London)).

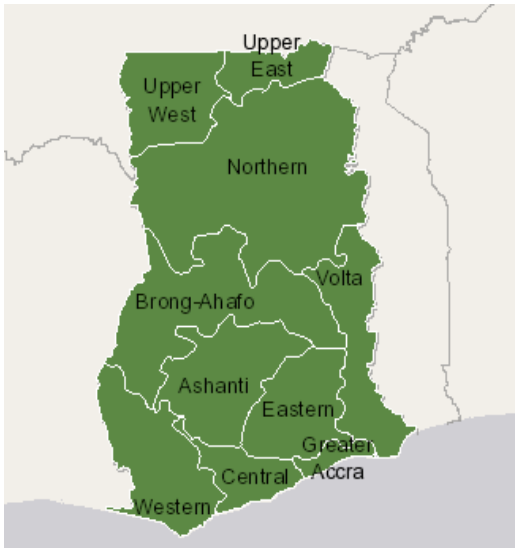
Ye, Y., Wamukoya, M., Ezeh, A., Emina, J. B., & Sankoh, O. (2012). Health and demographic surveillance systems: a step towards full civil registration and vital statistics system in sub-Sahara Africa?. *BMC Public Health*, *12*(1), 741.

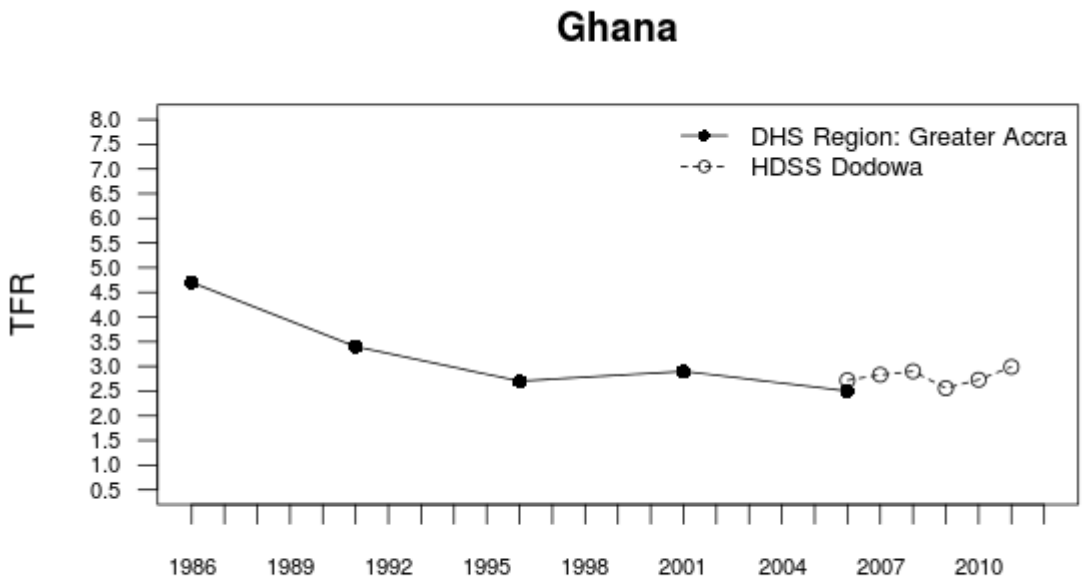
Appendix 1


GAMBIA
SENEGAL
NORTH ATLANTIC OCEAN
Ginak Kajata
Kebbe
Kuntair
NORTH BANK
Farafenni
Misira
Kau-ur
NJauri
Chalen
Kuntaur
Kudang
Pignai
MACCARTHY ISLAND
Georgetown
Borong Kunda
Bakau
Essau
Kerewan
Salekaine
Patchari
Bansang
Waliba
Brifu
Bakalari
Batelling
Mansa Konko
Bureng
Diabugu
UPPER RIVER
Sukuta
Banjul
Kaiaf
Cha Kunda
Fatoto
Brikama
Sika
Birong
LOWER RIVER
Basse Santa Su
Dinguirin
Tujering
Gunjur
Brefet
Bwiam
Kambalayba
WESTERN
Kassagne
Alakounda
SENEGAL
Demba Kunda
Sabi
Not to Scale
Kartung
ephotopix


Gambia HDSS Farafenni
TFR
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
1986
1989
1992
1995
1998
2001
2004
2007
2010

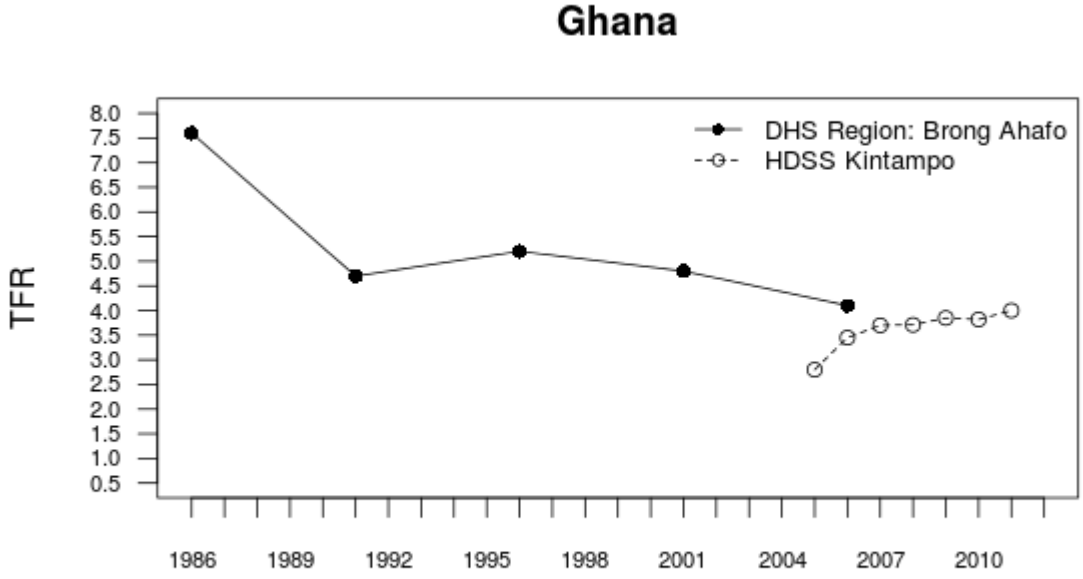

Dangme West
Dodowa
Greater Accra

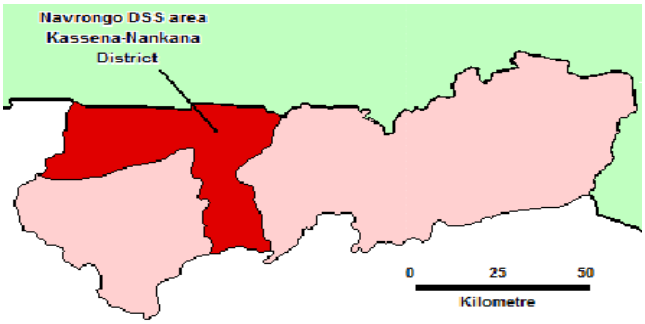

Upper East
Upper West
Northern
Volta
Brong-Ahafo
Ashanti
Eastern
Greater Accra
Central
Western

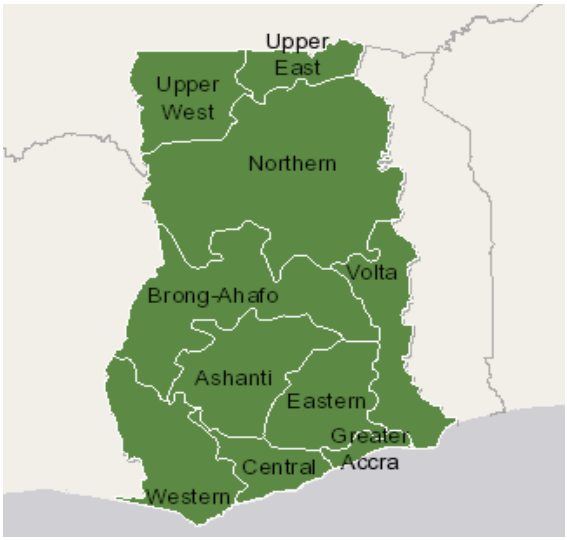

Ghana
TFR
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
1986
1989
1992
1995
1998
2001
2004
2007
2010
DHS Region: Greater Accra
HDSS Dodowa

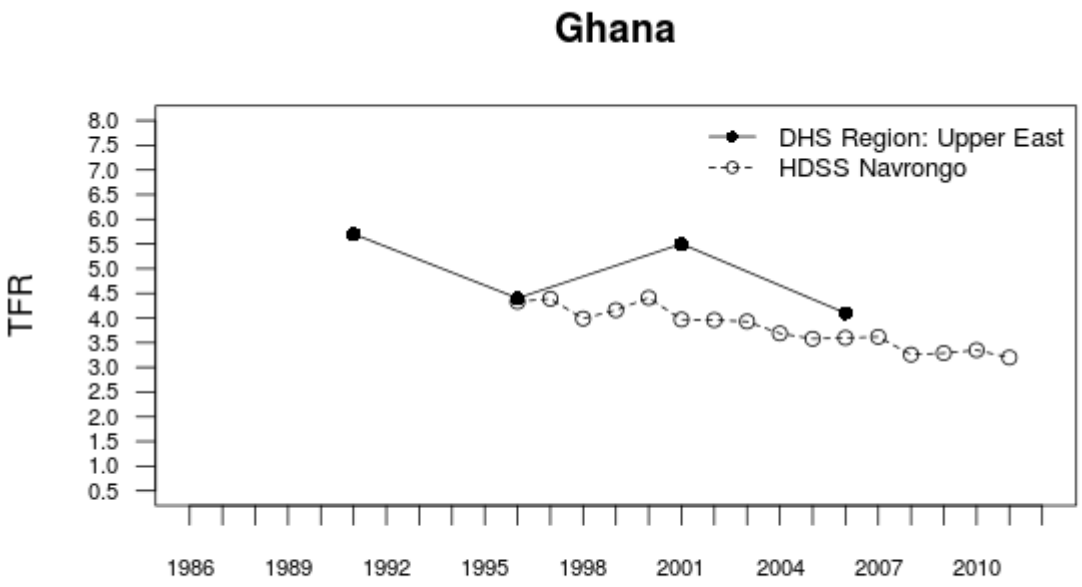

Kintampo
Brong Ahafo

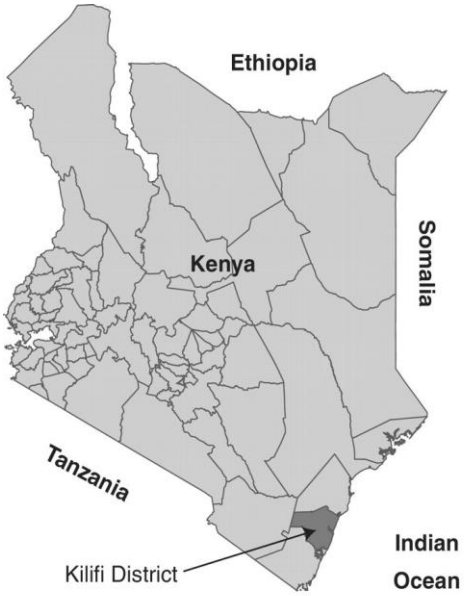

Upper
East
Upper
West
Northern
Volta
Brong-Ahafo
Ashanti
Eastern
Greater
Accra
Central
Western

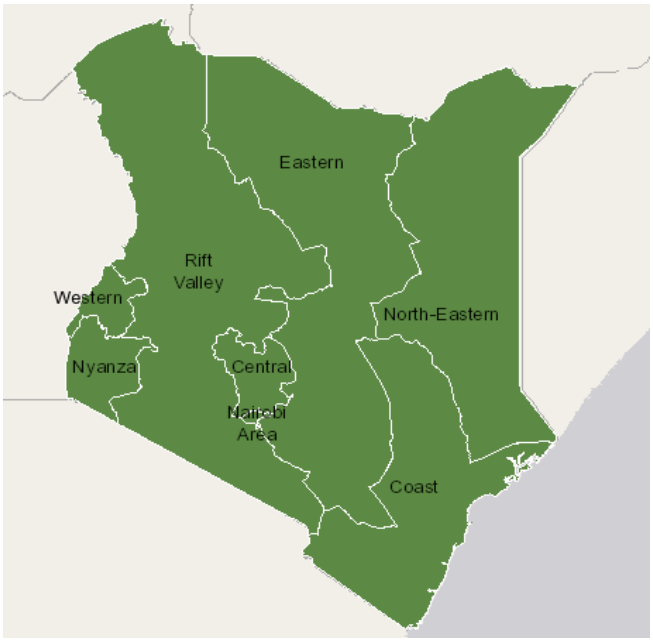

Ghana
TFR
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
1986
1989
1992
1995
1998
2001
2004
2007
2010
DHS Region: Brong Ahafo
HDSS Kintampo

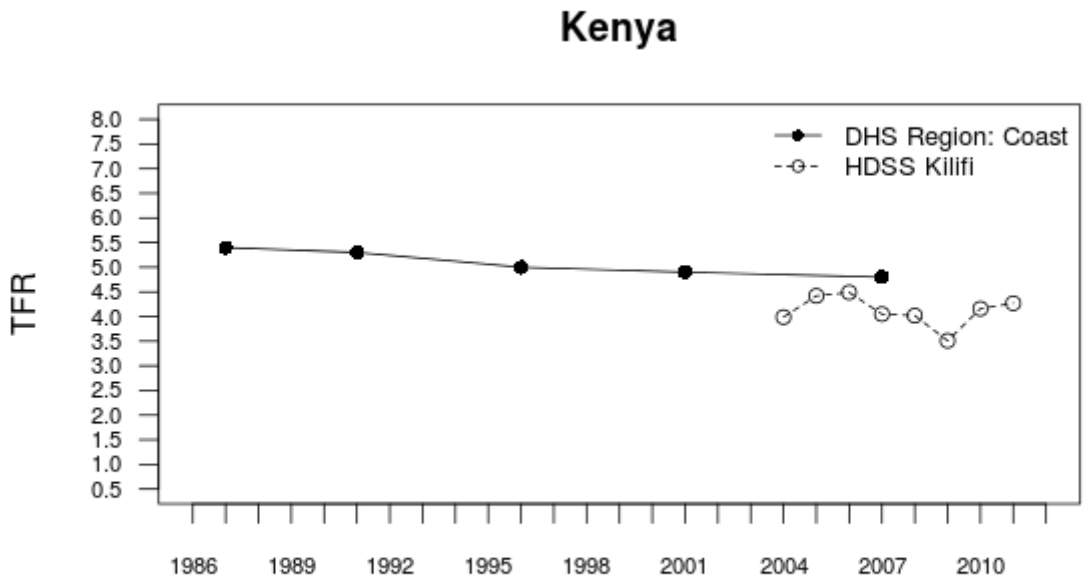

Navrongo DSS area
Kassena-Nankana
District
0
25
50
Kilometre


Upper
East
Upper
West
Northern
Volta
Brong-Ahafo
Ashanti
Eastern
Greater
Accra
Central
Western

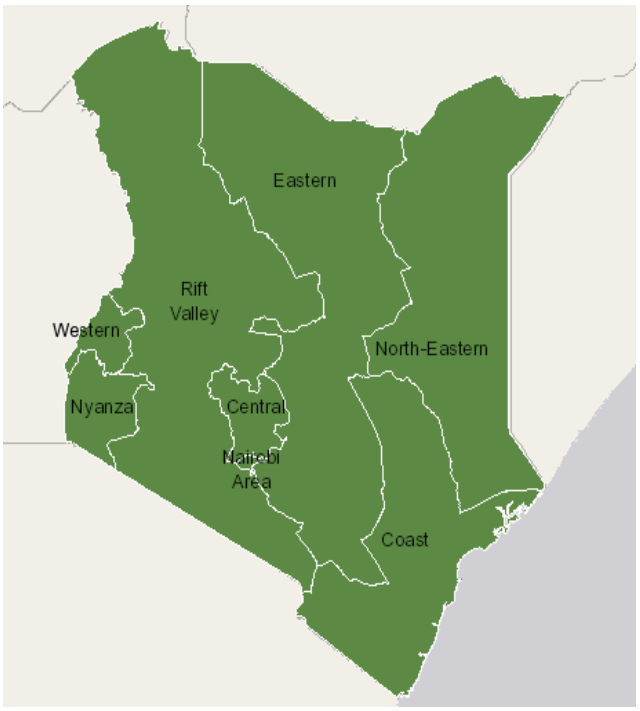

Ghana
TFR
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
1986
1989
1992
1995
1998
2001
2004
2007
2010
DHS Region: Upper East
HDSS Navrongo

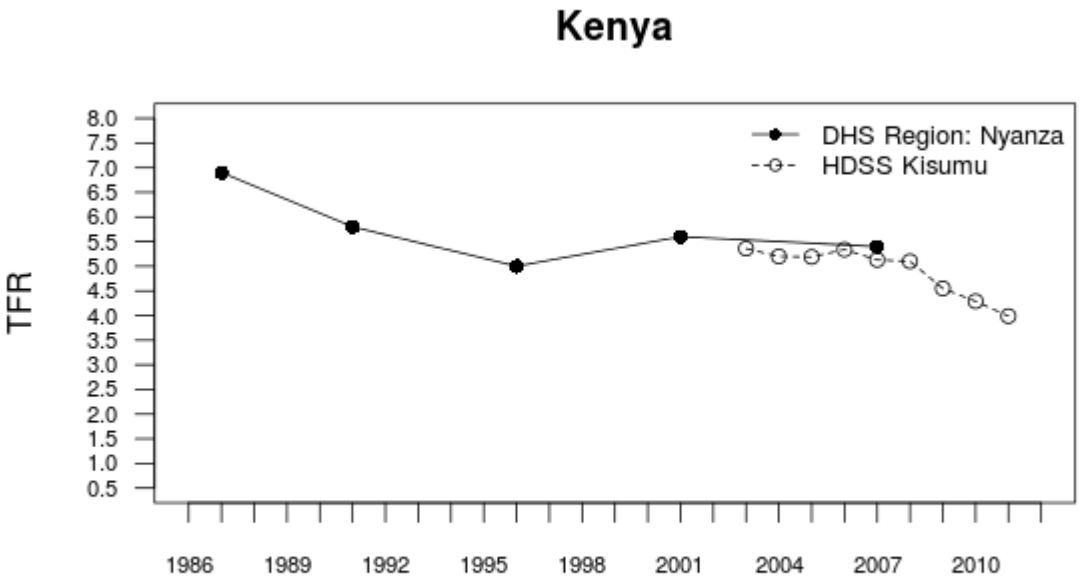

Ethiopia
Somalia
Kenya
Tanzania
Indian
Ocean
Kilifi District


Eastern
Rift
Valley
Western
North-Eastern
Nyanza
Central
Nairobi
Area
Coast

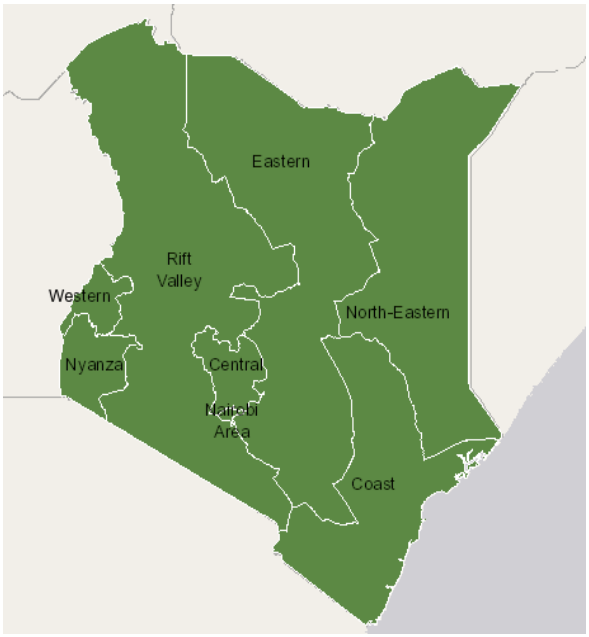

Kenya
TFR
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
1986
1989
1992
1995
1998
2001
2004
2007
2010
DHS Region: Coast
HDSS Kilifi

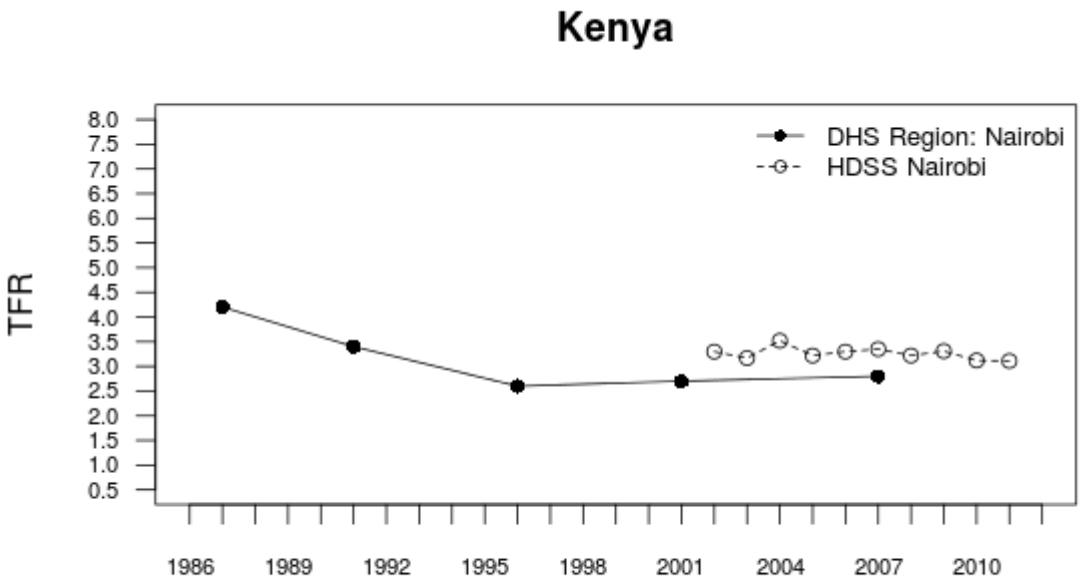

Uganda
KEMRI/CDC HDSS AREA
Kisumu
Kenya
NYANZA
PROVINCE
Kisii
Migori
Tanzania


Eastern
Rift
Valley
Western
North-Eastern
Nyanza
Central
Nairobi
Area
Coast

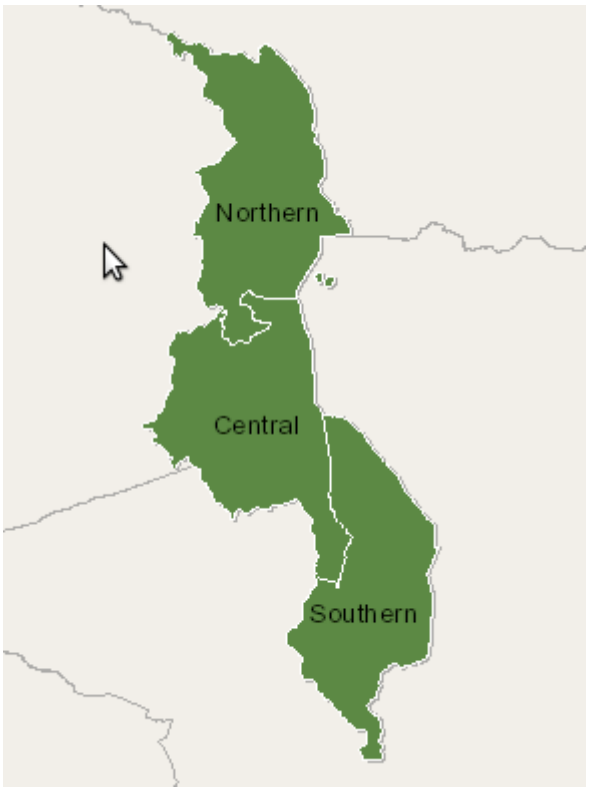

Kenya
TFR
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
1986
1989
1992
1995
1998
2001
2004
2007
2010
DHS Region: Nyanza
HDSS Kisumu

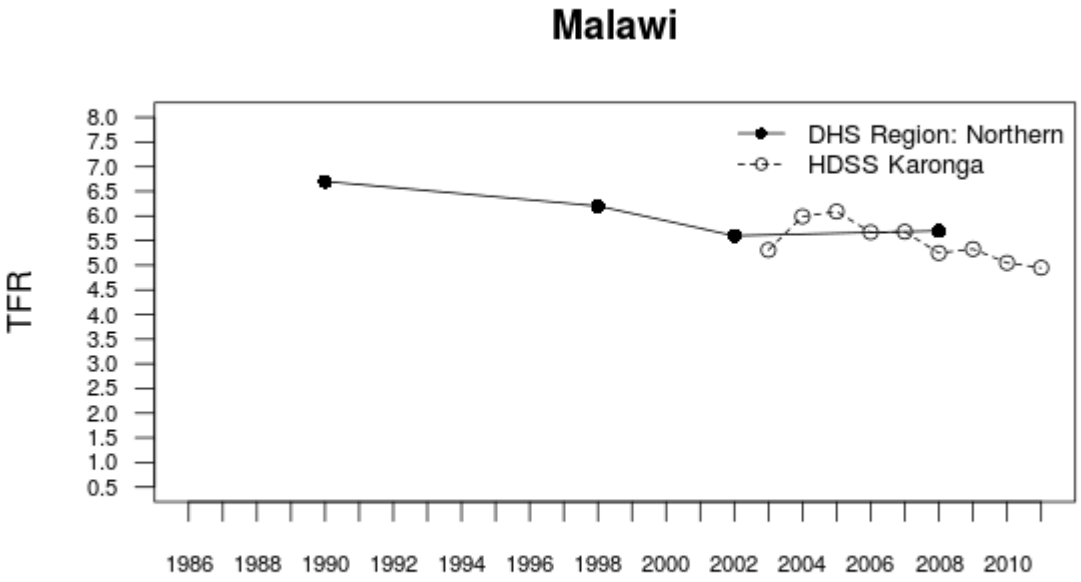

Korogocho
Nairobi
Viwanda
5 0 5
Kilometers

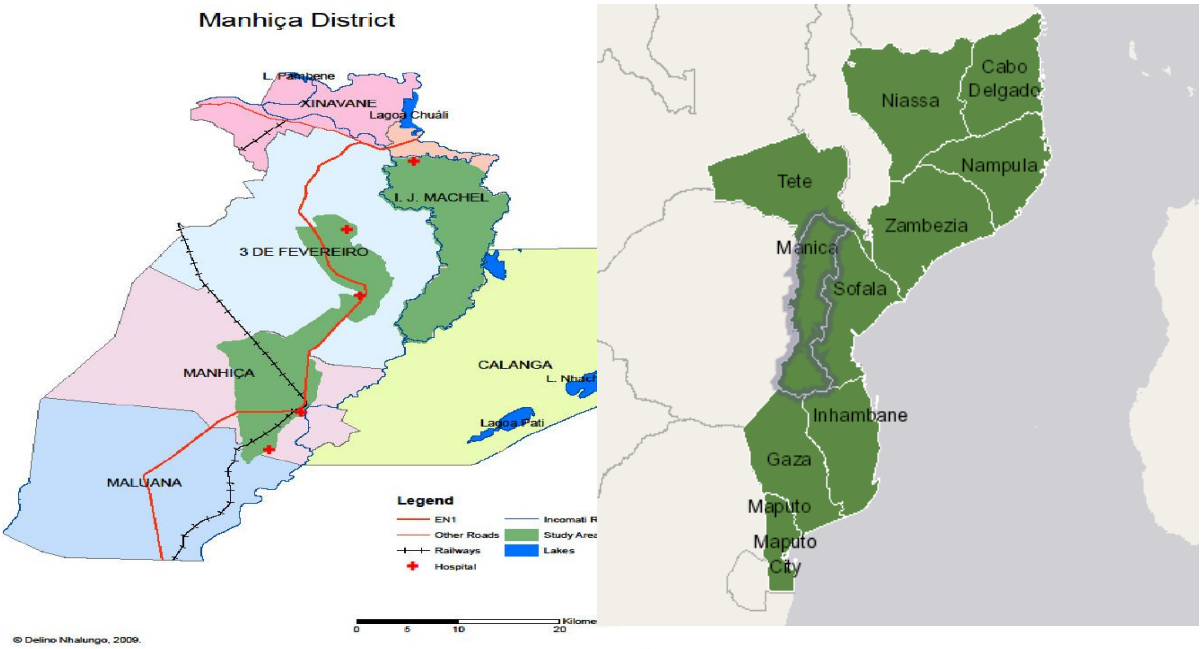

Eastern
Rift
Valley
Western
North-Eastern
Nyanza
Central
Nairobi
Area
Coast

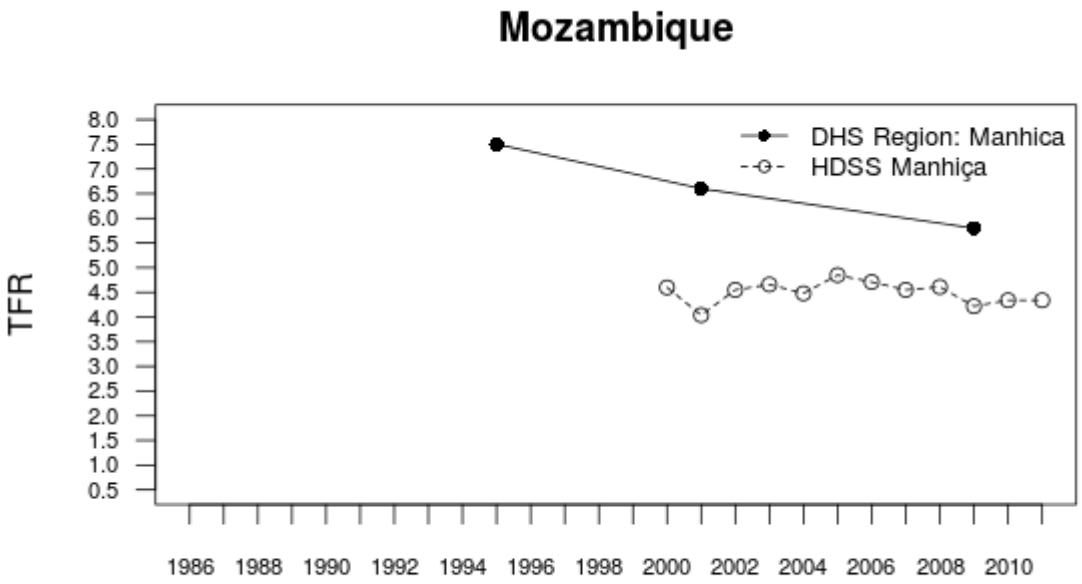

Kenya
TFR
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
1986
1989
1992
1995
1998
2001
2004
2007
2010
DHS Region: Nairobi
HDSS Nairobi

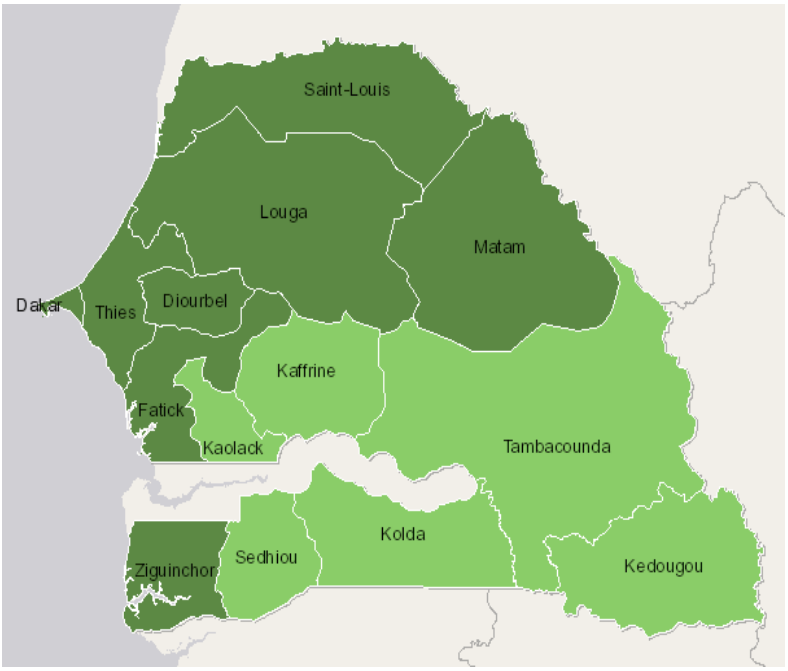

Karonga District
Tanzania
HDSS area
Zambia
Lake Malawi
Malawi
Mocambique
Zimbabwe

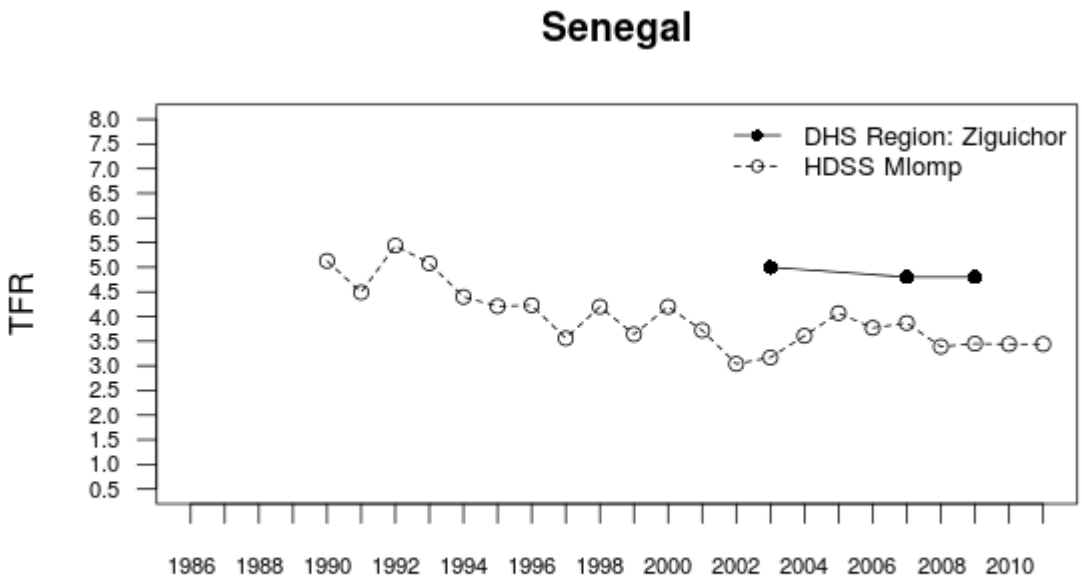

Northern
Central
Southern

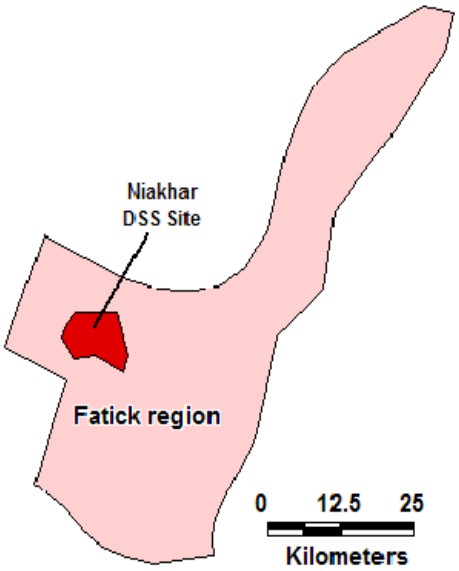

Malawi
TFR
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
DHS Region: Northern
HDSS Karonga

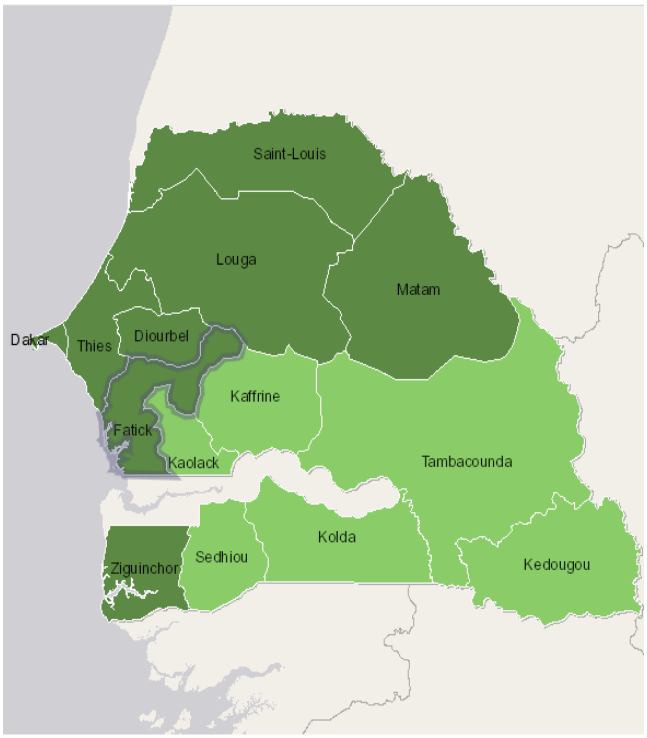

Manhiça District
XINAVANE
Lagoa Chuáli
I. J. MACHEL
3 DE FEVEREIRO
MANHIÇA
CALANGA
Lagoa Pati
MALUANA
Legend
EN1
Other Roads
Railways
Hospital
Lakes
© Delino Nhalungo, 2009.
Cabo Delgado
Niassa
Nampula
Tete
Zambezia
Manica
Sofala
Inhambane
Gaza
Maputo
Maputo City

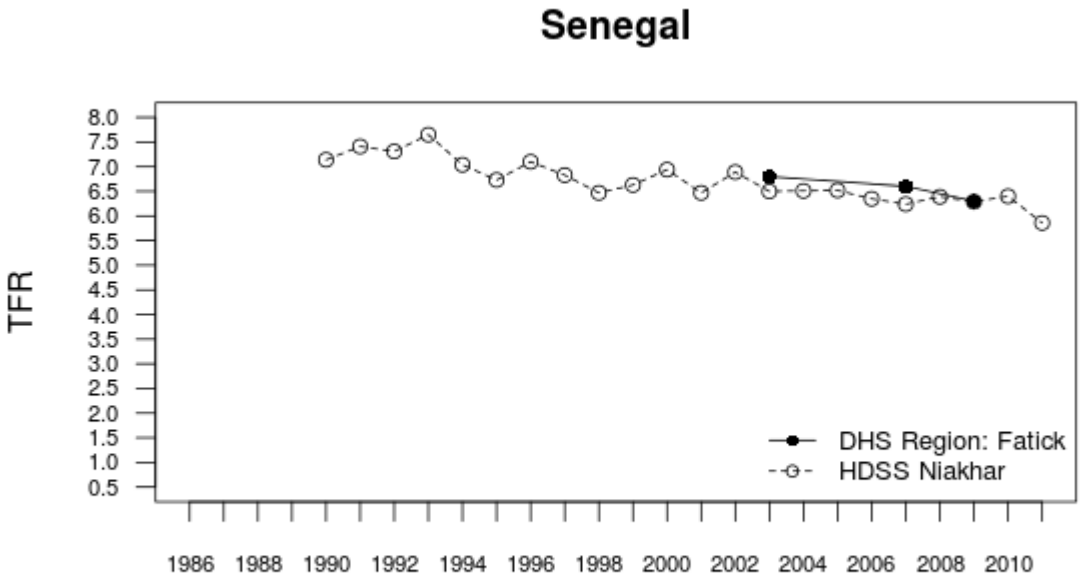

Mozambique
TFR
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
DHS Region: Manhica
HDSS Manhiça

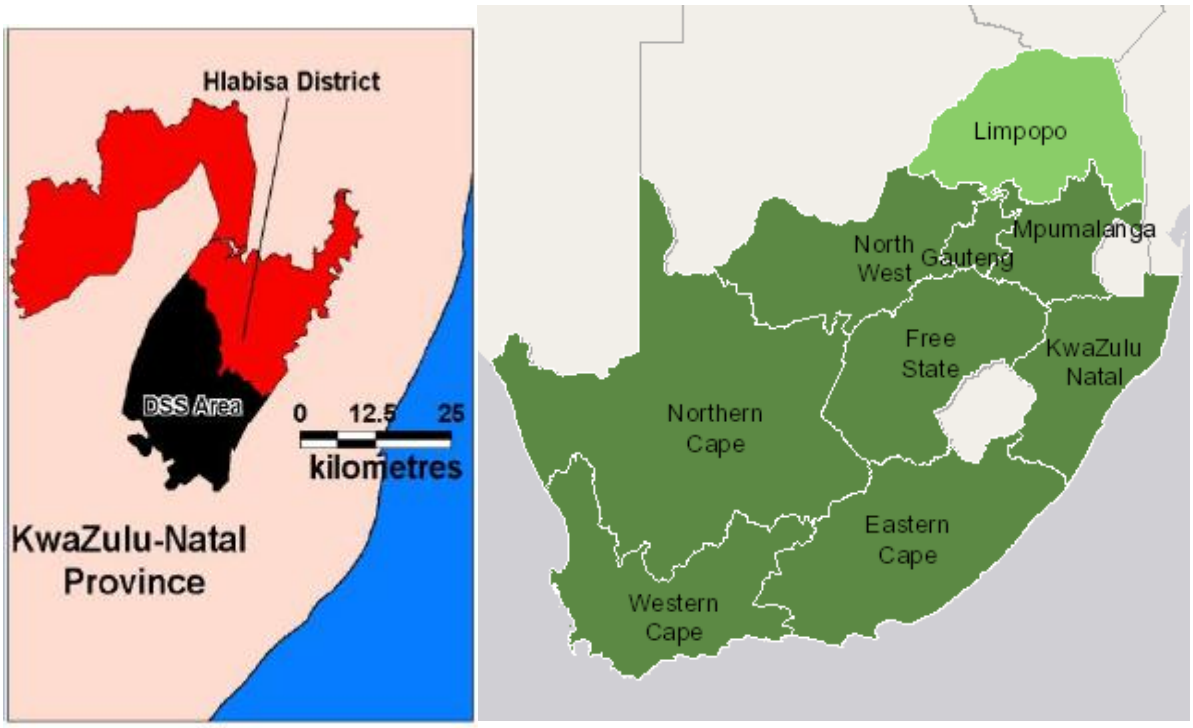

Saint-Louis
Louga
Matam
Dakar
Thies
Diourbel
Kaffrine
Fatick
Kaolack
Tambacounda
Kolda
Sedhiou
Ziguinchor
Kedougou

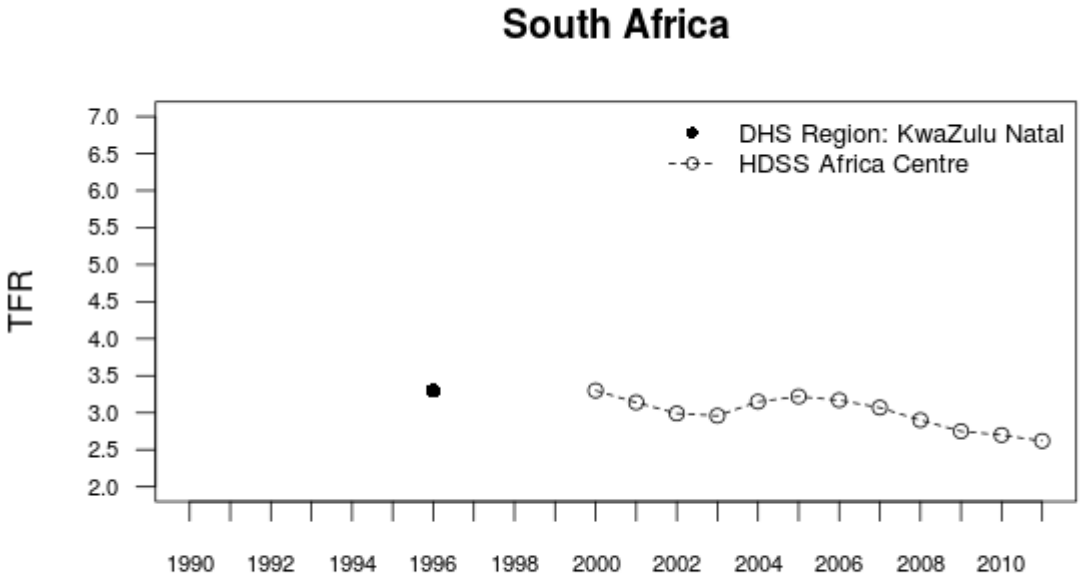

Senegal
TFR
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
DHS Region: Ziguichor
HDSS Mlomp

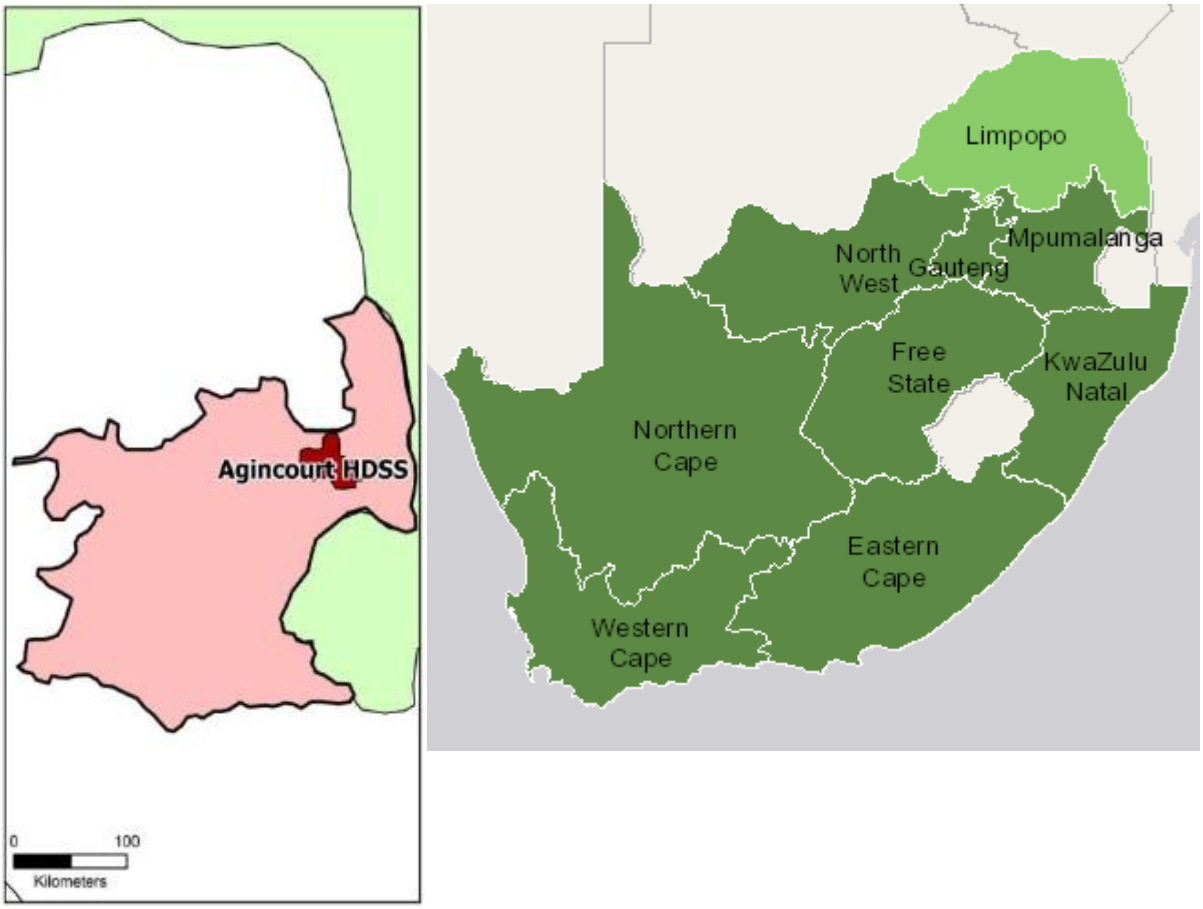

Niakhar
DSS Site
Fatick region
0
12.5
25
Kilometers

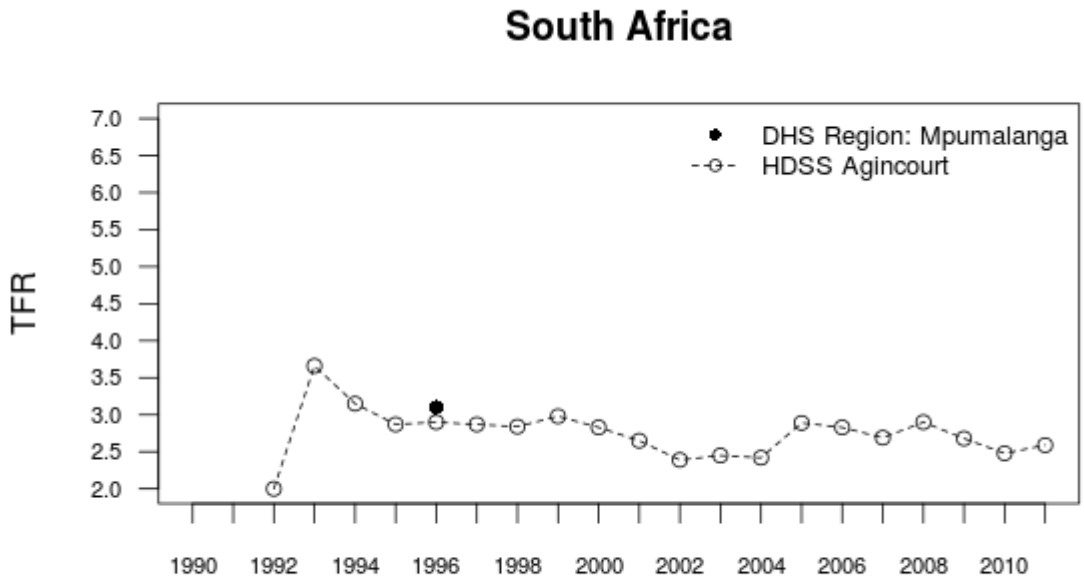

Saint-Louis
Louga
Matam
Dakar
Thies
Diourbel
Kaffrine
Fatick
Kaolack
Tambacounda
Kolda
Sedhiou
Ziguinchor
Kedougou


Senegal
TFR
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
DHS Region: Fatick
HDSS Niakhar


Hlabisa District
DSS Area
0 12.5 25
kilometres
KwaZulu-Natal
Province
Limpopo
North West
Gauteng
Mpumalanga
Free State
KwaZulu Natal
Northern Cape
Eastern Cape
Western Cape

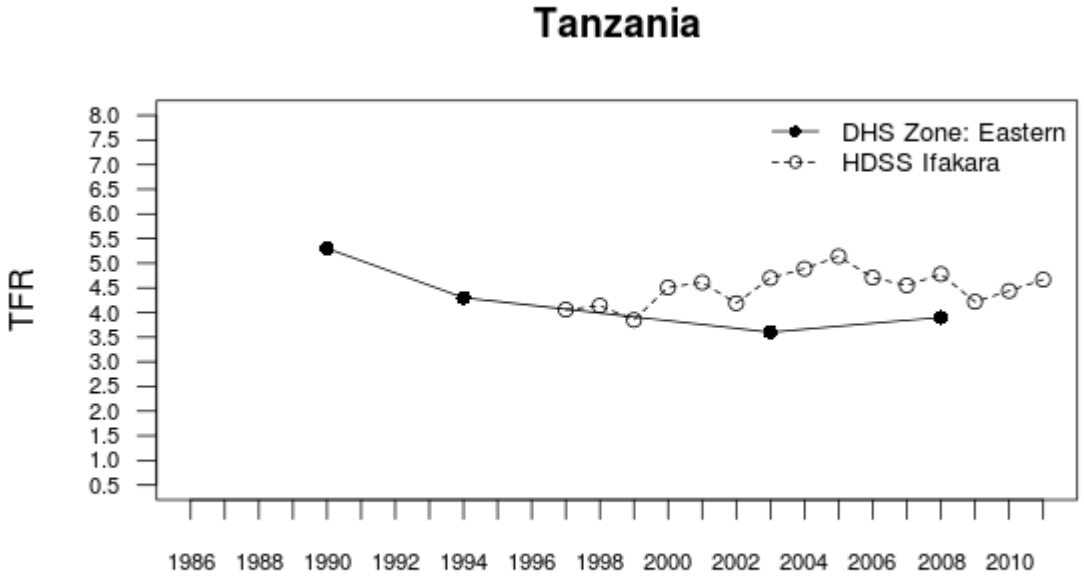

South Africa
TFR
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
DHS Region: KwaZulu Natal
HDSS Africa Centre


Agincourt HDSS
0
100
Kilometers
Limpopo
North West
Gauteng
Mpumalanga
Free State
KwaZulu Natal
Northern Cape
Eastern Cape
Western Cape


South Africa
TFR
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
DHS Region: Mpumalanga
HDSS Agincourt
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010

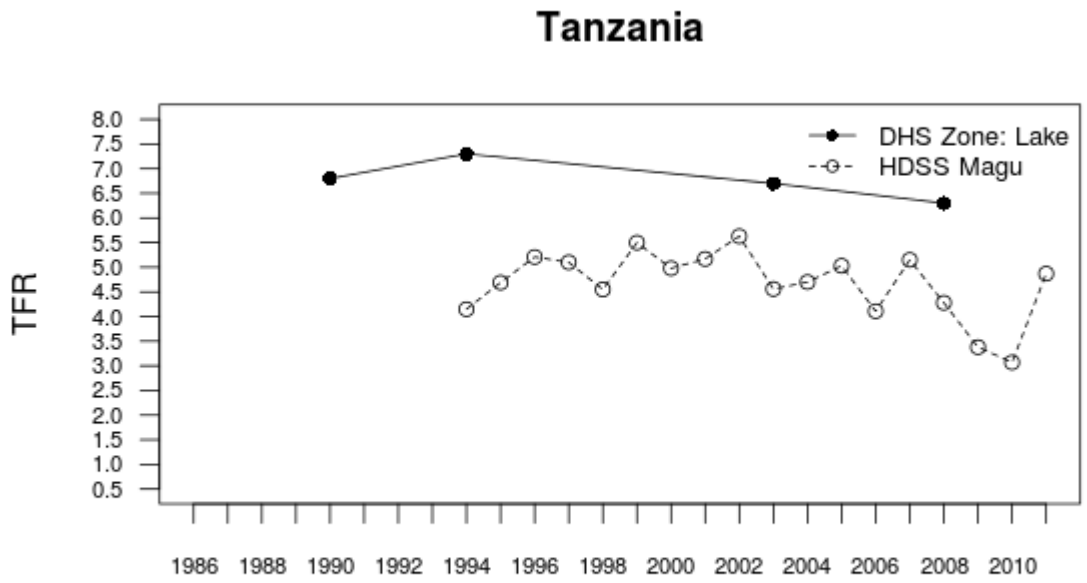

TANZANIA
Kilombero
District
Ulanga
District
0 100 200
Kilometre

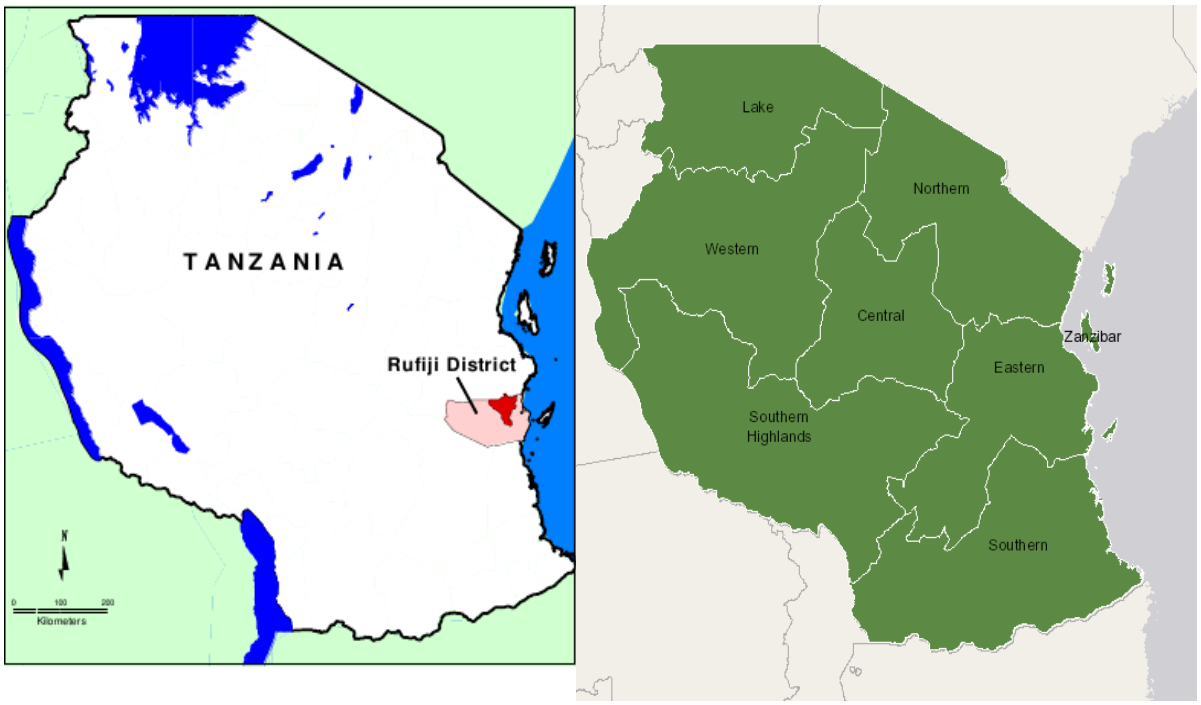

Lake
Northern
Western
Central
Zanzibar
Eastern
Southern
Highlands
Southern

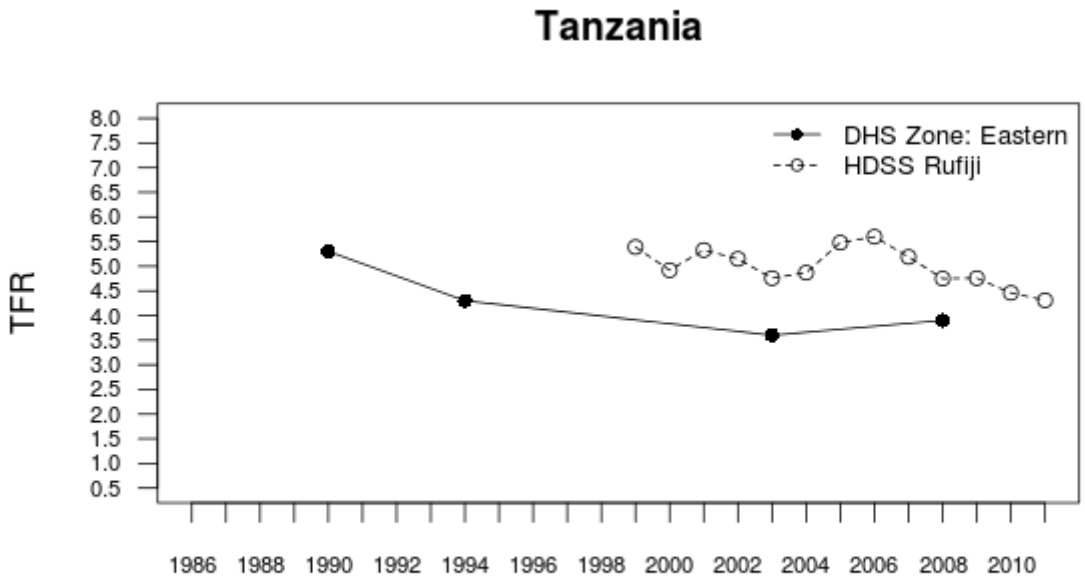

Tanzania
TFR
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
DHS Zone: Eastern
HDSS Ifakara


Mwanza
Tanzania
100 0 100
Kilometers


Lake
Northern
Western
Central
Zanzibar
Eastern
Southern
Highlands
Southern


Tanzania
TFR
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
DHS Zone: Lake
HDSS Magu


TANZANIA
Rufiji District
Kilometers
Lake
Northern
Western
Central
Zanzibar
Eastern
Southern
Highlands
Southern


Tanzania
TFR
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
DHS Zone: Eastern
HDSS Rufiji