Using New Methods and Data to Assess and Address Population, Fertility, and Environment links in the Lake Victoria Basin

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Abstract:

Lake Victoria is the largest lake in Africa, and the lake and its watershed are a critical resource for the livelihoods of millions of people across five countries: Tanzania, Kenya, Uganda, Burundi, and Rwanda. The FAO, however, reports that the population living around in the Lake Victoria Basin is among the poorest and most food insecure in all of East Africa due to declining land productivity, soil degradation, desertification, loss of biodiversity, livestock and crop diseases, declining fisheries, and poor development and trade policies. Policymakers concerned with the sustainable management of the Lake Victoria Basin, perceive population growth to be a key driving force of rapidly changing and degrading ecosystems, along with inadequate government policies and planning, regulations, provision of services. Data on basic population, health, and environment indicators, however, are unavailable at the landscape level of the basin making it difficult to assess, monitor, and communicate effectively about these connections. The varying data sources across the five countries and the lack of alignment of administrative units with the Lake Victoria Basin watershed are the principle data challenges. In this paper we highlight the efforts of a multidisciplinary research team to overcome these data challenges and develop demographic and health indicators for policy makers in the Lake Victoria Basin Commission as well as for program staff in an integrated Population, Health, Environment Program working with District leaders and communities on these issues in Uganda and Kenya.

Background

Population dynamics have been identified by a host of researchers as a significant determiner for environmental degradation (Miller et al. 2010; Carr 2005; Pan et al. 2004; Carr 2002; Mishra 2002; Walker et al. 2002; Carr et al 2009). Coupled population-environment dynamics remain complex and research suggests that there is a large variation in regards to population determiners of land change (Carr et al. 2009; Carr 2002, 2008). Further, population-environment dynamics may even reflect a positive feedback loop, in which environmental decline contributes to high population growth rates, which further degrades environmental conditions (Bhattacharya & Innes 2008; Bremner et al 2010).Population-Health-Environment (PHE) programs aim to integrate solutions to population, health, and environment problems with the aim of natural resource conservation in developing countries (Hahn et al. 2011). This paper reports on recent findings of population, health, and environment dynamics in the Lake Victoria Basin, Africa within the context of a multi-year and multinational PHE program initiative.

Lake Victoria is the world's second largest freshwater lake and the largest lake in Africa. The lake and its surrounding watershed are a critical resource and for millions of people across five countries: Tanzania, Kenya, Uganda, Burundi, and Rwanda. Fishing, agriculture, and industry surrounding the lake are critical to the economies of these countries. Over 80% of the population in the region relies on land, agriculture, and fishing for their livelihoods, and the Lake Victoria Fisheries Organization reports that the lake fisheries support almost 2 million people with household incomes. Almost 22 million people in the region rely on fish for their consumption needs. Yet, the Food and Agriculture Organization of the United Nations (FAO) reports that the population living around the LVB is among the poorest and most food insecure in all of East Africa due to declining land productivity, soil degradation, desertification, loss of biodiversity, livestock and crop diseases, declining fisheries, and poor development and trade policies.

The interdependence between human activities and the environment, as well as the international context of the Basin, call for a regional, integrated response to properly manage existing and emerging threats to the vulnerable natural resources of the Lake Victoria Basin and associated ecosystem services. Currently, there is a perception among policymakers and non-governmental organizations that many impacts on Lake Victoria are compounded by rapid population growth, and that inadequate government policies, regulations, and provision of services, are driving forces behind a rapidly changing and degrading ecosystem. Regional bodies tasked with cooperative governance on environment and development issues, such as the Lake Victoria Basin Commission (LVBC), however, do not have basic demographic or health information for the Lake Victoria Basin, by which they can assess population, health, and environment issues and the interconnections among them. The absence of this data is in part due to the challenges of matching a geographically designated watershed with the different administrative boundaries of five different countries. Added to this challenge are the different timing of census and survey data collection in each country, and the varying sub-national availability of data.

At the request of stakeholders concerned with population, health, and environment connections around the Lake Victoria Basin, we embarked on an effort to improve access to demographic and health data at an appropriate scale for basin. We used a mix of spatially derived data, census, and survey data to examine population and health trends of the area and create basic scenarios at the basin level that environment and development planners will be able to use and understand. Reproductive health indicators from the Demographic and Health Surveys were given particular attention in order to inform the development of an integrated Population, Health, and Environment pilot project in the Lake Victoria Basin area of Uganda and Kenya.

The Health of People and Environment-LVB (HoPE-LVB) Project is co-funded by John D. and Catherine T. MacArthur Foundation, the David and Lucile Packard Foundation and USAID's Office of Population and Reproductive Health. HoPE-LVB is bringing together a consortium of health and environment organizations, including Pathfinder International, ECO, and OSIENALA, who share an interest in improving interrelated maternal, neonatal and child (MNCH) and sexual/reproductive health (SRH), sustainable livelihoods, and conservation outcomes in the Lake Victoria Basin area through an integrated conservation and development approach. The goal of the project is to reduce threats to biodiversity conservation and ecosystem degradation in the Lake Victoria Basin, while simultaneously increasing access to family planning (FP) and SRH services in order to improve MNCH in project communities. To achieve this goal the partners aim to develop and demonstrate a model of integrated service delivery in Lake Victoria Basin sites that can be adopted and scaled up. Critical to this effort is presenting basic population and health data to decision makers, such as the LVBC, and other stakeholders at various levels to illustrate these issues.

Methods

Construction of Demographic Indicators

In order to attain data on population and health for the whole Lake Victoria Basin, we used publicly available demographic and health data and used various techniques to fit the data to a spatially defined boundary for the Lake Victoria Basin Watershed.

The datasets were derived using both the AfriPop 1-km population density and the 1-km demography datasets (www.afripop.org). AfriPop launched the *alpha* version Africa-wide 1km demography datasets at the beginning of 2012, which contains five-yearly time steps of density data for children under five years old from 2000 including a projection for 2015. The AfriPop demography data is based on a unique combination of the most recent country-specific census data, satellite imagery, and expert knowledge to map settlements and populations, as well as land cover, infrastructure and other geospatially-referenced ancillary data (Tatem and Linard 2011; Linard 2012a). We used this data to calculate a total population for the Lake Victoria Basin, the

percent change in children under 5 for the basin, as well as change in population density from 2000 to 2015.

In addition, population projections were developed from 2020-2050 projections applying United Nations country-specific population growth rates to each pixel according to the urban/rural classification in 2010 (urban being defined as Landsat-derived detailed settlement extents that are located within GRUMP urban extents) based on work by Tatem et al. 2007 and Linard et al. 2012 (see links above). The projected population data was subsequently extracted for the Lake Victoria Basin using zonal statistics to determine total population counts at each time step and to calculate percent changes in total population per squared kilometer that may be expected in the next several decades assuming current population growth rates.

Further information on the methodology used in deriving the datasets used in these analyses is presented in detail in the following two publications:
http://www.plosone.org/article/info:doi%2F10.1371%2Fjournal.pone.0001298

http://www.plosone.org/article/info%3Adoi%2F10.1371%2Fjournal.pone.0031743

Use of DHS to Assess Health Issues

To analyze demographic patterns within the Lake Victoria Basin, we used the Demographic and Health Surveys (DHS). The DHS project, funded by the United States Agency for International Development (USAID), and begun in 1984, measures trends in fertility, family planning, and maternal and child health in 85 countries around the world (DHS 2011). The DHS focus on measuring key indicators of child and maternal health, fertility, and family planning. Though DHS data is collected at the individual level (within household units) using a two-stage cluster sampling method (Aliaga and Ren 2006), for this project we used aggregated data released by DHS through the online "STATcompiler" program. The data we use is aggregated at the lowest possible sub-national level (for example states, districts, or departments).

Though DHS releases its data to the public in a loosely geocoded format (by "region" in DHS terminology), the raw data is not easily analyzed in a GIS without further cleaning and preparation. To analyze the data in a GIS, regional boundary polygons need to be determined and assigned based on the textual region names available in the DHS database. For example, we might know from DHS that a particular database row from the 2010 DHS in Burundi is assigned to the region "North" (DHS 2012). To analyze this data in a GIS, we need to 1) verify in the final report from the 2010 Burundi DHS the area this region covers (the Kirundo, Muyinga, Ngozi, and Kayanza provinces), and 2) assign a polygon covering the combined area of these provinces to this row of the database. For this process we use administrative boundary data from the Global Database of Administrative Areas database (GADM) (Hijman et al 2011). Our final dataset

includes 60 regions from the six countries surrounding the Lake Victoria Basin (Burundi, the Democratic Republic of the Congo, Kenya, Rwanda, Tanzania, and Uganda).

After geocoding the data, we overlaid a polygon of the Lake Victoria Watershed. We calculate a number of key demographic indicators: infant and child mortality rate (IMR), total fertility rate (TFR), percentage of currently married women using a modern contraceptive method, percentage of currently married women with an unmet need for contraception for spacing or liming of births, and percentage of children whose weight for age is below 2 standard deviations of the mean (percent of children who are moderately-severely underweight).

To produce estimates of these indicators within the watershed and a set of buffers surrounding the watershed, we use the estimated 2010 population from AfriPop, a 100 meter resolution gridded population dataset (A. J. Tatem, Noor, von Hagen, Di Gregorio, et al. 2007; A. Tatem and Linard 2011; Linard, Gilbert, Snow, Noor, et al. 2012). Using the AfriPop dataset, we calculated a weighted mean for each of the demographic indicators from DHS, with weights calculated according to the total population of each DHS region that is included within each particular buffer. The calculation of these weights is done at the DHS region level. To save computer memory and calculation time we aggregate the AfriPop to 500 meter spatial resolution – this aggregation has no significant impact on macro-scale results presented here.

Household Survey Data Results for Local Context and Project Monitoring

HoPE-LVB conducted a baseline study for researching population, health, and environment issues more closely in the context of project sites. The purpose of the baseline study was two-fold: 1) to provide baseline values for measuring change in key project outcomes, and 2) to gain additional in-depth understanding of the socio-cultural, environmental, and institutional conditions that are associated with HoPE-LVB project sites in order to inform future project decisions. Specific study objectives were the following:

    a. Assess the knowledge, attitudes, and practices of community members at the household level regarding SRH and good health, sustainable livelihoods, land use, and links with conservation and natural resource management;

    b. Explore whether local practices and factors constitute important threats to the LVB ecosystem, to individual and community well-being, and to the quality of health services;

    c. Engage community structures in discussions regarding: community needs, assets, project expectations, and contributions towards improving community member well-being and reducing LVB ecosystem threats, as well as community familiarity with and attitudes towards the existing conservation legal and regulatory frameworks;

       d.   Assess targeted health facilities in order to identify capacities and gaps regarding FP, SRH, and MNCH services;

The baseline involved a great number of data collection methods but the principle method was a household survey in only those locales in which the project is *directly* intervening. Sixty-one villages were included in the sampling frame, from which a random sample of households per village was selected with a probability of selection that was proportional to village size. Updated household lists were obtained from the local community chairperson to establish the sampling frame. A standard sample size formula was used to determine the total number of households to be selected in Kenya and Uganda and was based on a key indicator of interest – current contraceptive use.

The desired number of survey households[1] (N = 1794) was divided equally for a country-specific sample size of approximately 900. 1640 (91%) of the targeted 1800 households were surveyed, which involved 55 of the 61 villages targeted. Uganda constituted 54% of the final sample (n=887), and Kenya constituted 45% (n=753). The household survey was divided into two parts: Part A involved personal SRH questions for only the most senior female member of the household, aged 15-49, and present at the time of interview. She was interviewed privately. Part B involved livelihoods, conservation, and linked PHE questions for all household members present at the time of the Part A interview, including and with particular interest in household men.[2]

Results

These preliminary efforts to construct demographic and health data at various scales that would be useful for the project's efforts to talk to decision makers have yielded preliminary results. Table 1 shows our results for the estimated current population for the Lake Victoria Basin – 42 million inhabitants, as well as population projections through 2050. Interestingly, our population estimates derived for the Lake Victoria Basin reveal that the total population that most stakeholders for the basin, including the Lake Victoria Basin Commission, were commonly citing -- about 30 million inhabitants— is likely underestimated by more than 10 million people. While the number of 30 million people was being used in reports and other communications about the threat of population growth, we could identify no original source for this estimate. Furthermore, assuming population growth rates remain constant, total population in the basin is projected to nearly triple by 2050, faster than the national projections for many of these countries since these areas are likely experiencing a combination of natural population growth as well as in-migration due to the attraction of lake resources.

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[1] Household numbers rather than population size was used as the basis for this calculation for reasons explained below.
[2] Interviewers returned when specific household men were available to participate, if requested by the senior female (Part A) respondent.

Table 1: Total population and % increase relative to 2010

| Lake Victoria Basin	2010	2020	2030	2050
Total population (UN-adjusted)	42,394,936	60,781,332	76,517,200	113,197,070
% increase relative to 2010		43.36%	80.48%	167%

While migration may be part of the cause for population growth around the Lake Victoria Basin, our estimates of the growth in the total population of children under 5 for the Basin suggest that high fertility is also an important part of the population growth. Table 2 shows the total population of children under 5 for the Lake Victoria Basin for the years 2000, 2005, 2010, and 2015 was obtained from the AfriPop Demography dataset. The under 5 population increased from 6.43 million in 2000 to 8.27 million in 2010 and is projected to increase by approximately another million by 2015.

Table 2. Trend in the number of children in the LVB who are under 5 years of age

Lake Victoria Basin	2000	2010	2015
Under 5 population	6,431,950	8,266,539	9,272,774

Maps of percent growth of the under 5 population growth between 2010-2015 suggest that the Lake Victoria Basin is among a handful of most rapidly growing regions of under 5 growth on the continent.

Figure 1. Percent under five increase 2000-2015 for Africa and the Lake Victoria Basin..
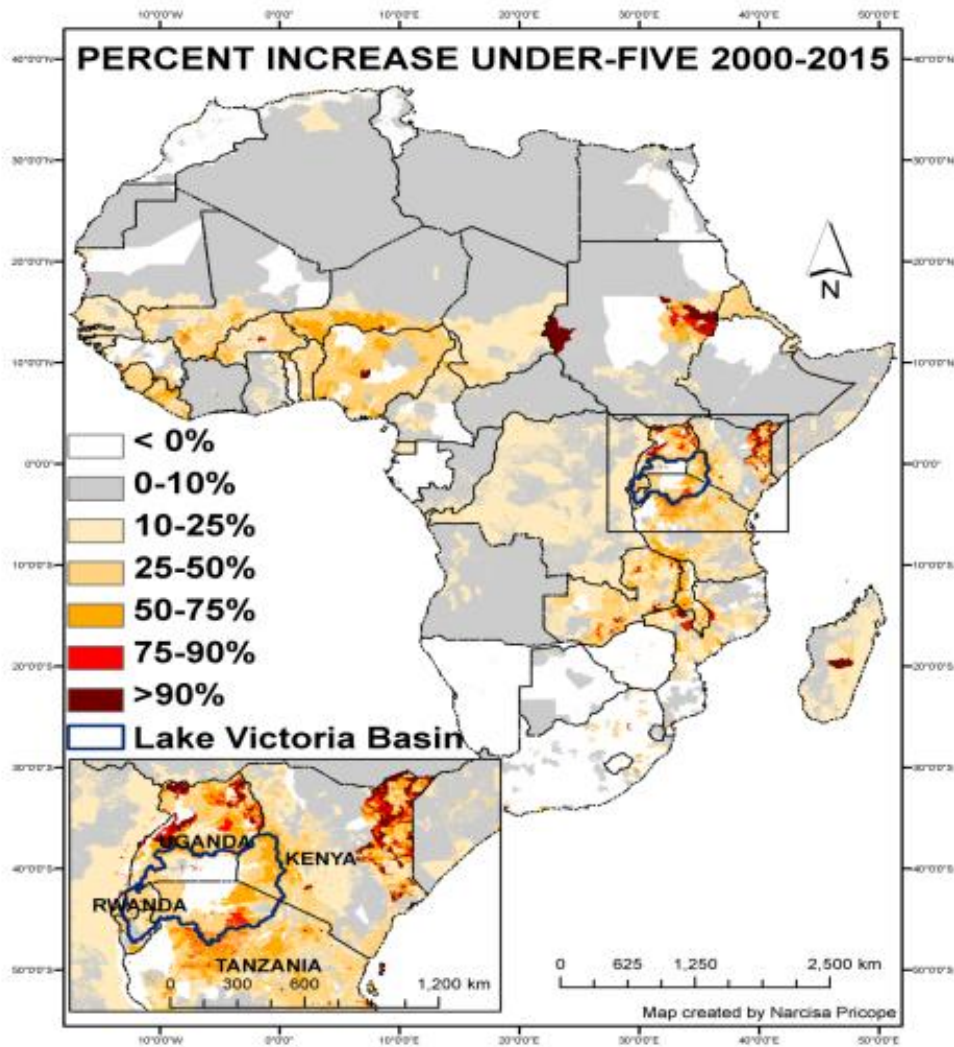
Maps of population density for the Lake Victoria Basin also present an interesting demographic picture that may be of use to decision makers. Highly concentrated population density along the shores of the lake, particularly in parts of Kenya, Uganda, and Tanzania, suggest a very direct impact of local livelihoods on the lake and indicate that further population growth will likely add to the already high population density along the lake's shores.

Figure 2. Lake Victoria Basin Population Density in 2010.
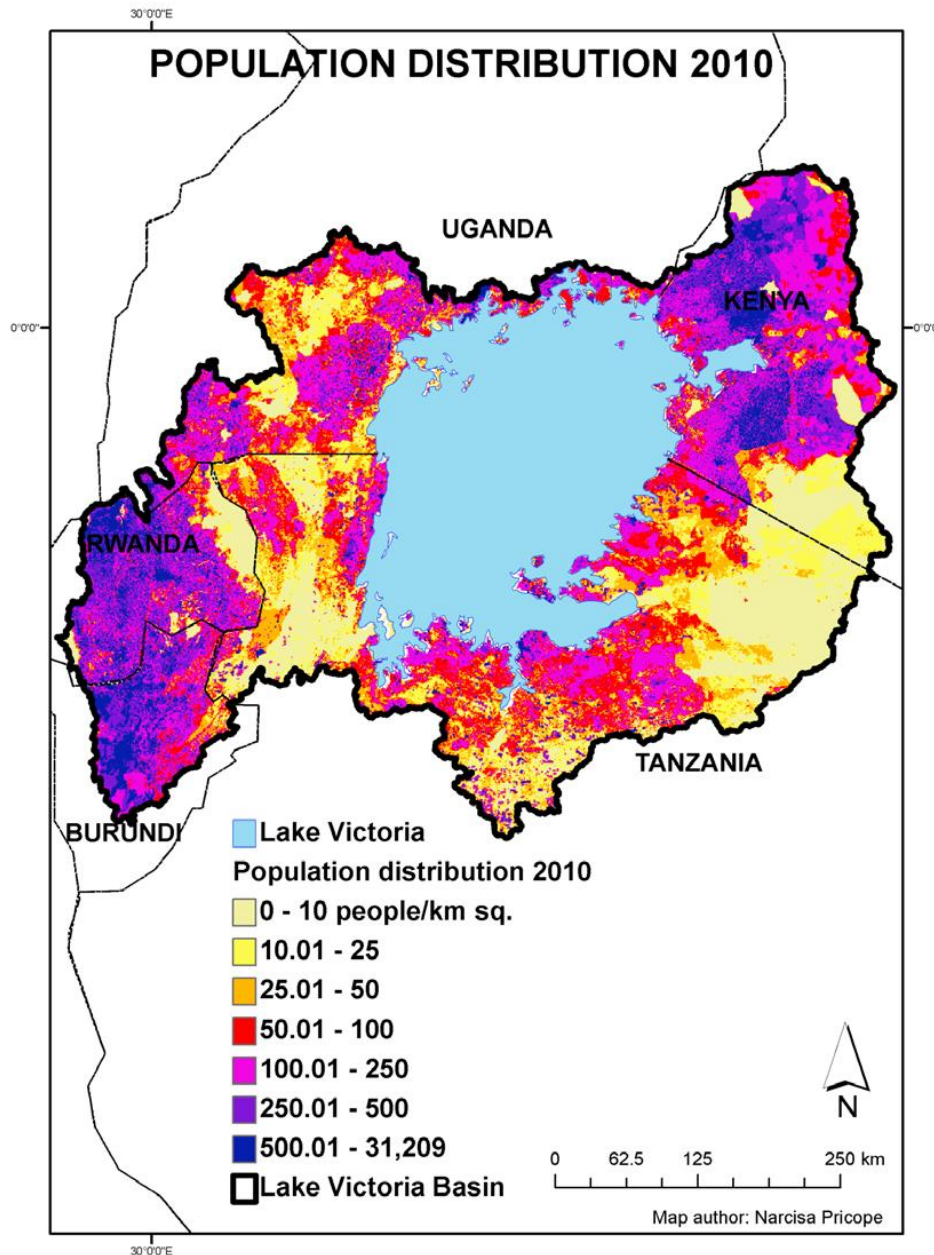
Results from the basin-wide DHS aggregation further support the importance of high fertility and low contraceptive prevalence as an explanation for population growth around the lake. Table 3 presents various health indicators for the Lake Victoria Basin and suggests low contraceptive use and high unmet need for family planning.

Table 3. Health indicators, contraceptive use, and unmet need for family planning for the Lake Victoria Basin

Area	Mean IMR	Mean TFR	% contraceptive Use	% Unmet Need	% Children Underweight
Lake Victoria Watershed	116.27	5.17	29.97	28.91	13.33
0 - 10 km outside watershed	114.84	5.36	26.84	30.10	14.04
10 - 25 km outside watershed	112.63	6.13	22.23	32.18	15.10
25 - 50 km outside watershed	113.84	6.59	20.08	34.37	16.18
50 - 100 km outside watershed	118.23	6.77	19.25	34.33	18.27
100 - 250 km outside watershed	94.24	5.46	30.08	28.37	17.41

Household Survey Results

The household survey results from the project areas in Kenya and Uganda largely reflect the overall pattern from the wider basin DHS analysis. The profile of female respondents to part A of the survey was not dissimilar to national demographic health survey findings for rural areas: The mean age of respondents was 30 years, 78% (74% Uganda and 84% Kenya) reported being currently married or in union, and 90% had attended school – mostly below secondary level.[3]

Family Planning and Maternal Health Findings
FP knowledge levels were impressively high in both Kenya and Uganda: almost everyone knew of one or more methods of contraception (97% mentioned knowledge of injectable contraceptives)[4] and 91% knew where contraceptives could be obtained. The most commonly known FP-access sites were public health centers (67%), government hospitals (30%), and private hospitals/clinics (28%) with some differences evident between the countries.[5]

Among women who were not pregnant at the time of the survey, 49% were currently using a contraceptive method and 43% were using a modern method. Consistent with country

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[3] Where the overall average is markedly different from country values or the latter differ substantially, multiple values are provided. Otherwise country values are close to what is cited.
[4] The least known method was moon beads (28% of respondents).
[5] Proportions for the place response options varied considerably by country. For example, 50% in Uganda Vs. 87% in Kenya mentioned that FP could be obtained from a health center and 44% vs. 9%, respectively, from a private hospital/clinic.

Demographic and Health Survey (DHS) findings, the most commonly used method was injectables (28% of responding women). Of note, 6.9% reported use of a LAPM.[6] The large majority (≥75%) of female respondents in both countries said they successfully obtained their desired method when last accessing FP, and that the places where they last obtained FP were similar to the sources of FP methods cited above. An important finding related to access was that less than one percent of respondents last obtained their contraceptives from a community-based distributor or clinic outreach service, which suggests that women must travel to public health centers, hospitals, clinics, or pharmacies to obtain an FP method.

Figure 3 shows that, of the currently-pregnant women (13% of total women surveyed), about half (roughly 50%) reported that they wanted the pregnancies at the time they became pregnant, while 44% would have preferred to become pregnant sometime in the future or to not have any more children. Of those who did not desire the pregnancy at that time, most (79%) desired to delay the pregnancy (82% in Uganda Vs. 75% in Kenya) and approximately 11% overall wanted no additional children (7% Uganda Vs. 16% Kenya). Among those not known to be pregnant, half overall expressed wanting a(nother) child (55% Uganda Vs. 43% Kenya), and approximately a third (34%) wanted none/no more children (27% Uganda Vs. 41% Kenya).

Figure 3. Desire for pregnancy among currently pregnant female respondents

*Percentages do not add up to 100% due to missing responses.

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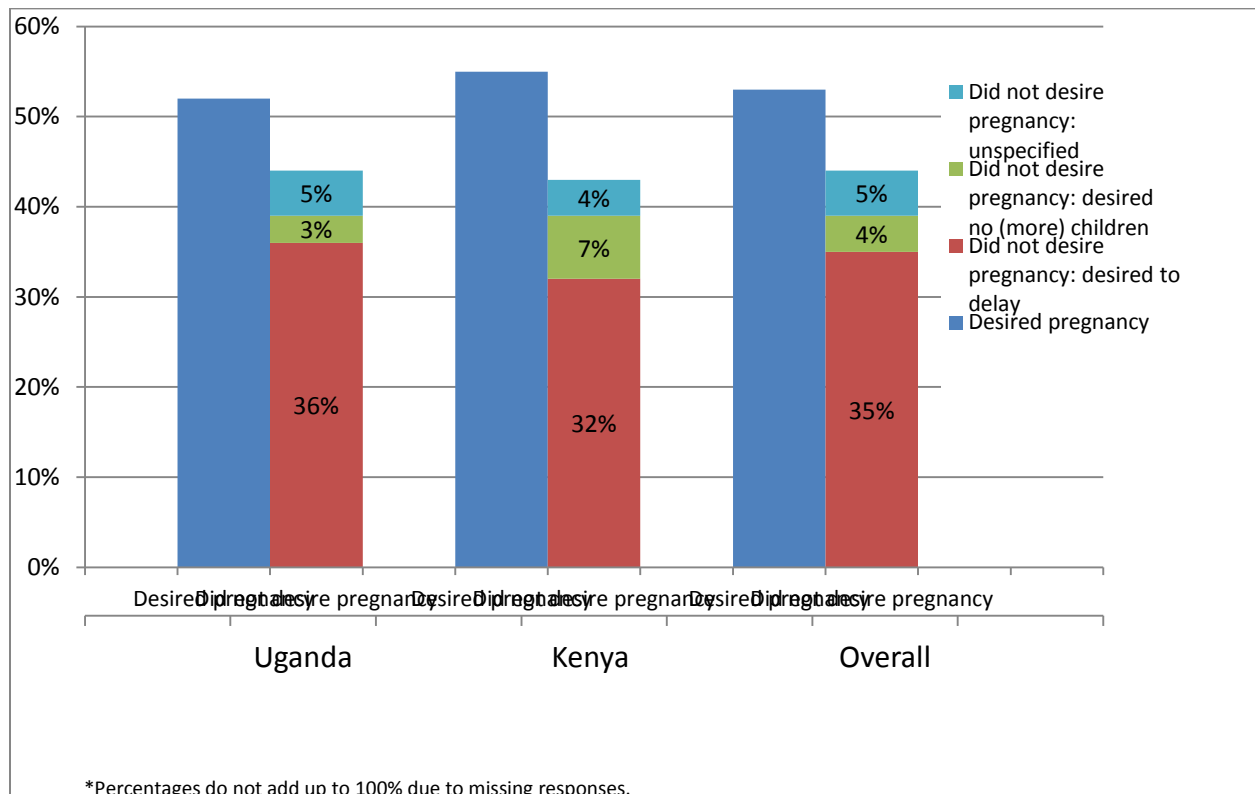
[6]LAPM = long acting or permanent method. There was no dual method use reported among this subset of respondents.

Pregnancy rates within the past 2 years were more than double the current rate (50% in Uganda, 33% in Kenya, and 42% overall). In Kenya and Uganda combined, among those who were pregnant within the past 2 years, antenatal care (ANC) attendance and safe delivery planning were both very high (88% and 81%, respectively).[7] Most (70%) respondents could identify at least one sign of pregnancy-related complication. Overall, 36% of those pregnant within the past 2 years (40% Uganda; 27% Kenya) had had a home birth. Most (75%) pregnancies within the past 2 years had been assisted by a nurse/midwife (52%) or by a Traditional Birth Attendant (23%).

Figure 4 illustrates one striking difference between the countries - while 92% of Kenyan respondents had heard one or more FP messages within the past 12 months, this was the case for only 53% of respondents in Uganda. The proportions that stated having heard any MCH messages mirrored those for FP. For youth RH messages, proportions were lower, but again different between the countries (81% Kenya, 26% Uganda). The main source for all message types was radio/TV.[8]

Figure 4. Proportions of respondents in Kenya and Uganda who had heard one or more FP
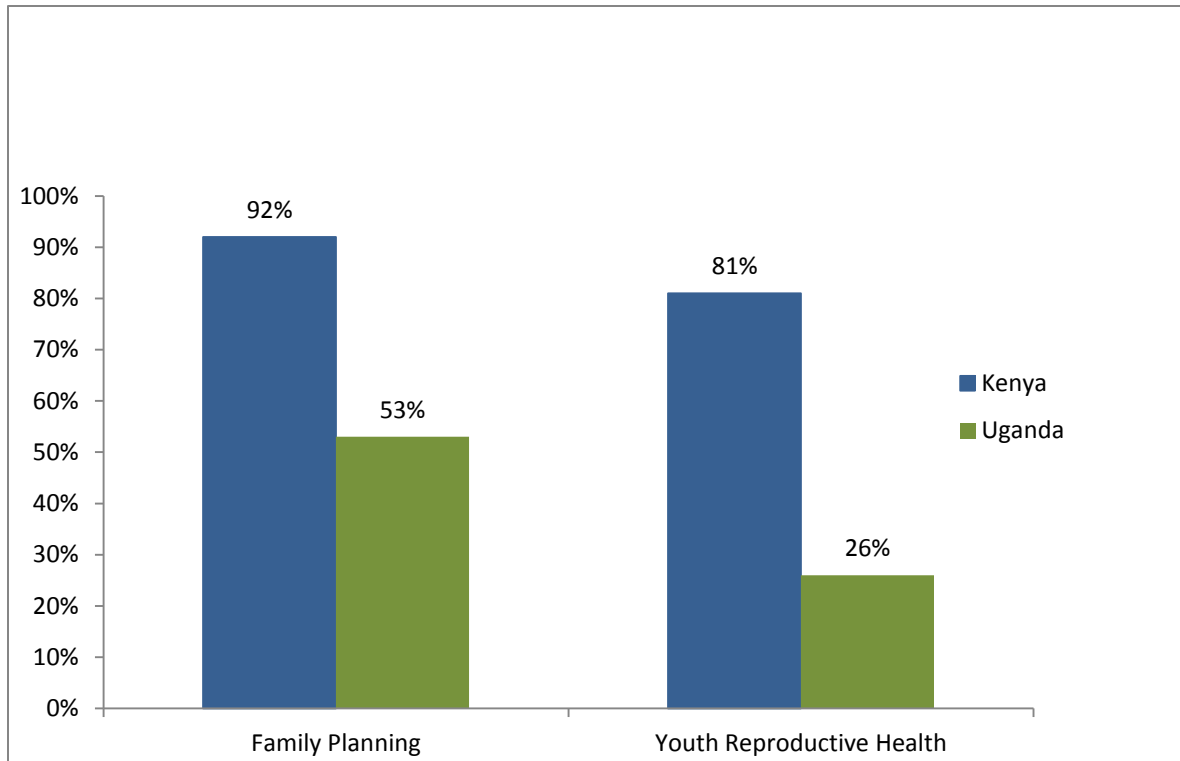
messages or Youth RH messages in the past 12 months

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[7] For this study, a safe delivery plan was defined as deciding in advance to which facility they would go to deliver.
[8] Mainly the former as most households did not report having a TV.

Discussion and Conclusion

The combination of analyses and different data sources to illustrate population and health indicators at various scales has already proving useful at assessing possible population, health, and environment challenges for the HoPE-LVB project. While these data weren't available at the outset of the project, spatially derived data, census data, and survey data are being combined to create data at geographic scales that matter for regional environment and development planners. The HoPE LVB project is using the household data for project planning, monitoring, and evaluation, and is using the broader scale population and DHS data for the Lake Victoria Basin in communications with stakeholders such as the Lake Victoria Basin Commission about population, SRH, and FP issues. The Lake Victoria Basin Commission itself has now begun a project to assess and population, health, and environment links with support from the USAID East Africa Regional Office. Through these efforts Lake Victoria Basin Commission is engaging national policymakers, whose interest is the lake's sustainable future, in policy dialogue about how population, reproductive health, and family planning play a part in that future. By continuing to improve on our own estimates and providing accurate data to these decision makers through these combined methods we aim to ensure that demographic and health data are part of this policy dialogue.

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