5. POPULATION ON CASE STUDY REGION

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5. POPULATION ON CASE STUDY REGION

5.1. POPULATION ISSUE

Population is the key driving force in global earth/human change. Whether it is a question of resources, environment, socio-economic globalization, etc., the level of population which is changing and being changed in return is a key factor. This reflexive, feedback, relationship between population and other dimensions of global earth/human change determine the extent and rate of change. Nature and humankind are coupled with the evolution of each influencing and being influenced by the other. To understand and to influence this change in a desirable way, this interdependence has to be the center of concern. Nevertheless, understanding population dynamics in itself is a sine qua non for understanding global change because of its overwhelming importance.

To understand the evolution of population three time spans have to be considered (we have just discussed this in chapter before): Where we are today? Where we are coming from? Where we might feasibly be going?

It is self-evident that the world population cannot continue to grow forever. This is strongly related with the main issue of this study. The question is at what level the population will reach its peak, at what time and what will be the composition of the population.

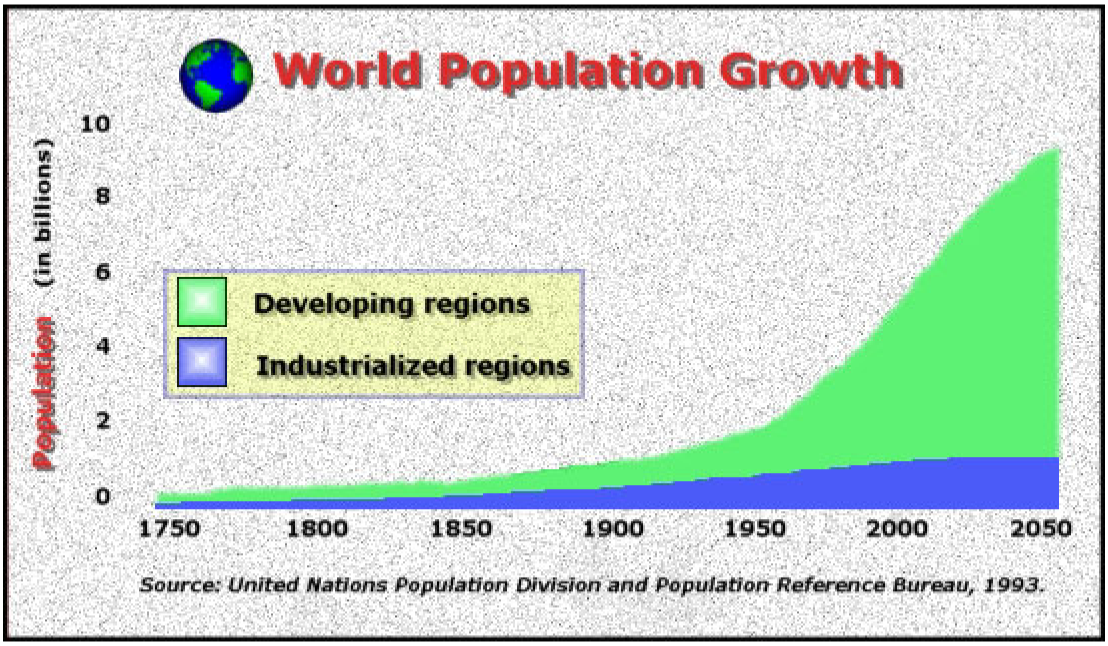
There is also the question of location. Population growth is a global problem but it makes its most obvious appearance on the local, regional, national or urban level.

To understand the past, several items are of importance: global population has been increasing at an exponential growth rate; the periodicity of population growth depends on the perspective, i.e., on the way the population variable is represented; the world is customarily divided into two categories: the developed world and the developing world.

To look into the future a number of assumptions have to be made. We shall use the UN and WB [B.3.1.] assessment as a reference case; it is the more accepted reference in the international world data. The principal underlying assumption is that the population replacement level is to be reached by the middle of the next century.

Present and future growth will take place overwhelmingly in the developing world. This is, however, a new phenomenon. Until the year 1950 the growth rate in the developed world was higher than in the developing world due to the high mortality rate. Population in the developed world is a recent phenomenon. The main trends on past and future global population were shown in Figures in chapter 1 and in the next Figure 5.1.

Figure 5.1.



5.2. POPULATION FIRST LEVEL MODEL

In order to make the scenario analysis and the reasoning behind the results understandable (while taking into account enough details needed for policy analysis), the hierarchical approach outlined in chapter 4 is used.

After outlining a hierarchy of models some key features of population dynamics are described, such as demographic transition.

The minimal set of items in terms of which the evolution of population over time can be represented is: population (**pops**, number of people in a region, national or world) and population growth rate (**rpop**, rate of change of **pops** over time).

The equation representing the population dynamics is then (we should remember the discussion in chapter before):

$$pops_t = pops_{t-1} * [1 + rpop_t /100]$$

This model will be referred to the level 1 or the 1st level model (the notation s is for the 1st level). The equation reflects the consistency aspect of population dynamics in the broadest of terms. It should be remembered and pointed out that the most aggregate representation is not less accurate ("true") than the more desegregate representations such as those developed subsequently. If the growth rate **rpop** is known, the population change follows the simple equation. The problem, of course, is that **rpop** encompasses an extraordinary range of uncertainties which determine population change, such as, e.g., family planning attitudes, economic/social factors, etc..

While this representation is as accurate as any, the uncertainty "compressed" in **rpop** is far too large. In other words, simplicity in representation is bought at the price of increased uncertainty. For example, without additional consideration the growth rate can be assumed to drop precipitously at a rate which more detailed representation (particularly when taking into account age cohorts) will prove to be unrealistic, i.e., unachievable without catastrophic events such as starvation, epidemic, war, etc..

In the way that we are in front of the simplest model that we could use in our study, we can show the structure of it which are common in the other models. So we can take a look at our C++ source code for 1st level model of population:

Figure 5.2.

```
#include "stdafx.h"
#include <stdio.h>
#include "crcp9899pop.hh"
long model(long firstYear, long year, FILE *fpl)
{
  int j,k,r;
  static float  spops[reg],spops_agg[reg];

        /******************************
        * POPULATION 1st LEVEL MODEL
        *******************************/

        if (year > firstYear) {
                for (r=0; r<reg; r++) {
                /* Compute total population of the region (population in millions) */
                        pops[r]=spops[r]*(1+rpopm[r]*rpop[r]/100.);
                }
        }
                for (r=0; r<reg; r++) {
                /* Compute total population density (land in 10^3he) */
                        popsds[r]=pops[r]/(land[r]/1000.);
                }
                /* Aggregation population region*/
                pops_agg=0.;
                land-agg=0.;
                for (r=0; r<reg; r++) {
                        pops_agg=pops_agg+pops[r];
                        land_agg=land_agg+land[r];
                }
                /*Aggregation population rate*/
                        rpop_agg=100*(pops_agg - spop_agg)/spop_agg;
                /*Aggregation population density*/
                        popsds_agg=pops_agg/land_agg;
                for (r=0; r<reg; r++) {
                /* Backup total population 1st level model variable */
                        spops[r]=pops[r];
                /* Backup total aggregation population 1st level model var. */
                                spops_agg=pops_agg;
                }
        return 1;
}
```

We can identify easily and quickly that

spops

is an internal program variable which is population in the preceding year, whereas

rpop and **land**

are **input** variables or constants (we denote it as “popinp” variable), and

rpopm

is a **scenario** variable (popscn), and

pops and **popsds**

are **output** variables (popout).

5.3. THE DEMOGRAPHIC TRANSITION

The first main step in order to understand population evolution is to present the phenomenon of Demographic Transition. Demographic transition refers to the transition of the population from one equilibrium level to another. At an equilibrium level the population is stationary, i.e., it does not change (the level of population remains the same over time).

At an equilibrium the number of births and deaths are the same

$$brt = dth$$

so that the population (level) does not change over time. The crude birth rate, **crbrtr**, is the number of births per thousand of population and the crude death rate, **crdthr**, is the number of deaths per thousand. So in terms of crude birth rate and crude death rate the condition becomes

$$crbrtr = crdthr$$

Transition from one equilibrium level to another depends on how the **crbrtr** and **crdthr** change over time. Let us assume that **crbrtr** and **crdthr** change from one equilibrium characterized by

$$crbrtr_1 = crdthr_1$$

to another equilibrium, which is determined by

$$crbrtr_2 = crdthr_2$$

For example, at the first equilibrium the rates could be, e.g., say 40 per thousand (as was the case in the developing countries before W.W.II.), while at the new equilibrium the rate is 15 per thousand (as it is presently in most of the developed world).

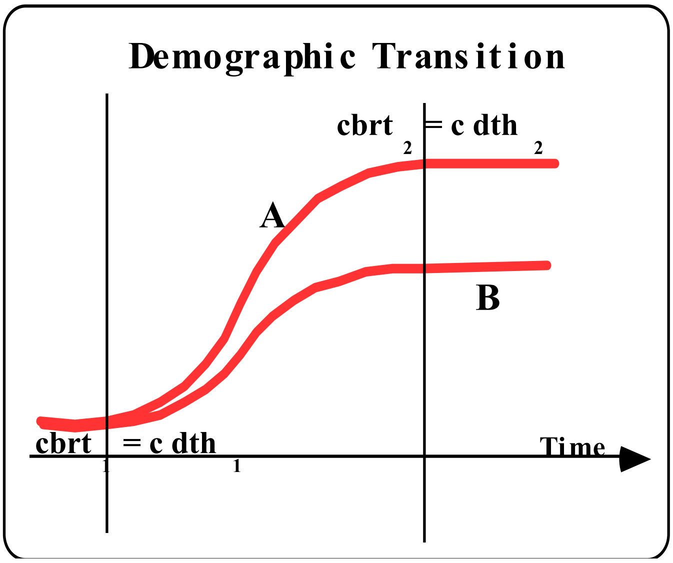
The important fact about the transition from one equilibrium level to another is that the level of the population at the new equilibrium depends not only on when it is achieved but also how it is achieved, i.e., it depends on the trajectories which **crbrtr** and **crdthr** follow in the transition time period. Let us consider the two cases of transition from one equilibrium to another over a fixed time period. Let us assume for the sake of simplicity that the change in **crdthr** is the same in both cases but in the first case the change in **crbrtr** is slower, catching up with the change in **crdthr** only towards the end of the time period. In the period when **crbrtr** is larger than **crdthr** the population growth rate is positive.

$$rpopo(t) = [crbrtr(t) - crdthr(r)]/10 > 0$$

i.e., the population continues to grow. A new equilibrium is therefore achieved at a higher population level.

The equilibrium level depends on how long a large, positive inequality persists. If **crbrtr** is very slow in changing at the beginning and catches up only towards the end of the time period, the equilibrium level will be high. This is shown in curve A of Figure 5.3. On the other hand, if change in **crbrtr** is more in step with **crdthr** the difference in the inequality is smaller and the increase ("accumulation" as it were) in population during the transition period will be smaller (curve B of Figure 5.3.)

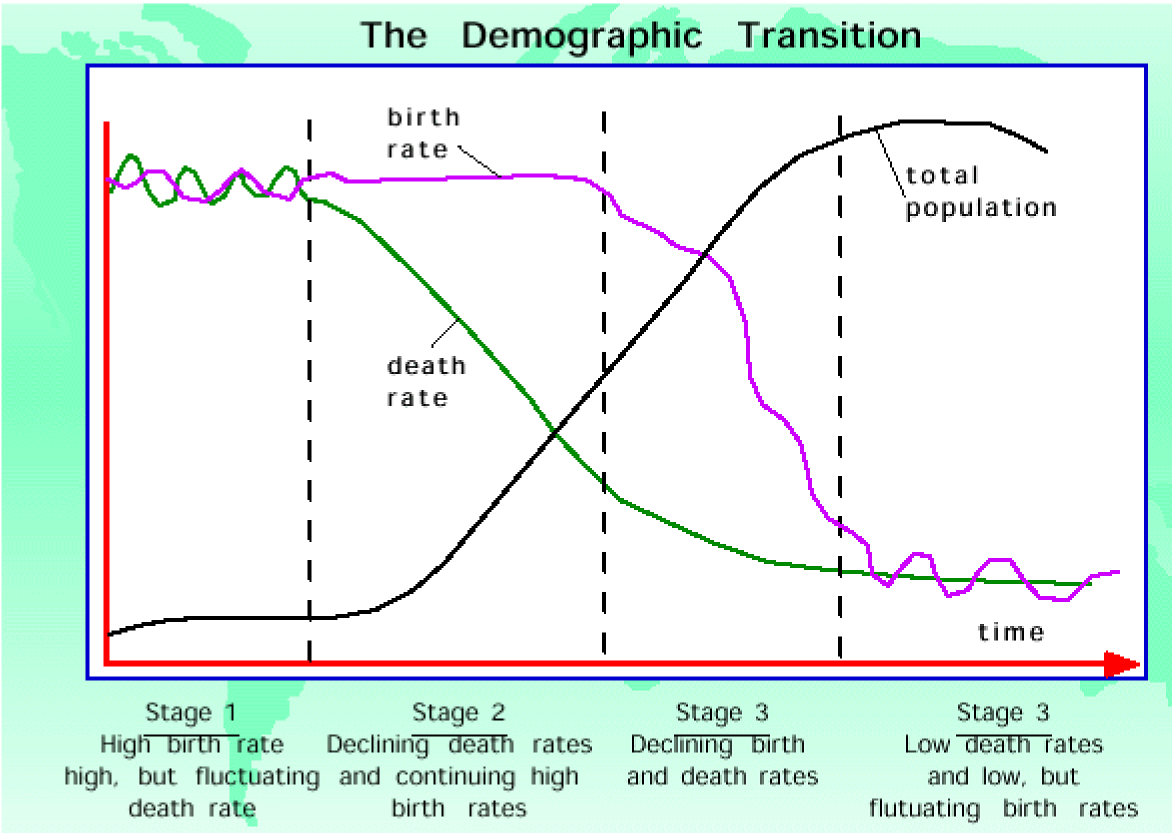
Figure 5.3.



This is precisely what is happening in the developing world at present. Due to the considerable reduction of the mortality rate in the South with a decline in the change of fertility rate lagging behind, the size of the population at a future equilibrium -which surely will be achieved (subject to possible oscillation around the equilibrium)- will be much higher. This simple but extremely important fact is behind the dramatic change in the population over the last 30-50 years, particularly in the discrepancies in population size between the North and South.

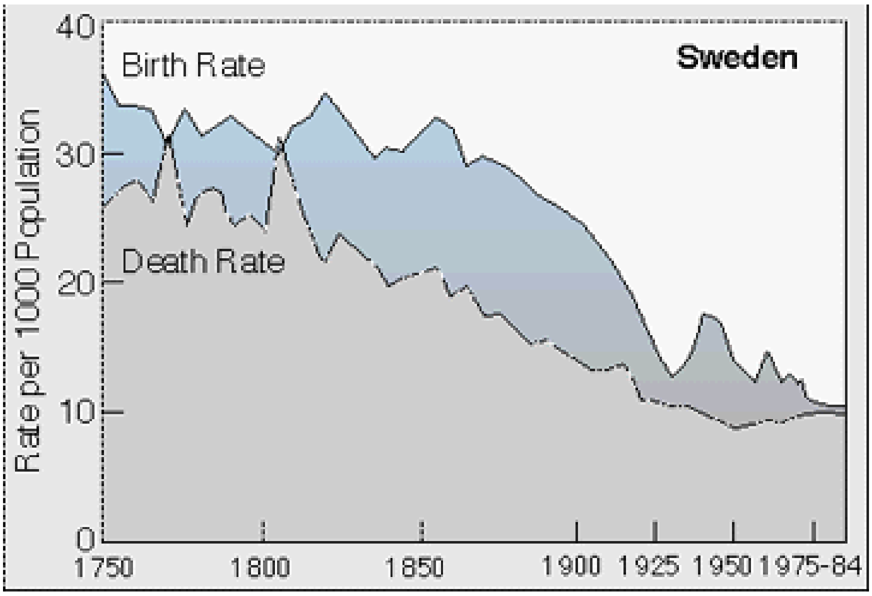
The following Figure 5.4. shows the classical representation to explain this important phenomenon of Demographic Transition from one equilibrium to another one.

Figure 5.4.



And the Figure 5.5. shows the historical trends of crude birth and death rates in the North (represented by Sweden) and South (represented by Mexico). It is apparent that the population of the South will continue to increase at a higher rate than that of the North because the "pressure" of discrepancy between **crbrtr** and **crdthr** is higher and more persistent. It is also noteworthy that the change of rates in the North proceed much less precipitously over time than in the South. That creates additional problems for the support of population in the South which increases over a much shorter time period. Before the advance of modern health care, sanitation, etc., the population growth in the North was higher than in the South due to the high death rate in the South. Only since the middle of the 20th century has the population of the South begun to increase at a higher rate than in the North. See also a general Figure 5.6. with past and projections trends in Sub-Saharan Africa.

Figures 5.5.:
Data for Sweden from Statistics Sweden, 1986 Statistical Yearbook (Stockholm 1985). Data for Mexico for 1895-1970 from Francisco Alba-Hernandez, The Population of Mexico (Mexico: Center of Economic and Demographic Studies, El Colegio de Mexico, 1976); for 1970-1985 from United Nations, Population Division, Demographic Indicators by Countries as Assessed in 1984, New York, December 1985.



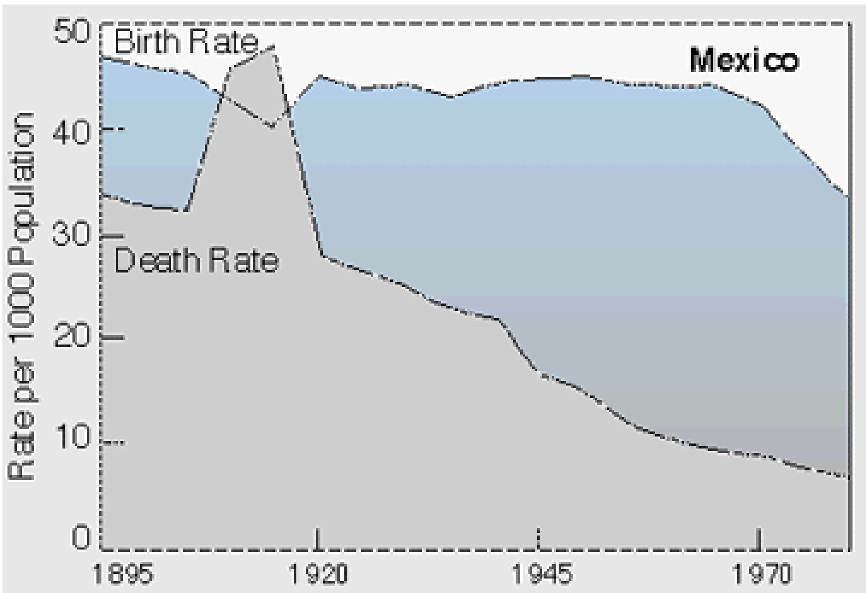
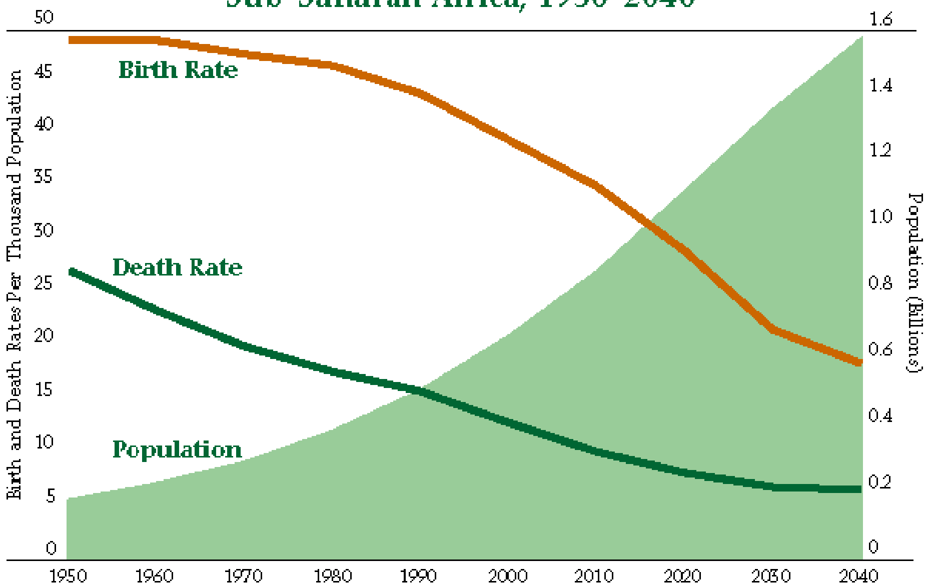


Figure 5.6.

FIGURE 1

Population Size and Birth and Death Rates
Sub-Saharan Africa, 1950-2040



Numbers for 1995-2040 based on United Nations medium projections.
SOURCE: United Nations. World Population Prospects: The 1996 Revision. New York: United Nations, 1996.

The demographic transition phenomenon clearly illustrates the need for the fertility reduction to be commensurate with mortality reduction, the latter surely declining as fast as possible for humanitarian reasons. The cost of the fertility decline lagging behind the mortality decline can be expressed in terms of an additional billions of people at a new population equilibrium.

Demographic transition indicates the importance of the dynamics of the demographic process, i.e., the population equilibrium will surely be reached but when and how depends on the changes in birth rates and death rates over time.

5.4. POPULATION SECOND LEVEL MODEL

The demographic transition phenomenon gives us the necessity and the opportunity to build the second level model, from the hierarchic point of view, on population.

The equations and definitions below are self-explanatory.

We have that

pop=spop+brt-dth

where

brt=total birth number in a given year
crbrtr=crude birth rate:birth number for year and for thousands of population
spop=population in the precedent year
brt=crbrtr*spop/1000
dth=total death number in given year
crdthr=crude death rate
dth=crdthr*spop/1000

and so the population growth rate becomes

rpopo=(crbrtr-crdthr)/10

and

pop=spop*(1+rpopo/100)

where:

inputs: crbrtr, crdthr, spop
outputs: rpopo, pop
scenarios: crbrtrm,crdthrm

The detailed model is in the appendix A.3.

5.5. FORESCATING POPULATION IN OUR CASE STUDY REGION: USING FIRST AND SECOND LEVEL MODEL

As mentioned before, population projection from WB and UN [B.3.1.] will be used as a basis for our study of population carrying capacity. In this section the projections for the countries of the case study region will be reproduced using GLOBESIGHT and shown in graphical format. Reader can validate the reproduced graphs from the original data source.

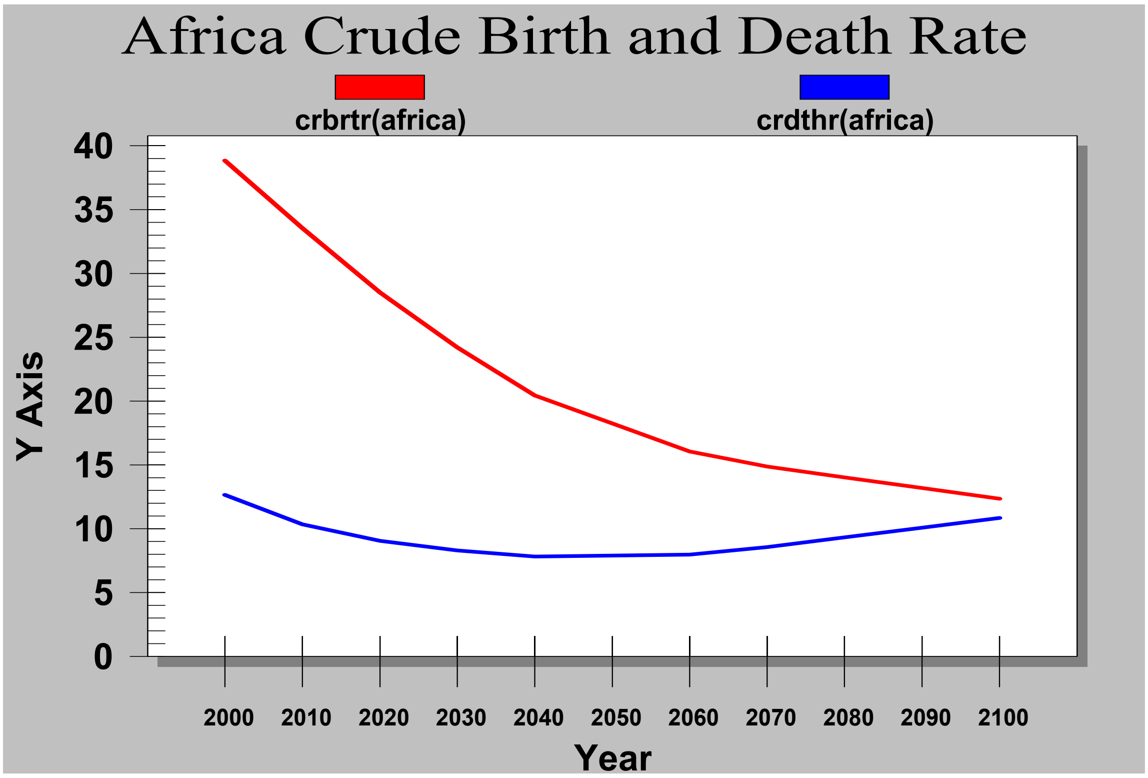
It is useful to have general and diverse numerical data of other regions but from the same sources. This is shown below in figure 5.7.. The total fertility is the average size of the family, i.e. the average of children in a family.

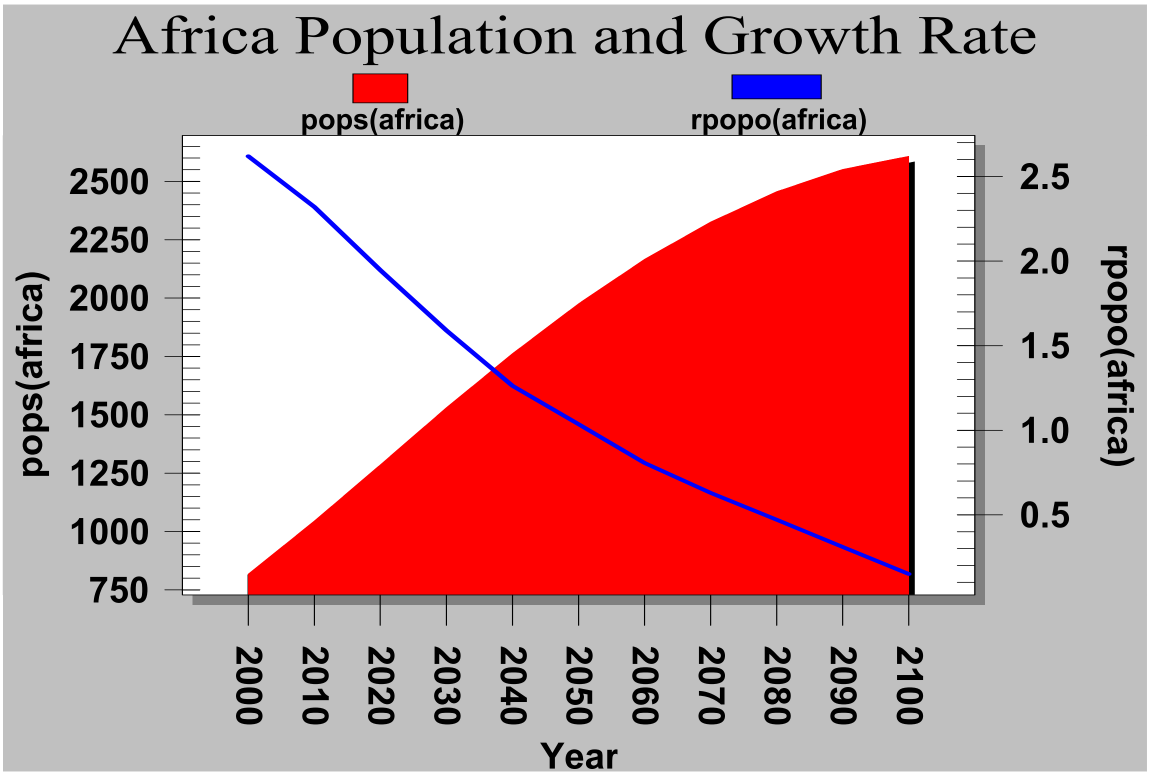
Figure 5.7.:
Population projections: 1990-2100
(population in millions)

Country/Year	1990	2000	2025	2050	2100	Tot. Fert. '90
China	1133	1255	1471	1556	1630	2
India	850	1016	1370	1623	1813	3.7
Indonesia	178	206	265	304	338	2.93
Brazil	149	172	224	254	275	2.75
Bangladesh	110	132	182	218	247	4
Nigeria	96	128	217	288	355	5.86
Pakistan	112	148	243	316	380	5.6
Mexico	82	99	136	162	177	3.16
Egypt	52	63	86	103	116	3.75
Developing Countries						
Africa	**627**	**821**	**1431**	**1999**	**2643**	**5.7**
East Asia	1788	2010	2430	2644	2824	2.28
South Asia	1185	1444	2038	2484	2847	4.04
Latin America	435	512	686	804	883	3.05
SUB-TOTAL	4035	4787	6585	7931	9197	
Developed Countries	1215	1273	1364	1367	1379	1.84
TOTAL	5250	6060	7949	9298	10576	

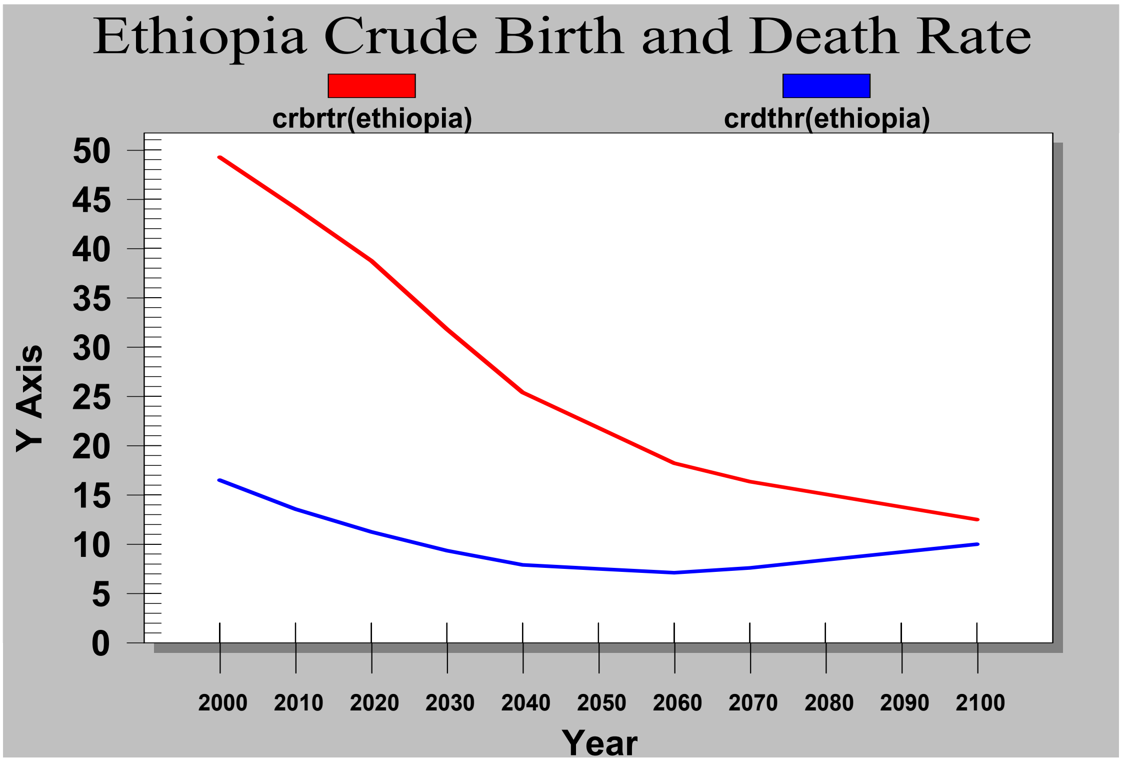
So the following are, finally, the projections for each country of our case study region, along with the aggregate value for the whole region itself.

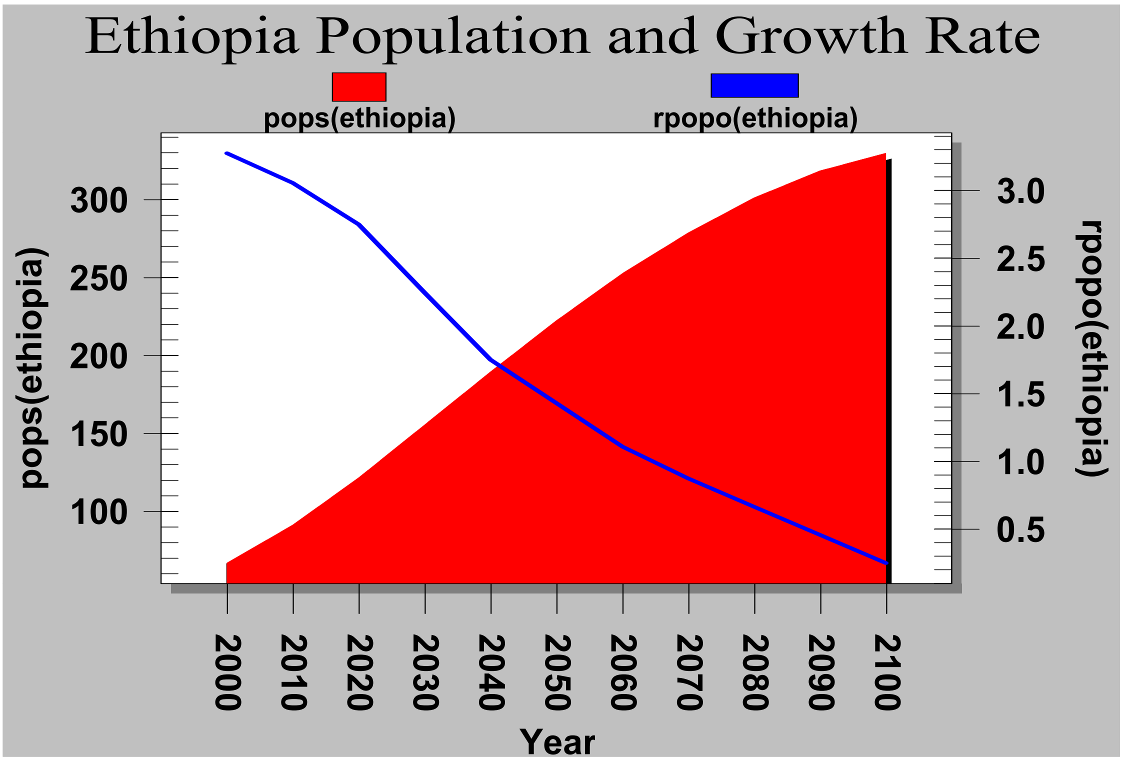
Figures 5.8.: Africa Population



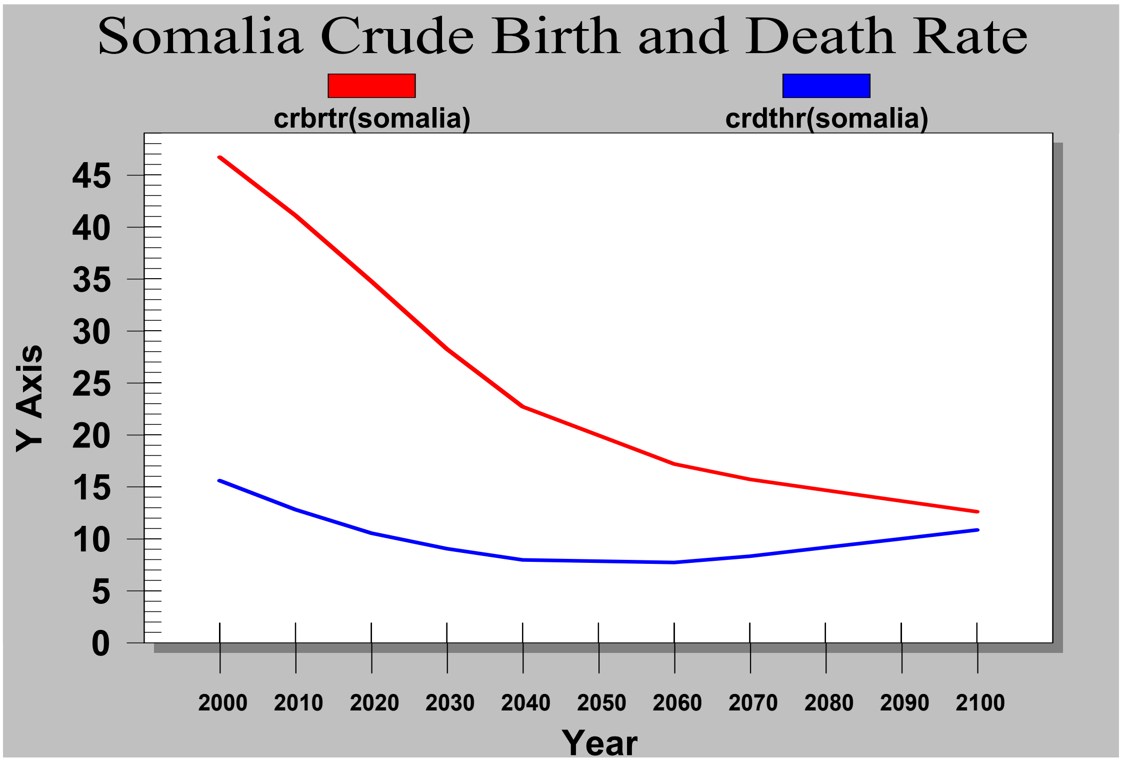


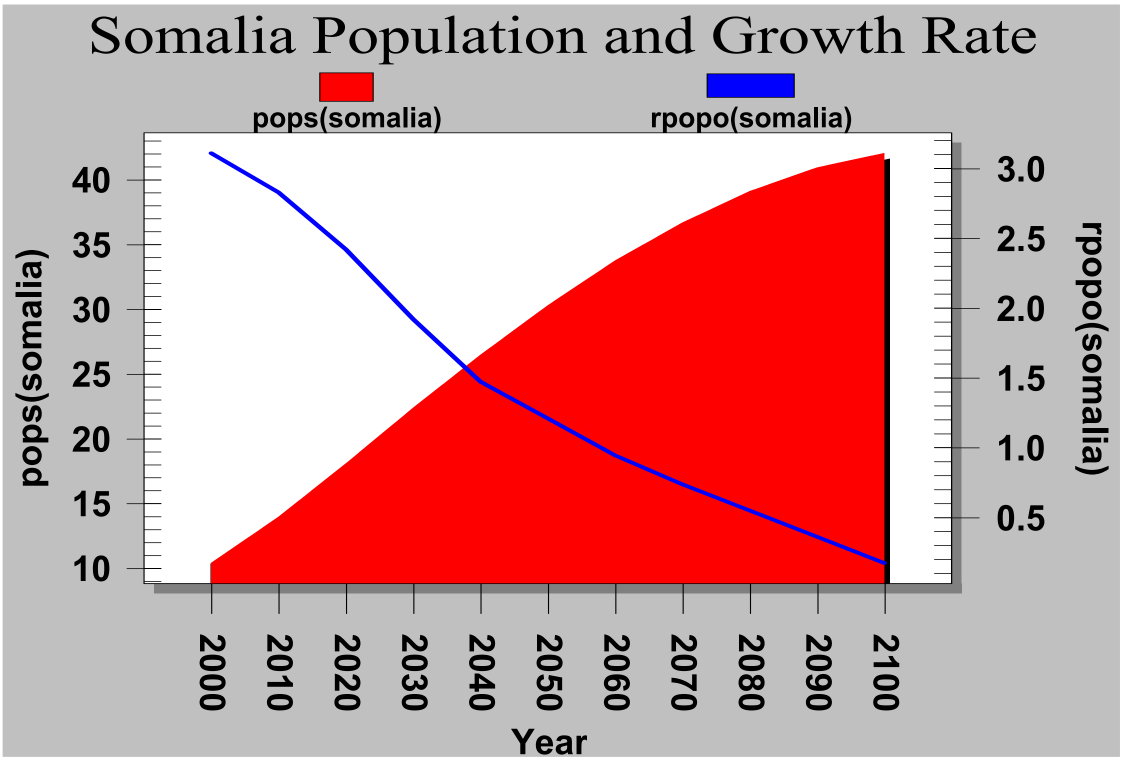
Figures 5.9.: Ethiopia Population



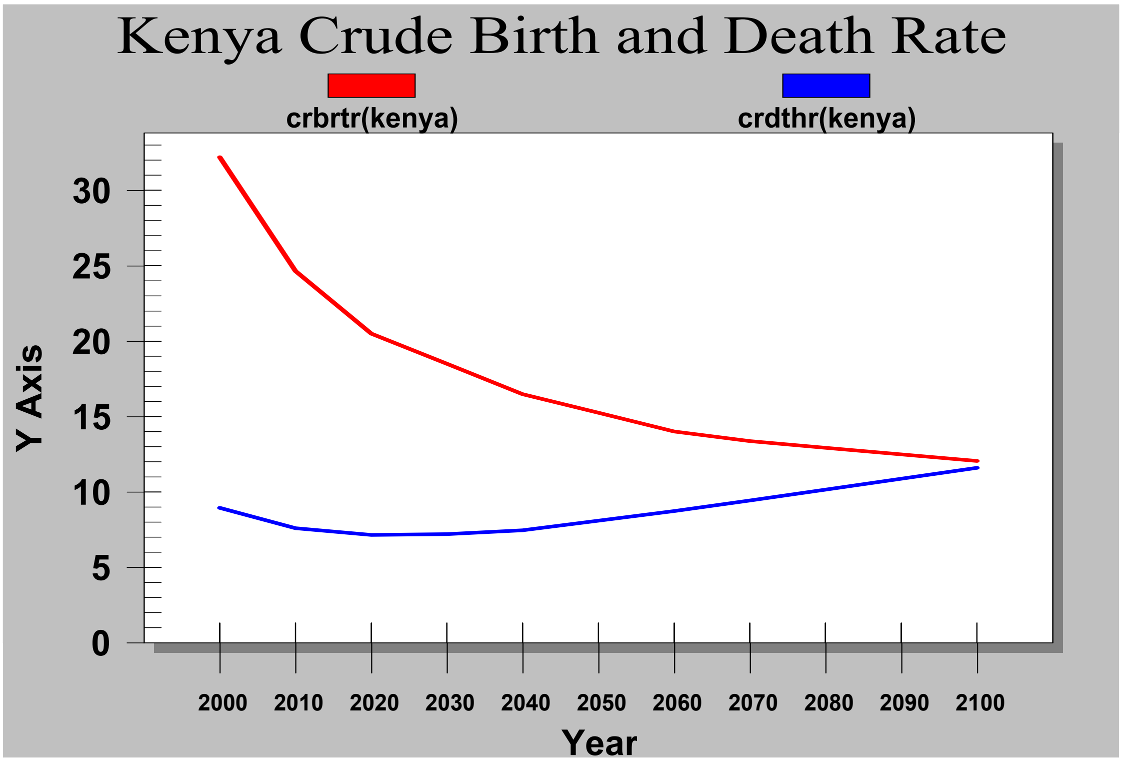


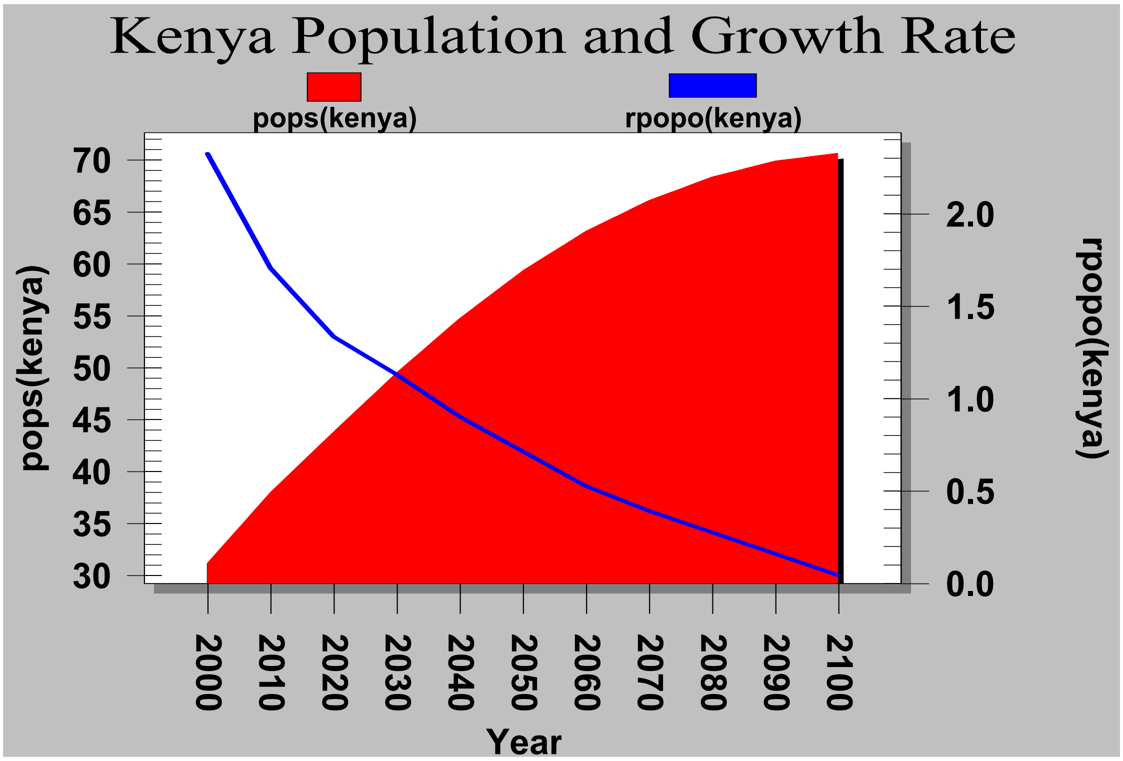
Figures 5.10.: Somalia Population



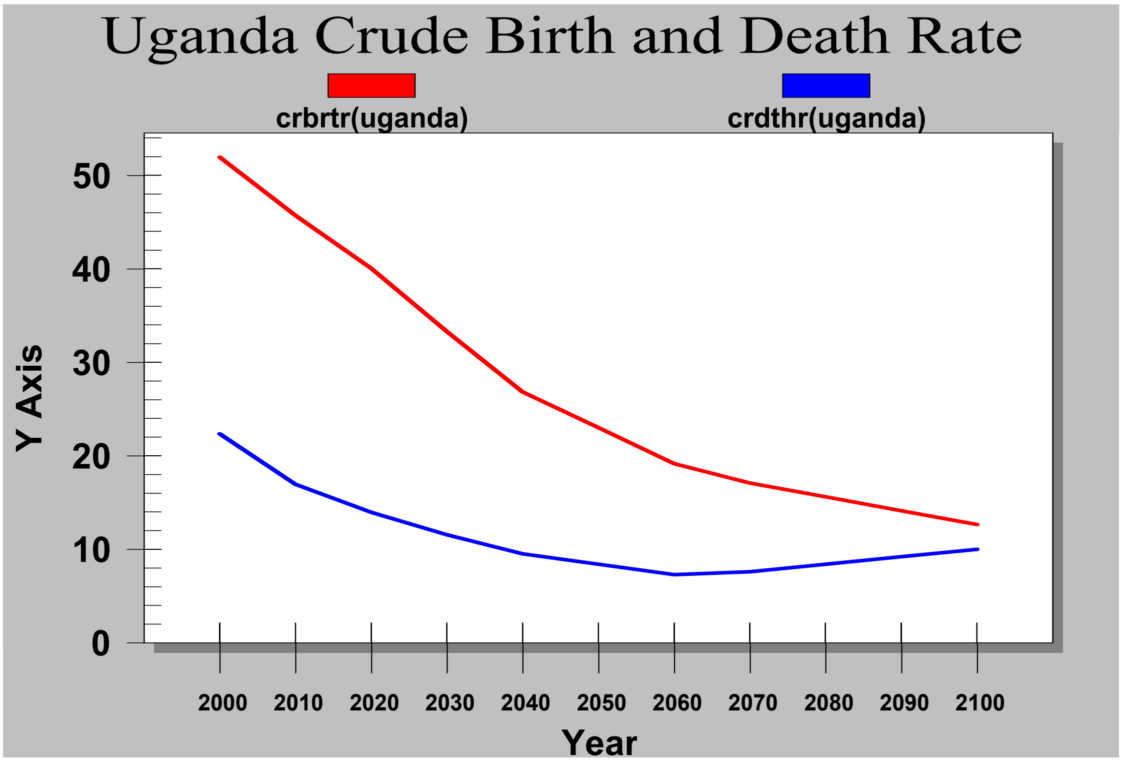


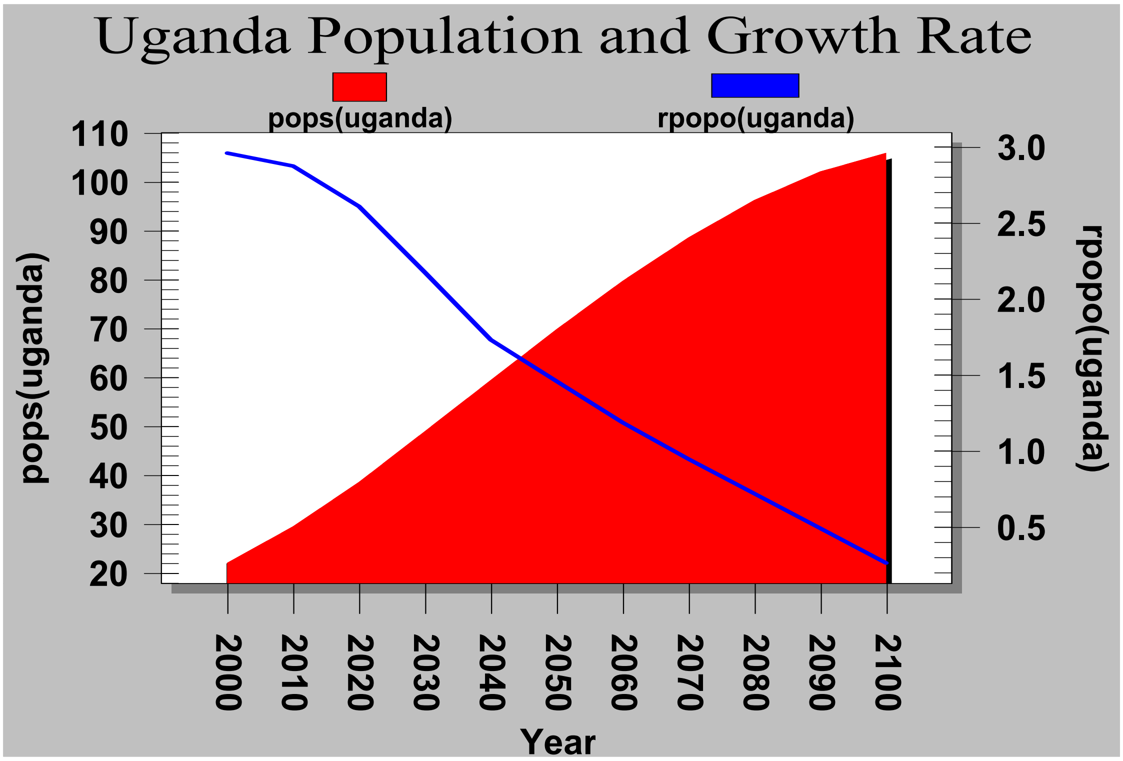
Figures 5.11.: Kenya Population



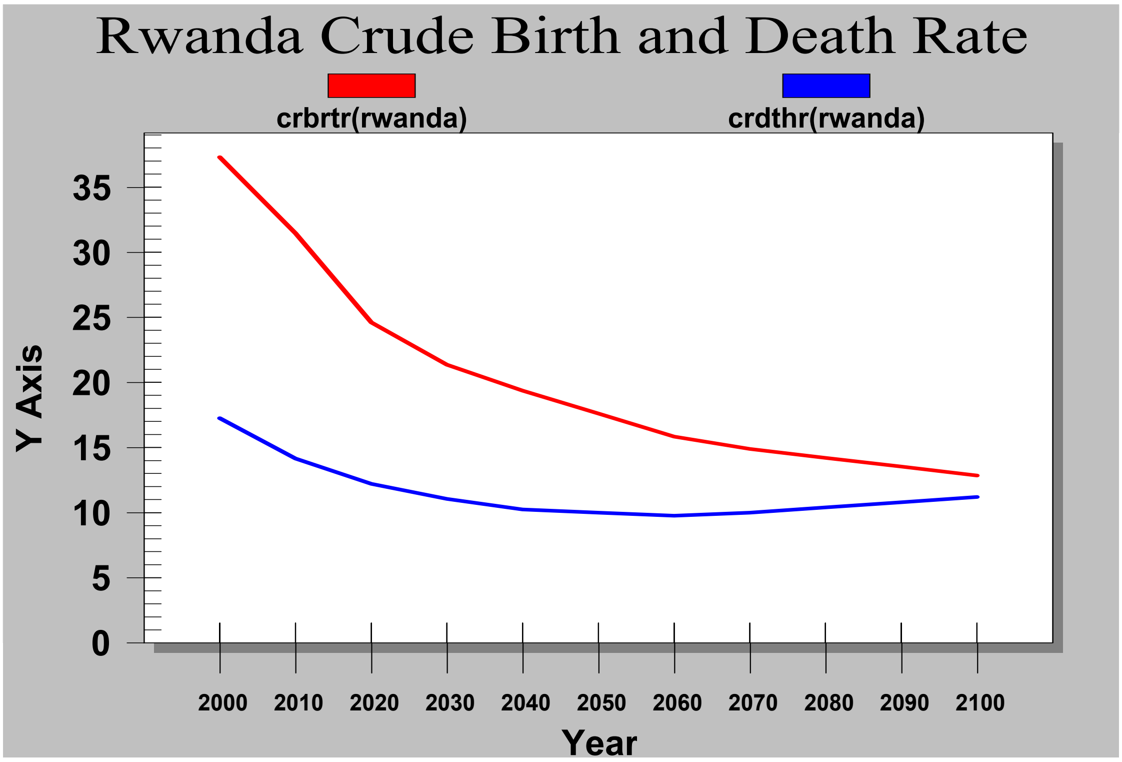


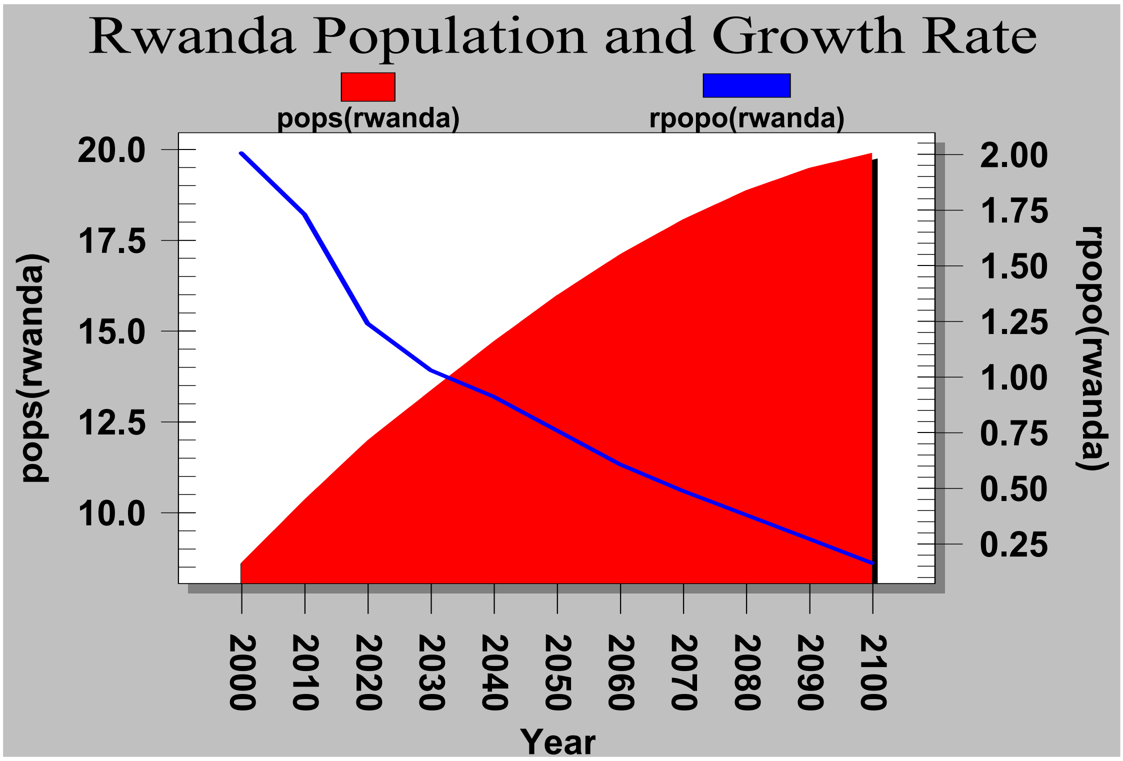
Figures 5.12.: Uganda Population



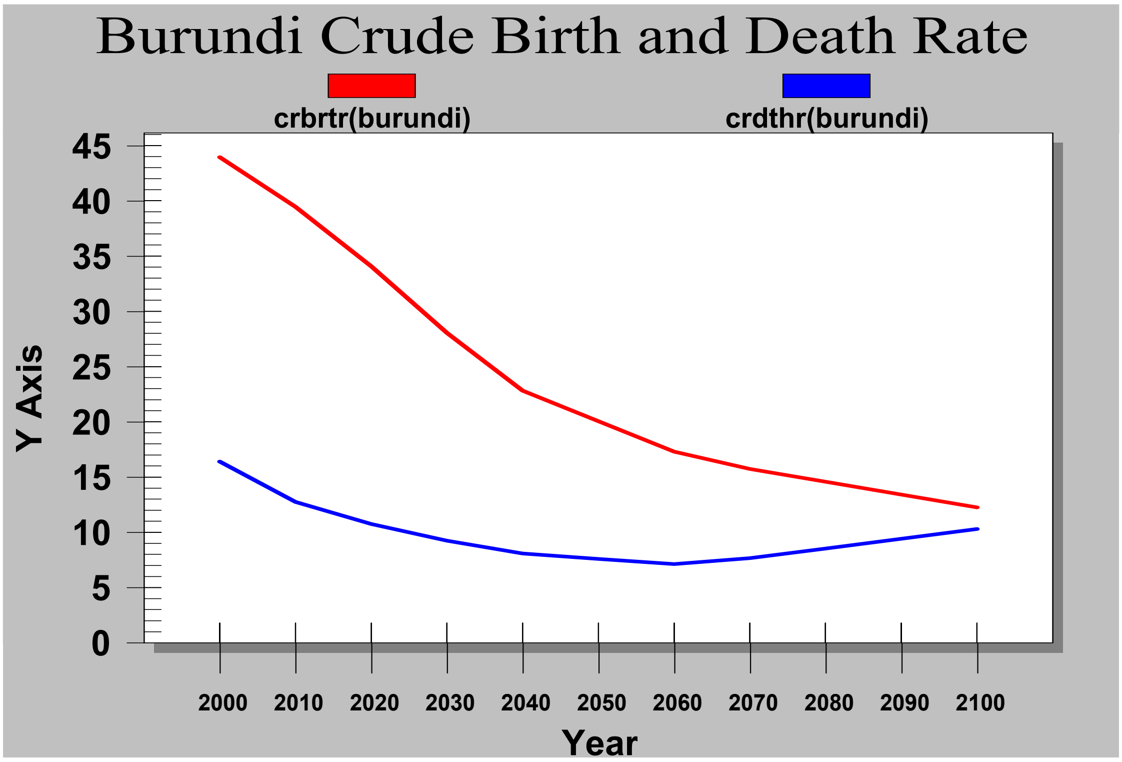


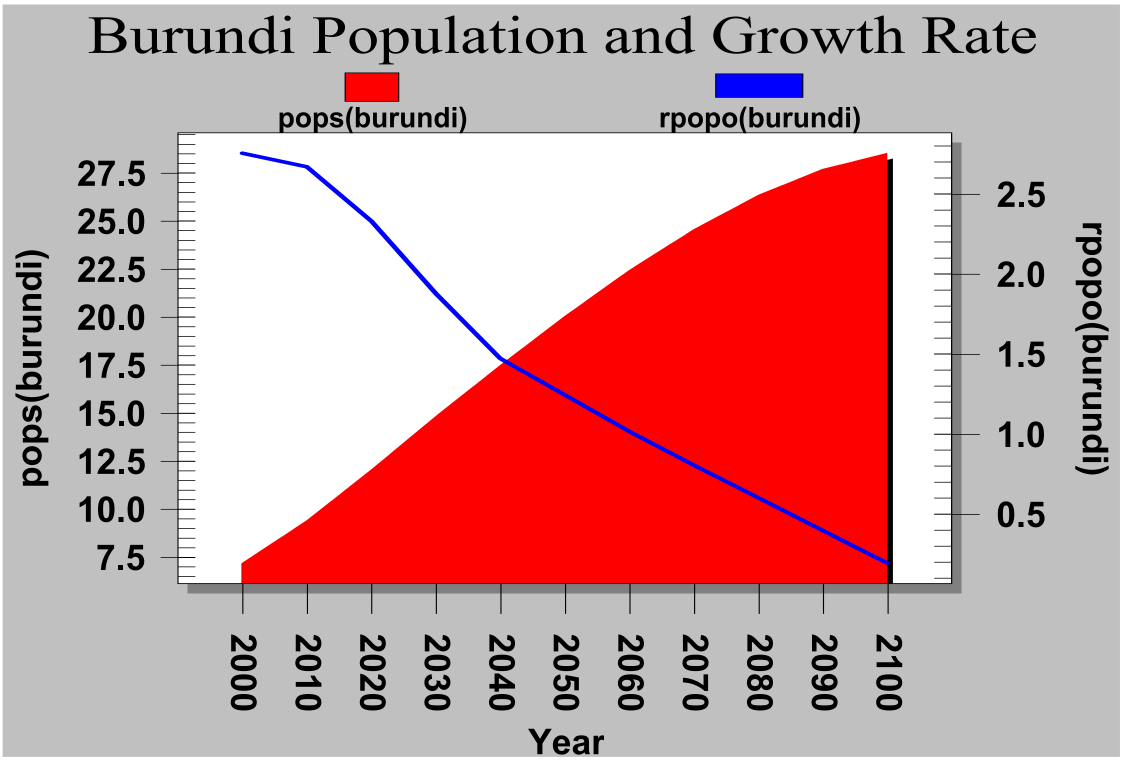
Figures 5.13.: Rwanda Population



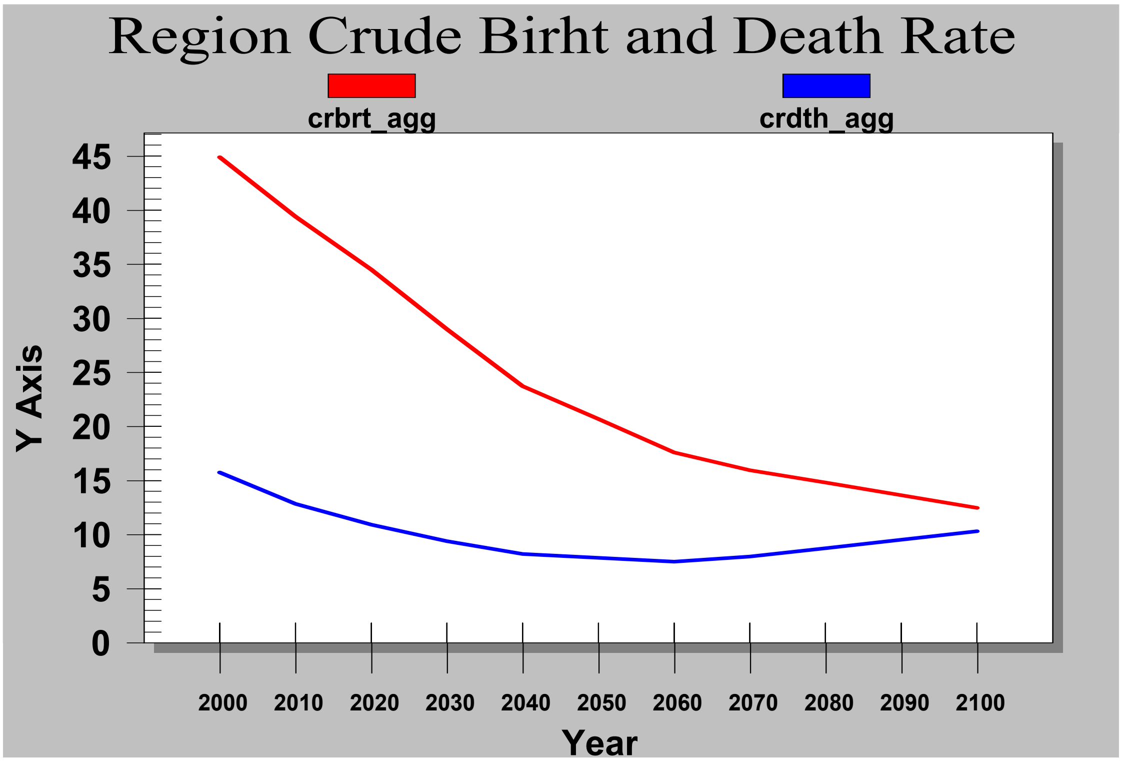


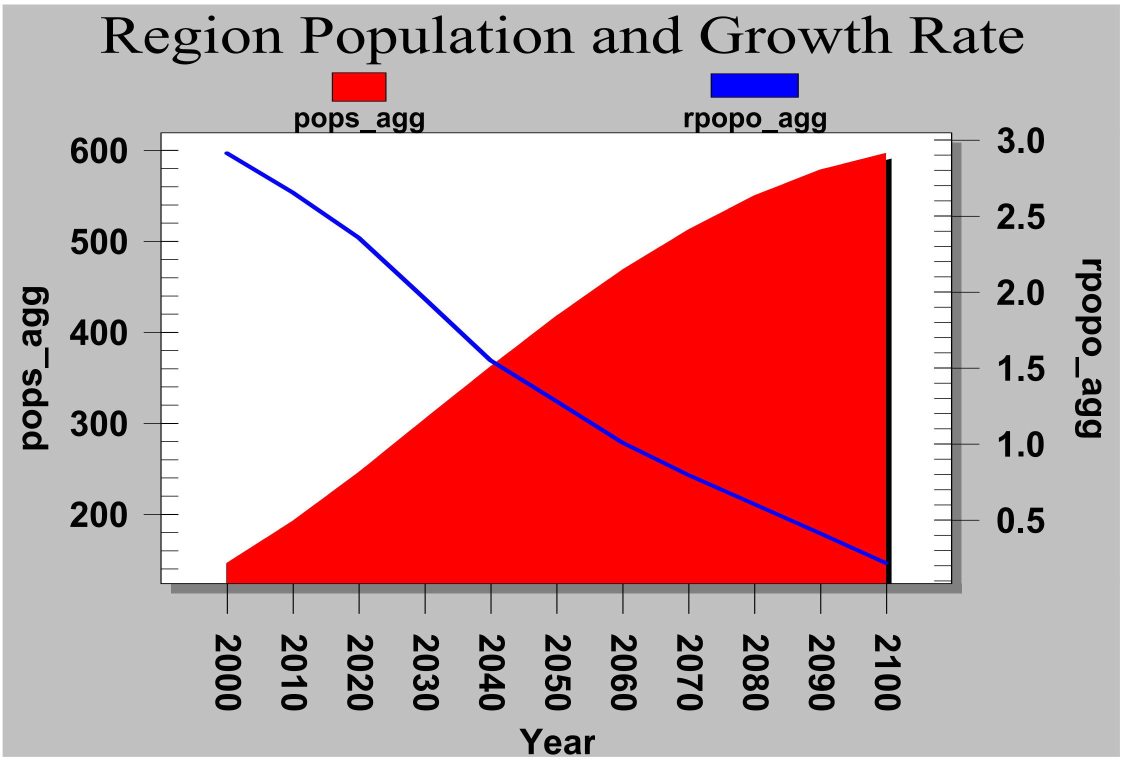
Figures 5.14.: Burundi Population





Figures 5.15.: Case Study Region Population





5.6. REMARKS

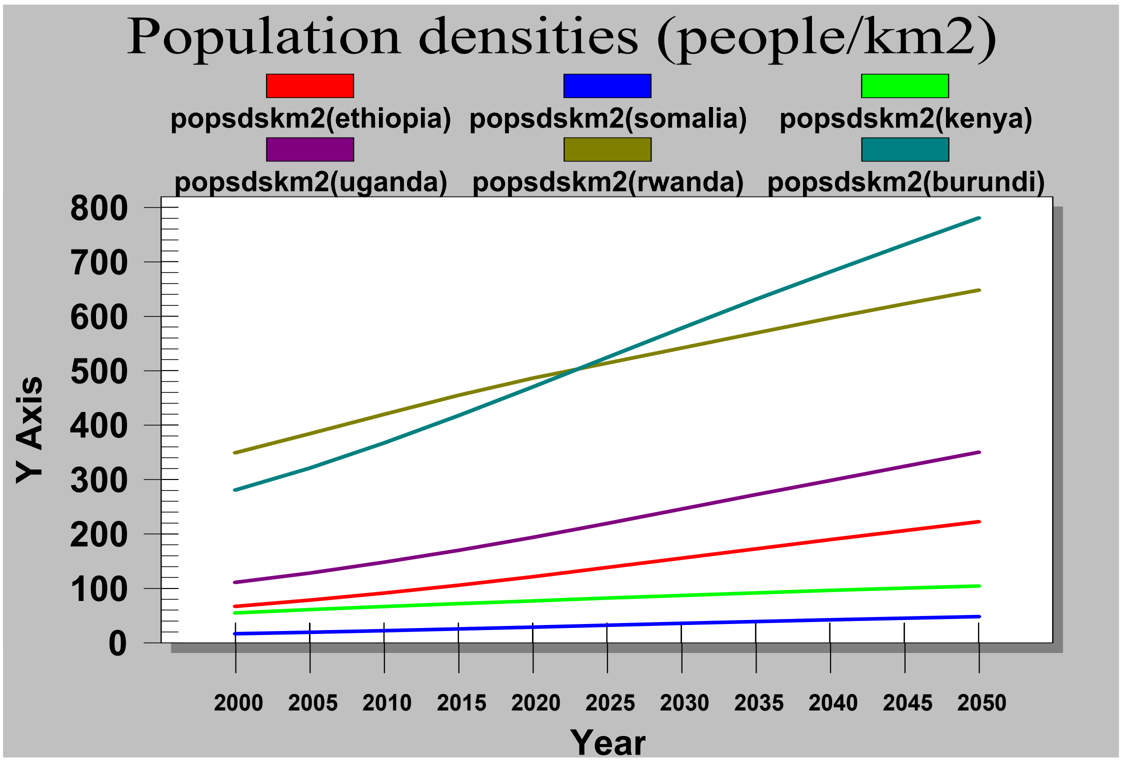
In the next 50 years, it is almost certain that Africa will double its population. More importantly, it is the continent with the highest growth rate in the world (currently 2.5% which corresponds to 6 children per family on average).

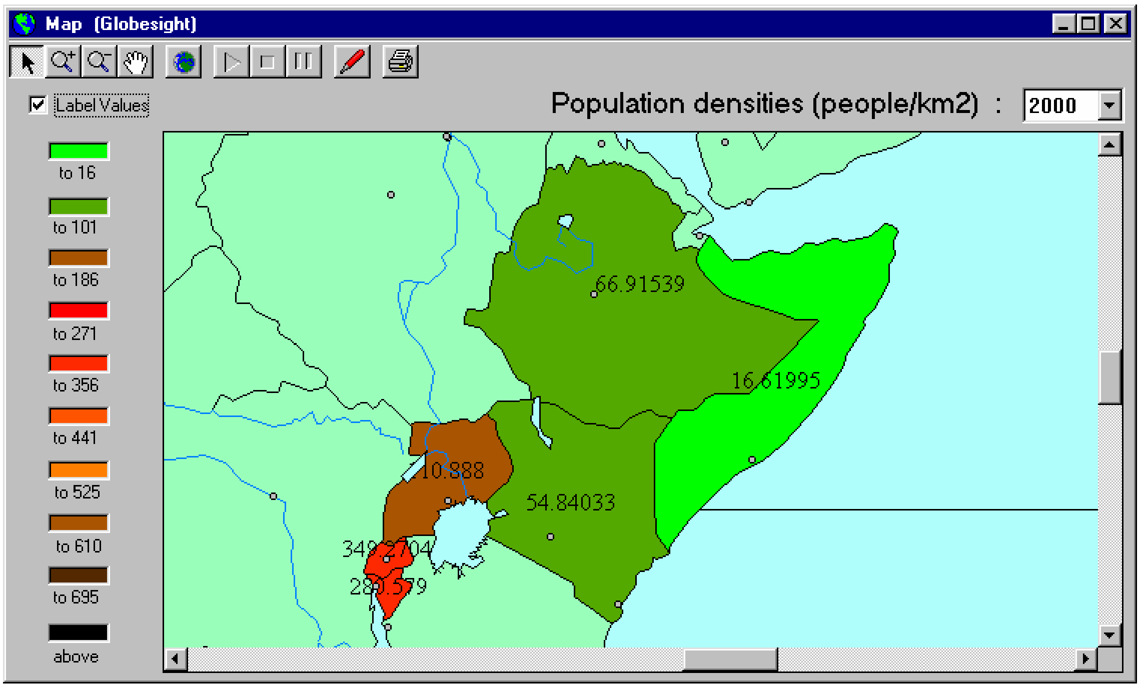
Our case study region will triple its population (from 145 to 415 Millions of people) with, on average, a growth rate close to 3% currently, especially in Ethiopia and Uganda.

In terms of population, the largest country in our case study region is Ethiopia followed by Uganda. Ethiopia represents half of the population in this region.

For thinking in the next chapter it shall be very useful to show the population densities of the countries of our case study region. See the last Figure 5.16.

Figure 5.16




Map (Globesight)
Label Values
Population densities (people/km2) :
2000
to 16
to 101
to 186
to 271
to 356
to 441
to 525
to 610
to 695
above
66.91539
16.61995
10.888
54.84033