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The Dynamics of Urban Population Developments: PROJECTION MODEL OF URBAN-RURAL GROWTH DIFFERENCES

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DECLARATION

I declare that this research report is my own, unaided work (except for where acknowledgements indicate otherwise). It is being submitted for the degree of Master of Art in Demography and Population Studies in the University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination in any University.

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Our thanks to:

The Almighty, for His provision and mercy even when there seemed to be no way: for His Love endures forever (Psalm 118:4, 5).

My Wife and Children for their patience through the long period of study,

My supervisor, Dr. Philippe Bocquier, for his guidance throughout this Research Report,

The United Nations – Department of Economic and Social Affairs – Population Division, for providing the original data

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ABSTRACT

The study aimed at projecting urban growth from 2010 to 2050 using United Nations, World Urbanization Prospects data. The result is compared to UN prediction on urban growth for the same period. As an alternative to the second order polynomial tested in previous research, a third order polynomial was used to model urban-rural growth difference from 1950 to 2005 country by country, then projections were drawn to 2050. The model was tested over the 1990-2005 period using the 1950-1990 data, giving very good results (mean percentage error of only 1.15%). Using the third order polynomial model, the world urban population is projected at 52.8% by 2050 and 54.2% without China while the UN predicts 67.9%. For the same year (2050), the third order polynomial model foresees that 48.8% of the population in the less developed countries will be living in urban areas while the UN predicts 64.7%. The projection of urban growth in least developed countries is estimated at 35.2% and 55.5% using respectively the third order polynomial model and the UN predictions. The findings suggest that UN predictions are excessively high mostly for less developed countries. The second order polynomial model fitted on the same data gives the same results.

NOTATIONS

In the present research, the following variables and notations are used as specified below unless otherwise specified:

$N\ t$	:	Population size at the time t
$U\ t$	:	Urban population size at the time t
$R\ t$	:	Rural population size at the time t
$PU\ t$	:	Percentage of population who are urban at the time t
n	:	Time interval between two population evaluations
$t, t+n$	:	Interval period between the initial year t and the final year $t+n$ (the final year is not included)
$r\ t+n$	:	Rural population growth rate in the time interval $t, t+n$
$u\ t+n$	:	Urban population growth rate in the time interval $t, t+n$
$rur\ t+n$	:	Urban-Rural Growth Difference in the time interval $t, t+n$
$xu\ t$	:	Excess urban population at the time t
$3rd\,GLS$	:	3^{rd} order polynomial model using Generalized Least Squares and Random Effects estimator options
$2nd\,GLS$	:	2^{nd} order polynomial model using Generalized Least Squares and Random Effect options

CHAPTER 1

INTRODUCTION

1.1. <u>DEMOGRAPHIC TRANSITION BACKGROUND</u>

Demographic transition theory began as a descriptive observation of demographic changes that had taken place in developed nations over time. It described the transition from high birth and death rates to low birth and death rates. At the end of the transition, the size of the population tends to be bigger than it had been at the start (Young, 1968). Demographic transition theory has dominated recent demographic debate and led to an inference that the demographic transition is actually a set of interrelated transitions. Urbanization is identified as one of the demographic transition processes.

Though demographic transition is not the focus of the present research, some of its concepts will be mentioned to introduce urban transition. The European Fertility Project, the theory of demographic change and response, the Easterlin hypothesis, and other researches suggest that usually, but not always, mortality transition is the first in the set of transitions to take place. The main reason is that the introduction of modern medical treatment and medication to control of communicable diseases reduces the infant mortality and causes life expectancy to increase with death due to degenerative diseases occurring at older ages (Galor *et al.*, 1998). Fertility transition, which is the shift from natural and high fertility to controlled and low fertility, follows in a delayed response to mortality transition. The rapid growth of population leads to overpopulation of rural areas (Cohen, 2004). Greater economic opportunities and better service delivery in urban areas stimulates rural to urban migration, which will lead to urban transition, defined as the shift from low to high urbanization. Urbanization growth begins with rural to urban migration but afterwards evolves and becomes a result of urban natural growth. Urban-Rural Growth Difference (URGD) is a measure used to evaluate urban transition and project urban trends over time. The analysis of URGD, based on urban transition experienced by developed countries, is inspired by Zelinsky's phases of mobility transition (Zelinsky, 1971). URGD is expected to increase rapidly at the beginning of transition, and then relent gradually until it reaches the maximum level. Thereafter, it decreases continuously and fluctuates around zero at the end of the transition (Bocquier, 2005).

Most of the developed countries have completed their urban transition. The UN World Urbanization Prospects (2008) estimates that more than three quarters of the population of these countries live in urban areas. Their experience shows how urban transition and development go hand in hand as endogenous processes (Zelinsky, 1971, Teitelbaum, 1975). Urbanization is a universal event and no developing country can expect to advance economically without urban growth (Bocquier, 2005). Stren already in 2003 estimated that half of the World's population lives in cities (Stren *et al.*, 2003). The UN projected that for the first time in history, the proportion of the population living in urban areas would reach 50% during 2008 (UN World Urbanization Prospects, 2007).

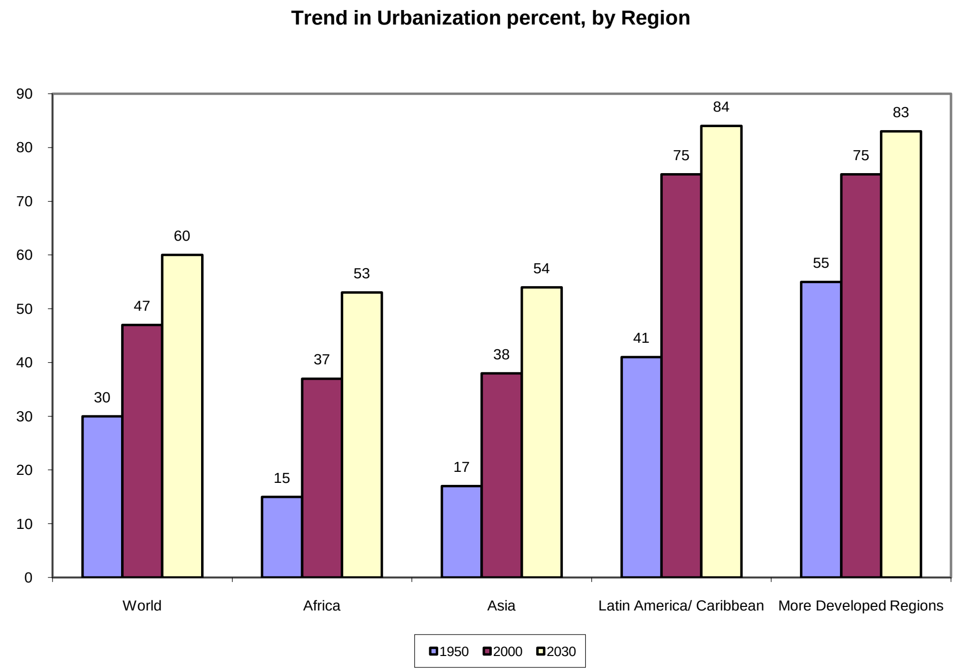

Figure 1: Trend in Urbanization, by Region according to UN projections

United Nations, *World Urbanization Prospects: The 2001 Revision* (medium scenario), 2002.

A number of authors describe two waves of urbanization in the World:

- The first wave started in the 18th century around 1750 and ended in the 20th century around the 1950s. It began in Europe and North America and produced the new urban industrial societies.

- The second wave started in the 20th century around the 1950s for the less developed regions of the World.

UN estimated that by 2050, 3.3 billion people in the World will live in the cities and much of this growth will come from the world's poorest countries (UN, World Urbanization Prospects, 2001). Developed countries passed through urban transition simultaneously with industrialization and demographic transition. Most of them have actually completed their urban transition. This transition is interdependent with other demographic, social and economic development. We cannot explain urbanization without development and at the same time, we cannot explain development without urbanization. There is no one-way causal relationship between the two phenomena, which are endogenous to each other. Developing countries are also going through phases of urbanization. The question is how developing countries' experience will differ from what was observed in developed countries.

1.2. STATEMENT OF THE PROBLEM

This study investigates how urbanization has evolved over time and what is the expected trend of urban growth in developing countries. Population projections are an essential input for economic and social development plans, for consumption estimation and for service delivery and maintenance. It is vital for countries to plan ahead using national projection which can tell where the majority of the population will be living. Projection can provide useful information for regional planning of future basic needs such as healthcare, housing and education, as well as the probable future labour supply.

No other organization outside of the United Nations has been successful in compiling a database on urban growth that is comparable to UN statistics in scope and quality (Bocquier, 2005). However the comparison of the United Nations' forecast for the year 2000 published in 1980 with the actual 2000 figures reveals that urban growth in developing regions was much slower than what was forecasted (Cohen, 2004). Already in 1999, Brockerhoff wrote that the projections that foresaw all of world population growth in the future occurring in urban areas of developing countries might be misconstrued, if the forces that retarded urban growth at the time persisted (Brockerhoff, 1999).

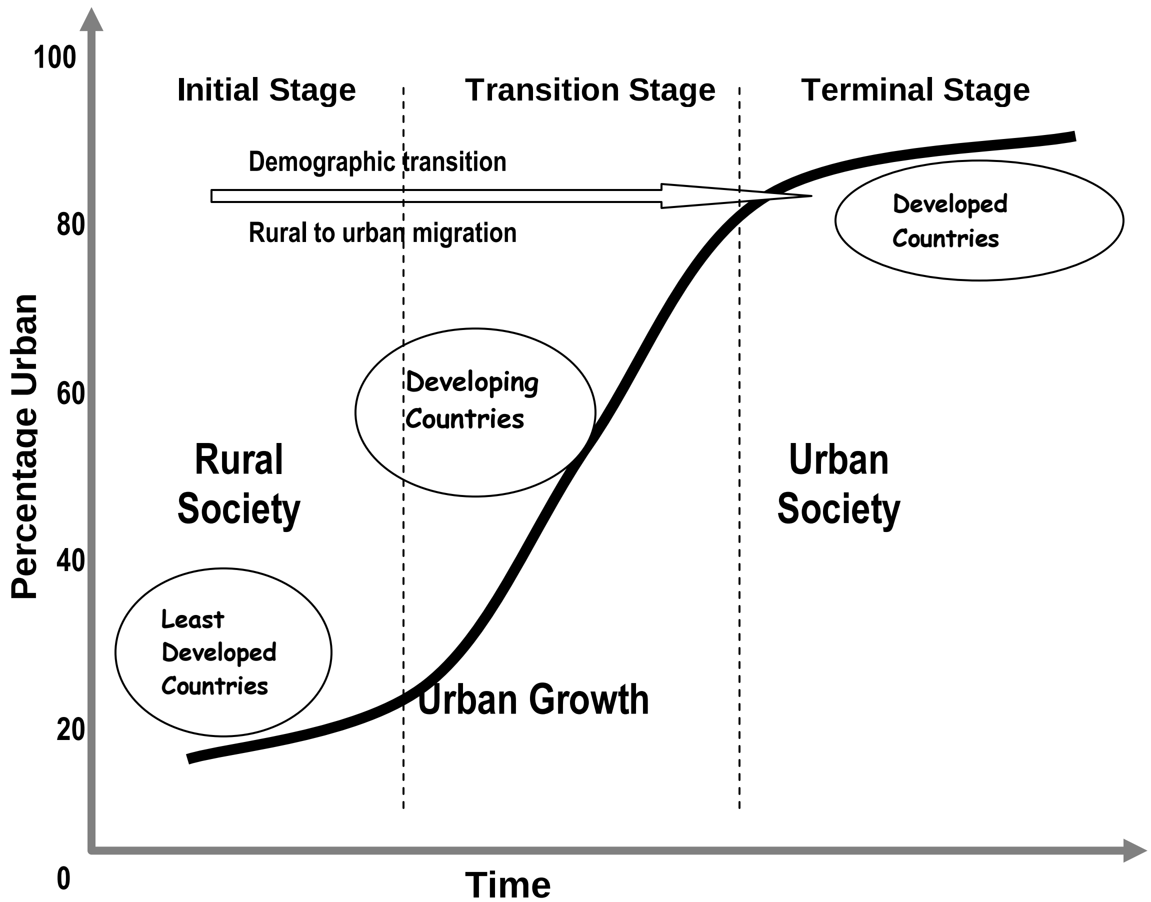

Figure 2: Stages of Urbanization: Urban Population as percentage of the total Population

Adapted from United Nations, *World Urbanization Prospects: The 2001 Revision* (medium scenario), 2002.

The UN model assumes that all countries will go through the same pattern of urban transition as shown in Figure 2. The recent urban growth trend shows that urbanization is universal but not homogeneous. Developing countries reflect a different pattern of urbanization when compared to developed countries (Bocquier, 2005).

The urban transition scenario developed by Bocquier (2005) reflects that urbanization starts at different points in time, evolves at different paces and finishes at different levels of urbanization as shown in Figure 3. It therefore becomes relevant to model urban growth using a model that takes into account the initial stage of the individual country and actual stage of urban transition while checking on its actual position in the world.

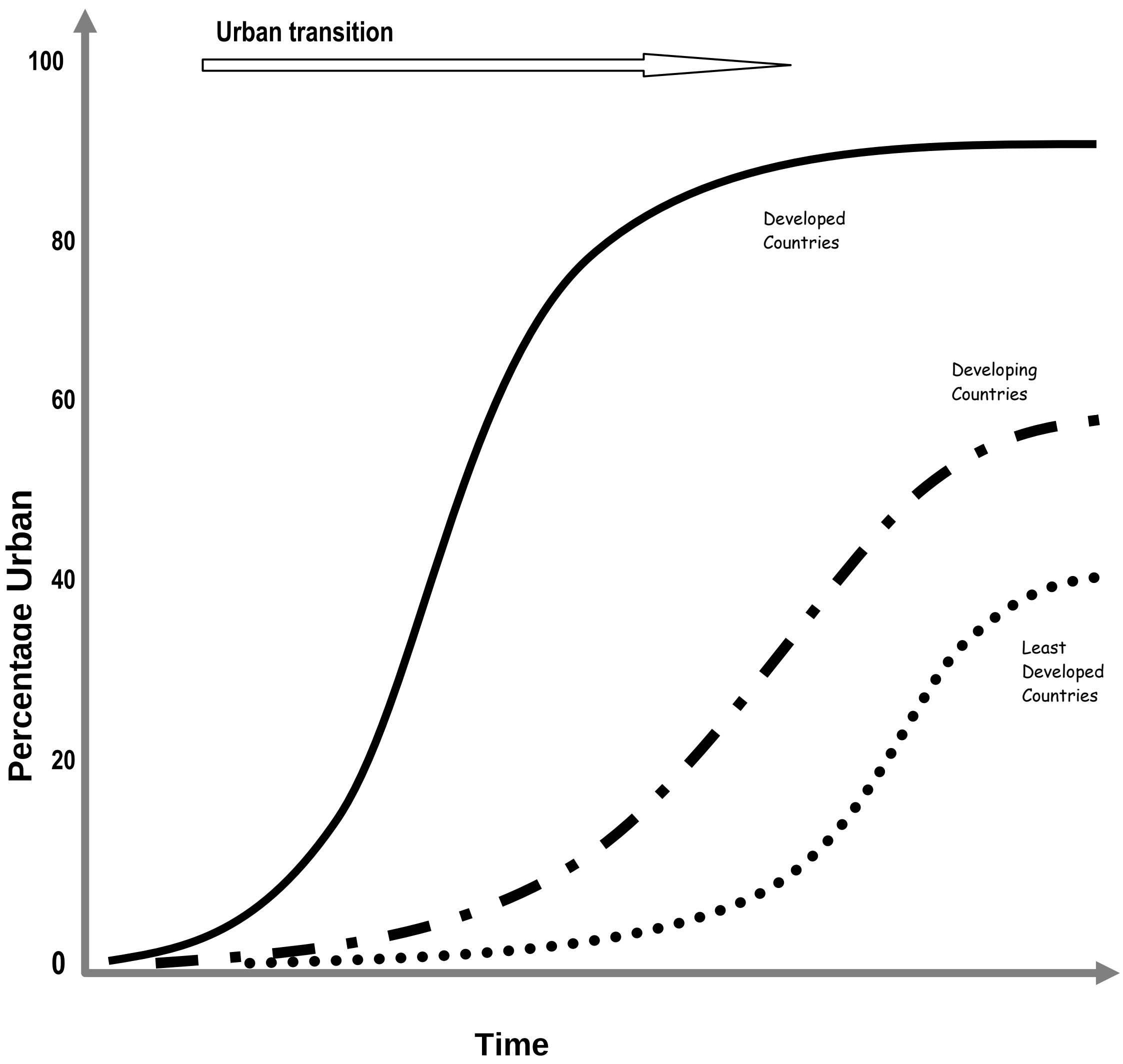

Figure 3: Proposed Stages of Urbanization adapted from Bocquier (2005)

A polynomial model is assumed to approximate closely the urban transition as measured by the relation between URGD and the proportion urban (PU). The model is based on Bocquier (2005)'s methodology, considering a set of URGD-PU country trajectories. In the present work, urban population refers to population in town and city areas as defined by the national statistics agencies of various the countries at stake.

The measurement of urban growth depends on the country's definition of urbanization. The definition of urban has changed over time for some countries introducing some unexpected irregularities in series. Unfortunately this research cannot account for these changes in definition as it would involve tracking changes in definition in more than 200 countries or territories of the UN database (World Urbanization Prospect 2007). The investigation into change of definition will be difficult because the way the UN report on change of definitions does not reflect the way countries are reporting on this changes, which by itself differs from the practice (Bocquier, 2003).

Therefore, the model used in this research project on urbanization is based on country data provided by the UN and does not attempt to account for eventual changes in urban definition.

The UN model adjusts Urban-Rural Growth Difference to predict urbanization level. URGD is the difference between Urban Growth and Rural Growth, denoted as:

$$rur(t+1) = u(t+1) - r(t+1) = \frac{U(t+1) - U(t)}{U(t)} - \frac{R(t+1) - R(t)}{R(t)} \qquad (1.1)$$

Where: $u(t+1)$ is the urban growth rate in the period $(t, t+1)$

$r(t+1)$ is the rural growth in the same period

$U(t)$ and $R(t)$ are respectively urban and rural population at the time t

The general form that considers n-year time period in the equation (1.1) will be dealt with in the literature review. The transformed urban-rural growth difference equation suggested by Bocquier (2005), expressing the excess population in urban area of country i at the time t is given by:

$$xu_i(t+n) = rur_i(t+n) * \left(\frac{U(t) * R(t)}{U(t) + R(t)} \right) \quad (1.2)$$

The dependent variable is $y = xu_i(t+n)$. The model estimates $\hat{y}$ which will be used to calculate the predicted $rur(t+n)$. In the present research $xu_i(t+n)$ will be modeled by a third order polynomial equation written as:

$$\hat{y} = f(PU_i(t)) = \beta_{i,0} + \beta_{i,1} * PU_i(t) + \beta_{i,2} * PU_i^2(t) + \beta_{i,3} * PU_i^3(t) \quad (1.3)$$

where $\hat{y}$ is a function of percentage of population of country i in urban areas at the time t denoted by $PU_i(t)$. This model allows each country, denoted by i, to reflect its own pattern of urban transition, leading to a particular level of urban saturation.

1.3. RESEARCH OBJECTIVE

Urban transition in developing countries is an on-going process and it becomes imperative that the quality of the available data is improved and the uncertainty of existing forecasts must be clarified (Cohen, 2004). United Nations Population Division estimates and projects urban population for five-year time periods from 1950 to 2050. Early projections tended to foresee a rapid growth and population explosion in poor countries leading to a prospect for much restriction on rural-to-urban migration (direct interventions against internal migration) (Brockerhoff, 1999 and Bocquier, 2005). The availability of data from recent censuses gives us an opportunity to verify whether predictive models of urban growth are reasonably accurate over past periods. In the present research, we will test a variation of the model proposed by Bocquier (2005) to project urban trends. The performance of the two models will be evaluated for the 1990-2005 period.

1.4. RATIONALE OF THE STUDY

Preston et al. (2001) present population projection as the most requested demographic technique by demography's "clients". Projection is a tool that allows governments to elaborate policies in anticipation of potential demand of services, government revenue and expenditure. Service delivery in a country can be planned ahead when population parameters such as size, composition, and growth are anticipated in their trends over time. It becomes paramount to measure population dynamism over time and forecast future developments. Many governments in low income countries developed national strategies and economic conditions that stimulated manufacturing rather than agricultural productivity. Governments in developing countries have a responsibility to manage diversity and inequalities in keeping up with population growth. An assessment of the recent patterns in urban growth trends will improve the basis for urban population projections, and thereby assist development planning in terms of services needed in urban and rural areas. The research will analyze a projection model that can measure urban and rural growth in both developed and developing countries

1.5. MAIN HYPOTHESIS

A non-linear relationship exists between urban-rural growth difference and the percentage of population in urban areas. Bocquier (2005) drew historical trends of urban growth from 1950 and showed that the general linear model used by the United Nations in 1980 was not based on observed historical trend.

There is a need to model URGD-PU relation by fitting a curve that can pass between points and take its shape close to the dispersion of points. The flexibility of higher order polynomials can be used to capture the curvilinear nature of the URGD-PU relation. The model should take into account country-specific trends as urbanization is universal but varies in its process from country to country.

This research paper will extend on the model used by Bocquier (2005) while using more recent data and evaluate the strength of the two models against recent trends. The assumption made is that the data on urban and total population of each country provided by Population Division of the Department of Economic and Social Affairs of the United Nations World Urbanization Prospects (2007 edition) reflect the actual situation of each country for t such that $t \leq 2005$.

CHAPTER 2

LITERATURE REVIEW

2.1. UNITED NATIONS URBAN PROJECTION MODEL

The United Nations Population Division provides the most comprehensive and widely used projections of urban growth at national level. UN generates data on urbanization by interpolation (starting from 1st July 1950 to the end estimation period, 1st July 2005) and extrapolation (from 2005 to 2050) based on linear projection, using available census data. The inter-census Urban-Rural Growth Difference, denoted rur at time $t+1$ in UN documents is calculated by:

$$rur\;t+1 = u\;t+1 - r\;t+1 \qquad (2.1)$$

Where u_{t+1} and r_{t+1} are respectively urban and rural growth rate in the interval of time $t, t+1$ and are derived respectively from urban and rural population at the time between time t and time $t+1$; The following measures are used for the analysis:

- Total Population at t

$$N\;t$$

- Population urban at t

$$U\;t$$

- Population rural at t can be derived as follow:

$$R(t) = N(t) - U(t)$$

- Percentage urban at t is:

$$PU(t) = \frac{U(t)}{P(t)} \times 100$$

- Urban growth between t and $t+1$ is determined by:

$$u(t+1) = \frac{U(t+1) - U(t)}{U(t)} \tag{2.2a}$$

- Similarly, rural growth between the t and $t+1$ is:

$$r(t+1) = \frac{R(t+1) - R(t)}{R(t)}, \tag{2.2b}$$

- Urban-Rural Growth Difference between t and $t+1$.

$$URGD(t+1) = u(t+1) - r(t+1)$$

- Rate of urbanization between t and $t+1$.

$$RU(t+1) = \frac{PU(t+1) - PU(t)}{PU(t)}.$$

The formula (2.1) is written in general form using (2.2a) and (2.2b) for any interval of time between two censuses occurring at time t and time $t+n$ in general with $n \geq 10$ as:

$$rur(t+n) = \frac{\ln\left(\frac{U(t+n) - U(t)}{U(t)}\right)}{n} - \frac{\ln\left(\frac{R(t+n) - R(t)}{R(t)}\right)}{n} \tag{2.3}$$

At any given time T such that $t < T < t+n$, the proportion urban PU is determined by the equation:

$$PU(T) = \frac{URR(T)}{1+URR(T)} \tag{2.4}$$

where

$$URR(T) = URR(t) \times e^{\left[rur(t+n) \times (T-t)\right]}$$

and

$$URR(t) = \frac{U(t)}{R(t)}$$, expressing the Urban Rural Ratio at the time t.

For $t+n<T$, the same principle is applied to extrapolate the proportion urban.

When the total population and the urban population are known at t and $t+n$, the UN projection model can be implemented by deriving the rest of quantities needed in the model. The UN projection model belongs to the class of endogenous autoregressive projection models (Bocquier, 2005). The UN model for urban projections is a weighted average of the rur estimated as per equation (2.3) and of the hypothetical URGD noted $hrur$ for the projection period, computed from a regression model of rur on countries of 2 million inhabitants and more, for the extrapolation period starting for example in 1995 :

$$\begin{aligned} rur^{*}_{i}(t+5) &= W_1(t) * rur_i(t) + W_2(t) * hrur \\ &= W_1(t) * rur_i(t) + W_2(t) * \left(0.037623 - 0.02604 * PU_i(t)\right) \end{aligned} \tag{2.5}$$

where

$$\begin{aligned} &W_1(t)=0.8 \quad W_2(t)=0.2 \quad when\ t=1995 \\ &W_1(t)=0.6 \quad W_2(t)=0.4 \quad when\ t=2000 \\ &W_1(t)=0.4 \quad W_2(t)=0.6 \quad when\ t=2005 \\ &W_1(t)=0.2 \quad W_2(t)=0.8 \quad when\ t=2010 \\ &W_1(t)=0 \quad\ \ \ W_2(t)=1 \quad\ \ \ when\ t\geq 2015 \end{aligned}$$

The same formula is used for extrapolation $rur^{*}\ T$ at time T outside of the period between censuses ($t+n<T$). The rur is determined from the urban and rural populations of the closest period between censuses $t, t+n$ available (United Nations, 2002).

National Research Council (2000), Cohen (2004) and Bocquier (2005) are among those who have criticized UN projection model because of its implicit assumption that all countries will follow the historical path processes of urbanization experienced by developed countries.

2.2. URBAN GROWTH IN DEVELOPING COUNTRIES

Cohen (2004) assessed the quality of the available data, and the uncertainty of UN urban projection. Though he considered the data provided by the UN World Urbanization Prospects as invaluable and comprehensive resource on urban population change, his paper found that there was no accuracy in past urban projections. The paper criticizes the UN assumption that urbanization in developing countries will continue more or less unchecked and that large agglomerations will continue to grow to extraordinary height into the future as source of projection errors. The paper considers the geographic position of cities to project urban growth in developing countries. Cohen (2004) distinguished trends in large cities, intermediate and smaller cities. He suggested that large cities will play a significant role in absorbing anticipated future growth but the majority of residents will still reside in much smaller urban settlements. Contrary to the popular view, he suggested that by 2015, the proportion of world's population living in large cities will approximate only 21%. Therefore 79% of the population will not be living in large cities (having a population of one million or more) and only 4.1% of the world's population is expected to be living in "mega-cities" (by convention, cities having 10 million or more inhabitants).

2.3. ALTERNATIVE TO THE UN MODEL OF PROJECTION

Bocquier (2005) suggested the following polynomial of second degree to better portrait the inverted-U shape historically observed up to 1995 in most developed countries in contrast with the general linear model suggested by the UN model:

$$xu_i(t+n) = f(PU_i(t)) = \beta_{i,0} + \beta_{i,1} * PU_i(t) + \beta_{i,2} * PU_i^2(t) \qquad (2.6)$$

With:

i : Region or country i

t : the year (time) of reference

$PU_i(t)$: Percentage of population that is urban (Percentage Urban)

n : n-year increment for step by step projection

$\beta_{i,0}, \beta_{i,1} and \beta_{i,2}$: Parameters computed for i, based on historical trends

The equation (2.6) models the excess in urban areas in the country i at the time t given the relation (1.2). It is understood that $rur_i(t+n)$ depends only on urban-rural growth differential while $xu_{i,t+n}$ depends not only on this differential but also on the total population growth of the country i expressing the ability to control for the population growth (Bocquier, 2005).

The model takes into account two factors: the speed of urban transition and possible urban saturation. The model enables us to tell when urban area will be saturated. Bocquier (2005) suggested that the population becomes totally urban when xu approximates $\beta_0 + \beta_1 + \beta_2$ ($xu \Rightarrow \beta_0 + \beta_1 + \beta_2$).

2.4. FORECASTING CITY GROWTH IN DEVELOPING COUNTRIES

Montgomery (2009) forecasted city population growth using the same time-series data provided by UN World Urbanization Prospects. He suggested that the equation modeling the basic city growth rate $g_i(t)$ is given by:

$$g_i(t) = \alpha + \beta TFR(t) + \delta q(t) + D_i'(t)\gamma + v_i(t)$$

with:

i denoting the i^{th} city and t a point in time.

$TFR(t)$ and $q(t)$ total fertility rate and infant mortality rate at the time t

$D_i'(t)$ includes a set of dummy variables indicating the start-of-period and the end-of-period units in which the city's population is recorded.

$v_i(t)$ the regression disturbance term

The model uses ordinary least squares (OLS) to estimate the influence of ecozones (Water, Low Elevation Costal Zone and Dryland) on the city growth.

CHAPTER 3

METHODOLOGY AND DATA ANALYSIS

3.1. URBAN POPULATION DATA

United Nations, Population Division provides urbanization data in its 2007 revision of the World Urbanization Prospects. The file presents UN estimates and projections of the total population in thousands and proportion urban in percentage. The data covers information on 229 countries or territories, the world as a whole, the more developed, the less developed and least developed regions grouped separately. UN estimates from major areas and regions of the world in the dataset cover annual values from 1950 to 2005. The UN projection period is from 2010 to 2050. The African continent comprises five major regions namely the Eastern, Middle, North, Southern and Western Africa. More developed regions comprise all regions of Europe, North America, Australia, New Zealand and Japan. Less developed regions include all African regions, Asia (excluding Japan), Latin America and the Caribbean, as well as Melanesia, Micronesia and Polynesia. The list of least developed countries comprises 50 countries, of which 34 are from Africa, 10 from Asia, 1 from Latin America and Caribbean and 5 from Oceania. Sub-Saharan Africa includes all countries in the Eastern Africa, Middle Africa, Southern Africa, Western Africa and Sudan. In the present report, classification of countries by major area and region will be kept the same as in the World Urbanization Prospects.

3.2. RESEARCH METHODOLOGY

Population data as provided for the study by UN World Population were in panel data format. UN urban and rural population data are processed using country results that are derived from census, country estimate, register of population, sample survey or UN estimate. Ideally, we would prefer to model these original data as provided by each country. However, the availability of empirical data is a problem for most countries. We are therefore relying on UN estimate to compensate for the shortage of empirical data mostly in developing countries. The UN is then interpolating urbanization at fixed dates starting from 1950 with 5-year increment up to 2005. This report will focus on two variables; namely country population and urban population, for any individual country. The two variables are repeated measures across countries and time, forming a cross-sectional 5-year interval time-series that can be analysed as panel data. The analysis is done here using Stata software.

3.2.1. Model

Polynomial regression will be used to fit the excess urban population (the transformed Urban-Rural Growth Difference) as suggested by Bocquier (2005). The curvilinear shape is more appropriate to fit the transform of URGD against PU than the general linear regression.

The regression will be based on the following polynomial equation relative to the observed data:

$$y = \beta_0 + \beta_1 x + \beta_2 x^2 + \beta_3 x^3 + ... + \beta_k x^k + \varepsilon \tag{3.1}$$

Where:

y is the observed value (URGD) for the model,

x is the proportion urban

$\beta_1, \beta_2, \beta_3, ..., \beta_k$ coefficients for jth power of the predictor ($j = 1, 2...k$)

β_0 is the intercept of Y, a constant which can be equaled to zero

ε is the error term

The polynomial regression will determine the values of parameters $\beta_0, \beta_1, \beta_2, \beta_3, ..., \beta_k$, which give us curves that best fit the data for respective countries. Contrary to linear regression, polynomial regression uses more parameters for a more flexible curve (Motulsky *et al.*, 1987). The values of parameters will be determined by values that minimize the sum of the squares of perpendicular distances between data points and fitted curve.

The mathematical rationale of the model is similar to a general linear regression model with k predictors to the power j and j varies from 1 to k based on the kth order of the polynomial equation for country i:

$$y_i = \beta_{i,0} + \sum_{j=1}^{k} \beta_{i,j} x^j + \varepsilon_i \tag{3.2a}$$

For $k = 2$, the polynomial equation is said to be of second order and the quadratic expression forms a parabolic curve. For $k = 3$, the polynomial equation is said to be of third order forming a cubic expression. Bocquier (2005) projected urban growth using the polynomial of second order. In this report, the scope of the research will be limited to a polynomial equation of third order, which is an extension of Bocquier (2005). The intercept β_0, will be equaled to zero to reflect that urban growth start from 0% urban population for all countries.

If $\beta_0 = 0$, therefore the equation (3.2a) for country i becomes:

$$y_i = \sum_{j=1}^{k} \beta_{i,j} x^j + \varepsilon_i \qquad (3.2a)$$

Replacing x by $PU(t)$, t being an index of time (year – time series), in the present research, we will model urban growth using a polynomial as suggested by Bocquier (2005) but extending to the polynomial of third degree for country i:

$$f\left(PU_i(t)\right) = \beta_{i,1} * PU_i(t) + \beta_{i,2} * PU_i^2(t) + \beta_{i,3} * PU_i^3(t) + \varepsilon_i \qquad (3.3b)$$

For the present report, i is the index for the country and t is the index for the year (time series) which can also be written as superscript or subscript.

The model will estimate the coefficient $\beta_{i,j}$ in fitting the data derived from the equality between the equation (3.3b) and the equation (1.2) representing the excess urban population at the time t for the country i. Therefore, the following relation can be established:

$$xu_i(t+n) = rur_i(t+n) * \left(\frac{U(t) * R(t)}{U(t) + R(t)} \right) = f\left(PU_i(t)\right) \qquad (3.3c)$$

The model takes into account the divergence in the individual behaviour of each region or country, i.e. the speed of urban transition and possible urban saturation as suggested by Bocquier (2005).

The research will exploit the random effect model. In its standard form, this model has a random constant intercept β_0 that is specific to each unit (country). However, we will set the intercept to zero to take into account the specificity of urbanization as urban growth in any country starts from zero urban population. In other words, the random effect model is constrained such that all countries intercepts β_0 are set to zero. Other regression parameters are specific to each country. The regression model is used to model the trend, but no attempt is made to use the goodness of fit or standard errors to project the trend or to give confidence interval of the trend. As the data are not real panel data (observed) but interpolated data at fixed time interval, the goodness of fit and standard errors are not reliable. The model is implemented with the command ‘xtreg’ in Stata.

Urban-Rural Growth Difference variable follows an inverted-U shape when plotted against the proportion of the population who live in urban area (PU) over the urban transition period. However some countries do not follow this pattern. The historical inverted-U shape referred to also as bell shape will be affected by country specific (idiosyncratic) historical trend. For example, South Africa’s inconsistency in urban trend can find its explanation in the apartheid history where people had no free movement from rural to urban areas until 1986, at a time when the economy was declining due to international trade restrictions. China’s urban trend is another example of a country where people were forced to live in rural areas (Cultural Revolution in China). When the policy restricting people to live in rural areas is lifted up a rebound is generally observed in the urban trend.

When the trend does not approximate the expected inverted-U curve, the country will be dealt with in one of the following two ways:

- Discard the early part of the series that has abnormal trends and use the rest (truncated series): the model will only take into account the period where there is consistency (bell shape) in URGD trend.
- If all the series cannot be used (a rare the case associated with poor quality of the original data), the country will be discarded.

A table of countries indicating the period affected by corrections is provided in the appendix (Appendix I).

3.2.2. Evaluation of the projection

The evaluation of the projection model will be done using historical data to see how accurate it would have been if it was used on 1950-1995 data to forecast urban growth from 1995 to 2005. The validity of the model will be anticipated using the method proposed by Keyfitz (1981). The Percentage Error will be determined by:

$$PE = \frac{\hat{y} - y}{y} \times 100 \qquad (3.4a)$$

Where $\hat{y}$ and y are respectively the modeled and observed data for 2005.

A positive PE $PE > 0$ will be an indication of an overestimation in the projections and a negative $PE < 0$ will reflect an underestimation. The model's objective will be to have Mean Percentage Error MPE such as $1 - MPE \geq 1 - \alpha$, with α being the acceptable error.

The Mean Absolute Percentage Error (MAPE) will evaluate the accuracy of proportion urban forecasts and will determined by:

$$MAPE = \frac{1}{n}\sum_{i=1}^{n}\left|\frac{\hat{y}_i - y_i}{y_i}\right| \times 100 \qquad (3.4b)$$

Where the number of countries i in the Development Group or Region is represented by n. To evaluate the distribution of countries' projections distance to the observed values, will compute the number of countries' projected values falling into 1%, 5%, 10%, 15% and 20% percentage error interval below or above the observed values.

CHAPTER 4

RESULTS AND CONCLUSION

4.1. URBAN POPULATION ESTIMATES AND PROJECTIONS RESULTS

4.1.1. Estimates and Projections of countries by development group

The third order polynomial (3rd GLS) model predicts that 52.8% of the world urban population will be living in urban areas by 2050 while the UN predicts 67.9%. For the same year, the 3rd GLS model foresees that the less developed countries will have 48.8% of their population living in urban areas while the UN prediction is at 64.7%. The 3rd GLS model predicts 35.2% and 75.8% of population of the least developed countries and more developed countries respectively will live in urban areas by 2050. This highly contradicts UN predictions, which suggest that 55.5% of population in the least developed countries and 86.0% of the population in the more developed countries will be living in urban areas by 2050 (Table 1).

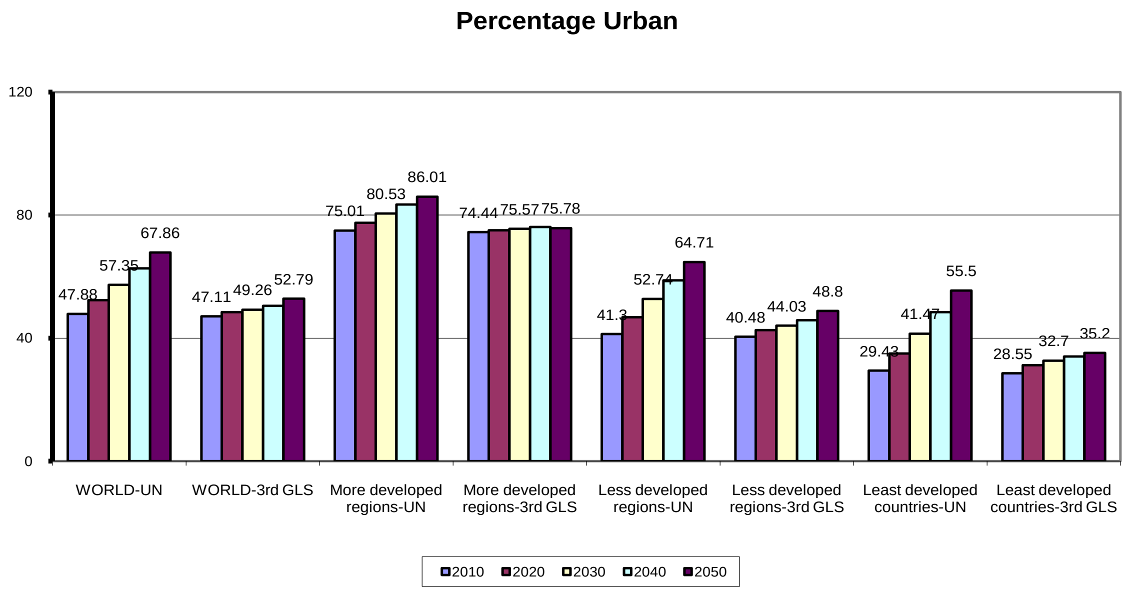

Figure 4a: Proportion Urban by Development Group: UN and 3rd GLS model

Generally, the UN predictions are higher compared to the 3rd GLS model throughout all development regions. The discrepancy increases with the projection interval: the longer the projection the higher the UN estimates are compared to 3rd GLS estimate for the same region. The discrepancy between the two models increases even more when considering the least developed regions (Table 1).

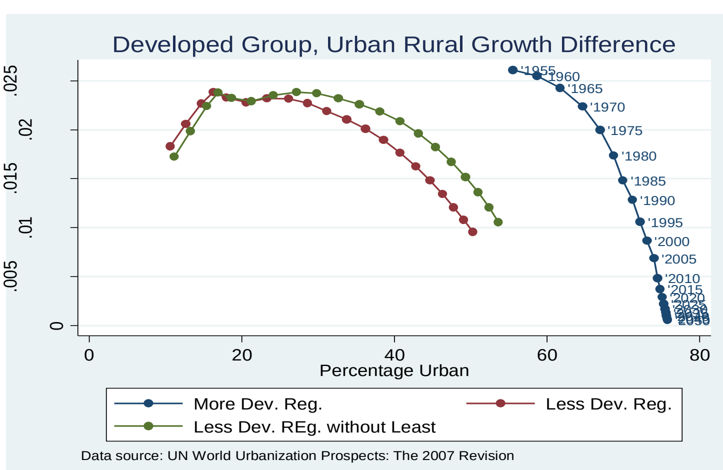

Figure 4: Approximate percentage urban projections using 3rd GLS Model

The group of more developed countries has kept the highest level of urbanization through time. The UN and the 3rd GLS model projections agree that the more developed region will have the highest percentage of population living in urban areas (Figure 4a).

Table 1: Projected Proportion Urban, by development Group: UN and 3rd GLS models

Development Group	Projected Proportion Urban (Percentage)									
	2010		2020		2030		2040		2050	
	UN	3rd GLS	UN	3rd GLS	UN	3rd GLS	UN	3rd GLS	UN	3rd GLS
WORLD	**47.88**	**47.11**	**52.32**	**48.4**	**57.35**	**49.26**	**62.64**	**50.54**	**67.86**	**52.79**
WORLD without China	48.69	48.1	52.09	49.12	56.64	50.09	61.71	51.58	66.85	54.2
More developed regions	75.01	74.44	77.53	75.05	80.53	75.57	83.45	76.09	86.01	75.78
Less developed regions	41.3	40.48	46.83	42.59	52.74	44.03	58.81	45.83	64.71	48.8
Less developed regions, excluding China	39.99	39.39	44.73	41.62	50.47	43.51	56.62	45.84	62.71	49.54
Less developed regions, excluding least developed countries	43.73	42.92	49.55	45.21	55.65	46.96	61.8	49.25	67.66	53.16
Least developed countries	29.43	28.55	34.98	31.16	41.47	32.7	48.44	33.98	55.5	35.2

The difference between UN and the 3rd GLS model projections of urban population for 2050 is 1.27 billion. The UN expects that 5.72 billion population will be living in urban areas by 2050 whilst we project that only 4.45 billion people will be living in urban areas.

Table 2: Projected Urban Population, by development Group: UN and 3rd GLS models

Development Group	Urban Population (in Billion)									
	2010		2020		2030		2040		2050	
	UN	3rd GLS	UN	3rd GLS	UN	3rd GLS	UN	3rd GLS	UN	3rd GLS
WORLD	**3.02**	**2.97**	**3.67**	**3.39**	**4.36**	**3.75**	**5.06**	**4.08**	**5.72**	**4.45**
WORLD, excluding China	2.42	2.39	2.91	2.74	3.48	3.08	4.09	3.42	4.69	3.8
More developed regions	0.92	0.92	0.97	0.94	1.02	0.95	1.05	0.96	1.07	0.94
Less developed regions	2.1	2.06	2.69	2.45	3.35	2.79	4.01	3.12	4.64	3.5
Less developed regions, excluding China	1.49	1.47	1.94	1.8	2.47	2.13	3.04	2.46	3.62	2.86
Less developed regions, excluding least developed countries	1.84	1.81	2.32	2.12	2.81	2.37	3.27	2.61	3.68	2.89
Least developed countries	0.25	0.25	0.38	0.34	0.54	0.43	0.74	0.52	0.97	0.61

The least developed countries pull down the overall less developed proportion urban from 51.7% proportion urban without the least developed countries, to 47.4% with the least developed countries for 2050 (Figure 4). The UN model estimates urban population in less developed countries at 64.7% in 2050. The discrepancy between the two models is huge for the less developed countries: 1.14 billion of difference. This represents 90% of the difference at the World level between the two models.

4.1.2. Correction made to some countries or territories with unusual trends

The 3rd GLS model suggests that Asia will have the lowest percentage of urban population (47.6%) followed by the African continent with 53.0% of its population living in urban areas in 2050. Instead, the UN predictions foresee the Asian continent will be at 66.2% urban and the African continent at 61.8% in 2050. The UN and the 3rd GLS projection models also differ on North America proportion of urban population. The UN foresees 90.13% of the population in North America living in urban areas as the highest proportion of urban population by 2050 while the 3rd GLS model projects the Latin America and the Caribbean as having the highest urban proportion for 2050, 86.9% (Table 3).

In the African Region, corrections using truncated series were made for 11 countries and no country was discarded out of 56 countries. All the corrections consisted of excluding part of the series where urban data (URGD plotted against proportion urban) were not approximating the inverted-U shape. Details on correction by country are given in Appendix 1, and the case of South Africa is used below for illustration.

In South Africa, it was noticed that urban proportions before 1975 were following abnormal trends. The predicted URGD almost came to a halt in the mid 1980s. The trends were not consistent with inverted-U shape (Figure 5).

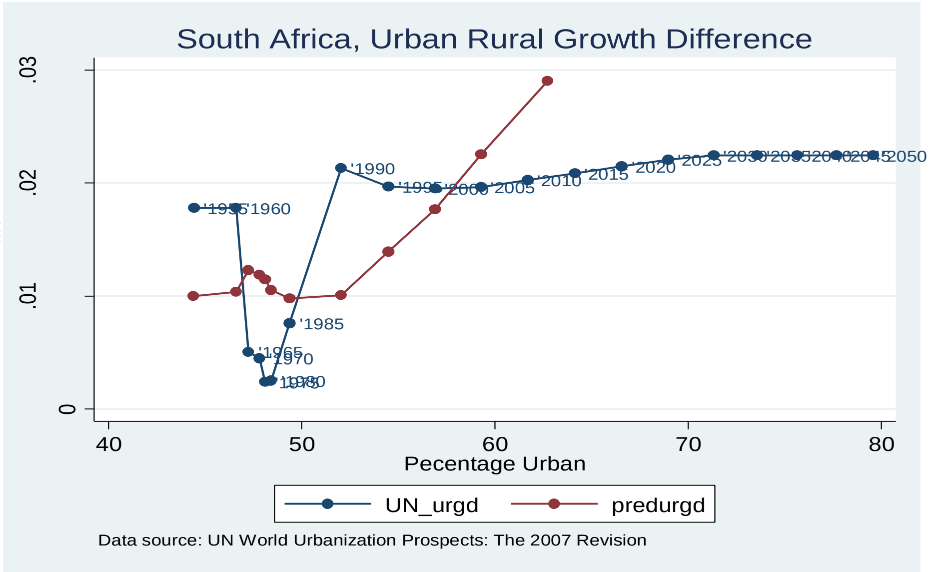

Figure 5: South African, Urban-Rural Growth Difference before correction

After removing the period before 1975, the shape of projected URGD plotted against the percentage urban seemed more consistent with the historical inverted-U shape. The end of urban transition coincides with the URGD approaching zero (Figure 6). In 2050, the percentage urban does not change sensibly, and it is around 62% for South Africa. By contrast, the UN model predicts for South Africa 79.6% of population living in urban areas by 2050, and still growing. The difference of estimates between UN and 3rd GLS model is huge.

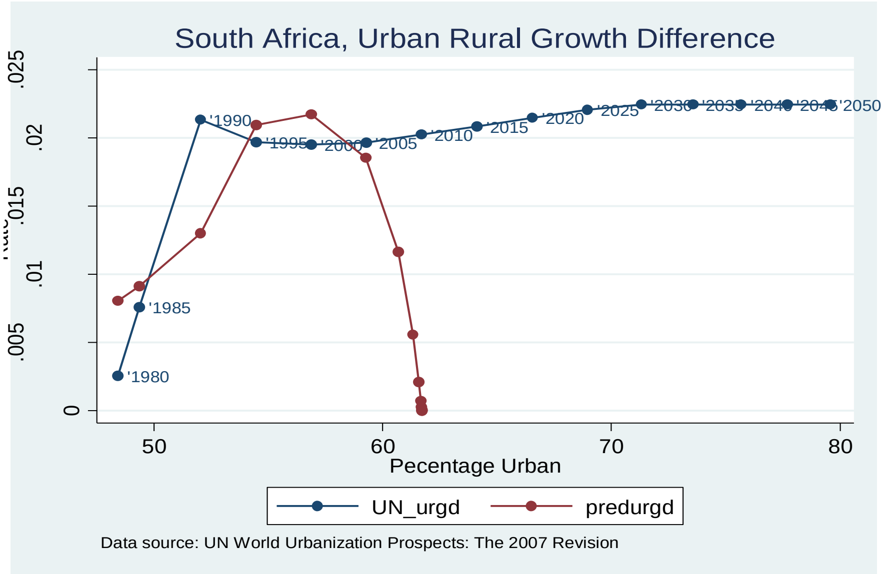

Figure 6: South Africa, Urban-Rural Growth Difference after correction

The reason for excluding some countries from urban projections can be explained by the case of Holy See urban population. For the period 1950 to 2005, its urban population data provided by the UN was inconsistent with the theory of urban growth. The disparity in URGD calculated from the UN data did not allow corrections. Even when using the recent data, URGD calculated from UN data were varying abnormally when referred to the historical urban transition theory (Figure 7). It was difficult to select the period suitable for projection as the URGD were alternatively increasing and decreasing over time in an abnormal way.

In the research, only 6 country's series were discarded for projection. For 32 countries, part of the series (consecutive recent years) the inverted-U shape was used to predict the URGD with the corresponding percentage urban. The cases of series discarded were minimal and could not affect the overall result of the research. The details on truncated series and on the discarded countries are provided in the Appendix 1.

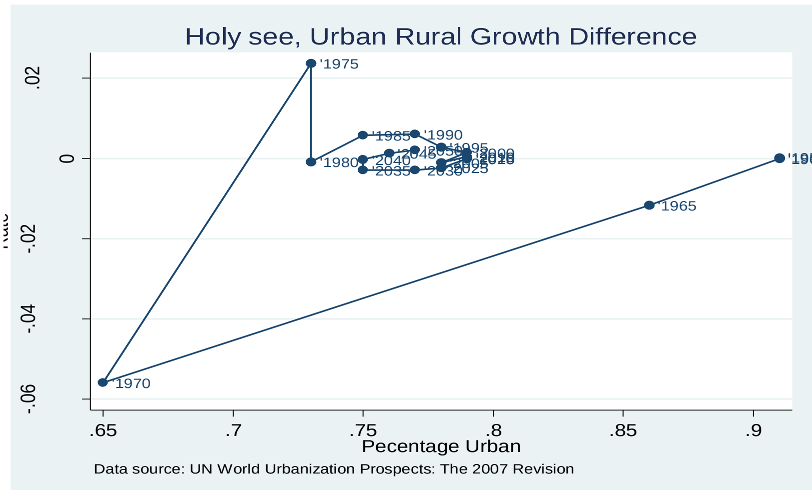

Figure 7: Holy See, Urban-Rural Growth Difference calculated using UN projection

4.1.3. <u>Estimates and Projections of countries by continent</u>

The detailed projected urban proportion per countries can be found in appendices 2 to 5.

<u>AFRICA</u>

Despite relatively poor data, only 11 countries or territories out of 56 had to be corrected for unusual trends. The Table 3 gives the UN and the 3rd GLS model projected percentage of the population in Africa by region that will be living in urban areas from 2010 to 2050. According to the 3rd GLS model and the UN model, Eastern Africa will have the least percentage of its population living in urban areas (34.0% and 47.6% respectively), followed by Central Africa (42.3% and 67.4% respectively) by 2050.

The UN model suggests that Southern Africa will have the highest percentage (77.6%) of its population living in urban areas while our model suggests that the Western Africa will have the highest percentage (75.8%).

South Africa's size of the population has a high weight on the overall majority of the population projected to be living in urban areas of the Southern Africa region by 2050. Lesotho and Namibia have low proportion of the population living in urban area (28.3% and 41.3% respectively as per 3rd GLS model) and do not have much influence on the overall Southern Africa region as they have a small population.

Table 3: Projected Percentage Urban for Major Regions: UN and GLS Models

Major Areas	2010		2020		2030		2040		2050	
	UN	3rd GLS	UN	3rd GLS	UN	3rd GLS	UN	3rd GLS	UN	3rd GLS
AFRICA	**39.94**	**39.36**	**44.57**	**42.13**	**50.02**	**44.98**	**55.87**	**48.37**	**61.76**	**53.02**
Sub-Saharan Africa	**37.32**	**36.69**	**42.38**	**40.00**	**48.18**	**43.44**	**54.30**	**47.47**	**60.47**	**52.81**
Eastern Africa	23.72	23.08	27.93	24.95	33.73	26.88	40.44	29.49	47.64	34.02
Middle Africa	42.93	40.65	49.16	41.62	55.30	42.03	61.44	42.23	67.41	42.33
Northern Africa	52.02	51.88	56.22	54.68	61.32	56.85	66.81	58.48	71.97	59.67
Southern Africa	58.78	57.69	63.78	58.63	68.76	58.73	73.40	58.71	77.61	58.67
Western Africa	44.62	44.62	50.51	50.79	56.52	57.68	62.39	65.78	67.95	75.82
ASIA	**42.47**	**41.60**	**48.12**	**43.41**	**54.13**	**44.34**	**60.27**	**45.47**	**66.21**	**47.63**
ASIA without China	**41.30**	**40.69**	**45.84**	**42.45**	**51.53**	**43.74**	**57.67**	**45.35**	**63.75**	**48.30**
Eastern Asia	48.46	47.10	55.87	48.76	62.40	48.82	68.52	48.74	74.10	48.65
Eastern Asia without China	71.04	70.19	73.81	70.44	77.14	70.60	80.40	70.69	83.27	70.71
South-Central Asia	32.18	31.59	36.68	33.26	43.02	34.85	50.09	37.19	57.20	41.49
South-Eastern Asia	48.23	47.59	55.54	51.65	61.84	53.36	67.78	53.94	73.25	54.37
Western Asia	66.28	65.92	69.10	67.11	72.51	68.23	76.00	69.55	79.26	71.24
EUROPE	**72.57**	**72.17**	**74.73**	**72.72**	**77.82**	**73.18**	**80.98**	**73.72**	**83.79**	**72.74**
Eastern Europe	68.43	68.61	70.00	68.87	73.13	68.94	76.69	68.99	79.94	69.03
Northern Europe	84.44	83.63	85.87	83.71	87.58	83.84	89.23	83.96	90.69	84.09
Southern Europe	67.40	66.56	70.39	67.01	74.19	67.27	77.84	67.44	81.12	67.55
Western Europe	76.95	76.24	79.12	77.01	81.70	77.78	84.23	78.90	86.46	74.61
LATIN AMERICA AND THE CARIBBEAN	**79.33**	**79.17**	**82.27**	**82.06**	**84.61**	**83.57**	**86.76**	**84.69**	**88.70**	**85.56**
Caribbean	66.61	67.07	71.28	77.82	75.27	78.25	78.91	78.70	82.24	79.19
Central America	71.68	71.23	74.66	72.69	77.70	73.70	80.64	74.44	83.33	74.98
South America	83.64	83.53	86.37	86.15	88.27	87.98	89.95	89.32	91.43	90.33
NORTHERN AMERICA	**82.11**	**81.23**	**84.57**	**81.33**	**86.65**	**81.38**	**88.50**	**81.41**	**90.13**	**81.44**
OCEANIA	**68.93**	**68.22**	**70.87**	**68.95**	**72.18**	**68.38**	**73.86**	**67.85**	**75.97**	**67.49**
Australia/New Zealand	88.72	88.10	90.22	88.50	91.47	88.84	92.58	89.11	93.55	89.35
Melanesia	18.89	18.79	20.69	19.22	24.71	19.18	29.83	18.98	35.81	18.71
Micronesia	51.80	38.39	54.67	39.38	58.10	40.24	61.63	40.27	64.96	40.00
Polynesia	21.08	20.92	40.76	37.70	46.02	38.00	51.03	38.4	55.86	38.74

ASIA

The UN and the 3rd GLS models foresee that the Western Asia will have the highest percentage of its population living in urban areas (79.3 % and 71.2% respectively) by 2050. The Eastern Asia without China, changes completely its projected urban proportion pattern from 74.1% to 83.3% using UN model and from 48.7% to 70.7% using 3rd GLS model. Only 6 out of 50 countries were corrected by using truncated series (Appendix 1).

EUROPE

The UN model predicts that more than three quarters of European continent population (77.8%) will be living in urban areas by 2030 and 83.8% by 2050. The 3rd GLS model predicts that 72.7% of the European population will live in urban areas by 2050. The UN model and the 3rd GLS model predict that Eastern Europe will have the lowest percentage of population living in urban areas throughout the entire projection period (Table 3).

Andorra and Holy See urban population data were not included in the research model projection because of the abnormal URGD variations. Data from Albania and Portugal were corrected by removing part of the series, which was not consistent with the pattern of urban transition. It was noticed that the two countries out of forty-six whose series were discarded for the projection were very small territories (Appendix 1).

LATIN AMERICA AND THE CARIBBEAN

British Virgin Islands and Montserrat territory were discarded for projection and eight others were corrected out of forty-two countries to allow projection using truncated series in accordance with the historical U-shape of URGD plotted against percentage urban (see appendix 1). South America is the region of the World with the highest projected percentage urban (90.3% in 2050) according to the 3rd GLS model.

NORTHERN AMERICA

The Northern America had no series discarded but only the United States of America out of five countries had to be corrected for consistency in URGD projections.

OCEANIA

Australia and New Zealand, which form the other developed region, follow the same pattern as Europe regarding differences between UN and 3rd GLS predictions (Table 3). The other less developed regions resemble Latin America and the Caribbean when comparing magnitude of difference between UN and 3rd GLS projections. These differences are also similar to African and Asian regions. Marshall Islands and Niue out of nineteen countries and territories were deleted from projection because the trend of urban population data which did not follow the theory of urban transition.

The general observation is that islands and small territories are usually difficult to adjust. A minimum size of population seems necessary to come up with reasonable trends, which can allow to the 3rd order polynomial to predict trends on long periods.

4.2. MODEL EVALUATION

The result of 3rd GLS model projection on urban proportion can be evaluated by comparison with another projection model, the 2nd order polynomial general least squares (2nd GLS), which can be used to project urban growth on the same data as was done by Bocquier (2005).

4.2.1. Evaluation by comparing the 3rd order polynomial and the 2nd order polynomial models

The 3rd GLS model is the model used for the research as explained in chapter three (methodology). The 2nd GLS is a second order polynomial using generalized least squares and random effect. The model refers to the paper published by Bocquier (see methodology section). The UN model refers to calculations derived directly from data provided by UN Population Division of the Department of Economic and Social affairs. The table below (Table 4) gives projections for 2010, 2030 and 2050 by UN, 3rd GLS and 2nd GLS.

Table 4: 2050 Projected urban Proportion (in percentage)

Development Group or Major Area	Percentage Urban								
	2010			2030			2050		
	UN	3rd GLS	2nd GLS	UN	3rd GLS	2nd GLS	UN	3rd GLS	2nd GLS
WORLD	**47.88**	**47.11**	**47.37**	**57.35**	**49.26**	**51.26**	**67.86**	**52.79**	**53.98**
WORLD without China	48.69	48.10	48.27	56.64	50.09	51.46	66.85	54.20	54.50
More developed regions	75.01	74.44	74.52	80.53	75.57	75.76	86.01	75.78	76.01
Less developed regions	41.30	40.48	40.78	52.74	44.03	46.39	64.71	48.80	50.15
Less developed regions, excluding China	39.99	39.39	39.60	50.47	43.51	45.18	62.71	49.54	49.85
Less developed regions, excluding least developed countries	43.73	42.92	43.24	55.65	46.96	49.46	67.66	53.16	53.88
Least developed countries	29.43	28.55	28.74	41.47	32.70	34.50	55.50	35.20	38.53
AFRICA	**39.94**	**39.36**	**39.50**	**50.02**	**44.98**	**45.54**	**61.76**	**53.02**	**51.27**
Sub-Saharan Africa	37.32	36.69	36.84	48.18	43.44	43.95	60.47	52.81	50.65
Eastern Africa	23.72	23.08	23.41	33.73	26.88	28.14	47.64	34.02	33.65
Middle Africa	42.93	40.65	40.89	55.30	42.03	43.41	67.41	42.33	44.63
Northern Africa	52.02	51.88	52.10	61.32	56.85	60.43	71.97	59.67	66.24
Southern Africa	58.78	57.69	57.83	68.76	58.73	59.67	77.61	58.67	59.86
Western Africa	44.62	44.62	44.47	56.52	57.68	55.28	67.95	75.82	65.99
ASIA	**42.47**	**41.60**	**41.93**	**54.13**	**44.34**	**47.20**	**66.21**	**47.63**	**50.13**
ASIA without China	41.30	40.69	40.91	51.53	43.74	45.84	63.75	48.30	49.68
Eastern Asia	48.46	47.10	47.61	62.40	48.82	53.01	74.10	48.65	53.69
Eastern Asia without China	71.04	70.19	70.48	77.14	70.60	71.34	83.27	70.71	71.51
South-Central Asia	32.18	31.59	31.61	43.02	34.85	34.90	57.20	41.49	38.23
South-Eastern Asia	48.23	47.59	48.35	61.84	53.36	62.69	73.25	54.37	70.98
Western Asia	66.28	65.92	66.24	72.51	68.23	69.59	79.26	71.24	73.09
EUROPE	**72.57**	**72.17**	**72.25**	**77.82**	**73.18**	**73.42**	**83.79**	**72.74**	**73.04**
Eastern Europe	68.43	68.61	68.68	73.13	68.94	69.25	79.94	69.03	69.39
Northern Europe	84.44	83.63	83.74	87.58	83.84	83.92	90.69	84.09	84.16
Southern Europe	67.40	66.56	66.66	74.19	67.27	67.76	81.12	67.55	68.30
Western Europe	76.95	76.24	76.28	81.70	77.78	77.78	86.46	74.61	74.65
LATIN AMERICA AND THE CARIBBEAN	**79.33**	**79.17**	**79.23**	**84.61**	**83.57**	**84.25**	**88.70**	**85.56**	**86.93**
Caribbean	66.61	67.07	66.64	75.27	78.25	78.52	82.24	79.19	79.48
Central America	71.68	71.23	71.36	77.7	73.70	74.47	83.33	74.98	76.46
South America	83.64	83.53	83.61	88.27	87.98	88.67	91.43	90.33	91.74
NORTHERN AMERICA	**82.11**	**81.23**	**81.29**	**86.65**	**81.38**	**81.49**	**90.13**	**81.44**	**81.54**
OCEANIA	**68.93**	**68.22**	**68.54**	**72.18**	**68.38**	**69.01**	**75.97**	**67.49**	**68.68**
Australia/New Zealand	88.72	88.10	88.08	91.47	88.84	88.73	93.55	89.35	89.17
Melanesia	18.89	18.79	19.15	24.71	19.18	20.53	35.81	18.71	21.98
Micronesia	51.80	38.39	51.51	58.10	40.24	55.21	64.96	40.00	57.44
Polynesia	21.08	20.92	21.18	46.02	38.00	41.38	55.86	38.74	42.50

By observing the results in table above (Table 4), the two GLS models yield projections that are closer to each other than they are to the projections of UN model. In general, the UN projections are higher than projections of the other two models (Appendix 2). The 2nd order polynomial model predictions are slightly higher than the 3rd order polynomial model but very low compared to the UN projections. The 3rd and 2nd GLS have the same pattern for almost all countries.

4.2.2. Selected Country's Urban-Rural Growth Difference

A closer look at some African countries will give a picture of the trend of URGD over time.

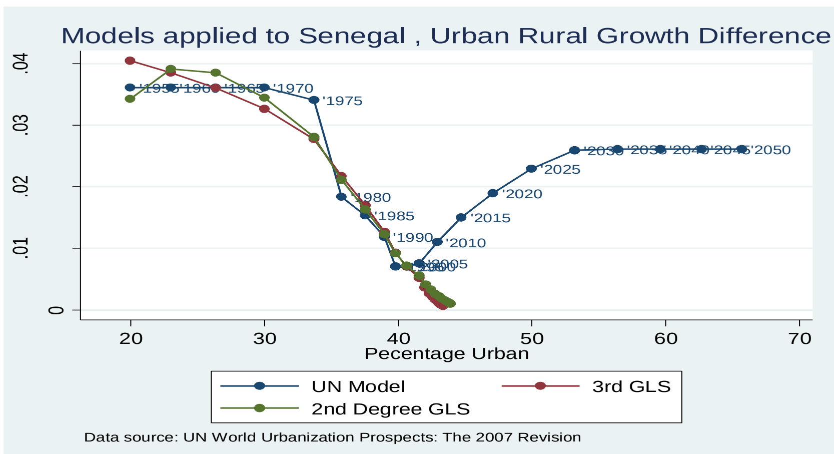

Figure 8: Senegal, Urban-Rural Growth Difference: Model estimates and projections

For Senegal, the two GLS models give approximately 43% proportion urban by 2050 while the UN estimate 65.7%. The patterns of URGD are similar for the two GLS models but differ with the UN in their projections (Figure 8). The UN predicts a growing Senegalese urban population by 2050 while the two GLS models predict a close to stationary urban growth.

Zimbabwe pattern of URGD is similar for the GLS models but also differs with the UN projections. The 2nd order polynomial model gives an urban growth which had a very small growth rate approaching zero but a lower urban proportion (47.5%) to the UN

(64.4%) by 2050. The 3rd order polynomial projects a stationary urban proportion in 2050 of 40.58%. The deviation comes around 2005 when 2nd order polynomial increased its predictions (Figure 9).

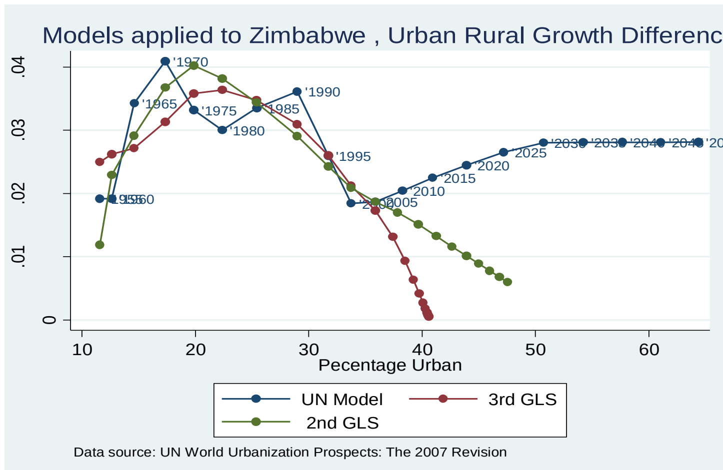

Figure 9: Zimbabwe, Urban-Rural Growth Difference: Model estimates and projections

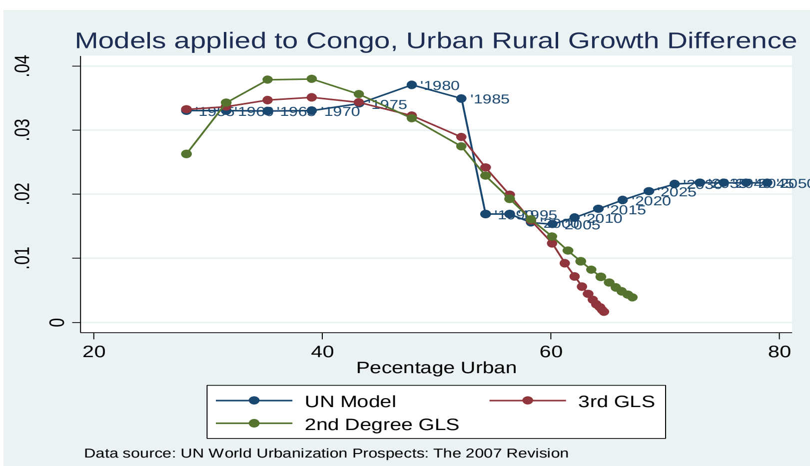

Figure 10: Congo, Urban-Rural Growth Difference: Model Estimates and projections

The Congo's URGD projections (Figure 10) can be assimilated to the Zimbabwe's pattern in terms of predictions by various models (figure 9). The two GLS models follow an identical trend completely different from the UN predictions.

The projections by the 3rd GLS and 2nd GLS models are identical when modelling South African URGD before 2005 (Figure 11). The two models project urban proportion at 61.7% and 62.4% respectively by 2050 while the UN predicts 79.6% of South African population living in urban areas.

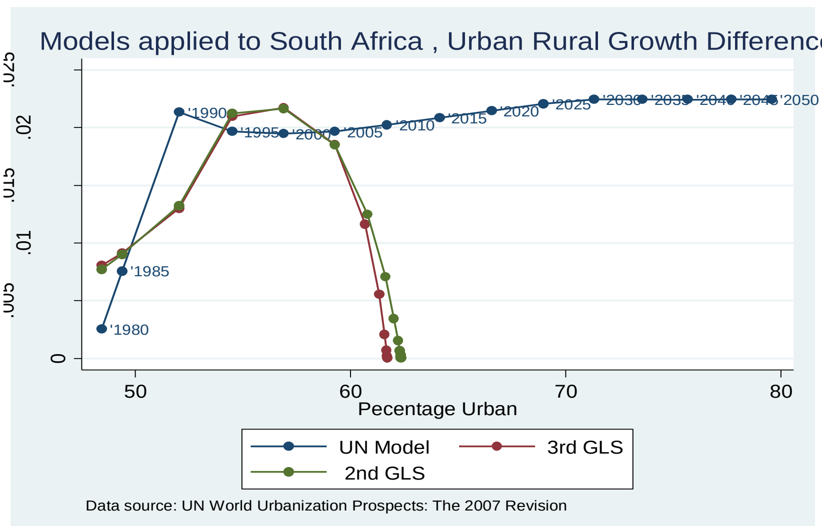

Figure 11: South Africa, Urban-Rural Growth Difference: Model Estimates and projections

These few examples illustrate how the UN projections are over estimating urban projections mostly in less developed countries. This inference is made on basis of projections using the same data as the UN.

4.2.3. <u>Evaluation of models using Percentage Error and Mean Percentage Error</u>

The table below (Table 5a) shows the difference between observed 2005 data (UN World Urbanization prospects, 2007) against projections for 2005 using 1950 to 1990 data (15 years projection). When calculating the percentage error, we assume that the urban proportion estimates in 2005 as provided by the UN World Urban Prospects are correct for each country.

Table 5a: Mean percentage Error per Development Group and Region

Location Name	2005 Baseline			
	Mean Percentage Error		Mean Absolute Percentage Error	
	3rd GLS	2nd GLS	3rd GLS	2nd GLS
WORLD	**-1.15**	**-0.12**	**7.72**	**5.76**
WORLD without China	-1.04	-0.03	7.64	5.70
More developed regions	-0.87	0.59	4.07	3.28
Less developed regions	-1.25	-0.37	9.03	6.63
Africa	**-3.66**	**-1.75**	**12.21**	**7.33**
Sub-Saharan Africa	-4.20	-2.34	13.31	7.62
Eastern Africa	-5.84	0.37	7.77	4.15
Middle Africa	-8.48	3.13	8.48	10.19
Northern Africa	3.86	4.60	6.48	6.49
Southern Africa	-7.58	-12.73	19.19	12.73
Western Africa	-1.40	-6.21	19.13	8.24
ASIA	**-0.57**	**-0.40**	**7.21**	**5.15**
ASIA without China	-0.10	-0.02	6.88	4.87
Eastern Asia	-3.61	-2.07	4.39	4.41
Eastern Asia without China	-0.50	0.58	1.41	2.15
South-Central Asia	-4.21	-1.56	9.18	7.15
South-Eastern Asia	3.75	-4.43	14.72	5.72
Western Asia	1.07	3.09	3.12	3.69
EUROPE	**-0.82**	**0.83**	**4.25**	**3.41**
Eastern Europe	1.63	2.40	3.38	3.61
Northern Europe	-0.52	-0.44	1.89	2.12
Southern Europe	-5.99	-1.60	6.78	3.12
Western Europe	2.97	4.28	4.97	5.35
LATIN AMERICA AND THE CARIBBEAN	**0.45**	**-0.02**	**4.99**	**5.89**
Caribbean	-0.34	0.26	6.40	7.42
Central America	3.58	4.16	6.27	5.94
South America	-0.15	-2.30	2.87	3.99
NORTHERN AMERICA	**-0.93**	**-0.34**	**4.11**	**3.32**
OCEANIA	**2.07**	**3.34**	**11.31**	**9.26**
Australia/New Zealand	-1.87	-1.83	1.87	1.83
Melanesia	4.00	3.83	8.84	6.97
Micronesia	7.33	-0.25	8.30	9.57
Polynesia	0.38	6.46	17.77	13.49

The mean percentage error (MPE) shows few differences between the 3rd GLS and 2nd GLS projections and UN estimates for 2005. The biggest differences are seen in Southern and Western Africa as well as in Polynesia, where the 3rd GLS performs better, as measured by the MPE. However, in these sub-regions, the precision as measured by the mean absolute percentage error (MAPE) is actually better for the 2nd GLS. Sub-regions where both the MPE and the MAPE are higher for the 2nd GLS than for the 3rd GLS are Western Asia, Western Europe and South America.

At the continental level, the 2nd GLS performs better than the 3rd GLS in Africa, Latin America and The Caribbean, as well as Asia and Northern America, whether considering the MPE or the MAPE. The MPE of the 3rd GLS is slightly lower than the MPE of the 2nd GLS for Oceania, but the opposite holds for the MAPE. The performance of the 3rd GLS and 2nd GLS are almost equivalent for Europe.

The overall performance of the two models can be assessed through the distribution of countries by categories of estimates of percentage urban that falls within 1%, 5%, 10%, 15%, 20% or beyond of the observed value of percentage urban (Table 5b). The 2nd GLS clearly outperforms the 3rd GLS by giving a higher proportion of countries within the 5% error (62.3% against 57.9%), and a lower proportion above the 15% error (9.2% against 16.4%).

To sum up, the 2nd GLS generally performs better than the 3rd GLS, but the difference are not substantial. The two models give very similar results in most instances. For the 2005-2050 period, particular caution should be given to projections for Africa in general as well as for South-Central Asia, South-Eastern Asia, and Oceania except Australia and New Zealand.

Table 5b: Distribution of countries or territories model estimates of percentage urban by percentage error

Percentage Error	2005 Baseline			
	Number of Countries		Percentage of the total	
	3rd GLS	2nd GLS	3rd GLS	2nd GLS
[-1, 1]	39	42	18.8%	20.3%
[-5, 5]	81	87	39.1%	42.0%
[-10, 10]	34	35	16.4%	16.9%
[-15, 15]	19	24	9.2%	11.6%
[-20, 20]	13	9	6.3%	4.4%
Beyond -20 & 20	21	10	10.1%	4.8%
Total	207	207	100.0%	100.0%

4.3. CONCLUSION AND RECOMMENDATIONS

The result of the research shows that the UN World Urbanization Prospects, 2007 projects urban proportion generally higher than what the 3rd GLS and the 2nd GLS models do based on the same data. The difference increases with the length of the projection period. The difference between the UN and the polynomial regression models is higher for less developed regions than it is for more developed region. For instance, UN projects the urban proportion for Less Developed Regions of Africa 64.7% for 2050 while the 3rd GLS model projects it at 48.8%, a difference of 15.9 percentage points. The difference between the two models for the More Developed Regions is only 7.2 percentage points. The UN expects a larger population living in urban areas over time but the research proves otherwise. For instance the UN projects that 44.2 million people will be living in South African urban areas by 2050 while the research shows that the urban population will only be of 34.3 million (Figure 12). A difference of almost 10 million can sensibly affect national planning.

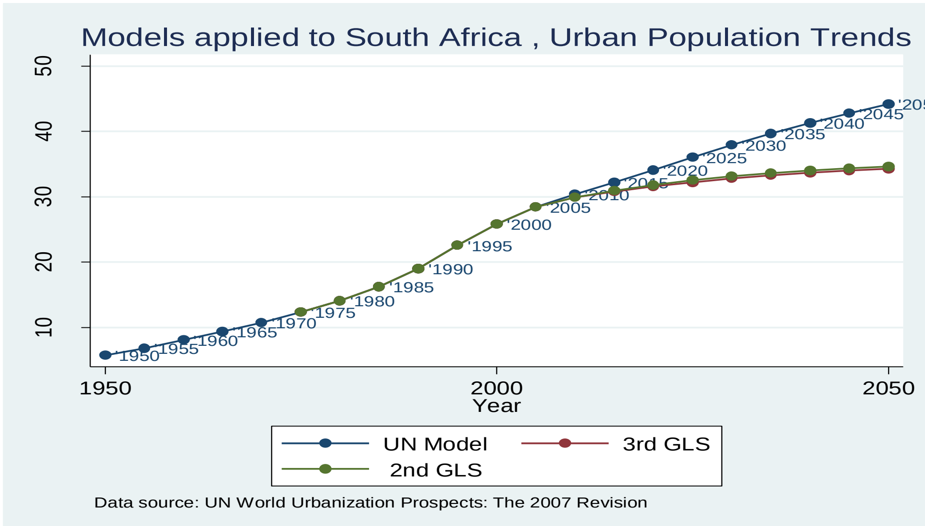

Figure 12: South Africa, Urban population for 1950 to 2050, using UN model, 3rd GLS and 2nd GLS

The UN model projects that the Urban Population Growth in Less Developed Regions will still be increasing by 2050. It means that most the population growth in those regions will be happening in urban areas. Nevertheless, past URGD trends show that urban growth is now decreasing. The research shows that by 2050, urban growth would be close to zero. The URGD in the majority of less developed countries would be almost insignificant. This means that there would be no difference in growth between urban and rural areas of countries belonging to the Less Developed Regions.

The quality of data and the specific (idiosyncratic) historical trends of urban population affect significantly projections using the 3rd order polynomial model. China and South Africa are some of the examples, with Cultural Revolution and Apartheid respectively affecting urban trends. However, the idiosyncratic historical trend effect can be efficiently corrected by truncating the series.

Small territories and islands trends are usually difficult to adjust. The polynomial models require a minimum population size to project reasonable trends. Despite the population size problem of few countries, only six countries' series out of 229 were deleted. It did not affect the result of the projection for the World or even for sub-continental regions.

The 2nd GLS appears generally better than the 3rd GLS for projections over the 1990-2005 period, but the difference is marginal. Therefore, it can be concluded that the 3rd order polynomial should give reasonable estimates for the 2005-2050 period. However, particular caution should be given to projections for Africa in general as well as for South-Central Asia, South-Eastern Asia, and Oceania except Australia and New Zealand.

Policy makers in the Less Developed Regions may encourage planning for larger proportion of population in rural areas than what was previously estimated by the UN. Countries in Less Developed Regions expect higher proportion of their population living in urban areas than it would actually be. It becomes important that the UN projection model be revisited to give projections that are more accurate. It is also crucial that service delivery be planned for the majority of the population that will be living in rural areas. The present research could be expanded at sub-country level (e.g. provinces or districts) to help governments to elaborate policies in anticipation of potential demand of services and expenditure for rural areas in provinces or regions.

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APPENDIX 1: Table of correction per country

Two types of correction: (1) part of the series is deleted; (2) the full series is deleted

Major Area, Region, Country or Area	Country series affected by correction			
	Type of Correction	Period of the series affected	Period of the series considered for projection	Observation
AFRICA				
Sub-Saharan Africa				
Eastern Africa				
Burundi	1	1950 - 1965	1970 - 2005	
Kenya	1	1950 - 1990	1995 - 2005	
Northern Africa				
Algeria	1	1950 - 1965	1970 - 2005	
Southern Africa				
Botswana	1	1950 - 1975	1980 - 2005	
Lesotho	1	1950 - 1980	1985 - 2005	
Namibia	1	1950 - 1985	1990 - 2005	
South Africa	1	1950 - 1970	1975 - 2005	
Western Africa				
Côte d'Ivoire	1	1950 - 1995	2000 - 2005	
Ghana	1	1950 - 1970	1975 - 2005	
Nigeria	1	1950 - 1965	1970 - 2005	
ASIA				
Eastern Asia				
China	1	1950 - 1965	1970 – 2005	
South-Central Asia				
Bhutan	1	1950 – 1980	1985 – 2005	
Pakistan	1	1950 – 1980	1985 – 2005	
South-Eastern Asia				
Cambodia	1	1950 – 1990	1995 – 2005	
Myanmar	1	1950 – 1975	1980 – 2005	
Viet Nam	1	1950 - 1980	1985 – 2005	
EUROPE				
Northern Europe				
Faeroe Islands	1	1950 - 1960	1965 – 2005	
Southern Europe				
Albania	1	1950 - 1965	1970 – 2005	
Andorra	2	1950 - 2005	Not applicable	Not included in the regional totals
Holy See	2	1950 - 2005	Not applicable	Not included in the regional totals
Portugal	1	1950 - 1965	1970 – 2005	
LATIN AMERICA AND THE CARIBBEAN				
Caribbean				
Anguilla	1	1950 - 1975	1980 – 2005	
British Virgin Islands	2	1950 - 2005	Not applicable	Not included in the regional totals
Cayman Islands	1	1950 – 1980	1985 – 2005	
Dominican Republic	1	1950 – 1985	1990 – 2005	
Haiti	1	1950 – 1975	1980 – 2005	
Montserrat	2	1950 – 2005	Not applicable	Not included in the regional totals
Central America				
Belize	1	1950 – 1985	1990 – 2005	

Guatemala	1	1950 - 1975	1980 – 2005	
Panama	1	1950 - 1965	1970 – 2005	
South America				
Argentina	1	1950 - 1975	1980 – 2005	
NORTHERN AMERICA				
United States of America	1	1950 - 1975	1980 – 2005	
OCEANIA				
Micronesia				
Marshall Islands	2	1950 – 2005	Not applicable	Not included in the regional totals
Nauru	1	1950 - 1975	1980 – 2005	
Palau	1	1950 - 1975	1980 – 2005	
Polynesia				
American Samoa	1	1950 - 1975	1980 – 2005	
Niue	2	1950 – 2005	Not applicable	Not included in the regional totals
Tonga	1	1950 - 1975	1980 – 2005	
Tuvalu	1	1950 - 1975	1980 – 2005	

APPENDIX 2: Development Group and African Regions Percentage Urban projections

Development Group or African Region	Percentage Urban								
	2010			2030			2050		
	UN	3rd GLS	2nd GLS	UN	3rd GLS	2nd GLS	UN	3rd GLS	2nd GLS
WORLD	**47.88**	**47.11**	**47.37**	**57.35**	**49.26**	**51.26**	**67.86**	**52.79**	**53.98**
WORLD without China	48.69	48.10	48.27	56.64	50.09	51.46	66.85	54.20	54.50
More developed regions	**75.01**	**74.44**	**74.52**	**80.53**	**75.57**	**75.76**	**86.01**	**75.78**	**76.01**
Less developed regions	**41.30**	**40.48**	**40.78**	**52.74**	**44.03**	**46.39**	**64.71**	**48.8**	**50.15**
Less developed regions, excluding China	39.99	39.39	39.60	50.47	43.51	45.18	62.71	49.54	49.85
Less developed regions, excluding least developed countries	43.73	42.92	43.24	55.65	46.96	49.46	67.66	53.16	53.88
Least developed countries	**29.43**	**28.55**	**28.74**	**41.47**	**32.70**	**34.50**	**55.50**	**35.20**	**38.53**
AFRICA	**39.94**	**39.36**	**39.50**	**50.02**	**44.98**	**45.54**	**61.76**	**53.02**	**51.27**
Sub-Saharan Africa	37.32	36.69	36.84	48.18	43.44	43.95	60.47	52.81	50.65
Eastern Africa	**23.72**	**23.08**	**23.41**	**33.73**	**26.88**	**28.14**	**47.64**	**34.02**	**33.65**
Burundi	11.00	10.73	10.89	19.79	13.75	17.64	33.35	14.64	28.37
Comoros	28.19	27.92	28.10	36.51	27.94	28.57	50.70	27.94	28.79
Djibouti	88.11	88.83	88.98	91.99	98.14	99.21	94.23	100	100
Eritrea	21.58	21.04	20.91	34.39	31.36	29.05	50.11	65.54	46.04
Ethiopia	17.55	17.23	17.21	27.35	22.24	21.99	42.11	28.48	27.31
Kenya	22.18	22.06	22.02	33.04	32.59	29.88	48.13	71.66	42.06
Madagascar	30.19	29.39	29.65	41.39	31.04	32.69	56.07	31.58	34.42
Malawi	19.77	19.53	19.79	32.42	25.92	33.88	48.47	27.87	62.19
Mauritius	42.57	42.83	42.74	51.06	42.90	42.88	63.41	42.90	42.89
Mozambique	38.43	36.85	37.68	53.69	39.56	45.79	67.39	39.83	49.58
Réunion	94.01	90.69	94.26	96.33	90.89	97.10	97.34	90.89	97.65
Rwanda	18.85	14.38	21.46	28.26	16.06	32.03	42.93	16.07	36.42
Seychelles	55.32	48.87	51.68	66.56	50.34	51.05	76.21	50.34	51.03
Somalia	37.45	36.94	36.90	49.86	43.05	42.73	63.65	48.21	47.57
Uganda	13.30	12.74	12.91	20.56	13.00	13.74	33.52	13.07	14.14
United Republic of Tanzania	26.38	25.63	25.57	38.66	29.48	29.39	54.01	31.54	31.70
Zambia	35.70	35.70	35.53	44.71	36.82	36.45	58.36	37.10	36.73
Zimbabwe	38.25	37.40	37.85	50.71	40.07	43.90	64.35	40.58	47.54
Middle Africa	**42.93**	**40.65**	**40.89**	**55.30**	**42.03**	**43.41**	**67.41**	**42.33**	**44.63**
Angola	58.50	56.79	58.02	71.62	60.29	68.25	80.54	60.82	73.24
Cameroon	58.40	58.41	58.41	70.99	72.75	73.64	79.88	83.41	87.17
Central African Republic	38.94	38.12	38.27	48.43	38.20	38.65	61.60	38.21	38.79
Chad	27.63	26.33	26.12	41.24	29.31	28.36	56.74	30.99	29.56
Congo	62.12	61.27	61.51	70.87	63.70	65.11	78.99	64.71	67.17
Democratic Republic of the Congo	35.22	31.78	31.84	49.16	31.32	31.43	63.23	31.19	31.30
Equatorial Guinea	39.70	39.36	39.64	49.43	39.88	41.69	62.37	39.97	43.02
Gabon	86.03	84.69	86.38	90.62	85.67	93.15	93.52	85.75	96.38
São Tomé and Príncipe	62.23	47.34	63.04	74.05	53.89	83.60	82.12	53.91	99.71
Northern Africa	**52.02**	**51.88**	**52.10**	**61.32**	**56.85**	**60.43**	**71.97**	**59.67**	**66.24**
Algeria	66.50	65.82	66.02	76.23	69.49	71.46	83.50	70.00	73.03
Egypt	42.80	42.81	42.80	49.92	43.08	43.06	62.38	43.15	43.13
Libyan Arab Jamahiriya	77.89	76.80	77.11	82.88	76.60	77.28	87.23	76.58	77.32
Morocco	56.74	56.02	56.35	65.93	57.60	59.38	75.37	57.91	60.54
Sudan	45.22	45.93	46.51	60.68	65.05	78.34	74.01	76.38	100

Tunisia	67.28	66.95	67.21	75.17	70.42	72.42	82.03	71.59	75.36
Western Sahara	81.83	83.09	81.28	85.93	84.26	82.26	89.45	84.32	82.76
Southern Africa	**58.78**	**57.69**	**57.83**	**68.76**	**58.73**	**59.67**	**77.61**	**58.67**	**59.86**
Botswana	61.13	58.74	58.47	72.69	60.01	59.54	81.06	60.11	59.64
Lesotho	26.88	26.03	26.53	42.35	28.28	36.75	58.06	28.28	41.05
Namibia	37.98	37.56	37.68	51.49	41.14	43.67	65.34	41.3	44.95
South Africa	61.70	60.68	60.78	71.32	61.70	62.29	79.57	61.71	62.35
Swaziland	25.49	22.11	24.26	37.04	22.97	24.52	51.94	23.04	24.58
Western Africa	**44.62**	**44.62**	**44.47**	**56.52**	**57.68**	**55.28**	**67.95**	**75.82**	**65.99**
Benin	42.04	40.73	41.07	53.74	41.89	43.49	66.55	42.24	44.64
Burkina Faso	20.42	19.23	19.30	32.60	20.65	21.42	48.36	20.98	22.33
Cape Verde	61.09	53.31	58.57	72.53	54.59	59.76	80.84	54.59	59.92
Côte d'Ivoire	50.15	50.94	50.28	62.77	99.86	77.71	73.67	100	100
Gambia	58.15	56.31	58.58	71.02	58.43	75.90	80.96	58.59	91.09
Ghana	51.47	50.39	50.71	64.69	53.09	55.92	75.64	53.24	57.00
Guinea	35.36	34.00	34.10	48.64	36.18	36.91	62.93	37.02	38.35
Guinea-Bissau	30.00	29.67	29.92	38.61	29.68	30.33	52.74	29.68	30.43
Liberia	61.51	60.48	61.31	73.69	64.19	69.50	83.08	65.17	73.99
Mali	33.34	32.74	32.86	47.41	39.58	41.41	62.32	43.43	48.55
Mauritania	41.43	40.01	40.71	51.71	39.95	41.15	64.38	39.95	41.27
Niger	16.67	16.29	16.36	23.67	16.29	16.48	37.06	16.29	16.52
Nigeria	49.80	49.84	49.88	63.58	64.18	65.14	75.42	77.42	81.41
Saint Helena	6.81	6.40	7.37	7.99	6.40	-	8.56	6.40	-
Senegal	42.89	41.99	42.05	53.20	42.94	43.27	65.71	43.37	43.91
Sierra Leone	38.40	37.40	37.53	49.02	38.54	39.23	62.44	38.95	40.02
Togo	43.44	43.50	43.32	57.30	57.66	53.93	69.84	68.85	59.80

APPENDIX 3: Asian Major region and countries projection

Asian Regions	Percentage Urban								
	2010			2030			2050		
	UN	3rd GLS	2nd GLS	UN	3rd GLS	2nd GLS	UN	3rd GLS	2nd GLS
ASIA	**42.47**	**41.60**	**41.93**	**54.13**	**44.34**	**47.20**	**66.21**	**47.63**	**50.13**
ASIA without China	41.30	40.69	40.91	51.53	43.74	45.84	63.75	48.30	49.68
Eastern Asia	**48.46**	**47.10**	**47.61**	**62.40**	**48.82**	**53.01**	**74.10**	**48.65**	**53.69**
Eastern Asia without China	71.04	70.19	70.48	77.14	70.60	71.34	83.27	70.71	71.51
China	44.93	43.49	44.04	60.33	45.77	50.44	72.92	45.79	51.38
China, Hong Kong SAR	100	100	100	100	100	100	100	100	100
China, Macao SAR	100	100	100	100	100	100	100	100	100
Dem. People's Republic of Korea	63.37	61.16	61.32	72.36	60.62	60.91	80.14	60.54	60.83
Japan	66.83	66.19	66.27	72.98	66.52	66.79	80.07	66.56	66.89
Mongolia	57.46	56.99	57.06	65.67	57.54	57.86	74.77	57.72	58.22
Republic of Korea	81.94	81.04	81.98	86.26	81.16	83.45	89.77	81.16	83.61
South-Central Asia	**32.18**	**31.59**	**31.61**	**43.02**	**34.85**	**34.90**	**57.20**	**41.49**	**38.23**
Afghanistan	24.79	24.11	23.97	36.23	27.63	26.83	51.48	29.98	28.53
Bangladesh	28.07	27.05	26.87	41.04	30.19	29.57	56.41	31.39	30.69
Bhutan	36.84	33.61	36.62	56.19	33.54	60.76	70.28	33.54	84.86
India	30.07	29.43	29.47	40.61	31.15	31.52	55.17	31.84	32.61
Iran (Islamic Republic of)	69.50	70.03	70.17	77.86	80.50	82.31	84.12	88.12	93.39
Kazakhstan	58.51	57.11	57.21	66.84	57.12	57.38	75.86	57.12	57.41
Kyrgyzstan	36.64	36.07	36.07	46.16	36.62	36.62	59.69	36.83	36.83
Maldives	40.48	29.60	38.43	60.73	31.05	74.67	73.67	31.05	100
Nepal	18.22	17.43	18.33	30.61	18.71	28.92	46.34	18.74	38.65
Pakistan	37.03	36.71	36.57	49.80	49.13	45.32	63.66	98.18	60.82
Sri Lanka	15.13	15.17	15.17	21.40	15.26	15.26	33.97	15.33	15.32
Tajikistan	26.54	25.88	25.93	34.12	24.34	24.69	48.26	23.33	23.99
Turkmenistan	49.50	47.20	47.20	60.44	47.04	47.04	71.60	46.99	46.99
Uzbekistan	36.94	36.89	36.9	46.15	37.43	37.45	59.30	37.73	37.75
South-Eastern Asia	**48.23**	**47.59**	**48.35**	**61.84**	**53.36**	**62.69**	**73.25**	**54.37**	**70.98**
Brunei Darussalam	75.65	74.29	75.04	82.33	75.76	80.09	87.21	76.24	84.12
Cambodia	22.80	22.66	22.59	36.98	35.15	33.21	53.24	48.08	41.60
Timor-Leste	28.12	26.20	27.18	39.89	26.25	29.44	54.92	26.25	30.36
Indonesia	53.69	53.46	54.81	68.94	60.66	81.21	79.44	60.96	99.30
Lao People's Democratic Republic	33.18	35.42	35.42	53.07	58.75	58.75	68.03	58.76	58.76
Malaysia	72.17	74	74.09	82.21	99.16	99.50	87.85	100	100
Myanmar	33.91	32.63	32.97	48.39	32.85	34.29	63.14	32.85	34.29
Philippines	66.38	65.42	66.23	76.69	69.04	74.87	83.89	69.50	78.64
Singapore	100	100	100	100	100	100	100	100	100
Thailand	33.96	32.75	32.89	45.77	33.50	34.21	59.96	33.66	34.71
Viet Nam	28.83	27.14	27.39	41.77	27.15	27.67	57.01	27.15	27.68
Western Asia	**66.28**	**65.92**	**66.24**	**72.51**	**68.23**	**69.59**	**79.26**	**71.24**	**73.09**

Armenia	63.72	65.12	64.99	69.07	66.06	66.03	76.75	66.09	66.09
Azerbaijan	52.19	51.77	51.76	60.05	52.19	52.16	70.57	52.31	52.27
Bahrain	88.61	88.56	88.56	90.63	88.97	88.95	92.76	89.25	89.22
Cyprus	70.27	68.49	69.38	76.41	68.40	69.43	82.60	68.40	69.43
Georgia	52.95	53.21	53.14	60.18	53.68	53.69	70.56	53.68	53.70
Iraq	66.39	67.27	67.22	70.48	67.85	67.77	77.76	68.00	67.95
Israel	91.72	91.75	91.77	93.05	92.02	92.11	94.58	92.12	92.24
Jordan	78.53	79.14	79.36	81.97	80.83	82.10	86.36	81.52	83.74
Kuwait	98.38	98.65	98.71	98.72	99.41	99.70	98.99	99.74	100
Lebanon	87.24	86.75	87.13	90.04	86.91	87.96	92.43	86.92	88.14
Occupied Palestinian Territory	72.05	72.05	72.11	77.22	72.97	73.26	83.00	73.37	73.80
Oman	71.71	71.90	72.75	76.35	72.13	75.16	82.29	72.14	76.02
Qatar	95.83	94.89	95.49	96.91	94.13	95.67	97.61	93.91	95.76
Saudi Arabia	82.07	81.70	82.00	86.24	83.08	84.46	89.70	83.60	85.73
Syrian Arab Republic	54.86	54.53	54.42	63.99	60.16	59.07	73.88	67.54	63.90
Turkey	69.65	68.42	69.24	77.73	69.83	73.62	84.00	70.02	75.37
United Arab Emirates	78.05	77.64	77.64	82.44	77.45	77.42	86.66	77.32	77.28
Yemen	31.80	31.82	31.85	45.35	45.02	45.56	60.17	61.88	64.24

APPENDIX 4: European Major Region urban Proportion Projections

European Regions	Percentage Urban								
	2010			2030			2040		
	UN	3rd GLS	2nd GLS	UN	3rd GLS	2nd GLS	UN	3rd GLS	2nd GLS
EUROPE	**72.57**	**72.17**	**72.25**	**77.82**	**73.18**	**73.42**	**83.79**	**72.74**	**73.04**
Eastern Europe	**68.43**	**68.61**	**68.68**	**73.13**	**68.94**	**69.25**	**79.94**	**69.03**	**69.39**
Belarus	74.26	72.29	72.83	81.15	72.39	73.66	86.23	72.39	73.72
Bulgaria	71.69	69.86	70.04	78.16	69.63	69.89	84.00	69.63	69.89
Czech Republic	73.54	74.59	74.47	77.97	74.82	74.86	83.36	74.82	74.86
Hungary	68.32	65.72	65.82	76.09	65.58	65.64	82.68	65.58	65.64
Poland	61.15	61.84	61.88	66.05	62.56	62.76	74.60	62.74	63.03
Republic of Moldova	41.24	44.30	43.91	46.25	45.11	45.10	58.57	45.11	45.13
Romania	54.65	54.26	54.40	63.13	55.09	55.83	73.04	55.17	56.16
Russian Federation	72.80	73.29	73.34	76.41	73.62	73.82	82.21	73.63	73.86
Slovakia	56.79	56.35	56.45	64.71	56.38	56.58	73.99	56.38	56.59
Ukraine	68.11	68.22	68.35	72.98	68.81	69.28	79.87	68.86	69.43
Northern Europe	**84.44**	**83.63**	**83.74**	**87.58**	**83.84**	**83.92**	**90.69**	**84.09**	**84.16**
Channel Islands	31.42	30.60	30.60	39.11	30.47	30.46	53.15	30.46	30.44
Denmark	87.20	85.58	85.63	90.83	85.40	85.44	93.11	85.39	85.44
Estonia	69.50	69.95	69.92	73.78	70.27	70.32	80.38	70.28	70.33
Faeroe Islands	42.54	28.37	43.05	55.03	35.46	70.38	57.94	36.14	100
Finland	63.92	61.08	61.53	71.80	61.15	61.34	79.51	61.15	61.34
Iceland	92.29	92.60	92.63	93.33	93.45	93.59	94.78	93.82	94.06
Ireland	61.94	61.35	61.30	69.78	64.29	63.87	77.98	66.92	65.87
Isle of Man	50.65	51.59	51.61	53.89	51.76	51.77	64.25	51.76	51.78
Latvia	68.17	68.50	68.49	72.96	68.70	68.79	79.82	68.70	68.80
Lithuania	67.15	67.22	67.35	72.49	67.56	68.15	79.58	67.57	68.21
Norway	77.62	77.21	77.13	81.35	77.10	76.90	85.94	77.08	76.87
Sweden	84.68	83.88	83.96	87.33	83.74	83.79	90.33	83.74	83.79
United Kingdom	90.14	89.42	89.53	92.16	89.36	89.46	93.96	89.36	89.46
Southern Europe	**67.40**	**66.56**	**66.66**	**74.19**	**67.27**	**67.76**	**81.12**	**67.55**	**68.30**
Albania	47.96	47.70	48.04	60.65	51.45	56.40	72.13	51.54	58.29
Andorra	*	*	*	*	*	*	*	*	*
Bosnia and Herzegovina	48.62	46.42	46.57	61.66	47.37	48.06	73.32	47.49	48.41
Croatia	57.76	56.30	56.60	66.54	56.19	56.76	75.69	56.18	56.77
Gibraltar	29.22	28.32	28.91	29.06	28.12	28.69	27.37	28.11	28.66
Greece	61.41	59.99	60.10	69.30	59.74	59.87	77.56	59.73	59.86
Holy See	*	*	*	*	*	*	*	*	*
Italy	68.36	67.47	67.51	74.55	67.35	67.4	81.19	67.34	67.39
Malta	94.67	96.17	96.15	96.64	100	100	97.45	100	100
Portugal	60.70	60.56	60.72	71.43	67.25	70.17	79.97	68.48	74.52
San Marino	31.46	24.62	33.84	33.25	27.98	55.96	32.69	27.88	61.33
Serbia	52.38	51.62	51.72	61.19	51.77	52.05	71.57	51.78	52.10
Montenegro	59.49	61.21	64.46	62.00	61.21	71.73	70.97	61.21	73.81

Slovenia	47.96	50.12	50.10	51.84	50.38	50.67	63.13	50.38	50.71
Spain	77.40	76.54	76.64	81.92	76.41	76.56	86.47	76.41	76.55
TFYR Macedonia	67.87	67.19	66.97	76.65	72.59	71.40	83.61	76.01	73.95
Western Europe	**76.95**	**76.24**	**76.28**	**81.70**	**77.78**	**77.78**	**86.46**	**74.61**	**74.65**
Austria	67.55	66.88	66.87	73.77	72.24	71.50	80.68	100	100
Belgium	97.43	97.39	97.40	97.97	97.55	97.57	98.41	97.57	97.60
France	77.78	76.06	76.11	82.87	75.58	75.61	87.30	75.55	75.58
Germany	73.85	73.26	73.26	78.34	73.16	73.16	83.81	73.15	73.15
Liechtenstein	14.20	14.67	14.87	18.59	14.75	15.34	30.30	14.75	15.45
Luxembourg	82.24	82.87	82.89	84.08	82.91	82.94	87.65	82.92	82.95
Monaco	33.05	32.27	32.95	35.80	32.28	33.61	37.34	32.28	33.70
Netherlands	82.86	84.45	84.61	88.59	99.92	100	91.82	100	100
Switzerland	73.62	73.81	73.91	77.87	74.28	74.79	83.42	74.31	74.93

* Series for these countries could not be used for projections

APPENDIX 5: Latin American and the Caribbean Major Region urban Projections

Regions	Percentage Urban								
	2010			2030			2050		
	UN	3rd GLS	2nd GLS	UN	3rd GLS	2nd GLS	UN	3rd GLS	2nd GLS
LATIN AMERICA AND THE CARIBBEAN	**79.33**	**79.17**	**79.23**	**84.61**	**83.57**	**84.25**	**88.7**	**85.56**	**86.93**
Caribbean	**66.61**	**67.07**	**66.64**	**75.27**	**78.25**	**78.52**	**82.24**	**79.19**	**79.48**
Anguilla	13.15	10.46	12.64	16.07	10.96	12.87	17.43	10.85	12.87
Antigua and Barbuda	30.34	32.10	32.14	38.37	33.75	33.88	51.91	34.11	34.19
Aruba	46.87	47.23	47.26	52.51	48.58	48.56	63.86	49.04	48.98
Bahamas	84.10	83.73	83.98	87.89	84.88	86.21	90.93	85.19	87.27
Barbados	40.78	37.66	37.65	53.42	37.27	37.23	66.61	37.26	37.21
British Virgin Islands	23.30	15.99	22.96	27.27	21.64	24.02	28.26	21.39	24.11
Cayman Islands	49.15	39.75	48.77	57.02	39.94	50.95	59.36	39.97	50.97
Cuba	75.73	75.55	75.64	79.35	75.52	75.66	84.43	75.52	75.66
Dominica	66.84	67.27	68.09	69.38	67.25	68.17	67.29	67.39	68.17
Dominican Republic	70.47	65.93	66.80	80.03	66.27	66.79	86.06	66.27	66.79
Grenada	31.03	30.93	30.94	40.48	31.61	31.61	54.44	31.84	31.83
Guadeloupe	98.24	98.47	98.47	98.45	98.45	98.45	98.75	98.48	98.49
Haiti	49.58	56.76	53.56	67.98	100	100	78.87	100	100
Jamaica	53.74	53.18	53.24	62.31	54.34	54.64	72.45	54.79	55.30
Martinique	98.04	98.33	98.90	98.44	98.33	99.91	98.77	98.33	99.99
Montserrat	*	*	*	*	*	*	*	*	*
Netherlands Antilles	93.18	94.67	94.76	95.49	100	100	96.64	100	100
Puerto Rico	98.78	99.78	99.88	99.57	100	100	99.71	100	100
Saint Kitts and Nevis	32.41	33.38	33.48	41.57	34.65	34.53	55.29	34.68	34.56
Saint Lucia	27.97	28.11	27.91	36.13	28.57	28.33	50.36	28.59	28.40
Saint Vincent and the Grenadines	47.78	39.41	47.10	58.60	39.83	49.37	70.14	37.72	50.02
Trinidad and Tobago	13.88	11.44	11.44	23.74	10.44	10.41	38.28	10.35	10.31
Turks and Caicos Islands	*	*	*	*	*	*	*	*	*
United States Virgin Islands	95.27	87.74	94.50	96.97	91.01	94.90	82.08	91.00	94.95
Central America	**71.68**	**71.23**	**71.36**	**77.70**	**73.70**	**74.47**	**83.33**	**74.98**	**76.46**
Belize	52.71	49.78	49.77	63.66	49.08	49.05	74.03	48.91	48.88
Costa Rica	64.32	63.63	64.14	73.81	66.52	70.11	81.48	66.97	72.67
El Salvador	61.30	60.93	61.32	69.45	61.86	63.58	77.80	61.91	63.96
Guatemala	49.46	49.17	49.18	60.63	55.97	56.23	71.82	61.06	62.10
Honduras	48.85	48.24	48.33	60.35	53.55	54.57	71.71	56.99	59.72
Mexico	77.83	77.45	77.55	83.27	80.41	81.06	87.63	81.90	83.21
Nicaragua	57.32	56.81	56.77	65.79	59.63	59.43	75.11	61.71	61.36
Panama	74.80	72.40	73.36	83.59	72.46	74.57	88.71	72.46	74.58
South America	**83.64**	**83.53**	**83.61**	**88.27**	**87.98**	**88.67**	**91.43**	**90.33**	**91.74**
Argentina	92.39	92.48	92.48	94.65	95.45	95.49	95.96	97.04	97.16
Bolivia	66.55	65.24	65.74	75.18	66.37	68.49	82.24	66.51	69.29
Brazil	86.53	86.56	86.63	91.13	92.97	93.75	93.57	96.48	98.23
Chile	89.00	88.54	88.53	92.25	91.17	91.14	94.22	92.87	92.84

Colombia	75.07	74.90	74.95	80.95	78.73	79.06	85.98	81.15	81.87
Ecuador	66.95	66.08	66.32	76.82	72.92	75.53	83.63	76.2	82.57
Falkland Islands (Malvinas)	3.06	2.26	3.10	3.28	2.72	3.55	3.37	2.69	3.86
French Guiana	76.35	74.42	75.7	81.37	74.39	75.89	86.1	74.39	75.95
Guyana	28.48	28.35	28.35	36.98	28.76	28.77	51.1	29.05	29.05
Paraguay	61.49	60.75	61.03	71.94	64.68	67.35	80.19	65.45	70.03
Peru	71.64	71.39	71.48	76.53	71.88	72.21	82.52	72.01	72.46
Suriname	75.65	72.10	72.69	82.01	72.32	72.58	87.03	72.32	72.58
Uruguay	92.55	92.56	92.61	94.33	93.53	93.81	95.64	93.7	94.08
Venezuela	94.04	94.07	94.13	96.56	95.43	95.84	97.48	95.45	95.9

* Series for these countries could not be used for projections

APPENDIX 6: Northern American and Oceania Major Region urban Projections

Northern American and Oceania Regions	Percentage Urban								
	2010			2030			2050		
	UN	3rd GLS	2nd GLS	UN	3rd GLS	2nd GLS	UN	3rd GLS	2nd GLS
NORTHERN AMERICA	82.11	81.23	81.29	86.65	81.38	81.49	90.13	81.44	81.54
Bermuda	65.00	64.39	65.08	65.87	64.60	67.43	62.68	64.61	68.52
Canada	80.58	80.48	80.43	84.00	81.47	81.27	87.90	82.07	81.74
Greenland	59.22	54.43	57.22	64.43	55.47	56.93	64.14	55.47	56.90
Saint Pierre and Miquelon	6.37	6.22	6.33	6.43	6.27	6.32	6.47	6.27	6.32
United States of America	82.30	81.34	81.42	86.96	81.40	81.55	90.40	81.4	81.55
OCEANIA	68.93	68.22	68.54	72.18	68.38	69.01	75.97	67.49	68.68
Australia/New Zealand	88.72	88.10	88.08	91.47	88.84	88.73	93.55	89.35	89.17
Australia	89.11	88.48	88.46	91.86	89.35	89.23	93.84	89.95	89.73
New Zealand	86.77	86.19	86.20	89.49	86.16	86.18	91.99	86.15	86.17
Melanesia	18.89	18.79	19.15	24.71	19.18	20.53	35.81	18.71	21.98
Fiji	53.40	53.65	54.08	64.35	62.35	72.06	74.55	65.29	98.96
New Caledonia	65.51	62.67	64.21	73.45	62.00	65.47	80.75	61.95	66.12
Papua New Guinea	12.53	13.04	12.88	18.18	13.58	13.31	29.75	13.65	13.40
Solomon Islands	18.55	13.68	18.05	29.20	15.55	22.18	44.31	15.54	26.21
Vanuatu	25.57	20.69	25.01	38.01	22.01	30.35	53.49	22.01	34.54
Micronesia	51.80	38.39	51.51	58.10	40.24	55.21	64.96	40.00	57.44
Guam	93.17	92.05	92.98	94.20	92.46	92.95	95.45	92.46	92.95
Kiribati	44.04	38.44	44.79	52.30	40.95	47.91	64.50	41.65	49.51
Marshall Islands	*	*	*	*	*	*	*	*	*
Micronesia (Fed. States of)	22.66	22.35	22.47	30.27	22.41	22.82	44.43	22.44	22.99
Nauru	10.26	10.20	10.18	11.09	13.92	10.34	10.86	13.92	10.38
Northern Mariana Islands	88.47	0.29	86.66	93.32	100	93.22	94.88	100	93.5
Palau	20.54	19.60	20.06	24.23	19.81	20.07	25.96	19.82	20.07
Polynesia	21.08	20.92	21.18	46.02	38.00	41.38	55.86	38.74	42.50
American Samoa	9.49	9.05	9.56	95.62	68.12	100	96.81	68.12	100
Cook Islands	12.51	15.09	13.86	11.42	15.61	13.16	11.99	15.75	11.68
French Polynesia	51.62	52.41	52.27	58.80	53.98	53.54	69.29	54.53	54.03
Niue	*	*	*	*	*	*	*	*	*
Samoa	23.40	23.04	23.05	33.18	25.14	25.73	47.89	25.40	26.78
Tonga	25.35	23.04	24.25	36.90	23.16	25.03	51.82	23.16	25.45
Tuvalu	10.66	10.08	10.54	11.67	10.24	10.62	11.86	10.24	10.63

* Series for these countries could not be used for projections