Population Distribution Patterns in Thailand and Nepal: Application of Factor Analysis

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ชื่อวิทยานิพนธ์ รูปแบบการแจกแจงของประชากรในประเทศไทยและเนปาล:การประยุกต์ใช้การวิเคราะห์องค์ประกอบ

ผู้เขียน Mrs. Binita Kumari Paudel

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บทคัดย่อ

การเปลี่ยนแปลงทางด้านประชากรศาสตร์ของประเทศไทยอยู่ในระยะคงที่ในระดับต่ำ (low stationary phase) และการเปลี่ยนแปลงทางด้านประชากรศาสตร์ของประเทศเนปาลอยู่ในระยะปลายของการขยายตัว (late expanding phase) ความน่าจะเป็นการเปลี่ยนแปลงของประชากรในอนาคตขึ้นอยู่กับอายุและเพศของประชากรในปัจจุบันเป็นหลัก ดังนั้นวิทยานิพนธ์เล่มนี้มีวัตถุประสงค์เพื่อประยุกต์ใช้การวิเคราะห์เชิงปัจจัย (Factor Analysis) ในการจัดกลุ่มประชากรของแต่ละจังหวัดและอำเภอ ที่ขึ้นกับการกระจายของประชากรตามอายุและเพศของประเทศไทยและเนปาล สถิติที่ใช้ในการวิเคราะห์ ได้แก่ การวิเคราะห์เชิงพรรณนา การวิเคราะห์เชิงเปรียบเทียบ ซึ่งรวมถึงวิธีการวิเคราะห์หลายปัจจัย เรียกว่า การวิเคราะห์เชิงปัจจัย ที่ประยุกต์ใช้กับข้อมูลประชากรศาสตร์ วิทยานิพนธ์ฉบับนี้ประกอบไปด้วยสามส่วนดังต่อไปนี้

ส่วนแรกของการศึกษามีวัตถุประสงค์เพื่อประยุกต์ใช้วิธีการวิเคราะห์เชิงปัจจัยในการจัดกลุ่มประชากรในประเทศไทยในแต่ละจังหวัดตามการกระจายของอายุและเพศ ข้อมูลประกอบไปด้วยจำนวนประชากรในแต่ละกลุ่มอายุโดยแบ่งเป็นกลุ่มอายุละ 5 ปี เพศ และจังหวัด ซึ่งมีทั้งหมด 76 จังหวัด ทั้งนี้จัดการข้อมูลด้วยการประมาณค่าในช่วงด้วยเส้นโค้งประเภท spline ผลจากการ

วิเคราะห์เชิงปัจจัยสามารถจัดกลุ่มประชากรของประเทศไทยได้สามกลุ่มที่มีรูปแบบที่แตกต่างกัน ทั้งนี้สามารถอธิบายรูปแบบ (pattern) ของประชากรตามการกระจายของอายุและเพศ พบว่า จำนวน 27 จังหวัดทางภาคใต้และภาคตะวันออกเฉียงเหนือของประเทศไทย ซึ่งส่วนใหญ่มีพรมแดนติดต่อกับประเทศพม่า กัมพูชา และมาเลเซีย มีรูปแบบการกระจายของประชากรตามมาตรฐาน (classical pattern) ส่วนประชากรในจังหวัดภาคกลางและภูเก็ตส่วนใหญ่มีรูปแบบการกระจายของประชากรที่คล้ายกัน ซึ่งมีจำนวนประชากรสูงสุดในกลุ่มอายุที่เป็นเยาวชน ในทางกลับกันจังหวัดทางภาคเหนือจำนวนประชากรส่วนใหญ่ลดลงในกลุ่มอายุที่เป็นเยาวชน สรุปได้ว่าการกระจายของประชากรในประเทศไทยไม่ได้มีสัดส่วนที่เหมือนกันทั่วประเทศ และการวิเคราะห์เชิงปัจจัยสามารถประมาณความแปรปรวนของประชากรได้อย่างเหมาะสม และสามารถจัดกลุ่มของประชากรในแต่ละจังหวัดได้สามกลุ่ม

ส่วนที่สองของการศึกษาใช้ข้อมูลจากการสำมะโนประชากรปี พ.ศ. 2554 ประเทศเนปาล การศึกษานี้เป็นการจัดกลุ่มประชากรในแต่ละอำเภอของประเทศเนปาล ซึ่งขึ้นอยู่กับรูปแบบโครงสร้างของอายุและเพศด้วยวิธีการวิเคราะห์เชิงปัจจัย เพื่อวิเคราะห์ประชากรอายุรายปี (single-year) ที่ปรับให้เรียบด้วยวิธี spline แยกตามเพศและอำเภอ ผลจากการวิเคราะห์เชิงปัจจัย ตัวแบบที่กลมกลืนกับข้อมูลประชากรในประเทศเนปาลมากที่สุด คือ ตัวแบบที่จัดปัจจัยเป็น 3 กลุ่ม ซึ่งอธิบายถึงรูปแบบการกระจาย 3 รูปแบบตามลักษณะของการกระจายของประชากรตามอายุและเพศ ทั้งนี้พบว่ากลุ่มอำเภอจำนวน 23, 17 และ 5 อำเภอมีความสัมพันธ์กับปัจจัยเดียวคือปัจจัยที่หนึ่ง สอง และสาม ตามลำดับ และพบว่าจำนวน 30 อำเภอมีความสัมพันธ์กับสองปัจจัยขึ้นไป สรุปได้ว่าโครงสร้างของอายุและเพศในประเทศเนปาลในปี พ.ศ. 2554 มีความ

แตกต่างกันอย่างมากในแต่ละอำเภอที่มีความความแตกต่างกัน และตัวแบบเชิงปัจจัยทั้งสามกลุ่มสามารถอธิบายความแปรปรวนของข้อมูลได้อย่างเหมาะสม

ส่วนที่สาม คือ การวิเคราะห์การเปลี่ยนแปลงระหว่างปีสำมะโนประชากร (inter-census) ในประเทศเนปาล โดยใช้ข้อมูลการสำรวจสำมะโนประชากรประเทศเนปาลปี พ.ศ. 2544 และ 2554 การศึกษาเชิงพรรณนาในครั้งนี้มีวัตถุประสงค์เพื่อสรุปความแปรปรวนในการเปลี่ยนแปลงระหว่างปีสำมะโนประชากรในระดับอำเภอ แยกตามกลุ่มอายุและเพศ และสำรวจองค์ประกอบที่เป็นไปได้ของการเปลี่ยนแปลงเหล่านี้ การจัดกลุ่มของประชากรแต่ละอำเภอขึ้นอยู่กับจำนวนและร้อยละของการเปลี่ยนแปลงระหว่างปีสำมะโนประชากร และนำเสนอข้อมูลด้วยแผนที่ ทั้งนี้ประชากรอายุรายปี (single year age population) สร้างกราฟสำหรับการประมาณค่าในช่วงด้วยเส้นโค้งประเภท spline สำหรับอายุรายปีของประชากร แยกตามอำเภอที่มีค่าร้อยละระหว่างปีสำมะโนประชากรที่เป็นค่าลบและบวกของในแต่ละเพศ อำเภอในสามอันดับแรกที่มีร้อยละของประชากรเพิ่มขึ้นสูง คือ กาฐมาณฑุ (Kathmandu) 61.23% ลาลิตเปอร์ (Lalitpur) 38.59% และ บัคตาเปอร์ (Bhaktapur) 35.12% ในขณะที่สามอันดับแรกของอำเภอที่มีประชากรลดลงอย่างรวดเร็ว คือ มานัง (Manang) -31.80% คอตัง (Khotang) -10.84% และ มุสตัง (Mustang) -10.21% รูปแบบที่มีการลดลงของประชากร พบในอำเภอที่อยู่ในเขตภูเขา และเนินเขาในภาคตะวันออก ภาคกลางและเขตพื้นที่การพัฒนาภาคตะวันตก ในขณะที่รูปแบบการเพิ่มขึ้นสามารถพบได้ในทุกอำเภอของพื้นที่เทอราย (Terai) และเกือบทุกอำเภอในภาคกลางและพื้นที่ห่างไกลในภาคตะวันตกของประเทศเนปาล รวมถึงสามอำเภอในหุบเขากาฐมาณฑุ (Kathmandu) ประชากรกลุ่มใหม่ที่มีขนาดเล็กในแต่ละกลุ่ม ชี้ให้เห็นถึงอัตราการเกิดที่ลดลงทั้งในเพศชายและ

หญิง ในขณะที่สัดส่วนของประชากรในกลุ่มอายุวัยทำงานกลับเพิ่มขึ้น สรุปได้ว่า การเปลี่ยนแปลงระหว่างปีสำมะโนประชากรมีสามแบบ แบบที่หนึ่งคือ การลดลงของประชากรกลุ่มใหม่ (new cohort) ในอำเภอส่วนใหญ่ แบบที่สอง คือ การเพิ่มขึ้นของประชากรกลุ่มอายุวัยทำงาน แต่ขาดแคลนเพศชายวัยผู้ใหญ่ (young adult male) ในบางอำเภอ และแบบสุดท้ายคือการเริ่มมีประชากรวัยชราเพิ่มขึ้น

สรุป การกระจายของประชากรตามอายุและเพศมีความแตกต่างกันอย่างมีนัยสำคัญทั้งในประเทศไทยและประเทศเนปาล จากผลของการศึกษาในส่วนที่หนึ่งและสอง พบว่า ตัวแบบที่จัดปัจจัยเป็นสามกลุ่มที่ได้จากการวิเคราะห์เชิงปัจจัยสามารถอธิบายความแปรปรวนของข้อมูลได้อย่างเหมาะสม วิธีการที่ใช้ในการศึกษานี้คือ ใช้หลักการและแนวคิดใหม่โดยการใช้วิเคราะห์เชิงปัจจัยเป็นพื้นฐานในการจัดกลุ่มประชากรแต่ละจังหวัด ซึ่งสามารถนำไปประยุกต์ใช้กับการศึกษาทางด้านประชากรศาสตร์ในโอกาสต่อไป การเปลี่ยนแปลงระหว่างปีสำมะโนประชากรมีความแตกต่างกันในแต่ละอำเภอของประเทศเนปาล อัตราการเกิดและการอพยพย้ายถิ่นเป็นองค์ประกอบหลักที่มีผลต่อความแปรปรวนของประชากร ผลจากการศึกษาครั้งนี้เชื่อได้ว่ามีความเกี่ยวข้องกับการเปลี่ยนแปลงประชากร ดังนั้นจึงสามารถนำไปประยุกต์ใช้ในการวางแผนด้านประชากรต่อไปได้

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ABSTRACT

Thailand is in the low stationary phase of demographic transition and Nepal is in the late expanding phase of demographic transition. The probability of future population change depends mainly on current age-sex distribution of the population. Therefore, this thesis focuses on application of factor analysis in clustering provinces and districts based on age-sex distribution of population in Thailand and Nepal. The descriptive and comparative analytical strategies were adopted, including application of multivariate statistical method called factor analysis in demographic data. This thesis consists of three parts.

The first part of the study aims to apply factor analysis to cluster provinces based on age-sex distribution of population in Thailand. The data table consists of population counts by 5 years age group for each sex and 76 provinces. Data were managed using spline interpolation. Three-factor model was best fitted to data. Three factors were interpreted as pattern of age-sex distribution. This study found three distinct patterns of population distribution in Thailand. Twenty-seven southern and northeastern region provinces, mainly bordering Myanmar, Cambodia or Malaysia, share the classical pattern of population distribution. The majority of central region provinces, and also Phuket from the south share a similar population distribution pattern, which peaked at

the young age group. So too, most of the northern region provinces share another pattern that dipped at the young age group. In conclusion, population distribution is not symmetrical across Thailand. The factor model approximated well this variation and clustered the provinces in three patterns.

The second part of this study used population data form 2011 census in Nepal. This study clustered the districts in Nepal based on the patterns of age-sex structures by applying factor analysis. The factor analysis was applied to spline smooth single-year age population by sex and district. A three-factor model was best fitted to the data from Nepal. These three common factors were interpreted as three different patterns based on common characteristics of age and sex distribution. The study found that 23, 17 and 5 districts correlated purely to factor 1, 2 and 3, respectively. Thirty districts were found correlated with two or more factors. In conclusion, the age-sex structure varied substantially between the different districts of Nepal in 2011. The variations were explained well by a three-factor model.

The third part focuses on inter-census population changes in Nepal. The population data from Nepal census 2001 and 2011 were used for this part. This descriptive study aimed to summarize the variation in inter-census population changes at the district level by age and sex and explore possible componentsof these changes. The districts were grouped based on both absolute number and percentage of inter-census changes and presented in the thematic map. Spline interpolated single year age population plotted separately for positive and negative inter census district by sex. The top three highly increased districts by percentage were Kathmandu (61.23%), Lalitpur (38.59%), Bhaktapur (35.12%) whereas the top three highly decreased districts were Manang (-31.80%), Khotang (-10.84%) and Mustang (-10.21%). The decreasing

pattern was found in mountain and hilly districts of Eastern, Central and Western development regions, whereas the increasing pattern was found in all the districts from Terai and almost all the districts of the Mid- and Far-western region of Nepal including three districts in Kathmandu valley. Each new smaller cohort indicated the decreasing fertility in both male and female but the proportion of working age population is increasing. In conclusion, three main inter-census population changes were found. The first is decreasing new cohorts in majority of the districts, the second one is increasing working age population, but absence of young adult male in some districts, and the last one is beginning of an ageing population.

In conclusion, the age-sex distribution varied substantially in both Thailand and Nepal. Based on the results obtained from first and second part of the study, the variations were explained well by three-factor models. The method used in this study is straightforward and the novel concept of using factor as a basis for clustering provinces is applicable to the further demographic studies. Inter-census population change also varied between districts in Nepal. Fertility and migration were the main components responsible for such variation. It is believed that the results from this study pertaining to population dynamics would greatly contribute to population programs.

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Binita Kumari Paudel

Table of Contents

List of Tables

List of Figures

List of Acronyms

AIDS	Acquired Immune Deficiency Syndrome
CBS	Central Bureau of Statistics
CIA	Central Intelligence Agency
DHS	Demographic and Health Survey
HIV	Human Immune deficiency Virus
ICR	Intelligent Character Recognition
ILO	International Labor Organization
MOPH	Ministry of Population and Health
NDHS	Nepal Demographic and Health Survey
NESDB	National Economic and Social Development Board
NPHC	Nepal Population Housing Census
TFR	Total fertility Rate
UBOS	Uganda Bureau of Statistics
VDC	Village Development Committee

Chapter 1

Introduction and Literature Review

1.1 Introduction

Population is the function of key demographic variables that are birth, death, and migration. Population Reference Bureau (2009) defines population distribution as the patterns of settlement and dispersal of a population. Settlement and dispersal of a population in different geographical area is called “spatial distribution of population” whereas age and sex distribution of population is called age-sex distribution. This thesis mainly focused on age–sex distribution patterns within a country and its geographic distribution. It is an undeniable fact that developed and developing countries have different types of age-sex distribution patterns (United Nations Secretariat, 2003). The countries having an epidemic, like HIV/AIDS in African countries, have dip among young age group (Figure 1.1). Developing countries mainly have the classical pattern of population distribution in which the number of children is high and the skew towards young ages like in Nepal (Figure 1.3), whereas in developed countries the skew tends to be towards older ages. The responsible phenomenon behind these dissimilarities is the differences in fertility, mortality and migration among countries and geographic regions. For instance, total fertility rates range from 0.9 children per woman in Taiwan to 7.0 in Nigeria (Population Reference Bureau, 2012).

The above-mentioned differences exist within a country. Even in United States, population change varies widely within states (Population Reference Bureau, 2012). The population pyramid of Thailand (Figure 1.2) and Nepal (Figure 1.4) may not

represent each province and districts. One can predict many differences in the pattern of population distribution within the country in Thailand and Nepal. In Thailand, there are 76 (currently 77) provinces and in Nepal, there are 75 districts. Therefore, the following questions were raised: Are there any differences in the pattern of population distribution among the seventy-six provinces in Thailand and among seventy-five districts in Nepal? If the answer is positive, does every province/district have a unique distribution pattern or do some of them follow the same pattern? Is there any statistical method to provide the evidence that some provinces/ districts follow the same pattern? Another question to ask is if some provinces/districts follow the same pattern, what are the characteristics of each pattern?

The researcher tried her best to search and reviewed many literatures, but could not find the answer of above-mentioned questions. So, in order to find the answer, this study applies a statistical method called “factor analysis”. Factor analysis was invented more than 100 years ago by psychologist Charles Spearman (1904) and has been used, since, mostly in psychological studies. This method also has been applied widely in different areas, for example, the assessment of water quality (Liu *et al*., 2003), in ecological data (Rittiboon *et al*., 2012), and in health care research (Pett *et al*., 2003). Carey (1966) had also applied this method to interpret the population and housing pattern. Lee and Carter (1992) used single factor model to forecast the mortality in United State. Therefore, there might be a scope of using factor analysis in demographic research to examine the age-sex structure pattern.

The information on the age-sex structure of population distribution is regarded as the indicator of development and health status. Thailand and Nepal, both countries are in the demographic transition (Porapakkham *et al*., 2010; Government of Nepal, 2011).

The detail information on population distribution is very advantageous for future demographic prediction**.** The demographic information is not only useful in formulating policy, plan and programs related to fertility, mortality and migration, but also related to other socio-economic issues like taking care of the aging population. Hence, the information obtained from this study would be useful to set up a long-term plan and policies on issues related to the demographic transition. Therefore, this study aims to fill the information gap up by clustering provinces and districts in both Thailand and Nepal and investigate the applicability of factor analysis for this purpose.

1.2 Objectives

The overall goal of this thesis is to identify the different patterns of the population distribution by applying factor analysis. The specific objectives of this thesis are as follows:

- To explore and describe the population distribution patterns of 76 provinces in Thailand using data from 2000 Thai population census.
- To explore and describe the population distribution patterns of 75 districts in Nepal using data from the 2011 population census.
- To explore and summarize the inter census population changes at the district level in Nepal.

The expected benefit of this study is twofold. The statistical method that was applied and the information, that was obtained from the study, both, would be an important and noble in the field of demographic. Firstly, factor analysis is a straightforward and widely used multivariate method, which also can be used widely in future

demographic studies. Secondly, the information on population distribution patterns in small geographical levels, such as districts and provinces, would help to develop some insight about the phenomenon of population distribution. Such evidence-based information would be very important to plan and implement programs related to fertility, mortality and migration. Allocation of the different resources also depends on the population distribution. Understanding the details on age sex structure pattern would be useful in future projections of population growth or decline.

1.3 Literature Review

1.3.1 Age- sex distribution of population in the world

Age and sex distribution pattern varies by country and geography**.** There are mainly four different patterns, namely expanding or traditional (Abbasi-Shavazi, 2001), stationary, contracting and spearhead. The population pyramid of Thailand (Figure 1.2) looks like moving from stationary to contracting pattern. The pyramid of Uganda (Figure 1.1) shows the dip or narrow in the middle in male. The United State population is growing slowly but there is variation within the country (Population Reference Bureau, 2012). Population structure within the country can also vary by wealth. In Malawi, 43% of the population is under age 15 among the households in the wealthiest quintile, whereas 53% among the household in the poorest quintile (Population Reference Bureau, 2012). According to Index Mundi, 25.79% of the world population are 0-14 years old and 8.32% are 65 years and over. Remaining 66% belong to working age group. However, vast differences can be found between developed and developing countries.

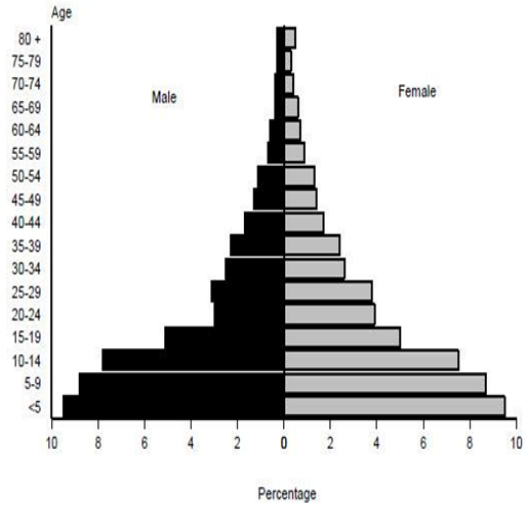

Figure 1.1: Population pyramid of Uganda

Source: DHS survey -2011

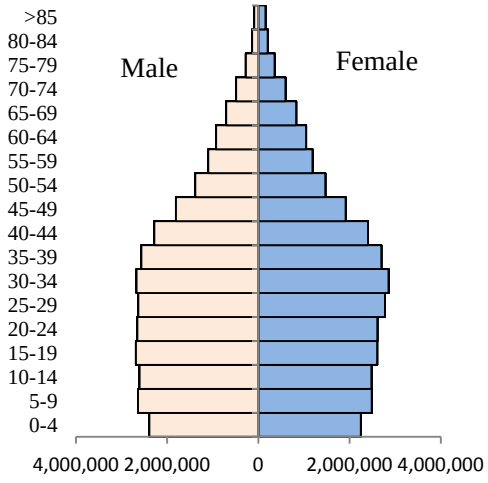

Figure 1.2: Population Pyramid of Thailand Census 2000

1.3.2 Age- sex distribution of population in Thailand

In Thailand, fertility was high until 1970. Then it moved into a decline phase. After 1990, it was in a low fertility phase for 6-7 years. Now, it is in the phase of 'below replacement' (Prasartkul *et al*., 2011). Mortality is also in a decreasing trend; infant mortality is decreasing at a slow pace. According to the CIA the world factbook 2012, the current net migration rate is zero but the internal migration within the country, from rural province to urban and industrial province, always remained substantial (International Organization for Migration, 2011; Guest *et al*., 1994). Similarly, the HIV epidemic in Thailand is yet another important event that affects the population distribution. It was estimated that the number of deaths from AIDS before the year 2000 was 550,000 (Surasiengsunk *et al*., 1998). AIDS was the leading cause of male deaths and the second leading cause of female deaths amounting to 16.5% and 6.3% respectively, of total deaths in 1999 (Porapakkham *et al*., 2010). The provinces in

Northern Thailand, adjacent to Myanmar and Laos, were greatly affected by this epidemic (Surasiengsunk *et al*., 1998). Thailand is in the low stationary phase of demographic transition where age-sex structure is moving from stationary to contracting pattern.

1.3.3 Age- sex distribution of population in Nepal

Nepal is in the late expanding phase of the demographic transition indicated by slowdown the natural increase rate due to the rapid decline of births and slow decline of deaths (Kunwar, 2012). Total Fertility Rate (TFR) (around 6.3) was relatively constant until mid eighties. Thereafter, it started to decline and there was a substantial reduction in fertility mainly during 1999-2004. Nepal Demographic and Health Survey 2006 estimated TFR for Nepal to be 3.1 (Government of Nepal, 2011). Similarly, mortality rates started to decline since 1930s (Feeney *et al*., 2001). Mortality declined relatively quicker due to increased access and improved health services. But declining fertility was slower than the mortality. As a result, Nepal's population was increasing fast (Government of Nepal, 2011). For last 5 decades since 1952-2001, annual exponential growth rates were more than 2%. However, it was found to be 1.35 in recent census-2011 (Central Bureau of Statistics, 2012). Other than fertility and mortality, migration has substantial effect on age-sex composition and growth of population in a country (Haupt *et al*., 2011; Tiwari, 2014). Internal and external migration has found to be substantially rising (Sharma *et al.,* 2014). The net migration rate for 2011 is estimated at -10.32 per thousand populations (Central Bureau of Statistics, 2014). The population pyramids of Nepal (Figure 1.3 and Figure

1.4) show that the new cohorts are becoming smaller in both male and female. However, the broad base pyramid of Nepal is indicating future population growth.

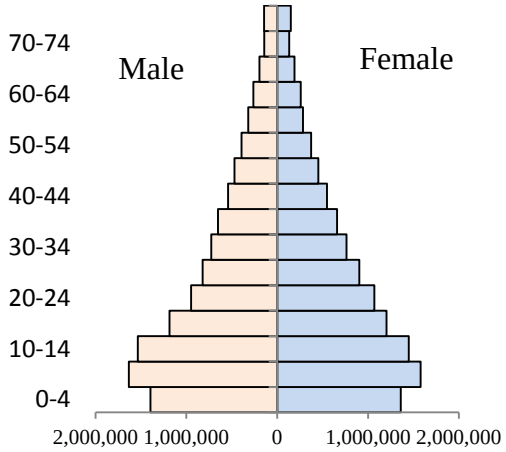

Figure 1.3: Population pyramid of Nepal, census 2001

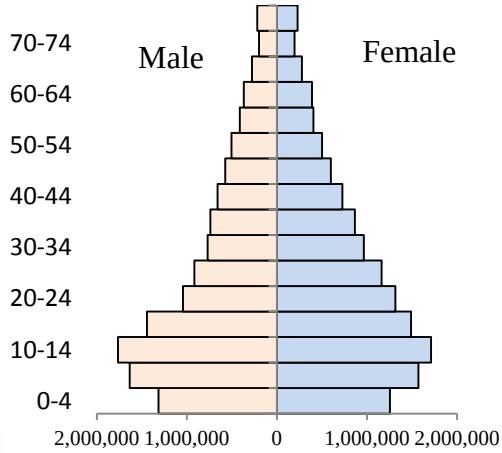

Figure 1.4: Population pyramid of Nepal, census 2011

1.3.4 Application of factor analysis

Factor analysis was invented more than 100 years ago by psychologist Charles Spearman (1904). Since, then it has been using widely not only in psychological study but also in different field of studies for different purposes. Most of the studies used factor analysis aiming to reduce the dimensionality of data for further analysis. In this case, the result from factor analysis would be in further modeling of data. For instance, the factor analysis was used as an intermediate analysis to determine a social-demographic poverty index and findings was used for further analysis (Latifa *et al.*, 2008). Lueangthuwapranit *et al*. (2011) also used factor analysis to explore five common factors to group the 12 different physicochemical variables. Then, they used this information in multiple linear regression analysis to see the relationship between phytoplankton density and physicochemical variables. Some studies used this method

as a final step of analyzing data. For instance, this method was used to assess the groundwater quality by using factor analysis (Liu *et al*., 2003) and 13 hydrochemical parameters were grouped into two common factors and interpreted as seawater salinization and arsenic pollutant. Another study categorizes the group of birds that are correlated with respect to their habitat and availability of food (Rittiboon *et al*., 2012). This study allocated 23 bird species in five interpretable groups from the Thale Noi Non-hunting Area, Southern Thailand. Carey (1966) had also applied this method, in the field of geography, to interpret the population and housing pattern. In the field of demography, Lee and Carter (1992) used single factor model to forecast the mortality in United State. This method also became very popular in forcasting mortality (Wang, 2007)

In summary, factor analysis, a multivariate statistical method, is well established and has been using widely not only for analyzing data from psychology, but also with data from different field including water quality assessment and classification of the species of different birds. The method is mainly used to group and describe the set of variables for further analysis. However, neither study used factors as a basis of describing age-sex distribution pattern of any countries. Therefore, this study assesses the scope of applying this method in demographic data specially to cluster provinces based on age and sex distribution of population.

Chapter 2

Methodology

This chapter describes the overall methodology used in all three papers included in this thesis. This chapter describes all aspects of methodology and organizes it in subheadings including research designs, data source and the approach of data management and analysis.

2.1 Research design

The descriptive and comparative analytical strategy was adopted, including application of multivariate statistical method called factor analysis in demographic data.

2.2 Data Source, approach of data collection and sample

This thesis analyzed the age-sex distribution of population using population census data from both Thailand and Nepal. The main reason behind using census data is its completeness and accuracy compared to any other survey or vital registration. Usually, census employs the de-facto or de-jure types of data collection. Therefore, census data provide the actual picture of whole country and its population's characteristics at specific point of time periodically, usually every10 years (Demena, 2005).

The main goal of this thesis was to investigate the applicability of statistical method in population data for clustering the provinces. We applied this method in data from 2000 Thai census. Population data either from recent census or from previous census

does not make any difference in overall conclusion of the study. Although, we had have used data from recent Thai census, our conclusion would be the same.

2.2.1 Data from Thailand

The population data of Thai census 2000 was retrieved from the website of National Statistical Office, Ministry of Information and Communication Technology, Thailand for each province separately (National Statistical Office, Thailand 2000). This census counted the number of population and their demographic and socioeconomic characteristics as well as housing characteristics. However, we used only number of population in each province by age groups and sex for this study. While data was collected for whole month of April 2000, April 1st was considered as a census day. Although major method of data collection was field interview, self-enumeration forms were also used mainly in apartment blocks (Boonperm, 2004).

Entire Thai citizens residing in the country on the census day including those persons having their usual residence in Thailand but temporarily away on that day were counted in the census. Citizens of foreign countries having their usual residence in Thailand, or those who have resided in Thailand for at least three months were also counted. Populations excluded in the census were hill tribes having no permanent place of residence, refugees or illegal immigrants located in the camps and foreigners who had been residing in Thailand for less than three months. Entire individuals and households were enumerated using the short form questionnaire except 20% sampled households from Bangkok, municipal and non-municipal areas. The sampled households were enumerated using the long form questionnaire (Boonperm, 2006).

Explanation of the original data table is provided below in the data management subsection.

2.2.2 Data from Nepal

The census counts**,** grouped by 5-year age gap, by sex and by districts, retrieved from table number 16 of the National Population and Housing Census 2011 (National Report) Volume 01, NPHC 2011 (Central Bureau of Statistics, 2012). The population data table 10 of National Report 2001 Census was retrieved from the website of the Government of Nepal, National Planning Commission Secretariat, Central Bureau of Statistics (Government of Nepal, 2005).

According to National Report of Population Census 2001, the data collection process was affected by political unrest in different parts of the country in 2001 census. There were 3,914 Village Development Committees (VDCs) and 58 municipalities during the 2001 census. There were 36,032 wards (35,226 rural wards and 806 urban wards) in the country. Of the total 36,032 wards, 957 (955 rural and 2 urban wards) from 12 different districts were affected because of this political conflicts. Seven hundred and forty seven wards were completely affected and remaining wards were partly affected. In some parts of the Salyan and Kalikot districts, listing was also disturbed. The population was estimated based on the listing sheet and following other estimation procedures in these 12 districts. The estimated total population was established as 23,151,423 (11,563,921 males and 11,587,502 females) in 2001 census. However, detail characteristics of households and population provided in statistical tables were based on information from 4,174,374 households and 22,736,934 population (11,369,378 male and 11,377,556 females) who were actually counted in the census

(Central Bureau of Statistics, 2005).Therefore, the data that was retrieved for this study was before adjustment for undercounts in 12 districts. The detail information on how we managed this data is explained in data management section below.

2.3 Approach of data management and analysis

The possible application of factor analysis in population data was examined by applying this method to Thai census data. First manuscript was prepared from this analysis. Then, same method was applied to analyze data from Nepal and prepared second manuscript. Third manuscript was prepared on inter census population changes at the districts level by age and sex in Nepal. The brief description of data management and analysis used for all three manuscripts stated below separately.

2.3.1 Management and analysis of Thai data

The population by 5 years age group from each province was retrieved separately and prepared a data table that contains 76 rows (provinces) and 36 columns (by 5 years interval age group and sex) from Thai census 2000. A discrepancy was found between total number of the population obtained from province level data used in this study and final population census report. The Preliminary Report of the 2000 Population and Housing Census cautioned data users about this problem (Central Bureau of Statistics, 2005). However, the conclusion of the study would not be distorted due to this discrepancy in counts.

Factor analysis, a multivariate statistical method, was used to cluster the provinces, which were based on age-sex structure of the population. The factor model starts with a numerical data array whose columns are outcomes and rows are occasions or subjects on which the outcome variables are measured (Manly, 1994). Since our

objective is to cluster the provinces, they have to be considered as variables or outcomes so the original data table needs to be transposed. In this case, there will be 76 provinces in the columns (as outcomes) and 36 sex-age groups in the rows (as subjects) in the new table. Doing the factor analysis, the data table needs to have many more rows than columns. Therefore, we have to add more rows by extending the population into single-year age groups. For this purpose, the natural cubic spline was applied (McNeil *et al*., 2011).

2.3.1.1 Natural Cubic Spline

McNeil *et al*. (2011) recommended an appropriate method for smoothing population data using spline function by placing an additional knot with a value chosen to make the function have zero derivatives at the maximum age.

For knot at ages x_i (i = 1,2,……,n) and artificial knot at age a, the functional form of the natural cubic spline is as equation 1.

$$s(x) = \sum_{i=1}^{n} c_i(x - x_i)_+^3 + g(x - a)_+^3 \text{ ……(1)}$$

For age-specific population in 5 years age groups up to 85 years and 85years and older, x_i thus takes values 0, 5, 10, …, 85 with the artificial knot at a=90. This method interpolated the data for single-year ages up to 105 of which 90 for each sex were used to create a data table with 76 columns and 180 rows for factor analysis.

Therefore, the new data matrix has 76 columns corresponding to the provinces and 90 *2 = 180 rows corresponding to a single year age population of males and females. Spearman rank-order correlation was used to construct the 76*76 covariance matrix for handling non-linear relationships between province variables.

2.3.1.2 Factor model and factor loadings

If y_{ij} is the outcome in row *i* and column *j* of the r * c matrix data array, the factor model is formulated as equation 2.

$$y_{ij} = \mu_j + \sum_{k=1}^{p} \lambda_j^{(k)} f_i^{(k)} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(2)$$

Where, μ_j is the mean of variable in columns, the *p* column vectors $f^{(k)}$ in this model are called common factors and the *p* row vectors $\lambda^{(k)}$ are called their loadings. The factor loadings obtained from factor analysis were used to determine the correlation between provinces and common factors.

2.3.1.3 Extraction of factors and factor rotation

There are different factors extraction methods used in factor model. Factor model, in this study, used maximum likelihood to account for correlations between the set of outcome variables in the data matrix and extraction of appropriate number of factors (Venables and Ripley, 2002; Costello and Osborne, 2005). Numbers of factors were decided by running multiple factor analysis and setting the number of factors to retain manually looking at the distribution of loading and variance explained by each factor.

In order to obtain a clearer pattern and interpretable result, the provisional factors can be transformed. This process is called “factor rotation”. The fit of the model is unchanged by rotating the factors (Johnson and Wichern, 1988). The factor rotation can be orthogonal or oblique. The “varimax” rotation is orthogonal and the “promax” rotation is oblique with the same purpose. The only desirable element in selection of type of rotation is that the factor loading should be either close to zero or very different from zero so that the result will be clear and interpretable (Manly, 1994). In this study, we tried both orthogonal and oblique rotation. Finally, “promax” rotation

provided the clearer pattern compared to “varimax” rotation. Therefore, we employed promax rotaion.

The factor model also gives the “uniquenesses” corresponding to each province, for which values close to 1 provide evidence that they cannot be associated with any factor, and thus should be omitted from the factor model (Mardia et al., 1980). In this study, the uniqueness ranges 0.005-0.060 so no evidence emerged to omit any province from the factor model. Therefore, all the variables (provinces) were included in the three factors model. The factors loading higher than 0.57 were considered as a significant level for a pure factor. For the variables (provinces) distributed into two or more factors, factor loadings between 0.33-0.56 were considered to indicate mixed factors.

2.3.2 Analysis of Nepal data

We further wanted to test the applicability of factor analysis in clustering districts based on age, sex distribution of population data from different country. We used the same methods “natural cubic spline” for data management, and “factor analysis” for modelling as stated above under the heading analysis of Thai data. The original data table from the 2011 census in Nepal was similar to that original data table from the 2000 census in Thailand. However, the number of rows and columns were not same. There were 75 rows (districts) and 38 columns (age-sex groups) from 2011 census. We modified the same method and used in this data.

2.3.2.1 Data management for 2001 census of Nepal

As motioned before, of the total 75 districts, the population was undercounts in 12 districts due to political unrest that was going on during 2001 census. Since this study

intends to analyze changes at the district level, we need 5 years age grouped data at district level. For this purpose, the overall proportion of undercount in each district was calculated separately by sex. Then, we used this proportion to rescale the population of those 12 districts having undercount due to political unrest in 2001. Spline interpolation was used to interpolate single year age population upto100 years (McNeil, *et al*., 2011).

2.3.2.2 Data analysis for inter-census population changes

First, the differences in population between 2001 census and 2011 census for each district were calculated. Then, percentage of inter-census changes was calculated and grouped the districts into five categories based on percentage of change and absolute number of changes. The results were presented in a thematic map. We were interested to see these changes by age and sex. Therefore, single year age population of 2001 and 2011 census was plotted separately for each district by sex. The population change was examined in three major age groups: <15 years, 15-64 years and 65 and above.

2.3.3 Computer programs used to manage and analysis data

Microsoft word, Microsoft excel and a statistical computing program R were used while preparing this thesis. Microsoft Excel was used to save data, manage data and create tables. Data management, analysis and preparation of graphics were done by using R (R Core Team, 2014). Report was prepared using Microsoft word.

Chapter 3

Results

This thesis focuses on three main objectives related to population distribution in Thailand and Nepal. This chapter is organized into three parts based on these objectives. Part one describes the results related to population distribution pattern in Thailand, including application of factor analysis followed by part two on population distribution in Nepal. Finally, part three presents and compares the inter census population changes in Nepal. Two manuscripts were prepared and published using the results related to first and second objectives. The third manuscript related to third objective is also under the revision process.

3.1 Population Distribution Patterns in Thailand

(**Article I**: Population Distribution Pattern of 76 Provinces in Thailand: Application of Factor Analysis (Paudel *et al*., 2015a)

3.1.1 Loadings from Factor Analysis

Table 3.1 presents the factor loading of the 76 provinces of Thailand. Provinces were sorted based on factor loading. This factor loading reflects the correlation between province variable and common factors. Three-factor model was best fitted with the data and it explains 72% of the total provinces variation. Unique differences ranged from 0.005 to 0.060. Based on the cutoff value (>0.33), this study found that 27, 15 and 14 provinces correlated purely to factor 1, 2 and 3, respectively. Twenty provinces were found to be correlated with two factors. In this study, three different factors represent the 3 different patterns of population distribution, which will be described in detail below.

Table 3.1: Loadings obtained from three-factor model for Thai province, gender-age population at the 2000 census

Province ID	Factor 1	Factor 2	Factor 3	Province ID	Factor 1	Factor 2	Factor 3
94	**0.989**			67	**0.434**	0.125	**0.496**
96	**0.989**			26	**0.382**	0.209	**0.458**
58	**0.982**			23	**0.362**	0.252	**0.437**
95	**0.977**			42	**0.343**	0.247	**0.468**
63	**0.974**			10	-0.112	**0.96**	0.151
34	**0.973**			11		**0.94**	0.124
31	**0.972**			74		**0.927**	
81	**0.950**	0.101		13		**0.926**	
33	**0.946**		0.16	20		**0.905**	
91	**0.939**	0.114		14	0.122	**0.872**	
32	**0.938**		0.162	83	0.109	**0.868**	
48	**0.925**			73		**0.863**	
45	**0.902**		0.114	21	0.161	**0.852**	
37	**0.897**		0.171	12	-0.168	**0.849**	0.329
49	**0.895**		0.103	24	0.25	**0.798**	
35	**0.885**		0.224	19		**0.759**	0.196
80	**0.885**			70	0.154	**0.666**	0.219
92	**0.862**		0.129	77	0.284	**0.652**	0.102
39	**0.858**	0.176		76	0.219	**0.586**	0.238
93	**0.822**		0.162	22		**0.614**	**0.398**
27	**0.820**	-0.108	0.312	75		**0.588**	**0.401**
82	**0.773**		0.227	50	-0.168	**0.467**	**0.704**
44	**0.702**	0.128	0.214	16	0.162	**0.372**	**0.504**
46	**0.702**	0.157	0.183	51	-0.201	**0.355**	**0.842**
30	**0.696**	0.108	0.24	54			**0.993**
71	**0.684**	0.192	0.162	18			**0.934**
40	**0.573**	0.311	0.167	56			**0.923**
47	**0.754**	**0.339**		52		0.119	**0.922**
43	**0.736**	**0.418**	-0.137	17			**0.916**
41	**0.669**	**0.463**	-0.107	53		0.188	**0.865**
90	**0.616**	**0.509**	-0.113	66	0.319	-0.17	**0.856**
84	**0.524**	**0.489**		57		0.107	**0.823**
85	**0.515**	**0.612**	-0.113	64	0.120	0.104	**0.809**
86	**0.473**	**0.360**	0.219	15	0.215		**0.763**

Table 3.1 (Continue)

Province ID	Factor 1	Factor 2	Factor 3	Province ID	Factor 1	Factor 2	Factor 3
25	**0.352**	**0.555**	0.128	55	0.223		**0.742**
36	**0.635**		**0.372**	60	0.222	0.106	**0.718**
62	**0.619**		**0.500**	65	0.158	0.243	**0.646**
61	**0.470**		**0.633**	72	0.266	0.175	**0.606**
		SS loadings			26.07	14.22	14.06
		Proportion Variance			0.34	0.19	0.19
		Cumulative Variance			0.34	0.53	0.72

Notes: Cutoff value is >0.33, single loading >0.33 is considered as pure factors and others are associated with mixed factor

Loadings below 0.1 are not shown and loadings > 0.33 are in bold font

Province ID in table corresponds to the province name as below:

10	Bangkok	39	Nong Bua Lam Phu	66	Phichit
11	SamutPrakan	40	KhonKaen	67	Petchabun
12	NonthaBuri	41	UdonThani	70	Ratchaburi
13	PathumThani	42	Loei	71	Kanchanaburi
14	Ayutthaya	43	NongKhai	72	SuphanBuri
15	Ang Thong	44	MahaSarakham	73	NakhonPathom
16	Lopburi	45	Roi Et	74	SamutSakhon
17	Sing Buri	46	Kalasin	75	SamutSongkharam
18	Chai Nat	47	SakonNakhon	76	Phetchaburi
19	Saraburi	48	NakhonPhanom	77	Prachuap
20	Chon Buri	49	Mukdahan	80	Nakhon Si Thamarat
21	Rayong	50	Chaing Mai	81	Krabi
22	Chanthaburi	51	Lamphun	82	Phangnga
23	NongKhai	52	Lampang	83	Phuket
24	Chachoengsao	53	Uttaradit	84	SuratThani
25	PrachinBuri	54	Phrae	85	Ranong
26	NakhonNayok	55	Nan	86	Chumphon
27	Sa Kaeo	56	Phayao	90	Songkhla
30	NakhonRatchasima	57	Chaing Rai	91	Satun
31	Buri Ram	58	Mae Hong Son	92	Trang
32	Surin	60	NakhonSawan	93	Phatthalung
33	Si Sa Ket	61	UthaiThani	94	Pattani
34	UbonRatchathani	62	KamphaengPhet	95	Yala
35	Yasothon	63	Tak	96	Narathiwat
36	Chiyaphum	64	Sukhothai		
37	Amnat Charoen	65	Phitsanulok		

3.1.2 Analyzing spline smooth population in Thai provinces at 2000 census

The main task after factor analysis was to define the common factors. For this purpose, we plotted the spline smooth population of all provinces in Figure 3.1 ordered by the factor loadings shown in Table 3.1.

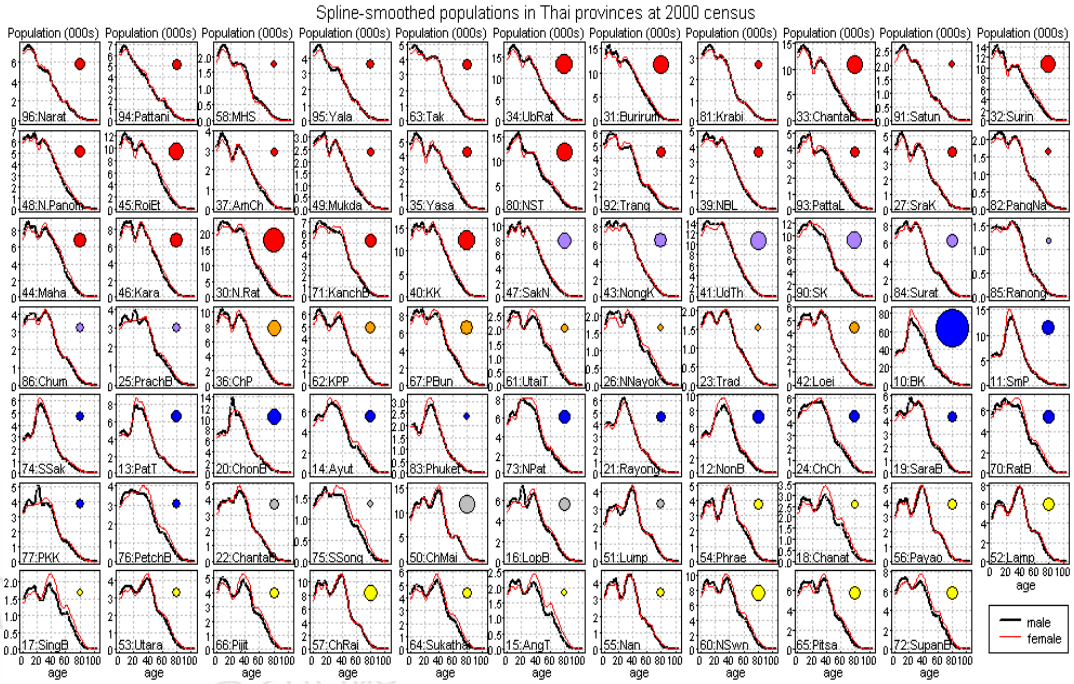

Figure 3.1: Spline smooth population, based on five-year age group, of 76 provinces in Thailand at 2000 census

Note: Intiger at the bottom of each graph indicates the province ID

X-Axis of the figure represent the single year age population and Y-Axis represent the population in 1000. Areas of each circle denotes the province population size and color of the circle indicates different factors in which provinces belongs to based on factor analysis. Circles coloured red, blue and yellow for provinces associated purely with factors 1, 2 and 3, respectively, and purple, orange and grey for provinces with loadings on factors 1+2, 1+3 and 2+3, respectively.

3.1.3 Interpretation of three factors

After careful examination of age-sex distribution of 76 provinces, we interpreted the three factors. Three factors obtained from factor analysis best represented by Narathiwat, Bangkok and Phrae, respectively (Figure 3.2). We defined three factors based on age-sex distribution of the population. The first factor, at the first column of Figure 3.2, shows a traditional pattern of population distribution characterized by a young age structure. In this pattern, each new cohort is larger, so the shape is like an exponential decay. The second factor, at the second column of Figure 3.2, shows the rapid declined of the population, and then leveled-off in the recent years. The third factor, at the third column of Figure 3.2, shows the fluctuating or complicated trends in the population distribution. This pattern includes the population dip between ages 20 and 40. Figure 3.3 presents the spline smooth single year age-sex structure for selected Thai provinces for more understanding of patterns. Five representative plots of the provinces associated purely with three factors arranged in first three rows and remaining eight plots are associated with mixed factors. Figure 3.2 and Figure 3.3 would help to understand the meaning of three factors and its pattern clearly.

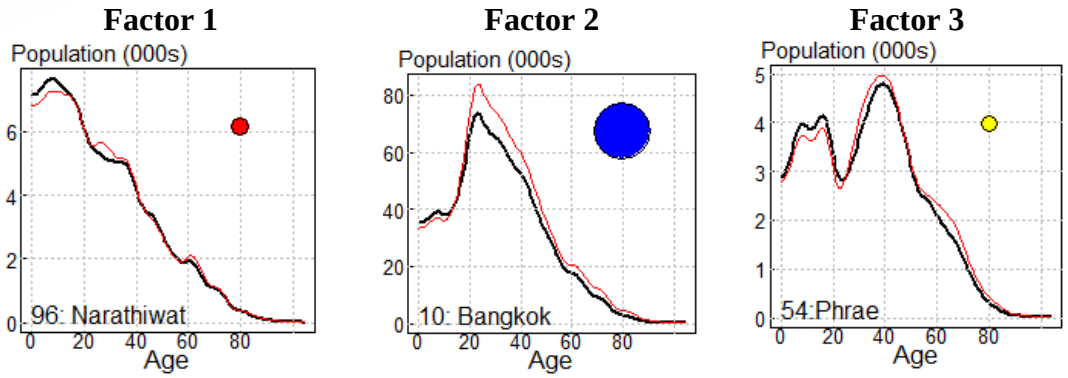

Figure 3.2: Provinces that best represented to the three factors from factor model in Thailand

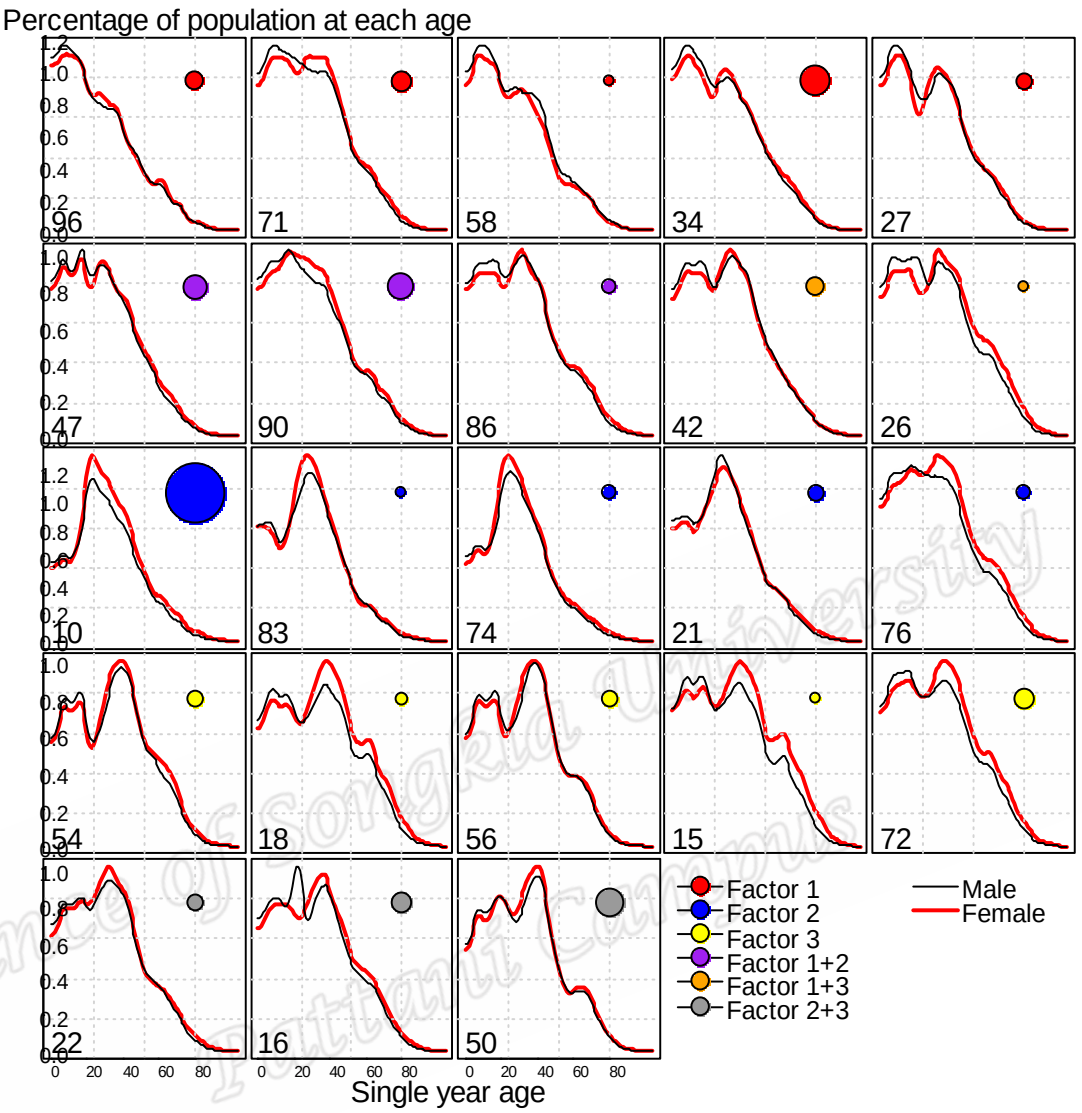

Figure 3.3: Spline-smoothed single year, age and sex distribution from selected Thai provinces at 2000 Census

Note: The area of the bubble in each province denotes its population size

Intiger at the bottom of each graph indicates the province ID, province name correspondence to province ID given in Table 3.1

3.1.4 Regional variation in population distribution patterns

Figure 3.4 shows the regional variation in population distribution pattern; denoted in six different colors from factor analysis. The majority of the provinces in the south and northeastern regions, mainly in the border provinces of Myanmar, Cambodia and Malaysia, shown in red color, have the same dominant traditional pattern of

population distribution. The Bangkok and surrounding provinces share a similar pattern of distribution that was peaked and then stabilized, shown in blue color. The central plain, north of Bangkok contains the provinces with the third pattern, with substantial dips in the population aged between 20 and 40 years in both male and female.

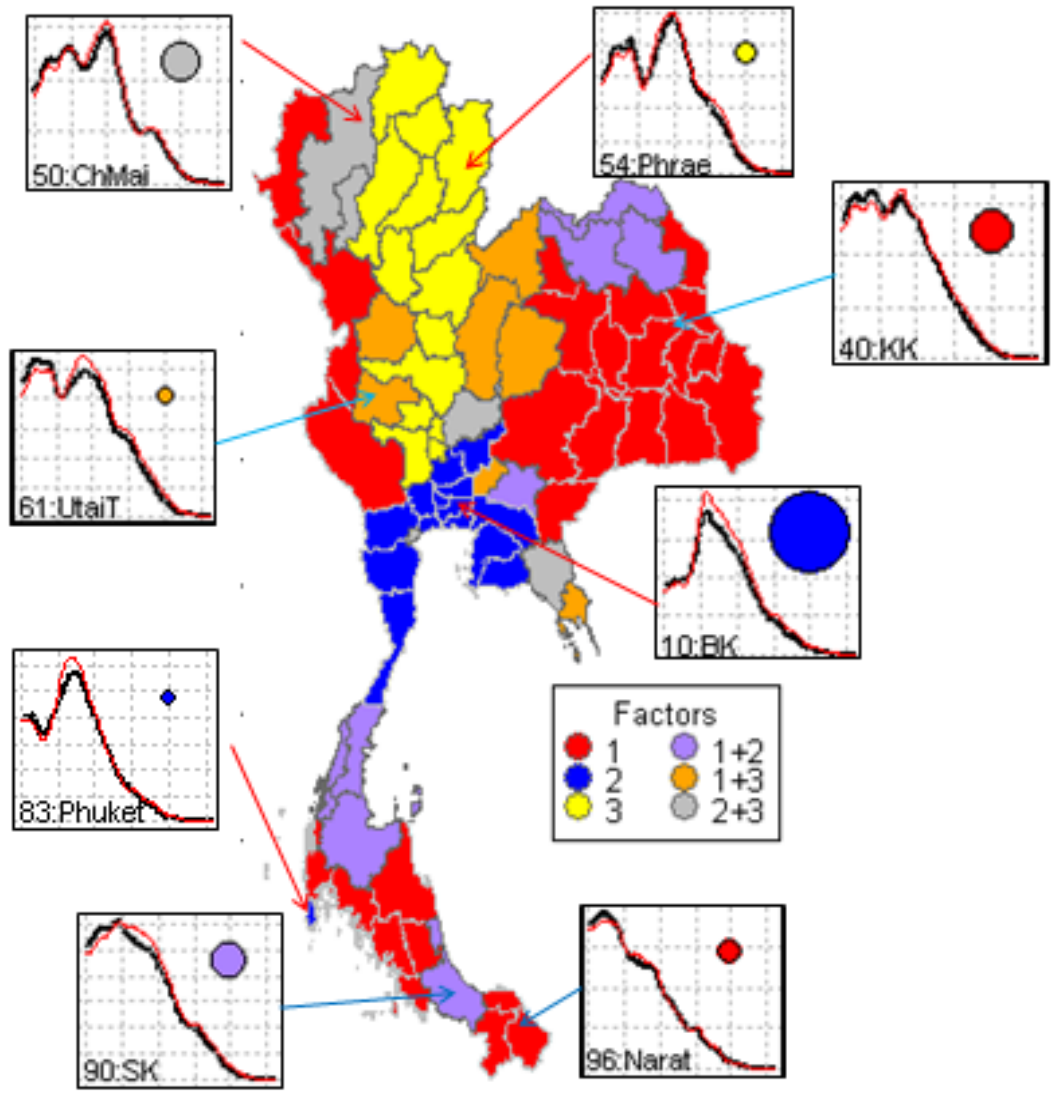

Figure 3.4: Thematic map of Thailand shows the regional variation in population distribution pattern in each province presented in colors from factor analysis of gender-age population at the 2000 census

3.2 Population Distribution Patterns in Nepal

(Article II: Analyzing Age-Sex Structure Patterns in Nepal Using Factor Analysis (Paudel *et al*., 2015b)

3.2.1 Loadings from Factor Analysis

The factor loading, presented in Table 3.2 reflects the correlation between districts (variables) and common factors. A three-factor model explained 50% of the total variation in the data of which factor 1 accounted for 24% followed by 16% and 10%, respectively by factor 2 and 3. Tabachnick and Fidell, (as cited in Costello and Osborne, 2005) suggested 0.32 as a good rule of thumb for the minimum loading of an item; we considered 0.33 as a cutoff value in this study. Twenty three, seventeen and five districts were grouped, respectively to factor 1, factor 2 and factor 3 without any "crossloading" more than the cutoff value. A "crossloading" is an item that loads more than 0.33 on two or more factors. We grouped such "crossloading" items and defined them as mixed factors. Twenty-seven districts were loaded on two factors and three districts were loaded on all three factors. Uniqueness of the districts ranges from 0.005-0.06.

Table 3.2: Loadings obtained from three factor model for gender-age population of 75 districts at the 2011 census in Nepal

DisID	Factor 1	Factor 2	Factor 3	DisID	Factor 1	Factor 2	Factor 3
46	**0.948**			59	**0.352**	**0.471**	0.229
36	**0.905**			55	**0.363**	**0.46**	0.229
39	**0.899**			29	**0.362**	**0.426**	0.262
37	**0.857**			20	**0.417**	**0.419**	0.216
51	**0.829**			24	**0.436**	0.210	**0.410**
44	**0.791**			48	**0.452**	0.268	**0.336**
45	**0.772**			4	**0.444**	0.231	**0.380**
47	**0.743**			5	**0.408**	0.292	**0.356**
38	**0.736**			58	**0.403**	0.302	**0.351**
21	**0.706**			40	**0.409**		**0.543**
12	**0.694**	0.223		35	**0.424**		**0.498**
22	**0.679**	0.209		3	**0.406**		**0.476**
43	**0.678**	0.274		65		**0.746**	
10	**0.670**	0.217		66		**0.724**	
13	**0.668**	0.247		64		**0.698**	
8	**0.654**		0.207	63		**0.688**	
2	**0.606**	0.218	0.223	62		**0.688**	
7	**0.598**		0.267	61	0.215	**0.664**	
1	**0.531**	0.315	0.203	34		**0.635**	0.221
30	**0.527**	0.288	0.236	32	0.218	**0.629**	
28	**0.480**	0.256	0.319	67	0.291	**0.602**	
23	**0.475**	0.312	0.265	33	0.240	**0.598**	0.208
11	**0.463**	**0.330**	0.259	19	0.270	**0.575**	0.202
52	**0.659**	**0.349**		60	0.315	**0.571**	
53	**0.508**	**0.431**		18	0.318	**0.555**	
9	**0.507**	**0.348**		50	0.291	**0.533**	0.225
14	**0.468**	**0.354**	0.230	15	0.329	**0.527**	
56	**0.408**	**0.350**	0.297	17	0.306	**0.523**	0.218
72	**0.393**	**0.364**	0.298	57	0.313	**0.437**	0.304
71	**0.359**	**0.367**	0.329	41		0.244	**0.896**
68	**0.356**	**0.559**		27			**0.884**
69	**0.383**	**0.541**		25			**0.877**
70	**0.409**	**0.539**		42			**0.846**

Table 3.2 (cont.)

DisID	Factor 1	Factor 2	Factor 3	DisID	Factor 1	Factor 2	Factor 3
16	**0.352**	**0.529**		26			**0.845**
75	**0.356**	**0.519**		6	**0.377**	**0.330**	**0.350**
74	**0.407**	**0.496**		49	**0.367**	**0.334**	**0.356**
54	**0.371**	**0.487**		31	**0.354**	**0.368**	**0.333**
73	**0.390**	**0.483**					
			SS Loadings		17.793	12.21	7.69
			Proportion Variance		0.237	0.163	0.103
			Cumulative Variance		0.237	0.400	0.503

Note: Cutoff value is >0.33, single loading >0.33 is considered as pure factors and other are associated with mixed factor

Loadings below 0.2 are not shown and loadings that exceed 0.33 are in bold font; Uniqueness ranges from 0.005 to 0.06

DisID in table correspond to the district ID and districts name as below

DisID	District Name	DisID	District Name	DisID	District Name
1	Taplejung	26	Bhaktapur	51	Arghakhanchi
2	Panchthar	27	Kathmandu	52	Pyuthan
3	Ilam	28	Nuwakot	53	Rolpa
4	Jhapa	29	Rasuwa	54	Rukum
5	Morang	30	Dhading	55	Salyan
6	Sunsari	31	Makwanpur	56	Dang
7	Dhankuta	32	Rautahat	57	Banke
8	Terhathum	33	Bara	58	Bardiya
9	Sankhuwasabha	34	Parsa	59	Surkhet
10	Bhojpur	35	Chitawan	60	Dailekh
11	Solukhumbu	36	Gorkha	61	Jajarkot
12	Okhaldhunga	37	Lamjung	62	Dolpa
13	Khotang	38	Tanahu	63	Jumla
14	Udayapur	39	Syangja	64	Kalikot
15	Saptari	40	Kaski	65	Mugu
16	Siraha	41	Manang	66	Humla
17	Dhanusa	42	Mustang	67	Bajura
18	Mahottari	43	Myagdi	68	Bajhang
19	Sarlahi	44	Parbat	69	Achham
20	Sindhuli	45	Baglung	70	Doti
21	Ramechhap	46	Gulmi	71	Kailali
22	Dolakha	47	Palpa	72	Kanchanpur
23	Sindhupalchok	48	Nawalparasi	73	Dadeldhura
24	Kavrepalanchok	49	Rupandehi	74	Baitadi
25	Lalitpur	50	Kapilvastu	75	Darchula

3.2.2 Interpretation of the three factors from factor model

In this study, three different factors corresponded to three different age-sex structure patterns. Age-sex structure of three districts in Figure 3.5 best represents the three factors. The spline-smoothed single-year age and sex plot (Figure 3.6) was examined carefully and three factors were interpreted as follows. The first factor shows that the young age (20-40 years) male population is missing and each new cohort (0-10 years of age) is smaller. Thus, the first factor is interpreted as "missing young adult pattern". The second factor shows that each new cohort is larger or just began decline and the shape represents an exponential decay. So, the second factor is interpreted as a "traditional pattern". The third factor shows the peak of the young adult population as well as a steep decline in each new cohorts. This factor best represents age-sex structure of the urban industrial area. Therefore, the third pattern is interpreted as an "urban pattern". The mixed factor presented in row 6th, 7th and 8th in Figure 3.6 shows the combine characteristics of corresponding factors.

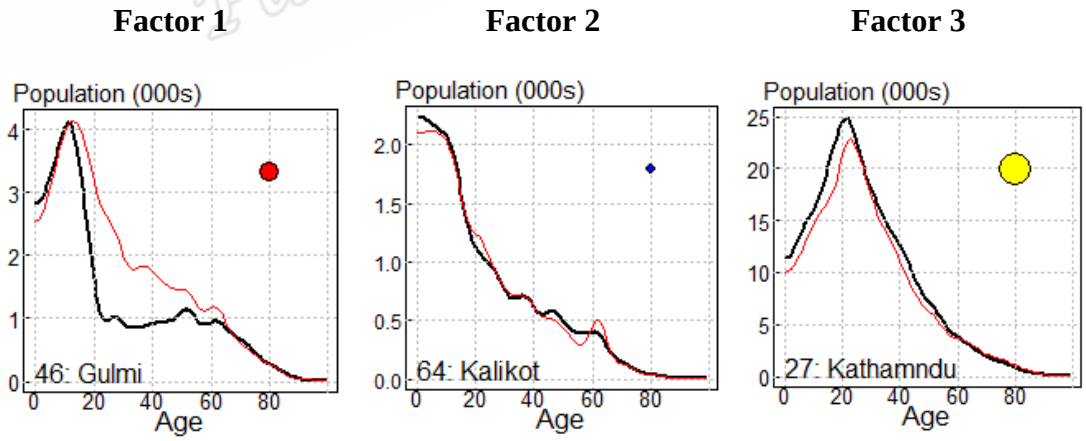

Figure 3.5: Age-sex structure of three districts that best represent the three factors extracted from factor model

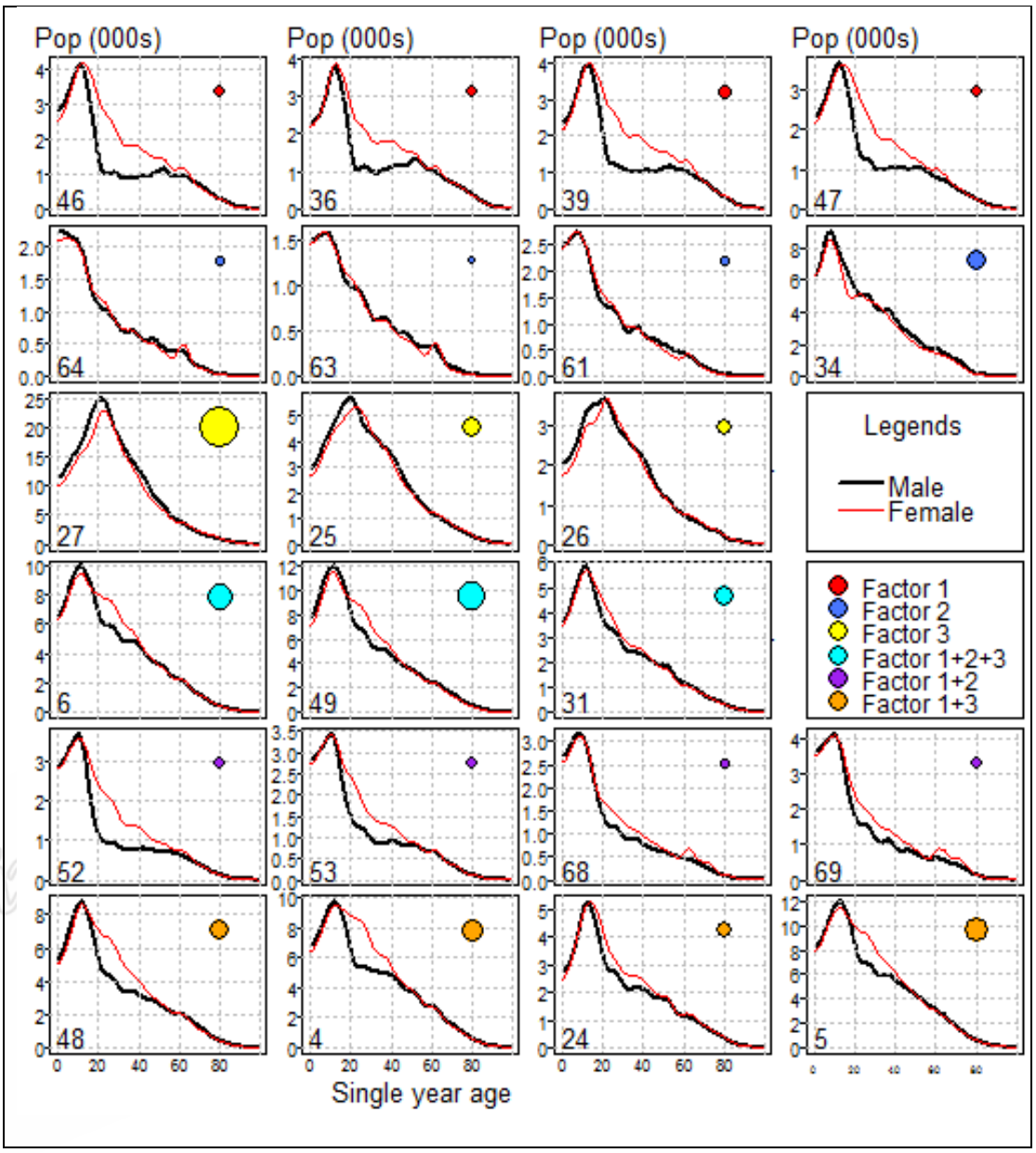

Figure 3.6: Spline-smoothed population distribution by single year age and sex from selected Districts in Nepal at 2011 Census

Notes: The size of each bubble indicates the population size of that specific district
The number at the bottom of each graph indicates District ID (DisID)
Full name correspond to DisID is provided in Table 3.2

3.2.3 Geographic variation in the age-sex structure pattern in Nepal

The information on age-sex structure pattern of all 75 districts in Nepal, explored by the factor model was further plotted in the thematic map (Figure 3.7) using six different colors based on the factor analysis. The thematic map again shows a clear pattern of the distribution of districts having the same patterns from the factor model. The dominant missing young adult pattern, denoted by red color, was mainly from the Eastern, Central and Western Hills of Nepal. Another traditional pattern, denoted by a blue color, was found mainly in the districts of central Terai and Karnali zone. The third pattern was found in the three districts of Kathmandu valley including Manang and Mustang. The mixed pattern of factor one and two is another dominant pattern, denoted by a violet color, found mainly in the Mid- and Far-Western regions.

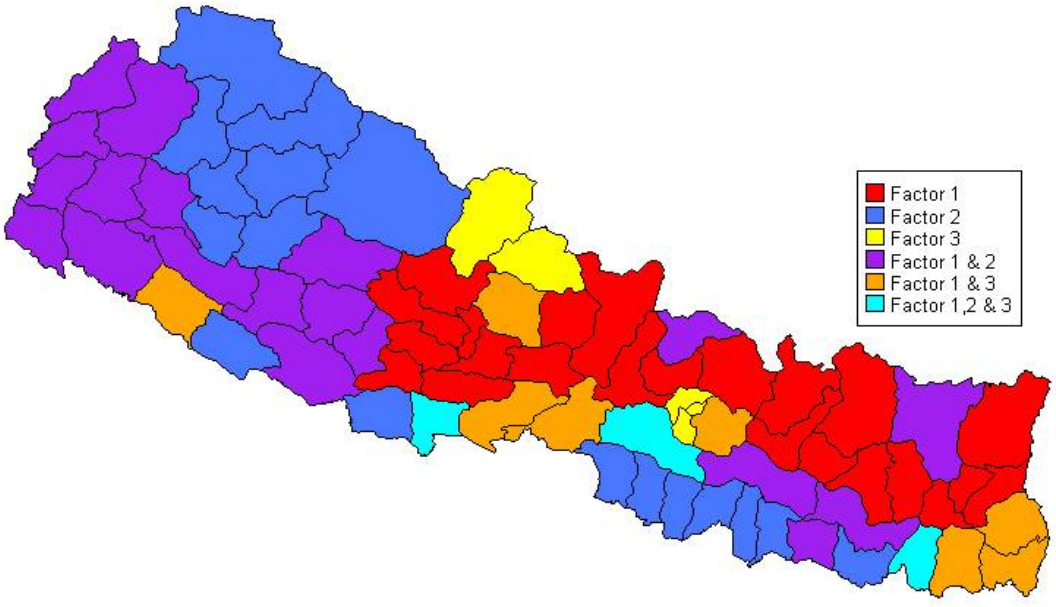

Figure 3.7: Thematic map of Nepal shows the regional variation in age-sex structure pattern in each district presented in colors from factor analysis for gender-age population at 2011 census

3.3 Inter census population changes in recent censuses in Nepal

(**Article III**: Inter-census Population Changes in Nepal: A District Level Analysis by Age and Sex (Submitted to Kasetsart Journal of Social Science for publication)

3.3.1 Top ten districts in Nepal with high intercensus population changes

Table 3.3 shows the top ten districts of Nepal that had increased or decreased population in recent census compared to 2001. The top three highly increased districts were Kathmandu (61.23%), Lalitpur (38.59%) and Bhaktapur (35.12%) while the top three highly decreased districts were Manang (-31.80%), Khotang (-10.84%) and Mustang (-10.21%).

Table 3.3: Top ten districts that have negative and positive inter-census population growth in Nepal, 2011 census

Top ten districts of Nepal that have negative population growth rate					
District ID	District	Total 2011	Total 2001	difference	% of change
41	Manang	6538	9587	-3049	-31.80
13	Khotang	206312	231385	-25073	-10.84
42	Mustang	13452	14981	-1529	-10.21
8	Terhathum	101577	113111	-11534	-10.20
10	Bhojpur	182459	203018	-20559	-10.13
39	Syangja	289148	317320	-28172	-8.88
22	Dolakha	186557	204229	-17672	-8.65
44	Parbat	146590	157826	-11236	-7.12
36	Gorkha	271061	288134	-17073	-5.93
23	Sindhupalchok	287798	305857	-18059	-5.90

Table 3.3 (Continue)

Top ten districts of Nepal that have positive population growth rate					
27	Kathmandu	1744240	1081845	662395	61.23
25	Lalitpur	468132	337785	130347	38.59
26	Bhaktapur	304651	225461	79190	35.12
64	Kalikot	136948	105580	31368	29.71
40	Kaski	492098	380527	111571	29.32
57	Banke	491313	385840	105473	27.34
61	Jajarkot	171304	134868	36436	27.02
32	Rautahat	686722	545132	141590	25.97
65	Mugu	55286	43937	11349	25.83
71	Kailali	775709	616697	159012	25.78

3.3.2 Geographic variation of inter census population changes in Nepal

The left panel of Figure 3.8 shows the inter census population change in percentage by district in Nepal. We categorised population changes into 5 groups. If the change is ±<5%, it is defined as small changes denoted by orange color. Positive changes were further divided into two groups as medium increased (5% to 10 %) and highly increased (>10%) respectively denoted by pink and red color. Similarly, negative changes were also further divided into two groups as medium decreased (-5% to -10%) and highly decreased (more than -10%), respectively denoted by yellow and cyne color. Fourteen districts have had only a small percentage of population changes (± <5%) either positive or negative.

The population in each district is not equally distributed. The most populous district was Kathmandu in census 2011. The population of Kathmandu (1,744,240) was 267 times higher compared to the least populous Manang district (6,538). Therefore, it is worth looking at population changes in absolute numbers. The right panel of Figure 3.8 shows the inter census population changes in the absolute number categorized into five groups as follows: highly increased (>10,000), medium increased (1,000 to 10,000), small changes (± 1000), medium decreased (-1000 to -10,000) and highly decreased (more than -10,000). The top three highly increased districts were Kathmandu (662,395), Rupandehi (171,777), Kailali (159,012) whereas the top three highly decreased districts were Syangja (-28,172), Khotang (-25,073) and Bhojpur (-20,559). Both thematic maps clearly show the pattern of population change in the district. The population was decreased in mountain and hilly districts of Eastern, Central and Western development regions, whereas it was increased in all the districts from the Terai and almost all the districts of the Mid- and Far-western region of Nepal including three districts in Kathmandu valley.

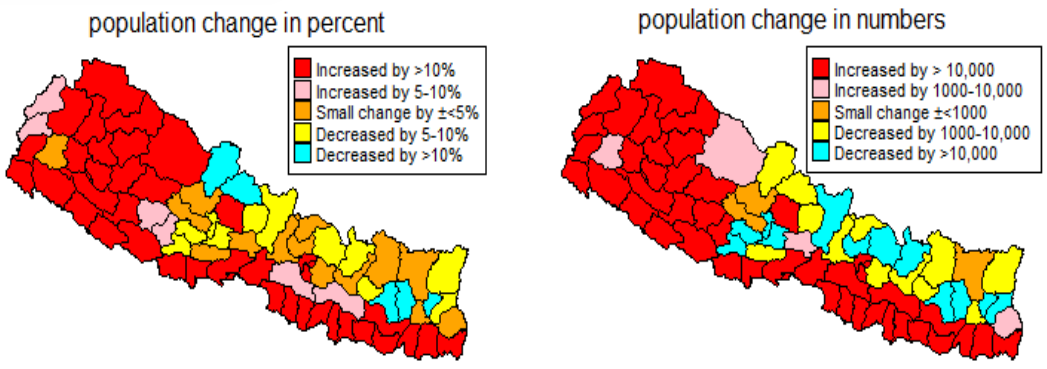

Figure 3.8: Thematic maps show the district level variation of inter census population change in Nepal, 2011 census

3.3.3 Intercensus population changes in districts by sex

Figure 3.9 and Figure 3.10 show the spline smooth single year age population in 2001 and 2011 census of all the districts in Nepal. Figure 3.9 shows for the 48 districts having a positive population growth separately for male and female. Figure 3.10 shows for the 27 districts having negative population growth in two separate graphs by sex. The red bubbles indicate the population increase and blue bubbles indicate the population decrease in recent census compared to 2001 census.

Among the 48 districts having overall positive growth, three districts, indicated by blue bubble (Figure 3.9), revealed negative growth in male. Similarly, among 27 districts having overall negative population changes, nine districts, indicated by red bubble (Figure 3.10), had positive growth in female. However, the small size bubbles in those districts indicated that there is only a small increment. It is also noted that the black lines pointing down at the beginning in both figures. It indicated that each new cohort is becoming smaller almost in all the districts except few districts belongs to Figure 3.9.

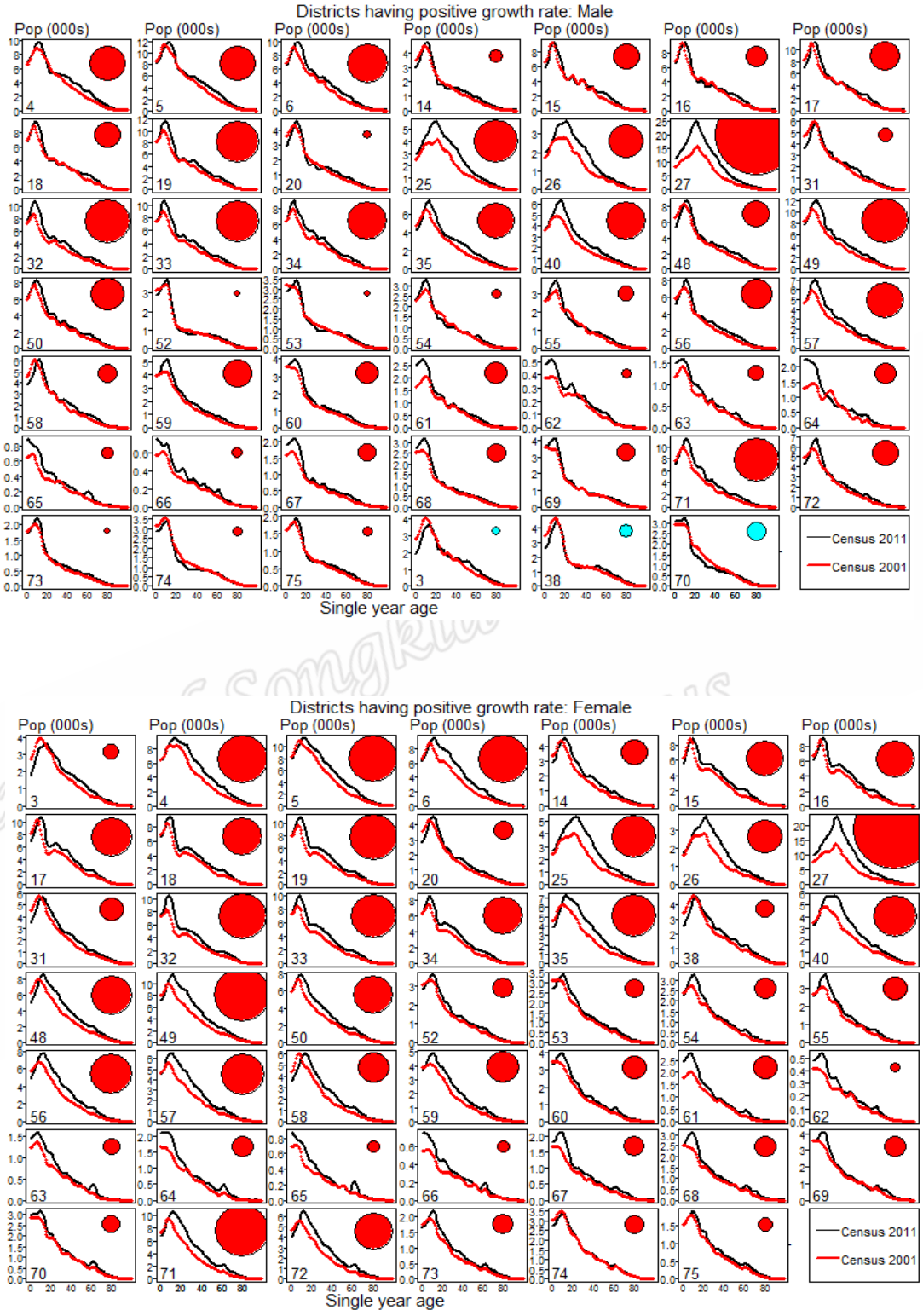

Figure 3.9: Spline smooth single year age distribution in 2001 and 2011 census

Note: Bubble size indicates the population size that increased (red) and decreased (blue) in 2011 compared to 2001

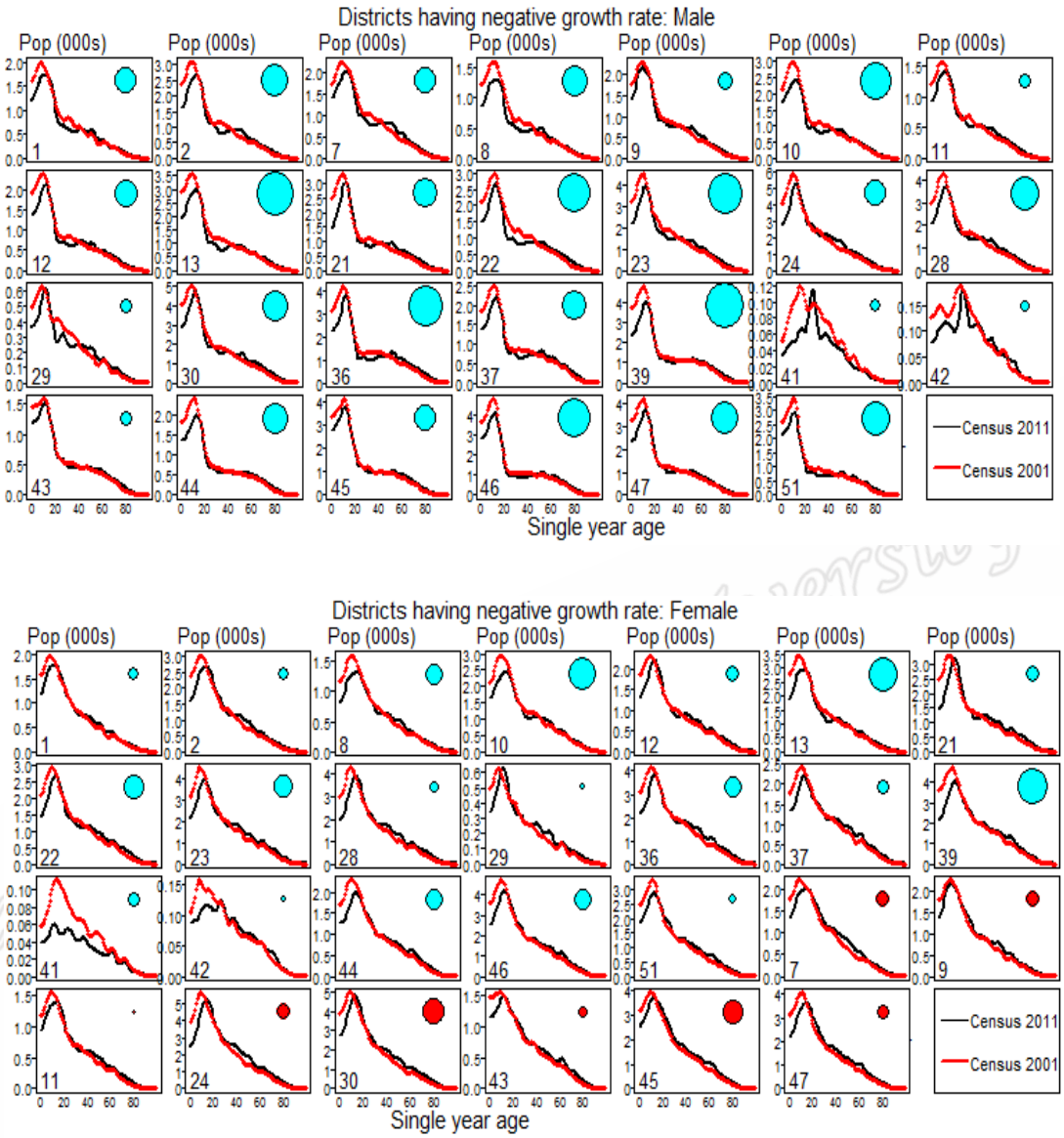

Figure 3.10: Spline smooth single year age distribution in 2001 and 2011 census

Note: bubble size indicates the population size that increased (red) and decreased (blue) in 2011 compared to 2001

3.3.4 Intercensus population changes by age groups

Table 3.4 shows the inter-census population changes in working age group and dependent population in two recent censuses. The districts were sorted based on percentage of population aged 15-64 years in the 2011 census. The working aged population increased by 3.4%, whereas <15 years age group population has decreased

by 4.5% in 2011 compared to 2001 in the country. The largest percentage of working age population was found in Kathmandu districts (72.2%) followed by Manang (71.5%) and Lalitpur (70.7%), respectively. It is also noted that aged population 64^{+} increased by 1% in recent census; the highest increase was in Dolakha (3.1%) and lowest increase was in Humala (0.2%). The proportion of aged population in 2011 census was 5.3%; the highest proportion was in Gorkha district (8.9%) and the lowest was in Jumla district (2.6%).

Table 3.4: Top ten districts having largest percentage of population aged 15-64 years in 2011 census, Nepal

District	2011				2001			
	Total Pop	15-64 year	<15 year	64^{+} year	Total Pop	15-64 year	<15 year	64^{+} year
Kathmandu	1744240	72.2	23.8	4.0	1081845	68.3	28.1	3.6
Manang	6538	71.5	21.6	6.9	9587	68.2	26.0	5.8
Lalitpur	468132	70.7	23.9	5.3	337785	66.5	29.0	4.5
Bhaktapur	304651	70.0	24.8	5.2	225461	64.5	30.8	4.7
Mustang	13452	69.6	22.4	8.0	14981	67.0	27.5	5.5
Kaski	492098	65.1	28.9	6.0	380527	60.1	34.7	5.2
Ilam	290254	64.9	29.6	5.5	282806	58.4	37.5	4.1
Chitawan	579984	64.6	29.5	5.9	472048	59.0	36.4	4.6
Jhapa	812650	63.8	30.3	5.9	688109	61.5	34.4	4.2
Morang	965370	63.3	31.5	5.3	843220	59.8	36.3	3.9
Nepal	26494504	59.8	34.9	5.3	23151421	56.4	39.4	4.2

Note: Districts are sorted based on percentage of population aged 15-64 years in 2011census

3.3.5 Age-sex structure of selected districts having negative population growth

Figure 3.11 shows the age-sex distribution of population in 2011 census only in 27 districts having negative growth. Age-sex structure looks similar in all districts. Each

new cohort was found smaller in recent years, both in male and female indicated the decreasing fertility. Imbalance in male ad female population was observed indicated by dip in young age male population(15-35 years) and feminization of population. Unlike other districts, age-sex structure in Manang and Mustang was found different where young age male was found higher than female.

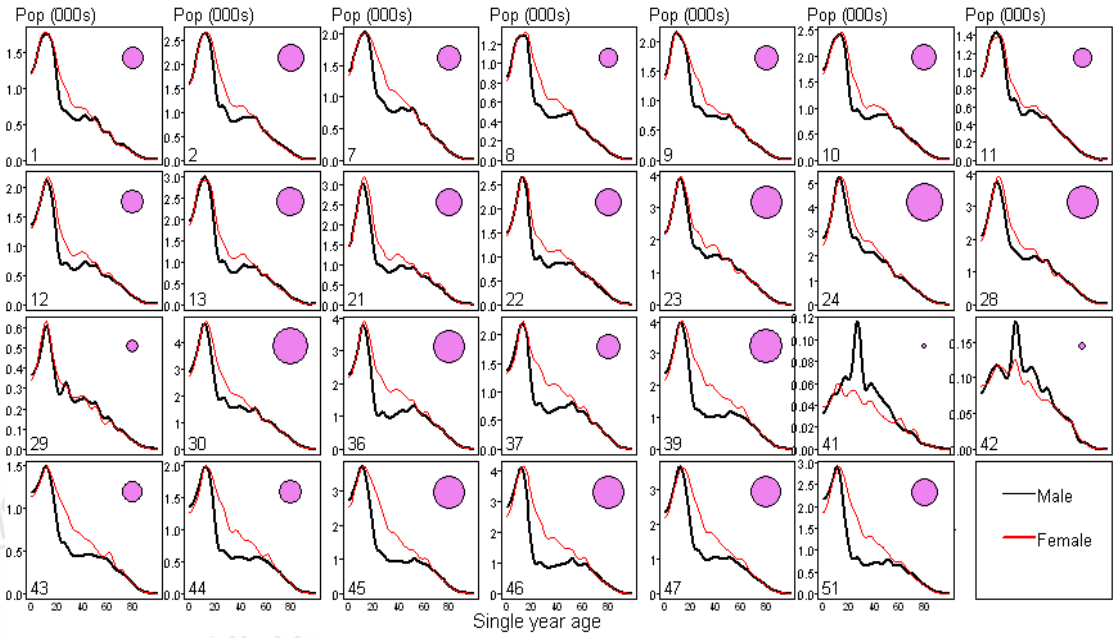

Figure 3.11: Spline smooth single year age- sex distribution of population in selected districts having negative population growth in Nepal, 2011

Note: Bubble size indicates the population size

Chapter 4

Discussion and Conclusions

This chapter presents the overall discussion covering all three manuscripts of this thesis under different subsections. First sub-section summarises the overall findings followed by sub-section two on discussion and conclusion separately for three manuscripts. Third sub-section mentions the strength and limitation of this study. Finally, fourth and fifth sub-section describe policy implications of the findings and recommendation respectively.

4.1 Summary of overall findings

The population distribution by age and sex varied a lot among 76 provinces in Thailand. The factor analysis was used to model this variation. This model identified three common factors. These factors were interpreted as patterns and further used as a basis for clustering the provinces. The factor model clustered the provinces into three patterns, namely a traditional pattern, missing young adult pattern and urban pattern.

The population data from Nepal was also analyzed using the same method. The district level variation of age, sex distribution was modelled using factor analysis that explored the three common factors. These factors were defined as a pattern of age-sex distribution of population and used as a basis for clustering districts. This method modeled the variation in age-sex distribution and clustered the provinces in Thailand and districts in Nepal very well. Therefore, it can be summarized that this method can used to analyze population data.

Inter-census population changes were also found to be varied in Nepal at district level. These variations were not random. There was a clear pattern of increasing and

decreasing in the population. The population was decreased in mountain and hilly districts of the Eastern, Central and Western development regions, whereas it was increased in all the districts from Terai and almost all the districts of the Mid- and Far-western region of Nepal including three districts in Kathmandu valley.Three main inter-census population changes were found in Nepal. The first one is decreasing new cohorts in majority of the districts, the second one is increasing working age population, but absence of young adult male in some districts indicated by population dip, and the last one is beginning of an ageing population.

4.2 Discussion and conclusions

In this subsection, we discuss about an application of factor analysis in different field of studies including demographic study. Then, we discuss the issues obtained from the result of factor analysis in both Thailand and Nepal. Finally, we discuss the inter-census population change in Nepal 2006 and 2011 census.

4.2.1 Application of factor analysis

Factor analysis, a multivariate statistical method, is well established and has been used widely (Costello and Osborne, 2005) not only for analyzing data from psychology, but also with data from different field, including water quality assessment (Liu *et al*., 2003; Lueangthuwapranit *et al*., 2011) and classification of the species of different birds (Rittiboon *et al*., 2012). Mostly, the factor analysis was used for the purpose of grouping and describing the set of variables for further analysis. The factor analysis was also used as an intermediate analysis to determine a social-demographic poverty index (Latifa *et al*., 2008). In the field of geography, Carey (1966) had applied this method to interpret the population and housing pattern. In

demography, Lee and Carter (1992) used factor analysis to forecast the mortality in United State. In this study, it was used to model the variation in age-sex structure of the population in Thailand. Again, same method used to model the variation in age-sex structure of the population in Nepal. The purpose of this study was different compared to all other above-mentioned studies. We interpreted the common factors as patterns of age sex distribution, and further used as a basis for clustering provinces. Since this method clustered provinces very well in both Thailand and Nepal, it is believed that this method will have potential wide application in the field of other scientific studies including population studies.

4.2.2 Age-sex distribution patterns in Thailand

The single year age population distribution found non-symmetrical in 76 provinces of Thailand. The factor model found three distinct patterns of age-sex structure. Each pattern has different characteristics of the distribution. The research brought up three principal issues on population distribution and related demographic factors; namely, fertility, mortality and migration.

The general fertility of Thailand has started to decline since the late 1960s. Now it is at the level of 'below replacement' (Prasartkul *et al*., 2011)**.** The first issue, raised in this study, is why the majority of the bordering provinces in Southern and Eastern and Northern regions have a classical pattern of population distribution. The population in these provinces has recently begun to decrease, whereas the young age population is still high. This type of population distribution pattern is also called "a young age population structure" and will probably experience further population growth (Abbasi-Shavazi, 2011). This finding is also supported by the findings of a year 2000

census related to the average size of the household in Thailand. The Northeast and the South most had the largest average size of household. In the Thailand Census-2000, looking at all provinces, Pattani had the largest size of household (4.8 persons), followed by Narathiwat (4.6 persons). The question here is why are the statistics of these provinces so different and not undergoing similar changes to the rest of the country of Thailand?

Another issue raised from this study is the peak and steep declining pattern. Most of the provinces of central Thailand, including Bangkok, follow the same pattern of population distribution. This might be because of the fast declining fertility rate and of the slow declining infant mortality rate. Fertility in Thailand has declined steadily over the last few decades. At around 1996, it fell below replacement level (Prasartkul *et al*., 2011). The reason behind the rise in the young adult population may also be due to internal migration from northern regions of the country, which now displays a gap in the population (25-35 years old); to these provinces where for the same age groups there is a peak in population distribution. Guest *et al*. (1994) found that migration is highly selective among young adults, females and highly educated adults, and more likely to occur in urban areas or in rural to urban areas. However, after 1990, internal migration rates have steadily declined compared to past statistics (Huguet *et al*., 2011), the population of municipal areas reached 41.1%; this was only 31.1% in 2000 and 29.4% in 1990 (National Statistical Office Thailand, 2012). Thailand is considered an industrialized country (Pansuwan, 2010).

The third issue is related to missing the young age population that shows by the dipping portion of the graph as a third pattern. It is interesting to note that such a type of dip is not usual and normal. However, this study is unable to explain the causes

behind this issue, based on the literature. Anyone can assume that this can be because of mortality and migration functions of the population. Some part of the gap might be because of the internal migration (Guest *et al*., 1994) as discussed above and some part might be because of the HIV epidemic (Weniger *et al*., 1991). Most provinces in the Northern Region, adjacent to Myanmar and Laos have this pattern were affected by this epidemic (Surasiengsunk *et al*., 1998; Nelson, 1998). AIDS was the first leading cause of death among males and the second leading cause of death among females; this accounted the 16.5% and 6.3 %, respectively of total deaths in 1999.

4.2.3 Age-sex distribution patterns and possible reasons in Nepal

Factor model clustered the districts, mainly into three groups. However, some districts were sharing two or more patterns as well. The first "missing young adult pattern" is not a usual and common pattern. The country facing high mortality due to any epidemic like HIV/AIDS in Uganda (Uganda Bureau of Statistics and ICF International Inc., 2012) or massive migration may have such pattern. However, in the context of Nepal, the first pattern possibly explained by underenumeration of young male adults. Young males are prone to the higher rate of underenumeration by the censuses. The districts such as Gulmi and Arghakhachi, grouped in the first pattern, have reported missing a high proportion of their population. According to the 2011 population census in Nepal, one in every four households had reported that at least one member is living outside of the country (Central Bureau of Statistics, 2012). As an impact, young adult female population found higher and newborn babies found lower. Many studies underscored that migration caused spousal separation and decrease fertility (Karki and Krishna, 2008; Ban *et al*., 2012; Agadjanian *et al*., 2011);

this representing one important rationale for the feminization of the young adult population and decreasing newborns in the first pattern.

The second “traditional pattern”, characterized by a larger new cohort, is also called “a young age population structure” and will probably experience further population growth (Abbasi-Shava, 2011). This pattern, which is common in underdeveloped countries and characterized by high fertility and high child mortality, was found in the districts from the poorest and most underdeveloped Mid-Western Mountain regions and Central Terai. These sub-regions have reported high fertility and high but declining child mortality over time. This may lead to growing female reproductive age population and hence increasing birth over time and tapering the number with increasing age. According to Nepal Living Standard Survey 2010/11, the numbers of children per women were found to be slightly higher (2.4) in the Mountain, Mid- and Far-Western Rural Hills and Rural Terai–Central Regions in comparison to the overall (2.1) number within the country (Central Bureau of Statistics, 2011). Similarly, TFR in Mid- and Far-Western regions were found to be higher than the total TFR (2.6) of the country in NDHS 2011 (MOHP, *et al*. 2012). According to population monograph of Nepal, infant and child mortality decreased significantly over time in Nepal, including these areas, but the rate is still high in these areas compared to other regions of the country (Central Bureau of Statistics, 2014). It is worth noting that the mixed pattern of missing young adults, as well as the traditional pattern, was found to be the most dominant pattern in the Mid and Far- Western regions where young adults were absent, but, in contrary to the first pattern, each new cohort is still quite high. Labor migration is a major livelihood strategy in these areas. According to NDHS 2011, the majorities of male migrants (55%) are from the Far-

Western Region and head to India followed by migrants from the Mid-Western region (31%). The migrant workers from the Eastern region represent 46%, followed by those from the Western region (37%) travel to countries other than India for work (MOHP, *et al*. 2012; Sherpa, 2010). Most of the migrant workers from these sub-regions migrate temporarily to India for seasonal work (Nepal, 2007). Therefore, these last migrants visit their families more often than those who work in other (more distant) countries do. Unlike the pattern one, couple separation effect in fertility trend did not observe in these districts having mixed pattern.

The third pattern, indicated by a steep decline in new cohorts and the peak of the young adult, found in the three districts of the Kathmandu valley. This urban pattern is common in urban and industrialized area where young adults move for education and/or employment opportunities (Abbasi-Shavazi, 2001). A similar pattern is also found in the urban centers in the Philippines (Gultiano and Xenos, 2004) and in Thailand. Although, fertility rates are declining faster in the urban area and there is a vast difference between urban and rural fertility rates in Nepal (Gubhaju, 2007), the steep decline of new cohorts in the districts with third pattern might not necessarily be attributed entirely to the declining fertility rates. It may be, in fact, the result of the young adult population migrating from the rural to the urban areas as found in the case of the Philippines (Gultiano and Xenos, 2004). Kathmandu, the capital city of Nepal, had the highest inter census population growth in the latest decade (Central Bureau of Statistics, 2012). The rural-urban migration is selective of specific age and sex. Migrating workforce in Nepal has predominantly represented by the young male population while in the Philippines the majority are women (Gultiano and Xenos, 2004). Therefore, the third pattern could be explained by the decreasing fertility rates

as well as the rural-urban migration patterns. However, the explanation unable to satisfy the age-sex distribution pattern found in two mountainous districts Manang and Mustang.

4.2.4 District level inter-census population change in Nepal

While age sex distribution of population varied by districts in Nepal, inter census population changes also varied. There was a clear pattern that population was decreased in hilly and mountain districts of eastern, central and western development regions. This study concluded three main changes in population of districts in Nepal. The first is decreasing new cohorts in majority districts, the second one is increasing working age population, but absence of young adult male in some districts, and the last one is beginning of an ageing population.

Smaller each new cohort in majority of the districts indicated the decreasing fertility that is consistent to other survey and studies (Government of Nepal. 2011; Ministry of Health and Population, *et al*., 2012). Such scenarios were found mainly in those districts, where many young men were absent. However, the situation was found different (each new cohort is still high) in almost all the districts in Mid- and Far western development region and some districts in Central Terai. There is no doubt that decreasing fertility is a result of massive implementation of family planning program after 1960. Nevertheless, this also, could be argued that it might be the impact of spousal separation (Karki and Krishna, 2008; Agadjanian *et al*., 2011; Ban *et al*., 2012) in districts where many young men are absent.

The positive aspect of the population change is increasing working age population due to decreasing fertility. From a socio-economic perspective, this youth bulge is called

"demographic dividend" or "window of opportunities", if the country can make use of this properly, on time (Gubhaju, 2007; Nair, 2010; Haupt *et al*., 2011). On the other hand, the increasing trend of missing young age (15-34 years) work force in some districts is not usual and it has a great impact in socio-economic condition of the country. Studies reported that it might happen either in any epidemic condition or in massive migration. In the context of Nepal, there is no evidence of any huge epidemic, but numerous studies reported about migration. According to Nepal labour force survey, about 20% of the population (30% in males and 11% in females) from 38.6% of the households reported to be absent (Central Bureau of Statistics, 2009). Similarly, every year 200,000 persons leave the country in search for jobs overseas (excluding India) with the vast majority of them are male (International Labour Organization, 2010). Thirty two percent of the women mentioned that they do not use contraception as husband away for the employment (MOHP *et al*., 2012). Therefore, missing young adults (15-34 years) can be explained by huge migration for the purpose of employment. On the other hand, the population in 3 districts in Kathmandu valley and in urban area of all other development regions found to be increased which is also associated with internal migration for education or work.

4.3 Strength and Limitations of the study

The method applied in this study is straightforward, well established and widely used in different field of studies. The model gave a robust result that was further used in clustering provinces and districts. The method is applicable in future demographic studies. Although the data is from 2000 census of Thailand, the assessment of the applicability of factor analysis does not affect.

However, the method is well established which estimated the robust results; there are some limitations in results associated with data. Result would be more informative, if we could include other demographic variables like fertility rate, mortality rates in modelling.

4.4 Policy implication of the findings

Although the main goal of this study was to assess the application of statistical method in modeling the variation in age-sex distribution of population, the results of this study also have important policy implications.

In the light of the evidence presented in this study, we critically underscore that the changing age structure carries great variations across one same country and brings both challenges and opportunities for economic development of the country. Same program development and policy reform may not be applicable or possible within all the districts of Nepal. Therefore, the governments must put in place effective policies to grip the opportunities and handle challenges arise from shifting and varying age-sex structure pattern in the country.

There is an urgent need in Nepal for governments to adopt appropriate measures as well as to develop effective population policies, plans and programs in order to handle migration and utilize this “demographic bonus” for the economic development of the country. Reaping the demographic dividend is not automatic and if we cannot make use of “demographic dividend”, it could be very costly and turn out to be a “demographic nightmare”.

Inequalities in use of population control programs such as family planning, indicated by bigger new cohorts and high fertility, need to be addressed (Mehata *et al*., 2014)

and must be focused and strengthened in those areas where new cohorts still bigger and higher fertility.

Although population ageing is not the current issue in Nepal, it is unavoidable and has already begun due to decreasing mortality and declining fertility. Therefore, the government must be prepared to implement effective policies relating to retirement and medical support for senior citizens.

4.5 Recommendation for further study

- This study used a distribution free method called “Spearman rank –order” to create the correlation matrix for factor analysis and used maximum likelihood factor extraction method which assumed normal distribution. However, this issue needs further investigation; it is beyond the scope of this thesis.
- This study clusterd the districts based on modeling of age and sex distribution only. Furhter study is recommended including other demographic information such as fertility rates, mortality rates and migration as well as other determinants of population change such as economic growth, urbanization, availability of road, water, heath care, education, employment etc.
- This study explored and raised issues related to population dynamics both in Thailand and in Nepal. Further study is recommended to investigate the reasons behind those issues for proper handling.
- This descriptive study provided the valuable information on spatial and demographic variation in population change in Nepal. Further study is recommended focusing on factor associated with variation in population change in Nepal.

- Finally, we recommend using factor analysis while modeling the variation in population distribution.

References

Abbasi-Shavazi, M. J. 2001. Recent changes and the future of fertility in Iran. http://www.un.org/esa/population/publications/completingfertility/2RevisedABBASIpaper.PDF [August 06, 2013]

Agadjanian, V., Yabiku, S.T. and Cau, B. 2011. Men's Migration and Women's Fertility in Rural Mozambique. Demography. 48, 1029–1048. DOI 10.1007/s13524-011-0039-y

Ban, B., Karki, S., Shrestha, A. and Hodgins, S. 2012. Spousal separation and interpretation of contraceptive use and unmet need in rural Nepal. International Perspective on Sexual and Reproductive Health. 38(1), 43–47.

Boonperm, J. 2004. Census 2000 and its implementation in Thailand: Lessons learnt for 2010 Census.United Nations Symposium on Population and Housing Censuses, 13-14 September 2004, New York. United Nations Secretariat, Department of Economic and Social Affairs Statistics Division.

Boonperm, J. 2006. Population and Housing Census in Thailand. Paper presented at the ASEAN meeting on the 2010 round of Population and Housing Census, SiemReab, Combodia, 31 July – 2 August 2006.

Carey, G. W. 1966. The regional interpretation of Manhattan population and housing patterns through factor analysis. Geographical Review. 56, 551-569.

Central Bureau of Statistics. 2005. National Population and Housing Census 2001 (National Report). Government of Nepal, National Planning Commission Secretariat, Central Bureau of Statistics, Kathmandu, Nepal.

Central Bureau of Statistics. 2009. Report on the Nepal Labour Force Survey 2008. Central Bureau of Statistics, Kathmandu Nepal.

Central Bureau of Statistics. 2011. Nepal Living Standard Survey 2010/11 (statistical report). Central Bureau of Statistics, National Planning Commission Secretariat, Government of Nepal, Kathmandu.1:117-122.

Central Bureau of Statistics. 2012. National Population and Housing Census 2011 (National Report). Government of Nepal, National Planning Commission Secretariat, Central Bureau of Statistics, Kathmandu, Nepal.

Central Bureau of Statistics. 2014. Population Monograph of Nepal. National Planning Commission, Kathmandu, Nepal.

Cohen, J.E. 2003. Human Population: The Next Half Century. Science. 302(5648), 1172-1175. doi: 10.1126/science.1088665

Costello, A. B. and Osborne, J. W. 2005. Best Practices in Exploratory Factor Analysis: Four Recommendations for Getting the Most From Your Analysis. Practical Assessment, Research and Evaluation.10(7).

Demena, M. 2005. Population and Development (lecture notes). Ethiopia Public Health Training Initiative, The Carter Center, the Ethiopia Ministry of Health, and the Ethiopia Ministry of Education.

Feeney, G., Thapa, S. and Sharma, K.R. 2001. One and a Half Centuries of Demographic Transition in Nepal. Journal of Health Population and Nutrition. 19(3), 160-166.

Government of Nepal. 2005. Nepal Population Census 2001 (Data). Government of Nepal, National Planning Commission Secretariat, Central Bureau of Statistics. http://cbs.gov.np/wp-content/uploads/2012/Population/National%20Report%202001/tab10.htm [March 02, 2013]

Government of Nepal. 2011. Nepal Population Report. Government of Nepal, Ministry of Health and Population, Population Division, Kathmandu, Nepal.

Gubhaju, B. 2007. Fertility Decline in Asia: Opportunities and Challenges. Japanese Journal of Population. 5(1), 19-42.

Guest, P., Chamratrithirong, A., Archavanitkul, K., Piriyathamwong, N. and Richter, K. 1994. Internal migration in Thailand. Asian and Pacific Migration Journal. 3(4), 531-545.

Gultiano, S. and Xenos, P. 2004. Age-structure and Urban Migration of Youth in the Philippines. Paper presented at the CICRED Seminar on Age-structural Transitions: Demographic Bonuses, But Emerging Challenges for Population and Sustainable Development, UNFPA, Paris.

Haupt, A., Kane, T. and Haub, C. 2011. Population Reference Bureau's Population Handbook (6th ed.). Population Reference Bureau, USA.

Huguet, J. W., Chamratrithirong, A. and Richter, K. 2011. Thailand Migration Profile. In Thailand Migration Report-2011, J. W. Huguet and A. Chamratrithirong, editors. Bangkok: International Organization for Migration,Thailand, pp. 9-15.

International Organization for Migration. 2011. Thailand Migration Report. International Organization for Migration, Bangkok, Thailand.

Johnson, R. A. and Wichern, D. W. 1988. Applied multivariate statistical analysis (2nd ed.) New Jersey: Prentice Hall International, Inc.

Karki, Y.B. and Krishna, R. 2008. Factors Responsible for the Rapid Decline of Fertility in Nepal—an Interpretation: Further Analysis of the 2006 Nepal Demographic and Health Survey, Calverton, MD, USA: Macro International.

Kunwar, L.S. 2012. Demographic and Epidemiological Transitions in Nepal: Demographic Implications By Juhee Vajracharya Suwal. Economic Journal of Development.13, 152-54.

Latifa, A., Aswatini and Romdiati, H. 2008. Population and Social Demographic Poverty: A Case Study in the Border Areas of East Kalimantan and North Sulawesi. Journal of Indonesian Social Sciences and Humanities. 1, 175–191.

Lee, R.D. and Carter, L.R. 1992. Modeling and forecasting U.S. mortality. Journal of the American Statistical Association. 87 (419), 659–671.

Liu, C. W., Lin, K. H. and Kuo, Y. M. 2003. Application of factor analysis in the assessment of groundwater quality in a Blackfoot disease area in Taiwan. The Science of The Total Environment. 313, 77–89.

Lueangthuwapranit, C., Sampantarak, U. and Wongsai, S. 2011. Distribution and Abundance of Phytoplankton: Influence of Salinity and turbidity Gradients in the Na Thap River, Songkla Province, Thailand. Journal of Coastal Research. 27(3), 585-594. doi: http://dx.doi.org/10.2112/JCOASTRES-D-10-00123.1

Manly, F. J. 1994. Multivariate statistical methods (2nd ed.). London: Chapman & Hall, pp. 93-106.

Mardia, K.V., Kent, J.T. and Bibby, J.M. 1980. Multivariate Analysis, Academic Press, London, pp. 255-280.

McNeil, N., Odton, P. and Ueranantasun, A. 2011. Spline interpolation of demographic data revisited. Songklanakarin Journal of Science and Technology. 33(1), 117-120.

Mehata, S., Paudel, Y.R., Dotel, B. R., Singh, D.R., Poudel, P., and Barnett, S. 2014. Inequalities in the Use of Family Planning in Rural Nepal. BioMed Research International. http://dx.doi.org/10.1155/2014/636439

Ministry of Health and Population (MOHP) Nepal, New ERA, and ICF International Inc. 2007. Nepal Demographic and Health Survey (NDHS) 2006. Kathmandu, Nepal: MOHP, New ERA, and ICF International, Calverton, Maryland.

MoHP Nepal, New ERA, and ICF International Inc. 2012. Nepal Demographic and Health Survey (NDHS) 2011. MOHP, New ERA, and ICF International, Calverton, Maryland.

Nair, P. S. 2010. Understanding Below-replacement Fertility in Kerala, India. Journal of Health Population and Nutrition. 28(4), 405-412.

National Statistical Office. 2000. Preliminary Report: The 2000 Population and Housing Census.National Statistical Office, Thailand.

National Statistical Office. 2012. Advance Results: Population and Housing Census 2000. National Statistical Office, Thailand.

National Statistical Office. 2012 Population and Housing Census 2000. (Data) National Statistical Office,Thailand. Available: http://web.nso.go.th/census/poph/cen_poph.htm [November 02, 2012]

Nelson, K.E. 1998. The demographic impact of the HIV epidemic in Thailand (Editorial). AIDS. 12, 813-814.

Nepal, B. 2007. Population Mobility and Spread of HIV across the Indo-Nepal Border. Journal of Health Population and Nutrition. 25(3), 267-277.

Pansuwan, A. 2010. Industrial Decentralization Policies and Industrialization in Thailand. Silpakorn University International Journal. 9-10, 117-147.

Paudel, B. K., Lim, A., and Dureh, N. 2015a. Population distribution Pattern of 76 provinces in Thailand: Application of Factor Analysis. Asian Social Science 11(12), 55-61.

Paudel, B. K., Lim, A., and Guragain A. M. 2015b. Analyzing Age Sex Structure Pattern of Nepal using Factor Analysis. Songklanakarin Journal of Science and Technology 37(04) xx-xx (in press).

Pett, M.A., Lackey, N.R. and Sullivan, J.J. 2003. Making Sense of Factor Analysis: The Use of Factor Analysis for Instrument Development in Health Care Research. California, Sage Publications.

Population Reference Bureau (PRB), 2009. Human Population: Population Change. Population Reference Bureau, USA.

Population Reference Bureau. 2012. World population data sheet. World population highlights. Population Reference Bureau. http://www.prb.org/pdf12/2012-population-data-sheet_eng.pdf [August 12, 2013]

Porapakkham, Y., Rao, C., Pattaraarchachai, J., Polprasert, W., Vos, T., Adair, T. and Lopej, A.D. 2010. Estimated causes of death in Thailand, 2005: implications for health policy. Population Health Metrics. 8, 14.

Prasartkul, P., Patama, V. and Varachai, T. 2011. Fertility Transition and Its Impact. In G. Jones (Eds), Impact of demographic change in Thailand (pp. 17-23). Bangkok: United Nations Population Fund.

R Core Team. 2014. R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL http://www.R-project.org/

Rittiboon, K.,Tongkumchum, P. and Karntanut, W. 2012. Bird Assemblages in the ThaleNoi Non-hunting Area, Southern Thailand.Journal of Sustainable Science and Management, 7(1), 42-48.

Sharma, S., Pandey, S., Pathak, D. and Sijapati-Basnett, B. 2014. State of Migration in Nepal. Centre for the Study of Labour and Mobility. Kathmandu, Nepal

Sherpa, D. 2010. Labor Migration and Remittances in Nepal: Report of a case study. The International Centre for Integrated Mountain Development (ICIMOD).

Spearman, C. 1904. "General Intelligence," objectively determined and measured. American Journal of Psychology. 15, 201-293.

Surasiengsunk, S., Kiranandana, S., Wongboonsin, K., Garnett, G.P., Anderson, R. and Griensven, G. 1998. Demographic impact of the HIV epidemic in Thailand. AIDS. 12(7), 775-784.

Tiwari, P. R. 2014. Foreign migration: Population dividend perspective in Nepal (Abstract). First National Population Conference 2014 June 5-7. www.pan-nepal.org/event [August 15, 2014]

Uganda Bureau of Statistics (UBOS), ICF International Inc. 2012. Uganda Demographic and Health Survey 2011. Kampala, Uganda: UBOS and Calverton, Maryland: ICF International Inc, 2012.

United Nations Secretariat. 2003. Fertility, Contraception and Population Policies. United Nations Secretariat, Population Division, Department of Economics and Social Affairs.

United Nations. 2013. World Population Ageing. ST/ESA/SER.A/348. United Nations, Department of Economic and Social Affairs, Population Division.

Venables, W.N. and Ripley, B.D. 2002. Modern Applied Statistics with S, Springer, New York, U.S.A., pp. 321-325.

Wang, J. Z. 2007. Fitting and Forecasting Mortality for Sweden: Applying the Lee-Carter Model (Thesis). Dept. of Mathematical Statistics, Stockholm University, SE–106 91 Stockholm, Sweden. http://www2.math.su.se/matstat/reports/serieb/2007/rep1/report.pdf [June 05, 2015]

Weniger, B. G., Limpakarnjanarat, K., Ungchusak, K., Thanprasertsuk, S., Choopanya, K., Vanichseni, S. and Wasi, C. 1991. The epidemiology of HIV infection and AIDS in Thailand. AIDS. 5(2), 71-85.

Zimmer, Z. 2009. Household composition among elders in Sub-Saharan Africa in the context of HIV/AIDS. Journal of Marraiage and Family, 71(4), 1086-1099. DOI: 10.1111/j.1741-3737.2009.00654.x

Appendix I

Article I: "Population Distribution Pattern of 76 Provinces in Thailand: Application of Factor Analysis"

Appendix II

Article II: Analyzing Age-Sex Structure Patterns in Nepal Using Factor Analysis

Appendix III

Article III: Inter-census Population Changes in Nepal: A District Level Analysis by Age and Sex

Appendix IV

Proceeding (Oral Presentation)

The result from preliminary analysis of the Thai population census data was presented orally in 7th International Conference on Reproductive Health and Social Science Research organized by Institute for Population and Social Sciences Research, Mahidol University on August 19, 2013 in Bangkok. Full paper was published from final analysis of same data. Abstract submitted in the conference and certificate of oral presentation is attached below.

Population Distribution Pattern of 76 Provinces in Thailand: Application of Factor Analysis

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Abstract

The descriptive design was used to explore and describe the single year age population distribution pattern of 76 provinces in Thailand. The 2000 census population data of 76 provinces was retrieved from the website of National Statistical Office, Ministry of Information and Communication Technology Thailand. Factor analysis based on spline smoothed single year population, was used to cluster the province which was based on a pattern of population distribution. The study found three distinct patterns of population distribution in Thailand. Twenty-seven provinces from Southern and North Eastern region, mainly bordering to Myanmar, Cambodia and Malaysia, have the same classical pattern of population distribution. The majority of the provinces, from the central region included Phuket from the south; also have a similar population distribution pattern. Most of the provinces of northern region have a similar pattern which dips at the young age group. In conclusion, this study found the population distribution is not found symmetrical in Thailand. The findings of this study will be helpful to understand past trends in population distribution and guide in planning and implementing the family planning, migration related programs. The detail describing the pattern of distribution will also be helpful for population

projection. It is also suggested that the method used in this study is straightforward and can be widely used in future demographic studies.

Keywords: population distribution, factor analysis, Thailand

Certificate of Presenatation

Mahidol University
Wisdom of the Land

CERTIFICATE OF PRESENTATION

This is to acknowledge that

Binita Kumari Paudel

presented the paper

Title *"Population Distribution Pattern of 76 Provinces in Thailand: Application of Factor Analysis"*

At the 7th International Conference on

Reproductive Health and Social Sciences Research

Organized by the Institute for Population and Social Research, Mahidol University

On August 19th, 2013

Pimonpan Isarabhakdi, Ph.D.
Chair, 7th International Conference on Reproductive Health and Social Sciences Research

Sureeporn Punpuing, Ph.D.
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Appendix V

Proceeding (Poster Presentation)

The poster was prepared from some part of the results obtained from the thesis and presented in First National Population Conference 2014 held in Kathmandu Nepal on 5-7 June 2014. The main objective of the conference was to provide a forum for national and international scholars working in the population and development issues to exchange ideas and experiences. Abstract, invitation letter and conference proceding cover page are included in this appendix.

Age Sex Distribution of Population in Selected Districts having Negative Inter Census Changes in 2006 and 2011, Nepal

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Abstract

Nepal is in a demographic transition. The population has increased by 3,343,081 at the rate of 1.35/annum (inter census changes 14.44%), but it has also decreased in 27 districts across Nepal in last decade. Comparing age-sex structure is the best way of understanding the population dynamics. Thus, this study aimed to explore specific reasons behind this change in 27 districts by comparing age-sex distribution of population between 2001 and 2011censuses. The population data by 5-year age groups, sex and districts was retrieved from the website of Central Bureau of Statistics. The districts were grouped based on percentage of inter-census changes and presented in thethematic map. Spline interpolation was used to create single year age population and plotted separately by sex. The highest population decline was in Syangja (28,172) district followed by Khotang (25,073),whereas the lowest decline was in Baglung (324) followed by Sankhuwasabha (461). In the stratified analysis, the population showed to have declined and was substantially higher in the male than in

the female group. Each new smaller cohort indicated the decreasing fertility both in male and female. The population differenceat aged 20-35 mainly in the male indicated young adult migration. The decreasing pattern was found in mountain and hilly districts of eastern, central and western development regions. In conclusion, the data showed that migration and fertility contributed overall negative population growth in 27 districts across Nepal. It is believed that the results from this study pertaining to population dynamics in Nepal would greatly contribute to population programs.

Keywords: Nepal, census, age-sex distribution, negative growth, population

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Paper Theme : **Demographic Methods, Age-Sex Structure and Demographic Dividend**

Dear Colleague (s),

We are pleased to inform you that the **Conference Scientific Committee (CSC)** through a blind review process has selected your abstract entitled **"Age Sex Distribution of Population in Selected Districts having Negative Inter Census Changes in 2006 and 2011, Nepal"** for the poster presentation at the First National Population Conference 2014 being held in Kathmandu, Nepal on 5-7 June 2014.

Please be prepared for a poster presentation following guidelines available in conference website (http://pan-nepal.org/event) and also confirm your participation by sending the completed registration form (http://pan-nepal.org/event/registration-form.php) before 05 May 2014.

Congratulation and looking forward to seeing you at the conference.

With best wishes,

Prof. Dr. Ram Sharan Pathak
Head
(Chair, Conference Organizing Committee (COC))

First National Population Conference, 5-7 June 2014
Communicating Population for Development Planning

For further information, please contact:
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First National Population Conference 2014

Communicating Population for Development Planning

5-7 June 2014, Kathmandu

Post-Conference Proceedings

VITAE

Name Mrs. Binita Kumari Paudel

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Educational Attainment

Degree	Name of Institution	Year of Graduation
Diploma in Nursing	Tribhuwan University, Nepal	1994
Bachelor in Nursing	Tribhuwan University, Nepal	2000
Master's in Public Health	Northern University, Bangladesh	2007

Scholarship Awards during Enrolment

- Graduate Study Grant from Graduate School, Prince of Songkla University, Thailand
- Thesis support grant from Graduate School, Prince of Songkla University, Thailand
- Full scholarship for attending an International Conference in University of Public Health, Yangon, Myanmar

Work – Position and Address

Position Associate Professor

Institution Nepal Institute of Health Science
(Affiliated to Purbanchal University)
Boudha- 6, Kathmandu,
Nepal

List of Publications and Proceedings

Publications

Paudel, B. K., Lim, A., and Dureh, N. 2015. Population distribution Pattern of 76 provinces in Thailand: Application of Factor Analysis. Asian Social Science 11(12), 55-61.

Paudel, B. K., Lim, A., and Guragain A. M. 2015. Analyzing Age Sex Structure Pattern of Nepal using Factor Analysis. Songklanakarin Journal of Science and Technology 37(04) xx-xx (in press).

Guragain, A. M., **Paudel, B. K**., Lim, A., and Choonpradub, C. 2015. Orphanhood and living arrangements of children in Nepal. Asian Social Science 11 (12), 84-92.

Guragain, A. M., Choonpradub, C., **Paudel, B.K.** and Lim, A. 2015. Sub-regional level disparities in magnitude of orphan children in Nepal. Journal of Social Sciences & Humanities (JSSH) 23(3).xx-xx (Accepted)

Paudel, B. K., Lim, A., Pipatjaturon, N. and Guragain A. M. 2015. Estimating Child Death from Perinatal Originating Conditions and Congenital Malformations in Thailand. Asian Social Science. (In review)

Guragain, A. M., **Paudel, B. K**., Lim, A., and Choonpradub, C. 2015. Adolescent marriage in Nepal: A Subregional Level Analysis. Marriage and Family Review. (In review)

Paudel, B. K., Guragain, A. M. and Lim, A. 2015. Inter-census Population Changes in Nepal: A District Level Analysis by Age and Sex. Kasetsart Journal of Social Sciences. (Submitted)

Procedings

Paudel, B. K. and Lim, A. 2013. Population distribution Pattern of 76 provinces in Thailand: Application of Factor Analysis. 7th International Conference on Reproductive Health and Social Science Research organized by Institute for Population and Social Sciences Research , Mahidol University on August 19, 2013 in Bangkok. (Oral Presentation)

Paudel, B. K., Lim, A., Pipatjaturon, N. and Guragain A. M. 2013. Estimating Child Death from Perinatal Originating Conditions and Congenital Malformations in Thailand 1996-2009 based on the 2005 Verbal Autopsy Study. 5th International Conference on Public Health among Greater Mekong Sub-Regional Countries, 28–29 September 2013 at University of Public Health, Yangon, Myanmar. (Oral presentation)

Paudel, B. K., Lim, A., Guragain A. M. and Pokhrel B. 2014. Age Sex Distribution of Population in Selected Districts having Negative Inter-census population Changes in 2006 and 2011, Nepal. First National Population Conference , 5-7 June 2014, Kathmandu, Nepal. (Poster Presenation)