INFLUENCING FACTORS FOR WATER DEMAND FORECASTING OF MEGACITY CASE STUDY OF BANGKOK METROPOLITAN ADMINISTRATION.

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A Thesis Submitted in Partial Fulfillment of the Requirements
for the Degree of Master of Engineering Program of Infrastructure in Civil Engineering
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ปัจจัยที่มีอิทธิพลสำหรับการพยากรณ์ปริมาณความต้องการน้ำของเมืองขนาดใหญ่
กรณีศึกษา : กรุงเทพมหานคร

นาย วันปิยะ ผิวงาม

วิทยานิพนธ์นี้เป็นส่วนหนึ่งของการศึกษาตามหลักสูตรปริญญาวิศวกรรมศาสตรมหาบัณฑิต
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Thesis Title	INFLUENCING FACTORS FOR WATER DEMAND FORECASTING OF MEGACITY CASE STUDY OF BANGKOK METROPOLITAN ADMINISTRATION.
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วันปิยะ ผิวงาม : ปัจจัยที่มีอิทธิพลสำหรับการพยากรณ์ปริมาณความต้องการน้ำของเมืองขนาดใหญ่ กรณีศึกษา: กรุงเทพมหานคร. (INFLUENCING FACTORS FOR WATER DEMAND FORECASTING OF MEGACITY CASE STUDY OF BANGKOK METROPOLITAN ADMINISTRATION) อ.ที่ปรึกษาวิทยานิพนธ์หลัก: รศ.ดร.ธเรศ ศรีสถิตย์, 215 หน้า.

การวิจัยนี้ได้ทำการวิเคราะห์ข้อมูลของปัจจัยที่คาดว่ามีอิทธิพลต่อปริมาณความต้องการน้ำ(Y) ในเมืองใหญ่ 8 ปัจจัยและแทนค่าด้วยตัวแปร X_1 ถึง X_8 อันได้แก่ 1.) จำนวนประชากรในพื้นที่,X_1 2.) ปริมาณน้ำฝนเฉลี่ยต่อปี,X_2 3.)ขนาดของครอบครัว,X_3 4.)ราคาขายเฉลี่ยของน้ำประปา,X_4 5.)อุณหภูมิเฉลี่ยต่อปี,X_5 6.) รายได้ต่อหัวต่อคนของประชากร,X_6 7.)ความหนาแน่นของประชากร,X_7 8.)เงินงบประมาณของแต่ละพื้นที่,X_8 โดยทำการศึกษาพื้นที่ของกรุงเทพมหานครทุกเขต แบ่งเป็น 3 พื้นที่ศึกษาคือ พื้นที่กรุงเทพชั้นนอก, พื้นที่กรุงเทพชั้นกลาง, พื้นที่กรุงเทพชั้นใน การวิจัยครั้งนี้มีจุดมุ่งหมายในการทำการพยากรณ์ที่เหมาะสมสำหรับความต้องการน้ำของเมืองใหญ่จากปัจจัยที่น่าจะมีอิทธิพลเหล่านั้น

ผลการวิจัยพบว่า พื้นที่ชั้นในของกรุงเทพได้จัดลำดับความสำคัญของปัจจัยออกเป็น 3 กลุ่มคือ กลุ่มแรกได้แก่ X_1, X_4 และ,X_8 กลุ่มที่สองได้แก่ X_7,X_3,X_8 และกลุ่มที่สามได้แก่ X_5 ,X_2 และสมการถดถอยพหุเชิงเส้นปริมาณความต้องการน้ำของพื้นที่ชั้นในของกรุงเทพได้แก่ $Y_{inner} = 5.2x10^{-5}X_1 - 3.1x10^{-3}X_2 + 3.7x10^{-4}X_3 + 1.782X_5 - 2.7x10^{-4}X_7 + 3.1229$. สำหรับพื้นที่ชั้นกลางของกรุงเทพได้จัดลำดับความสำคัญของปัจจัยออกเป็น 3 กลุ่มคือ กลุ่มแรกได้แก่ X_4 and X_8 กลุ่มที่สองได้แก่ X_1, X_3, X_7,X_8และกลุ่มที่สามได้แก่ X_2 and X_5 และสมการถดถอยพหุเชิงเส้นปริมาณความต้องการน้ำของพื้นที่ชั้นกลางของกรุงเทพได้แก่ $Y_{intermidiat} = 3.93x10^{-5}X_1 - 4.3x10^{-3}X_2 + 3.62x10^{-4}X_3 + 4.092X_5 - 5.9x10^{-4}X_7 + 1.35x10^{-7}X_8 + 4.556$และพื้นที่ชั้นนอกของกรุงเทพได้จัดลำดับความสำคัญของปัจจัยออกเป็น 4 กลุ่มคือ กลุ่มแรกได้แก่ X_4 ,X_6 กลุ่มที่สองได้แก่ X_2,X_5,X_8 กลุ่มที่สามได้แก่ X_1,X_3 กลุ่มที่สี่ได้แก่ X_7และสมการถดถอยพหุเชิงเส้นปริมาณความต้องการน้ำของพื้นที่ชั้นนอกของกรุงเทพได้แก่ $Y_{outer} = 3.93x10^{-5}X_1 - 4.3x10^{-3}X_2 + 3.62x10^{-4}X_3 + 4.092X_5 - 5.9x10^{-4}X_7 + 1.35x10^{-7}X_8 + 4.36$

จากผลการวิจัยพบว่า ปัจจัยที่มีอิทธิพลกับปริมาณความต้องการน้ำทั้งสามพื้นที่ส่วนใหญ่ คือ จำนวนประชากร,ปริมาณน้ำฝนเฉลี่ยรายปี,ราคาขายน้ำประปาเฉลี่ย และรายได้ทั้งปีของประชากรต่อหัวต่อคน แต่สำหรับในบางปัจจัย ก็มีผลแตกต่างไปในแต่ละพื้นที่ เช่น ปัจจัยด้านจำนวนประชากรมีผลกับพื้นที่ของกรุงเทพชั้นใน,ปัจจัยด้านความหนาแน่นของประชากรและงบประมาณของแต่ละพื้นที่มีผลกับพื้นที่ชั้นกลางและชั้นนอก

และสมการถดถอยพหูเชิงส้นดังกล่าวได้ทำการพยากรณ์ปริมาณความต้องการน้ำในแต่ละพื้นที่ของกรุงเทพมหานครในอีก 10 ปีข้างหน้าหรือในปี 2562 ว่าจะมีปริมาณความต้องการน้ำเพิ่มขึ้นอีก 7-12 % หรือเพิ่มขึ้นเป็น 3.67 ล้านลูกบาศก์เมตรต่อวัน

ภาควิชา วิศวกรรมโยธา ลายมือชื่อนิสิต ....

สาขาวิชา โครงสร้างพื้นฐานในงานวิศวกรรมโยธา ลายมือชื่ออ.ที่ปรึกษาวิทยานิพนธ์หลัก ....

ปีการศึกษา 2552

##5071623021 : MAJOR INFRACTRUCTURE IN CIVIL ENGINEERING

KEYWORDS : WATER DEMAND /MEGA CITY/ BANGKOK/ FORECAST

WANPIYA PHIW-NGAM: INFLUENCING FACTORS FOR WATER DEMAND FORECASTING OF MEGACITY CASE STUDY OF BANGKOK METROPOLITAN ADMINISTRATION. THESIS ADVISOR: ASST.PROF. THARES SRISATIT, Ph.D.215 pp.

This research has analyzed all information of 8 factors which might influence to water demand consumption(Y) in Bangkok metropolitan area. All 8 factors are 1).Total population,X_1 (capita) 2).Total precipitation,X_2(mm/year) 3).Size of family,X_3(/capita/family) 4).Average selling price,X_4 (Baht/cu.m.) 5).Average temperature,X_5 (degree Celsius) 6).Income per capita,X_6(Baht/capita) 7).Density of population per area,X_7(capita/sq.km) 8).Budget of each district,X_8(Baht/year).By separate study area in 3 sections 1). Inner area 2).Intermediate area 3).Outer area of Bangkok metropolitan, The aim of this study is to study the relation of water demand and all influence factors and to study the proper prediction, forecasting of water demand in megacity by using the influence factors.

For the inner area, the relations of factors are in 3 groups(Group 1 = X_1,X_4,X_6), (Group 2 = X_7,X_3,X_8),(Group 3 =X_8 ,X_2).The forecasting equation of inner area is $Y_{inner} = 5.2x10^{-5}X_1 - 3.1x10^{-3}X_2 + 3.7x10^{-4}X_3 + 1.782X_5 - 2.7x10^{-4}X_7 + 3.1229$ .For the intermediate area, the relations of factors are in 3 groups. (Group 1= X_4 and X_6), (Group 2= X_1, X_3, X_7,X_8), (Group 3= X_2 and X_5). And The forecasting equation of intermediate area is

$Y_{interim} = 3.93x10^{-5}X_1 - 4.3x10^{-3}X_2 + 3.62x10^{-4}X_3 + 4.092X_5 - 5.9x10^{-4}X_7 + 1.35x10^{-7}X_8 + 4.556$. For the outer area the relations of factors are in 4 groups. (Group 1 =X_4 ,X_6), (Group 2= X_2,X_8,X_6), (Group 3=X_1,X_3), (Group 4=X_7).). And the forecasting equation of outer area is $Y_{outer} = 3.93x10^{-5}X_1 - 4.3x10^{-3}X_2 + 3.62x10^{4}X_3 + 4.092X_5 - 5.9x10^{-4}X_7 + 1.35x10^{-7}X_8 + 4.36$

As the result, the most of factors that influence to the water demand consumption in all three sections are number of population, amount of precipitation, average selling price and income per capita.But there are some factors which effect in individual section e.g. number of population in the inner area, density of population and budget of district in the intermediate and outer area. And their equations have forecast the water demand consumption in each area for next 10 years (2009-2019) will increase about 7 – 12% or total consumption will be 3.67 million cubic meters per day in 2019.

Department : Civil engineering .... Student's Signature ....

Field of Study: Infrastructure in civil engineering Advisor's Signature ....

Academic Year : 2009 ....

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CHAPTER I

INTRODUCTION

1.1 Background & Problem statement:

For the century, increasing population and urbanization in the megacity have resulted in various environmental problems. Among those the most serious is water shortage. People around the world are beginning to realize the interactions between human beings and the environment. Human activities have been affecting the natural water ecological cycle in many ways .Reduction of forest, the grass land, and the spread of urban growth resulted in increased runoff; overexploitation of groundwater resources have decreased groundwater levels and caused problems of seawater intrusion. Toxic industrial discharge and the extensive use of chemical fertilizers have polluted much of the water supply. Many regions in the world have been uncounted the great impact of water shortage and pollution, and the situation is getting worse(Changyu,2004) The United Nations Environment Program (UNEP) identified that water shortage and global warming are the two most worrying problems for the new millennium, in addition, the World Water Council believes that by 2020 the world will need 17% more water than is currently available (WWC, 2000).

In urban area and Mega cities, water demands have increased rapidly. Expansion of water supply is usually the only mean employed to meet the growing water demands. In the mean time, the economical and ecological limits of the water supplies have generally been ignored. The fact is that in many regions of the world, water consumption is nearing or surpassing the limits of natural systems (Postal and Oasis, 1993).Bangkok, megacity in south east Asia, So there are many factor which directly effect to water demand in mega cities e.g.; sell price of water, temperature of region & season, population quantities, Number of families in the cities, Precipitation in urban area. But how effect in each parameter. Which one should be strong considered or which parameter can be ignore. And how is the relationship between each factor. This thesis will identify in each parameter in order to find out the relation between each factors that influence with water demand in megacity, in Bangkok as a model to be studied. Result of this thesis may significant information for forecasting water demand in another megacity.

Bangkok is the capital, largest urban area and primate city of Thailand. It was a small trading post at the mouth of the Chao Phraya River during the Ayutthaya Kingdom and came to the forefront of Thailand when it was given the status as the capital city in 1768 A.D. after the moving a capital city from Thonburi kingdom.

Bangkok is the world's 22nd largest city by population with approximately 5,695,956 residents in the Bangkok with area 1,568.737 sq.km. Due to a large unregistered influx of migrants from the many provinces of Thailand and of many nations across Asia, the population of greater Bangkok is estimated at nearly 15 million people. The Bangkok Province borders six other provinces: Nontaburi, Pathum Thani, Chachoengsao, Samut Prakan, Samut Sakhon and Nakhon Pathom. All six provinces are joined in the combination of the great Bangkok. (DOPA, 2006)

Figure1.1 presents the map of Bangkok with 50 districts. Detail of Bangkok is summarized as follows.

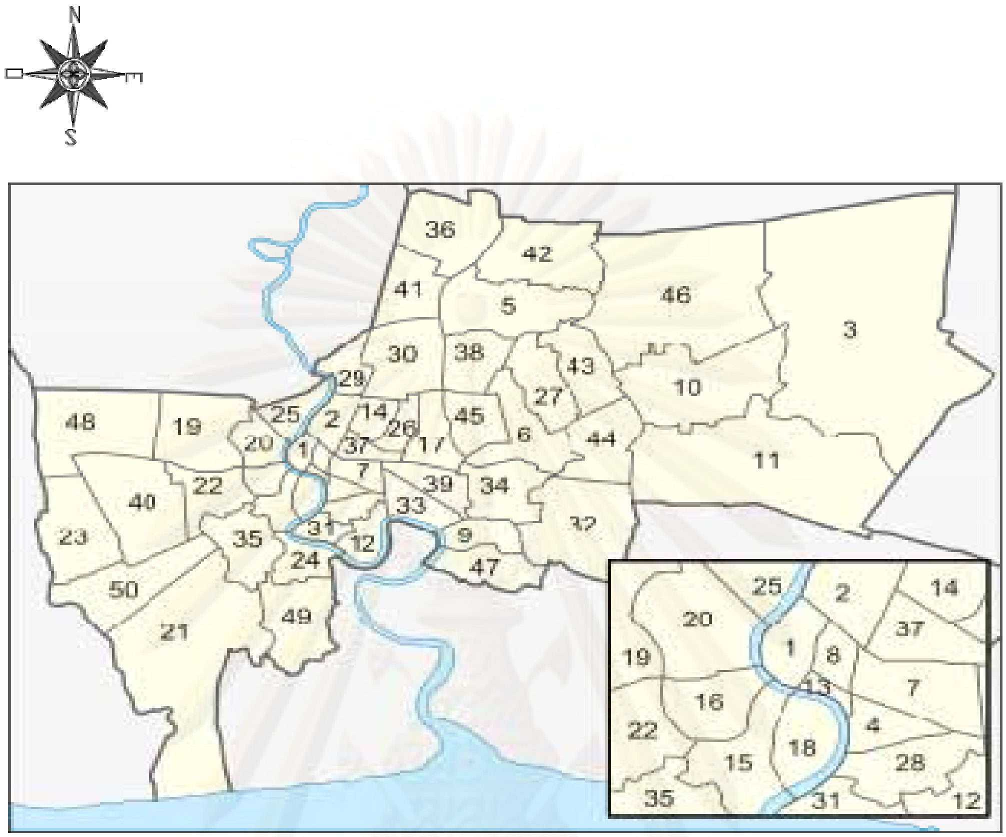

Figure 1.1 Bangkok: 50 districts separated.

(Source: Bangkok district map, 2008)

Location: Bangkok is situated on the low flat of Chao Phraya River which extends to Gulf of Thailand. Its latitude is 13º45’ north, and the longitude is 100º28’east.The elevation is 2.31 meters at Mean Sea Level .

Population: The total population in Bangkok as of 2006 was 5,658,953 which was 10% of the total population of Thailand. The population density is 4,051 per sq.km, with an increase of 0.98% per year. And the age’s structure is shown in Figure 1.2. (DOPA, 2006)

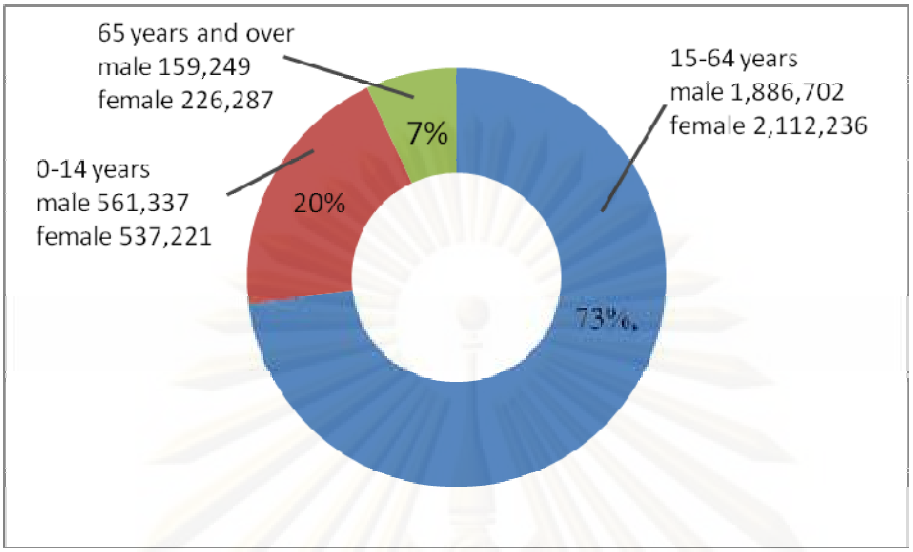

Figure 1.2 Age structure of Bangkok's population, 2007.

Source: Department of Provincial Administration, Ministry of Interior, 2007.(DOPA,2007)

Existing land use: The total area of Bangkok is 1,568,737 sq.km, which consist of an urbanized area of 700 sq.km; 23% resident use of 366.38 sq.km. and less for commercial, industrial and government use, as shown in Figure 1.3.

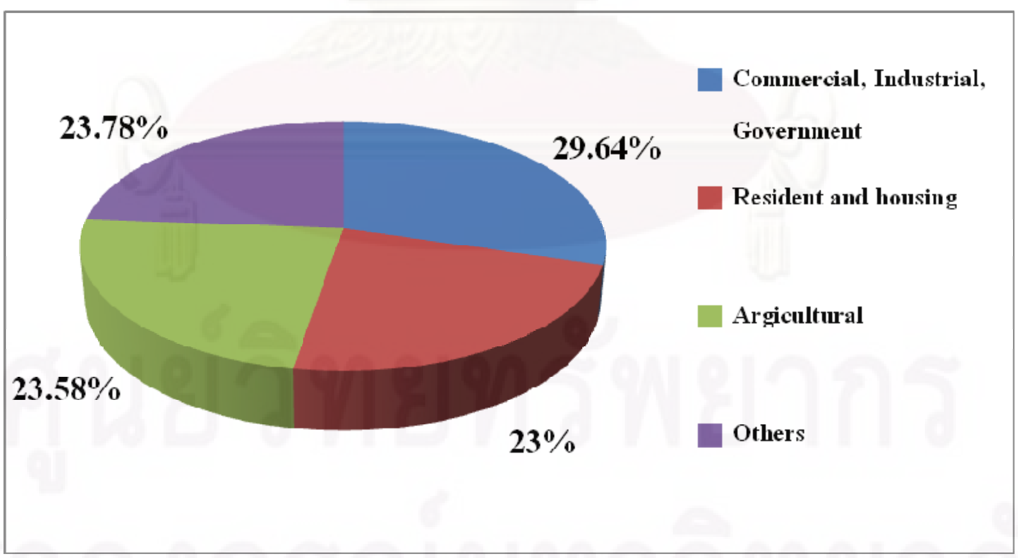

Figure 1.3 *Land use of Bangkok 2005.*

Source: Department of Provincial administration, Ministry of Interior, 2005.(DOPA,2005)

1.2 Bangkok metropolitan water demand situation.

At the present the Metropolitan Water work Authority have total water production for whole district of BMA are 1,765.7 millon cubic meter per year. And the total water sales are1,250.6 millon cubic meters per year.(about 70.83% of water production),increse 3.1% from year 2007.(MWA,2008)[3]

Number of consumers are increasing from 1,804,324 person to 1,859,573 person (about 3.1%) from year 2007 and the service area have increase from 2,139.2 sq.km. to 2,250.5 sq.km. (about 5.2%) from year 2007.(MWA,2008)[3]

Water demand is a main topic which should make a proper prediction to near realistic usage even in short or long term period. Because the prediction are use for the operation plan in each year. If the prediction have more precise and accurate then the efficiently plan will made.

Metropolitan Water Work (MWA) of Bangkok have made a long term plan for more than 10 year to year 2017 (Table 1.1) but there are long period which some factors that concern may change during the year so the factor analysis and multiple linear regression may use for apply or observe some factors that changed and effect to water demand consumption in short observe period.

Table 1.1 Forecasting production water and retail sale water volume of MWA from 2003 to 2017(MWA,2003)[1]

Year	Production water volume(million cu.m.)	Retail sale water volume(million cu.m.)
2003	1,005	1,012
2004	1,041	1,048
2005	1,065	1,072
2006	1,089	1,096
2007	1,112	1,120
2008	1,138	1,145
2009	1,156	1,164
2010	1,178	1,186
2011	1,200	1,208
2012	1,226	1,234
2013	1,245	1,254
2014	1,266	1,274
2015	1,287	1,296
2016	1,312	1,321
2017	1,330	1,339

Source : Annual report 2003 of BMA, Metropolitan Water Works.

1.3 Objective:

1.2.1 Study the relation of water demand and all influencing factors.

1.2.2 Study the proper prediction, forecasting of water demand in megacity by using the influencing factors

1.4 Scope of work:

This thesis has chosen Bangkok as a study model .By separate Bangkok area to 3 region;inner area,interim area and outer area.Collecting information from 8 interesting factors which related to domestic water demand consumption.(not include for industrial and agriculture using).All information have collected in past 10 years from year 1997 to year 2007.Those information are 1) selling price of water , 2)average annual temperature , 3)number of population , 4)density of population per area , 5)Number of family , 6)average annual precipitation , 7)Annual income per capita and 8)Estimate budget for each district of Bangkok .All information will be collected in a form of statistic data.Analizing them to find out the correlation group of each factors on factor analysis basis and create the water consumption equations of each regions from that correlation on multiple linear regression basis by using statistic program(SPSS).Validating water consumption equations with the actual water consumption volume from MWA in year 2008 for correction.Using statistic program "MINITAB" in term of double exponential smoothing forecasting method to forcast 8 interesting factors for next 10 years(2009 to 2019).Finally using water consumption equations which had validated to forcast amount of water consumption volume for next 10 years(2009 to 2019) base on information of 8 factors which had been predicted before.

1.5 Contribution of thesis:

This thesis may use for make a planning forecasting of water demand in megacity especially consider factors which mainly effect to increasing use. This data will make an optimum forecasting of water demand modelling in other megacity if just change any factor which many difference in each city.

1.6 Expected benefit:

This thesis will lead to make a proper forecast for water demand of other megacities. Because of the result will show the magnitude of each influence, easy to terminate or less considering in non-magnificent factors. It will make a model of forecasting for water demand in the future for Bangkok or the other megacities.

CHAPTER II
LITERATURE REVIEW

2.1 Megacity and urban area definition.

2.1.1 Definition of megacity

A megacity is generally defined as a metropolitan area with *a total population in excess of 10 million people.* Some definitions also set a minimum level for population density (at least 2,000 persons/square km). Megacities can be distinguished from global cities by their rapid growth, new forms of spatial density of population, formal and informal economics, as well as poverty, crime, and high levels of social fragmentation. A megacity can be a single metropolitan area or two or more metropolitan areas that converge upon one another. The terms conurbation and retroflex are also applied to the latter. The terms *mega polis* and megalopolis are sometimes used synonymously with *megacity*. The term *megacity* is also sometimes used to describe cities with more than 20 million people. (Wikipedia, 2008)[1]

In the year1800 only 3% of the world's population lived in cities. By the 20th century's close, 47% did so. In 1950, there were 83 cities with populations exceeding one million; but by 2007, this had risen to 468 agglomerations of more than one million. If the trend continues, the world's urban populations will double every 38 years, say researchers. The UN forecasts that today's urban population of 3.2 billion will rise to nearly 5 billion by 2030, when three out of five people will live in cities.(Wikipedia, 2008) [1]

Bangkok ,a city which have the registered number of population around 5,710,883 people.(DOPA,2008) and its area cover for 1,568 sq.km. so we may consider that Bangkok as a megacity because off its popupation density per area which is around 3,642 people per square kilometers even a total population are less than 10 million people.

2.1.2 Definition of urban area.

An **urban area** is an area with an increased density of human-created structures in comparison to the areas surrounding it. Urban areas may be cities, towns or conurbations, but the term is not commonly extended to rural settlements such as villages and hamlets. (Wikipedia, 2008)[2]

Definitions vary somewhat amongst different nations. The minimum density requirement is generally 400 persons per square kilometer.European countries define urbanized areas on the basis of urban-type land use, not allowing any gaps of typically more than 200 meters, and use satellite photos instead of census blocks to determine the boundaries of the urban area. In less developed countries, in addition to land use and density requirements, a requirement that a large majority of the population, typically 75%, is not engaged in agriculture and/or fishing is sometimes used. (Wikipedia, 2008)[2]

There are many definitions as some examples show in some of each nation as follows.

Definition of urban area in Australia

In Australia, urban areas are referred to as "urban centers" and are defined as population clusters of 1000 or more people, with a density of 200 or more persons per square kilometers (ASGC, 2001) .

Definition of urban area in China

In China, an urban area is an urban district, city and town with a population density higher than 1,500 persons per square kilometer. As for urban districts with a population density lower than 1,500 persons per square kilometer, only the population that lives in streets, town sites, and adjacent villages is counted as urban population. (Wikipedia, 2008)[2]

Definition of urban area in United State of America

In the United States there are two categories of urban area. The term *urbanized area* denotes an urban area of 50,000 or more people. Urban areas under 50,000 people are called *urban clusters.* Urbanized areas were first delineated in the United States in the 1950 census, while urban clusters were added in the 2000 census. There are 1371 United States Urban Areas & Urban Clusters with more than 10,000 people. (Wikipedia, 2008)[2]

The US Census Bureau defines an urban area as: "Core census block groups or blocks that have a population density of at least 1,000 people per square mile (386 per square kilometer) and surrounding census blocks that have an overall density of at least 500 people per square mile (193 per square kilometer). (Wikipedia, 2008)[2]

The concept of Urbanized Areas as defined by the US Census Bureau are often used as a more accurate gauge of the size of a city, since in different cities and states the lines between city borders and the urbanized area of that city are often not the same. For example, the city of Greenville, South Carolina has a city population under 60,000 but an urbanized area over 300,000, while Greensboro, North Carolina has a city population over 200,000 but an urbanized area population of around 270,000--meaning that Greenville is actually "larger" for some intents and purposes, but not for others, such as taxation, local elections, etc. (Wikipedia, 2008)[2]

About 70% of the population of the United States lives within the boundaries of urbanized area (210 out of 300 million). Combined, these areas occupy about 2% of the United States. The majority of urbanized area residents are suburbanites; core central city residents make up about 30% of the urbanized area population (about 60 out of 210 million). (Wikipedia, 2008)[2]

2.2 Megacity, their water demand and management.

In each megacities have their domestic water management themselves ,so we may show how are their characteristic and action for some megacities. In this thesis we present for two megacities below. San Francisco in the USA and Beijing in China.

2.2.1 San Fransisco, USA.

2.2.1.1 Background of San fransisco

San Francisco is located on the West Coast of the U.S. at the tip of the San Francisco Peninsula and includes significant stretches of the Pacific Ocean and San Francisco Bay within its boundaries. Several islands—Alcatraz, Treasure Island, and the adjacent Yerba Buena Island, and small portions of Alameda island, Red Rock Island, and Angel Island are part of the city. Also included are the uninhabited Farallon Islands, 27 miles (43 km) offshore in the Pacific Ocean. The mainland within the city limits roughly forms a "seven-by-seven-mile square," a common local colloquialism referring to the city's shape, though its total area, including water, is nearly 232 square miles (600 km^2).(Wikipedia,2008)[3]

San Francisco's climate is characteristic of California's Mediterranean climate with mild, wet winters and dry summers. Since it is surrounded on three sides by water, San Francisco's climate is strongly influenced by the cool currents of the Pacific Ocean which tends to moderate temperature swings and produce a remarkably mild climate with little seasonal temperature variation. The dry period of May to October is mild to warm, with average high temperatures of 64-70°F (17-21°C) and lows of 51-56°F (10-13°C). The rainy period of November to April is cool with high temperatures of 56-64°F (13-17°C) and lows of 46-51°F (7-10°C). On average, temperatures exceed 75°F (24°C) 28 days a year. Annual precipitation is about 20.4 inches (510 mm) which occurs mainly during the cooler months of November through April. On average, there are 67 rainy days a year. (Wikipedia,2008)[3]

The estimated 2008 population of San Francisco was 808,976. With over 17,000 people per square mile, San Francisco is the second-most densely populated major American city.So San Fransisco is one of megacity in the USA. (Wikipedia,2008)[3]

2.2.1.1 San fransisco water management (SFPUC,2009)

The San Francisco Public Utilities Commission (SFPUC) has prepared 2005 Urban Water Management Plan for the City and County of San Francisco. The purpose of the Act is to ensure that water suppliers plan for long-term conservation and efficient use of California's water supplies. The Act requires all urban water suppliers to prepare an Urban Water Management Plan every 5 years. The 2005 Urban Water Management Plans are due to the California Department of Water Resources by December 31, 2005.

Supplier service area: The SFPUC provides water to both retail and wholesale water customers. A population of over 2.4 million people within the counties of San Francisco, San Mateo, Santa Clara, Alameda and Tuolumne rely entirely or in part on the water supplied by the SFPUC which shown detail below.

<u>Alameda County</u>

- Alameda County Water District.
- City of Hayward.

<u>Santa Clara County</u>

- City of Milpitas,Mountain View,Palo Alto,San Jose,Santa Clara,Sunnyvale,Purissima Hill water District,Standford University.

<u>San Mateo County</u>

- City of Brisbane,Burlingame,Daly city,Town of Hillsborough,Melo Park, Milbrae,Redwood city,Mid-Pensula district,Coastside County Water District,East Palo Alto,Estero Municipal Improvement District,Guadalupe Valey,North Cost,San Bruno,Skyline county,Westborough,Cordilleras.

Households, Household Population, and Household Size: San Francisco projects water use within its residential sectors using factors such as household population, households and household size (the household population divided by the number of households). .A summary of household population and housing trends for the 1990 through 2030 historical and forecast period is shown in Table 2.1. The annual growth rate for households is about 0.4 percent for the next 25 years. The majority of new housing will be multi-family units.

Table 2.1 San Francisco County Demographic Trends

San Francisco County Demographic Trends(Unit: People)								
Demographi	**1990**	**2000**	**2005**	**2010**	**2015**	**2020**	**2025**	**2030**
Population	723,959	776,733	798,000	809,000	824,000	840,000	855,000	871,000
Household Population	699,330	756,976	772,470	787,965	803,459	818,954	834,448	849,942
Households	305,584	329,703	337,005	344,306	351,608	358,909	366,211	373,513
Persons Per Household	2.29	2.30	2.31	2.30	2.29	2.27	2.28	2.28
Single-family Units	105,521	108,255	109,985	111,410	111,725	111,745	111,765	111,785
Multi-family Units	200,063	221,448	227,020	232,896	239,883	247,164	254,446	261,728

Source: City and County of San Francisco Retail Water Demands and Conservation Potential Technical Memo(Hannaford, 2004).

Definition :

Household population means peoples who live in individual housing unit.

Households mans occupied dwelling units.

Water Supply sources: Approximately 96 percent of San Francisco's demand is provided by the SFPUC Regional Water System(RWS), which is made up of a combination of runoff into local Bay Area reservoirs and diversions from the Tuolumne River through the Hetch Hetchy Water and Power Project (HHWP). The RWS supplies are distributed within San Francisco through SFPUC's in-City distribution system. A small portion of San Francisco's water demand is met through locally-produced groundwater and secondary-treated recycled water.The SFPUC have collect an information of current and project amount if water supplies as detail in Table 2.2 below.

Table 2.2 Current and Projected Water Supplies Amount (SFPUC,2009)

Current and Projected Water Supplies Amount (mgd : million Gallon per day)							
Water Supply Source	2000	2005	2010	2015	2020	2025	2030
Purchases from SFPUC Regional Water System	90.1 mgd	88.9 mgd	88.5 mgd	88.4 mgd	88.6 mgd	89.1 mgd	89.9 mgd
Recycled water	< 1	< 1	< 1	< 1	< 1	< 1	< 1
Groundwater	3.5	3.5	3.5	3.5	3.5	3.5	3.5
Total	93.6	92.4	92.0	91.9	92.1	92.6	93.4

SFPUC Regional Water System Resources : The SFPUC RWS currently serves an average of approximately 265 million gallons per day (mgd) to 2.4 million users in Tuolumne, Alameda, Santa Clara, San Mateo and San Francisco counties. The SFPUC RWS is a complex system, shown in Figure 2.1, and supplies water from two primary sources:

- Tuolumne River through the Hetch Hetchy Reservoir; and
- Local runoff into reservoirs in Bay Area reservoirs (San Andres reservior,Pilardtos

reservior and Crystal spring reservior) in the Alameda and Peninsula watersheds.

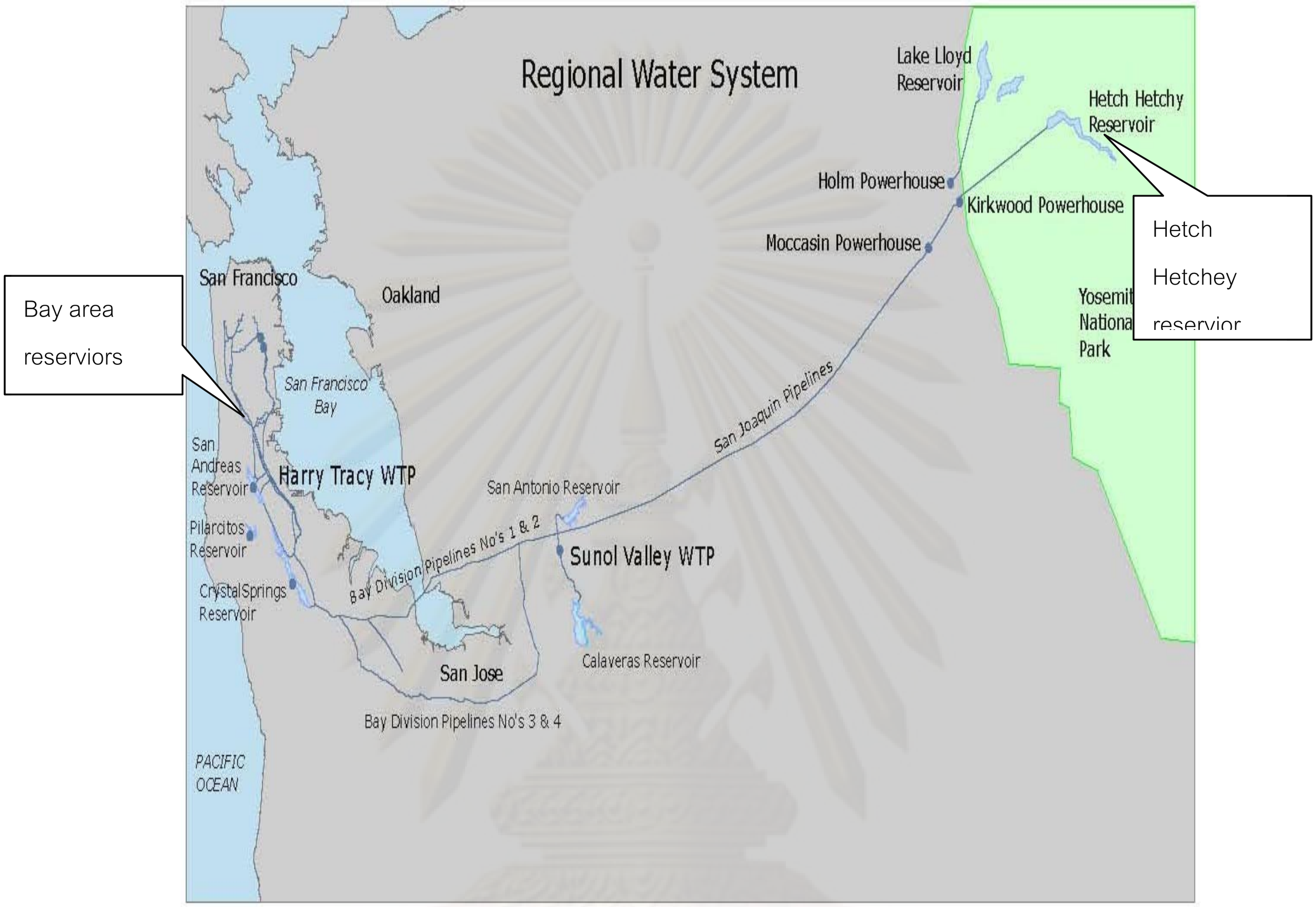

Figure 2.1 SFPUC Region Water System resources(SFPUC,2009)

Water developed by Hetch Hetchy Reservoir through the Hetch Hetchy Water and Power (HHWP) Project represents the majority of the water supply available to San Francisco. On average, the HHWP Project provides over 85 percent of the water delivered by the SFPUC. During drought, the water received from the HHWP Project can amount to over 93 percent of the total water delivered.

Bay Area reservoirs provide on average approximately 15 percent of the water delivered by the SFPUC RWS. The local watershed facilities are operated to conserve local runoff for delivery.

SFPUC Regional Water System : San Francisco's Water System, the in-city distribution system, was developed during the one- hundred year period between 1860 and 1960, reflecting the patterns and rates of growth in the City. San Francisco's retail water supply is delivered to the City in several major pipelines. One pipeline provides water to the eastside of the in-city distribution system and three pipelines serve the westside of the in-city distribution system.

Figure 2.2 San Francisco water system facilities(SFPUC,2009)

Definition : *Blue rectangular represent reservoirs.(10 places)*

Green triangle represent pumping stations. (18 places)

Brown circles represent storage tank. (8 places)

As shown in Figure 2.2, San Francisco's Water System includes 10 reservoirs and 8 water tanks that store the water delivered by the HHWP Project and the local Bay Area water system. The 18 pump stations and approximately 1,250 miles of pipelines move water throughout the system and deliver water to homes and businesses in the City. Several major pipelines convey water from the Peninsula System to San Francisco. Water to the Eastside of the City distribution system is fed by two pipelines that terminate at University Mound. Water to the Westside of the City distribution system is fed by two pipelines that terminate at Sunset Reservoir and one that terminates at Merced Manor Reservoir.

Water Use Provision : All of SFPUC's retail water customers have been metered since 1916. Currently, total water use by SFPUC retail customers is approximately 90 million gallons per day (mgd). Approximately 53 percent of this total is delivered to San Francisco residential customers. Non-residential water use accounts for approximately 38 percent of the demand with unaccounted water amounting to approximately 9 percent (Figure 2.3). Both the total consumption and the per capita use of water have been on a general decline in San Francisco since the mid-1970s.

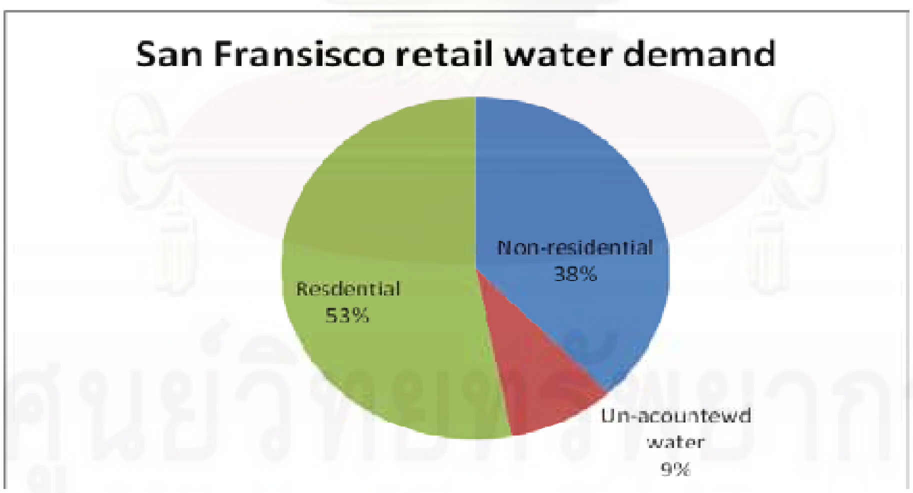

Figure 2.3 San Francisco retail water demand (SFPUC,2009)

Retail residential water use: Single-family units comprise approximately 33 percent of the total households in San Francisco, and use approximately 40 percent of the total water delivered to the residential sector. The remainder of residential water use (60 percent) occurs from multi-family units such as apartments.

Combined, the single-family and multi-family residential sectors have a current per capita consumption rate of 62 gpcd. Due to the moderate climate and the high density housing in San Francisco, water use within the residential sector is used almost entirely indoors. For multi-family units, the average outdoor water use is considered negligible. For single-family residential units, the average, outdoor water use is less than ten percent of their total use.

Retail Non-residential water use: Non-residential water use accounts for approximately 38 percent of San Francisco's retail water demands. This category of water use includes all sectors of water users not designated as residential, such as manufacturing, transportation, trade, finance, and government employment sectors, and the large services sector. Figure 2.4 illustrates the current distribution of jobs among the various employment categories within San Francisco.

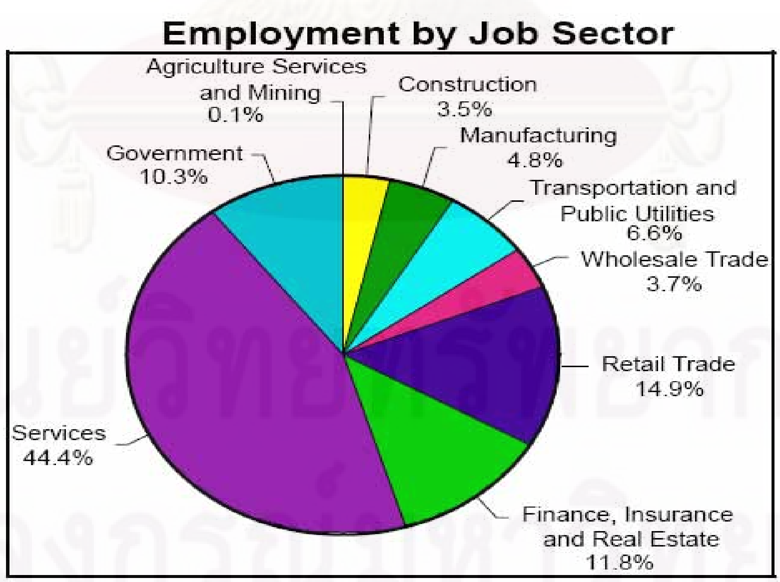

Figure 2.4 Employment by job sector of San Francisco.(SFPUC,2009)

Average employee-use rates, gallons per employee-day (GED), have been estimated for the various employment categories in the development of the end-use study. These values range from approximately 19 GED for the very small construction employment category to approximately 80 GED for the manufacturing employment category.

Table 2.3 provides a breakdown by industry type of SFPUC's predicted water demands for the retail non-residential sector for 2000 through 2030 in 5-year increments. The total demands for each 5-year increment, with anticipated reductions due to the plumbing code applied, are presented again in Table 2.3 as the "In-City Customers/Non-residential" data.

Table 2.3 SFPUC Projected Retail Water Demands: Non-Residential Sector Breakdown(SFPUC,2009)

SFPUC Projected Retail Water Demands: Non-Residential Sector Breakdown (mgd)							
Non-Residential	Year 2000	Year 2005	Year 2010	Year 2015	Year 2020	Year 2025	Year 2030
Agriculture, Mining	0.07	0.07	0.07	0.07	0.07	0.07	0.07
Construction	0.43	0.44	0.46	0.48	0.50	0.51	0.53
Manufacturing	2.45	2.50	2.64	2.77	2.86	2.99	3.11
Transportation	0.95	0.99	1.02	1.07	1.11	1.14	1.17
Wholesale Trade	1.38	1.41	1.49	1.56	1.61	1.68	1.75
Retail Trade	5.09	5.27	5.53	5.76	5.97	6.16	6.35
F.I.R.E.	1.36	1.41	1.46	1.53	1.59	1.63	1.68
Services	15.71	16.25	17.2	18.0	18.6	19.2	19.92
Government	1.19	1.24	1.28	1.33	1.39	1.43	1.47
Total	28.62	29.57	31.2	32.5	33.6	34.8	36.04
Total with plumbing code savings	27.9	29.2	30.2	31.0	31.7	32.6	33.5

Methodology used to predict retail water demand : The SFPUC uses disaggregated end-use models to project its retail water demands.San Francisco's water demand is segregated into three distinct categories of water use: non- residential (industrial, commercial and municipal uses); multi-family residential (multiple family dwellings such as townhouses and apartments); and single-family residential. The remainder of San Francisco's water demands such as unaccounted water and minor uses such as docks and shipping are forecast through trend analysis.

Non-residential water use is estimated using relationships between employment within San Francisco and employee-use of water. These coefficients are segregated by type of business or service enterprise, which is based on SIC(Standard Industry Code) code. The determination of appropriate employee-use rates within San Francisco's model came from extensive review of industry literature.

Two separate use models estimate multi-family and single-family residential water use. These models rely on a desegregation of household end-use of water, such as the number and volume of toilet flushes, duration of showering, and the size and frequency of use of washing machines and dishwashers. These data came from available residential end-use monitoring studies.

The models have been verified with water delivery records for historical periods, including periods of time when water demands were affected by drought induced rationing programs. Water use projections through the year 2030 were developed using these models. The water use projections incorporate the effects of water-saving plumbing code requirements, among other factors.

Projected water use for SFPUC's retail customers has been estimated using San Francisco's water use models. These models have incorporated economic and demographic forecast data, including projections of population, housing stock and employment. This forecast data was based on the Association of Bay Area Government report titled *Projections 2002: Forecasts for the San Francisco Bay Area to the Year 2025*, which summarizes demographic projections for the City at 5-year intervals. ABAG(Associate of Bay Area Government) projections were then reviewed and refined by San Francisco City Planning using up-to-date planning information for the City. City Planning accepted the industry data provided by ABAG in their 2002 projections but revised the population and household population projections based on projected future development.

Results of the water demand forecasts show that SFPUC's retail water demand will only slightly increase by the year 2030 (Table 2.4), even though the population in San Francisco is expected to increase by 15 percent for the same period (year 2005 through year 2030).The projected increase in retail water demands is due to estimated growth in business and industry activity, which will translate into a commensurate increase in water use. However, the expected increase in water use within these sectors is forecast to be partially counter balanced by decreases in water use within the residential sector.

The decreased water use forecast for both single-family and multi-family residential sectors is attributed primarily to the following factors:

• Population density within housing units will decline in the future, and

• Market penetration of current plumbing codes within the residential sectors will increase as time progresses, resulting in an increase in current water savings due to the installation of more water-efficient fixtures.

In tandem, these two factors (residential and non-residential sectors)will lead to a lower water use by a slowly increasing population.

Table 2.4 SFPUC Projected Retail Water Demands (mgd). (SFPUC,2009)

SFPUC Projected Retail Water Demands (mgd)							
	Year	Year	Year	Year	Year	Year	Year
In-City Customers							
Single-family Residential	18.8	18.4	17.8	17.3	16.8	16.4	16.2
Multi-family Residential	28.8	27.7	26.9	26.5	26.4	26.5	26.7
Non-residential	27.9	29.2	30.2	31.0	31.7	32.6	33.5
Other (B&C, D&S)	0.24	0.24	0.24	0.24	0.24	0.24	0.24
Sub-total		75.5	75.1	75.0	75.2	75.7	76.5
Other Retail Customers	4.9	4.9	4.9	4.9	4.9	4.9	4.9
Other Retail Customers	0.4	0.4	0.4	0.4	0.4	0.4	0.4
Groveland Community Services District	0.8	0.8	0.8	0.8	0.8	0.8	0.8
Retail Demand Met by SFPUC RWS	**90.1**	**88.9**	**88.5**	**88.4**	**88.6**	**89.1**	**89.9**
Existing Groundwater							
Golden Gate Park, San Francisco Zoo	2.5	2.5	2.5	2.5	2.5	2.5	2.5
and	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Total SFPUC Water System Retail Demand	**93.6**	**92.4**	**92.0**	**91.9**	**92.1**	**92.6**	**93.4**

Wholesale Water Demands

The SFPUC provides water to 28 entities that comprise the wholesale water customers. These entities receive almost two-thirds of the total water delivered by the SFPUC.

Methodology Used to Project Wholesale Water Demands

The SFPUC in coordination with the wholesale customers and BAWSCA(Bay Area Water Supply and Conservation Agency)conducted a comprehensive water demand forecast of its wholesale service area. Similar in methodology to the retail demand projection model, the Least Cost Decision Support System (DSS) model, an end-use model that disaggregates water account data to end-uses, was employed. End-use models allow one to portray the effects of the plumbing code on each account type over time as high water use fixtures are replaced with low water use fixtures. The DSS model disaggregates water use in an account by each water using fixture and incorporates the effects of plumbing and appliance codes on fixtures and appliances including toilets (1.6 gallons per flush), showerheads (2.5 gallons per minute) and washing machines (lower water use) on existing accounts. In projecting water demands for current users using the DSS model, the effects of the plumbing code are applied to the future water use of existing accounts. New water demands are determined by applying the growth rate in population and employment to the applicable water accounts.

Wholesale Water Demands

Water supplied by the SFPUC to its wholesale customers is metered. The total water demands of the wholesale water customers are shown in Table 2.3 Wholesale customers collectively in 2001 received about 67% of their water supply from the SFPUC RWS. Future projections indicate that between 2010 and 2030 this figure will be in the range of 64-65%. The data shows that for the year 2030, water demands of the wholesale water customers (regardless of water source) will increase to approximately 324 mgd. Other water supplies available and developed by the wholesale customers, which include increased water conservation and recycling, show a net increase of about 10 mgd. As shown in Table 2.3 the purchase of SFPUC water by the wholesale customers is projected to increase from approximately 178 mgd to 209 mgd by the year 2030.

Table 2.5 SFPUC Wholesale Customer Water Demands and Supplies (SFPCU,2009)

SFPUC Wholesale Customer Water Demands and Supplies (mgd)							
	2001	**2005**	**2010**	**2015**	**2020**	**2025**	**2030**
Wholesale Customer Purchase from the SFPUC RWS[1]	170.6	177.9	188.9	191.6	197.5	203.6	209.4
Other Supplies[2]	101.4	104.1	103.1	107.4	110.5	111.4	114.6
Total Wholesale Customer Demand[3, 4]	272	282	292	299	308	315	324

San Francisco, Megacity with around 2.4 million people and their water demand around 265 million gallon per day. They have separate their planning for retail and whole sale water consumption by their difference factors by using end user modeling, empirically recorded information which reference by standard industrial code , observing the trendy of household usage, family type expanding to make a precise and correct project prediction.

2.2.2 Beijing

2.2.2.1 Background of Beijing

Beijing is situated at the northern tip of the roughly triangular North China Plain. Mountains to the north, northwest and west shield the city and northern China's agricultural heartland from the encroaching desert steppes. The northwestern part of the municipality, especially Yanqing County and Huairou District, are dominated by the Jundu Mountains, while the western part of the municipality is framed by the Xishan Mountains. Beijing is also the northern terminus of the Grand Canal of China which was built across the North China Plain to Hangzhou. Miyun Reservoir, built on the upper reaches of the Chaobai River, is Beijing's largest reservoir, and crucial to its water supply.(Wikipedia,2008)[4]

The city's climate is a monsoon-influenced humid continental climate, characterized by hot, humid summers due to the East Asian monsoon, and generally cold, windy, dry winters that reflect the influence of the vast Siberian anticyclone. Average daytime high temperatures in January are at around 1 °C (33°F), while average temperatures in July are around 30°C (87 °F). The highest temperature ever recorded was 42 °C and the lowest recorded was -27 °C. In 2005, the total precipitation was 410.77 mm; the majority of it occurred in the summer. .(Wikipedia,2008)[4]

Municipal government is regulated by the local Chinese Communist Party (CCP) in issuing administrative orders, collecting taxes, and operating the economy. The local party authority is headed by the Beijing CPC Secretary .The local CCP also directs a standing committee of the Municipal People's Congress in making policy decisions and overseeing local government. Local government figures include a mayor, vice-mayor, and numerous bureaus focusing on law, public security, and other affairs. Additionally, as the capital of China, Beijing houses all the important national governmental and political institutions, including the National People's Congress. (Wikipedia,2008)[4]

The population of Beijing Municipality, defined as the total number of people who reside in Beijing for 6 months or more per year, was 17.4 million at the end of 2007. There were 12.04 million people in Beijing Municipality who had Beijing hukou (permanent residence), and the remainder were on temporary residence permits. In 2006, a study by the Beijing Statistics Bureau estimated the total of all people living in Beijing (permanent, temporary, unregistered and others) to be "close to 20 million." Recent statistics cited by China Daily put the number of migrant workers in the service and construction industries in Beijing at "more than 5.1 million." In addition, there is a large number of migrant workers (min gong) who live illegally in Beijing without any official residence permit (or unregistered people). (Wikipedia,2008)[4]

The population of Beijing's urban core is over 13 million. After Chongqing and Shanghai, Beijing is the third largest of the four municipalities of the People Republic of China, which are equivalent to provinces in China's administrative structure. (Wikipedia,2008)[4]

Most of Beijing's residents belong to the Han Chinese majority. Other ethnic minorities include the Manchu, Hui, and Mongol. A Tibetan-language high school exists for youth of Tibetan ancestry, nearly all of whom have come to Beijing from Tibet expressly for their studies. A sizable international community exists in Beijing, many attracted by the highly growing foreign business and trade sector, others by the traditional and modern culture of the city. Much of this international community lives in the areas around the Beijing, Sanlitun, and Wudaokou. In recent years there has also been an influx of South Koreans who live in Beijing predominantly for business and study purpose. Many of them live in the Wangjing and Wudaokou areas. (Wikipedia,2008)[4]

2.2.2.2 Beijing and their water management

service area (PIBG,2009) : Under its jurisdiction are 16 districts and two rural counties as follows

- 4 core city districts of 92 square kilometers
- 4 near suburbs of 1,289 square kilometers
- 8 outer suburbs of 12,405 square kilometers
- 2 rural counties of 4,316 square kilometers

The current estimate of population includes several million people classified by the central government as “floating population” – the official term for temporary residents or migrant workers registered as residents elsewhere. In 2007, Beijing’s population expanded by 520,000. Of these people, 157,000 have household registration in Beijing municipality and 363,000 are classified as “floating population.”

Table 2.6 Beijing’s population by district and county.(PIBG,2008)

Name of District	Population	
Dongcheng	600,000	Urban
Xicheng	750,000	
Chongwen	410,000	
Xuanwu	550,000	
Chaoyang	2.3 million	Suburban
Haidian	2.24 million	
Fengtai	1.4 million	
Shijingshan	489,000	
Mentougou	270,000	Outlying suburban
Shunyi	637,000	
Tongzhou	870,000	
Fangshan	814,000	
Changping	615,000	
Pinggu	396,000	
Huairou	296,000	
Daxing	671,000	
Miyun	420,000	Counties
Yanqing	275,000	
Total: 14,003,000		

Water supplies sources(PIBG,2009) : Beijing’s water resources include surface water and groundwater. Surface water refers to water in rivers, lakes, and reservoirs. The amount of surface water available fluctuates within and between years depending on rainfall.

Beijing's rainfall varies geographically, seasonally and annually. Eighty-five percent of the annual precipitation falls between July and September. Rainfall also varies between the sub-watersheds within the municipality and particularly between mountainous areas and the low-lying plain.

Beijing's average yearly precipitation is 590 millimeters (mm) with a recorded high of 1,406 mm in 1959 and a low of 242 mm in 1869. In comparison, Shanghai, a city with roughly the same population as Beijing, receives an average annual rainfall of 1,411 mm. New York City, which is at the same latitude as Beijing, receives an average rainfall of 1,090 mm. (PIBG,2009)

The total amount of surface runoff in Beijing's five river systems is estimated to be 4.7 billion cubic meters in a normal year, which drops by 45 percent to 2.6 billion cubic meters in a dry year. To regulate and store surface runoff, Beijing built a total of 85 dams and reservoirs between 1950 and 1995. The amount of surface water available for use (either from rivers or reservoirs) in an average year is 1.67 billion cubic meters and only 1 billion cubic meters in a dry year. In the last few decades, the volume of surface runoff entering Beijing's two largest reservoirs, Guanting and Miyun, has dropped sharply. According to Figure 2-2, the average inflow to Guanting reservoir dropped 90 percent between the 1950s and 2000.The location of both reservoir are as shown in Figure 2.5 below.

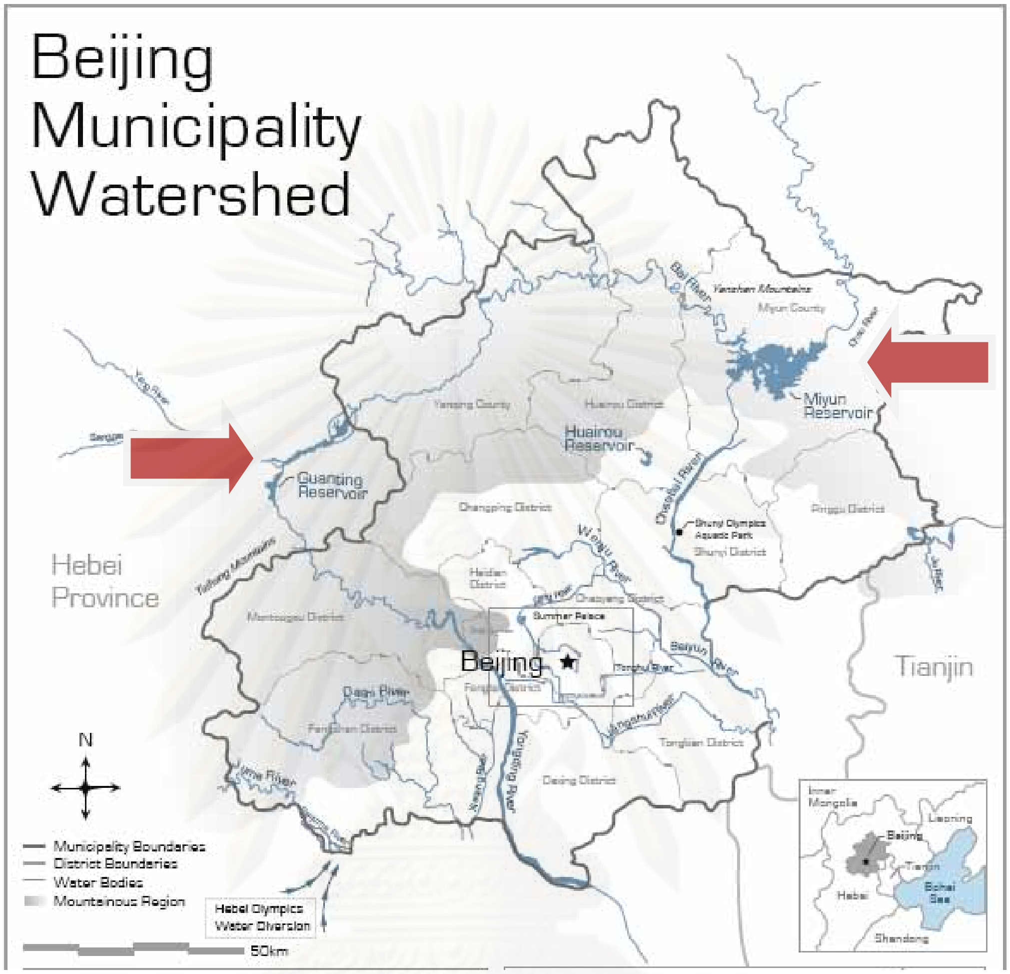

Figure 2.5 Miyun and Guanting reservoir 's location (PIBG,2008)

The shallow groundwater on the Beijing plain is recharged 44 percent by precipitation and 31 percent by seepage of surface water. As the area covered by buildings and roads has increased dramatically in recent years, less water is able to seep through the ground naturally. Both the rate and volume of groundwater recharge are decreasing. The term "available groundwater" usually refers to water found at shallow depths (i.e. 1 to 100 meters) that is easily extracted, quickly replenished by rainfall and seepage, and doesn't cause subsidence problems when extracted. The Beijing Water Bureau estimates that its available groundwater

– that which can be safely extracted without depleting the resource – ranges from 2.0 to 2.45 billion cubic meters per year, depending on rainfall. (PIBG,2009)

Available water supply refers to the amount of water available for treatment and distribution through the city's water pipeline system. These figures do not include water that is reused after treatment. Taking surface water and groundwater, the Beijing Water Bureau estimates the volume of exploitable water resources ranges from 3.0 to 4.12 billion cubic meters per year, depending on rainfall. (PIBG,2009)

Table 2.7 Resources of available water of Beijing.(PIBG,2009)

Available Water Resources	Range	Current
Surface Water	1.0 – 1.67	0.80
Groundwater	2.0 – 2.45	2.45
Total	3.0 – 4.12	3.25

Under present conditions, the Beijing Water Bureau estimates its total available water supply is approximately 3.25 billion cubic meters annually with 0.8 billion cubic meters supplied by the Miyun and Guanting reservoirs and 2.45 billion cubic meters from groundwater sources. (PIBG, 2009)

Water consumption: Table 2.7 indicates how much water is consumed by each sector. The amounts for domestic, agriculture, industry, and urban environment sectors were obtained from the 2005 Beijing water resources bulletin. (PIBG, 2009)

Table 2.8 Water usage by sector of Beijing. (PIBG,2009)

Sector	Volume(million cubic meters)	Percent of Total water supply
Domestic	1,338	39
Agriculture	1,332	38
Industry	680	20
UrbanEnvironment	110	3
TOTAL	3,450	100

As the record of Beijing Water Bureau from year 1995 to 2005 , they have indicate water use changing as shown in Figure 2.6

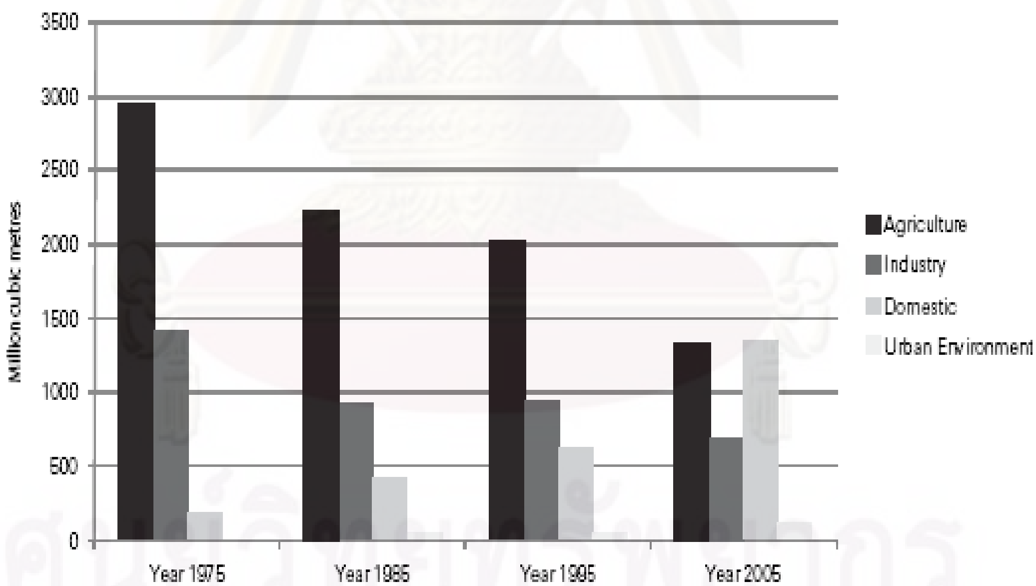

Figure 2.6 Water usage by sector changing of Beijing from 1995 to 2005(PIBG,2009)

Since 1975, the amount of water used for agriculture has dropped by more than one-half while domestic consumption has increased ten-fold.

- From 1995 to 2005, the volume of water used for domestic purposes has more than doubled, accounting for 39 percent of total water use in 2005, up from 17 percent in 1995.

-The volume of water used for agriculture has dropped by one-third, accounting for just 38 percent of total water use in 2005 compared to 56 percent in 1995.

-The volume of water used by industry has dropped by one quarter, accounting for 20 percent of total water use in 2005 compared to 26 percent in 1995.

Domestic water use(PIBG,2009) : As Beijing's urban population grew and lifestyles changed, the municipality expanded its water supply system to reach more households.

The data presented in Figure 2.6 show the following:

- Daily per capita domestic water use in urban districts increased seventeen-fold from 0.018 cubic meters in 1950 to 0.302 cubic meters in 1995.
- The volume of tap water used in urban districts increased from 7.0 million cubic meters in
1950 to 466 million cubic meters in 1995.
- As of 1995, tap water use had increased to 76 percent of total domestic water supply in urban districts, compared to 49 percent of total water use in 1970.

In the last decade, 10 new waterworks have been built to provide Beijing municipality with a daily water supply capacity of up to 2.68 million cubic meters. By 2010, another five waterworks are to be constructed and three extended which, if completed, will increase the municipality's capacity
of water supply to 3.65 million cubic meters daily.

Beijing, megacity with more than 13 million people. With increasing water consumption trendy by their city's characteristic. After founding new China. Water resources are mainly from under ground water, rapid growth of the city and drought problem. Even there are not many study factors about water consumption in China, the Republic People of China Communist Party have plan to make development of Beijing water supply system by combined in “The South-to-North Division Project” by 2010 ,the capacity of water supply will be increase to 3.65 million cu.m. per day and increasing of tab water service area from 608 sq.km. to 1,620 sq.km.(Anjun,2008)

Case study about water demand in Beijing.

WEI, GNAUCK and LEI (2008) have make a practical simulation approach to analyze domestic water demand and its future uncertainty in water scarce area through a case study of Beijing .The analysis model were used to analyze the interrelationship between domestic water demand and some socio-economic factors of Beijing. The forecasting model were applied to predict domestic water demand from 2009 to 2015 ,and this model was validated by comparing the prediction value with the observation. Scenario analysis was applied to simulate uncertainty and risk in domestic water demand in future. The simulation result proved that domestic water demand will increase from 13.9 X 10^8 cu.m. to 16.7 X 10^8 cu.m. from 2009 to 2015.

2.2.3.1 Bangkok, their water demand and management

As we have explained about Bangkok as a type of megacity in the introduction chapter.Bangkok itself have made their water management unit call Metropolitan Water Work(MWA) to support their water demand and management in BMA and their detail are shown below.

2.2.3.1 Background of MWA.

The Metropolitan Waterworks Authority (MWA) was established on August 16, 1967, in accordance with the Metropolitan Waterworks Authority Act 1967 by consolidating 4 preceding agencies namely; the Bangkok Waterworks Authority of the Municipal Public Works Department, Thonburi Waterworks Authority of Thonburi Municipality, Nonthaburi Waterworks Authority under the Provincial Waterworks Division of the Municipal Public Works Department, and Samutprakarn Waterworks Authority of Samutprakarn Municipality called "the Metropolitan Waterworks Authority".(DOPA,2008)

The Bangkok Waterworks Authority hold its service on November 14,1914 under the Department of Sanitation, Ministry of Municipality, afterward, changed to be the Municipal Public Works Department, the Ministry of interior. Subsequently, the Bangkok Waterworks Authority was transferred to be under the Bangkok Municipality in 1939, and transferred back to the Municipal Public Works Department in 1952 and finally established to be the Metropolitan Waterworks Authority on August 16, 1967. (DOPA,2008)

The Thonburi Waterworks Authority, initially obtained treated water to supply in its area from the Bangkok Waterworks Authority via the distribution pipes along with the King Rama I Bridge. Later, during the World War II, the Bridge was bombed by plane, thus treated water unable to be distributed from Bangkok to Thonburi area. Therefore, the Thonburi Municipality started to implement its waterworks operation by drilling deep wells water and supplied to the people in the area in 1953, and later merged to MWA in accordance with the MWA Act 1967, the MWA has taken over the operation on August 14,1968. (DOPA,2008)

The Nonthaburi Waterworks Authority was operated on January 15,1960, under the supervision of the Municipal Public Works Department, Ministry of Interior, and transferred to consolidate with the MWA in accordance with the MWA Act 1967, the MWA has taken over the Nonthaburi Waterworks Authority on December 14, 1967

The Samutprakarn Waterworks Authority was inaugurated its service on June 20, 1936, under the control of Samutprakarn Municipality, and combined with the MWA in accordance with the MWA Act 1967, the MWA has taken over its operation on March 22,1969. (DOPA,2008).So at the present MWA have all these 4 authority became integrate to same organization and operations under MWA for their 3 objective.

1. Exploration and serve raw water for BMA.
2. Production and transmission drinking water for Bangkok, Nontaburi and Samutprakan.
3. Proceed other concern business for MWA.

Water transmission system : MWA have collect raw water resource by 2 main rivers. Chao Phraya river and Mae Klong river. Cho Phraya river have received raw water from Bhumipol Dam , Sirikit Dam and Pasak Dam .Mae Klong river have received raw water from Vajiralongkorn Dam and Srinagarindra Dam. We can see their resource amount in Figure 2.7

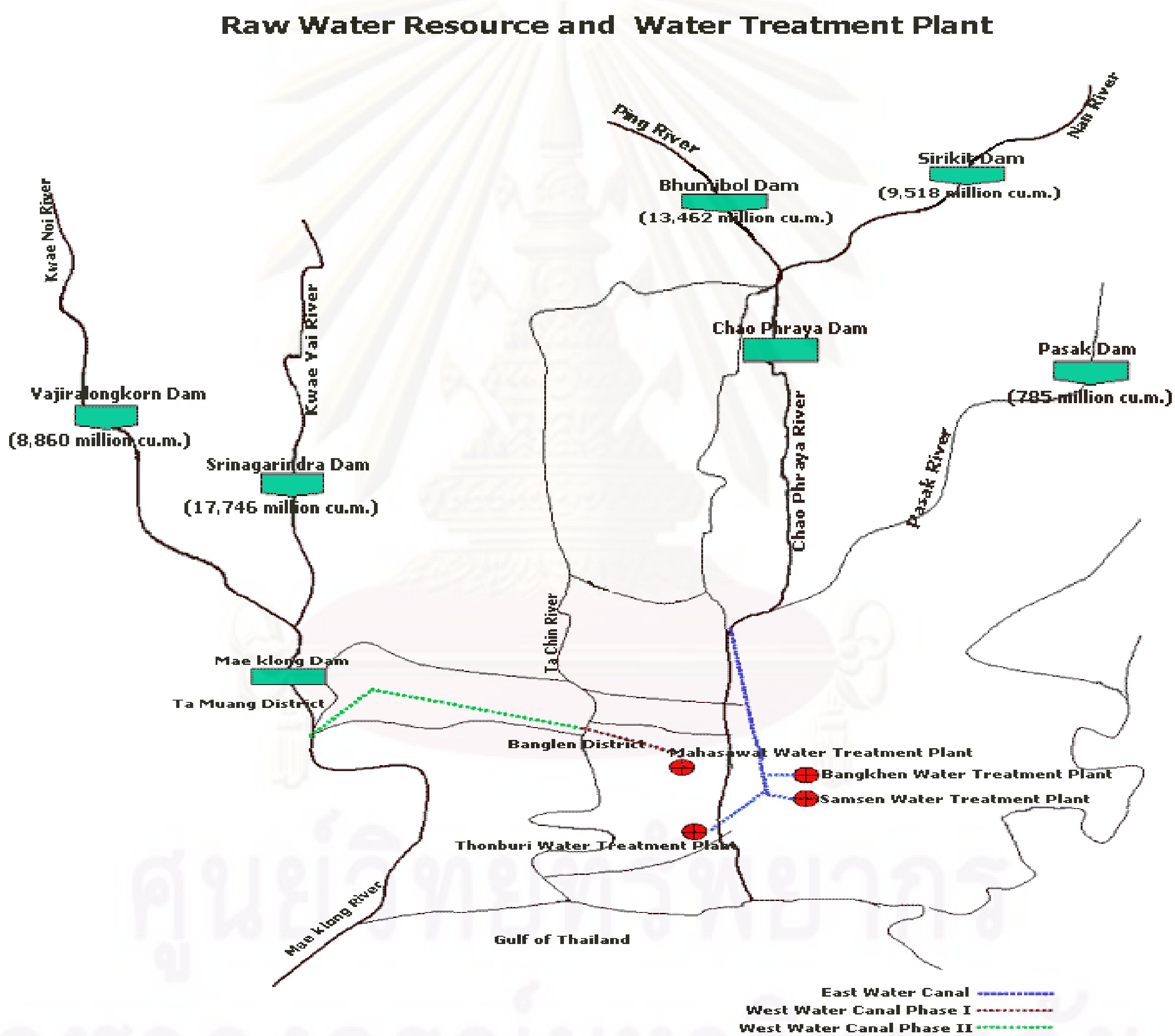

Figure 2.7 Raw water resources and water treatment plant .(MWA,2009)

By the separated resource so MWA have 2 line of service. East side and West side of Bangkok as shown in diagram in Figure2.8. That we can explain their procedure of each section by flowchart in Figure 2.8

Figure 2.8 Diagram of water resources and their transmission to consumers. (MWA,2009)

East side of BMA (Chao Phraya river)

From the Figure 2.8 above ,on the left hand side .The first point that takes water from the Chao Phraya river into the MWA's East Canal is called “Sam Lae” pumping station , Pratumthani province. The capacity of the station is 3.8 million cu.m per day.

After that water have transport by East canal from the source at Sam Lae, the raw water flows straight along Prachachuen road to Bangkhen water treatment plant, Samsen water treatment plant and Thonburi treatment plant, consequently. The total length of the canal is 31 kilometers.

The capacity of Bangken treatment is 3,200,000 cu.m. of water supply per day. The capacity of Samsen plant is 700,000 cu.m. of water supply per day. And the capacity of Thonburi treatment plant is 170,000 cu.m. of water supply per day.

Then the treated water have pumped by pumping station .In the East side we have 7 pumping stations . All 7 pumping station have total capacity around 1,965,000 cu.m. per day. Detail of each pumping are as shown below.

1. <u>Sam Rong Pumping Station</u>

Location : 73 Moo 10 Sam Rong Tai, Phra Pradang, Samut Prakan.

Number of Pumps : 5.

First Operation : 1988 .

Capacity : 459,000 cu.m. per day.

Water Supply Source : Bangkhen Water Treatment Plant.

Service Areas : Sukhumvit Road from Bangna to Bangpu intersection, Nakrom Road to Puchao Samingphlai intersection, Tangrotfai Saikao Road, Taiban Road, Sailuad Road, Thepharak Road, Srinagarindra Road to Bangna-Trad intersection, Suan Som Road, Suk Sawat Road from Khlong Bangchak to Phra Pradang.

2. Lumphini Pumping Station

Location : Ratchadamri Road, Wang Mai, Pathumwan, Bangkok

Number of Pumps : 4

First Operation : 1979.

Capacity : 272,000 cu.m. per day.

Water Supply Source : Bangkhen Water Treatment Plant .

Service Areas : Sathon Nuea-Tai Road, RAMA IV Road from express way to Hua Lamphong, Henri Dunant Road, Chan Road, Suan Phlu Road, Nanglinchi Road, Sathu Pradit Road, RAMA III Road, Charoen Krung Road from Silom Road to RAMA III Road, Silom Road, Si Phraya Road, Ratchadamri Road from RAMA IV Road to Sathon Road.

3. Lad Krabang Pumping Station

Location : 20/14 Khlong Songtonnoon, Lat Krabang, Bangkok.

Number of Pumps : 3 .

First Operation : 1997.

Capacity : 299,000 cu.m. per day .

Water Supply Source : Bangkhen Water Treatment Plant .

Service Areas : Lat Krabang Road, On-Nuch Road to Sinakarin Road, Pattanakhan Road, Kingkaew Road, East Ring Road, Bangna-Trad Road from Srinagarindra Road to the end of boundary, Ram Intra Road to Nawamin Road, Sihaburanakit Road, Bangbo-Khlong dan Road.

4. Lad Phrao Pumping Station

Location : 591 Soi Teplila 1, Wangthonglang, Bangkapi, Bangkok.

Number of Pumps : 4

First Operation : 1988.

Capacity : 335,000 cu.m. per day .

Water Supply Source : Bangkhen Water Treatment Plant

Service Areas : Lat Phrao Road, Ramkhamhaeng Road, Nawamin Road, Sukhaphiban 2 Road, Sukhaphiban 3 Road, Sriwara Road, Teplila Road.

5. Klong Toei Pumping Station

Location : 41 Sukhumvit 40, RAMA IV Road, Prakhanong, Khlong Toei, Bangkok.

Number of Pumps : 5

First Operation : 1984.

Capacity : 260,000 cu.m. per day .

Water Supply Source : Bangkhen Water Treatment Plant .

Service Areas : RAMA IV Road to express way, Sukhumvit Road from Phloenchit to Bangna, On-Nuch Road from Sukhumvit Road to Srinagarindra Road, Sinakarin Road, Sukhumvit 71 Road, Asoke-Din Daeng Road, Ratchadaphisek Road from Phetchaburi Road to RAMA IV Road, Ekkamai Road, Thong lor Road.

6. Phahon Yothin Pumping Station

Location : Soi Intramara, Sutthisan Road, Bangkok.

Number of Pumps : 3

First Operation : 1983

Capacity : 180,000 cu.m. per day .

Water Supply Source : Bangkhen Water Treatment Plant.

Service Areas : Vibhavadi-Rangsit Road to Phahon Yothin Road, Lat Phrao Road, Sutthisan Vinitchai Road, Pracha Songkhro Road, Ratchadaphisek Road from RAMA IX Road to Phahon Yothin Road, Pracharat Bamphen Road, Thiam Ruam Mit Road, Pracha U-Thit Road.

7. Minburi Pumping station.

Location : Nimitmai Road, Minburi, Bangkok.

Number of Pumps : 3

First Operation : 2004

Capacity : 160,000 cu.m. per day.

Water Supply Source : Bangkhen Water Treatment Plant

Service Areas : Nimit Mai Road, Romklao Road, Chalong Krung Road, Chaokhuntahan

Road, Bueng Khum Road, Ramkhamhang Road, Suwinthawong Road, East Ring Road, Bangkok-Chonburi Road.

West side of BMA (Mae Klong)

From the Figure 2.8 above ,on the right hand side .The first point that takes water from the Mae Klong river into the MWA's West Canal is called “Ta Maung” pumping station , Kanjanaburi province. The capacity of the station is 3.8 million cu.m per day.

Then raw water have transmits by West canal. The water flows by the gravity from the source, passes under the Tachin river via a tunnel, to Banglen raw water pumping station, Nakhon Pathom. The total length from Ta Muang raw water intake to Banglen raw water pumping station is 72 kilometers. There are 4 types of canal depending on the geography namely U-shape reinforced concrete canal, lined concrete canal, earth canal, and elevated flume.

After that raw water have treated at Mahasawat treatment plant and pumped by 3 pumping stations which are Tapra pumping station , Ratburana pumping station and Phetkasem pumping station. Total water treatment volume around 773,000 cu.m. per day. Detail of each pumping are as shown below.

1.<u>Tapra water pumping station.</u>

Location : 108/1 Phet Kasem Road, Tha Phra, Bangkok Yai, Bangkok.

Number of Pumps : 5.

First Operation : 1989 .

Capacity : 204,000 cu.m. per day .

Water Supply Source : Bangkhen Water Treatment Plant and Mahasawat Water Treatment Plant.

Service Areas : Intharapitak Road, Ratchadaphisek Road, Taksin Road, Prachatipok Road, Somdet Chao Phraya Road, Lat Ya Road, Krungthonburi Road, Charoen Nakhon Road Chomthong Road, Ekkachai Road from Khlong Ratchamontri to Wutthakat Road, Phet Kasem from Intharapitak Road to Siam University, Charansanitwong Road from Tha Phra intersection to Khlong Mon.

2. Ratburana pumping station

Location : 52/2 Moo 6 Bangmod, Chomthong, Bangkok.

Number of Pumps : 4.

First Operation : 1993.

Capacity : 255,000 cu.m. per day.

Water Supply Source : Bangkhen Water Treatment Plant

Service Areas : RAMA II Road to Bangmod Hospital, Suksawat Road, Rat Burana Road, Pracha Uthit Road, Phuttha Bucha Road, Kheuan Khan Road

3.Phetkasem pumping station

Location : 186/38 Moo 1 Bangkhae Nuea, Bangkhae, Bangkok .

Number of Pumps : 3.

First Operation : 2000.

Capacity : 314,000 cu.m. per day .

Water Supply Source : Mahasawat Water Treatment Plant.

Service Areas : Phet Kasem Road from Siam University to the end of the boundary, Kanchanaphisek Road from Khlong Bangcheuaknang to RAMA II Road, Nawamin Road, Ekkachai Road from Khlong Ratchamontri to the end of the boundary.

Distribution stations

After pass trough all the pumping stations , supply water have separated to network lines in 15 district of MWA branch office as detail follow. Each branches have separate boundary area by river system in BMA.

Figure 2.9 Distribution Branches and its boundary of MWA.(MWA,2003)

1. Bangbuathong

   Service area : 375.22 sq.km.

   Number of consumer :174,807 consumers.

   Retail water volume per year :59,553,735 cu.m.

2. Bangken

   Service area : 90.32 sq.km.

   Number of consumer :106,087 consumers.

   Retail water volume per year :59,930,227 cu.m.

3. Bangkok-Noi

   Service area : 76.14 sq.km.

   Number of consumer :106,346 consumers.

   Retail water volume per year :56,529,494 cu.m.

4. Ladprao

   Service area : 93.78 sq.km.

   Number of consumer :140,509 consumers.

   Retail water volume per year :83,608,629 cu.m.

5. Mansri

   Service area : 34.58 sq.km.

   Number of consumer :140,498 consumers.

   Retail water volume per year :91,644,238 cu.m.

6. Minburi

   Service area : 343.78 sq.km.

   Number of consumer :126,188 consumers.

   Retail water volume per year :74,419,104 cu.m.

7. Nontaburi

   Service area : 90.77 sq.km.

   Number of consumer :110,945 consumers.

   Retail water volume per year :61,216,839 cu.m.

8. Pasicharoen

   Service area : 106.08 sq.km.

   Number of consumer :154,939 consumers.

   Retail water volume per year :80,612,786 cu.m.

9. Phayathai

Service area : 55.4 sq.km.

Number of consumer :84,090 consumers.

Retail water volume per year :87,175,992 cu.m.

10. Prachashuan

Service area : 55.48 sq.km.

Number of consumer :89,219 consumers.

Retail water volume per year :52,222,136 cu.m.

11. Prakanong

Service area : 127.46 sq.km.

Number of consumer :106,952 consumers.

Retail water volume per year :106,952,880 cu.m.

12. Samutprakan

Service area : 463.74 sq.km.

Number of consumer :149,473 consumers.

Retail water volume per year :124,383,085 cu.m.

13. Sukumvit

Service area : 89.06 sq.km.

Number of consumer :105,204 consumers.

Retail water volume per year :107,229,652 cu.m.

14. Taksin

Service area : 216.80 sq.km.

Number of consumer :231,496 consumers.

Retail water volume per year :142,189,651 cu.m.

15. Tungmahamek

Service area : 31.85 sq.km.

Number of consumer :72,446 consumers.

Retail water volume per year :65,844,441 cu.m.

Bangkok ,a study area which have more than 6 million people and their demand around 1,675 million cu.m. per year in production volume(MWA,2009). The planning unit of WMA have recorded everyday's information from distribution branches for water pressure trend curve(a pressure of distribution tab water in each period of time in every single day of each branch of MWA ,monitoring and keep in requirement of water consumption and its pressure of each area) , area of water requirement from past year(base on increasing number of population). And submit this information daily to Control Center of Pumping and Transmission system to make a planning for next month. And all records are integrated and submitted to make an annual action plan for next 5 year by the planning unit of MWA all record .(Sampaothong and Chaiwanichpol ,interview, 7 August 2009)

2.3 Case study about water demand forecasting for MWA

Ong-intasiri(2003) have made a short term water demand forecasting of WMA by using BOX-JENKIN forecasting method. In this study he use the time series of monthly of retail water volume to represent the water demand consumption of BMA from October 1991 to October 2003.

By the BOX-JENKIN forecasting method, he have found that the time series of water demand have movement character as a seasonal in February of each year which may say that the information is non-stationary type. So it has to adjust for seasonal effect for second adjustment for next month. After second adjustment ,using model by least square will gave parameter value -0.458 for moving average and -0.886 for seasonal model average.

2.4 Thesis theories

2.4.1 Multiple linear regressions

Multiple linear regression attempts to model the relationship between two or more explanatory variables and a response variable by fitting a linear equation to observed data. Every value of the independent variable x is associated with a value of the dependent variable y. The population regression line for p explanatory variables x_1, x_2, ... , x_p is defined to be $\mu_y = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + ... + \beta_p x_p$. This line describes how the mean response μ_y changes with the explanatory variables. The observed values for y vary about their means μ_y and are assumed to have the same standard deviation σ. The fitted values b_0, b_1, ..., b_p estimate the parameters β_0, β_1, ..., β_p of the population regression line. Since the observed values for y vary about their means μ_y, the multiple regression models includes a term for this variation. In words, the model is expressed as DATA = FIT + RESIDUAL, where the "FIT" term represents the expression $\beta_0 + \beta_1 x_1 + \beta_2 x_2 + ... \beta_p x_p$. The "RESIDUAL" term represents the deviations of the observed values y from their means μ_y, which are normally distributed with mean 0 and variance σ. The notation for the model deviations is ε.

Formally, the model for multiple linear regression, given n observations, is $y_i = \beta_0 + \beta_1 x_{i1} + \beta_2 x_{i2} + ... \beta_p x_{ip} + \varepsilon_i$ for i = 1,2, ... n. In the least-squares model, the best-fitting line for the observed data is calculated by minimizing the sum of the squares of the vertical deviations from each data point to the line (if a point lies on the fitted line exactly, then its vertical deviation is 0). Because the deviations are first squared, then summed, there are no cancellations between positive and negative values. The least-squares estimates b_0, b_1, ... b_p are usually computed by statistical software. The values fit by the equation $b_0 + b_1x_{i1} + ... + b_px_{ip}$ are denoted $\hat{y}_i$, and the residuals e_i are equal to $y_i - \hat{y}_i$, the difference between the observed and fitted values. The sum of the residuals is equal to zero. The variance σ^2 may be estimated by $s^2 = \frac{\sum e_i^2}{n - p - 1}$, also known as the mean-squared error.

The estimate of the standard error s is the square root of the mean-squared error.

2.4.2 Factor analysis (Garson,2009)

Factor analysis is used to uncover the latent structure (dimensions) of a set of variables. It reduces attribute space from a larger number of variables to a smaller number of factors and as such is a "non-dependent" procedure (that is, it does not assume a dependent variable is specified). Factor analysis could be used for any of the following purposes:

Using to reduce a large number of variables to a smaller number of factors for modeling purposes, where the large number of variables precludes modeling all the measures individually. As such, factor analysis is integrated in structural equation modeling (SEM), helping confirm the latent variables modeled by SEM. However, factor analysis can be and is often used on a stand-alone basis for similar purposes.

-To establish that multiple tests measure the same factor, thereby giving justification for administering fewer tests. Factor analysis originated a century ago with Charles Spearman's attempts to show that a wide variety of mental tests could be explained by a single underlying intelligence factor (a notion now rejected, by the way).

-To validate a scale or index by demonstrating that its constituent items load on the same factor, and to drop proposed scale items which cross-load on more than one factor.

-To select a subset of variables from a larger set based on which original variables have the highest correlations with the principal component factors.

-To create a set of factors to be treated as uncorrelated variables as one approach to handling multicollinearity in such procedures as multiple regression
To identify clusters of cases and/or outliers.

-To determine network groups by determining which sets of people cluster together (using Q-mode factor analysis, discussed below)

Factor analysis is part of the general linear model family of procedures and makes many of the same assumptions as multiple regressions: linear relationships, interval or near-interval data, untruncated variables, proper specification (relevant variables included, extraneous ones excluded), lack of high multicollinearity, and multivariate normality for purposes of significance testing. Factor analysis generates a table in which the rows are the observed raw indicator variables and the columns are the factors or latent variables which explain as much of the variance in these variables as possible. The cells in this table are factor loadings, and the meaning of the factors must be induced from seeing which variables are most heavily loaded on which factors. This inferential labeling process can be fraught with subjectivity as diverse researchers impute different labels.

Types of Factoring

There are different methods of extracting the factors from a set of data. The method chosen will matter more to the extent that the sample is small, the variables are few, and/or the communality estimates of the variables differ.
Principal components analysis *(PCA):* By far the most common form of factor analysis, PCA seeks a linear combination of variables such that the maximum variance is extracted from the variables. It then removes this variance and seeks a second linear combination which explains the maximum proportion of the remaining variance, and so on. This is called the principal axis method and results in orthogonal (uncorrelated) factors. PCA analyzes total (common and unique) variance.

Common factor analysis, also called *principal factor analysis (PFA)* or *principal axis factoring* (PAF), Common factor analysis is a form of factor analysis which seeks the least number of factors which can account for the common variance (correlation) of a set of variables, whereas the more common principal components analysis (PCA) in its full form seeks the set of factors which can account for all the common and unique (specific plus error) variance in a set of variables. PFA uses a PCA strategy but applies it to a correlation matrix in which the diagonal elements are not 1's, as in PCA, but iteratively-derived estimates of the communalities.

Key Concepts and Terms

Exploratory factor analysis (EFA) seeks to uncover the underlying structure of a relatively large set of variables.This is the most common form of factor analysis. There is no prior theory and one uses factor loadings to intuit the factor structure of the data.

Confirmatory factor analysis (CFA) seeks to determine if the number of factors and the loadings of measured (indicator) variables on them conform to what is expected on the basis of pre-established theory. Indicator variables are selected on the basis of prior theory and factor analysis is used to see if they load as predicted on the expected number of factors. A minimum requirement of confirmatory factor analysis is that one hypothesizes beforehand the number of factors in the model.

Factors and components: Both are the dimensions (or latent variables) identified with clusters of variables, as computed using factor analysis.

Technically speaking, *factors* (as from PFA -- principal factor analysis, as know as principal axis factoring, as know as common factor analysis) represent the common variance of variables, excluding unique variance, and is thus a correlation-focused approach seeking to reproduce the intercorrelation among the variables.

By comparison, *components* (from PCA - principal components analysis) reflect both common and unique variance of the variables and may be seen as a variance-focused approach seeking to reproduce both the total variable variance with all components and to reproduce the correlations. PCA is far more common than PFA, however, and it is common to use "factors" interchangeably with "components."

PCA is generally used when the research purpose is data reduction (to reduce the information in many measured variables into a smaller set of components). PFA is generally used when the research purpose is to identify latent variables which contribute to the common variance of the set of measured variables, excluding variable-specific (unique) variance.

Factor loadings: The factor loadings, also called component loadings in PCA, are the correlation coefficients between the variables (rows) and factors (columns). Analogous to Pearson's r, the squared factor loading is the percent of variance in that indicator variable explained by the factor. To get the percent of variance in all the variables accounted for by each factor, add the sum of the squared factor loadings for that factor (column) and divide by the number of variables. (Note the number of variables equals the sum of their variances as the variance of a standardized variable is 1.) This is the same as dividing the factor's eigenvalue by the number of variables.

Interpreting factor loadings. By one rule of thumb in confirmatory factor analysis, loadings should be .7 or higher to confirm that independent variables identified a priori are represented by a particular factor, on the rationale that the .7 level corresponds to about half of the variance in the indicator being explained by the factor. However, the .7 standard is a high one and real-life data may well not meet this criterion, which is why some researchers, particularly for exploratory purposes, will use a lower level such as .4 for the central factor and .25 for other factors (Raubenheimer, 2004). Hair et al. (1998) call loadings above .6 "high" and those below .4 "low". In any event, factor loadings must be interpreted in the light of theory, not by arbitrary cutoff levels.

In the example below, focused on subjects' music preferences (coded from 1 = "like it" to 3 = "dislike it"), the red cells show the loadings for the measured (row) variables most associated with each of the six extracted components (factors). The green cell illustrates a weak to moderate cross-loading. Ideally, the researcher wants a "simple factor structure," with all main loadings greater than .70 and no cross-loadings greater than .40. Usually, as here, actual patterns fall short of simple factor structure, though this example comes close. Rap music preference in component 3 is the most clearly and heavily loaded. Component 1 is the most diverse, associated with disliking classical, opera, Broadway, and big band music and crossloaded with being less educated.

Table 2.9 Example of factor loading by using type of music as factors. (Garson, 2009)

Rotated Component Matrix[a]

	Component					
	1	2	3	4	5	6
Classical Music	.912	.133	-.056	-.083	.079	-.034
Classical Music (3)	.895	.149	-.060	-.073	.098	-.033
Opera	.729	.111	.103	.107	-.072	-.013
Broadway Musicals	.672	.170	.077	.051	-.327	.246
Bigband Music	.530	.263	-.005	.382	-.304	.004
Blues and R&B Music	.089	.866	.038	.135	.004	-.013
Blues or R & B Music	.104	.858	.063	.172	.012	-.021
Jazz Music (3)	.197	.837	.077	-.110	.053	-.038
Jazz Music	.203	.834	.074	-.124	.033	-.033
Rap Music	.024	.094	.956	.009	.174	.027
Rap Music (3)	.017	.111	.953	-.022	.139	.039
Bluegrass Music	.221	.159	-.050	.743	.006	-.161
Country Western Music	-.064	-.041	.039	.732	-.114	.079
Highest Year of School Completed	-.391	-.105	-.023	.478	.056	.335
Heavy Metal Music	.035	.035	.170	.052	.775	-.075
Age of Respondent	-.161	.110	.173	-.291	.690	.086
Respondent's Sex	-.129	.000	-.079	.148	.251	-.794
Respondent's Income	-.079	-.103	-.015	.233	.415	.708

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.

a. Rotation converged in 6 iterations.

Factor, component, pattern, and structure matrices. In SPSS, the factor loadings are found in a matrix labeled Factor Matrix if common factor analysis is requested or in one labeled Component Matrix if PCA is requested. (Note SPSS output gives both a factor or component matrix and a rotated factor or component matrix. The rotated version is used to induce factor meanings).

In oblique rotation, one gets both a pattern matrix and a structure matrix. The *structure matrix* is simply the factor loading matrix as in orthogonal rotation, representing the variance in a measured variable explained by a factor on both a unique and common contributions basis. The *pattern matrix*, in contrast, contains coefficients which just represent unique contributions. The more factors, the lower the pattern coefficients as a rule since there will be more common contributions to variance explained. For oblique rotation, the researcher looks at both the structure and pattern coefficients when attributing a label to a factor.

The sum of the squared factor loadings for all factors for a given variable (row) is the variance in that variable accounted for by all the factors, and this is called the *communality*. In a complete PCA, with no factors dropped, this will be 1.0, or 100% of the variance. The ratio of the squared factor loadings for a given variable (row in the factor matrix) shows the relative importance of the different factors in explaining the variance of the given variable. Factor loadings are the basis for imputing a label to the different factors.

Communallity, h^2, is the *squared multiple correlation* for the variable as dependent using the factors as predictors. The communality measures the percent of variance in a given variable explained by all the factors jointly and may be interpreted as the *reliability of the indicator*. In the example below, focused on subjects' music preferences (see example below), the extracted factors explain over 95% of preferences for rap music but only 56% for country western music. In general, communalities show for which measured variables the factor analysis is working best and least well.

Uniqueness is $1 - h^2$. That is, uniqueness is the variability of a variable minus its communality.

Eigen value Also called *characteristic roots*. The eigenvalue for a given factor measures the variance in all the variables which is accounted for by that factor. The ratio of eigenvalues is the ratio of explanatory importance of the factors with respect to the variables. If a factor has a low eigenvalue, then it is contributing little to the explanation of variances in the variables and may be ignored as redundant with more important factors.

Eigenvalues measure the amount of variation in the total sample accounted for by each factor. Note that the eigenvalue is <u>not</u> the percent of variance explained but rather a measure of amount of variance in relation to total variance (since variables are standardized to have means of 0 and variances of 1, total variance is equal to the number of variables). SPSS will output a corresponding column titled '% of variance'. A factor's eigenvalue may be computed as the sum of its squared factor loadings for all the variables.

In the example below, again on analysis of music preferences, 18 components (factors) would be needed to explain 100% of the variance in the data. However, using the conventional criterion of stopping when the initial eigenvalue drops below 1.0, only 6 of the 18 factors were actually extracted in this analysis. These six account for 72% of the variance in the data.

<u>Table 2.10</u> Example of Eigen value by using type of music as factors. (Garson, 2009)

Total Variance Explained

	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
Component	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	4.433	24.629	24.629	4.433	24.629	24.629	3.252	18.069	18.069
2	2.595	14.415	39.044	2.595	14.415	39.044	3.114	17.299	35.368
3	1.863	10.348	49.392	1.863	10.348	49.392	1.933	10.740	46.108
4	1.738	9.656	59.048	1.738	9.656	59.048	1.727	9.596	55.703
5	1.215	6.749	65.797	1.215	6.749	65.797	1.603	8.903	64.606
6	1.143	6.351	72.148	1.143	6.351	72.148	1.358	7.542	72.148
7	.885	4.915	77.063						
8	.791	4.396	81.459						
9	.673	3.739	85.198						
10	.562	3.121	88.320						
11	.524	2.912	91.231						
12	.500	2.777	94.008						
13	.417	2.319	96.327						
14	.381	2.115	98.442						
15	.092	.513	98.955						
16	.078	.432	99.387						
17	.060	.335	99.722						
18	.050	.278	100.000						

Extraction Method: Principal Component Analysis.

<u>Extraction sums of squared loadings</u>. Initial eigenvalues and eigenvalues after extraction are the same for PCA extraction, but for other extraction methods, eigenvalues after extraction will be lower than their initial counterparts. SPSS also prints "Rotation Sums of Squared Loadings" and even for PCA, these eigenvalues will differ from initial and extraction eigenvalues, though their total will be the same.

<u>Trace</u> is the sum of variances for all factors, which is equal to the number of variables since the variance of a standardized variable is 1.0. A factor's eigenvalue divided by the trace is the percent of variance it explains in all the variables, usually labeled *percent of trace* in computer output. Computer output usually lists the factors in descending order of eigenvalue, along with a cumulative percent of trace for as many factors as are extracted.

<u>Factor scores</u> Also called *component scores* in PCA, factor scores are the scores of each case (row) on each factor (column). To compute the factor score for a given case for a given factor, one takes the case's standardized score on each variable, multiplies by the corresponding factor loading of the variable for the given factor, and sums these products. Thus the component scores shown in pink multiplied by a subject's standardized measured scores on the row variables would sum to that subject's component score on component 1. Computing factor scores allows one to look for factor outliers. Also, factor scores may be used as variables in subsequent modeling.

<u>Rotation methods.</u> Rotation serves to make the output more understandable and is usually necessary to facilitate the interpretation of factors. The sum of eigenvalues is not affected by rotation, but rotation will alter the eigenvalues (and percent of variance explained) of particular factors and will change the factor loadings. Since alternative rotations may explain the same variance (have the same total eigenvalue) but have different factor loadings, and since factor loadings are used to intuit the meaning of factors, this means that different meanings may be ascribed to the factors depending on the rotation - a problem often cited as a drawback to factor analysis. If factor analysis is used, the researcher may wish to experiment with alternative rotation methods to see which leads to the most interpretable factor structure.

- Oblique rotations, discussed below, allow the factors to be correlated, and so a factor correlation matrix is generated when oblique is requested. Normally, however, an orthogonal method such as varimax is selected and no factor correlation matrix is produced as the correlation of any factor with another is zero.

No rotation is the default in SPSS, but it is a good idea to select a rotation method, usually varimax. The original, unrotated principal components solution maximizes the sum of squared factor loadings, efficiently creating a set of factors which explain as much of the variance in the original variables as possible. The amount explained is reflected in the sum of the eigenvalues of all factors. However, unrotated solutions are hard to interpret because variables tend to load on multiple factors.

- *Varimax rotation* is an orthogonal rotation of the factor axes to maximize the variance of the squared loadings of a factor (column) on all the variables (rows) in a factor matrix, which has the effect of differentiating the original variables by extracted factor. Each factor will tend to have either large or small loadings of any particular variable. A varimax solution yields results which make it as easy as possible to identify each variable with a single factor. This is the most common rotation option.
- *Quartimax rotation* is an orthogonal alternative which minimizes the number of factors needed to explain each variable. This type of rotation often generates a general factor on which most variables are loaded to a high or medium degree. Such a factor structure is usually not helpful to the research purpose.
- *Equimax rotation* is a compromise between Varimax and Quartimax criteria.
- *Direct oblimin rotation* is the standard method when one wishes a non-orthogonal (oblique) solution -- that is, one in which the factors are allowed to be correlated. This will result in higher eigenvalues but diminished interpretability of the factors. See below. See also hierarchical factor analysis.
- *Promax rotation* is an alternative non-orthogonal (oblique) rotation method which is computationally faster than the direct oblimin method and therefore is sometimes used for very large datasets.

2.4.3 Forecasting method: Double exponential smoothing method (NIST,2009)

This is a very popular scheme to produce a smoothed Time Series. Whereas in Single Moving Averages the past observations are weighted equally, Exponential Smoothing assigns *exponentially decreasing weights* as the observation get older. In other words, *recent observations are given relatively more weight in forecasting than the older observations*.

In the case of moving averages, the weights assigned to the observations are the same and are equal to 1/*N*. In exponential smoothing, however, there are one or more *smoothing parameters* to be determined (or estimated) and these choices determine the weights assigned to the observations.

Single exponential smoothing method: This smoothing scheme begins by setting S_2 to y_1,

where

S_i stands for smoothed observation or Exponential Weight Moving Average.

y stands for the original observation.

The subscripts refer to the time periods, 1, 2, ..., *n*. For the third period, $S_3 = \alpha y_2 + (1-\alpha) S_2$; and so on. There is no S_1; the smoothed series starts with the smoothed version of the second observation.

For any time period *t*, the smoothed value S_t is found by computing

$$S_t = \alpha y_{t-1} + (1-\alpha) S_{t-1} \qquad 0 < \alpha \leq 1 \qquad t \geq 3$$

This is the *basic equation of exponential smoothing* and the constant or parameter α is called the *smoothing constant*.

Why it call "Exponential".

Let us expand the basic equation by first substituting for S_{t-1} in the basic equation to obtain

$S_t = \alpha y_{t-1} + (1-\alpha) [\alpha y_{t-2} + (1-\alpha) S_{t-2}]$

$= \alpha y_{t-1} + \alpha(1-\alpha) y_{t-2} + (1-\alpha)^2 S_{t-2}$

By substituting for S_{t-2}, then for S_{t-3}, and so forth, until we reach S_2 (which is just y_1), it can be shown that the expanding equation can be written as:

$$S_t = \alpha \sum_{i=1}^{t-2} (1-\alpha)^{i-1} y_{t-i} + (1-\alpha)^{t-2} S_2, \quad t \geq 2$$

For example, the expanded equation for the smoothed value S_5 *is:*

$$S_5 = \alpha \left[(1-\alpha)^0 y_{5-1} + (1-\alpha)^1 y_{5-2} + (1-\alpha)^2 y_{5-3} \right] + (1-\alpha)^3 S_2$$

This illustrates the exponential behavior. The weights, $\alpha(1-\alpha)^t$ decrease geometrically, and their sum is unity as shown below, using a property of geometric series:

$$\alpha \sum_{i=0}^{t-1} (1-\alpha)^i = \alpha \left[\frac{1-(1-\alpha)^t}{1-(1-\alpha)} \right] = 1-(1-\alpha)^t$$

From the last formula we can see that the summation term shows that the contribution to the smoothed value S_t becomes less at each consecutive time period.

Double exponential smoothing method: As was previously observed, Single Smoothing does not excel in following the data when there is a trend. This situation can be improved by the introduction of a second equation with a second constant, γ, which must be chosen in conjunction with α.

Here are the two equations associated with Double Exponential Smoothing:

$$S_t = \alpha y_t + (1-\alpha)(S_{t-1} + b_{t-1}) \qquad 0 \leq \alpha \leq 1$$
$$b_t = \gamma (S_t - S_{t-1}) + (1-\gamma) b_{t-1} \qquad 0 \leq \gamma \leq 1$$

As in the case for single smoothing, there are a variety of schemes to set initial values for S_t and b_t in double smoothing.

S_1 is in general set to y_1. Here are three suggestions for b_1:

$b_1 = y_2 - y_1$

$b_1 = [(y_2 - y_1) + (y_3 - y_2) + (y_4 - y_3)]/3$

$b_1 = (y_n - y_1)/(n - 1)$

The first smoothing equation adjusts S_t directly for the trend of the previous period, b_{t-1}, by adding it to the last smoothed value, S_{t-1}. This helps to eliminate the lag and brings S_t to the appropriate base of the current value.

The second smoothing equation then updates the trend, which is expressed as the difference between the last two values. The equation is similar to the basic form of single smoothing, but here applied to the updating of the trend. The values for $\alpha$and γcan be obtained via non-linear optimization techniques, such as the Marquardt Algorithm.

The double exponential forecasting method is a forecasting method that proper for non seasoning information and there are separated the trend and level of information. So this method would use in the water consumption demand forecasting in BMA because our information ,most are not acting as seasoning type and difference in level and trend in each considered factors also.

2.5 International study & literature review.

2.5.1 Water demand system design

Howe and Linaweaver (1967) had researched for water demand in USA by create model of water demand of residential consumption and use cross section data with variable detail as follow

Q_{ad} = Average water consumption (Gallon/day/house)

v = market value (unit: 1000 USD)

d_p = Amount of resident.(People)

A = Age of house(Year.)

k = Water pressure (lb)

p_w = Price of tab water and waste water.(USD)

By separate the analysis in the different place of measurement meter and use the aggregate flow rate.

(1) $Q_{ad} = F(v,a,d_p,k,p_w)$

Then the equation is

$$Q_{ad} = 206+3047v-103\,p_w \quad (2\text{-}1)$$

In are which use constant consumption rate e.g. apartment

(2) $Q_{ad} = F(v, a, d_p, k)$

Then the equation is

$$Q_{ad} = 28.9+4.39v-33.6dp \quad (2\text{-}2)$$

In are which use of measurement meter and limit storage tank.

(3) $Q_{ad} = F(v,a,d_p,k, p_w)$

Then the equation is

$$Q_{ad} = 30.2+3.95\,d_p \quad (2\text{-}3)$$

And get the result as follow

1. The maximum consumption is in the morning &evening.

2. There are no water usage follow seasons.

3. There are 25% different usage between the limit storage tank and piping system.

4. Maximum water demand rate per day / the average demand per year is 1.54:1 and the maximum hour /average is 3.73:1.

5. Consumers did not mention in the maximum consumption period.

6. Flexibility of price in the equation (1) is -0.23.

Flexibility of income is +0.35 by use the variable (v) as a factor and have separate the study of water usage which use Sprinkling in the summer season.

Hanke and Davis (1971) have study about water demand in Ontario ,Canada by use the time- series to observe the changing of demand format when they have change from the constant rate to be measurement by meter by the follow equation.

$Q_t = a_1 + B_1Q_t$ (Flat rate) …………………………………………… (2-4)

$Q_t = a_1 + B_2Q_t$ (After install meter)……… …………………………… (2-5)

Then use the information and equation together

$Q_t = a_1 + a_1X_2 + B_1Q_t + B_2Z$…………………………………… (2-6)

By $Z = X_2Q_2$……………………………………………………... (2-7)

Z = considerd variable model volume.

Hint X_2 (the variable model) = 0 in flat rate period.

X_2 (the variable model) = 1 after install meter.

Then $Q_1 = a_1 + B_1Q_t$ in flat rate period………….. (2-8)

$Q_1 = (a_1 + a_2)+(B_{1+} B2) Q_t$ after install meter. ………… (2-9)

By Q_t = Water consumption volume at time t. (Gallon).

B_1 = Coefficient value of flat rate.

B_2 = Coefficient value of meter installed rate.

a_1 , a_2 = constant value.

The result is before install meter, the true sprinkling usages is more than calculation. But after install meter, true sprinkling usages is less than calculation.

Darr,Feldman and Kamen (1976) had studied the water usage in Israel by separate the study in 2 part .1). Find the factor that specify the water demand of resident consumer 2) Study the format or characteristic of consumer by chosen 30 cities to analyze. Find the relation between selling price and income of consumer and the influence to water consumption.

By Q = F (P, I)

Q = Water usage (m^3/capita/yr).

P = selling price per unit.

I = Income per person.

After analysis they found that income is the important variable, selling price are not significance. They mention on the observe area which use the selling as advance rate so when the consumption rate increase will bring price rise as well. So then the analysis will result as follow

The optimize equation is Q = 1.35 + 0.659I .... (2-10)

In this case they have study for characteristic by using 1892 sample from 4 cities and the question contain following question:

1. Size of family.
2. Income per person.
3. Native country.
4. Type of meter.
5. Education.
6. Density per room.

Then integrate them in the equation will

Q_d, Qa , Q_s = $F(I_c,N_p,N_r,A,C,E,S)$

Q_d = Water quantities (m^3/capita/family/year) exclude for water plantation.

Q_a = Water quantities (m^3/capita/family/year) include for water plantation

Q_s = Water quantities (m^3/capita/family/year) for water plantation only.

I_c = Income/month/capita/family(Agorot/month/capita/family)

N_p = Number of member in family.(People)

N_r = Number of room in a family.(Rooms)

A = Age of family leader.(Years)

C = Cultural variable for water usage.(Jew,Muslim,Christian)

E = Education level of family leader.(Matriculation,Higher education)

S = Places where a family are settled. (Northen, Southern,Haifa, TelAviv ,Center,Jerusalem)

Finally the equation will be:

$Q_d = F(I_c, N_r, A, C)$

$Q_a = F(N_p, A, C, E)$

$Q_s = F(I_c, N_r, A, C, E)$

Then the suitable equation is

$$Q_a = 1.8021 - 0.51333N_p + 0.1035\ A + 0.0816\ E \qquad (2\text{-}11)$$

$$Q_a = 0.7848 - 0.3085I_c + 0.1910\ A \qquad (2\text{-}12)$$

$$Q_d = 1.8015 - 0.4766N_p \qquad (2\text{-}13)$$

$$Q_d = 1.1359 - 0.1477I_c + 0.1105\ A - 0.0888C \qquad (2\text{-}14)$$

From this equation show that just some variable can describe but some variable value can not explained.

Williams and Suh (1986) had tested a model which separate the consumer into several groups e.g. business group & industrial group and also using the marginal price and average price to test with.

P_z = Selling price with consumer type i.

Ni = Quantity of consumer.

Y = Income per head.

RN = Rain quantity.

TM = Average temperature.

PD = Population density.

V = Industrial increase volume

RP = Business income

μ1, μ2, μ3 = Contingency value.

In the residential demand function will result a flexibility of average price per demand = -0.484 and the marginal price = -0.253.In business consumer group = -0.36 and -0.141 accordingly. For the industrial consumer group is -0.735 and -0.438.So it can define that the relation between price and resident group and business consumer group are inelastic but the industrial consumer group have more elasticity value.

Agthe and Billings (1980) had tested the model

By Q = Average consumption rate/month/family (100 cubic feet)

P = Marginal price (cent / cubic feet)

D = different value between real consumer price and marginal price(dollar)

Y = Income per family (dollar per month)

W= Evaporation rate minus from precipitation

t = period.

a_i , c_i , d_i , f_i = Co-efficient value .

μ = error term.

The consider period is between January 1974 to September 1977. A group of model means single house , apartment , condominium, mobile home , 2 stories house , 3 stories house , and use the model to test with following equation;

$$Q = a_0 + a_1P + a_2D + a_3Y + a_4W + \mu \quad (2\text{-}15)$$

$$Q_t = c_0 + c_1P + c_2D + c_3Y + c_4W + c_5Q_{t-1} + \mu \quad (2\text{-}16)$$

$$\ln Q_t = d_0 + d_1\ln(P_t+P_{t-1}) + d_2\ln(D_t+D_{t-1}) + d_3\ln(Y_t+Y_{t-1}) + d_4\ln(W_t+W_{t-1}) + d_5\ln Q_{t-1} + \mu \quad (2\text{-}17)$$

$$Q_t = f_0 + f_1P_{t-1} + f_2\Delta P + f_3 D_{t-1} + f_3\Delta D_{t-1} + f_5 Y_{t-1} + f_6 \Delta Y + f_7 W_{t-1} + f_8 \Delta W + f_9 Q_{t-1} + \mu \quad (2\text{-}18)$$

Equation 3-17 is static model.

Equation 3-18 is dynamic model.

Equation 3-19 is Flow adjustment model.

Equation 3-20 is Stock adjustment model.

Agthe and Billings said the conclusion is the both static and dynamic model of water demand of the resident have proper with monthly report of Tucson Arizona.Stock adjustment and Logarithmic Flow Adjustment have the (t) in the variable factor which can not explain .But the linear Flow adjustment , the t value in Q_{t-1} can explained. The Linear & Logarithmic of static and dynamic model will result the flexibility of Long Run Marginal Price Elasticity of Demand which have varies between -0.226 to -0.486.

Danielson (1979) had studied about factor which specifies the water demand. By provide the water demand will depend on Temperature, Precipitation, Selling price of house, size of family. His use cross section all data from 261 house, time series from May 1969 to December 1974, Raleigh of North Carolina and separate the water demand into 3 equations 1. Total water demand 2. Demand in the winter season 3. Water demand of outdoor using in summer season .Three demands have present the clear relationship with selling price. Difference with topic 2 and 3, shoe in equations as below

1.Y_t= Ft(X_1,X_2,X3,X_4,X_5,X_6)…………………………………………..…............… (2-19)

2.Y_w = F_w(X_1, X_4, X_5, X_6) …………………………………………………….… (2-20)

3.Y_s = F_s(X_1, X_2, X_3, X_4, X_5) ………………………………..………...……… (2-21)

Y_t = Total water demand

Y_w = Water demand in summer

Y_s = water demand of outdoor using in summer season.(gallon)

X_1 = constant value

X_2 = Average rainfall quantity in test date.(inch)

X_3 = Average temperature in test period.(Degree Fahrenheit)

X_4 = House Price. (USD)

X_5 = Real price. (cent per gallon)

X_6 = Size of family

And take more conclusion as follow

1. The total water demand should not depend on variable of average consumption rate per person. But should depend on the other factor e.g. size of family.

2. Selling price is the significant factor which consider in summer season.

3. Water policy should separate the consumption for internal & external house to get the proper result.

Martin and Wilder (1992) had analyzed to find the flexibility of water demand to price. Using plenty from Columbia and South Carolina from July 1980 to June 1981, the general format is

$Q = F (P, Y, M, (Y^* M)$

Q = Water consumption per month.

P = Selling water per unit.

Y = Income of family.

M = Model variable factor e.g. Relation to the season.

Y^*M = the variable which relate to model variable.

All variable are the natural logarithms except M and the conclusion is the flexibility of average water demand per average selling price (AP) is between -0.70 to -0.49 which higher than flexibility of water consumption to marginal price between -0.60 to -0.32.Income has no effect to the equation. Notice that the marginal price should rise up align with water consumption .But in case that the average selling price should low for support the lower income family.

Nieswiadomy and Monolina (1989) had studied comparing between water demand of decreasing block rate and increasing block rate by using the information of consumer of Denton in A.D.1976 – 80 as the decreasing block rate and in A.D.1981 – 85 as the increasing block rate and thee equation is

$$Q_i = b_1P_i + b_2D_i + b_3M_i + x_ia + U_i \quad \text{.......} \quad (2\text{-}22)$$

By $Q_i = \sum d_{ji}P_{ji}$

$Di = \sum d_{ji}D_{ji}$

$d_{ji} = 1$: If the family i consume water in j block.

$$D_{ji} = \sum q_{k-1} (P_{k-1},i - P_k)+\text{Flat} \quad \text{.......} \quad (2\text{-}23)$$

D_{ji} = Monthly variable.

M_i = Monthly income.

J_i = Number of Block of family i.

q_j = Maximum of Block j.

P_{ij} = Marginal price of Block j of family i.

P_k = Marginal price of Block k.

Flat = Initial rate.

x_i = other variable e.g. constant value, size of yard, size of home.

U_i = Contingency value.

a_i,b_i = Constant value.

The elasticity of water demand per price = 3.5 (Ordinary Least Square), -0.86(Forth stage least square), -0.55(Two Stage Least Square) in period of increasing block rate and -0.68 (Ordinary Least Square), -0.09(Forth stage least square), -.036(Two Stage Least Square) in period of decrease block rate. And The elasticity of water demand per price = 0.10 (Ordinary Least Square), 0.14(Four stage least square), 0.14(2LS)in period of increasing block rate and 0.07 (Ordinary Least Square) , 0.20(Forth stage least square), 0.15(Two Stage Least Square) in period of decrease block rate.

CHAPTER III

RESEARCH METHODOLOGY

3.1 Step of study.

1.)Study the influencing parameters by collecting all information (period of past 10 years for Bangkok area, 1997-2007).And identification in each parameters.

- Number of population in each district of Bangkok and growth rate (registered population, on-registered population, and tourist)

- Water consumption volume (Liters/capita/day).

-Precipitation volume (mm/day).

-Number of family (person/family).

-Selling price of water (Baht/m^3).

-Average temperature of Bangkok (degree Celsius).

-Income per capita.(Thai baht).

-Density of capita per area (capita/ km^2.)

-Estimated budget for each district of BMA per year (Baht).

2.)Input all information as variables following the theories; the factor analysis to consider for correlation of each factors and the multiple linear regressions for determine the major influence factors.

For example for the multiple linear regressions will use the format as follow

$y_i = \beta_0 + \beta_1 x_i + \beta_2 x_i + \ldots \beta_n x_i + \varepsilon_i$ for i = 1,2, ... n.

by X_1= Number of population in each district of Bangkok (capita).

X_2= Precipitation volume. (Millimeter/year)

X_3= Number of family. (Family/district)

X_4= Selling price of water. (Baht/ m^3)

X_5= Average temperature of Bangkok. (Degree Celsius)

X_6= Income per person.(Baht/capita/year)

X_7 = Density of person (Capita/square kilometers)

X_8 = Estimated budget for each district of BMA per year. (Baht/year)

Y = Water consumption volume deducted loss. (Million cubic meters/year).

β_n = Coefficient value at n position.

3.)Using SPSS program for input variables and make a model process.

4.)Find out independent and dependent variables.

5.)Bring independent and dependent variables to forecast water demand volume by using statistic tools e.g. F-test, T-test.

6.)Find out all the validate factor which suitable for this study.

7.)Validate the multiple linear regression equations of each area with actual information of year 2008.

8.)Forecasting 8 factors (X_1 to X_8) by using MINITAB program in term of double exponential smoothing method for next 10 year(2009 to 2019).

9.)Forecast water demand(Y) in next 10 years (2009 to 2019) by using multiple linear regression equation which validated by year 2008.

3.2 Research methodology planning diagram

1.)Collecting all information (period 10 years for Bangkok area, 1997-2007).

-Population volume: Collect information from the National Statistical office of Thailand for Bangkok area.

-Water consumption volume: Collect information from Water work of metropolitan Authority for 10 year recorded water consumption in Bangkok area.

-Precipitation volume for 10 year recorded from the Thai Meteorological Department.

-Number family record from Bangkok Metropolitan Authority.

-Average temperature from the Thai Meteorological Department.

-Income capita from the National Statistical office of Thailand.

-Density per room/room per family from the National Statistical office of Thailand. Etc.

2.)Consider and review all information by using SPSS program.

-Consider by separate in 3 groups by area of Bangkok (BMA, 2005) for figure them as partitions.

- Inner area group.(17 district) as shown in Figure 3.1 in green color are

: Dusit, Khlongtoei, Pomprapsattruphai, Phranakhon, Wattana, Pathumwan, Samphantawong, Phrakanong, Bangrak, Phayathai, Bangna, Yannawa, Ratchathevee, Bangkholaem, Huaikhwang, Sathon, Din-Dang.

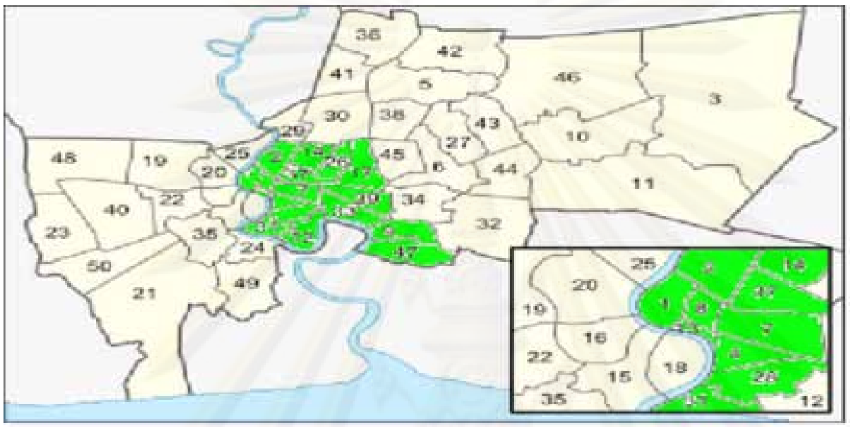

Figure 3.1 Inner area of BMA in green colored .(Wanpiya,developed from district map of BMA 2008)

- Interim area(19 District) as show in Figure 3.2 in green color are

: Bangsue, Ladphrao, Thonburi, Khlongsan, Laksi, Bungkum, Chatuchak, Wangthonglang, Ratburana, Donmaung, Bangkapi, Thungkru, Saunlaung, Bangkhen, Chomthong, Saimai, Pravet, Sapansoong, Kannayao.

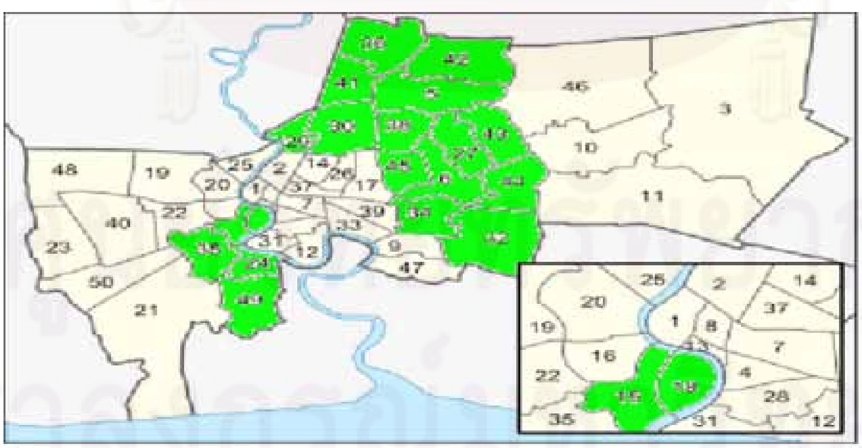

Figure 3.2 Interim area of BMA in green colored.(Wanpiya,developed from district map of BMA 2008

- Outer area(14 District) as show in Figure 3.3 in green color are

: Minburi, Bangplad, Phasicharoen, Nongjok, Bangkoknoi, Bangkokyai, Bangkae, Ladkrabang, Thawiwatthana, Klongsamwa, Talingshan, Nongkham, Bangbon, Bangkhunthian.

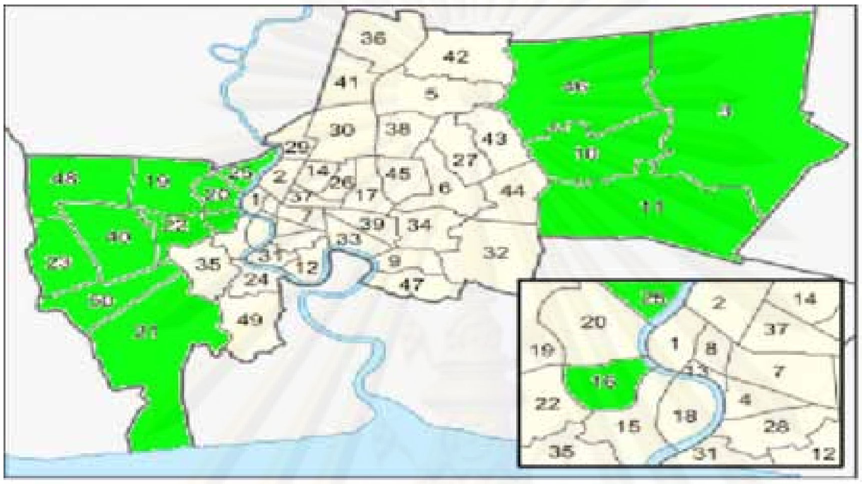

Figure 3.3 Outer area of BMA in green colored.(Wanpiya,developed from district map of BMA 2008)

Number which shown in Figure 3.1 , 3.2 and 3.3 are represent 50 district of BMA.Each number represent each district as shown in appendix C.

3.)Separate variable for both method to be considered using; Factor analysis and multiple linear regression.

4.)Get result of independent variable and independent variable

5.)Validate optimize influence for each group of area.

6.)Trail forecasting by using statistic tool.

In Figure 3.4 will show the study steps of this thesis.

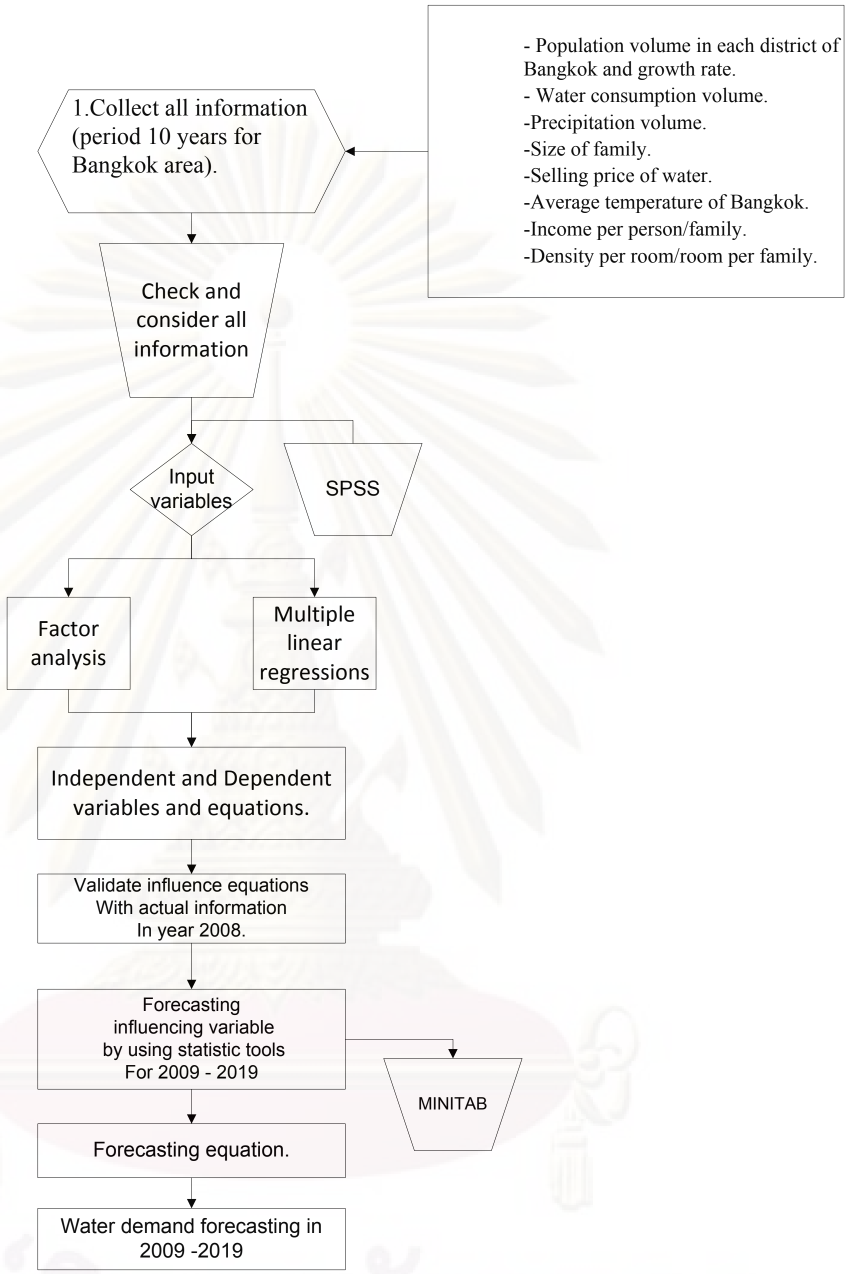

Figure 3.4 Research planning diagram.

CHAPTER IV

RESULT

4.1The inner area of Bangkok metropolitan

4.1.1 Factor analysis result

After all data of variable X_1 to X_8 have been input and process by a program SPSS as shown in Appendix B its result as shown. Factors component have group in 3 groups of component.

Factor component #1 are contain with 3 variables .X_1, X_4, and X_6 (population volume, selling price and income per person).

Factor component #2 are contain with 3 variables .X_3, X_7 and X_8 (Number of family, density of person and budget of district.)

Factor component #3 are contain with 2 variables. X_2 and X_5. (precipitation volume and average temperature).

The step of calculation and logical consideration arel show in Appendix A.In this result of calculation shown that the inner area of BMA are set thr priority of population volume, selling price and income per person as the first priority. Number of family, density of person and budget of district as the second priority. Precipitation volume and average temperature as a third priority.

4.1.2 Multiple linear regression analysis result

The inner area gave a multiple linear regression equation as follow.

$$Y_1 = 5.2x10^{-5}X_1-3.1x10^{-3}X_2+3.7x10^{-4}X_3+1.782X_5-2.7x10^{-4}X_7-34.426 \qquad (1)$$

This equation have F-Test value = 34.027 and Significant value less than 0.05 (95% Trusted) from selected model#5 of stepwise method.And the T-test value of this equation are shown folow.

The testing for X_1,the statistic t –test = 6.159 and the specific significant value less than 0.05 .

The testing for X_2 , the statistic t –test = -2.874 and the specific significant value less than 0.05 .

The testing for X_3 , the statistic t –test = 4.483 and the specific significant value less than 0.05 .

The testing for X_5 , the statistic t –test = 2.242 and the specific significant value less than 0.05.

The testing for X_7 , the statistic t –test = -6.735 and the specific significant value less than 0.05 .

The coeficient value and T-test value are show in Appendix A.Because each F-test ,t-test and significant value are shown that the testing of hypothesis in varience,means value and significant value more than 95%.So the equation are confidencially. But if in case that we adjust the level unit of collected data themselves e.g. number of population , number of family , income per capita , density of person per area and the budget.

4.1.3 Validation value of water consumption volume by using multiple linear regression equation result compare to real water consumption collecting from MWA .(Inner area of BMA)

When we use the variable value X in year 2008 replace in the equation (1) and compare in the real collect information, we will have the table as follow to be adjust the equation for realistic value.

Table 4.1 Validate value for water consumption volume compare to exact value by using the equation, the inner area of BMA.

District	X_1	X_2	X_3	X_5	X_7	Predicted Y	Exact Y 2008	residual
Klong toey	119909	1684	22538	29.1	9228	24.460	28.293	3.832
Dusit	117867	1684	8484	29.1	11052	18.662	16.433	-2.229
Dindeang	141765	1684	4960	29.1	16970	17.003	27.011	10.007
Bangrak	49124	1684	4985	29.1	8874	14.381	13.450	-0.931
Bang koleam	103391	1684	11916	29.1	9467	19.607	20.368	0.761
Bangna	101360	1684	13325	29.1	5395	21.122	25.960	4.837
Patumwan	149883	1684	8711	29.1	2855	22.624	32.548	9.923
Pomprabsatrupai	61040	1684	2754	29.1	7294	14.601	13.465	-1.136
Pranakorn	98496	1684	5345	29.1	7042	17.576	20.017	2.441
Prakanong	77202	1684	6952	29.1	8046	16.792	17.872	1.079
Phayathai	64356	1684	5049	29.1	11625	14.454	10.221	-4.232
Yanawa	88061	1684	59596	29.1	5285	37.580	22.991	-14.589
Rajathevi	92929	1684	4933	29.1	5888	17.445	18.036	0.590
Watana	114984	1684	2954	29.1	5877	17.863	26.926	9.062
Sampantawong	173076	1684	2204	29.1	3879	21.146	40.942	19.7963
Sathorn	116293	1684	7665	29.1	4911	19.935	26.856	6.920
Huangkwang	135554	1684	4426	29.1	3784	20.042	27.001	6.958

And after validation there is a multiple linear regression equation represent for inner area as follow.

$Y_{1\ validated} = 5.2x10^{-5}X_1 - 3.1x10^{-3}X_2 + 3.7x10^{-4}X_3 + 1.782X_5 - 2.7x10^{-4}X_7 + 3.1229$.............. (1)

4.2 The interim area of Bangkok metropolitan

4.2.1Factor analysis result

After all data of variable X_1 to X_8 have been input X_8 have been input and process by a program SPSS as shown in Appendix B, its result as shown. Factors component have group in 3 groups of component.

There are the results of variable X1 to X8 as follow

Factor component #1 is containing with 2 variables .X_4 and X_6(Selling price and income per capita)

Factor components #2 is containing with 4 variables X_1, X_3, X_7 and X_8.(Population, Number of family, density of population and budget of district.)

Factor component #3 is containing with 2 variables. X_2 and X_5.(Precipitation and average temperature).

The step of calculation and logical consideration will show in Appendix A .In this result of calculation shown that the inner area of BMA are set thr priority of selling price and income per capita as the first priority. Population, Number of family, density of population and budget of district. as the second priority. Precipitation volume and average temperature as a third priority.

4.2.2. Multiple linear regression analysis result

The interim area gave a multiple linear regression equation as follow. The step of calculation and logical consideration will show in appendix A.

$Y_2 = 3.93x10^{-5}X_1 - 4.3x10^{-3}X_2 + 3.62x10^{-4}X_3 + 4.092X_5 - 5.9x10^{-4}X_7 + 1.35x10^{-7}X_8 + 116.484$.....(2)

This equation have F-Test value = 44.928 and Significant value less than 0.05 (95% Trusted) from selected model#6 of stepwise method.And the T-test value of this equation are shown folow.

The testing for X_1,the statistic t –test = 4.342 and the specific significant value less than 0.05 .

The testing for X_2 , the statistic t –test = -3.381 and the specific significant value less than 0.05 .

The testing for X_3 , the statistic t –test = 3.964 and the specific significant value less than 0.05 .

The testing for X_5 , the statistic t –test = 4.273 and the specific significant value less than 0.05.

The testing for X_7 , the statistic t –test = -7.689 and the specific significant value less than 0.05 .

The testing for X_8 , the statistic t –test = 10.649 and the specific significant value less than 0.05 .

The coeficient value and T-test value are show in Appendix A Because each F-test ,t-test and significant value are shown that the testing of hypothesis in varience,means value and significant value more than 95%.So the equation are confidencially.

4.2.3 Validation value of water consumption volume by using multiple linear regression equation result compare to real water consumption collecting from MWA . (Interim area of BMA)

When we use the variable value X in year 2008 replace in the equation (2) and compare in the real collect information, we will have the table as follow to be adjust the equation for realistic value.

Table 4.2 Validate value for water consumption volume compare to exact value by using the equation, the interim area of BMA.

District	X_1	X_2	X_3	X_5	X_7	X_8	Predicted Y	Exact Year 2008	residual
Klongsan	84821	1684	10942	29.1	14018	150,053,685	14.63	15.8915	1.26
Kannayao	85027	1684	6548	29.1	3273	132,993,603	17.09	16.1056	-0.98
Jatujak	166581	1684	9968	29.1	5062	245,647,091	35.68	42.5473	6.86
Jomthong	165070	1684	11020	29.1	6285	208,351,815	30.25	31.7847	1.54
Don Maung	163080	1684	19079	29.1	4431	197,152,949	32.67	33.3545	0.69
Toongkru	111621	1684	6396	29.1	3631	153,941,552	20.69	23.0056	2.31
Thonburi	132034	1684	13725	29.1	15441	197,756,640	23.10	24.3336	1.24
Bangken	182335	1684	21113	29.1	4329	204,043,015	35.15	43.659	8.51
Bangkapi	150139	1684	5983	29.1	5264	93,748,609	12.97	46.0455	33.08
Baungkoom	145172	1684	8293	29.1	5971	168,769,144	23.32	32.7778	9.46
Bangsue	147797	1684	11473	29.1	12802	186,171,570	22.89	25.7519	2.86
Pravet	57461	1684	7814	29.1	29757	170,857,119	5.95	10.6738	4.73
Ratburana	97747	1684	5520	29.1	13717	221,645,239	23.02	18.7216	-4.30
Ladprao	120417	1684	10245	29.1	5509	126,863,487	17.67	25.5185	7.85
Wangthonglang	80744	1684	3769	29.1	6426	184,504,887	21.01	26.7095	5.70
Suanluang	92021	1684	9419	29.1	9867	104,130,227	10.61	18.8392	8.23
Saimai	86043	1684	17414	29.1	3059	124,321,497	20.02	15.3254	-4.69
Sapansoong	30646	1684	8687	29.1	21643	132,923,933	4.88	7.3547	2.48
Laksi	77033	1684	15891	29.1	5124	155,829,128	22.15	21.8888	-0.26

And after validation there is a multiple linear regression equation represent for interim area as follow.

$Y_{2\ validated}$ $3.93x10^{-5}X_1-4.3x10^{-3}X_2+3.62x10^{-4}X_3+4.092X_5-5.9x10^{-4}X_7+1.35x10^{-7}X_8$ *+4.556.....(2)*

4.3 The outer area of Bangkok metropolitan.

4.3.1 Factor analysis result

After all data of variable X_1 to X_8 have been input as shown in Appendix B, and process by a program SPSS, its result as shown. Factors component have group in 4 groups of component.

There are the results of variable X1 to X8 as follow

Factor component #1 is containing with 2 variables. X_4 and X_6. (Selling price and income per capita)

Factor component #2 is containing with 3 variables. X_2, X_5 and X_8.(Precipitation, average temperature and budget of district)

Factor component #3 is containing with 2 variables. X_1 andX_3. (number of population and Number of family).

Factor component #4 is containing with 1 variable. X_7.(Density of population)

The step of calculation and logical consideration will show in appendix A. In this result of calculation shown that the inner area of BMA are set thr priority of selling price and income per capita as the first priority. Precipitation, average temperature and budget of district as the second priority. Number of population and Number of family as a third priority. And density of population as a forth priority.

4.3.2 Multiple linear regression analysis result

The outer area gave a multiple linear regression equation as follow. The step of calculation and logical consideration will show in appendix A.

$Y_3 = 5.98x10^{-5}X_1-3.56x10^{-3}X_2+1.36x10^{-4}X_3+2.537X_5+8.15x10^{-5}X_6-1.7x10^{-4}X_7+2.47x10^{-8}X_8$ - 79.019..(3)

This equation have F-Test value = 21.292 and Significant value less than 0.05 (95% Trusted) from selected model#6 of stepwise method.And the T-test value of this equation are shown folow.

The testing for X_1,the statistic t –test = 6.317 and the specific significant value less than 0.05 .

The testing for X_2 , the statistic t –test = -2.551 and the specific significant value less than 0.05 .

The testing for X_3 , the statistic t –test = 2.771 and the specific significant value less than 0.05 .

The testing for X_5 , the statistic t –test = 2.658 and the specific significant value less than 0.05.

The testing for X_6 , the statistic t –test = 2.390 and the specific significant value less than 0.05 .

The testing for X_7 , the statistic t –test = -2.032 and the specific significant value less than 0.05 .

The testing for X_8 , the statistic t –test = -3.297 and the specific significant value less than 0.05 .

The coeeficient value and T-test value are show in Appendix A. A Because each F-test ,t-test and significant value are shown that the testing of hypothesis in varience,means value and significant value more than 95%.So the equation are confidencially

4.3.3 Validation value of water consumption volume by using multiple linear regression equation result compare to real water consumption collecting from MWA . (Interim area of BMA)

When we use the value X in year 2008 replace in the equation (3) and compare in the real collect information, we will have the table as follow to be adjust the equation for realistic value

Table 4.3 Validate value for water consumption volume compare to exact value by using the equation, the outer area of BMA.

District	X_1	X_2	X_3	X_5	X_6	X_7	X_8	Predicted Y	Exact Year2008	residual
Kolngsamwa	144,423	1,684	8,426	29	213,565	1305	179,746,152	23.454	28.9924	5.538
Talingshan	107,812	1,684	5,650	29	213,565	3657	167,708,426	19.973	19.3521	-0.621
Taweewatana	70,196	1,684	2,319	29	213,565	1398	154,099,353	17.074	15.7008	-1.373
Bangkokyai	79,637	1,684	5,660	29	213,565	12886	194,615,838	17.870	14.2802	-3.590
Bangkoknoi	130,540	1,684	19,073	29	213,565	10929	143,399,539	20.884	24.5886	3.705
Bangkuntien	141,698	1,684	10,950	29	213,565	1174	220,205,478	25.384	31.2103	5.826
Bangplud	105,347	1,684	12,342	29	213,565	9274	148,789,501	18.973	20.7161	1.743
Bangkae	192,597	1,684	9,421	29	213,565	4332	108,098,485	22.896	40.4025	17.506
Bangbon	101,263	1,684	1,275	29	213,565	2914	127,827,846	17.410	25.5579	8.148
Pasicharoen	134,407	1,684	9,197	29	213,565	7537	158,828,601	21.007	25.0866	4.079
Minburi	127,727	1,684	10,493	29	213,565	2007	136,291,166	20.762	25.7303	4.969
Ladkrabang	144,800	1,684	14,761	29	213,565	1169	119,684,770	21.797	33.4987	11.702
Nongjok	138,667	1,684	10,836	29	213,565	587	212,229,570	24.947	25.1659	0.219
Nongkam	116,055	1,684	11,589	29	213,565	5081	187,099,096	21.860	25.0322	3.172

And after validation there is a multiple linear regression equation represent for outer area as follow.

$Y_{3\ validated}$ = $3.93x10^{-5}X_1$-$4.3x10^{-3}X_2$+$3.62x10^{-4}X_3$+$4.092X_5$-$5.9x10^{-4}X_7$+$1.35x10^{-7}X_8$
+4.36...(3)

So Conclusion for validated multiple linear regression equation of 3 region.

1. The inner area , validated multiple linear regression equation is

$Y_{1\ validated}$ = $5.2x10^{-5}X_1$-$3.1x10^{-3}X_2$+$3.7x10^{-4}X_3$+$1.782X_5$-$2.7x10^{-4}X_7$ +3.1229……………… (1)

2. The interim area , validated multiple linear regression equation is

$Y_{2\ validated}$ $3.93x10^{-5}X_1$-$4.3x10^{-3}X_2$+$3.62x10^{-4}X_3$+$4.092X_5$-$5.9x10^{-4}X_7$+$1.35x10^{-7}X_8$
+4.556...(2)

3. The outer area , validated multiple linear regression equation is

$Y_{3\ validated}$ = $3.93x10^{-5}X_1$-$4.3x10^{-3}X_2$+$3.62x10^{-4}X_3$+$4.092X_5$-$5.9x10^{-4}X_7$+$1.35x10^{-7}X_8$
+4.36...(3)

4.4 Forecasting for next 10 year of water demand volume.(2009 – 2019)

We will use the double exponential smoothing by statistic program MINITAB in term of double exponential smoothing method to forecasting all the factors X_1 to X_8. The forecasting value of each factors from 2009 to 2019 are shown in Appendix B and their graphs are shown below.

4.4.1 Number of population (X_1) from 2009-2019.

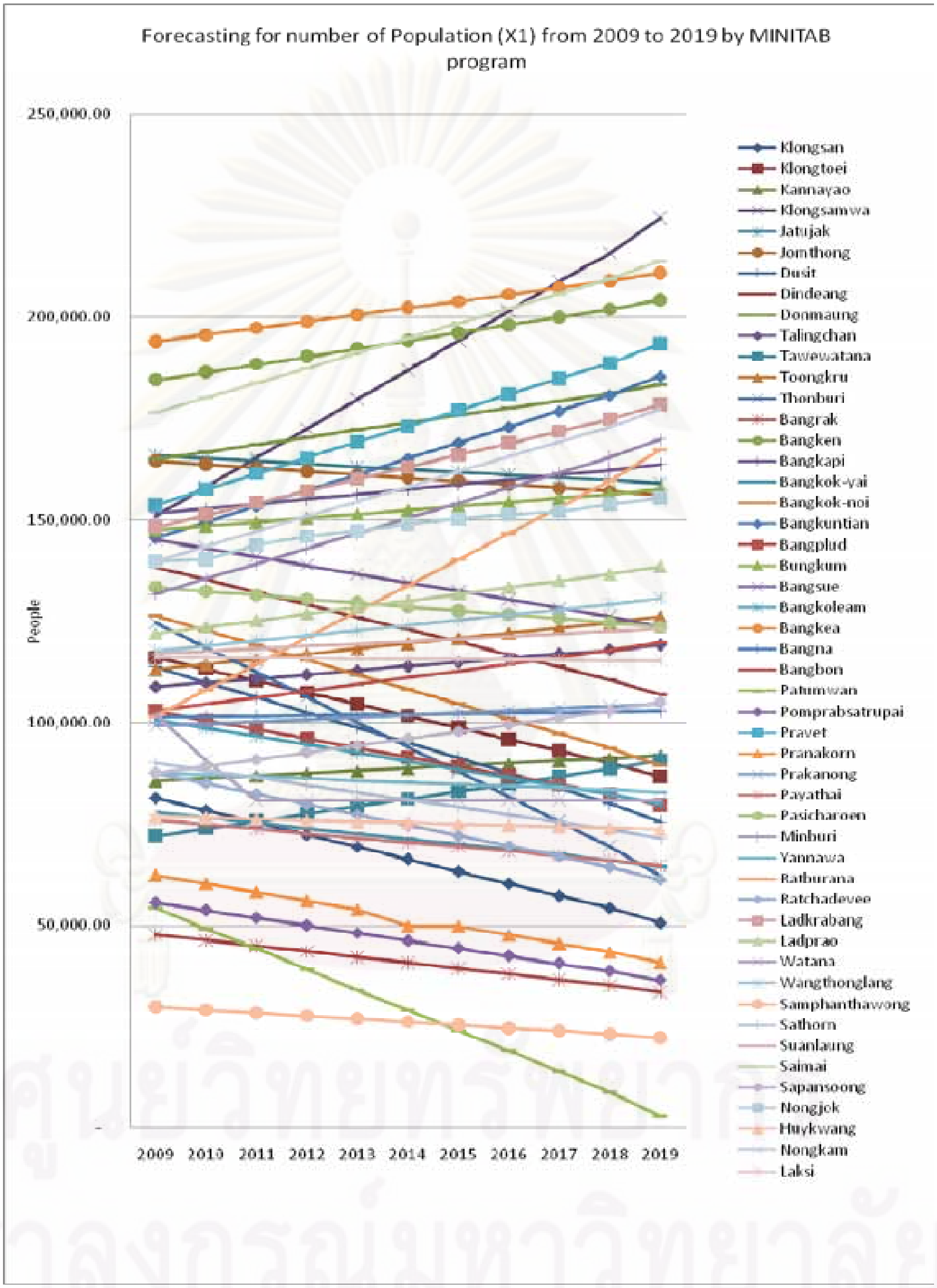

Figure 4.1 Forecasting for number of Population (X_1) from 2009 to 2019 by MINITAB program.

In Figure 4.1 Shown that the district in the inner area e.g. Ladprao , Pranakorn , Pratumwan etc. The number of population have slightly reduce . But in the other hand in the interim area and outer area ,number of population increased which might came from the increase land pricing 's effect.

4.4.2 Precipitation volume (X_2) from 2009-2019.

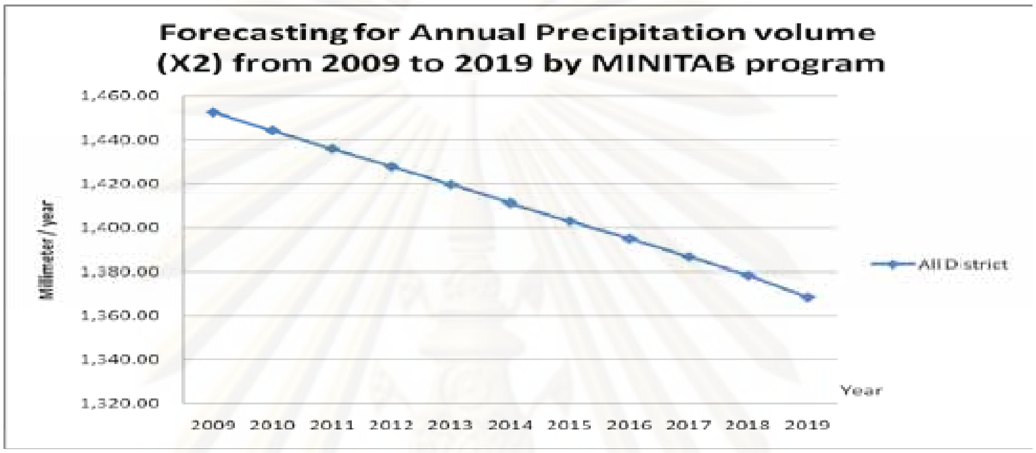

Figure 4.2 Forecasting Annual precipitation (X_2) from 2009 to 2019 by MINITAB program

The trend of double exponential smoothing method is -5.78% in next 10 year.But if we collect information pass back from 1960 to 2007 of precipitation in Bangkok and create the extrapolate of precipitation in Figure 4.3, we will have the result equation Y = -0.98x+3310.7 which have reduction rate about -1.37% from 1960 – 2007.

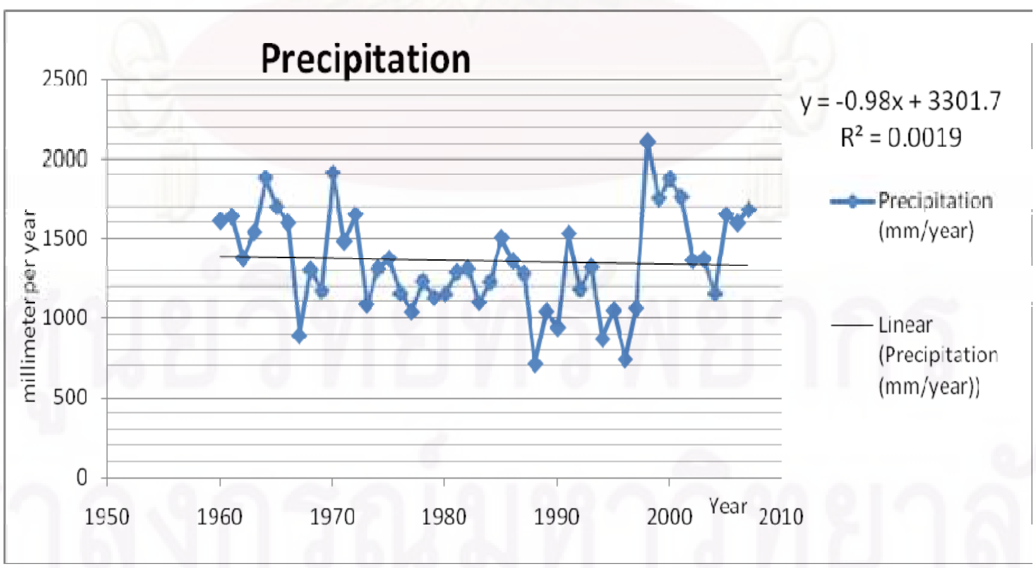

Figure 4.3 Precipitation record of Bangkok from 1960 to 2007 and their extrapolate equation. *(Reseources: http://docs.lib.noaa.gov/rescue/data_rescue_thailand.html)*

4.4.3 Number of family (X_3) from 2009-2019.

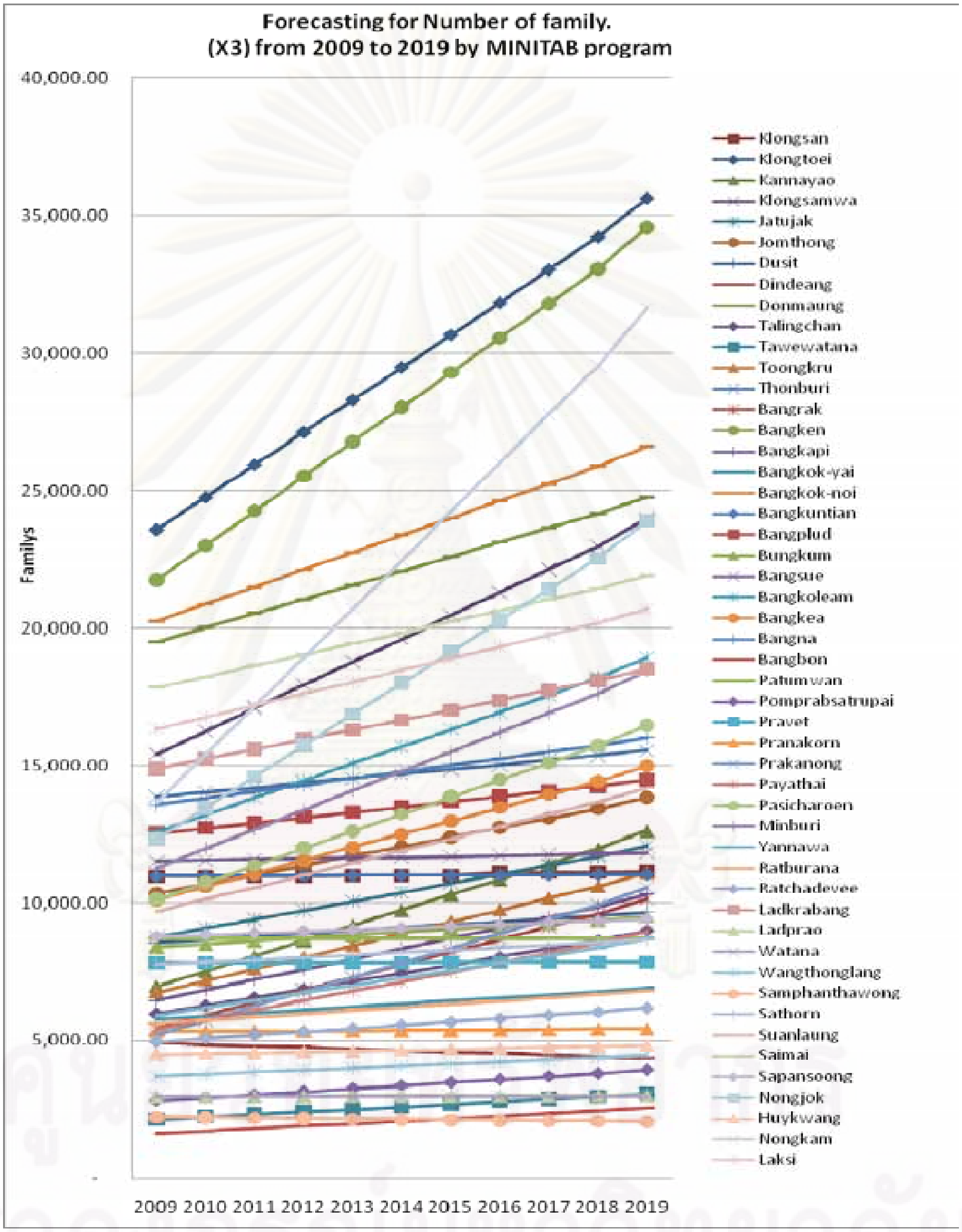

Figure 4.4 Forecasting number of family(X_3) from 2009 to 2019 by MINITAB program

Number of family are increasing in the outer area and interim area but in the inner area is slighly increasing.

4.4.4 Average seling price(X_4) from 2009-2019.

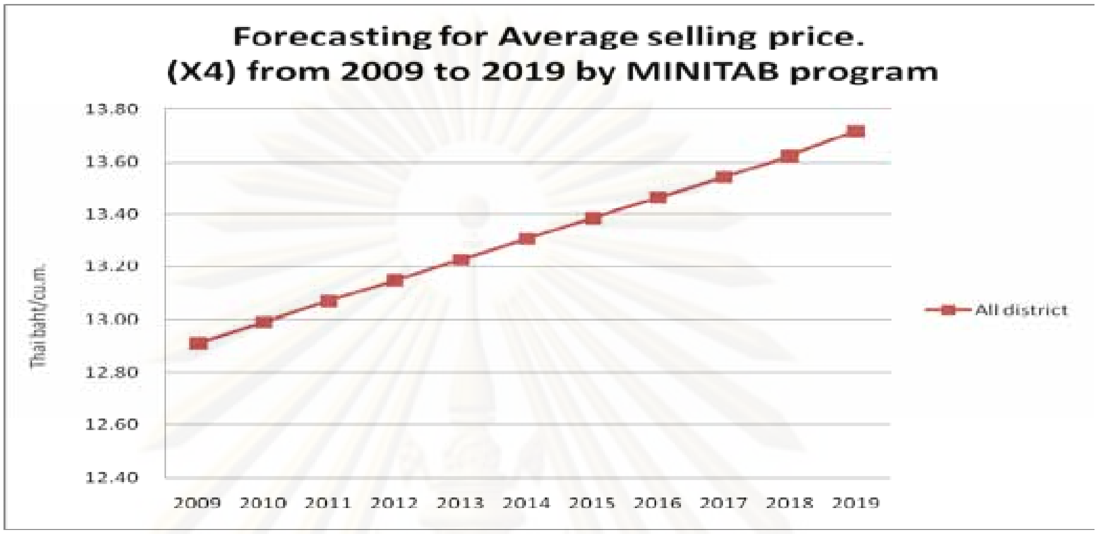

Figure 4.5 Forecasting average selling price(X_4) from 2009 to 2019 by MINITAB program

The selling price have the increasing rate about 6.27% in next 10 year.But the selling price are set up by MWA which may have difference factor that effect their calculation.

5.4.5 Average temperature (X_5) from 2009-2019.

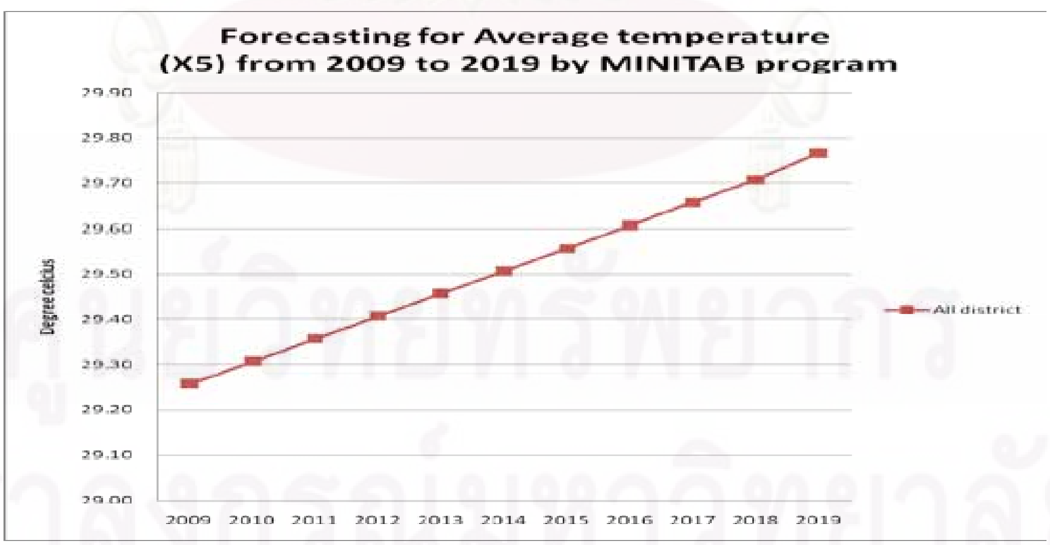

Figure 4.6 Forecasting average temperature(X_5) from 2009 to 2019 by MINITAB program

The trend of double exponential smoothing method is 1.75% increase in next 10 year.But if we collect information pass back from 1960 to 2007 of annual average temperature in Bangkok and create the extrapolate of annual average temperature in Figure 4.7, we will have the result equation Y = 0.0419x-54.97 which have increasing rate about 3.51% from 1960 – 2007.

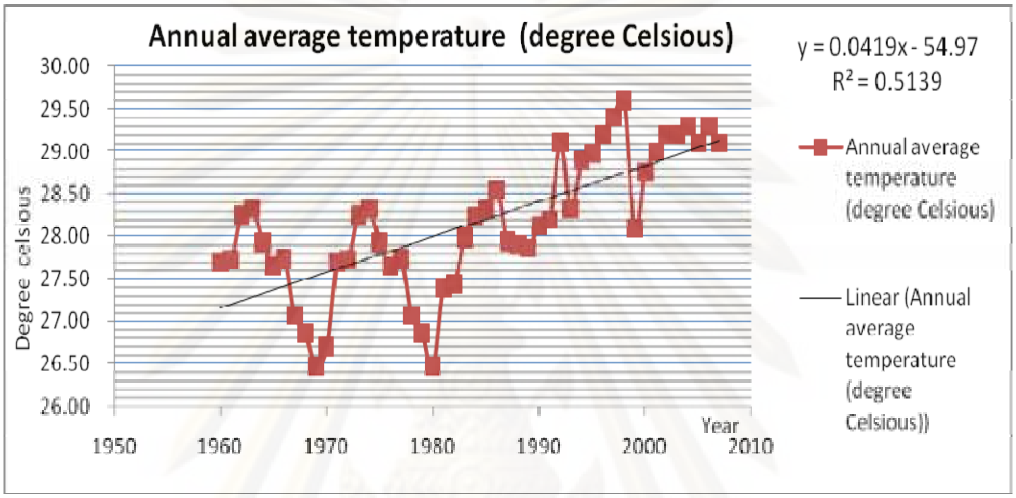

Figure 4.7 Annual average temperature record of Bangkok from 1960 to 2007 and their extrapolate equation.

(Reseources:http://docs.lib.noaa.gov/rescue/data_rescue_thailand.html)

5.4.6 Income per person (X_6) from 2009-2019.

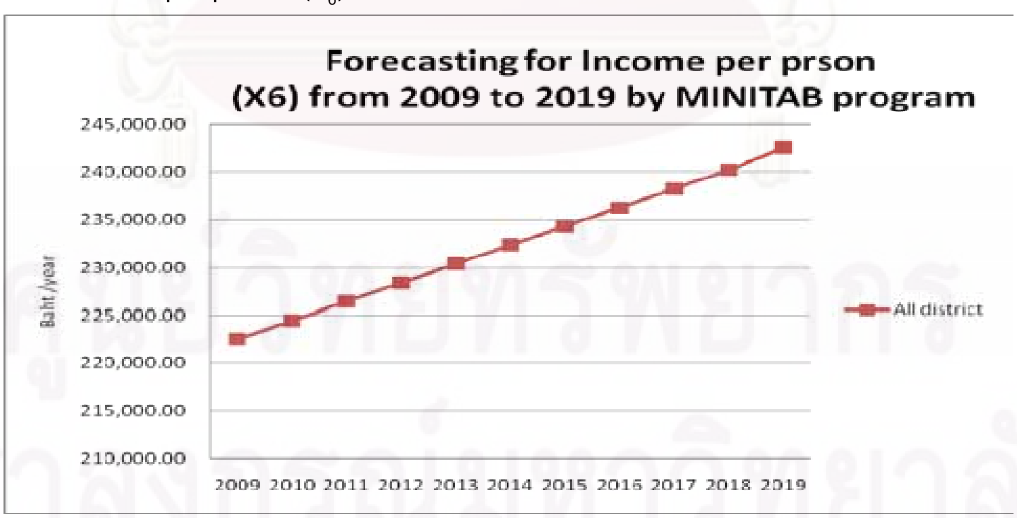

Figure 4.8 Forecasting income per person(X_6) from 2009 to 2019 by MINITAB program

The average income of Bangkok are increase about 8.9% or up to 242,539 Thai Baht per year in 2019.

4.4.7 Density of people per area (X_7) from 2009-2019.

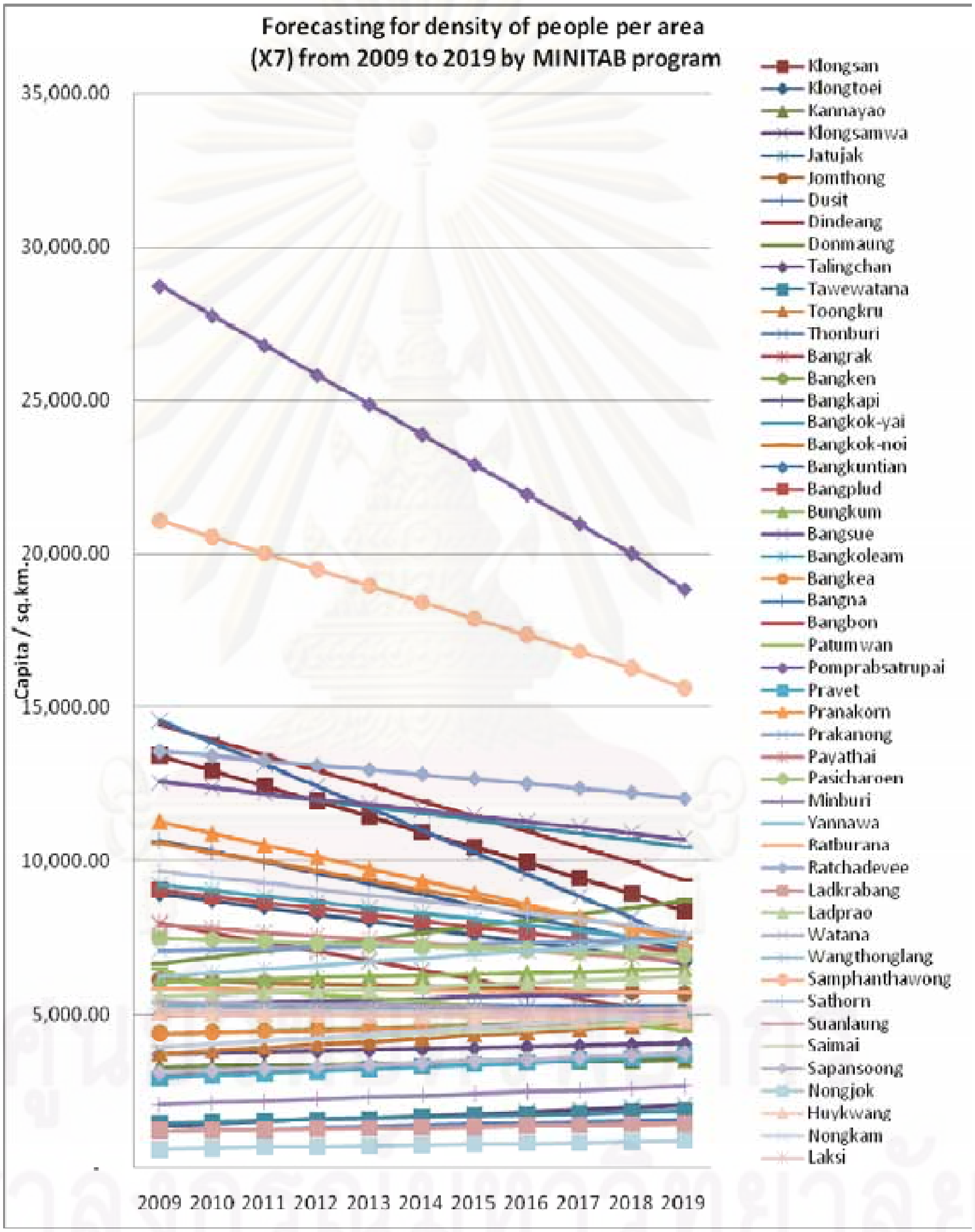

Figure 4.9 Forecasting density of person per area(X_7) from 2009 to 2019 by MINITAB program.

Density of people per area are reduce in the some district of interim area and almost slighly increase in the outer area.

4.4.8 Estimated budget for each district (X_8) from 2009-2019.

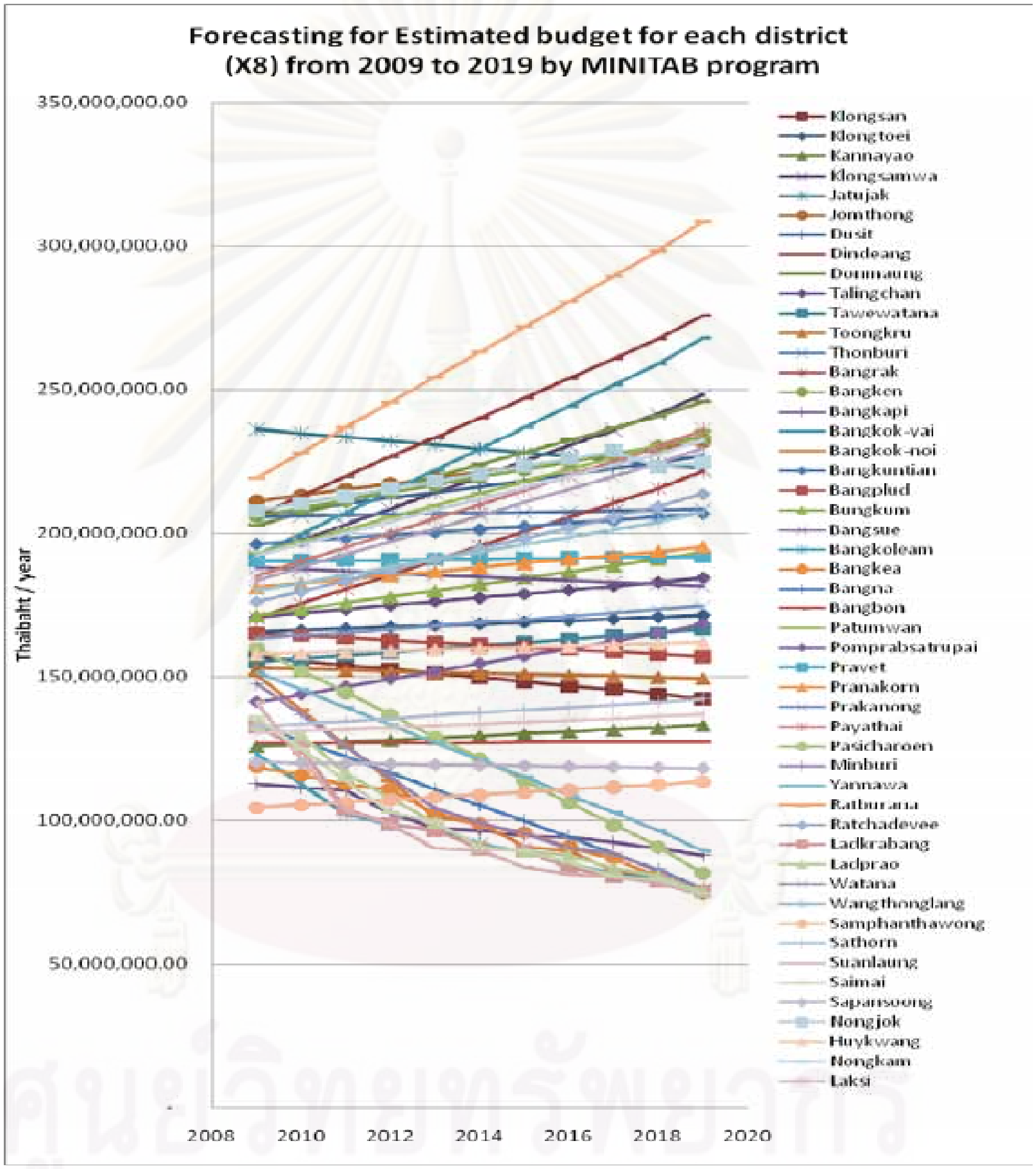

Figure 4.10 Forecasting estimated budget for each area(X_8) from 2009 to 2019 by MINITAB program.

Estimate budget are set up from the BMA by their planning so this parameter have change on their development planning which may different from the forecasting by MINITAB.

4.4.9 Inner area forecasting water demand volume of BMA.

From the validate equation of inner area in each district as shown in table and the forecasting value of X1 to X8 we will have the forecasting volume for next 10 year water demand as follow.(for precision & correction we prefer to use 10 year result for this prediction).

X_1= Number of population in each district of Bangkok (capita/year).

X_2= Precipitation volume. (Millimeter/year)

X_3= Number of family. (Family)

X_4= Selling price of water.(Baht/cu.m.)

X_5= Average temperature of Bangkok. (Degree Celsius)

X_6= Income per person. (Baht/capita)

X_7 = Density of person (capita/square kilometers)

X_8 = Estimated budget for each district of BMA per year.(Baht/year)

Y = Water consumption volume deducted loss.(Million cubic meters).

Table 4.4 Year 2009

District	x1	x2	x3	x5	x7	Forecasting Y value from equation.
Klongtoei	116059	1452.49	23557	29.26	8932	25.69
Dusit	113768	1452.49	8556	29.26	10668	19.55
Dindang	138378	1452.49	4920	29.26	14440	18.47
Bangrak	47545	1452.49	5447	29.26	7993	15.68
Bangkoleam	100759	1452.49	12565	29.26	9227	20.75
Bangna	101363	1452.49	13562	29.26	5380	22.19
Patumwan	54206	1452.49	8707	29.26	6470	17.65
Pomprabsatrupai	55501	1452.49	2810	29.26	28742	9.52
Pranakorn	62439	1452.49	5348	29.26	11279	15.53
Prakanong	99189	1452.49	5196	29.26	7090	18.52
Payathai	75975	1452.49	5405	29.26	7918	17.16
Yanawa	87599	1452.49	5911	29.26	5257	18.68
Rajathevee	87620	1452.49	4962	29.26	13579	16.08
Wathana	121943	1452.49	2954	29.26	5418	19.32
Sampanthawong	29849	1452.49	2210	29.26	21080	10.03
sathorn	90170	1452.49	7763	29.26	9668	18.30
Huakwang	76832	1452.49	4481	29.26	5063	17.64

Table 4.5Year 2010

District	x1	x2	x3	x5	x7	Forecasting Y value from equation.
Klongtoei	113180	1444.26	24741	29.31	8710	26.15
Dusit	110027	1444.26	8665	29.31	10317	19.61
Dindang	135302	1444.26	4862	29.31	13944	18.54
Bangrak	46169	1444.26	5908	29.31	7685	15.98
Bangkoleam	98701	1444.26	13188	29.31	9038	21.04
Bangna	101505	1444.26	13802	29.31	5366	22.40
Patumwan	49162	1444.26	8707	29.31	5864	17.66
Pomprabsatrupai	53625	1444.26	2920	29.31	27770	9.84
Pranakorn	60310	1444.26	5348	29.31	10895	15.64
Prakanong	99715	1444.26	5723	29.31	7126	18.84
Payathai	74859	1444.26	5753	29.31	7802	17.38
Yanawa	87129	1444.26	6183	29.31	5229	18.87
Rajathevee	85029	1444.26	5082	29.31	13428	16.14
Wathana	80775	1444.26	2954	29.31	5386	17.31
Sampanthawong	29094	1444.26	2195	29.31	20547	10.24
sathorn	88334	1444.26	7851	29.31	9471	18.41
Huakwang	76515	1444.26	4513	29.31	5039	17.75

Table 4.6 Year 2011

District	x1	x2	x3	x5	x7	Forecasting Y value from equation.
Klongtoei	110300	1436.03	25924	29.36	8488	26.62
Dusit	106286	1436.03	8774	29.36	9966	19.66
Dindang	132227	1436.03	4803	29.36	13447	18.60
Bangrak	44792	1436.03	6369	29.36	7376	16.27
Bangkoleam	96642	1436.03	13811	29.36	8850	21.33
Bangna	101646	1436.03	14041	29.36	5353	22.62
Patumwan	44118	1436.03	8706	29.36	5758	17.54
Pomprabsatrupai	51749	1436.03	3030	29.36	26798	10.16
Pranakorn	58182	1436.03	5353	29.36	10510	15.75
Prakanong	100240	1436.03	6250	29.36	7163	19.17
Payathai	73742	1436.03	6101	29.36	7686	17.60
Yanawa	86660	1436.03	6455	29.36	5201	19.07
Rajathevee	82438	1436.03	5202	29.36	13277	16.21
Wathana	80786	1436.03	2954	29.36	5353	17.43
Sampanthawong	28340	1436.03	2181	29.36	20014	10.46
sathorn	86498	1436.03	7940	29.36	9274	18.51
Huakwang	76198	1436.03	4546	29.36	5016	17.87

Table 4.7 Year 2012

District	x1	x2	x3	x5	x7	Forecasting Y value from equation.
Klongtoei	107421	1427.8	27108	29.41	8267	27.08
Dusit	102546	1427.8	8883	29.41	9615	19.72
Dindang	129152	1427.8	4745	29.41	12950	18.67
Bangrak	43415	1427.8	6830	29.41	7068	16.57
Bangkoleam	94584	1427.8	14434	29.41	8662	21.61
Bangna	101788	1427.8	14280	29.41	5339	22.83
Patumwan	39073	1427.8	8706	29.41	5625	17.43
Pomprabsatrupai	49873	1427.8	3140	29.41	25827	10.48
Pranakorn	56053	1427.8	5356	29.41	10125	15.86
Prakanong	100766	1427.8	6777	29.41	7200	19.50
Payathai	72625	1427.8	6449	29.41	7569	17.81
Yanawa	86190	1427.8	6727	29.41	5173	19.27
Rajathevee	79847	1427.8	5322	29.41	13126	16.27
Wathana	80798	1427.8	2954	29.41	5321	17.55
Sampanthawong	27585	1427.8	2166	29.41	19481	10.67
sathorn	84662	1427.8	8029	29.41	9077	18.62
Huakwang	75880	1427.8	4578	29.41	4992	17.99

Table 4.8Year 2013

District	x1	x2	x3	x5	x7	Forecasting value from equation.
Klongtoei	104542	1419.56	28292	29.46	8045	27.54
Dusit	98805	1419.56	8992	29.46	9265	19.77
Dindang	126077	1419.56	4687	29.46	12454	18.74
Bangrak	42039	1419.56	7291	29.46	6760	16.87
Bangkoleam	92526	1419.56	15057	29.46	8473	21.90
Bangna	101929	1419.56	14519	29.46	5326	23.04
Patumwan	34029	1419.56	8706	29.46	5532	17.30
Pomprabsatrupai	47996	1419.56	3250	29.46	24855	10.80
Pranakorn	53925	1419.56	5357	29.46	9741	15.96
Prakanong	101291	1419.56	7304	29.46	7237	19.82
Payathai	71508	1419.56	6797	29.46	7453	18.03
Yanawa	85720	1419.56	6998	29.46	5144	19.47
Rajathevee	77256	1419.56	5442	29.46	12975	16.34
Wathana	80809	1419.56	2954	29.46	5289	17.68
Sampanthawong	26831	1419.56	2152	29.46	18948	10.88
sathorn	82826	1419.56	8118	29.46	8880	18.72
Huakwang	75563	1419.56	4611	29.46	4968	18.10

Table 4.9 Year 2014

District	x1	x2	x3	x5	x7	Forecasting Y value from equation.
Klongtoei	101663	1411.33	29476	29.51	7824	28.00
Dusit	95065	1411.33	9101	29.51	8914	19.83
Dindang	123001	1411.33	4629	29.51	11957	18.80
Bangrak	40662	1411.33	7752	29.51	6451	17.16
Bangkoleam	90467	1411.33	15680	29.51	8285	22.19
Bangna	102071	1411.33	14759	29.51	5312	23.26
Patumwan	28985	1411.33	8705	29.51	5440	17.18
Pomprabsatrupai	46120	1411.33	3360	29.51	23883	11.11
Pranakorn	49667	1411.33	5361	29.51	9356	15.96
Prakanong	101817	1411.33	7830	29.51	7274	20.15
Payathai	70392	1411.33	7146	29.51	7337	18.25
Yanawa	85251	1411.33	7270	29.51	5116	19.66
Rajathevee	74665	1411.33	5562	29.51	12824	16.40
Wathana	80821	1411.33	2954	29.51	5257	17.80
Sampanthawong	26077	1411.33	2137	29.51	18416	11.10
sathorn	80990	1411.33	8207	29.51	8683	18.83
Huakwang	75246	1411.33	4643	29.51	4945	18.22

Table 4.10 Year 2015

District	x1	x2	x3	x5	x7	Forecasting Y value from equation.
Klongtoei	98784	1403.1	30659	29.56	7602	28.46
Dusit	91324	1403.1	9209	29.56	8563	19.88
Dindang	119926	1403.1	4571	29.56	11460	18.87
Bangrak	39285	1403.1	8213	29.56	6143	17.46
Bangkoleam	88409	1403.1	16304	29.56	8097	22.48
Bangna	23941	1403.1	8705	29.56	5258	17.08
Patumwan	44244	1403.1	3470	29.56	22911	11.43
Pomprabsatrupai	49667	1403.1	5361	29.56	8972	16.18
Pranakorn	102342	1403.1	8357	29.56	7311	20.48
Prakanong	69275	1403.1	7494	29.56	7221	18.46
Payathai	84781	1403.1	7542	29.56	5088	19.86
Yanawa	72074	1403.1	5682	29.56	12673	16.46
Rajathevee	80833	1403.1	2954	29.56	5225	17.92
Wathana	25322	1403.1	2123	29.56	17883	11.31
Sampanthawong	79154	1403.1	8296	29.56	8486	18.93
sathorn	74929	1403.1	4675	29.56	4921	18.33
Huakwang	73978	1378.4	4676	29.66	4874	18.50

Table 4.11 Year 2016

District	x1	x2	x3	x5	x7	Forecasting Y value from equation.
Klongtoei	95905	1394.87	31843	29.61	7381	28.93
Dusit	87583	1394.87	9318	29.61	8212	19.93
Dindang	116851	1394.87	4512	29.61	10964	18.94
Bangrak	37909	1394.87	8674	29.61	5834	17.76
Bangkoleam	86350	1394.87	16927	29.61	7909	22.77
Bangna	102354	1394.87	15237	29.61	5286	23.68
Patumwan	18896	1394.87	8704	29.61	5012	17.00
Pomprabsatrupai	42368	1394.87	3579	29.61	21940	11.75
Pranakorn	47539	1394.87	5380	29.61	8587	16.29
Prakanong	102868	1394.87	8884	29.61	7348	20.80
Payathai	68158	1394.87	7842	29.61	7104	18.68
Yanawa	84312	1394.87	7814	29.61	5060	20.06
Rajathevee	69483	1394.87	5802	29.61	12522	16.53
Wathana	80844	1394.87	2954	29.61	5193	18.04
Sampanthawong	24568	1394.87	2108	29.61	17350	11.52
sathorn	77318	1394.87	8385	29.61	8289	19.03
Huakwang	74612	1394.87	4708	29.61	4898	18.45

Table 4.12 Year 2017

District	x1	x2	x3	x5	x7	Forecasting Y value from equation.
Klongtoei	93026	1386.63	33027	29.66	7159	29.39
Dusit	83843	1386.63	9427	29.66	7862	19.99
Dindang	113776	1386.63	4454	29.66	10467	19.00
Bangrak	36532	1386.63	9135	29.66	5526	18.05
Bangkoleam	84292	1386.63	17550	29.66	7720	23.06
Bangna	102495	1386.63	15477	29.66	5272	23.90
Patumwan	13852	1386.63	8704	29.66	4852	16.89
Pomprabsatrupai	40492	1386.63	3689	29.66	20968	12.07
Pranakorn	45410	1386.63	5396	29.66	8203	16.41
Prakanong	103393	1386.63	9411	29.66	7385	21.13
Payathai	67041	1386.63	8190	29.66	6988	18.89
Yanawa	83842	1386.63	8086	29.66	5031	20.26
Rajathevee	66892	1386.63	5922	29.66	12371	16.59
Wathana	80856	1386.63	2954	29.66	5161	18.17
Sampanthawong	23813	1386.63	2094	29.66	16817	11.74
sathorn	75482	1386.63	8474	29.66	8092	19.14
Huakwang	74295	1386.63	4740	29.66	4874	18.56

Table 4.13 Year 2018

District	x1	x2	x3	x5	x7	Forecasting Y value from equation.
Klongtoei	90146	1378.4	34211	29.71	6937	29.85
Dusit	80102	1378.4	9536	29.71	7511	20.04
Dindang	110701	1378.4	4396	29.71	9970	19.07
Bangrak	35155	1378.4	9596	29.71	5218	18.35
Bangkoleam	82233	1378.4	18173	29.71	7532	23.34
Bangna	102637	1378.4	15716	29.71	5259	24.11
Patumwan	8808	1378.4	8704	29.71	4652	16.80
Pomprabsatrupai	38615	1378.4	3799	29.71	19996	12.39
Pranakorn	43282	1378.4	5404	29.71	7818	16.52
Prakanong	103919	1378.4	9938	29.71	7422	21.45
Payathai	65925	1378.4	8538	29.71	6872	19.11
Yanawa	83372	1378.4	8358	29.71	5003	20.45
Rajathevee	64301	1378.4	6042	29.71	12220	16.66
Wathana	80867	1378.4	2954	29.71	5129	18.29
Sampanthawong	23059	1378.4	2079	29.71	16284	11.95
sathorn	73645	1378.4	8563	29.71	7895	19.24
Huakwang	73978	1378.4	4773	29.71	4850	18.68

Table 4.14 Year 2019

District	x1	x2	x3	x5	x7	Forecasting Y value from equation.
Klongtoei	90,883	1,380.00	34,490.20	28.20	6,994.04	27.29
Dusit	80,757	1,380.00	9,613.84	28.20	7,572.08	17.40
Dindang	111,606	1,380.00	4,432.01	28.20	10,051.69	16.42
Bangrak	35,443	1,380.00	9,674.63	28.20	5,260.16	15.69
Bangkoleam	82,905	1,380.00	18,321.73	28.20	7,593.45	20.73
Bangna	103,476	1,380.00	15,844.35	28.20	5,301.77	21.50
Patumwan	8,880	1,380.00	8,774.70	28.20	4,689.57	14.13
Pomprabsatrupai	38,931	1,380.00	3,830.37	28.20	20,159.53	9.68
Pranakorn	43,635	1,380.00	5,448.17	28.20	7,882.10	13.84
Prakanong	104,768	1,380.00	10,019.22	28.20	7,482.47	18.82
Payathai	66,464	1,380.00	8,608.18	28.20	6,927.74	16.46
Yanawa	84,054	1,380.00	8,425.91	28.20	5,044.03	17.81
Rajathevee	64,826	1,380.00	6,090.99	28.20	12,320.08	13.98
Wathana	81,528	1,380.00	2,978.14	28.20	5,170.62	15.63
Sampanthawong	23,247	1,380.00	2,096.38	28.20	16,417.09	9.24
sathorn	74,247	1,380.00	8,632.82	28.20	7,959.90	16.59
Huakwang	74,582	1,380.00	4,811.63	28.20	4,889.86	16.02

So we can create group of linear graph which can figure the water consumption demand of the inner area of BMA as figure 4.11 below.

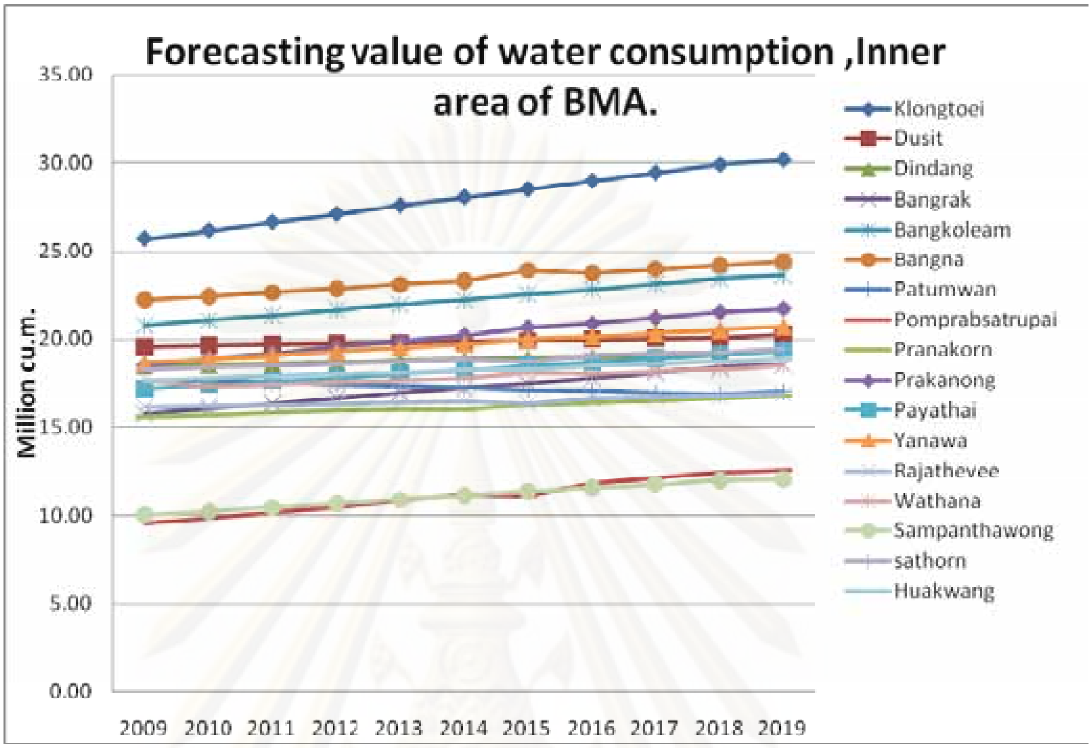

Figure 4.11 Forecasting value of water consumption ,Inner area of BMA from year 2008 to 2017.

5.4.10 Interim area forecasting water demand volume of BMA.

From the validate equation of inner area in each district as shown in table 4.1and the forecasting value of X1 to X8 we will have the forecasting volume for next 10 year(2009 – 2019) water demand as follow.

Table 4.15 Year 2009

District	x1	x2	x3	x5	x7	x8	Forecasting Y value from equation.
Klongsan	81,277.30	1,452.49	10,958.00	29.26	13,432.20	156,945,496.00	17.41
Kannayao	85,578.40	1,452.49	6,967.70	29.26	3,293.57	125,735,704.00	17.91
Jatujak	165,826.00	1,452.49	8,751.70	29.26	5,238.66	236,158,431.00	35.47
Jomthong	164,534.00	1,452.49	10,336.00	29.26	6,129.74	211,252,724.00	32.10
Donmaung	164,882.00	1,452.49	19,510.90	29.26	6,647.20	202,739,678.00	33.98
Tunkru	113,032.00	1,452.49	6,758.40	29.26	3,718.00	152,951,651.00	22.33
Thonburi	124,722.00	1,452.49	13,863.70	29.26	14,586.00	205,676,379.00	26.07
Bangken	184,483.00	1,452.49	21,748.40	29.26	4,379.97	205,965,123.00	37.33
Bangkapi	151,499.00	1,452.49	6,438.00	29.26	5,312.01	112,569,295.00	17.34
Buangkum	147,542.00	1,452.49	8,403.00	29.26	6,068.65	171,188,180.00	25.36
Bangsue	145,076.00	1,452.49	11,503.40	29.26	12,567.00	188,192,938.00	24.85
Pravet	153,629.00	1,452.49	7,820.00	29.26	2,926.09	190,312,274.00	29.82
Ratburana	101,512.00	1,452.49	5,629.17	29.26	5,838.03	219,331,969.00	29.18
Ladprao	121,943.00	1,452.49	2,960.00	29.26	5,588.76	133,345,292.00	17.56
Wangthonglang	117,669.00	1,452.49	3,681.60	29.26	6,224.31	180,061,492.00	23.58
Suanlaung	116,930.00	1,452.49	9,679.80	29.26	4,937.82	141,113,272.00	21.23
Saimai	176,575.00	1,452.49	17,817.00	29.26	3,957.83	136,102,514.00	26.42
Saphansoong	87,493.00	1,452.49	8,773.95	29.26	3,110.29	120,068,858.00	17.98
Laksi	116,072.00	1,452.49	16,327.20	29.26	5,112.01	130,500,602.00	22.06

Table 4.16 Year 2010

District	x1	x2	x3	x5	x7	x8	Forecasting Y value from equation.
Klongsan	78,266.00	1,444.26	10,965.00	29.31	12,934.00	155,502,667.00	17.64
Kannayao	86,200.00	1,444.26	7,522.40	29.31	3,317.36	126,468,281.00	18.46
Jatujak	165,147.00	1,444.26	9,077.70	29.31	5,239.79	234,806,328.00	35.61
Jomthong	163,696.00	1,444.26	10,678.60	29.31	6,086.18	213,252,144.00	32.73
Donmaung	166,690.00	1,444.26	20,024.00	29.31	6,850.10	206,974,656.00	34.93
Tunkru	114,320.00	1,444.26	7,183.30	29.31	3,812.00	152,613,142.00	22.68
Thonburi	118,592.00	1,444.26	14,028.40	29.31	13,869.20	205,932,910.00	26.59
Bangken	186,417.00	1,444.26	23,004.70	29.31	4,425.86	208,662,845.00	38.44
Bangkapi	152,690.00	1,444.26	6,817.00	29.31	5,354.28	111,369,295.00	17.57
Buangkum	148,517.00	1,444.26	8,509.70	29.31	6,108.45	173,364,638.00	25.95
Bangsue	142,960.00	1,444.26	11,533.60	29.31	12,383.70	187,539,889.00	25.03
Pravet	157,522.00	1,444.26	7,820.00	29.31	3,000.21	190,452,428.00	30.19
Ratburana	107,967.00	1,444.26	5,744.62	29.31	5,826.36	228,082,645.00	30.91
Ladprao	123,569.00	1,444.26	2,967.00	29.31	5,654.16	129,815,964.00	17.35
Wangthonglang	118,940.00	1,444.26	3,759.83	29.31	6,344.54	182,717,717.00	24.19
Suanlaung	117,549.00	1,444.26	10,121.10	29.31	4,963.99	121,413,253.00	18.98
Saimai	180,230.00	1,444.26	18,217.50	29.31	4,039.82	124,953,915.00	25.39
Saphansoong	89,214.00	1,444.26	8,835.62	29.31	3,171.38	119,867,957.00	18.25
Laksi	116,000.00	1,444.26	16,753.30	29.31	5,098.69	131,113,334.00	22.55

Table 4.17 Year 2011

District	x1	x2	x3	x5	x7	x8	Forecasting Y value from equation.
Klongsan	75,254.60	1,436.03	10,973.00	29.36	12,436.90	154,059,837.00	17.86
Kannayao	86,821.60	1,436.03	8,077.20	29.36	3,341.14	127,200,858.00	19.01
Jatujak	164,469.00	1,436.03	9,403.70	29.36	5,240.91	233,454,225.00	35.76
Jomthong	162,859.00	1,436.03	11,021.20	29.36	6,042.63	215,251,563.00	33.35
Donmaung	168,498.00	1,436.03	20,538.00	29.36	7,053.00	211,209,635.00	35.88
Tunkru	115,607.00	1,436.03	7,608.30	29.36	3,942.00	152,274,634.00	23.00
Thonburi	112,463.00	1,436.03	14,193.00	29.36	13,152.50	206,189,442.00	27.10
Bangken	188,351.00	1,436.03	24,261.00	29.36	4,471.75	211,360,567.00	39.55
Bangkapi	153,882.00	1,436.03	7,195.90	29.36	5,396.55	110,459,295.00	17.85
Buangkum	149,492.00	1,436.03	8,616.30	29.36	6,148.25	175,541,096.00	26.53
Bangsue	140,844.00	1,436.03	11,563.80	29.36	12,200.40	186,886,840.00	25.22
Pravet	161,415.00	1,436.03	7,824.80	29.36	3,074.32	190,592,582.00	30.56
Ratburana	114,423.00	1,436.03	5,860.07	29.36	5,814.70	236,833,320.00	32.63
Ladprao	125,196.00	1,436.03	2,969.00	29.36	5,719.56	116,286,637.00	15.79
Wangthonglang	120,211.00	1,436.03	3,838.06	29.36	6,464.78	185,373,942.00	24.79
Suanlaung	118,168.00	1,436.03	10,562.40	29.36	4,990.16	103,413,467.00	16.95
Saimai	183,885.00	1,436.03	18,617.70	29.36	4,121.81	113,805,315.00	24.37
Saphansoong	90,934.00	1,436.03	8,897.28	29.36	3,232.47	119,667,056.00	18.51
Laksi	115,927.00	1,436.03	17,179.30	29.36	5,085.36	131,726,065.00	23.03

Table 4.18 Year 2012

District	x1	x2	x3	x5	x7	x8	Forecasting Y value from equation.
Klongsan	72,243.30	1,427.80	10,973.00	29.41	11,939.30	152,617,008.00	18.08
Kannayao	87,443.20	1,427.80	8,632.00	29.41	3,364.93	127,933,435.00	19.56
Jatujak	163,791.00	1,427.80	9,729.70	29.41	5,242.04	232,102,122.00	35.91
Jomthong	162,021.00	1,427.80	11,363.80	29.41	5,999.08	217,250,983.00	33.98
Donmaung	170,306.00	1,427.80	21,051.60	29.41	7,255.90	215,444,613.00	36.83
Tunkru	116,894.00	1,427.80	8,033.20	29.41	4,021.00	151,936,126.00	23.35
Thonburi	106,333.00	1,427.80	14,357.70	29.41	12,435.70	206,445,974.00	27.62
Bangken	190,285.00	1,427.80	25,517.20	29.41	4,517.65	214,058,289.00	40.66
Bangkapi	155,073.00	1,427.80	7,574.90	29.41	5,438.82	102,540,295.00	17.18
Buangkum	150,466.00	1,427.80	8,723.00	29.41	6,188.06	177,717,555.00	27.12
Bangsue	138,727.00	1,427.80	11,594.00	29.41	12,017.20	186,233,791.00	25.41
Pravet	165,307.00	1,427.80	7,830.30	29.41	3,148.44	190,732,736.00	30.93
Ratburana	120,878.00	1,427.80	5,975.52	29.41	5,803.03	245,583,995.00	34.35
Ladprao	126,822.00	1,427.80	2,973.00	29.41	5,784.96	107,757,309.00	14.90
Wangthonglang	121,482.00	1,427.80	3,916.29	29.41	6,585.02	188,030,167.00	25.40
Suanlaung	118,787.00	1,427.80	11,003.70	29.41	5,016.33	98,611,788.00	16.71
Saimai	187,539.00	1,427.80	19,017.90	29.41	4,203.81	102,656,716.00	23.34
Saphansoong	92,655.00	1,427.80	8,958.95	29.41	3,293.56	119,466,155.00	18.78
Laksi	115,854.00	1,427.80	17,605.40	29.41	5,072.04	132,338,797.00	23.51

Table 4.19 Year 2013

District	x1	x2	x3	x5	x7	x8	Forecasting Y value from equation.
Klongsan	69,232.00	1,419.56	10,981.00	29.46	11,441.00	151,174,179.00	18.31
Kannayao	88,064.80	1,419.56	9,186.70	29.46	3,388.72	128,666,013.00	20.11
Jatujak	163,112.00	1,419.56	10,055.80	29.46	5,243.17	230,750,019.00	36.06
Jomthong	161,184.00	1,419.56	11,706.40	29.46	5,955.52	219,250,402.00	34.61
Donmaung	172,113.00	1,419.56	21,565.20	29.46	7,458.80	219,679,591.00	37.78
Tunkru	118,181.00	1,419.56	8,458.10	29.46	4,111.00	151,597,618.00	23.70
Thonburi	100,204.00	1,419.56	14,522.30	29.46	11,719.00	206,702,505.00	28.14
Bangken	192,219.00	1,419.56	26,773.50	29.46	4,563.54	216,756,011.00	41.77
Bangkapi	156,264.00	1,419.56	7,953.90	29.46	5,481.10	97,569,295.00	16.91
Buangkum	151,441.00	1,419.56	8,829.60	29.46	6,227.86	179,894,013.00	27.71
Bangsue	136,611.00	1,419.56	11,624.30	29.46	11,833.90	185,580,742.00	25.60
Pravet	169,200.00	1,419.56	7,834.20	29.46	3,222.55	190,872,890.00	31.30
Ratburana	127,334.00	1,419.56	6,090.97	29.46	5,791.37	254,334,670.00	36.08
Ladprao	128,448.00	1,419.56	2,978.00	29.46	5,850.36	99,227,981.00	14.02
Wangthonglang	122,752.00	1,419.56	3,994.52	29.46	6,705.26	190,686,391.00	26.01
Suanlaung	119,407.00	1,419.56	11,445.00	29.46	5,042.50	90,315,643.00	16.00
Saimai	191,194.00	1,419.56	19,418.10	29.46	4,285.80	99,508,116.00	23.40
Saphansoong	94,376.00	1,419.56	9,020.62	29.46	3,354.65	119,265,254.00	19.05
Laksi	115,782.00	1,419.56	18,031.50	29.46	5,058.72	132,951,529.00	23.99

Table 4.20 Year 2014

District	x1	x2	x3	x5	x7	x8	Forecasting Y value from equation.
Klongsan	66,220.70	1,411.33	10,985.00	29.51	10,944.00	149,731,349.00	18.53
Kannayao	88,686.30	1,411.33	9,741.50	29.51	3,412.50	129,398,590.00	20.66
Jatujak	162,434.00	1,411.33	10,381.80	29.51	5,244.30	229,397,916.00	36.21
Jomthong	160,346.00	1,411.33	12,049.10	29.51	5,911.97	221,249,822.00	35.23
Donmaung	173,921.00	1,411.33	22,078.70	29.51	7,661.60	223,914,569.00	38.73
Tunkru	119,469.00	1,411.33	8,883.00	29.51	4,217.00	151,259,110.00	24.03
Thonburi	94,075.00	1,411.33	14,687.00	29.51	11,002.20	206,959,037.00	28.65
Bangken	194,153.00	1,411.33	28,029.80	29.51	4,609.43	219,453,733.00	42.87
Bangkapi	157,455.00	1,411.33	8,332.90	29.51	5,523.37	96,569,295.00	17.17
Buangkum	152,416.00	1,411.33	8,936.30	29.51	6,267.66	182,070,471.00	28.30
Bangsue	134,495.00	1,411.33	11,654.50	29.51	11,650.60	184,927,693.00	25.79
Pravet	173,092.00	1,411.33	7,834.20	29.51	3,296.67	191,013,044.00	31.67
Ratburana	133,789.00	1,411.33	6,206.42	29.51	5,779.70	263,085,346.00	37.80
Ladprao	130,075.00	1,411.33	2,981.00	29.51	5,915.76	90,698,653.00	13.14
Wangthonglang	124,023.00	1,411.33	4,072.75	29.51	6,825.49	193,342,616.00	26.61
Suanlaung	120,026.00	1,411.33	11,886.30	29.51	5,068.67	89,618,764.00	16.32
Saimai	194,849.00	1,411.33	19,818.40	29.51	4,367.79	90,359,533.00	22.64
Saphansoong	96,096.00	1,411.33	9,082.28	29.51	3,415.74	119,064,353.00	19.31
Laksi	115,709.00	1,411.33	18,457.60	29.51	5,045.40	133,564,260.00	24.47

Table 4.21 Year 2015

District	x1	x2	x3	x5	x7	x8	Forecasting Y value from equation.
Klongsan	63,209.30	1,403.10	10,995.00	29.56	10,446.30	148,288,520.00	18.75
Kannayao	89,307.90	1,403.10	10,296.30	29.56	3,436.29	130,131,167.00	21.21
Jatujak	161,756.00	1,403.10	10,707.80	29.56	5,245.42	228,045,813.00	36.36
Jomthong	159,509.00	1,403.10	12,391.70	29.56	5,868.42	223,249,242.00	35.86
Donmaung	175,729.00	1,403.10	22,592.30	29.56	7,864.50	228,149,547.00	39.68
Tunkru	120,756.00	1,403.10	9,308.00	29.56	4,335.00	150,920,602.00	24.36
Thonburi	87,945.00	1,403.10	14,851.00	29.56	10,285.50	207,215,569.00	29.17
Bangken	196,087.00	1,403.10	29,286.10	29.56	4,655.32	222,151,455.00	43.98
Bangkapi	158,646.00	1,403.10	8,711.90	29.56	5,565.64	94,569,295.00	17.30
Buangkum	153,391.00	1,403.10	9,042.90	29.56	6,307.46	184,246,929.00	28.88
Bangsue	132,378.00	1,403.10	11,684.70	29.56	11,467.30	184,274,644.00	25.97
Pravet	176,985.00	1,403.10	7,839.10	29.56	3,370.79	191,153,198.00	32.04
Ratburana	140,245.00	1,403.10	6,321.87	29.56	5,768.04	271,836,021.00	39.53
Ladprao	131,701.00	1,403.10	2,981.00	29.56	5,981.16	89,169,325.00	13.20
Wangthonglang	125,294.00	1,403.10	4,150.99	29.56	6,945.73	195,998,841.00	27.22
Suanlaung	120,645.00	1,403.10	12,327.60	29.56	5,094.84	83,616,788.00	15.92
Saimai	198,504.00	1,403.10	20,218.60	29.56	4,449.78	89,359,517.00	22.99
Saphansoong	97,817.00	1,403.10	9,143.95	29.56	3,476.83	118,863,452.00	19.58
Laksi	115,636.00	1,403.10	18,883.60	29.56	5,032.08	134,176,992.00	24.96

Table 4.22 Year 2016

District	x1	x2	x3	x5	x7	x8	Forecasting Y value from equation.
Klongsan	60,198.00	1,394.87	11,108.00	29.61	9,948.70	146,845,691.00	19.01
Kannayao	89,929.50	1,394.87	10,851.00	29.61	3,460.08	130,863,744.00	21.76
Jatujak	161,077.00	1,394.87	11,033.80	29.61	5,246.55	226,693,711.00	36.50
Jomthong	158,672.00	1,394.87	12,734.30	29.61	5,824.86	225,248,661.00	36.49
Donmaung	177,537.00	1,394.87	23,105.80	29.61	8,067.40	232,384,525.00	40.63
Tunkru	122,043.00	1,394.87	9,732.90	29.61	4,401.00	150,582,094.00	24.72
Thonburi	81,816.00	1,394.87	15,016.00	29.61	9,568.70	207,472,101.00	29.69
Bangken	198,020.00	1,394.87	30,542.30	29.61	4,701.22	224,849,177.00	45.09
Bangkapi	159,838.00	1,394.87	9,090.90	29.61	5,607.91	94,254,935.00	17.66
Buangkum	154,365.00	1,394.87	9,149.60	29.61	6,347.27	186,423,387.00	29.47
Bangsue	130,262.00	1,394.87	11,714.90	29.61	11,284.10	183,621,595.00	26.16
Pravet	180,878.00	1,394.87	7,841.50	29.61	3,444.90	191,293,352.00	32.41
Ratburana	146,700.00	1,394.87	6,437.32	29.61	5,756.37	280,586,696.00	41.25
Ladprao	133,327.00	1,394.87	2,984.00	29.61	6,046.56	87,639,997.00	13.26
Wangthonglang	126,565.00	1,394.87	4,229.22	29.61	7,065.97	198,655,066.00	27.83
Suanlaung	121,264.00	1,394.87	12,768.90	29.61	5,121.01	81,416,698.00	16.03
Saimai	202,159.00	1,394.87	20,618.80	29.61	4,531.78	85,349,527.00	22.93
Saphansoong	99,537.00	1,394.87	9,205.62	29.61	3,537.92	118,662,551.00	19.85
Laksi	115,564.00	1,394.87	19,309.70	29.61	5,018.75	134,789,724.00	25.44

Table 4.23 Year 2017

District	x1	x2	x3	x5	x7	x8	Forecasting Y value from equation.
Klongsan	57,186.70	1,386.63	11,113.00	29.66	9,451.00	145,402,861.00	19.24
Kannayao	90,551.10	1,386.63	11,405.80	29.66	3,483.87	131,596,321.00	22.31
Jatujak	160,399.00	1,386.63	11,359.80	29.66	5,247.68	225,341,608.00	36.65
Jomthong	157,834.00	1,386.63	13,076.90	29.66	5,781.31	227,248,081.00	37.12
Donmaung	179,344.00	1,386.63	23,619.40	29.66	8,270.30	236,619,503.00	41.57
Tunkru	123,330.00	1,386.63	10,157.80	29.66	4,519.00	150,243,586.00	25.05
Thonburi	75,686.00	1,386.63	15,181.00	29.66	8,851.90	207,728,632.00	30.20
Bangken	199,954.00	1,386.63	31,798.60	29.66	4,747.11	227,546,899.00	46.20
Bangkapi	161,029.00	1,386.63	9,469.80	29.66	5,650.18	92,379,395.00	17.81
Buangkum	155,340.00	1,386.63	9,256.20	29.66	6,387.07	188,599,846.00	30.06
Bangsue	128,146.00	1,386.63	11,745.10	29.66	11,100.80	182,968,546.00	26.35
Pravet	184,770.00	1,386.63	7,848.20	29.66	3,519.02	191,433,506.00	32.78
Ratburana	153,115.00	1,386.63	6,552.76	29.66	5,744.71	289,337,372.00	42.97
Ladprao	134,954.00	1,386.63	2,987.00	29.66	6,111.96	83,110,670.00	12.91
Wangthonglang	127,836.00	1,386.63	4,307.45	29.66	7,186.20	201,311,290.00	28.43
Suanlaung	121,883.00	1,386.63	13,210.30	29.66	5,147.18	80,489,736.00	16.31
Saimai	205,813.00	1,386.63	21,019.00	29.66	4,613.77	80,359,517.00	22.74
Saphansoong	101,258.00	1,386.63	9,267.28	29.66	3,599.01	118,461,650.00	20.11
Laksi	115,491.00	1,386.63	19,735.80	29.66	5,005.43	135,402,455.00	25.92

Table 4.24 Year 2018

District	x1	x2	x3	x5	x7	x8	Forecasting Y value from equation.
Klongsan	54,175.40	1,378.40	11,120.00	29.71	8,953.30	143,960,032.00	19.46
Kannayao	91,172.70	1,378.40	11,960.60	29.71	3,507.65	132,328,898.00	22.86
Jatujak	159,721.00	1,378.40	11,685.80	29.71	5,248.80	223,989,505.00	36.80
Jomthong	156,997.00	1,378.40	13,419.60	29.71	5,737.76	229,247,501.00	37.74
Donmaung	181,152.00	1,378.40	24,132.90	29.71	8,473.20	240,854,482.00	42.52
Tunkru	124,618.00	1,378.40	10,582.70	29.71	4,608.00	149,905,078.00	25.40
Thonburi	69,557.00	1,378.40	15,345.60	29.71	8,135.20	207,985,164.00	30.72
Bangken	201,888.00	1,378.40	33,054.90	29.71	4,793.00	230,244,621.00	47.31
Bangkapi	162,220.00	1,378.40	9,848.80	29.71	5,692.45	90,369,394.00	17.93
Buangkum	156,315.00	1,378.40	9,362.90	29.71	6,426.87	190,776,304.00	30.65
Bangsue	126,029.00	1,378.40	11,775.30	29.71	10,917.50	182,315,497.00	26.54
Pravet	188,663.00	1,378.40	7,850.10	29.71	3,593.13	191,573,660.00	33.15
Ratburana	159,611.00	1,378.40	6,668.21	29.71	5,733.04	298,088,047.00	44.70
Ladprao	136,580.00	1,378.40	2,989.00	29.71	6,177.36	80,581,342.00	12.84
Wangthonglang	129,107.00	1,378.40	4,385.68	29.71	7,306.44	203,967,515.00	29.04
Suanlaung	122,502.00	1,378.40	13,651.60	29.71	5,173.35	78,210,456.00	16.41
Saimai	209,468.00	1,378.40	21,419.20	29.71	4,695.76	79,210,917.00	23.06
Saphansoong	102,978.00	1,378.40	9,328.95	29.71	3,660.10	118,260,749.00	20.38
Laksi	115,418.00	1,378.40	20,161.90	29.71	4,992.11	136,015,187.00	26.40

Table 4.25 Year 2019

District	x1	x2	x3	x5	x7	x8	Forecasting Y value from equation.
Klongsan	54,618.18	1,380.00	11,210.88	29.76	9,026.48	145,136,617.34	19.83
Kannayao	91,917.85	1,380.00	12,058.35	29.76	3,536.32	133,410,422.08	23.26
Jatujak	161,026.40	1,380.00	11,781.31	29.76	5,291.70	225,820,171.22	37.32
Jomthong	158,280.14	1,380.00	13,529.28	29.76	5,784.65	231,121,140.83	38.27
Donmaung	182,632.56	1,380.00	24,330.14	29.76	8,542.45	242,822,985.68	43.09
Tunkru	125,636.50	1,380.00	10,669.19	29.76	4,645.66	151,130,252.20	25.82
Thonburi	70,125.49	1,380.00	15,471.02	29.76	8,201.69	209,685,026.75	31.18
Bangken	203,538.03	1,380.00	33,325.06	29.76	4,832.17	232,126,410.29	47.91
Bangkapi	163,545.82	1,380.00	9,929.29	29.76	5,738.97	91,107,983.06	18.30
Buangkum	157,592.56	1,380.00	9,439.42	29.76	6,479.40	192,335,518.73	31.11
Bangsue	127,059.04	1,380.00	11,871.54	29.76	11,006.73	183,805,561.56	26.97
Pravet	190,204.94	1,380.00	7,914.26	29.76	3,622.50	193,139,391.52	33.64
Ratburana	160,915.50	1,380.00	6,722.71	29.76	5,779.90	300,524,320.61	45.28
Ladprao	137,696.27	1,380.00	3,013.43	29.76	6,227.85	81,239,933.31	13.16
Wangthonglang	130,162.19	1,380.00	4,421.52	29.76	7,366.16	205,634,541.50	29.49
Suanlaung	123,503.21	1,380.00	13,763.17	29.76	5,215.63	78,849,670.06	16.76
Saimai	211,179.98	1,380.00	21,594.26	29.76	4,734.14	79,858,307.82	23.46
Saphansoong	103,819.64	1,380.00	9,405.20	29.76	3,690.01	119,227,294.10	20.76
Laksi	116,361.31	1,380.00	20,326.68	29.76	5,032.91	137,126,839.12	26.83

So we can create group of linear graph which can figure the water consumption demand of the interim area of BMA as figure 4.12 below.

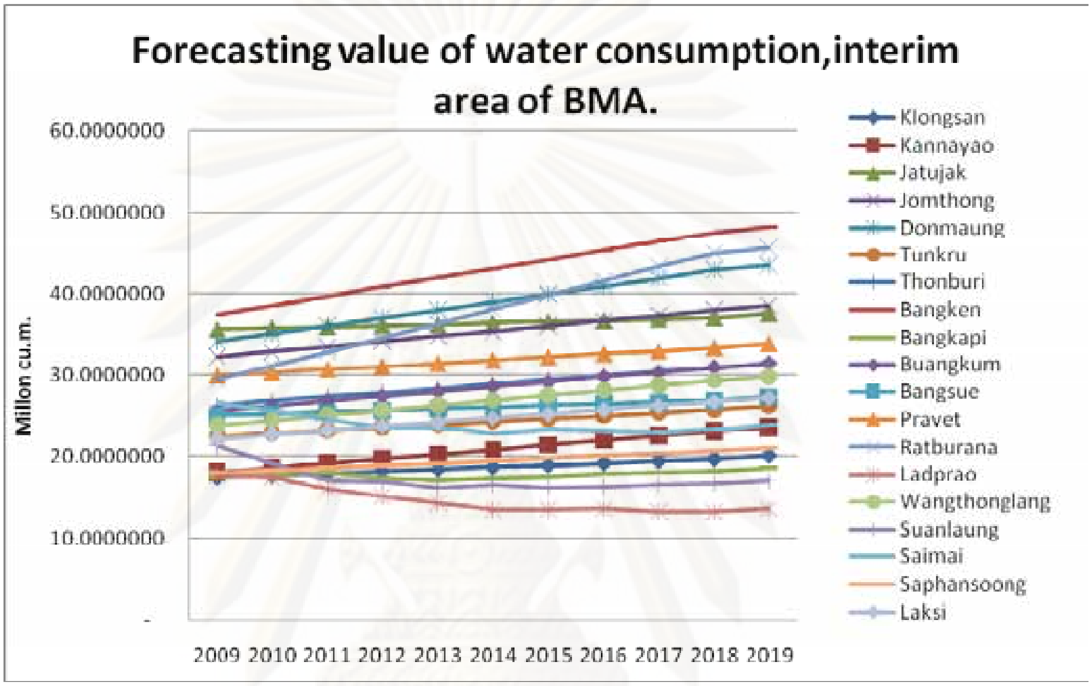

Figure 4.12 Forecasting value of water consumption ,Interim area of BMA from year 2009 to 2019.

4.4.11 The Outer area forecasting water demand volume of BMA.

From the validate equation of inner area in each district as shown in 4.2 , and the forecasting value of X1 to X8 we will have the forecasting volume for next 10 year water demand as follow.

Table 4.26 Year 2009

District	x1	x2	x3	x5	x6	x7	x8	Forecasting Y value from equation.
Klongsamwa	150,906.00	1,452.49	15,408.50	29.26	222,525.00	1,365.57	191,937,952.00	27.25
Talingchan	108,820.00	1,452.49	5,974.50	29.26	222,525.00	3,691.15	170,693,394.00	22.15
Tawewatana	72,022.00	1,452.49	2,140.14	29.26	222,525.00	1,433.91	155,185,293.00	19.15
Bangkok-yai	77,924.10	1,452.49	5,776.00	29.26	222,525.00	12,607.70	192,399,191.00	19.69
Bangkok-noi	126,316.00	1,452.49	20,245.20	29.26	222,525.00	10,576.20	150,725,512.00	23.12
Bangkhuntian	145,463.00	1,452.49	10,959.00	29.26	222,525.00	1,204.79	196,131,567.00	26.53
Bangplud	102,833.00	1,452.49	12,523.60	29.26	222,525.00	9,052.29	165,171,032.00	21.54
Bangkae	193,995.00	1,452.49	10,097.70	29.26	222,525.00	4,362.57	118,625,703.00	25.47
Bangbon	102,917.00	1,452.49	1,599.06	29.26	222,525.00	2,983.68	126,985,536.00	19.46
Pasicharoen	133,482.00	1,452.49	10,117.60	29.26	222,525.00	7,485.00	159,817,218.00	23.08
Minburi	131,744.00	1,452.49	11,247.60	29.26	222,525.00	2,070.07	147,563,240.00	23.53
Ladkrabang	148,205.00	1,452.49	14,874.70	29.26	222,525.00	1,195.33	132,647,196.00	24.52
Nongjok	139,721.00	1,452.49	12,309.00	29.26	222,525.00	612.04	207,691,052.00	26.96
Nongkham	139,745.00	1,452.49	13,627.60	29.26	222,525.00	3,902.57	192,281,214.00	25.93

Table 4.27 Year 2010

District	x1	x2	x3	x5	x6	x7	x8	Forecasting Y value from equation.
Klongsamwa	158,120.00	1,444.26	16,248.00	29.31	224,487.00	1,432.31	197,446,385.00	28.34
Talingchan	109,829.00	1,444.26	6,270.20	29.31	224,487.00	3,725.33	172,054,639.00	22.62
Tawewatana	73,854.00	1,444.26	2,231.25	29.31	224,487.00	1,475.96	156,299,368.00	19.63
Bangkok-yai	76,605.90	1,444.26	5,885.50	29.31	224,487.00	12,394.40	199,804,203.00	20.29
Bangkok-noi	122,693.00	1,444.26	20,870.60	29.31	224,487.00	10,273.10	138,387,792.00	22.83
Bangkhuntian	149,377.00	1,444.26	10,963.00	29.31	224,487.00	1,237.00	197,179,360.00	27.12
Bangplud	100,563.00	1,444.26	12,713.70	29.31	224,487.00	8,852.43	164,360,636.00	21.74
Bangkae	195,660.00	1,444.26	10,576.60	29.31	224,487.00	4,400.05	115,625,732.00	25.82
Bangbon	104,560.00	1,444.26	1,693.07	29.31	224,487.00	3,058.90	127,019,877.00	19.87
Pasicharoen	132,516.00	1,444.26	10,739.30	29.31	224,487.00	7,430.87	152,135,798.00	23.10
Minburi	135,493.00	1,444.26	11,952.00	29.31	224,487.00	2,129.11	136,714,239.00	23.69
Ladkrabang	151,164.00	1,444.26	15,231.20	29.31	224,487.00	1,220.81	124,981,670.00	24.73
Nongjok	140,213.00	1,444.26	13,444.40	29.31	224,487.00	638.78	210,307,048.00	27.57
Nongkham	143,443.00	1,444.26	15,393.50	29.31	224,487.00	4,014.02	196,219,534.00	26.85

Table 4.28 Year 2011

District	x1	x2	x3	x5	x6	x7	x8	Forecasting Y value from equation.
Klongsamwa	165,333.00	1,436.03	17,087.00	29.36	226,449	1,499.06	202,954,817	29.43
Talingchan	110,838.00	1,436.03	6,565.90	29.36	226,449	3,759.51	173,415,884	23.09
Tawewatana	75,687.00	1,436.03	2,322.35	29.36	226,449	1,518.02	157,413,443	20.11
Bangkok-yai	75,287.70	1,436.03	5,995.01	29.36	226,449	12,181.20	207,209,216	20.90
Bangkok-noi	119,071.00	1,436.03	21,496.10	29.36	226,449	9,970.00	126,050,071	22.53
Bangkhuntian	153,291.00	1,436.03	10,967.00	29.36	226,449	1,269.21	198,227,154	27.71
Bangplud	98,292.00	1,436.03	12,903.80	29.36	226,449	8,652.57	163,550,241	21.95
Bangkae	197,324.00	1,436.03	11,055.50	29.36	226,449	4,437.53	112,468,323	26.15
Bangbon	106,202.00	1,436.03	1,787.08	29.36	226,449	3,134.11	127,054,218	20.29
Pasicharoen	131,550.00	1,436.03	11,361.60	29.36	226,449	7,376.75	144,454,378	23.13
Minburi	139,242.00	1,436.03	12,656.50	29.36	226,449	2,188.15	125,865,238	23.85
Ladkrabang	154,123.00	1,436.03	15,587.70	29.36	226,449	1,246.30	103,951,650	24.37
Nongjok	143,782.00	1,436.03	14,579.80	29.36	226,449	665.52	212,923,044	28.36
Nongkham	147,140.00	1,436.03	17,159.40	29.36	226,449	4,125.48	200,157,854	27.78

Table 4.29 Year 2012

District	x1	x2	x3	x5	x6	x7	x8	Forecasting Y value from equation.
Klongsamwa	172,546.00	1,427.80	17,927.00	29.41	228,411.00	1,565.81	208,463,249.00	30.51
Talingchan	111,847.00	1,427.80	6,861.60	29.41	228,411.00	3,793.69	174,777,129.00	23.56
Tawewatana	77,519.00	1,427.80	2,413.46	29.41	228,411.00	1,560.07	158,527,518.00	20.59
Bangkok-yai	73,969.50	1,427.80	6,104.51	29.41	228,411.00	11,968.00	214,614,228.00	21.50
Bangkok-noi	115,448.00	1,427.80	22,121.50	29.41	228,411.00	9,666.90	113,712,350.00	22.24
Bangkhuntian	157,204.00	1,427.80	10,975.00	29.41	228,411.00	1,301.42	199,274,947.00	28.30
Bangplud	96,022.00	1,427.80	13,093.80	29.41	228,411.00	8,452.71	162,739,846.00	22.15
Bangkae	198,988.00	1,427.80	11,534.50	29.41	228,411.00	4,475.01	110,875,763.00	26.56
Bangbon	107,844.00	1,427.80	1,881.09	29.41	228,411.00	3,209.33	127,088,560.00	20.71
Pasicharoen	130,584.00	1,427.80	11,982.90	29.41	228,411.00	7,322.62	136,772,958.00	23.15
Minburi	142,991.00	1,427.80	13,360.90	29.41	228,411.00	2,247.19	115,016,236.00	24.02
Ladkrabang	157,082.00	1,427.80	15,944.10	29.41	228,411.00	1,271.79	98,951,670.00	24.69
Nongjok	145,875.00	1,427.80	15,715.10	29.41	228,411.00	692.26	215,539,039.00	29.07
Nongkham	150,838.00	1,427.80	18,925.40	29.41	228,411.00	4,236.93	204,096,174.00	28.71

Table 4.30 Year 2013

District	x1	x2	x3	x5	x6	x7	x8	Forecasting Y value from equation.
Klongsamwa	179,759.00	1,419.56	18,766.60	29.46	230,373.00	1,632.55	213,971,682.00	31.60
Talingchan	112,856.00	1,419.56	7,157.30	29.46	230,373.00	3,827.87	176,138,374.00	24.03
Tawewatana	79,352.00	1,419.56	2,504.56	29.46	230,373.00	1,602.12	159,641,592.00	21.07
Bangkok-yai	72,651.40	1,419.56	6,214.01	29.46	230,373.00	11,754.70	222,019,241.00	22.11
Bangkok-noi	111,825.00	1,419.56	22,747.00	29.46	230,373.00	9,363.80	101,374,630.00	21.95
Bangkhuntian	161,118.00	1,419.56	10,981.50	29.46	230,373.00	1,333.64	200,322,740.00	28.89
Bangplud	93,752.00	1,419.56	13,283.90	29.46	230,373.00	8,252.85	161,929,451.00	22.36
Bangkae	200,652.00	1,419.56	12,013.40	29.46	230,373.00	4,512.49	102,463,743.00	26.68
Bangbon	109,487.00	1,419.56	1,975.10	29.46	230,373.00	3,284.54	127,122,901.00	21.12
Pasicharoen	129,618.00	1,419.56	12,604.70	29.46	230,373.00	7,268.49	129,091,538.00	23.18
Minburi	146,741.00	1,419.56	14,065.40	29.46	230,373.00	2,306.23	104,167,235.00	24.18
Ladkrabang	160,041.00	1,419.56	16,300.60	29.46	230,373.00	1,297.28	96,451,859.00	25.12
Nongjok	147,239.00	1,419.56	16,850.50	29.46	230,373.00	719.00	218,155,035.00	29.73
Nongkham	154,536.00	1,419.56	20,691.30	29.46	230,373.00	4,348.38	208,034,493.00	29.63

Table 4.31 Year2014

District	x1	x2	x3	x5	x6	x7	x8	Forecasting Y value from equation.
Klongsamwa	186,972.00	1,411.33	19,606.10	29.51	232,336.00	1,699.30	219,480,114.00	32.68
Talingchan	113,865.00	1,411.33	7,453.00	29.51	232,336.00	3,862.05	177,499,619.00	24.50
Tawewatana	81,184.00	1,411.33	2,595.66	29.51	232,336.00	1,644.17	160,755,667.00	21.54
Bangkok-yai	71,333.20	1,411.33	6,323.51	29.51	232,336.00	11,541.50	229,424,254.00	22.71
Bangkok-noi	108,202.00	1,411.33	23,372.40	29.51	232,336.00	9,060.70	98,936,909.00	22.09
Bangkhuntian	165,032.00	1,411.33	10,989.40	29.51	232,336.00	1,365.85	201,370,534.00	29.48
Bangplud	91,481.00	1,411.33	13,474.00	29.51	232,336.00	8,052.99	161,119,056.00	22.57
Bangkae	202,317.00	1,411.33	12,492.40	29.51	232,336.00	4,549.97	98,625,803.00	26.99
Bangbon	111,129.00	1,411.33	2,069.11	29.51	232,336.00	3,359.76	127,157,243.00	21.54
Pasicharoen	128,652.00	1,411.33	13,226.50	29.51	232,336.00	7,214.36	121,410,118.00	23.20
Minburi	150,490.00	1,411.33	14,769.80	29.51	232,336.00	2,365.27	99,318,234.00	24.60
Ladkrabang	163,000.00	1,411.33	16,657.10	29.51	232,336.00	1,322.77	90,357,950.00	25.40
Nongjok	149,032.00	1,411.33	17,985.90	29.51	232,336.00	745.74	220,771,031.00	30.41
Nongkham	158,233.00	1,411.33	22,457.20	29.51	232,336.00	4,459.83	211,972,813.00	30.56

Table 4.32 Year2015

District	x1	x2	x3	x5	x6	x7	x8	Forecasting Y value from equation.
Klongsamwa	194,186.00	1,403.10	20,445.60	29.56	234,298.00	1,766.04	224,988,547.00	33.77
Talingchan	114,874.00	1,403.10	7,748.70	29.56	234,298.00	3,896.23	178,860,864.00	24.97
Tawewatana	83,017.00	1,403.10	2,686.77	29.56	234,298.00	1,686.22	161,869,742.00	22.02
Bangkok-yai	70,015.00	1,403.10	6,433.01	29.56	234,298.00	11,328.20	236,829,266.00	23.32
Bangkok-noi	104,579.00	1,403.10	23,997.90	29.56	234,298.00	8,757.60	90,699,188.00	21.97
Bangkhuntian	168,946.00	1,403.10	10,993.20	29.56	234,298.00	1,398.06	202,418,327.00	30.07
Bangplud	89,211.00	1,403.10	13,664.10	29.56	234,298.00	7,853.13	160,308,661.00	22.77
Bangkae	203,981.00	1,403.10	12,971.30	29.56	234,298.00	4,587.45	95,624,583.00	27.33
Bangbon	112,771.00	1,403.10	2,163.12	29.56	234,298.00	3,434.97	127,191,584.00	21.95
Pasicharoen	127,686.00	1,403.10	13,848.30	29.56	234,298.00	7,160.24	113,728,698.00	23.23
Minburi	154,239.00	1,403.10	15,474.30	29.56	234,298.00	2,424.30	95,358,221.00	25.06
Ladkrabang	165,959.00	1,403.10	17,013.60	29.56	234,298.00	1,348.26	89,560,557.00	25.90
Nongjok	150,237.00	1,403.10	19,121.30	29.56	234,298.00	772.48	223,387,027.00	31.06
Nongkham	161,931.00	1,403.10	24,223.10	29.56	234,298.00	4,571.28	215,911,133.00	31.49

Table 4.33 Year 2016

District	x1	x2	x3	x5	x6	x7	x8	Forecasting Y value from equation.
Klongsamwa	201,399.00	1,394.87	21,285.10	29.61	236,260.00	1,832.79	230,496,979.00	34.85
Talingchan	115,883.00	1,394.87	8,044.40	29.61	236,260.00	3,930.41	180,222,109.00	25.44
Tawewatana	84,850.00	1,394.87	2,777.87	29.61	236,260.00	1,728.28	162,983,817.00	22.50
Bangkok-yai	68,696.80	1,394.87	6,542.52	29.61	236,260.00	11,115.00	244,234,279.00	23.92
Bangkok-noi	100,956.00	1,394.87	24,623.30	29.61	236,260.00	8,454.50	89,361,468.00	22.15
Bangkhuntian	172,859.00	1,394.87	10,997.60	29.61	236,260.00	1,430.27	203,466,120.00	30.66
Bangplud	86,941.00	1,394.87	13,854.20	29.61	236,260.00	7,653.27	159,498,265.00	22.98
Bangkae	205,645.00	1,394.87	13,450.20	29.61	236,260.00	4,624.93	90,628,203.00	27.59
Bangbon	114,414.00	1,394.87	2,257.13	29.61	236,260.00	3,510.19	127,225,926.00	22.37
Pasicharoen	126,720.00	1,394.87	14,470.00	29.61	236,260.00	7,106.11	106,047,278.00	23.25
Minburi	157,988.00	1,394.87	16,178.70	29.61	236,260.00	2,483.34	90,348,225.00	25.47
Ladkrabang	168,918.00	1,394.87	17,370.00	29.61	236,260.00	1,373.75	83,271,629.00	26.17
Nongjok	151,346.00	1,394.87	20,256.70	29.61	236,260.00	799.22	226,003,023.00	31.70
Nongkham	165,629.00	1,394.87	25,989.00	29.61	236,260.00	4,682.73	219,849,452.00	32.42

Table 4.34 Year2017

District	x1	x2	x3	x5	x6	x7	x8	Forecasting Y value from equation.
Klongsamwa	208,612.00	1,386.63	22,124.60	29.66	238,222.00	1,899.54	236,005,412.00	35.94
Talingchan	116,892.00	1,386.63	8,340.20	29.66	238,222.00	3,964.59	181,583,354.00	25.90
Tawewatana	86,682.00	1,386.63	2,868.98	29.66	238,222.00	1,770.33	164,097,891.00	22.98
Bangkok-yai	67,378.60	1,386.63	6,652.02	29.66	238,222.00	10,901.70	251,639,291.00	24.53
Bangkok-noi	97,334.00	1,386.63	25,248.80	29.66	238,222.00	8,151.40	82,367,668.00	22.09
Bangkhuntian	176,773.00	1,386.63	11,008.30	29.66	238,222.00	1,462.49	204,513,914.00	31.25
Bangplud	84,671.00	1,386.63	14,044.30	29.66	238,222.00	7,453.41	158,687,870.00	23.18
Bangkae	207,309.00	1,386.63	13,929.20	29.66	238,222.00	4,662.41	86,624,501.00	27.90
Bangbon	116,056.00	1,386.63	2,351.14	29.66	238,222.00	3,585.40	127,260,267.00	22.78
Pasicharoen	125,754.00	1,386.63	15,091.80	29.66	238,222.00	7,051.98	98,365,858.00	23.27
Minburi	161,738.00	1,386.63	16,883.10	29.66	238,222.00	2,542.38	88,439,233.00	26.01
Ladkrabang	171,877.00	1,386.63	17,726.50	29.66	238,222.00	1,399.23	80,721,629.00	26.60
Nongjok	152,098.00	1,386.63	21,392.10	29.66	238,222.00	825.96	228,619,019.00	32.33
Nongkham	169,326.00	1,386.63	27,754.90	29.66	238,222.00	4,794.18	223,787,772.00	33.34

Table 4.35 Year 2018

District	x1	x2	x3	x5	x6	x7	x8	Forecasting Y value from equation.
Klongsamwa	215,825.00	1,378.40	22,964.10	29.71	240,185.00	1,966.28	241,513,844.00	37.02
Talingchan	117,901.00	1,378.40	8,635.90	29.71	240,185.00	3,998.77	182,944,599.00	26.37
Tawewatana	88,515.00	1,378.40	2,960.08	29.71	240,185.00	1,812.38	165,211,966.00	23.46
Bangkok-yai	66,060.40	1,378.40	6,761.52	29.71	240,185.00	10,688.50	259,044,304.00	25.13
Bangkok-noi	93,711.00	1,378.40	25,874.20	29.71	240,185.00	7,848.30	80,361,468.00	22.24
Bangkhuntian	180,687.00	1,378.40	11,019.20	29.71	240,185.00	1,494.70	205,561,707.00	31.84
Bangplud	82,400.00	1,378.40	14,234.40	29.71	240,185.00	7,253.55	157,877,475.00	23.39
Bangkae	208,974.00	1,378.40	14,408.10	29.71	240,185.00	4,699.89	80,534,801.00	28.11
Bangbon	117,698.00	1,378.40	2,445.14	29.71	240,185.00	3,660.62	127,294,609.00	23.20
Pasicharoen	124,788.00	1,378.40	15,713.60	29.71	240,185.00	6,997.85	90,684,438.00	23.30
Minburi	165,487.00	1,378.40	17,587.60	29.71	240,185.00	2,601.42	82,469,236.00	26.38
Ladkrabang	174,836.00	1,378.40	18,083.00	29.71	240,185.00	1,424.72	79,256,103.00	27.07
Nongjok	153,876.00	1,378.40	22,527.50	29.71	240,185.00	852.70	23,123,501.00	24.12
Nongkham	173,024.00	1,378.40	29,520.90	29.71	240,185.00	4,905.63	227,726,092.00	34.27

Table 4.36 Year 2019

District	x1	x2	x3	x5	x6	x7	x8	Forecasting Y value from equation.
Klongsamwa	217,588.94	1,380.00	23,151.79	29.80	240,185.00	1,982.35	243,487,736.65	37.47
Talingchan	118,864.60	1,380.00	8,706.48	29.80	240,185.00	4,031.45	184,439,805.21	26.73
Tawewatana	89,238.43	1,380.00	2,984.27	29.80	240,185.00	1,827.19	166,562,243.40	23.79
Bangkok-yai	66,600.31	1,380.00	6,816.78	29.80	240,185.00	10,775.86	261,161,473.10	25.48
Bangkok-noi	94,476.90	1,380.00	26,085.67	29.80	240,185.00	7,912.44	81,018,262.28	22.56
Bangkhuntian	182,163.75	1,380.00	11,109.26	29.80	240,185.00	1,506.92	207,241,762.83	32.24
Bangplud	83,073.46	1,380.00	14,350.74	29.80	240,185.00	7,312.83	159,167,807.60	23.72
Bangkae	210,681.94	1,380.00	14,525.86	29.80	240,185.00	4,738.30	81,193,011.93	28.48
Bangbon	118,659.95	1,380.00	2,465.12	29.80	240,185.00	3,690.54	128,334,987.84	23.53
Pasicharoen	125,807.89	1,380.00	15,842.03	29.80	240,185.00	7,055.04	91,425,601.91	23.63
Minburi	166,839.53	1,380.00	17,731.34	29.80	240,185.00	2,622.68	83,143,257.07	26.74
Ladkrabang	176,264.93	1,380.00	18,230.79	29.80	240,185.00	1,436.36	79,903,863.13	27.43
Nongjok	155,133.63	1,380.00	22,711.62	29.80	240,185.00	859.67	23,312,489.37	24.46
Nongkham	174,438.13	1,380.00	29,762.17	29.80	240,185.00	4,945.72	229,587,297.35	34.69

So we can create group of linear graph which can figure the water consumption demand of the outer area of BMA as figure 4.13 below.

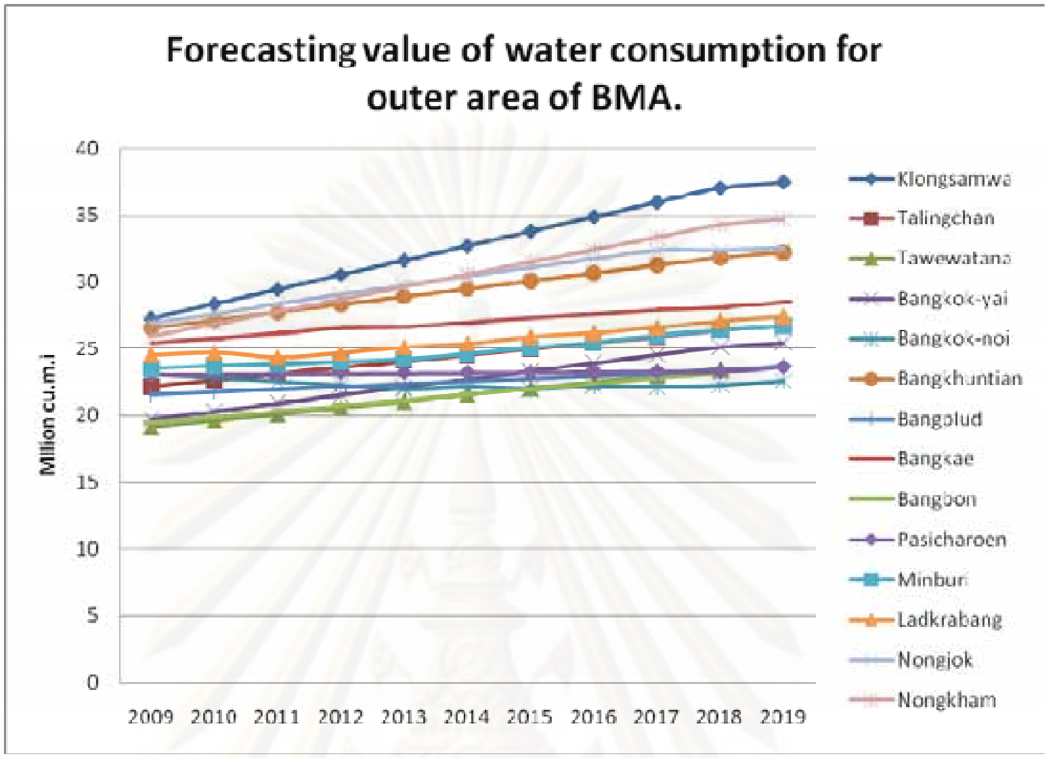

Figure 4.13 Forecasting value of water consumption ,Outer area of BMA from year 2008 to 2017.

4.4.12 Comparing with the forecasting from MWA.

Metropolitan Water Work of Bangkok have made a forecasting from 2003 to 2017 with whole water production and sell volume which shown in Table 1.1.So we can make a comparing between that table and our equation's result and it shown in table 5.34 below.

Table 5.37 Comparing with the forecasting from MWA.

Year	2009	2010	2011	2012	2013	2014	2015	2016	2017
MWA 's forecasting (million cu.m.)	1,164.00	1,186.00	1,208.00	1,234.00	1,254.00	1,274.00	1,296.00	1,321.00	1,339.00
Result from mulitiple liner regression equation.(million cu.m.)	1,107.11	1,119.44	1,132.26	1,144.25	1,163.12	1,180.30	1,200.12	1,217.81	1,236.08
Different amount (million cu.m.)	56.89	66.56	75.74	89.75	90.88	93.70	95.88	103.19	102.92
Different Percentage	4.89%	5.61%	6.27%	7.27%	7.25%	7.35%	7.40%	7.81%	7.69%

So we may say that the multiple linear regression equation that we have made from 8 factors a under amount of forecasting by MWA around 4.89% to 7.69% or increasing around 56.89 to 102.92 milliion cu.m. per year.

CHAPTER V

CONCLUSION AND RECOMENDATION

5.1 Main conclusion

5.1.1. The factor analysis has the relation conclusion of variable as follow

1) The inner area, factors component have separate to 3 groups. The first group is population volume, selling price and income per person. The second group is density of person per area, Number of family and estimated budget of each district. The third group is average temperature and precipitation volume.

2) The interim area, factors component have separate to 3 groups. The first group is selling price and income per person. The second group is population volume, Number of family, density of person per area and estimated budget of each district. The third group is average temperature and precipitation volume.

3) The outer area, factors component have separate to 4 groups. The first group is selling price and income per person. The second group is precipitation volume, average temperature and estimated budget of each district. The third group is population volume and Number of family. The forth group is density of person per area.

5.1.2. The multiple linear regressions have the conclusion of variables as follow.

1) The multiple linear regression equation for the inner area is

$$Y_{1\ validated} = 5.2x10^{-5}X_1-3.1x10^{-3}X_2+3.7x10^{-4}X_3+1.782X_5-2.7x10^{-4}X_7+3.1229$$

2) The multiple linear regression equation for the interim area is

$$Y_{2\ validated}\ 3.93x10^{-5}X_1-4.3x10^{-3}X_2+3.62x10^{-4}X_3+4.092X_5-5.9x10^{-4}X_7+1.35x10^{-7}X_8\ +4.556$$

3) The multiple linear regression equation for the outer area is

$$Y_{3\ validated} = 3.93x10^{-5}X_1-4.3x10^{-3}X_2+3.62x10^{-4}X_3+4.092X_5-5.9x10^{-4}X_7+1.35x10^{-7}X_8\ +4.36$$

The relation of 8 factors which influenced to the water consumption in each area of BMA can consider by their results. The main influencing factors in all area are 5 factors. Population volum(X_1), precipitation volume(X_2), number of family(X_3), average temperature(X_5) and density of person. But their coefficient values have relied on their characteristic of each area. And in the interim and outer area respectively have more value of influencing factors such as estimate budget of each district and income per capita.

And trendy of water consumption of each area after validated the multiple linear equations which made to suit in each district. The interim area consume the most of water consumption .The outer area, inner area are follow respectively. The increasing rate is approximately 7-12 % for in2019 or in these equations have predicted that BMA will require about 1,267 million cubic meter per year in 2019.

5.2 Recommendations

1. The forecasting for water demand volume by using the statistic model by create the multiple linear regression, analyze by factor component are require all integrated information from many government unit. Forecasting value will depend on all recorded information so all information should correct, precise and have complete record. The procedure of recording would verified by collected unit. The frequency of information collecting would uniformly.

2. The 8 factors information has difference characteristic e.g. income per capita, temperature, average selling price. There would be more precise if we can set all factors in similar characteristic by data collecting method which made by a responsible unit. The forecasting value using a time–series method are not proper for this model because of the difference characteristic. The out put value by time-series method gave the much larger amount than normal so we use the Holt's smoothing method to adjust the upper and lower peak value.

3. The equations which made are easy for using. The adjust value which happen can make more precision and correction of forecasting in each year record and district.

4.The other megacity may have difference factor which effect to the water demand volume so the procedure of creating an equation will change even the other forecasting procedure may considered because off the characteristic of that cities.

5. The process which create equations can be used in other on planning e.g. forecasting for wastewater in district, the city expansion, the solid waste forecasting.

5.3 The next step of research.

1. Try to use other forecasting method e.g. other smoothing method, decomposit method, triple exponential time series method to find out the forecasting value that proper for all these equations.

2. Set the process to input information easily by input as a computer sofeware and easy to understand for the output information.

3. Try to use other mathematical calculation which may give more exact value of each factor concerning and reduce the gap with actual value.

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Appendix A

Calculations and logical consideration of SPSS program.

1.1 The inner area of Bangkok metropolitan

There is the result of variable X1 to X8 as follow

Table 1.1 KMO and Bartlett's test of the inner area of BMA.

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.458
Bartlett's Test of Sphericity	*Approx. Chi-Square*	415.714
	df	28
	Sig.	.000

Table 1.1 are explain the Kaiser-Meyer-Olkin method had used in the Factor Analysis technique and the result is 0.482 which less than 0.5. So it means this technique may not proper enough because the result have the difference value not much than 0.5 .So we would use the Bartlett's Test of Sphericity to find their relation ship of all variables , the result as follow

Bartlett's Test of Sphreicity use the hypothesis that

H_0: All variable($X_1 \ldots X_8$) are not related to each other.

H_1: All variable ($X_1 \ldots X_8$) are related to each other.

From the table above ,the Chi – square = 413.325 and Sig = .000 which less than 0.05 , there will reject H_0 ,so all variable $X_1,\ldots,X_8$ are related to each other in the significant value 0.05 ,then the Factor Analysis technique will use to analyze later on.

<u>Table 1.2</u> Communalities value of the inner area of BMA by the principal component analysis method.

	Initial	*Extraction*
X1_total population (person)	1.000	.728
X2_total precipitation volume (mm./year)	1.000	.660
X3_Number of family (family)	1.000	.592
X4_average selling price (baht/m^3)	1.000	.872
X5_average temperature (degree Celsius)	1.000	.609
X6_income per capital (bath)	1.000	.915
X_7density of person (person/km^2)	1.000	.345
X_8the budget estimate (baht)	1.000	.681

Extraction Method: Principal Component Analysis.

From the table 1.2, the extraction method by using the principle component analysis, the ratio of variance of the variable can explain by the common factor .If the communalities = 0 means the common factor can not explain all the variance but if they = 1 means they can explain all of variance.

The initial value which give the communalities value = 1, means not start to integrate all variable in factors.

The Extraction value is the communalities of a variable after extracted. As we found that the extraction value of X_7 is minimum = 0.403, which may place in both side of factors (can explain or can not explain the relation).So the axis rotation will make to verify that where X_7 will place.

Table 1.3 Total variance explained of the inner area of BMA.

	Initial Eigenvalues			*Extraction Sums of Squared Loadings*			*Rotation Sums of Squared Loadings*		
	Total	*% of Var.*	*%Cum.*	*Total*	*% of Var.*	*%Cum.*	*Total*	*% of Var.*	*%Cum.*
1	2.234	27.926	27.926	2.234	27.926	27.926	1.960	24.498	24.498
2	1.964	24.556	52.482	1.964	24.556	52.482	1.939	24.233	48.731
3	1.210	15.122	67.604	1.210	15.122	67.604	1.510	18.874	67.604
4	.838	10.478	78.082						
5	.706	8.823	86.906						
6	.557	6.960	93.866						
7	.363	4.539	98.405						
8	.128	1.595	100.000						

Extraction Method: Principal Component Analysis.

Table 1.3 can explain that the components are all 8 factors. And the procedures which use is an extraction method then rotate the axis to verify any factor in correct side.

1. Total Eigenvalues means the variance in initial value which will not consider the value of factor that less than 1 Factor.

2. % of variance is the percentage of each factor that can vary itself ,e.g. the first factor component = 27.926 % means the first factor can vary up to 27.926% .

3. Extraction Sum of Square Loading by using the principal component .The Initial Eigen value and the extraction sum of square loading will equally. And the result of actor will show the Eigen value which more than1.

4. Rotation Sums of Square Loading will give the value after rotate the axis, the factors still perpendicular and free to each other by using the Varimax method.

Table 1.4 The component matrix of[a], the inner area of BMA.

	Component		
	1	2	3
X1_total population(person)	.390	.618	.440
X2_total precipitation volume(mm./year)	-.303	.595	-.464
X3_Number of family (family)	.661	.329	.216
X4_average selling price (bath/m^3)	.610	-.361	-.608
X5_average temperature (degree Celsius)	.058	-.382	.678
X6_income per capital (bath)	.640	-.710	-.041
X_7density of person (person/km^2)	-.533	-.246	-.016
X_8the budget estimate (baht)	.701	.409	-.150

Extraction Method: Principal Component Analysis.

a. 3 components extracted.

From the table 1.4 can explain the co efficient call "Factor loading" ,the value that explain the relation of 3 factors before rotate the axis. In this analysis we use the Principal Component Analysis which gives Factor loading to be a co-relation with factors.

For considering all variables in factor groups as follow, we consider on the co-efficient value (Factor loading value) of the variables by separate them in two sides. The higher one(value reach to 1 or -1)and the lower one (reach to 0).

- The variable X_1, X_2 and X_7 which have factor loading quite similarly so all these should make an axis rotation again in the next table.

And the others variable have the result as below.

The variable X_3 have a Factor loading in the group of Factor component# 2 = 0.617, while the factor loading value in the Factor component #1 and # 3 have a low value. So it should be place in the Factor component# 2.

The variable X_4 have a Factor loading in the group of Factor component #1 = 0.723, while the factor loading value in the Factor component#2 and# 3 have a low value. So it should be place in the Factor component# 1.

The variable X_5 have a Factor loading in the group of Factor component #3 = 0.721, while the factor loading value in the Factor component#1 and# 2 have a low value. So it should be place in the Factor component# 3.

The variable X_6 have a Factor loading in the group of Factor component #1 = 0.926, while the factor loading value in the Factor component#2 and# 3 have a low value. So it should be place in the Factor component# 1.

The variable X_8 have a Factor loading in the group of Factor component #2 = 0.761, while the factor loading value in the Factor component#1 and# 3 have a low value. So it should be place in the Factor component# 2.

<u>Table 1.5</u> The rotated matrix component matrix ,The inner are of BMA.

Rotated Component Matrix[a]

	Component		
	1	2	3
X1_total population(person)	.758	-.388	.055
X2_total precipitation volume(mm./year)	-.001	-.231	-.779
X3_Number of family (family)	.758	.063	.115
X4_average selling price (bath/m^3)	.144	.915	-.121
X5_average temperature (degree Celsius)	-.024	-.157	.764
X6_income per capital (bath)	.092	.790	.531
X_7density of person (person/km^2)	-.566	-.156	.018
X_8the budget estimate (baht)	.756	.260	-.207

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.

a. Rotation converged in 5 iterations.

After rotate axis by the Varimax method. We have found that some of factor loading value will change. So we will re-arrange the factor loading value again to suit with the factors groups.

The variable X_1 have Factor loading in the group of Factor component #1 = -0.626, while the factor loading value in the Factor component#2 and# 3 have a low value. So it should be place in the Factor component# 1.

The variable X_2 have Factor loading in the group of Factor component # 3 = 0.715 , while the factor loading value in the Factor component#1 and # 2 have a low value. So it should be place in the Factor component# 3.

The variable X_7 have Factor loading in the group of Factor component # 2 = -0.628 , while the factor loading value in the Factor component#1 and # 3 have a low value. So it should be place in the Factor component # 2.

So the conclusion is

Factor component #1 are contain with 3 variables .X_1, X_4, and X_6.

Factor component #2 are contain with 3 variables .X_7, X_3 and X_8.

Factor component #3 are contain with 2 variables. X_5 and X_2.

Table 1.6 Component transformation matrixes, the inner area of BMA.

	1	2	3
1	.841	.365	-.399
2	-.182	.886	.427
3	-.509	.286	-.812

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.

The table 1.6 is the changing of the rotation matrix of factor loading in the component matrix to the rotated component matrix by using the Varimax method. Then we can plot the relation of each 3 factor components to each other as follow.

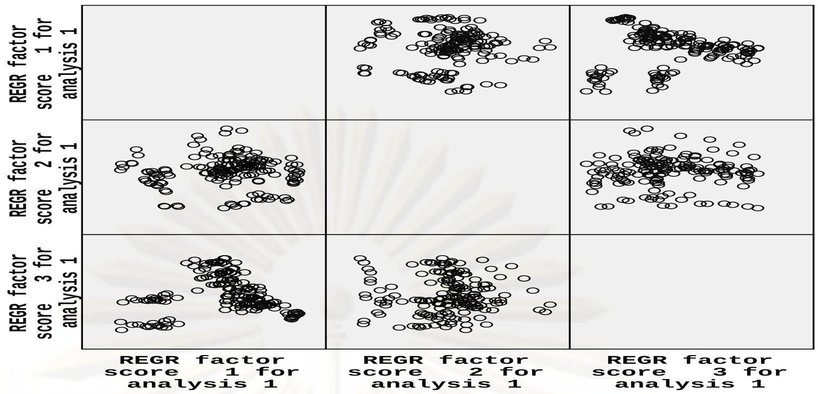


Figure A The correlation of 3 factors component, the inner area of BMA.

Table 1.7 The correlation value of 3 factor component, the inner area of BMA.

		REGR factor score 1 for analysis 1	*REGR factor score 2 for analysis 1*	*REGR factor score 3 for analysis 1*
REGR factor score 1 for analysis 1	*Pearson Correlation*	1	.000	.000
	Sig. (2-tailed)		1.000	1.000
	N	169	169	169
REGR factor score 2 for analysis 1	*Pearson Correlation*	.000	1	.000
	Sig. (2-tailed)	1.000		1.000
	N	169	169	169
REGR factor score 3 for analysis 1	*Pearson Correlation*	.000	.000	1
	Sig. (2-tailed)	1.000	1.000	
	N	169	169	169

And the test results show that each don't have relation to each other by the significant value which less than 0.05.

Then we have analyzed the multiple linear regressions by using the step wise method and the result as show below.

Variables Entered/Removed a

	Variables Entered	Variables Removed	Method
1	X3_Number of family (family)	.	Stepwise (Criteria: Probability-of-F-to-enter <= .050, Probability-of-F-to-remove >= .100).
2	X_7density of person (person/km^2)	.	Stepwise (Criteria: Probability-of-F-to-enter <= .050, Probability-of-F-to-remove >= .100).
3	X1_total population (person)	.	Stepwise (Criteria: Probability-of-F-to-enter <= .050, Probability-of-F-to-remove >= .100).
4	X2_total precipitation volume(mm./year)	.	Stepwise (Criteria: Probability-of-F-to-enter <= .050, Probability-of-F-to-remove >= .100).
5	X5_ average temperature (degree Celsius)	.	Stepwise (Criteria: Probability-of-F-to-enter <= .050, Probability-of-F-to-remove >= .100).

a. Dependent Variable: Y_water sales (million cu.m

From the table above is the bring in and take out factors by using the stepwise method which after finish the process we will have the 5 model for considering as a table 5.8 below.

Table 1.9 Model summary, the inner area of BMA.[f]

	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.493a	.243	.238	4.8654551	
2	.614b	.377	.370	4.4256648	
3	.678c	.460	.450	4.1336708	
4	.704d	.496	.483	4.0070879	
5	.715e	.511	.496	3.9587724	2.670

a. Predictors: (Constant), X3_Number of family (family)

b. Predictors: (Constant), X3_Number of family (family), X_7density of person (person/km^2)

c. Predictors: (Constant), X3_Number of family (family), X_7density of person (person/km^2), X1_total population(person)

d. Predictors: (Constant), X3_Number of family (family), X_7density of person (person/km^2), X1_total population(person), X2_total precipitation volume(mm./year)

e. Predictors: (Constant), X3_Number of family (family), X_7density of person (person/km^2), X1_total population(person), X2_total precipitation volume(mm./year), X5_average temperature (degree Celsius)

f. Dependent Variable: Y_water sales (million cu.m.)

From the table 1.9 is the model that select for the equation from 5 models. We will select the model which has the high R square value. The highest R square model is R square = 2.670 and contains with 5 factors. There are X1_total population (person), X2_total precipitation volume, X3_Number of family (family), X5_average temperature and X_7 density of person. All factors can explain the variance of Y value (water consumption) at 51.1 %.

Table 1.10 Testing hypothesis ANOVA for 5 models, the inner area of BMA.

ANOV f

		Sum of Squares	df	Mean Square	F	Sig.
1	Regressio	1267.48	1	1267.48	53.542	.000a
	Residua	3953.33	167	23.673		
	Tota	5220.82	168			
2	Regressio	1969.45	2	984.73	50.276	.000b
	Residua	3251.36	166	19.587		
	Tota	5220.82	168			
3	Regressio	2401.42	3	800.47	46.846	.000c
	Residua	2819.39	165	17.087		
	Tota	5220.82	168			
4	Regressio	2587.51	4	646.87	40.287	.000d
	Residua	2633.30	164	16.057		
	Tota	5220.82	168			
5	Regressio	2666.30	5	533.26	34.027	.000e
	Residua	2554.51	163	15.672		
	Tota	5220.82	168			

a. Predictors: (Constant), X3_Number of family

b. Predictors: (Constant), X3_Number of family (family), X_7density of person (person/k ^2)

c. Predictors: (Constant), X3_Number of family (family), X_7density of person (person/k ^2), X1_total population(person)

d. Predictors: (Constant), X3_Number of family (family), X_7density of person (person/k ^2), X1_total population(person), X2_total precipitation volume(mm./year)

e. Predictors: (Constant), X3_Number of family (family), X_7density of person (person/k ^2), X1_total population(person), X2_total precipitation volume(mm./year), X5_average temperature (degree Celsius)

f. Dependent Variable: Y_water sales (million cu.m.)

From the model 5 from the table 1.10 is the testing that test the hypothesis as

H_0: $\beta_1 = \beta_2 = \beta_3 = \beta_5 = \beta_7 = 0$

H_0 have β_1 at least 1 value which $\neq 0$; $i = 1, 2, 3, 5, 7$

And the F – test from the table ANOVA above.

If accept H_0 ,we can say that X_1, X_2, X_3, X_5, X_7 not relate to Y.

If reject H_0 ,we can say that X_i have at least 1 value that relate to Y. The next test to find out which factors are related to Y .From the model #5,we have the F-test value = 34.027 and the significant value less than 0.05(specific significant).So the test is reject H_0

		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	t	Sig.
1	(Constant)	12.093	.659		18.363	.000
	X3_Number of family (family)	.001	.000	.493	7.317	.000
2	(Constant)	16.200	.911		17.786	.000
	X3_Number of family (family)	.001	.000	.398	6.285	.000
	X_7density of person (person/km^2)	.000	.000	-.379	-5.987	.000
3	(Constant)	13.269	1.031		12.866	.000
	X3_Number of family (family)	.000	.000	.302	4.854	.000
	X_7density of person (person/km^2)	.000	.000	-.383	-6.476	.000
	X1_total population(person)	4.20E-005	.000	.303	5.028	.000
4	(Constant)	18.309	1.786		10.249	.000
	X3_Number of family (family)	.000	.000	.274	4.510	.000
	X_7density of person (person/km^2)	.000	.000	-.382	-6.670	.000
	X1_total population(person)	5.05E-005	.000	.364	5.958	.000
	X2_total precipitation volume(mm./year)	-.004	.001	-.198	-3.404	.001
5	(Constant)	-34.426	23.585		-1.460	.146
	X3_Number of family (family)	.000	.000	.269	4.483	.000
	X_7density of person (person/km^2)	.000	.000	-.381	-6.735	.000
	X1_total population(person)	5.17E-005	.000	.373	6.159	.000
	X2_total precipitation volume(mm./year)	-.003	.001	-.169	-2.874	.005
	X5_average temperature (degree Celsius)	1.782	.795	.127	2.242	.026

a. Dependent Variable: Y_water sales (million cu.m.)

Table 5.11 is the testing that which variable X are related to Y.

Considered only the model #5 that.

The hypothesis $H_0 : \beta_i = 0$

$H_1 : \beta_i \neq 0 ; i = 1,2,3,5,7$

From the test will use the t – test value from table

If accept $H_{0,}$ we can say that X_i is not relate to Y.

If reject H_0 , we can say that X_i is relate to Y .

From model #5,we can say as these.

The testing for X_1,the statistic t –test = 6.159 and the specific significant value less than 0.05 which say that the testing is reject H_0 so X_1 is relate to Y and X_1 should have in the regression equation.

The testing for X_2 , the statistic t –test = -2.874 and the specific significant value less than 0.05 which say that the testing is reject H_0 so X_2 is relate to Y and X_2 should have in the regression equation.

The testing for X_3 , the statistic t –test = 4.483 and the specific significant value less than 0.05 which say that the testing is reject H_0 so X_3 is relate to Y and X_3 should have in the regression equation.

The testing for X_5 , the statistic t –test = 2.242 and the specific significant value less than 0.05 which say that the testing is reject H_0 so X_5 is relate to Y and X_5 should have in the regression equation.

The testing for X_7 , the statistic t –test = -6.735 and the specific significant value less than 0.05 which say that the testing is reject H_0 so X_7 is relate to Y and X_7 should have in the regression equation.

So we can create the linear regression equation as follow.

$Y_1 = 0.000052X_1 - 0.003X_2 + 0.00037X_3 + 1.782X_5 - 0.00027X_7 - 34.426$

Table 1.12 The residual statistic [a] value, the inner area of BMA.

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	4.100492	25.548008	16.057679	3.9838240	169
Residual	-9.82834	14.76912	.0000000	3.8994171	169
Std. Predicted Value	-3.001	2.382	.000	1.000	169
Std. Residual	-2.483	3.731	.000	.985	169

a. Dependent Variable: Y_water sales (million cu.m.)

The residual value of the linear regression equation as the table 1.12.

When we use the value X in year 2007 replace in the equation (1) and compare in the real collect information, we will have the table as follow to be adjust the equation for realistic value.

2. The interim area of Bangkok metropolitan

There are the results of variable X1 to X8 as follow

Table 2.1 KMO and Bartlett's test, the interim area of BMA.

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.454
Bartlett's Test of Sphericity	*Approx. Chi-Square*	434.490
	df	28
	Sig.	.000

Table 2.1, The Kaiser-Meyer-Olkin method have use in the Factor Analysis technique and the result is 0.454 So it means this technique may not proper enough because the result have the difference value not much than 0.5 .So we would use the Bartlett's Test of Sphericity to find their relation ship of all variables , the result as follow

Bartlett's Test of Sphreicity use the hypothesis that

H_0 : All variable(X_1,…X_8) are not related to each other.

H_1 : All variable (X_1,…X_8) are related to each other

From the table above ,the Chi – square = 434.490 and Sig = .000 which less than 0.05 , there will reject H_0 ,so all variable X_1,…,X_8 are related to each other in the significant value 0.05 ,then the Factor Analysis technique will use to analyze later on.

Table 2.2 Communalities value, the interim area of BMA.

	Initial	Extraction
X1_total Population (person)	1.000	.721
X2_total precipitation Volume (mm./year)	1.000	.615
X3_Number of family (family)	1.000	.469
X4_average selling price (baht/m^3)	1.000	.855
X5_average temperature (Degree Celsius)	1.000	.611
X6_income per capital (bath)	1.000	.907
X_7density of person (Person/km^2)	1.000	.506
X_8the budge estimate (baht)	1.000	.562

Extraction Method: Principal Component Analysis.

From the table 2.2, the extraction method by using the principle component analysis, the ratio of variance of the variable can explain by the common factor .If the communalities = 0 means the common factor can not explain all the variance but if they = 1 means they can explain all of variance.

The initial value which give the communalities value = 1, means not start to integrate all variable in factors.

The Extraction value is the communalities of a variable after extracted. As we found that the extraction value of X_3 is minimum = 0.469, which may place in both side of factors (can explain or can not explain the relation).So the axis rotation will make to verify that where X_3 will place.

<u>Table 2.3</u> Total variance, the interim area of BMA.

	Initial Eigenvalues			*Extraction Sums of Squared Loa*			*Rotation Sums of Squared Load ngs*		
	Total	*% of Var.*	*%Cum.*	*Total*	*% of Var.*	*%Cum .*	*Total*	*% of Var.*	*%Cum.*
1	2.187	27.340	27.340	2.187	27.340	27.340	1.912	23.904	23.90
2	1.829	22.864	50.204	1.829	22.864	50.204	1.714	21.420	45.32
3	1.231	15.381	65.585	1.231	15.381	65.585	1.621	20.261	65.58
4	.832	10.394	75.979						
5	.789	9.868	85.847						
6	.644	8.051	93.898						
7	.362	4.530	98.427						
8	.126	1.573	100.000						

Extraction Method: Principal Component Analysis.

Table 2.3 can explain that the components are all 8 factors. And the procedure which use is an extraction method then rotate the axis to verify any factor in correct side.

5. Total Eigenvalues means the variance in initial value which will not consider the value of factor that less than 1 Factor.

6. % of variance is the percentage of each factor that can vary itself ,e.g. the first factor component = 27.340 % means the first factor can vary up to 27.340%

7. Extraction Sum of Square Loading by using the principal component .The Initial Eigen value and the extraction sum of square loading will equally. And the result of actor will show the Eigen value which more than1.

8. Rotation Sums of Square Loading will give the value after rotate the axis, the factors still perpendicular and free to each other by using the Varimax method.

Table 2.4 Component matrix [a], the interim area of BMA.

	Component		
	1	2	3
X1_total Population (person)	-.578	.586	.210
X2_total precipitation volume (mm./year)	-.675	.137	-.374
X3_Number of family (family)	.225	.606	.227
X4_average selling price (Bath/m^3)	.600	.455	-.537
X5_average temperature (Degree Celsius)	.333	-.245	.663
X6_income per capital (Bath)	.931	.194	-.049
X_7density of person (Person/km^2)	-.076	.489	.511
X_8the budge estimate (baht)	-.054	.745	-.057

Extraction Method: Principal Component Analysis.

a. 3 components extracted.

From the table 2.4 above can explain the co efficient call “Factor loading” ,the value that explain the relation of 3 factors before rotate the axis. In this analysis we use the Principal Component Analysis which gives Factor loading to be a co-relation with factors.

For considering all variables in factor groups as follow, we consider on the co-efficient value (Factor loading value) of the variables by separate them in two sides. The higher one (value reach to 1 or -1) and the lower one (reach to 0).

- The variable X_1, X_2, X_4, X_5 and X_7 which have factor loading quite similarly so all these should make an axis rotation again in the next table.
- And the others variable have the result as below.

The variable X_3 have Factor in the group of Factor component# 2 = 0.606, while the factor loading value in the Factor component #1 and # have a low value. So it should be place in the Factor component #2.

The variable X_6 have the factor loading in the group of Factor component # 1 = 0.931, while the factor loading value in the factor component #2 and # 3 have a low value. So it should be place in the Factor component #1.

The variable X_8 have the factor in the group of Factor component # 2 = 0.745, while the factor loading value in the Factor component# 1 and #3 have a low value. So it should be place in the Factor component #2

Table 2.5 Rotated component matrix[a], the interim area of BMA.

	Component		
	1	2	3
X1_total population(person)	-.336	.694	-.357
X2_total precipitation volume(mm./year)	-.301	.048	-.723
X3_Number of family (family)	.297	.604	.130
X4_average selling price (bath/m^3)	.905	.071	-.175
X5_average temperature (degree Celsius)	-.150	.037	.766
X6_income per capital (bath)	.832	.015	.463
X_7density of person (person/km^2)	-.123	.673	.196
X_8the budget est. (baht)	.267	.638	-.290

Extraction Method: Principal Component Analysis.

Rotation Method: Varimax with Kaiser Normalization.

a. Rotation converged in 6 iterations.

After rotate axis by the Varimax method. We have found that some of factor loading value will change. So we will re-arrange the factor loading value again to suit with the factors groups.

The variable X_1 have the factor loading in the group of Factor component # 2 = 0.694 715 , while the factor loading value in the Factor component#1 and # 3 2 have a low value. So it should be place in the Factor component #2.

The variable X_2 have the factor loading in the group of Factor component # 3 = -0.723 715 , while the factor loading value in the Factor component#1and # 2 have a low value. So it should be place in the Factor component #3.

The variable X_4 have the factor loading in the group of Factor component #1 = 0.905, while the factor loading value in the Factor component# 2 and #3 have a low value. So it should be place in the Factor component # 1.

The variable X_5 have the factor loading in the group of Factor component #3 = 0.766, while the factor loading value in the Factor component# 1 and #2 have a low value. So it should be place in the Factor component #3.

The variable X_7 have the factor loading in the group of Factor component #2 = 0. , while the factor loading value in the Factor component#1 and #3 have a low value. So it should be place in the Factor component #2.

So the conclusion is

Factor component #1 is containing with 2 variables .X_4 and X_6

Factor components #2 is containing with 4 variables X_1, X_3, X_7 and X_8.

Factor component #3 is containing with 2 variables. X_2 and X_5.

Table 2.6 Component transformation matrix, the interim area of BMA.

	1	2	3
1	.790	-.144	.597
2	.378	.880	-.288
3	-.484	.453	.749

Extraction Method: Principal Component Analysis.

Rotation Method: Varimax with Kaiser Normalization.

The table 2.6 is the changing of the rotation matrix of factor loading in the component matrix to the rotated component matrix by using the Varimax method. Then we can plot the relation of each 3 factor components to each other as follow.

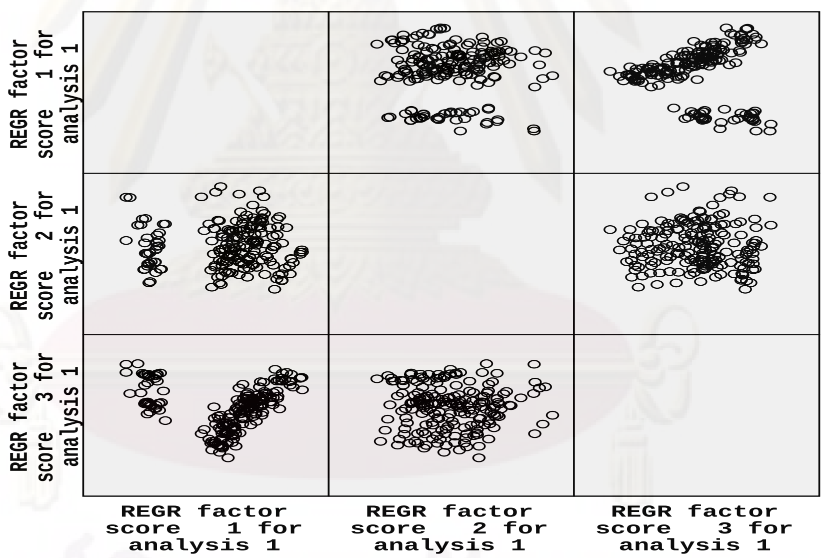


Figure B The correlation of 3 factors component, the interim area of BMA.

And we will have the test result of each correlation as the table

Table 2.7 Correlation, the interim area of BMA.

		REGR factor score 1 for analysis 1	REGR factor score 2 for analysis 1	REGR factor score 3 for analysis 1
REGR factor score 1 for analysis 1	Pearson Correlation	1	.000	.000
	Sig. (2-tailed)		1.000	1.000
	N	189	189	189
REGR factor score 2 for analysis 1	Pearson Correlation	.000	1	.000
	Sig. (2-tailed)	1.000		1.000
	N	189	189	189
REGR factor score 3 for analysis 1	Pearson Correlation	.000	.000	1
	Sig. (2-tailed)	1.000	1.000	
	N	189	189	189

And the test results show that each don't have relation to each other by the significant value which less than 0.05.

Then we have analyzed the multiple linear regressions by using the step wise method and the result as show below.

Table 2.7, the bringing in and take out factors by using the stepwise method which after finish the process we will have the 6 model for considering as a table below.

Variables Entered/Removed[a]

Model	*Variables Entered*	*Variables Removed*	*Method*
1	X_8the bud est. (bath)	.	Stepwise (Criteria: Probability-of-F-to-enter <= .050, Probability-of-F-to-remove >= .100).
2	X_7density of person (person/km^2)	.	Stepwise (Criteria: Probability-of-F-to-enter <= .050, Probability-of-F-to-remove >= .100).
3	X5_ average temperature (degree Celsius)	.	Stepwise (Criteria: Probability-of-F-to-enter <= .050, Probability-of-F-to-remove >= .100).
4	X3_Number of family (family)	.	Stepwise (Criteria: Probability-of-F-to-enter <= .050, Probability-of-F-to-remove >= .100).
5	X1_total population (person)	.	Stepwise (Criteria: Probability-of-F-to-enter <= .050, Probability-of-F-to-remove >= .100).
6	X2_total precipitation volume(mm./year)	.	Stepwise (Criteria: Probability-of-F-to-enter <= .050, Probability-of-F-to-remove >= .100).

a. Dependent Variable: Y_water sales (million

Table 2.9 Model summary, the interim area of BMA.

Model Summary[g]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.596[a]	.355	.352	6.2377464	
2	.660[b]	.436	.430	5.8480810	
3	.704[c]	.496	.488	5.5431576	
4	.739[d]	.546	.536	5.2767202	
5	.756[e]	.572	.560	5.1392661	
6	.773[f]	.597	.584	4.9987674	1.544

a. Predictors: (Constant), X_8the budget est. (baht)

b. Predictors: (Constant), X_8the budget est. (baht), X_7density of person (person/km^2)

c. Predictors: (Constant), X_8the budget est. (baht), X_7density of person (person/km^2), X5_average temperature (degree Celsius)

d. Predictors: (Constant), X_8the budget est. (baht), X_7density of person (person/km^2), X5_average temperature (degree Celsius), X3_Number of fa ily (family)

e. Predictors: (Constant), X_8the budget est. (baht), X_7density of person (person/km^2), X5_average temperature (degree Celsius), X3_Number of fa ily (family), X1_total population(person)

f. Predictors: (Constant), X_8the budget est. (baht), X_7density of person (person/km^2), X5_average temperature (degree Celsius), X3_Number of fa ily (family), X1_total population(person), X2_total precipitation volume(mm. /year)

g. Dependent Variable: Y_water sales (million cu.m.)

Table 2.9 is the model that select for the equation from 6 models. We will select the model which has the high R square value = 1.544670 and contains with 6 factors There are factor .X1_total population(person), X2_total precipitation volume ,X3_Number of family (family), X5_average temperature, X_7 density of person และ X_8 the budget All factors can explain the variance of Y value (water consumption) at 59.7 %

Table 2.10 Testing hypothesis ANOVA[g] for 5 models, the inner area of BMA.

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	4007.615	1	4007.615	102.998	.000a
	Residual	7276.073	187	38.909		
	Total	11283.688	188			
2	Regression	4922.478	2	2461.239	71.966	.000b
	Residual	6361.210	186	34.200		
	Total	11283.688	188			
3	Regression	5599.267	3	1866.422	60.743	.000c
	Residual	5684.420	185	30.727		
	Total	11283.688	188			
4	Regression	6160.433	4	1540.108	55.312	.000d
	Residual	5123.255	184	27.844		
	Total	11283.688	188			
5	Regression	6450.281	5	1290.056	48.843	.000e
	Residual	4833.406	183	26.412		
	Total	11283.688	188			
6	Regression	6735.930	6	1122.655	44.928	.000f
	Residual	4547.757	182	24.988		
	Total	11283.688	188			

a. Predictors: (Constant), X_8the budget est. (baht)

b. Predictors: (Constant), X_8the budget est. (bath), X_7density of person (person/km^)

c. Predictors: (Constant), X_8the budget est. (bath), X_7density of person (person/km^ , X5_average temperature (degree Celsius)

d. Predictors: (Constant), X_8the budget est. (bath), X_7density of person (person/km^), X5_average temperature (degree Celsius), X3_Number of family (family)

e. Predictors: (Constant), X_8the budget est. (bath), X_7density of person (person/km^ , X5_average temperature (degree Celsius), X3_Number of family (family), X1_total population(person)

f. Predictors: (Constant), X_8the budget est. (bath), X_7density of person (person/km^: , X5_ average temperature (degree Celsius), X3_Number of family (family), X1_total population(person), X2_total precipitation volume(mm./year)

g. Dependent Variable: Y_water sales (million cu.m.)

From the model 6 from the table is the testing that test the hypothesis as

H_0: $\beta_1 = \beta_2 = \beta_3 = \beta_5 = \beta_7 = \beta_8 = 0$

H_1 have β_i at least 1 value which $\neq 0$; i=1,2,3,5,7,8.

And the F – test from the table 2.10 ANOVA above.

If accept H_0 ,we can say that X_1,X_2 ,X_3 ,X_5 ,X_7,X_8 not relate to Y..

If reject H_0 ,we can say that X_i have at least 1 value that relate to Y. The next test to find out which factors are related to *Y* .From the model #6,we have the F-test value = 44.928 and the significant value less than 0.05(specific significant).So the test is reject H_0.

Table 2.11 Coefficient, the interim area of BMA.

Coefficients a

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-1.708	2.519		-.678	.499
	X_8the budget est. (bath)	1.42E-007	.000	.596	10.149	.000
2	(Constant)	-1.084	2.365		-.459	.647
	X_8the budget est. (bath)	1.55E-007	.000	.652	11.620	.000
	X_7density of person (person/km^2)	.000	.000	-.290	-5.172	.000
3	(Constant)	-143.117	30.346		-4.716	.000
	X_8the budget est. (bath)	1.64E-007	.000	.689	12.818	.000
	X_7density of person (person/km^2)	.000	.000	-.299	-5.615	.000
	X5_average temperature (degree Celsius)	4.831	1.029	.248	4.693	.000
4	(Constant)	-137.674	28.913		-4.762	.000
	X_8the budget est. (bath)	1.56E-007	.000	.658	12.733	.000
	X_7density of person (person/km^2)	-.001	.000	-.348	-6.708	.000
	X5_average temperature (degree Celsius)	4.582	.981	.235	4.669	.000
	X3_Number of family (family)	.000	.000	.232	4.489	.000
5	(Constant)	-144.736	28.241		-5.125	.000
	X_8the budget est. (bath)	1.40E-007	.000	.589	10.805	.000
	X_7density of person (person/km^2)	-.001	.000	-.372	-7.288	.000
	X5_average temperature (degree Celsius)	4.827	.959	.247	5.035	.000
	X3_Number of family (family)	.000	.000	.212	4.179	.000
	X1_total population(person)	2.90E-005	.000	.182	3.313	.001
6	(Constant)	-116.484	28.711		-4.057	.000
	X_8the budget est. (bath)	1.35E-007	.000	.568	10.649	.000
	X_7density of person (person/km^2)	-.001	.000	-.382	-7.689	.000
	X5_average temperature (degree Celsius)	4.092	.957	.210	4.273	.000
	X3_Number of family (family)	.000	.000	.196	3.954	.000
	X1_total population(person)	3.93E-005	.000	.246	4.342	.000
	X2_total precipitation volume(mm./year)	-.004	.001	-.175	-3.381	.001

a. Dependent Variable: Y_water sales (million cu.m.)

From the table 2.11 is the testing that which variable X are related to Y.

Considered only the model #6 that.

The hypothesis H_o: $\beta_i = 0$.

$H1$: $\beta_i \neq 0$;i=1,2,3,5,7,8.

If accept H_0 , we can say that X_i is not relate toY.

If reject H_0 , we can say that X_i is relate to Y.

From model #6,we can say as these.

The testing for X_1, the statistic t –test 4.342 and the specific significant value less than 0.05 which say that the testing is reject H_0 so X_1 is relate to Y and X_1 should have in the regression equation.

The testing for X_2 , the statistic t –test = -3.381 and the specific significant value less than 0.05 which say that the testing is reject H_0 so X_2 is relate to Y and X_2 should have in the regression equation.

The testing for X_3 , the statistic t –test = 3.964 and the specific significant value less than 0.05 which say that the testing is reject H_0 so X_3 is relate to Y and X_3 should have in the regression equation.

The testing for X_5 , the statistic t –test = 4.273 and the specific significant value less than 0.05 which say that the testing is reject H_0 so X_5 is relate to Y and X_5 should have in the regression equation.

The testing for X_7 , the statistic t –test =-7.689 and the specific significant value less than 0.05 which say that the testing is reject H_0 so X_7 is relate to Y and X_7 should have in the regression equation.

The testing for X_8 , the statistic t –test = 10.649 and the specific significant value less than 0.05 which say that the testing is reject H_0 so X_8 is relate to Y and X_8 should have in the regression equation.

So we can create the linear regression equation as follow.

$Y_2 = 0.0000393X_1-0.0043X_2+0.000362X_3+4.092X_5-0.00059X_7+0.000000135X_8 +116.484$

Table 2.12 Residual statistic[s], the interim area of BMA.

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	10.491076	39.250214	23.437861	5.9857679	189
Residual	-19.4534	23.32939	.0000000	4.9183531	189
Std. Predicted Value	-2.163	2.642	.000	1.000	189
Std. Residual	-3.892	4.667	.000	.984	189

a. Dependent Variable: Y_water sales (million cu.m.)

When we use the value X in year 2008 replace in the equation (1) and compare in the real collect information, we will have the table as follow to be adjust the equation for realistic value.

3.The outer area of Bangkok metropolitan.

There are the results of variable X1 to X8 as follow

Table 3.1 KMO and Bartlett's test, the outer area of BMA.

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.410
Bartlett's Test of Sphericity	*Approx. Chi-Square*	309.362
	df	28
	Sig.	.000

Table 3.1,the Kaiser-Meyer-Olkin method have use in the Factor Analysis technique and the result is 0.410 So it means this technique may not proper enough because the result have the difference value not much than 0.5 .So we would use the Bartlett's Test of Sphericity to find their relation ship of all variables , the result as follow

Bartlett's Test of Sphreicity use the hypothesis that

H_0 : All variable(X_1,…X_8) are not related to each other.

H_1 : All variable (X_1,…X_8) are related to each other

From the table 5.26 ,the Chi – square = 309.362 and Sig = .000 which less than 0.05 , there will reject H_0 ,so all variable X_1,…,X_8 are related to each other in the significant value 0.05 ,then the Factor Analysis technique will use to analyze later on.

Table 3.2 Communalities value ,the outer area of BMA.

	Initial	Extraction
X1_total population(person)	1.000	.675
X2_total precipitation volume(mm./year)	1.000	.617
X3_Number of family (family)	1.000	.695
X4_average selling price (bath/m^3)	1.000	.852
X5_average temperature (degree Celsius)	1.000	.667
X6_income per capital (bath)	1.000	.919
X_7density of person (person/km^2)	1.000	.941
X_8the bud est. (baht)	1.000	.820

Extraction Method: Principal Component Analysis.

Table 3.2, the extraction method by using the principle component analysis, the ratio of variance of the variable can explain by the common factor .If the communalities = 0 means the common factor can not explain all the variance but if they = 1 means they can explain all of variance.

The initial value which give the communalities value = 1, means not start to integrate all variable in factors.

The Extraction value is the communalities of a variable after extracted. As we found that the extraction value of X_3 is minimum = 0.617, which may place in both side of factors (can explain or can not explain the relation).So the axis rotation will make to verify that where X_3 will place

Table 3.3 Total variance, the outer area of BMA.

Componen	*Initial Eigenvalues*			*Extraction Sums of Squared Loadings*			*Rotation Sums of Squared Loadings*		
	Total	*% of Varianc*	*Cumulative*	*Total*	*% of Variance*	*Cumulative*	*%Total*	*% of Variance*	*Cumulative %*
1	2.139	26.739	26.739	2.139	26.739	26.739	1.838	22.977	22.977
2	1.641	20.513	47.252	1.641	20.513	47.252	1.604	20.048	43.025
3	1.345	16.813	64.066	1.345	16.813	64.066	1.592	19.904	62.929
4	1.061	13.263	77.328	1.061	13.263	77.328	1.152	14.400	77.328
5	.711	8.891	86.219						
6	.629	7.864	94.083						
7	.347	4.332	98.414						
8	.127	1.586	100.000						

Extraction Method: Principal Component Analysis.

Table 3.3 explained that the components are all 8 factors. And the procedures which use is an extraction method then rotate the axis to verify any factor in correct side.

-Total Eigenvalues means the variance in initial value which will not consider the value of factor that less than 1 Factor.

-% of variance is the percentage of each factor that can vary itself ,e.g. the first factor component = 26.739 % means the first factor can vary up to 26.739% .

-Extraction Sum of Square Loading by using the principal component .The Initial Eigen value and the extraction sum of square loading will equally. And the result of actor will show the Eigen value which more than1.

-Rotation Sums of Square Loading will give the value after rotate the axis, the factors still perpendicular and free to each other by using the Varimax method.

Table 3.4 Component matrix [a], the outer area of BMA.

	Component			
	1	*2*	*3*	*4*
X1_total population(person)	-.530	.528	.273	.200
X2_total precipitation volume(mm./year)	-.692	.130	-.342	.068
X3_Number of family (family)	-.023	.547	.622	-.093
X4_average selling price (bath/m^3)	.617	.411	-.412	.365
X5_average temperature (degree Celsius)	.315	-.245	.648	-.297
X6_income per capital (bath)	.938	.133	.028	.145
X_7density of person (person/km^2)	-.120	-.160	.415	.853
X_8the bud est. (baht)	.071	.880	-.056	-.192

Extraction Method: Principal Component Analysis.

a. 4 components extracted.

From the table 3.4 explained the co efficient call “Factor loading”, the value that explain the relation of 4 factors before rotate the axis. In this analysis we use the Principal Component Analysis which gives Factor loading to be a co-relation with factors.

For considering all variables in factor groups as follow, we consider on the co-efficient value (Factor loading value) of the variables by separate them in two sides. The higher one (value reach to 1 or -1) and the lower one (reach to 0).

The variable X_1, X_2, X_3, X_4 and X_5 which have factor loading quite similarly so all these should make an axis rotation again in the next table.

- And the others variable have the result as below.

The variable X_6 have the factor loading in the group of Factor component # 1 = 0.938, while the factor loading value in the factor component # 2, #3 and # 4 have a low value. So it should be place in the Factor component # 1.

The variable X_7 have the factor loading in the group of Factor component # 4 = 0.853 , while the factor loading value in the factor component # 1,#2 and #3 have a low value. So it should be place in the Factor component # 4.

The variable X_8 have the factor loading in the group of Factor component # 2 = 0.880 while the factor loading value in the factor component #1,#3 and #4 have a low value. So it should be place in the Factor component # 2.

Table 3.5 Rotated component matrix [a] , the outer area of BMA.

	Component			
	1	2	3	4
X1_total population(person)	-.231	-.319	.677	.246
X2_total precipitation volume(mm./year)	-.353	-.697	.082	-.016
X3_Number of family (family)	-.047	.304	.773	.060
X4_average selling price (bath/m^3)	.909	-.162	.017	-.014
X5_average temperature (degree Celsius)	-.169	.798	.050	.013
X6_income per capital (bath)	.828	.478	-.065	-.012
X_7density of person (person/km^2)	.015	.007	.045	.969
X_8the bud est. (baht)	.342	-.182	.722	-.385

Extraction Method: Principal Component Analysis.

Rotation Method: Varimax with Kaiser Normalization.

a. Rotation converged in 6 iterations.

After rotate axis by the Varimax method. We have found that some of factor loading value will change. So we will re-arrange the factor loading value again to suit with the factors groups.

The variable X_1 have the factor loading in the group of Factor component # 3 = 0.677 715 , while the factor loading value in the Factor component#1,#2 and #4 2 have a low value. So it should be place in the Factor component #3.

The variable X_2 have the factor loading in the group of Factor component # 2 = -0.697 , while the factor loading value in the Factor component#1and #1,#3 and #4 have a low value. So it should be place in the Factor component # 2.

The variable X_3 have the factor loading in the group of Factor component #3 = 0. , while the factor loading value in the Factor component#1,#2 and #4 have a low value. So it should be place in the Factor component #3.

The variable X_4 have the factor loading in the group of Factor component #1 = 0.909, while the factor loading value in the Factor component#2, #3 and# 4 have a low value. So it should be place in the Factor component # 1.

The variable X_5 have the factor loading in the group of Factor component # 2 = 0. , while the factor loading value in the Factor component# 1 ,#3 and #4 have a low value. So it should be place in the Factor component #2.

So the conclusion is

Factor component #1 is containing with 2 variables. X_4 and X_6.

Factor component #2 is containing with 3 variables. X_2, X5 and X_8.

Factor component #3 is containing with 2 variables. X_1 andX_3

Factor component #4 is containing with 1 variable. X_7.

Table 3.6 Component transformation matrix, the outer area of BMA.

Component Transformation Matrix

Component	1	2	3	4
1	.783	.575	-.198	-.131
2	.384	-.276	.856	-.209
3	-.331	.706	.476	.407
4	.361	-.307	-.046	.880

Extraction Method: Principal Component Analysis.

Rotation Method: Varimax with Kaiser Normalization.

The table 3.6 is the change of the rotation matrix of factor loading in the component matrix to the rotated component matrix by using the Varimax method. Then we can plot the relation of each 3 factor components to each other as follow.

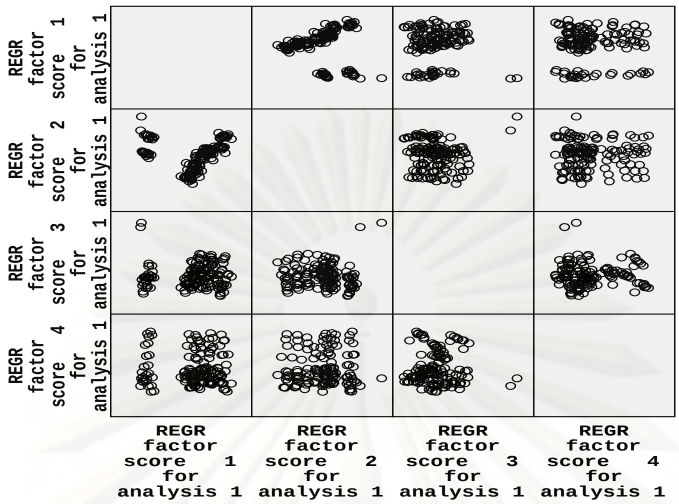


Figure C The correlation of 3 factors component, the outer area of BMA.

And we will have the test result of each correlation as the table.

Table 3.7 Correlations of 4 factors component ,the outer area of BMA.

Correlations

		REGR factor score 1 for analysis 1	REGR factor score 2 for analysis 1	REGR factor score 3 for analysis 1	REGR factor score 4 for analysis 1
REGR factor score 1 for analysis 1	*Pearson Correlation*	1	.000	.000	.000
	Sig. (2-tailed)		1.000	1.000	1.000
	N	138	138	138	138
REGR factor score 2 for analysis 1	*Pearson Correlation*	.000	1	.000	.000
	Sig. (2-tailed)	1.000		1.000	1.000
	N	138	138	138	138
REGR factor score 3 for analysis 1	*Pearson Correlation*	.000	.000	1	.000
	Sig. (2-tailed)	1.000	1.000		1.000
	N	138	138	138	138
REGR factor score 4 for analysis 1	*Pearson Correlation*	.000	.000	.000	1
	Sig. (2-tailed)	1.000	1.000	1.000	
	N	138	138	138	138

And the test results show that each don't have relation to each other by the significant value which less than 0.05.

Then we have analyzed the multiple linear regressions by using the step wise method and the result as show.

Table 3.8Variable entered / Removed , the outer area of BMA.

Variables Entered/Removed [a]

Model	Variables Entered	Variables Removed	Method
1	X_8the bud est. (bath)	.	Stepwise (Criteria: Probability-of-F-to-enter <= .050, Probability-of-F-to-remove >= .100).
2	X5_ average temperature (degree Celsius)	.	Stepwise (Criteria: Probability-of-F-to-enter <= .050, Probability-of-F-to-remove >= .100).
3	X1_total population (person)	.	Stepwise (Criteria: Probability-of-F-to-enter <= .050, Probability-of-F-to-remove >= .100).
4	X2_total precipitation volume(mm./year)	.	Stepwise (Criteria: Probability-of-F-to-enter <= .050, Probability-of-F-to-remove >= .100).
5	X3_Number of family (family)	.	Stepwise (Criteria: Probability-of-F-to-enter <= .050, Probability-of-F-to-remove >= .100).
6	X6_income per capital (bath)	.	Stepwise (Criteria: Probability-of-F-to-enter <= .050, Probability-of-F-to-remove >= .100).
7	X_7density of person (person/km^2)	.	Stepwise (Criteria: Probability-of-F-to-enter <= .050, Probability-of-F-to-remove >= .100).

a. Dependent Variable: Y_water sales (million cu.m.)

From the table above 5.34 is the bring in and take out factors by using the stepwise method which after finish the process we will have the 6 model for considering as a table below.

Table 3.9 Model summary , the outer area of BMA.

Model Summary[h]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.488a	.239	.233	5.0699887	
2	.571b	.327	.317	4.7858488	
3	.646c	.418	.405	4.4665541	
4	.696d	.484	.469	4.2197810	
5	.709e	.503	.484	4.1596935	
6	.721f	.519	.497	4.1044249	
7	.731g	.534	.509	4.0562796	1.194

a. Predictors: (Constant), X_8the bud est. (bath)

b. Predictors: (Constant), X_8the bud est. (bath), X5_average temperature (de ee Celsius)

c. Predictors: (Constant), X_8the bud est. (bath), X5_average temperature (de ee Celsius), X1_total population(person)

d. Predictors: (Constant), X_8the bud est. (bath), X5_average temperature (de ee Celsius), X1_total population(person), X2_total precipitation volume(mm. /year)

e. Predictors: (Constant), X_8the bud est. (bath), X5_average temperature (de ee Celsius), X1_total population(person), X2_total precipitation volume(mm. /year), X3_Number of family (family)

f. Predictors: (Constant), X_8the bud est. (bath), X5_average temperature (deg ee Celsius), X1_total population(person), X2_total precipitation volume(mm. /year), X3_Number of family (family), X6_income per capital (bath)

g. Predictors: (Constant), X_8the bud est. (bath), X5_average temperature (de ee Celsius), X1_total population(person), X2_total precipitation volume(mm. /year), X3_Number of family (family), X6_income per capital (bath), X_7dens y of person (person/km^2)

h. Dependent Variable: Y_water sales (million cu.m.)

From the table 5.35 is the model that selects for the equation from7 models. We will select the model which has the high R square value =1.194,model #7and contains with 7 factors There are factor X1_total population(person), X2_total precipitation volume

,X3_Number of family (family), X5_average temperature, X6_income per capital ,X_7 density of person และ X_8the budget est. All factors can explain the variance of Y value (water consumption) at 53.4 %.

Table 3.10 Testing hypothesis ANOVA, the outer area of BMA.

ANOVA h

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	1095.375	1	1095.375	42.614	.000 a
	Residual	3495.851	136	25.705		
	Total	4591.225	137			
2	Regression	1499.138	2	749.569	32.726	.000 b
	Residual	3092.087	135	22.904		
	Total	4591.225	137			
3	Regression	1917.911	3	639.304	32.045	.000 c
	Residual	2673.314	134	19.950		
	Total	4591.225	137			
4	Regression	2222.954	4	555.739	31.210	.000 d
	Residual	2368.271	133	17.807		
	Total	4591.225	137			
5	Regression	2307.223	5	461.445	26.668	.000 e
	Residual	2284.003	132	17.303		
	Total	4591.225	137			
6	Regression	2384.360	6	397.393	23.589	.000 f
	Residual	2206.866	131	16.846		
	Total	4591.225	137			
7	Regression	2452.283	7	350.326	21.292	.000 g
	Residual	2138.943	130	16.453		
	Total	4591.225	137			

a. Predictors: (Constant), X_8the bud est. (bath)

b. Predictors: (Constant), X_8the bud est. (bath), X5_average temperature (degree Cel ɹs)

c. Predictors: (Constant), X_8the bud est. (bath), X5_average temperature (degree Cel: ɹs), X1_total population(person)

d. Predictors: (Constant), X_8the bud est. (bath), X5_average temperature (degree Cel ɹs), X1_total population(person), X2_total precipitation volume(mm./year)

e. Predictors: (Constant), X_8the bud est. (bath), X5_average temperature (degree Cel: ɹs), X1_total population(person), X2_total precipitation volume(mm./year), X3_Number of family (family)

f. Predictors: (Constant), X_8the bud est. (bath), X5_average temperature (degree Cels ıs), X1_total population(person), X2_total precipitation volume(mm./year), X3_Number of family (family), X6_income per capital (bath)

g. Predictors: (Constant), X_8the bud est. (bath), X5_average temperature (degree Cel ɹs), X1_total population(person), X2_total precipitation volume(mm./year), X3_Number of family (family), X6_income per capital (bath), X_7density of person (person/km^2)

h. Dependent Variable: Y_water sales (million cu.m.)

From the model# 7 from the table is the testing that test the hypothesis as

H_0: $\beta_1 = \beta_2 = \beta_3 = \beta_5 = \beta_6 = \beta_7 = \beta_8 = 0$

H_1 : has β_i at least 1 value which $\neq 0$; $i = 1,2,3,5,7,6,8$

And the F – test from the table ANOVA above.

If accept H_0 ,we can say that X_1,X_2 ,X_3 ,X_5 , X_6,X_7,X_8 not relate to Y .

If reject H_0 ,we can say that X_i have at least 1 value that relate to Y . The next test to find out which factors are related to Y

From the model #7, we have the F-test value = 21.292 and the significant value less than 0.05(specific significant).So the test is reject H_0

Table 3.11 Coefficients, the outer area of BMA.

Coefficients a

Model		Unstandardized Coefficients B	Std. Error	Standardized Coefficients Beta	t	Sig.
1	(Constant)	4.743	2.363		2.007	.047
	X_8the bud est. (bath)	8.27E-008	.000	.488	6.528	.000
2	(Constant)	-123.640	30.659		-4.033	.000
	X_8the bud est. (bath)	9.08E-008	.000	.536	7.495	.000
	X5_average temperature (degree Celsius)	4.362	1.039	.300	4.199	.000
3	(Constant)	-129.925	28.646		-4.536	.000
	X_8the bud est. (bath)	7.39E-008	.000	.436	6.214	.000
	X5_average temperature (degree Celsius)	4.536	.970	.312	4.675	.000
	X1_total population(person)	4.14E-005	.000	.319	4.582	.000
4	(Constant)	-94.882	28.357		-3.346	.001
	X_8the bud est. (bath)	6.87E-008	.000	.405	6.073	.000
	X5_average temperature (degree Celsius)	3.610	.944	.249	3.825	.000
	X1_total population(person)	5.15E-005	.000	.397	5.800	.000
	X2_total precipitation volume(mm./year)	-.005	.001	-.276	-4.139	.000
5	(Constant)	-81.626	28.591		-2.855	.005
	X_8the bud est. (bath)	6.05E-008	.000	.357	5.149	.000
	X5_average temperature (degree Celsius)	3.177	.951	.219	3.342	.001
	X1_total population(person)	4.84E-005	.000	.373	5.456	.000
	X2_total precipitation volume(mm./year)	-.005	.001	-.268	-4.064	.000
	X3_Number of family (family)	.000	.000	.150	2.207	.029
6	(Constant)	-	28.261		-3.015	.003
	X_8the bud est. (bath)	5.27E-008	.000	.312	4.346	.000
	X5_average temperature (degree Celsius)	2.736	.960	.188	2.849	.005
	X1_total population(person)	5.42E-005	.000	.417	5.915	.000
	X2_total precipitation volume(mm./year)	-.003	.001	-.186	-2.468	.015
	X3_Number of family (family)	.000	.000	.159	2.373	.019
	X6_income per capital (bath)	7.33E-005	.000	.173	2.140	.034
7	(Constant)	-	28.095		-2.813	.006
	X_8the bud est. (bath)	4.27E-008	.000	.252	3.297	.001
	X5_average temperature (degree Celsius)	2.537	.954	.175	2.658	.009
	X1_total population(person)	5.98E-005	.000	.460	6.317	.000
	X2_total precipitation volume(mm./year)	-.004	.001	-.190	-2.551	.012
	X3_Number of family (family)	.000	.000	.182	2.711	.008
	X6_income per capital (bath)	8.15E-005	.000	.192	2.390	.018
	X_7density of person (person/km^2)	.000	.000	-.134	-2.032	.044

a. Dependent Variable: Y_water sales (million cu.m.)

From the table 5.37 is the testing that which variable X are related to Y.

Considered only the model #7 that.

The hypothesis $H_0 : \beta_i = 0$

$H_1 : \beta_i \neq 0 \; ; i = 1,2,3,5,6,7,8$

If accept H_0 , we can say that X_i is not relate to Y .

If reject H_0 , we can say that X_i is relate to Y

From model #7,we can say as these.

The testing for X_1 ,the statistic t –test = 6.317 and the specific significant value less than 0.05 which say that the testing is reject H_0 so X_1 is relate to Y and X_1 should have in the regression equation.

The testing for X_2 ,the statistic t –test = -2.551 and the specific significant value less than 0.05 which say that the testing is reject H_0 so X_1 is relate to Y and X_1 should have in the regression equation.

The testing for X_3 ,the statistic t –test = 2.771 and the specific significant value less than 0.05 which say that the testing is reject H_0 so X_1 is relate to Y and X_1 should have in the regression equation.

The testing for X_5 X_3 ,the statistic t –test = 2.658 and the specific significant value less than 0.05 which say that the testing is reject H_0 so X_1 is relate to Y and X_1 should have in the regression equation.

The testing for X_6 ,the statistic t –test = 2.390 and the specific significant value less than 0.05 which say that the testing is reject H_0 so X_1 is relate to Y and X_1 should have in the regression equation.

The testing for X_6 ,the statistic t –test = -2.032 and the specific significant value less than 0.05 which say that the testing is reject H_0 so X_1 is relate to Y and X_1 should have in the regression equation.

The testing for X_8 ,the statistic t –test = -3.297 and the specific significant value less than 0.05 which say that the testing is reject H_0 so X_1 is relate to Y and X_1 should have in the regression equation.

So we can create the linear regression equation as follow.

$Y_3 = 0.0000598X_1 - 0.00356X_2 + 0.000136X_3 + 2.537X_5 + 0.0000815X_6 -$

$0.00017X_7 + 0.0000000247X_8 \quad -79.019$

Table 3.12 The residual statistic value, the outer area of BMA.

Residuals Statistics [a]

	Minimum	*Maximum*	*Mean*	*Std. Deviation*	*N*
Predicted Value	11.065622	34.049065	19.905957	4.2308244	138
Residual	-9.21999	15.48053	.0000000	3.9512934	138
Std. Predicted Value	-2.090	3.343	.000	1.000	138
Std. Residual	-2.273	3.816	.000	.974	138

a. Dependent Variable: Y_water sales (million cu.m.)

When we use the value X in year 2007 replace in the equation (1) and compare in the real collect information, we will have the table as follow to be adjust the equation for realistic value

Appendix B

Collected variable information for 10 year record. (1997 – 2007)

Table of collected information for 10 year record. (1997 – 2007)

By X_1= Population volume in each district of Bangkok (person).

X_2= Precipitation volume. (Millimeter/year)

X_3= Number of family. (family)

X_4= Selling price of water. (Baht)

X_5= Average temperature of Bangkok. (Degree Celsius)

X_6= Income per person/family. (Baht)

X_7 = Density of person (Person/square kilometers)

X_8 = Estimated budget for each district of BMA per year.(Baht)

Y = Water consumption volume deducted loss.(Million cubic meters).

Year 1997

District	Y	x1	x2	x3	x4	x5	x6	x7	x8
Klongsan	14.50	117,301	1,064	6,965	8.57	29.40	186,433	19,385	161,890,014
Klongtoei	27.00	147,855	1,064	9,287	8.57	29.40	186,433	11,379	183,974,748
Kannayao	11.72	71,377	1,064	1,264	8.57	29.40	186,433	2,747	125,759,064
Kolngsamwa	17.71	73,640	1,064	4,055	8.57	29.40	186,433	665	138,134,740
Jatujak	34.21	171,326	1,064	5,242	8.57	29.40	186,433	5,206	255,707,574
Jomthong	25.91	169,360	1,064	1,216	8.57	29.40	186,433	6,448	196,483,314
Dusit	13.93	161,995	1,064	7,672	8.57	29.40	186,433	15,189	161,540,781
Dindang	23.95	171,062	1,064	13,911	8.57	29.40	186,433	20,477	129,215,058
Donmaung	25.49	136,636	1,064	12,887	8.57	29.40	186,433	3,713	148,525,737
Talingchan	25.64	145,490	1,064	3,380	8.57	29.40	186,433	4,935	157,612,746
Taweewatana	99.00	99	1,064	99	8.57	29.40	186,433	99	128,216,928
Toongkru	99.00	99	1,064	99	8.57	29.40	186,433	99	155,309,280
Thonburi	21.72	198,377	1,064	9,421	8.57	29.40	186,433	23,199	171,153,058
Bangrak	12.45	64,989	1,064	2,922	8.57	29.40	186,433	11,739	108,075,072
Bangken	34.65	162,765	1,064	10,163	8.57	29.40	186,433	3,864	184,423,446
Bangkapi	32.41	139,870	1,064	1,718	8.57	29.40	186,433	4,904	177,892,840
Bangkok-yai	13.60	93,859	1,064	4,045	8.57	29.40	186,433	15,188	115,271,793
Bangkok-noi	21.52	169,378	1,064	12,315	8.57	29.40	186,433	14,181	165,665,136
Bangkuntian	36.54	164,570	1,064	59,571	8.57	29.40	186,433	1,364	218,758,686
Bangplud	19.99	127,566	1,064	9,344	8.57	29.40	186,433	11,229	133,383,575
Bungkum	22.87	134,573	1,064	7,244	8.57	29.40	186,433	5,535	135,328,502
Bangsue	22.69	165,644	1,064	7,771	8.57	29.40	186,433	14,348	186,766,080
Bangkoleam	17.25	123,082	1,064	3,210	8.57	29.40	186,433	11,270	123,962,857
Bamgkae	24.87	135,682	1,064	4,682	8.57	29.40	186,433	3,052	197,286,709
Bangna	99.00	99	1,064	99	8.57	29.40	186,433	99	128,166,410
Bangbon	99.00	99	1,064	99	8.57	29.40	186,433	99	126,465,923
Patumwan	14.06	112,597	1,064	3,916	8.57	29.40	186,433	13,454	162,713,358
Pomprabsatrupai	9.50	79,182	1,064	2,341	8.57	29.40	186,433	41,006	121,648,566
Pravet	18.43	112,259	1,064	6,217	8.57	29.40	186,433	2,139	149,962,310
Pranakorn	9.40	81,656	1,064	1,439	8.57	29.40	186,433	14,750	188,010,276
Prakanong	36.59	200,693	1,064	1,442	8.57	29.40	186,433	14,350	152,227,860
Payathai	13.48	93,296	1,064	1,728	8.57	29.40	186,433	9,723	121,660,395
Pasicharoen	21.23	143,113	1,064	3,834	8.57	29.40	186,433	8,025	152,271,209
Minburi	15.18	89,184	1,064	3,648	8.57	29.40	186,433	1,401	147,094,948
Yanawa	20.06	94,223	1,064	2,555	8.57	29.40	186,433	5,655	144,172,830
Ratburana	33.44	183,253	1,064	4,134	8.57	29.40	186,433	11,612	129,967,526
Ratchathevee	13.26	109,016	1,064	4,109	8.57	29.40	186,433	15,298	123,680,936
Ladkrabang	18.79	102,562	1,064	3,588	8.57	29.40	186,433	828	189,349,742
Ladprao	19.20	105,158	1,064	5,288	8.57	29.40	186,433	4,878	133,082,099
Watana	21.06	79,902	1,064	3,019	8.57	29.40	186,433	6,359	122,822,137
Wangthonglang	21.31	102,218	1,064	2,857	8.57	29.40	186,433	5,146	127,601,265
Sampanthawong	7.33	38,984	1,064	1,346	8.57	29.40	186,433	27,531	109,617,870
Sathorn	16.38	113,612	1,064	7,414	8.57	29.40	186,433	12,182	141,241,440
Suanlaung	21.84	108,644	1,064	3,885	8.57	29.40	186,433	4,588	147,144,732
Saimai	27.54	131,179	1,064	10,872	8.57	29.40	186,433	2,940	145,281,773
Saphansoong	11.20	67,700	1,064	8,144	8.57	29.40	186,433	2,407	135,121,440
Nongjok	11.66	79,585	1,064	3,793	8.57	29.40	186,433	337	203,416,560
Huawkwang	16.59	79,793	1,064	4,102	8.57	29.40	186,433	5,308	169,485,444
Nongkam	26.52	133,590	1,064	9,088	8.57	29.40	186,433	3,729	138,922,830
Laksi	20.07	116,976	1,064	10,817	8.57	29.40	186,433	5,121	154,031,220

Year 1998

District	Y	x1	x2	x3	x4	x5	x6	x7	x8
Klongsan	13.79	115,794	2,109	7,837	9.37	29.60	185,994	19,136	165,127,814
Klongtoei	25.66	144,595	2,109	12,698	9.37	29.60	185,994	11,128	187,654,243
Kannayao	12.44	74,979	2,109	1,760	9.37	29.60	185,994	2,886	128,274,245
Kolngsamwa	17.66	82,445	2,109	4,427	9.37	29.60	185,994	745	140,897,435
Jatujak	33.98	170,901	2,109	5,344	9.37	29.60	185,994	5,193	260,821,725
Jomthong	26.16	176,309	2,109	3,139	9.37	29.60	185,994	6,713	200,412,980
Dusit	13.56	160,243	2,109	7,534	9.37	29.60	185,994	15,025	164,771,597
Dindang	22.86	168,552	2,109	11,304	9.37	29.60	185,994	20,176	131,799,359
Donmaung	25.07	140,562	2,109	14,014	9.37	29.60	185,994	3,819	151,496,251
Talingchan	14.32	98,550	2,109	3,493	9.37	29.60	185,994	3,343	160,765,001
Taweewatana	10.64	50,066	2,109	459	9.37	29.60	185,994	997	130,781,267
Toongkru	16.86	84,561	2,109	2,195	9.37	29.60	185,994	2,751	158,415,466
Thonburi	20.36	193,783	2,109	10,441	9.37	29.60	185,994	22,662	174,576,120
Bangrak	11.78	64,345	2,109	3,323	9.37	29.60	185,994	11,623	110,236,573
Bangken	33.29	165,357	2,109	11,183	9.37	29.60	185,994	3,926	188,111,915
Bangkapi	31.34	141,308	2,109	2,488	9.37	29.60	185,994	4,954	181,450,696
Bangkok-yai	13.06	91,584	2,109	4,069	9.37	29.60	185,994	14,819	117,577,229
Bangkok-noi	21.01	167,171	2,109	13,859	9.37	29.60	185,994	13,996	168,978,439
Bangkuntian	19.03	101,728	2,109	61,181	9.37	29.60	185,994	843	223,133,860
Bangplud	18.00	125,451	2,109	9,344	9.37	29.60	185,994	11,043	136,051,246
Bungkum	21.96	135,851	2,109	7,365	9.37	29.60	185,994	5,588	138,035,072
Bangsue	21.78	163,245	2,109	8,621	9.37	29.60	185,994	14,140	190,501,402
Bangkoleam	16.41	121,853	2,109	3,894	9.37	29.60	185,994	11,158	126,442,114
Bamgkae	30.57	169,615	2,109	5,355	9.37	29.60	185,994	3,815	201,232,443
Bangna	19.36	99,312	2,109	2,998	9.37	29.60	185,994	5,286	130,729,739
Bangbon	16.44	69,829	2,109	638	9.37	29.60	185,994	2,010	128,995,241
Patumwan	13.59	111,052	2,109	4,941	9.37	29.60	185,994	13,269	165,967,625
Pomprabsatrupai	9.00	78,376	2,109	2,055	9.37	29.60	185,994	40,588	124,081,537
Pravet	19.26	115,697	2,109	6,189	9.37	29.60	185,994	2,204	152,961,557
Pranakorn	8.95	83,742	2,109	2,188	9.37	29.60	185,994	15,127	191,770,482
Prakanong	16.29	101,757	2,109	2,938	9.37	29.60	185,994	7,276	155,272,417
Payathai	12.96	92,852	2,109	1,897	9.37	29.60	185,994	9,677	124,093,603
Pasicharoen	20.36	142,694	2,109	4,113	9.37	29.60	185,994	8,001	155,316,633
Minburi	14.64	92,480	2,109	4,334	9.37	29.60	185,994	1,453	150,036,847
Yanawa	19.16	94,019	2,109	3,332	9.37	29.60	185,994	5,643	147,056,287
Ratburana	14.43	95,564	2,109	4,481	9.37	29.60	185,994	6,055	132,566,876
Ratchathevee	12.93	108,085	2,109	4,131	9.37	29.60	185,994	15,168	126,154,555
Ladkrabang	18.56	108,017	2,109	5,364	9.37	29.60	185,994	872	193,136,737
Ladprao	18.48	106,704	2,109	5,198	9.37	29.60	185,994	4,950	135,743,741
Watana	20.11	80,601	2,109	3,003	9.37	29.60	185,994	6,415	125,278,580
Wangthonglang	21.26	104,800	2,109	2,938	9.37	29.60	185,994	5,276	130,153,290
Sampanthawong	6.95	38,628	2,109	1,578	9.37	29.60	185,994	27,280	111,810,227
Sathorn	15.73	112,227	2,109	7,404	9.37	29.60	185,994	12,034	144,066,269
Suanlaung	20.99	109,797	2,109	4,733	9.37	29.60	185,994	4,637	150,087,627
Saimai	26.53	136,103	2,109	10,808	9.37	29.60	185,994	3,051	148,187,409
Saphansoong	10.85	69,787	2,109	8,203	9.37	29.60	185,994	2,481	137,823,869
Nongjok	11.87	84,481	2,109	4,052	9.37	29.60	185,994	358	207,484,891
Huawkwang	15.25	79,070	2,109	4,136	9.37	29.60	185,994	5,260	172,875,153
Nongkam	19.60	106,202	2,109	8,400	9.37	29.60	185,994	2,964	141,701,286
Laksi	19.65	117,075	2,109	11,281	9.37	29.60	185,994	5,126	157,111,844

Year 1999

District	Y	x1	x2	x3	x4	x5	x6	x7	x8
Klongsan	12.76	113,817	1,756	8,708	10.42	28.10	189,535	18,810	171,732,927
Klongtoei	23.83	142,029	1,756	16,109	10.42	28.10	189,535	10,930	195,160,413
Kannayao	11.65	76,535	1,756	2,256	10.42	28.10	189,535	2,946	133,405,215
Kolngsamwa	16.65	88,957	1,756	4,799	10.42	28.10	189,535	804	146,533,332
Jatujak	31.91	170,408	1,756	5,445	10.42	28.10	189,535	5,178	271,254,594
Jomthong	24.20	174,611	1,756	5,061	10.42	28.10	189,535	6,648	208,429,499
Dusit	12.72	157,331	1,756	7,395	10.42	28.10	189,535	14,752	201,925,977
Dindang	21.17	166,187	1,756	8,696	10.42	28.10	189,535	19,893	161,518,823
Donmaung	23.27	143,737	1,756	15,140	10.42	28.10	189,535	3,906	185,657,171
Talingchan	13.42	99,695	1,756	3,605	10.42	28.10	189,535	3,382	167,195,601
Taweewatana	9.95	52,099	1,756	501	10.42	28.10	189,535	1,037	160,271,160
Toongkru	15.69	87,609	1,756	2,879	10.42	28.10	189,535	2,850	164,752,084
Thonburi	18.85	188,610	1,756	11,460	10.42	28.10	189,535	22,057	213,941,323
Bangrak	11.03	63,038	1,756	3,723	10.42	28.10	189,535	11,387	135,093,840
Bangken	31.08	168,060	1,756	12,203	10.42	28.10	189,535	3,990	195,636,392
Bangkapi	29.64	142,347	1,756	3,258	10.42	28.10	189,535	4,991	222,366,050
Bangkok-yai	12.08	89,763	1,756	4,092	10.42	28.10	189,535	14,525	144,089,741
Bangkok-noi	19.43	162,502	1,756	15,403	10.42	28.10	189,535	13,605	207,081,420
Bangkuntian	17.97	105,616	1,756	7,729	10.42	28.10	189,535	875	232,059,214
Bangplud	16.49	123,035	1,756	9,344	10.42	28.10	189,535	10,831	166,729,469
Bungkum	20.54	136,617	1,756	7,485	10.42	28.10	189,535	5,620	169,160,628
Bangsue	20.45	161,393	1,756	9,470	10.42	28.10	189,535	13,979	198,121,458
Bangkoleam	15.18	120,388	1,756	4,942	10.42	28.10	189,535	11,024	154,953,572
Bamgkae	28.44	172,026	1,756	6,027	10.42	28.10	189,535	3,870	246,608,387
Bangna	18.07	100,201	1,756	3,774	10.42	28.10	189,535	5,333	160,208,013
Bangbon	15.66	72,726	1,756	829	10.42	28.10	189,535	2,093	158,082,404
Patumwan	11.26	104,066	1,756	5,966	10.42	28.10	189,535	12,435	172,606,330
Pomprabsatrupai	8.27	76,602	1,756	1,017	10.42	28.10	189,535	39,670	129,044,799
Pravet	18.42	118,330	1,756	6,160	10.42	28.10	189,535	2,254	187,452,888
Pranakorn	8.27	82,921	1,756	2,936	10.42	28.10	189,535	14,979	195,605,891
Prakanong	14.96	100,071	1,756	3,435	10.42	28.10	189,535	7,155	158,377,866
Payathai	12.14	91,616	1,756	2,066	10.42	28.10	189,535	9,548	152,075,494
Pasicharoen	18.87	142,174	1,756	4,391	10.42	28.10	189,535	7,972	190,339,011
Minburi	15.51	98,303	1,756	5,019	10.42	28.10	189,535	1,545	183,868,685
Yanawa	17.80	93,774	1,756	3,110	10.42	28.10	189,535	5,628	180,216,038
Ratburana	13.33	94,620	1,756	4,827	10.42	28.10	189,535	5,995	162,459,407
Ratchathevee	11.99	106,728	1,756	4,153	10.42	28.10	189,535	14,977	154,601,171
Ladkrabang	17.74	112,967	1,756	7,140	10.42	28.10	189,535	912	236,687,178
Ladprao	17.20	107,372	1,756	5,108	10.42	28.10	189,535	4,981	166,352,624
Watana	18.69	80,930	1,756	2,987	10.42	28.10	189,535	6,441	153,527,672
Wangthonglang	19.82	106,563	1,756	3,018	10.42	28.10	189,535	5,364	159,501,581
Sampanthawong	6.19	37,593	1,756	1,809	10.42	28.10	189,535	26,549	114,046,432
Sathorn	14.52	110,491	1,756	7,393	10.42	28.10	189,535	11,848	146,947,594
Suanlaung	19.56	111,047	1,756	5,580	10.42	28.10	189,535	4,690	183,930,915
Saimai	27.02	141,713	1,756	10,743	10.42	28.10	189,535	3,176	181,602,217
Saphansoong	10.18	71,629	1,756	8,261	10.42	28.10	189,535	2,547	140,580,346
Nongjok	11.46	88,095	1,756	4,310	10.42	28.10	189,535	373	211,634,589
Huawkwang	14.20	78,593	1,756	4,170	10.42	28.10	189,535	5,228	176,332,656
Nongkam	18.24	109,320	1,756	7,712	10.42	28.10	189,535	3,052	173,653,537
Laksi	18.83	117,644	1,756	11,745	10.42	28.10	189,535	5,151	160,254,081

Year 2000

District	Y	x1	x2	x3	x4	x5	x6	x7	x8
Klongsan	12.95	112,012	1,878	9,580	11.70	28.76	190,011	18,511	163,146,281
Klongtoei	24.13	138,803	1,878	19,520	11.70	28.76	190,011	10,682	185,402,392
Kannayao	11.91	77,610	1,878	2,752	11.70	28.76	190,011	2,987	126,734,954
Kolngsamwa	17.26	95,481	1,878	5,171	11.70	28.76	190,011	863	152,394,665
Jatujak	33.09	169,943	1,878	5,547	11.70	28.76	190,011	5,164	257,691,865
Jomthong	25.05	172,863	1,878	6,984	11.70	28.76	190,011	6,581	198,008,025
Dusit	13.07	155,744	1,878	7,257	11.70	28.76	190,011	14,603	208,171,110
Dindang	21.46	162,002	1,878	6,089	11.70	28.76	190,011	19,392	166,514,250
Donmaung	23.99	146,525	1,878	16,267	11.70	28.76	190,011	3,981	191,399,145
Talingchan	13.86	100,509	1,878	3,718	11.70	28.76	190,011	3,410	162,248,415
Taweewatana	10.27	53,801	1,878	1,092	11.70	28.76	190,011	1,071	165,228,000
Toongkru	16.13	90,427	1,878	3,563	11.70	28.76	190,011	2,942	159,877,200
Thonburi	19.17	184,181	1,878	12,480	11.70	28.76	190,011	21,539	220,558,065
Bangrak	11.18	61,994	1,878	4,124	11.70	28.76	190,011	11,198	139,272,000
Bangken	31.71	170,089	1,878	13,223	11.70	28.76	190,011	4,038	189,847,665
Bangkapi	30.58	143,046	1,878	4,028	11.70	28.76	190,011	5,015	229,243,350
Bangkok-yai	12.27	88,809	1,878	4,116	11.70	28.76	190,011	14,370	148,546,125
Bangkok-noi	19.86	160,035	1,878	16,947	11.70	28.76	190,011	13,399	213,486,000
Bangkuntian	18.74	109,723	1,878	9,340	11.70	28.76	190,011	909	225,192,765
Bangplud	16.79	120,200	1,878	9,344	11.70	28.76	190,011	10,581	171,886,050
Bungkum	21.20	137,184	1,878	7,606	11.70	28.76	190,011	5,643	174,392,400
Bangsue	20.91	160,755	1,878	10,320	11.70	28.76	190,011	13,924	192,259,200
Bangkoleam	15.42	118,485	1,878	8,283	11.70	28.76	190,011	10,849	159,745,950
Bamgkae	29.72	174,466	1,878	6,700	11.70	28.76	190,011	3,924	254,235,450
Bangna	18.56	100,312	1,878	7,051	11.70	28.76	190,011	5,339	165,162,900
Bangbon	16.46	76,040	1,878	1,020	11.70	28.76	190,011	2,189	162,971,550
Patumwan	11.47	102,776	1,878	6,991	11.70	28.76	190,011	12,281	167,499,045
Pomprabsatrupai	8.41	75,220	1,878	1,926	11.70	28.76	190,011	38,954	125,226,465
Pravet	19.41	121,459	1,878	6,132	11.70	28.76	190,011	2,314	193,250,400
Pranakorn	8.41	81,687	1,878	3,685	11.70	28.76	190,011	14,756	193,539,990
Prakanong	15.23	100,481	1,878	4,932	11.70	28.76	190,011	7,184	156,705,150
Payathai	12.49	91,091	1,878	2,235	11.70	28.76	190,011	9,494	156,778,860
Pasicharoen	19.25	141,063	1,878	4,670	11.70	28.76	190,011	7,910	196,225,785
Minburi	16.06	102,375	1,878	5,705	11.70	28.76	190,011	1,609	189,555,345
Yanawa	18.20	93,403	1,878	3,888	11.70	28.76	190,011	5,606	185,789,730
Ratburana	13.58	93,482	1,878	5,174	11.70	28.76	190,011	5,923	167,483,925
Ratchathevee	12.23	104,816	1,878	4,175	11.70	28.76	190,011	14,709	159,382,650
Ladkrabang	18.66	116,844	1,878	8,916	11.70	28.76	190,011	943	244,007,400
Ladprao	17.60	108,125	1,878	5,018	11.70	28.76	190,011	5,016	171,497,550
Watana	18.90	80,905	1,878	2,971	11.70	28.76	190,011	6,439	158,275,950
Wangthonglang	20.35	107,903	1,878	3,099	11.70	28.76	190,011	5,432	164,434,620
Sampanthawong	6.29	36,925	1,878	2,041	11.70	28.76	190,011	26,077	112,841,925
Sathorn	14.79	109,014	1,878	7,383	11.70	28.76	190,011	11,689	145,395,600
Suanlaung	20.12	111,898	1,878	6,428	11.70	28.76	190,011	4,726	189,619,500
Saimai	27.75	145,892	1,878	10,679	11.70	28.76	190,011	3,270	187,218,780
Saphansoong	10.54	72,745	1,878	8,320	11.70	28.76	190,011	2,587	139,095,600
Nongjok	12.30	92,180	1,878	4,569	11.70	28.76	190,011	390	209,399,400
Huawkwang	14.38	78,595	1,878	4,204	11.70	28.76	190,011	5,228	167,516,023
Nongkam	18.75	112,579	1,878	7,024	11.70	28.76	190,011	3,142	179,024,265
Laksi	19.39	117,883	1,878	12,209	11.70	28.76	190,011	5,161	158,561,550

Year 2001

District	Y	x1	x2	x3	x4	x5	x6	x7	x8
Klongsan	13.50	109,773	1,765	10,451	11.81	29.00	190,982	18,141	154,988,966
Klongtoei	25.45	136,467	1,765	22,931	11.81	29.00	190,982	10,502	176,132,272
Kannayao	12.71	79,570	1,765	3,248	11.81	29.00	190,982	3,063	120,398,207
Kolngsamwa	18.53	102,601	1,765	5,543	11.81	29.00	190,982	927	144,774,932
Jatujak	34.72	170,717	1,765	5,648	11.81	29.00	190,982	5,188	244,807,272
Jomthong	26.22	173,184	1,765	8,906	11.81	29.00	190,982	6,594	188,107,623
Dusit	13.87	152,872	1,765	7,118	11.81	29.00	190,982	14,334	222,743,088
Dindang	22.39	159,570	1,765	3,481	11.81	29.00	190,982	19,101	178,170,248
Donmaung	25.54	150,914	1,765	17,393	11.81	29.00	190,982	4,101	204,797,085
Talingchan	14.67	101,600	1,765	3,830	11.81	29.00	190,982	3,447	154,135,994
Taweewatana	10.98	55,705	1,765	1,682	11.81	29.00	190,982	1,109	176,793,960
Toongkru	17.13	93,496	1,765	4,247	11.81	29.00	190,982	3,041	151,883,340
Thonburi	19.96	180,867	1,765	13,499	11.81	29.00	190,982	21,152	235,997,130
Bangrak	11.76	61,175	1,765	4,524	11.81	29.00	190,982	11,050	149,021,040
Bangken	33.70	173,558	1,765	14,243	11.81	29.00	190,982	4,120	180,355,282
Bangkapi	32.47	144,896	1,765	4,798	11.81	29.00	190,982	5,080	245,290,385
Bangkok-yai	12.82	87,201	1,765	4,139	11.81	29.00	190,982	14,110	158,944,354
Bangkok-noi	20.69	157,170	1,765	18,491	11.81	29.00	190,982	13,159	228,430,020
Bangkuntian	20.24	113,865	1,765	10,950	11.81	29.00	190,982	943	213,933,127
Bangplud	17.26	118,748	1,765	9,344	11.81	29.00	190,982	10,453	183,918,074
Bungkum	22.42	139,424	1,765	7,726	11.81	29.00	190,982	5,735	186,599,868
Bangsue	21.92	159,466	1,765	11,169	11.81	29.00	190,982	13,813	182,646,240
Bangkoleam	16.07	117,327	1,765	11,624	11.81	29.00	190,982	10,743	170,928,167
Bamgkae	31.21	177,003	1,765	7,372	11.81	29.00	190,982	3,982	272,031,932
Bangna	19.50	100,854	1,765	10,327	11.81	29.00	190,982	5,368	176,724,303
Bangbon	17.58	79,765	1,765	1,210	11.81	29.00	190,982	2,296	174,379,559
Patumwan	11.90	99,919	1,765	8,016	11.81	29.00	190,982	11,939	159,124,093
Pomprabsatrupai	8.77	73,979	1,765	2,835	11.81	29.00	190,982	38,311	118,965,142
Pravet	21.39	125,836	1,765	6,103	11.81	29.00	190,982	2,397	206,777,928
Pranakorn	8.90	80,118	1,765	4,433	11.81	29.00	190,982	14,472	183,862,991
Prakanong	16.00	100,497	1,765	6,428	11.81	29.00	190,982	7,186	148,869,893
Payathai	13.34	90,780	1,765	2,404	11.81	29.00	190,982	9,461	167,753,380
Pasicharoen	20.15	140,293	1,765	4,948	11.81	29.00	190,982	7,867	209,961,590
Minburi	17.02	105,877	1,765	6,390	11.81	29.00	190,982	1,664	202,824,219
Yanawa	18.96	93,032	1,765	4,665	11.81	29.00	190,982	5,583	198,795,011
Ratburana	15.20	96,130	1,765	5,520	11.81	29.00	190,982	6,091	179,207,800
Ratchathevee	13.02	102,997	1,765	4,197	11.81	29.00	190,982	14,454	170,539,436
Ladkrabang	20.40	121,739	1,765	10,692	11.81	29.00	190,982	983	261,087,918
Ladprao	18.54	109,619	1,765	4,928	11.81	29.00	190,982	5,085	183,502,379
Watana	19.80	81,427	1,765	2,955	11.81	29.00	190,982	6,480	169,355,267
Wangthonglang	21.53	109,844	1,765	3,179	11.81	29.00	190,982	5,530	175,945,043
Sampanthawong	6.36	36,899	1,765	2,272	11.81	29.00	190,982	26,059	107,199,829
Sathorn	15.53	108,148	1,765	7,372	11.81	29.00	190,982	11,596	138,125,820
Suanlaung	19.90	113,396	1,765	7,275	11.81	29.00	190,982	4,789	202,892,865
Saimai	29.31	150,906	1,765	10,614	11.81	29.00	190,982	3,382	200,324,095
Saphansoong	11.35	74,990	1,765	8,378	11.81	29.00	190,982	2,666	132,140,820
Nongjok	13.64	97,381	1,765	4,827	11.81	29.00	190,982	412	198,929,430
Huawkwang	15.04	79,404	1,765	4,238	11.81	29.00	190,982	5,282	159,140,222
Nongkam	19.64	115,560	1,765	6,336	11.81	29.00	190,982	3,226	191,555,964
Laksi	20.51	119,644	1,765	12,673	11.81	29.00	190,982	5,238	150,633,473

Year 2002

District	Y	x1	x2	x3	x4	x5	x6	x7	x8
Klongsan	13.90	108,426	1,363	10,727	11.85	29.20	210,713	17,919	165,838,194
Klongtoei	26.32	134,802	1,363	21,473	11.85	29.20	210,713	10,374	188,461,532
Kannayao	13.37	81,048	1,363	3,851	11.85	29.20	210,713	3,120	128,826,081
Kolngsamwa	19.94	109,156	1,363	6,679	11.85	29.20	210,713	986	154,909,177
Jatujak	36.27	171,868	1,363	6,448	11.85	29.20	210,713	5,223	261,943,781
Jomthong	27.04	172,815	1,363	8,906	11.85	29.20	210,713	6,580	201,275,157
Dusit	14.73	151,511	1,363	7,118	11.85	29.20	210,713	14,206	189,336,581
Dindang	23.11	157,896	1,363	3,490	11.85	29.20	210,713	18,901	151,448,675
Donmaung	26.81	154,832	1,363	16,760	11.85	29.20	210,713	4,207	174,082,080
Talingchan	15.33	103,020	1,363	3,877	11.85	29.20	210,713	3,495	164,925,514
Taweewatana	11.77	58,004	1,363	1,682	11.85	29.20	210,713	1,155	150,278,800
Toongkru	18.35	97,164	1,363	4,873	11.85	29.20	210,713	3,161	162,515,174
Thonburi	20.49	177,938	1,363	13,053	11.85	29.20	210,713	20,809	200,602,812
Bangrak	11.43	60,775	1,363	4,524	11.85	29.20	210,713	10,978	126,671,200
Bangken	35.15	175,190	1,363	13,363	11.85	29.20	210,713	4,159	192,980,151
Bangkapi	34.10	147,434	1,363	5,082	11.85	29.20	210,713	5,169	208,502,285
Bangkok-yai	13.18	86,134	1,363	4,231	11.85	29.20	210,713	13,938	135,106,238
Bangkok-noi	21.23	155,251	1,363	15,205	11.85	29.20	210,713	12,998	194,170,600
Bangkuntian	21.78	118,611	1,363	10,950	11.85	29.20	210,713	983	228,908,446
Bangplud	17.72	117,561	1,363	9,626	11.85	29.20	210,713	10,349	156,334,455
Bungkum	23.44	141,017	1,363	7,726	11.85	29.20	210,713	5,801	158,614,040
Bangsue	22.57	159,217	1,363	11,169	11.85	29.20	210,713	13,791	195,431,477
Bangkoleam	16.47	114,638	1,363	11,624	11.85	29.20	210,713	10,497	145,292,745
Bamgkae	32.60	180,136	1,363	7,897	11.85	29.20	210,713	4,052	231,233,195
Bangna	20.15	102,125	1,363	10,327	11.85	29.20	210,713	5,435	150,219,590
Bangbon	18.52	84,660	1,363	1,214	11.85	29.20	210,713	2,437	148,226,505
Patumwan	12.12	98,532	1,363	8,396	11.85	29.20	210,713	11,773	170,262,779
Pomprabsatrupai	9.00	73,240	1,363	2,835	11.85	29.20	210,713	37,929	127,292,702
Pravet	22.76	130,383	1,363	6,103	11.85	29.20	210,713	2,484	175,765,840
Pranakorn	9.17	78,351	1,363	4,481	11.85	29.20	210,713	14,153	196,733,400
Prakanong	16.97	100,878	1,363	6,580	11.85	29.20	210,713	7,213	159,290,785
Payathai	13.73	90,492	1,363	3,290	11.85	29.20	210,713	9,431	142,594,106
Pasicharoen	20.88	140,254	1,363	6,781	11.85	29.20	210,713	7,864	178,472,024
Minburi	18.05	109,241	1,363	6,688	11.85	29.20	210,713	1,716	172,405,100
Yanawa	19.67	92,649	1,363	4,665	11.85	29.20	210,713	5,560	168,980,183
Ratburana	15.69	97,690	1,363	5,520	11.85	29.20	210,713	6,190	152,330,618
Ratchathevee	13.41	102,663	1,363	3,919	11.85	29.20	210,713	14,407	144,962,315
Ladkrabang	22.00	126,792	1,363	11,683	11.85	29.20	210,713	1,024	221,930,540
Ladprao	19.64	114,067	1,363	4,928	11.85	29.20	210,713	5,291	155,981,105
Watana	20.43	82,098	1,363	2,954	11.85	29.20	210,713	6,534	143,955,745
Wangthonglang	22.19	109,942	1,363	3,179	11.85	29.20	210,713	5,534	149,557,202
Sampanthawong	6.51	36,127	1,363	2,272	11.85	29.20	210,713	25,513	114,703,817
Sathorn	15.76	107,136	1,363	7,372	11.85	29.20	210,713	11,488	147,794,627
Suanlaung	20.68	115,086	1,363	7,669	11.85	29.20	210,713	4,860	172,463,450
Saimai	30.59	155,252	1,363	11,021	11.85	29.20	210,713	3,480	170,279,938
Saphansoong	11.98	77,482	1,363	8,378	11.85	29.20	210,713	2,755	141,390,677
Nongjok	15.01	102,564	1,363	5,257	11.85	29.20	210,713	434	212,854,490
Huawkwang	15.69	79,871	1,363	4,238	11.85	29.20	210,713	5,313	170,280,038
Nongkam	20.45	119,380	1,363	6,262	11.85	29.20	210,713	3,332	162,826,832
Laksi	21.27	120,760	1,363	13,345	11.85	29.20	210,713	5,287	161,177,816

Year 2003

District	Y	x1	x2	x3	x4	x5	x6	x7	x8
Klongsan	14.16	108,426	1,372	10,942	11.88	29.20	222,781	17,918	172,471,722
Klongtoei	26.78	133,131	1,372	21,473	11.88	29.20	222,781	10,245	195,999,993
Kannayao	13.95	82,573	1,372	4,390	11.88	29.20	222,781	3,178	133,979,124
Kolngsamwa	21.76	117,060	1,372	7,300	11.88	29.20	222,781	1,057	161,105,545
Jatujak	27.85	173,133	1,372	6,797	11.88	29.20	222,781	6,591	272,421,532
Jomthong	37.86	176,501	1,372	9,309	11.88	29.20	222,781	5,363	209,326,163
Dusit	14.68	150,365	1,372	7,737	11.88	29.20	222,781	14,098	206,376,873
Dindang	27.96	157,643	1,372	3,774	11.88	29.20	222,781	4,266	165,079,056
Donmaung	23.60	155,766	1,372	17,110	11.88	29.20	222,781	18,645	189,749,467
Talingchan	15.93	104,254	1,372	4,460	11.88	29.20	222,781	3,536	171,522,534
Taweewatana	12.53	61,177	1,372	1,758	11.88	29.20	222,781	1,218	163,803,892
Toongkru	19.11	101,254	1,372	5,226	11.88	29.20	222,781	3,293	169,015,781
Thonburi	20.93	175,768	1,372	13,053	11.88	29.20	222,781	20,555	218,657,065
Bangrak	11.66	60,300	1,372	4,524	11.88	29.20	222,781	5,581	138,071,608
Bangken	36.91	178,864	1,372	16,050	11.88	29.20	222,781	4,246	200,699,358
Bangkapi	37.20	149,747	1,372	5,170	11.88	29.20	222,781	5,250	227,267,491
Bangkok-yai	13.36	85,075	1,372	5,660	11.88	29.20	222,781	13,766	147,265,799
Bangkok-noi	21.68	152,867	1,372	16,773	11.88	29.20	222,781	12,798	211,645,954
Bangkuntian	23.63	123,525	1,372	10,950	11.88	29.20	222,781	1,023	238,064,783
Bangplud	18.05	116,271	1,372	11,893	11.88	29.20	222,781	10,235	170,404,556
Bungkum	24.14	141,465	1,372	7,836	11.88	29.20	222,781	5,818	172,889,304
Bangsue	23.11	158,079	1,372	11,169	11.88	29.20	222,781	13,692	203,248,736
Bangkoleam	17.14	113,781	1,372	11,916	11.88	29.20	222,781	10,418	158,369,092
Bamgkae	32.20	183,809	1,372	8,200	11.88	29.20	222,781	4,134	252,044,183
Bangna	22.06	102,777	1,372	11,941	11.88	29.20	222,781	5,470	163,739,353
Bangbon	20.75	89,140	1,372	1,275	11.88	29.20	222,781	2,565	161,566,890
Patumwan	12.30	97,533	1,372	8,572	11.88	29.20	222,781	11,654	177,073,290
Pomprabsatrupai	9.85	72,040	1,372	2,835	11.88	29.20	222,781	37,307	132,384,410
Pravet	24.60	135,549	1,372	6,103	11.88	29.20	222,781	2,582	191,584,766
Pranakorn	17.51	76,230	1,372	5,345	11.88	29.20	222,781	13,769	204,602,736
Prakanong	9.34	101,370	1,372	6,580	11.88	29.20	222,781	7,274	165,662,416
Payathai	14.11	90,557	1,372	3,970	11.88	29.20	222,781	9,437	155,427,576
Pasicharoen	21.51	140,051	1,372	6,862	11.88	29.20	222,781	7,853	194,534,506
Minburi	19.22	112,734	1,372	7,488	11.88	29.20	222,781	1,771	187,921,558
Yanawa	20.42	92,110	1,372	4,665	11.88	29.20	222,781	5,528	184,188,399
Ratburana	15.17	97,273	1,372	5,520	11.88	29.20	222,781	6,163	166,040,373
Ratchathevee	16.04	101,892	1,372	3,919	11.88	29.20	222,781	14,298	158,008,923
Ladkrabang	23.56	132,027	1,372	13,710	11.88	29.20	222,781	1,065	241,904,289
Ladprao	20.73	115,656	1,372	4,989	11.88	29.20	222,781	5,291	170,019,404
Watana	21.03	82,582	1,372	2,954	11.88	29.20	222,781	6,572	156,911,762
Wangthonglang	23.45	111,978	1,372	3,249	11.88	29.20	222,781	5,723	163,017,350
Sampanthawong	6.63	35,547	1,372	2,272	11.88	29.20	222,781	25,103	119,291,969
Sathorn	22.22	106,333	1,372	7,479	11.88	29.20	222,781	11,401	153,706,412
Suanlaung	32.34	116,961	1,372	7,669	11.88	29.20	222,781	4,939	187,985,161
Saimai	12.63	160,170	1,372	16,095	11.88	29.20	222,781	3,590	185,605,132
Saphansoong	16.27	79,974	1,372	8,378	11.88	29.20	222,781	2,843	147,046,304
Nongjok	16.91	109,789	1,372	7,818	11.88	29.20	222,781	464	221,368,670
Huawkwang	16.06	79,916	1,372	4,366	11.88	29.20	222,781	5,282	177,091,239
Nongkam	21.85	121,815	1,372	7,125	11.88	29.20	222,781	3,434	177,481,246
Laksi	21.19	123,045	1,372	15,545	11.88	29.20	222,781	5,333	167,624,928

<u>Year 2004</u>

District	Y	x1	x2	x3	x4	x5	x6	x7	x8
Klongsan	14.73	89,200	1,160	10,942	11.93	29.30	221,701	14,741	158,715,700
Klongtoei	25.97	125,254	1,160	14,477	11.93	29.30	221,701	9,639	180,367,400
Kannayao	14.96	83,611	1,160	4,655	11.93	29.30	221,701	3,218	123,293,200
Kolngsamwa	24.23	124,476	1,160	14,577	11.93	29.30	221,701	1,125	168,457,000
Jatujak	38.87	169,983	1,160	7,132	11.93	29.30	221,701	5,165	250,693,700
Jomthong	29.36	167,794	1,160	9,314	11.93	29.30	221,701	6,389	192,630,700
Dusit	15.38	123,282	1,160	8,039	11.93	29.30	221,701	11,559	198,258,200
Dindang	24.72	147,398	1,160	4,202	11.93	29.30	221,701	17,644	158,585,000
Donmaung	29.74	157,989	1,160	17,593	11.93	29.30	221,701	4,293	182,284,900
Talingchan	17.14	104,680	1,160	4,460	11.93	29.30	221,701	3,551	154,522,300
Taweewatana	13.60	64,220	1,160	1,833	11.93	29.30	221,701	1,279	157,360,000
Toongkru	20.29	104,827	1,160	5,811	11.93	29.30	221,701	3,410	152,264,000
Thonburi	22.01	139,573	1,160	13,053	11.93	29.30	221,701	16,322	210,055,300
Bangrak	12.26	50,735	1,160	4,524	11.93	29.30	221,701	9,165	132,640,000
Bangken	39.51	177,062	1,160	16,568	11.93	29.30	221,701	4,203	180,807,300
Bangkapi	40.28	147,694	1,160	5,368	11.93	29.30	221,701	5,178	218,327,000
Bangkok-yai	13.70	82,676	1,160	5,660	11.93	29.30	221,701	13,378	141,472,500
Bangkok-noi	22.77	135,944	1,160	17,923	11.93	29.30	221,701	11,382	203,320,000
Bangkuntian	26.07	127,697	1,160	10,950	11.93	29.30	221,701	1,058	214,469,300
Bangplud	18.94	110,331	1,160	11,995	11.93	29.30	221,701	9,712	163,701,000
Bungkum	26.16	138,340	1,160	8,095	11.93	29.30	221,701	5,690	166,088,000
Bangsue	24.24	154,079	1,160	11,169	11.93	29.30	221,701	13,346	183,104,000
Bangkoleam	18.01	106,499	1,160	11,916	11.93	29.30	221,701	9,752	152,139,000
Bamgkae	35.80	186,744	1,160	8,712	11.93	29.30	221,701	4,201	242,129,000
Bangna	23.32	101,737	1,160	12,197	11.93	29.30	221,701	5,415	157,298,000
Bangbon	22.53	93,225	1,160	1,275	11.93	29.30	221,701	2,683	155,211,000
Patumwan	12.17	64,168	1,160	8,642	11.93	29.30	221,701	7,667	159,522,900
Pomprabsatrupai	10.08	61,220	1,160	2,835	11.93	29.30	221,701	31,704	119,263,300
Pravet	27.00	139,009	1,160	6,183	11.93	29.30	221,701	2,648	184,048,000
Pranakorn	9.71	69,188	1,160	5,345	11.93	29.30	221,701	12,498	184,323,800
Prakanong	18.34	98,957	1,160	6,766	11.93	29.30	221,701	7,075	149,243,000
Payathai	15.02	78,294	1,160	4,716	11.93	29.30	221,701	8,160	149,313,200
Pasicharoen	22.64	137,473	1,160	7,684	11.93	29.30	221,701	7,708	186,881,700
Minburi	20.33	115,212	1,160	8,214	11.93	29.30	221,701	1,810	180,528,900
Yanawa	19.03	88,986	1,160	4,715	11.93	29.30	221,701	5,341	176,942,600
Ratburana	16.80	95,041	1,160	4,820	11.93	29.30	221,701	6,022	159,508,500
Ratchathevee	16.01	103,086	1,160	4,720	11.93	29.30	221,701	14,466	151,793,000
Ladkrabang	25.51	134,834	1,160	13,710	11.93	29.30	221,701	1,089	232,388,000
Ladprao	22.17	116,305	1,160	5,879	11.93	29.30	221,701	5,321	163,331,000
Watana	22.47	80,217	1,160	2,954	11.93	29.30	221,701	6,384	150,739,000
Wangthonglang	25.22	113,166	1,160	3,329	11.93	29.30	221,701	5,784	156,604,400
Sampanthawong	6.93	32,194	1,160	2,204	11.93	29.30	221,701	22,736	107,468,500
Sathorn	17.29	96,714	1,160	7,479	11.93	29.30	221,701	10,370	138,472,000
Suanlaung	23.46	114,940	1,160	8,495	11.93	29.30	221,701	4,854	180,590,000
Saimai	34.90	161,749	1,160	16,360	11.93	29.30	221,701	3,625	178,303,600
Saphansoong	13.38	81,784	1,160	8,443	11.93	29.30	221,701	2,908	132,472,000
Nongjok	20.03	117,385	1,160	7,948	11.93	29.30	221,701	497	199,428,000
Huawkwang	17.24	76,452	1,160	4,366	11.93	29.30	221,701	5,086	166,162,200
Nongkam	22.59	125,545	1,160	7,673	11.93	29.30	221,701	3,504	170,499,300
Laksi	23.10	117,163	1,160	15,545	11.93	29.30	221,701	5,130	151,011,000

Year 2005

District	Y	x1	x2	x3	x4	x5	x6	x7	x8
Klongsan	15.38	87,853	1,651	10,942	11.98	29.10	201,378	14,519	152,550,900
Klongtoei	26.59	122,919	1,651	7,480	11.98	29.10	201,378	9,460	186,702,000
Kannayao	15.17	84,080	1,651	4,920	11.98	29.10	201,378	3,236	133,939,000
Kolngsamwa	26.27	132,172	1,651	21,853	11.98	29.10	201,378	1,194	180,334,000
Jatujak	40.25	169,113	1,651	7,467	11.98	29.10	201,378	5,139	246,001,000
Jomthong	30.48	167,175	1,651	9,318	11.98	29.10	201,378	6,365	208,501,000
Dusit	15.93	121,336	1,651	8,341	11.98	29.10	201,378	11,377	197,303,100
Dindang	25.84	146,031	1,651	4,630	11.98	29.10	201,378	17,480	200,944,700
Donmaung	31.19	159,506	1,651	18,076	11.98	29.10	201,378	4,334	197,177,000
Talingchan	18.10	105,730	1,651	4,460	11.98	29.10	201,378	3,587	167,920,000
Taweewatana	14.42	66,354	1,651	1,908	11.98	29.10	201,378	1,321	154,133,000
Toongkru	21.30	107,609	1,651	6,396	11.98	29.10	201,378	3,501	154,115,000
Thonburi	22.83	136,971	1,651	13,053	11.98	29.10	201,378	16,018	200,192,000
Bangrak	12.84	50,023	1,651	4,524	11.98	29.10	201,378	9,036	195,393,000
Bangken	41.05	178,986	1,651	17,086	11.98	29.10	201,378	4,249	204,043,200
Bangkapi	43.29	149,093	1,651	5,565	11.98	29.10	201,378	5,227	146,569,900
Bangkok-yai	14.03	81,727	1,651	5,660	11.98	29.10	201,378	13,224	211,227,000
Bangkok-noi	23.56	133,669	1,651	19,073	11.98	29.10	201,378	11,191	162,209,100
Bangkuntian	28.25	132,313	1,651	10,950	11.98	29.10	201,378	1,096	222,693,100
Bangplud	19.51	108,597	1,651	12,096	11.98	29.10	201,378	9,560	154,838,000
Bungkum	27.68	138,501	1,651	8,354	11.98	29.10	201,378	5,697	168,829,000
Bangsue	25.05	151,788	1,651	11,169	11.98	29.10	201,378	13,148	186,200,000
Bangkoleam	18.87	105,685	1,651	11,916	11.98	29.10	201,378	9,677	129,251,800
Bamgkae	37.75	189,257	1,651	9,224	11.98	29.10	201,378	4,257	158,410,000
Bangna	24.58	101,667	1,651	12,453	11.98	29.10	201,378	5,411	138,470,000
Bangbon	23.72	96,723	1,651	1,275	11.98	29.10	201,378	2,784	129,305,000
Patumwan	12.64	63,192	1,651	8,711	11.98	29.10	201,378	7,551	189,304,000
Pomprabsatrupai	10.40	60,001	1,651	2,835	11.98	29.10	201,378	31,073	139,027,000
Pravet	29.32	142,633	1,651	6,263	11.98	29.10	201,378	2,717	177,040,000
Pranakorn	9.99	67,357	1,651	5,345	11.98	29.10	201,378	12,167	196,022,300
Prakanong	19.09	98,564	1,651	6,952	11.98	29.10	201,378	7,047	161,820,700
Payathai	16.11	77,232	1,651	5,462	11.98	29.10	201,378	8,049	183,825,000
Pasicharoen	22.87	136,240	1,651	8,506	11.98	29.10	201,378	7,639	165,996,800
Minburi	21.94	118,019	1,651	8,940	11.98	29.10	201,378	1,854	154,668,800
Yanawa	20.73	88,556	1,651	4,765	11.98	29.10	201,378	5,315	157,097,000
Ratburana	17.47	94,097	1,651	4,119	11.98	29.10	201,378	5,962	241,032,000
Ratchathevee	16.64	99,827	1,651	5,520	11.98	29.10	201,378	14,009	170,733,300
Ladkrabang	27.02	138,327	1,651	13,710	11.98	29.10	201,378	1,117	162,152,400
Ladprao	23.64	117,711	1,651	6,769	11.98	29.10	201,378	5,386	139,917,000
Watana	23.84	80,121	1,651	2,954	11.98	29.10	201,378	6,377	179,264,700
Wangthonglang	25.63	114,132	1,651	3,409	11.98	29.10	201,378	5,833	194,234,400
Sampanthawong	7.14	31,674	1,651	2,136	11.98	29.10	201,378	22,369	112,939,900
Sathorn	17.78	95,089	1,651	7,479	11.98	29.10	201,378	10,196	145,755,000
Suanlaung	24.98	115,120	1,651	9,321	11.98	29.10	201,378	4,862	133,797,400
Saimai	36.87	165,491	1,651	16,625	11.98	29.10	201,378	3,709	145,155,000
Saphansoong	14.24	83,147	1,651	8,508	11.98	29.10	201,378	2,956	133,791,400
Nongjok	22.26	126,126	1,651	8,077	11.98	29.10	201,378	534	213,055,000
Huawkwang	18.62	76,213	1,651	4,366	11.98	29.10	201,378	5,070	173,018,300
Nongkam	23.78	128,493	1,651	8,220	11.98	29.10	201,378	3,587	187,131,000
Laksi	24.07	116,713	1,651	15,545	11.98	29.10	201,378	5,110	158,778,000

Year 2006

District	Y	x1	x2	x3	x4	x5	x6	x7	x8
Klongsan	15.59	86,163	1,599	10,942	12.00	29.30	208,631	14,239	172,068,900
Klongtoei	26.99	121,504	1,599	22,538	12.00	29.30	208,631	9,351	204,892,000
Kannayao	15.66	84,562	1,599	6,208	12.00	29.30	208,631	3,255	145,191,800
Kolngsamwa	27.51	138,962	1,599	7,637	12.00	29.30	208,631	1,255	190,630,070
Jatujak	41.05	167,837	1,599	9,719	12.00	29.30	208,631	5,100	255,331,700
Jomthong	31.05	166,377	1,599	10,037	12.00	29.30	208,631	6,335	214,078,200
Dusit	16.12	119,927	1,599	8,484	12.00	29.30	208,631	11,245	220,008,700
Dindang	26.40	144,461	1,599	4,960	12.00	29.30	208,631	17,292	192,275,300
Donmaung	32.56	161,600	1,599	19,007	12.00	29.30	208,631	4,391	194,999,300
Talingchan	18.65	106,811	1,599	5,072	12.00	29.30	208,631	3,623	173,880,500
Taweewatana	15.05	68,423	1,599	2,319	12.00	29.30	208,631	1,362	151,855,700
Toongkru	22.18	110,469	1,599	6,396	12.00	29.30	208,631	3,594	159,285,200
Thonburi	23.05	134,589	1,599	13,725	12.00	29.30	208,631	15,740	222,272,300
Bangrak	13.12	49,730	1,599	4,524	12.00	29.30	208,631	8,983	130,244,500
Bangken	42.11	181,390	1,599	19,777	12.00	29.30	208,631	4,306	204,237,500
Bangkapi	43.78	149,860	1,599	5,634	12.00	29.30	208,631	5,254	234,558,600
Bangkok-yai	14.07	80,863	1,599	5,660	12.00	29.30	208,631	13,085	151,992,500
Bangkok-noi	23.76	132,394	1,599	19,073	12.00	29.30	208,631	11,085	217,445,700
Bangkuntian	29.68	137,934	1,599	10,950	12.00	29.30	208,631	1,143	246,229,800
Bangplud	20.10	107,139	1,599	12,342	12.00	29.30	208,631	9,431	185,440,900
Bungkum	30.17	140,580	1,599	8,293	12.00	29.30	208,631	5,783	165,650,100
Bangsue	25.55	150,547	1,599	11,473	12.00	29.30	208,631	13,040	188,500,800
Bangkoleam	18.98	104,479	1,599	11,916	12.00	29.30	208,631	9,567	183,444,300
Bamgkae	39.24	191,521	1,599	9,076	12.00	29.30	208,631	4,308	247,684,000
Bangna	25.15	101,695	1,599	13,325	12.00	29.30	208,631	5,412	166,469,900
Bangbon	24.52	99,348	1,599	1,275	12.00	29.30	208,631	2,859	143,125,400
Patumwan	12.76	62,102	1,599	8,711	12.00	29.30	208,631	7,420	189,511,700
Pomprabsatrupai	10.50	58,768	1,599	2,835	12.00	29.30	208,631	30,434	139,502,900
Pravet	30.79	146,401	1,599	7,814	12.00	29.30	208,631	2,789	210,125,000
Pranakorn	10.07	65,835	1,599	5,345	12.00	29.30	208,631	11,892	213,036,700
Prakanong	19.45	98,096	1,599	6,952	12.00	29.30	208,631	7,014	163,349,500
Payathai	16.70	77,343	1,599	4,819	12.00	29.30	208,631	8,061	169,687,800
Pasicharoen	23.72	135,149	1,599	9,197	12.00	29.30	208,631	7,578	200,491,700
Minburi	24.62	122,825	1,599	10,153	12.00	29.30	208,631	1,930	207,983,400
Yanawa	21.87	88,383	1,599	4,865	12.00	29.30	208,631	5,304	185,500,900
Ratburana	17.68	93,548	1,599	5,520	12.00	29.30	208,631	5,928	172,673,900
Ratchathevee	17.70	98,601	1,599	4,119	12.00	29.30	208,631	13,837	169,673,900
Ladkrabang	29.05	142,460	1,599	14,735	12.00	29.30	208,631	1,150	245,135,700
Ladprao	24.54	119,168	1,599	10,068	12.00	29.30	208,631	5,452	182,653,500
Watana	25.32	80,596	1,599	2,954	12.00	29.30	208,631	6,414	173,845,000
Wangthonglang	26.19	114,950	1,599	3,409	12.00	29.30	208,631	5,875	150,762,500
Sampanthawong	7.20	31,142	1,599	2,298	12.00	29.30	208,631	21,993	122,315,500
Sathorn	18.39	93,808	1,599	7,665	12.00	29.30	208,631	10,059	159,117,300
Suanlaung	26.15	115,490	1,599	9,419	12.00	29.30	208,631	4,878	196,800,500
Saimai	39.31	169,109	1,599	16,873	12.00	29.30	208,631	3,790	200,146,700
Saphansoong	14.82	84,934	1,599	8,582	12.00	29.30	208,631	3,020	144,564,500
Nongjok	23.62	133,415	1,599	10,614	12.00	29.30	208,631	565	226,316,300
Huawkwang	20.59	76,402	1,599	4,426	12.00	29.30	208,631	5,082	186,679,800
Nongkam	25.30	131,344	1,599	10,843	12.00	29.30	208,631	3,666	184,687,600
Laksi	24.47	116,922	1,599	15,891	12.00	29.30	208,631	5,119	180,416,300

Year 2007

District	Y	x1	x2	x3	x4	x5	x6	x7	x8
Klongsan	15.89	84,821	1,684	10,942	12.03	29.10	213,565	14,018	150,053,685
Klongtoei	28.29	119,909	1,684	22,538	12.03	29.10	213,565	9,228	184,929,785
Kannayao	16.11	85,027	1,684	6,548	12.03	29.10	213,565	3,273	132,993,603
Kolngsamwa	28.99	144,423	1,684	11,020	12.03	29.10	213,565	1,305	179,746,152
Jatujak	42.55	166,581	1,684	8,426	12.03	29.10	213,565	5,062	245,647,091
Jomthong	31.78	165,070	1,684	9,968	12.03	29.10	213,565	6,285	208,351,815
Dusit	16.43	117,867	1,684	8,484	12.03	29.10	213,565	11,052	194,690,144
Dindang	27.01	141,765	1,684	4,960	12.03	29.10	213,565	16,970	200,570,674
Donmaung	33.35	163,080	1,684	19,079	12.03	29.10	213,565	4,431	197,152,949
Talingchan	19.35	107,812	1,684	5,650	12.03	29.10	213,565	3,657	167,708,426
Taweewatana	15.70	70,196	1,684	2,319	12.03	29.10	213,565	1,398	154,099,353
Toongkru	23.01	111,621	1,684	6,396	12.03	29.10	213,565	3,631	153,941,552
Thonburi	24.33	132,034	1,684	13,725	12.03	29.10	213,565	15,441	197,756,640
Bangrak	13.45	49,124	1,684	4,985	12.03	29.10	213,565	8,874	173,670,998
Bangken	43.66	182,335	1,684	21,113	12.03	29.10	213,565	4,329	204,043,015
Bangkapi	46.05	150,139	1,684	5,983	12.03	29.10	213,565	5,264	93,748,609
Bangkok-yai	14.28	79,637	1,684	5,660	12.03	29.10	213,565	12,886	194,615,838
Bangkok-noi	24.59	130,540	1,684	19,073	12.03	29.10	213,565	10,929	143,399,539
Bangkuntian	31.21	141,698	1,684	10,950	12.03	29.10	213,565	1,174	220,205,478
Bangplud	20.72	105,347	1,684	12,342	12.03	29.10	213,565	9,274	148,789,501
Bungkum	32.78	145,172	1,684	8,293	12.03	29.10	213,565	5,971	168,769,144
Bangsue	25.75	147,797	1,684	11,473	12.03	29.10	213,565	12,802	186,171,570
Bangkoleam	20.37	103,391	1,684	11,916	12.03	29.10	213,565	9,467	106,530,050
Bamgkae	40.40	192,597	1,684	9,421	12.03	29.10	213,565	4,332	108,098,485
Bangna	25.96	101,360	1,684	13,325	12.03	29.10	213,565	5,395	132,808,164
Bangbon	25.56	101,263	1,684	1,275	12.03	29.10	213,565	2,914	127,827,846
Patumwan	32.55	61,040	1,684	8,711	12.03	29.10	213,565	7,294	189,303,772
Pomprabsatrupai	13.47	57,461	1,684	2,754	12.03	29.10	213,565	29,757	139,025,371
Pravet	10.67	149,883	1,684	7,814	12.03	29.10	213,565	2,855	170,857,119
Pranakorn	20.02	64,356	1,684	5,345	12.03	29.10	213,565	11,625	194,545,479
Prakanong	17.87	98,496	1,684	6,952	12.03	29.10	213,565	7,042	161,806,257
Payathai	10.22	77,202	1,684	5,049	12.03	29.10	213,565	8,046	182,737,768
Pasicharoen	25.09	134,407	1,684	9,197	12.03	29.10	213,565	7,537	158,828,601
Minburi	25.73	127,727	1,684	10,493	12.03	29.10	213,565	2,007	136,291,166
Yanawa	22.99	88,061	1,684	5,959	12.03	29.10	213,565	5,285	151,961,437
Ratburana	18.72	97,747	1,684	5,520	12.03	29.10	213,565	5,888	221,645,239
Ratchathevee	18.04	92,929	1,684	4,933	12.03	29.10	213,565	13,717	170,726,726
Ladkrabang	33.50	144,800	1,684	14,761	12.03	29.10	213,565	1,169	119,684,770
Ladprao	25.52	120,417	1,684	10,245	12.03	29.10	213,565	5,509	126,863,487
Watana	26.93	80,744	1,684	2,954	12.03	29.10	213,565	5,877	179,100,847
Wangthonglang	26.71	114,984	1,684	3,769	12.03	29.10	213,565	6,426	184,504,887
Sampanthawong	40.94	30,646	1,684	2,204	12.03	29.10	213,565	21,643	112,161,593
Sathorn	26.86	92,021	1,684	7,665	12.03	29.10	213,565	9,867	144,529,992
Suanlaung	18.84	116,293	1,684	9,419	12.03	29.10	213,565	4,911	104,130,227
Saimai	15.33	173,076	1,684	17,414	12.03	29.10	213,565	3,879	124,321,497
Saphansoong	7.35	86,043	1,684	8,687	12.03	29.10	213,565	3,059	132,923,933
Nongjok	25.17	138,667	1,684	10,836	12.03	29.10	213,565	587	212,229,570
Huawkwang	27.00	77,033	1,684	4,426	12.03	29.10	213,565	5,081	171,939,590
Nongkam	25.03	135,554	1,684	11,589	12.03	29.10	213,565	3,784	187,099,096
Laksi	21.89	116,055	1,684	15,891	12.03	29.10	213,565	5,124	155,829,128

Appendix C

Table of forecasting value for next 10 year by double exponential smoothing method

This forecasting have made by MINITAB program in term of double smoothing method(ARIMA optimal) for year 2009 to 2019.

By X_1= Number of population in each district of Bangkok (people).

X_2= Precipitation volume. (Millimeter/year)

X_3= Number of family. (Family)

X_4= Selling price of water.(Baht)

X_5= Average temperature of Bangkok.(Degree Celsius)

X_6= Income per person/family.(Baht / year)

X_7 = Density of person(Person/square kilometers)

X_8 = Estimated budget for each district of BMA per year.(Baht/year)

Y = Water consumption volume deducted loss.(Million cubic meters/year).

Year 2009

District	x1	x2	x3	x4	x5	x6	x7	x8
Klongsan	81,277	1,452	10,958	12.91	29.26	222,525	13,432	156,945,496
Klongtoei	116,059	1,452	23,557	12.91	29.26	222,525	8,932	165,677,536
Kannayao	85,578	1,452	6,968	12.91	29.26	222,525	3,294	125,735,704
Klongsamwa	150,906	1,452	15,409	12.91	29.26	222,525	1,366	191,937,952
Jatujak	165,826	1,452	8,752	12.91	29.26	222,525	5,239	236,158,431
Jomthong	164,534	1,452	10,336	12.91	29.26	222,525	6,130	211,252,724
Dusit	113,768	1,452	8,556	12.91	29.26	222,525	10,668	206,003,454
Dindeang	138,378	1,452	4,920	12.91	29.26	222,525	14,440	205,908,587
Donmaung	164,882	1,452	19,511	12.91	29.26	222,525	6,647	202,739,678
Talingchan	108,820	1,452	5,975	12.91	29.26	222,525	3,691	170,693,394
Tawewatana	72,022	1,452	2,140	12.91	29.26	222,525	1,434	155,185,293
Toongkru	113,032	1,452	6,758	12.91	29.26	222,525	3,718	152,951,651
Thonburi	124,722	1,452	13,864	12.91	29.26	222,525	14,586	205,676,379
Bangrak	47,545	1,452	5,447	12.91	29.26	222,525	7,993	170,418,970
Bangken	184,483	1,452	21,748	12.91	29.26	222,525	4,380	205,965,123
Bangkapi	151,499	1,452	6,438	12.91	29.26	222,525	5,312	112,569,295
Bangkok-yai	77,924	1,452	5,776	12.91	29.26	222,525	12,608	192,399,191
Bangkok-noi	126,316	1,452	20,245	12.91	29.26	222,525	10,576	150,725,512
Bangkuntian	145,463	1,452	10,959	12.91	29.26	222,525	1,205	196,131,567
Bangplud	102,833	1,452	12,524	12.91	29.26	222,525	9,052	165,171,032
Bungkum	147,542	1,452	8,403	12.91	29.26	222,525	6,069	171,188,180
Bangsue	145,076	1,452	11,503	12.91	29.26	222,525	12,567	188,192,938
Bangkoleam	100,759	1,452	12,565	12.91	29.26	222,525	9,227	123,049,834
Bangkea	193,995	1,452	10,098	12.91	29.26	222,525	4,363	118,625,703
Bangna	101,363	1,452	13,562	12.91	29.26	222,525	5,380	133,188,473
Bangbon	102,917	1,452	1,599	12.91	29.26	222,525	2,984	126,985,536
Patumwan	54,206	1,452	8,707	12.91	29.26	222,525	6,470	192,763,036
Pomprabsatrupai	55,501	1,452	2,810	12.91	29.26	222,525	28,742	141,220,529
Pravet	153,629	1,452	7,820	12.91	29.26	222,525	2,926	190,312,274
Pranakorn	62,439	1,452	5,348	12.91	29.26	222,525	11,279	181,189,976
Prakanong	99,189	1,452	5,196	12.91	29.26	222,525	7,090	163,244,964
Payathai	75,975	1,452	5,405	12.91	29.26	222,525	7,918	184,998,498
Pasicharoen	133,482	1,452	10,118	12.91	29.26	222,525	7,485	159,817,218
Minburi	131,744	1,452	11,248	12.91	29.26	222,525	2,070	147,563,240
Yannawa	87,599	1,452	5,911	12.91	29.26	222,525	5,257	151,575,887
Ratburana	101,512	1,452	5,629	12.91	29.26	222,525	5,838	219,331,969
Ratchadevee	87,620	1,452	4,962	12.91	29.26	222,525	13,579	175,982,604
Ladkrabang	148,205	1,452	14,875	12.91	29.26	222,525	1,195	132,647,196
Ladprao	121,943	1,452	2,960	12.91	29.26	222,525	5,589	133,345,292
Watana	121,943	1,452	2,954	12.91	29.26	222,525	5,418	183,482,348
Wangthonglang	117,669	1,452	3,682	12.91	29.26	222,525	6,224	180,061,492
Samphanthawong	29,849	1,452	2,210	12.91	29.26	222,525	21,080	104,539,917
Sathorn	90,170	1,452	7,763	12.91	29.26	222,525	9,668	132,572,340
Suanlaung	116,930	1,452	9,680	12.91	29.26	222,525	4,938	141,113,272
Saimai	176,575	1,452	17,817	12.91	29.26	222,525	3,958	136,102,514
Sapansoong	87,493	1,452	8,774	12.91	29.26	222,525	3,110	120,068,858
Nongjok	139,721	1,452	12,309	12.91	29.26	222,525	612	207,691,052
Huykwang	76,832	1,452	4,481	12.91	29.26	222,525	5,063	157,906,469
Nongkam	139,745	1,452	13,628	12.91	29.26	222,525	3,903	192,281,214
Laksi	116,072	1,452	16,327	12.91	29.26	222,525	5,112	130,500,602

Year 2010

District	x1	x2	x3	x4	x5	x6	x7	x8
Klongsan	78266	1444.26	10965	12.99	29.31	224487	12934	155502667
Klongtoei	113180	1444.26	24741	12.99	29.31	224487	8710	166240192
Kannayao	86200	1444.26	7522	12.99	29.31	224487	3317	126468281
Klongsamwa	158120	1444.26	16248	12.99	29.31	224487	1432	197446385
Jatujak	165147	1444.26	9078	12.99	29.31	224487	5240	234806328
Jomthong	163696	1444.26	10679	12.99	29.31	224487	6086	213252144
Dusit	110027	1444.26	8665	12.99	29.31	224487	10317	208047569
Dindeang	135302	1444.26	4862	12.99	29.31	224487	13944	212757740
Donmaung	166690	1444.26	20024	12.99	29.31	224487	6850	206974656
Talingchan	109829	1444.26	6270	12.99	29.31	224487	3725	172054639
Tawewatana	73854	1444.26	2231	12.99	29.31	224487	1476	156299368
Toongkru	114320	1444.26	7183	12.99	29.31	224487	3812	152613142
Thonburi	118592	1444.26	14028	12.99	29.31	224487	13869	205932910
Bangrak	46169	1444.26	5908	12.99	29.31	224487	7685	175445766
Bangken	186417	1444.26	23005	12.99	29.31	224487	4426	208662845
Bangkapi	152690	1444.26	6817	12.99	29.31	224487	5354	111369295
Bangkok-yai	76606	1444.26	5886	12.99	29.31	224487	12394	199804203
Bangkok-noi	122693	1444.26	20871	12.99	29.31	224487	10273	138387792
Bangkuntian	149377	1444.26	10963	12.99	29.31	224487	1237	197179360
Bangplud	100563	1444.26	12714	12.99	29.31	224487	8852	164360636
Bungkum	148517	1444.26	8510	12.99	29.31	224487	6108	173364638
Bangsue	142960	1444.26	11534	12.99	29.31	224487	12384	187539889
Bangkoleam	98701	1444.26	13188	12.99	29.31	224487	9038	112545584
Bangkea	195660	1444.26	10577	12.99	29.31	224487	4400	115625732
Bangna	101505	1444.26	13802	12.99	29.31	224487	5366	127606616
Bangbon	104560	1444.26	1693	12.99	29.31	224487	3059	127019877
Patumwan	49162	1444.26	8707	12.99	29.31	224487	5864	196968225
Pomprabsatrupai	53625	1444.26	2920	12.99	29.31	224487	27770	143882898
Pravet	157522	1444.26	7820	12.99	29.31	224487	3000	190452428
Pranakorn	60310	1444.26	5348	12.99	29.31	224487	10895	182578391
Prakanong	99715	1444.26	5723	12.99	29.31	224487	7126	164348933
Payathai	74859	1444.26	5753	12.99	29.31	224487	7802	190001356
Pasicharoen	132516	1444.26	10739	12.99	29.31	224487	7431	152135798
Minburi	135493	1444.26	11952	12.99	29.31	224487	2129	136714239
Yannawa	87129	1444.26	6183	12.99	29.31	224487	5229	145464975
Ratburana	107967	1444.26	5745	12.99	29.31	224487	5826	228082645
Ratchadevee	85029	1444.26	5082	12.99	29.31	224487	13428	179682209
Ladkrabang	151164	1444.26	15231	12.99	29.31	224487	1221	124981670
Ladprao	123569	1444.26	2967	12.99	29.31	224487	5654	129815964
Watana	80775	1444.26	2954	12.99	29.31	224487	5386	188001716
Wangthonglang	118940	1444.26	3760	12.99	29.31	224487	6345	182717717
Samphanthawong	29094	1444.26	2195	12.99	29.31	224487	20547	105412934
Sathorn	88334	1444.26	7851	12.99	29.31	224487	9471	133521332
Suanlaung	117549	1444.26	10121	12.99	29.31	224487	4964	121413253
Saimai	180230	1444.26	18218	12.99	29.31	224487	4040	124953915
Sapansoong	89214	1444.26	8836	12.99	29.31	224487	3171	119867957
Nongjok	140213	1444.26	13444	12.99	29.31	224487	639	210307048
Huykwang	76515	1444.26	4513	12.99	29.31	224487	5039	158301975
Nongkam	143443	1444.26	15394	12.99	29.31	224487	4014	196219534
Laksi	116000	1444.26	16753	12.99	29.31	224487	5099	131113334

Year 2011

District	x1	x2	x3	x4	x5	x6	x7	x8
Klongsan	75255	1436.03	10973	13.07	29.36	226449	12437	154059837
Klongtoei	110300	1436.03	25924	13.07	29.36	226449	8488	166802849
Kannayao	86822	1436.03	8077	13.07	29.36	226449	3341	127200858
Klongsamwa	165333	1436.03	17087	13.07	29.36	226449	1499	202954817
Jatujak	164469	1436.03	9404	13.07	29.36	226449	5241	233454225
Jomthong	162859	1436.03	11021	13.07	29.36	226449	6043	215251563
Dusit	106286	1436.03	8774	13.07	29.36	226449	9966	210091684
Dindeang	132227	1436.03	4803	13.07	29.36	226449	13447	219606894
Donmaung	168498	1436.03	20538	13.07	29.36	226449	7053	211209635
Talingchan	110838	1436.03	6566	13.07	29.36	226449	3760	173415884
Tawewatana	75687	1436.03	2322	13.07	29.36	226449	1518	157413443
Toongkru	115607	1436.03	7608	13.07	29.36	226449	3942	152274634
Thonburi	112463	1436.03	14193	13.07	29.36	226449	13153	206189442
Bangrak	44792	1436.03	6369	13.07	29.36	226449	7376	180472562
Bangken	188351	1436.03	24261	13.07	29.36	226449	4472	211360567
Bangkapi	153882	1436.03	7196	13.07	29.36	226449	5397	110459295
Bangkok-yai	75288	1436.03	5995	13.07	29.36	226449	12181	207209216
Bangkok-noi	119071	1436.03	21496	13.07	29.36	226449	9970	126050071
Bangkuntian	153291	1436.03	10967	13.07	29.36	226449	1269	198227154
Bangplud	98292	1436.03	12904	13.07	29.36	226449	8653	163550241
Bungkum	149492	1436.03	8616	13.07	29.36	226449	6148	175541096
Bangsue	140844	1436.03	11564	13.07	29.36	226449	12200	186886840
Bangkoleam	96642	1436.03	13811	13.07	29.36	226449	8850	102041334
Bangkea	197324	1436.03	11056	13.07	29.36	226449	4438	112468323
Bangna	101646	1436.03	14041	13.07	29.36	226449	5353	122024760
Bangbon	106202	1436.03	1787	13.07	29.36	226449	3134	127054218
Patumwan	44118	1436.03	8706	13.07	29.36	226449	5758	201173413
Pomprabsatrupai	51749	1436.03	3030	13.07	29.36	226449	26798	146545267
Pravet	161415	1436.03	7825	13.07	29.36	226449	3074	190592582
Pranakorn	58182	1436.03	5353	13.07	29.36	226449	10510	183966805
Prakanong	100240	1436.03	6250	13.07	29.36	226449	7163	165452903
Payathai	73742	1436.03	6101	13.07	29.36	226449	7686	195004215
Pasicharoen	131550	1436.03	11362	13.07	29.36	226449	7377	144454378
Minburi	139242	1436.03	12657	13.07	29.36	226449	2188	125865238
Yannawa	86660	1436.03	6455	13.07	29.36	226449	5201	139354063
Ratburana	114423	1436.03	5860	13.07	29.36	226449	5815	236833320
Ratchadevee	82438	1436.03	5202	13.07	29.36	226449	13277	183381814
Ladkrabang	154123	1436.03	15588	13.07	29.36	226449	1246	103951650
Ladprao	125196	1436.03	2969	13.07	29.36	226449	5720	116286637
Watana	80786	1436.03	2954	13.07	29.36	226449	5353	192521084
Wangthonglang	120211	1436.03	3838	13.07	29.36	226449	6465	185373942
Samphanthawong	28340	1436.03	2181	13.07	29.36	226449	20014	106285951
Sathorn	86498	1436.03	7940	13.07	29.36	226449	9274	134470325
Suanlaung	118168	1436.03	10562	13.07	29.36	226449	4990	103413467
Saimai	183885	1436.03	18618	13.07	29.36	226449	4122	113805315
Sapansoong	90934	1436.03	8897	13.07	29.36	226449	3232	119667056
Nongjok	143782	1436.03	14580	13.07	29.36	226449	666	212923044
Huykwang	76198	1436.03	4546	13.07	29.36	226449	5016	158697480
Nongkam	147140	1436.03	17159	13.07	29.36	226449	4125	200157854
Laksi	115927	1436.03	17179	13.07	29.36	226449	5085	131726065

Year 2012

District	x1	x2	x3	x4	x5	x6	x7	x8
Klongsan	72243	1427.8	10973	13.15	29.41	228411	11939	152617008
Klongtoei	107421	1427.8	27108	13.15	29.41	228411	8267	167365505
Kannayao	87443	1427.8	8632	13.15	29.41	228411	3365	127933435
Klongsamwa	172546	1427.8	17927	13.15	29.41	228411	1566	208463249
Jatujak	163791	1427.8	9730	13.15	29.41	228411	5242	232102122
Jomthong	162021	1427.8	11364	13.15	29.41	228411	5999	217250983
Dusit	102546	1427.8	8883	13.15	29.41	228411	9615	212135800
Dindeang	129152	1427.8	4745	13.15	29.41	228411	12950	226456047
Donmaung	170306	1427.8	21052	13.15	29.41	228411	7256	215444613
Talingchan	111847	1427.8	6862	13.15	29.41	228411	3794	174777129
Tawewatana	77519	1427.8	2413	13.15	29.41	228411	1560	158527518
Toongkru	116894	1427.8	8033	13.15	29.41	228411	4021	151936126
Thonburi	106333	1427.8	14358	13.15	29.41	228411	12436	206445974
Bangrak	43415	1427.8	6830	13.15	29.41	228411	7068	185499359
Bangken	190285	1427.8	25517	13.15	29.41	228411	4518	214058289
Bangkapi	155073	1427.8	7575	13.15	29.41	228411	5439	102540295
Bangkok-yai	73970	1427.8	6105	13.15	29.41	228411	11968	214614228
Bangkok-noi	115448	1427.8	22122	13.15	29.41	228411	9667	113712350
Bangkuntian	157204	1427.8	10975	13.15	29.41	228411	1301	199274947
Bangplud	96022	1427.8	13094	13.15	29.41	228411	8453	162739846
Bungkum	150466	1427.8	8723	13.15	29.41	228411	6188	177717555
Bangsue	138727	1427.8	11594	13.15	29.41	228411	12017	186233791
Bangkoleam	94584	1427.8	14434	13.15	29.41	228411	8662	98537084
Bangkea	198988	1427.8	11535	13.15	29.41	228411	4475	110875763
Bangna	101788	1427.8	14280	13.15	29.41	228411	5339	116442904
Bangbon	107844	1427.8	1881	13.15	29.41	228411	3209	127088560
Patumwan	39073	1427.8	8706	13.15	29.41	228411	5625	205378602
Pomprabsatrupai	49873	1427.8	3140	13.15	29.41	228411	25827	149207636
Pravet	165307	1427.8	7830	13.15	29.41	228411	3148	190732736
Pranakorn	56053	1427.8	5356	13.15	29.41	228411	10125	185355219
Prakanong	100766	1427.8	6777	13.15	29.41	228411	7200	166556872
Payathai	72625	1427.8	6449	13.15	29.41	228411	7569	200007074
Pasicharoen	130584	1427.8	11983	13.15	29.41	228411	7323	136772958
Minburi	142991	1427.8	13361	13.15	29.41	228411	2247	115016236
Yannawa	86190	1427.8	6727	13.15	29.41	228411	5173	133243151
Ratburana	120878	1427.8	5976	13.15	29.41	228411	5803	245583995
Ratchadevee	79847	1427.8	5322	13.15	29.41	228411	13126	187081419
Ladkrabang	157082	1427.8	15944	13.15	29.41	228411	1272	98951670
Ladprao	126822	1427.8	2973	13.15	29.41	228411	5785	107757309
Watana	80798	1427.8	2954	13.15	29.41	228411	5321	197040452
Wangthonglang	121482	1427.8	3916	13.15	29.41	228411	6585	188030167
Samphanthawong	27585	1427.8	2166	13.15	29.41	228411	19481	107158968
Sathorn	84662	1427.8	8029	13.15	29.41	228411	9077	135419317
Suanlaung	118787	1427.8	11004	13.15	29.41	228411	5016	98611788
Saimai	187539	1427.8	19018	13.15	29.41	228411	4204	102656716
Sapansoong	92655	1427.8	8959	13.15	29.41	228411	3294	119466155
Nongjok	145875	1427.8	15715	13.15	29.41	228411	692	215539039
Huykwang	75880	1427.8	4578	13.15	29.41	228411	4992	159092986
Nongkam	150838	1427.8	18925	13.15	29.41	228411	4237	204096174
Laksi	115854	1427.8	17605	13.15	29.41	228411	5072	132338797

Year 2013

District	x1	x2	x3	x4	x5	x6	x7	x8
Klongsan	69232	1419.56	10981	13.23	29.46	230373	11441	151174179
Klongtoei	104542	1419.56	28292	13.23	29.46	230373	8045	167928161
Kannayao	88065	1419.56	9187	13.23	29.46	230373	3389	128666013
Klongsamwa	179759	1419.56	18767	13.23	29.46	230373	1633	213971682
Jatujak	163112	1419.56	10056	13.23	29.46	230373	5243	230750019
Jomthong	161184	1419.56	11706	13.23	29.46	230373	5956	219250402
Dusit	98805	1419.56	8992	13.23	29.46	230373	9265	214179915
Dindeang	126077	1419.56	4687	13.23	29.46	230373	12454	233305200
Donmaung	172113	1419.56	21565	13.23	29.46	230373	7459	219679591
Talingchan	112856	1419.56	7157	13.23	29.46	230373	3828	176138374
Tawewatana	79352	1419.56	2505	13.23	29.46	230373	1602	159641592
Toongkru	118181	1419.56	8458	13.23	29.46	230373	4111	151597618
Thonburi	100204	1419.56	14522	13.23	29.46	230373	11719	206702505
Bangrak	42039	1419.56	7291	13.23	29.46	230373	6760	190526155
Bangken	192219	1419.56	26774	13.23	29.46	230373	4564	216756011
Bangkapi	156264	1419.56	7954	13.23	29.46	230373	5481	97569295
Bangkok-yai	72651	1419.56	6214	13.23	29.46	230373	11755	222019241
Bangkok-noi	111825	1419.56	22747	13.23	29.46	230373	9364	101374630
Bangkuntian	161118	1419.56	10982	13.23	29.46	230373	1334	200322740
Bangplud	93752	1419.56	13284	13.23	29.46	230373	8253	161929451
Bungkum	151441	1419.56	8830	13.23	29.46	230373	6228	179894013
Bangsue	136611	1419.56	11624	13.23	29.46	230373	11834	185580742
Bangkoleam	92526	1419.56	15057	13.23	29.46	230373	8473	96543584
Bangkea	200652	1419.56	12013	13.23	29.46	230373	4512	102463743
Bangna	101929	1419.56	14519	13.23	29.46	230373	5326	110861048
Bangbon	109487	1419.56	1975	13.23	29.46	230373	3285	127122901
Patumwan	34029	1419.56	8706	13.23	29.46	230373	5532	209583791
Pomprabsatrupai	47996	1419.56	3250	13.23	29.46	230373	24855	151870005
Pravet	169200	1419.56	7834	13.23	29.46	230373	3223	190872890
Pranakorn	53925	1419.56	5357	13.23	29.46	230373	9741	186743633
Prakanong	101291	1419.56	7304	13.23	29.46	230373	7237	167660842
Payathai	71508	1419.56	6797	13.23	29.46	230373	7453	205009933
Pasicharoen	129618	1419.56	12605	13.23	29.46	230373	7268	129091538
Minburi	146741	1419.56	14065	13.23	29.46	230373	2306	104167235
Yannawa	85720	1419.56	6998	13.23	29.46	230373	5144	127132239
Ratburana	127334	1419.56	6091	13.23	29.46	230373	5791	254334670
Ratchadevee	77256	1419.56	5442	13.23	29.46	230373	12975	190781024
Ladkrabang	160041	1419.56	16301	13.23	29.46	230373	1297	96451859
Ladprao	128448	1419.56	2978	13.23	29.46	230373	5850	99227981
Watana	80809	1419.56	2954	13.23	29.46	230373	5289	201559820
Wangthonglang	122752	1419.56	3995	13.23	29.46	230373	6705	190686391
Samphanthawong	26831	1419.56	2152	13.23	29.46	230373	18948	108031985
Sathorn	82826	1419.56	8118	13.23	29.46	230373	8880	136368310
Suanlaung	119407	1419.56	11445	13.23	29.46	230373	5043	90315643
Saimai	191194	1419.56	19418	13.23	29.46	230373	4286	99508116
Sapansoong	94376	1419.56	9021	13.23	29.46	230373	3355	119265254
Nongjok	147239	1419.56	16851	13.23	29.46	230373	719	218155035
Huykwang	75563	1419.56	4611	13.23	29.46	230373	4968	159488492
Nongkam	154536	1419.56	20691	13.23	29.46	230373	4348	208034493
Laksi	115782	1419.56	18032	13.23	29.46	230373	5059	132951529

Year 2014

District	x1	x2	x3	x4	x5	x6	x7	x8
Klongsan	66221	1411.33	10985	13.31	29.51	232336	10944	149731349
Klongtoei	101663	1411.33	29476	13.31	29.51	232336	7824	168490818
Kannayao	88686	1411.33	9742	13.31	29.51	232336	3413	129398590
Klongsamwa	186972	1411.33	19606	13.31	29.51	232336	1699	219480114
Jatujak	162434	1411.33	10382	13.31	29.51	232336	5244	229397916
Jomthong	160346	1411.33	12049	13.31	29.51	232336	5912	221249822
Dusit	95065	1411.33	9101	13.31	29.51	232336	8914	216224030
Dindeang	123001	1411.33	4629	13.31	29.51	232336	11957	240154353
Donmaung	173921	1411.33	22079	13.31	29.51	232336	7662	223914569
Talingchan	113865	1411.33	7453	13.31	29.51	232336	3862	177499619
Tawewatana	81184	1411.33	2596	13.31	29.51	232336	1644	160755667
Toongkru	119469	1411.33	8883	13.31	29.51	232336	4217	151259110
Thonburi	94075	1411.33	14687	13.31	29.51	232336	11002	206959037
Bangrak	40662	1411.33	7752	13.31	29.51	232336	6451	195552951
Bangken	194153	1411.33	28030	13.31	29.51	232336	4609	219453733
Bangkapi	157455	1411.33	8333	13.31	29.51	232336	5523	96569295
Bangkok-yai	71333	1411.33	6324	13.31	29.51	232336	11542	229424254
Bangkok-noi	108202	1411.33	23372	13.31	29.51	232336	9061	98936909
Bangkuntian	165032	1411.33	10989	13.31	29.51	232336	1366	201370534
Bangplud	91481	1411.33	13474	13.31	29.51	232336	8053	161119056
Bungkum	152416	1411.33	8936	13.31	29.51	232336	6268	182070471
Bangsue	134495	1411.33	11655	13.31	29.51	232336	11651	184927693
Bangkoleam	90467	1411.33	15680	13.31	29.51	232336	8285	91537084
Bangkea	202317	1411.33	12492	13.31	29.51	232336	4550	98625803
Bangna	102071	1411.33	14759	13.31	29.51	232336	5312	105279192
Bangbon	111129	1411.33	2069	13.31	29.51	232336	3360	127157243
Patumwan	28985	1411.33	8705	13.31	29.51	232336	5440	213788979
Pomprabsatrupai	46120	1411.33	3360	13.31	29.51	232336	23883	154532374
Pravet	173092	1411.33	7834	13.31	29.51	232336	3297	191013044
Pranakorn	49667	1411.33	5361	13.31	29.51	232336	9356	188132047
Prakanong	101817	1411.33	7830	13.31	29.51	232336	7274	168764811
Payathai	70392	1411.33	7146	13.31	29.51	232336	7337	210012791
Pasicharoen	128652	1411.33	13227	13.31	29.51	232336	7214	121410118
Minburi	150490	1411.33	14770	13.31	29.51	232336	2365	99318234
Yannawa	85251	1411.33	7270	13.31	29.51	232336	5116	121021327
Ratburana	133789	1411.33	6206	13.31	29.51	232336	5780	263085346
Ratchadevee	74665	1411.33	5562	13.31	29.51	232336	12824	194480628
Ladkrabang	163000	1411.33	16657	13.31	29.51	232336	1323	90357950
Ladprao	130075	1411.33	2981	13.31	29.51	232336	5916	90698653
Watana	80821	1411.33	2954	13.31	29.51	232336	5257	206079188
Wangthonglang	124023	1411.33	4073	13.31	29.51	232336	6825	193342616
Samphanthawong	26077	1411.33	2137	13.31	29.51	232336	18416	108905001
Sathorn	80990	1411.33	8207	13.31	29.51	232336	8683	137317302
Suanlaung	120026	1411.33	11886	13.31	29.51	232336	5069	89618764
Saimai	194849	1411.33	19818	13.31	29.51	232336	4368	90359533
Sapansoong	96096	1411.33	9082	13.31	29.51	232336	3416	119064353
Nongjok	149032	1411.33	17986	13.31	29.51	232336	746	220771031
Huykwang	75246	1411.33	4643	13.31	29.51	232336	4945	159883997
Nongkam	158233	1411.33	22457	13.31	29.51	232336	4460	211972813
Laksi	115709	1411.33	18458	13.31	29.51	232336	5045	133564260

Year 2015

District	x1	x2	x3	x4	x5	x6	x7	x8
Klongsan	63209	1403.1	10995	13.38	29.56	234298	10446	148288520
Klongtoei	98784	1403.1	30659	13.38	29.56	234298	7602	169053474
Kannayao	89308	1403.1	10296	13.38	29.56	234298	3436	130131167
Klongsamwa	194186	1403.1	20446	13.38	29.56	234298	1766	224988547
Jatujak	161756	1403.1	10708	13.38	29.56	234298	5245	228045813
Jomthong	159509	1403.1	12392	13.38	29.56	234298	5868	223249242
Dusit	91324	1403.1	9209	13.38	29.56	234298	8563	218268146
Dindeang	119926	1403.1	4571	13.38	29.56	234298	11460	247003506
Donmaung	175729	1403.1	22592	13.38	29.56	234298	7865	228149547
Talingchan	114874	1403.1	7749	13.38	29.56	234298	3896	178860864
Tawewatana	83017	1403.1	2687	13.38	29.56	234298	1686	161869742
Toongkru	120756	1403.1	9308	13.38	29.56	234298	4335	150920602
Thonburi	87945	1403.1	14851	13.38	29.56	234298	10286	207215569
Bangrak	39285	1403.1	8213	13.38	29.56	234298	6143	200579748
Bangken	196087	1403.1	29286	13.38	29.56	234298	4655	222151455
Bangkapi	158646	1403.1	8712	13.38	29.56	234298	5566	94569295
Bangkok-yai	70015	1403.1	6433	13.38	29.56	234298	11328	236829266
Bangkok-noi	104579	1403.1	23998	13.38	29.56	234298	8758	90699188
Bangkuntian	168946	1403.1	10993	13.38	29.56	234298	1398	202418327
Bangplud	89211	1403.1	13664	13.38	29.56	234298	7853	160308661
Bungkum	153391	1403.1	9043	13.38	29.56	234298	6307	184246929
Bangsue	132378	1403.1	11685	13.38	29.56	234298	11467	184274644
Bangkoleam	88409	1403.1	16304	13.38	29.56	234298	8097	89032834
Bangkea	203981	1403.1	12971	13.38	29.56	234298	4587	95624583
Bangna	102212	1403.1	14998	13.38	29.56	234298	5299	99697336
Bangbon	112771	1403.1	2163	13.38	29.56	234298	3435	127191584
Patumwan	23941	1403.1	8705	13.38	29.56	234298	5258	217994168
Pomprabsatrupai	44244	1403.1	3470	13.38	29.56	234298	22911	157194743
Pravet	176985	1403.1	7839	13.38	29.56	234298	3371	191153198
Pranakorn	49667	1403.1	5361	13.38	29.56	234298	8972	189520462
Prakanong	102342	1403.1	8357	13.38	29.56	234298	7311	169868781
Payathai	69275	1403.1	7494	13.38	29.56	234298	7221	215015650
Pasicharoen	127686	1403.1	13848	13.38	29.56	234298	7160	113728698
Minburi	154239	1403.1	15474	13.38	29.56	234298	2424	95358221
Yannawa	84781	1403.1	7542	13.38	29.56	234298	5088	114910415
Ratburana	140245	1403.1	6322	13.38	29.56	234298	5768	271836021
Ratchadevee	72074	1403.1	5682	13.38	29.56	234298	12673	198180233
Ladkrabang	165959	1403.1	17014	13.38	29.56	234298	1348	89560557
Ladprao	131701	1403.1	2981	13.38	29.56	234298	5981	89169325
Watana	80833	1403.1	2954	13.38	29.56	234298	5225	210598556
Wangthonglang	125294	1403.1	4151	13.38	29.56	234298	6946	195998841
Samphanthawong	25322	1403.1	2123	13.38	29.56	234298	17883	109778018
Sathorn	79154	1403.1	8296	13.38	29.56	234298	8486	138266295
Suanlaung	120645	1403.1	12328	13.38	29.56	234298	5095	83616788
Saimai	198504	1403.1	20219	13.38	29.56	234298	4450	89359517
Sapansoong	97817	1403.1	9144	13.38	29.56	234298	3477	118863452
Nongjok	150237	1403.1	19121	13.38	29.56	234298	772	223387027
Huykwang	74929	1403.1	4675	13.38	29.56	234298	4921	160279503
Nongkam	161931	1403.1	24223	13.38	29.56	234298	4571	215911133

Year 2016

District	x1	x2	x3	x4	x5	x6	x7	x8
Klongsan	60198	1394.87	11108	13.46	29.61	236260	9949	146845691
Klongtoei	95905	1394.87	31843	13.46	29.61	236260	7381	169616130
Kannayao	89930	1394.87	10851	13.46	29.61	236260	3460	130863744
Klongsamwa	201399	1394.87	21285	13.46	29.61	236260	1833	230496979
Jatujak	161077	1394.87	11034	13.46	29.61	236260	5247	226693711
Jomthong	158672	1394.87	12734	13.46	29.61	236260	5825	225248661
Dusit	87583	1394.87	9318	13.46	29.61	236260	8212	220312261
Dindeang	116851	1394.87	4512	13.46	29.61	236260	10964	253852659
Donmaung	177537	1394.87	23106	13.46	29.61	236260	8067	232384525
Talingchan	115883	1394.87	8044	13.46	29.61	236260	3930	180222109
Tawewatana	84850	1394.87	2778	13.46	29.61	236260	1728	162983817
Toongkru	122043	1394.87	9733	13.46	29.61	236260	4401	150582094
Thonburi	81816	1394.87	15016	13.46	29.61	236260	9569	207472101
Bangrak	37909	1394.87	8674	13.46	29.61	236260	5834	205606544
Bangken	198020	1394.87	30542	13.46	29.61	236260	4701	224849177
Bangkapi	159838	1394.87	9091	13.46	29.61	236260	5608	94254935
Bangkok-yai	68697	1394.87	6543	13.46	29.61	236260	11115	244234279
Bangkok-noi	100956	1394.87	24623	13.46	29.61	236260	8455	89361468
Bangkuntian	172859	1394.87	10998	13.46	29.61	236260	1430	203466120
Bangplud	86941	1394.87	13854	13.46	29.61	236260	7653	159498265
Bungkum	154365	1394.87	9150	13.46	29.61	236260	6347	186423387
Bangsue	130262	1394.87	11715	13.46	29.61	236260	11284	183621595
Bangkoleam	86350	1394.87	16927	13.46	29.61	236260	7909	85062854
Bangkea	205645	1394.87	13450	13.46	29.61	236260	4625	90628203
Bangna	102354	1394.87	15237	13.46	29.61	236260	5286	94115480
Bangbon	114414	1394.87	2257	13.46	29.61	236260	3510	127225926
Patumwan	18896	1394.87	8704	13.46	29.61	236260	5012	222199357
Pomprabsatrupai	42368	1394.87	3579	13.46	29.61	236260	21940	159857112
Pravet	180878	1394.87	7842	13.46	29.61	236260	3445	191293352
Pranakorn	47539	1394.87	5380	13.46	29.61	236260	8587	190908876
Prakanong	102868	1394.87	8884	13.46	29.61	236260	7348	170972751
Payathai	68158	1394.87	7842	13.46	29.61	236260	7104	220018509
Pasicharoen	126720	1394.87	14470	13.46	29.61	236260	7106	106047278
Minburi	157988	1394.87	16179	13.46	29.61	236260	2483	90348225
Yannawa	84312	1394.87	7814	13.46	29.61	236260	5060	108799503
Ratburana	146700	1394.87	6437	13.46	29.61	236260	5756	280586696
Ratchadevee	69483	1394.87	5802	13.46	29.61	236260	12522	201879838
Ladkrabang	168918	1394.87	17370	13.46	29.61	236260	1374	83271629
Ladprao	133327	1394.87	2984	13.46	29.61	236260	6047	87639997
Watana	80844	1394.87	2954	13.46	29.61	236260	5193	215117924
Wangthonglang	126565	1394.87	4229	13.46	29.61	236260	7066	198655066
Samphanthawong	24568	1394.87	2108	13.46	29.61	236260	17350	110651035
Sathorn	77318	1394.87	8385	13.46	29.61	236260	8289	139215287
Suanlaung	121264	1394.87	12769	13.46	29.61	236260	5121	81416698
Saimai	202159	1394.87	20619	13.46	29.61	236260	4532	85349527
Sapansoong	99537	1394.87	9206	13.46	29.61	236260	3538	118662551
Nongjok	151346	1394.87	20257	13.46	29.61	236260	799	226003023
Huykwang	74612	1394.87	4708	13.46	29.61	236260	4898	160675009
Nongkam	165629	1394.87	25989	13.46	29.61	236260	4683	219849452
Laksi	115564	1394.87	19310	13.46	29.61	236260	5019	134789724

Year 2017

District	x1	x2	x3	x4	x5	x6	x7	x8
Klongsan	57187	1386.63	11113	13.54	29.66	238222	9451	145402861
Klongtoei	93026	1386.63	33027	13.54	29.66	238222	7159	170178786
Kannayao	90551	1386.63	11406	13.54	29.66	238222	3484	131596321
Klongsamwa	208612	1386.63	22125	13.54	29.66	238222	1900	236005412
Jatujak	160399	1386.63	11360	13.54	29.66	238222	5248	225341608
Jomthong	157834	1386.63	13077	13.54	29.66	238222	5781	227248081
Dusit	83843	1386.63	9427	13.54	29.66	238222	7862	222356377
Dindeang	113776	1386.63	4454	13.54	29.66	238222	10467	260701813
Donmaung	179344	1386.63	23619	13.54	29.66	238222	8270	236619503
Talingchan	116892	1386.63	8340	13.54	29.66	238222	3965	181583354
Tawewatana	86682	1386.63	2869	13.54	29.66	238222	1770	164097891
Toongkru	123330	1386.63	10158	13.54	29.66	238222	4519	150243586
Thonburi	75686	1386.63	15181	13.54	29.66	238222	8852	207728632
Bangrak	36532	1386.63	9135	13.54	29.66	238222	5526	210633340
Bangken	199954	1386.63	31799	13.54	29.66	238222	4747	227546899
Bangkapi	161029	1386.63	9470	13.54	29.66	238222	5650	92379395
Bangkok-yai	67379	1386.63	6652	13.54	29.66	238222	10902	251639291
Bangkok-noi	97334	1386.63	25249	13.54	29.66	238222	8151	82367668
Bangkuntian	176773	1386.63	11008	13.54	29.66	238222	1462	204513914
Bangplud	84671	1386.63	14044	13.54	29.66	238222	7453	158687870
Bungkum	155340	1386.63	9256	13.54	29.66	238222	6387	188599846
Bangsue	128146	1386.63	11745	13.54	29.66	238222	11101	182968546
Bangkoleam	84292	1386.63	17550	13.54	29.66	238222	7720	81032834
Bangkea	207309	1386.63	13929	13.54	29.66	238222	4662	86624501
Bangna	102495	1386.63	15477	13.54	29.66	238222	5272	88533624
Bangbon	116056	1386.63	2351	13.54	29.66	238222	3585	127260267
Patumwan	13852	1386.63	8704	13.54	29.66	238222	4852	226404545
Pomprabsatrupai	40492	1386.63	3689	13.54	29.66	238222	20968	162519481
Pravet	184770	1386.63	7848	13.54	29.66	238222	3519	191433506
Pranakorn	45410	1386.63	5396	13.54	29.66	238222	8203	192297290
Prakanong	103393	1386.63	9411	13.54	29.66	238222	7385	172076720
Payathai	67041	1386.63	8190	13.54	29.66	238222	6988	225021367
Pasicharoen	125754	1386.63	15092	13.54	29.66	238222	7052	98365858
Minburi	161738	1386.63	16883	13.54	29.66	238222	2542	88439233
Yannawa	83842	1386.63	8086	13.54	29.66	238222	5031	102688591
Ratburana	153115	1386.63	6553	13.54	29.66	238222	5745	289337372
Ratchadevee	66892	1386.63	5922	13.54	29.66	238222	12371	20557944
Ladkrabang	171877	1386.63	17727	13.54	29.66	238222	1399	80721629
Ladprao	134954	1386.63	2987	13.54	29.66	238222	6112	83110670
Watana	80856	1386.63	2954	13.54	29.66	238222	5161	219637292
Wangthonglang	127836	1386.63	4307	13.54	29.66	238222	7186	201311290
Samphanthawong	23813	1386.63	2094	13.54	29.66	238222	16817	111524052
Sathorn	75482	1386.63	8474	13.54	29.66	238222	8092	140164280
Suanlaung	121883	1386.63	13210	13.54	29.66	238222	5147	80489736
Saimai	205813	1386.63	21019	13.54	29.66	238222	4614	80359517
Sapansoong	101258	1386.63	9267	13.54	29.66	238222	3599	118461650
Nongjok	152098	1386.63	21392	13.54	29.66	238222	826	228619019
Huykwang	74295	1386.63	4740	13.54	29.66	238222	4874	161070514
Nongkam	169326	1386.63	27755	13.54	29.66	238222	4794	223787772
Laksi	115491	1386.63	19736	13.54	29.66	238222	5005	135402455

Year 2018

District	x1	x2	x3	x4	x5	x6	x7	x8
Klongsan	54175	1378.4	11120	13.62	29.71	240185	8953	143960032
Klongtoei	90146	1378.4	34211	13.62	29.71	240185	6937	170741443
Kannayao	91173	1378.4	11961	13.62	29.71	240185	3508	132328898
Klongsamwa	215825	1378.4	22964	13.62	29.71	240185	1966	241513844
Jatujak	159721	1378.4	11686	13.62	29.71	240185	5249	223989505
Jomthong	156997	1378.4	13420	13.62	29.71	240185	5738	229247501
Dusit	80102	1378.4	9536	13.62	29.71	240185	7511	224400492
Dindeang	110701	1378.4	4396	13.62	29.71	240185	9970	267550966
Donmaung	181152	1378.4	24133	13.62	29.71	240185	8473	240854482
Talingchan	117901	1378.4	8636	13.62	29.71	240185	3999	182944599
Tawewatana	88515	1378.4	2960	13.62	29.71	240185	1812	165211966
Toongkru	124618	1378.4	10583	13.62	29.71	240185	4608	149905078
Thonburi	69557	1378.4	15346	13.62	29.71	240185	8135	207985164
Bangrak	35155	1378.4	9596	13.62	29.71	240185	5218	215660136
Bangken	201888	1378.4	33055	13.62	29.71	240185	4793	230244621
Bangkapi	162220	1378.4	9849	13.62	29.71	240185	5692	90369394
Bangkok-yai	66060	1378.4	6762	13.62	29.71	240185	10689	259044304
Bangkok-noi	93711	1378.4	25874	13.62	29.71	240185	7848	80361468
Bangkuntian	180687	1378.4	11019	13.62	29.71	240185	1495	205561707
Bangplud	82400	1378.4	14234	13.62	29.71	240185	7254	157877475
Bungkum	156315	1378.4	9363	13.62	29.71	240185	6427	190776304
Bangsue	126029	1378.4	11775	13.62	29.71	240185	10918	182315497
Bangkoleam	82233	1378.4	18173	13.62	29.71	240185	7532	79528584
Bangkea	208974	1378.4	14408	13.62	29.71	240185	4700	80534801
Bangna	102637	1378.4	15716	13.62	29.71	240185	5259	82951768
Bangbon	117698	1378.4	2445	13.62	29.71	240185	3661	127294609
Patumwan	8808	1378.4	8704	13.62	29.71	240185	4652	230609734
Pomprabsatrupai	38615	1378.4	3799	13.62	29.71	240185	19996	165181850
Pravet	188663	1378.4	7850	13.62	29.71	240185	3593	191573660
Pranakorn	43282	1378.4	5404	13.62	29.71	240185	7818	193685704
Prakanong	103919	1378.4	9938	13.62	29.71	240185	7422	173180690
Payathai	65925	1378.4	8538	13.62	29.71	240185	6872	230024226
Pasicharoen	124788	1378.4	15714	13.62	29.71	240185	6998	90684438
Minburi	165487	1378.4	17588	13.62	29.71	240185	2601	82469236
Yannawa	83372	1378.4	8358	13.62	29.71	240185	5003	96577679
Ratburana	159611	1378.4	6668	13.62	29.71	240185	5733	298088047
Ratchadevee	64301	1378.4	6042	13.62	29.71	240185	12220	209279048
Ladkrabang	174836	1378.4	18083	13.62	29.71	240185	1425	79256103
Ladprao	136580	1378.4	2989	13.62	29.71	240185	6177	80581342
Watana	80867	1378.4	2954	13.62	29.71	240185	5129	224156660
Wangthonglang	129107	1378.4	4386	13.62	29.71	240185	7306	203967515
Samphanthawong	23059	1378.4	2079	13.62	29.71	240185	16284	112397069
Sathorn	73645	1378.4	8563	13.62	29.71	240185	7895	141113272
Suanlaung	122502	1378.4	13652	13.62	29.71	240185	5173	78210456
Saimai	209468	1378.4	21419	13.62	29.71	240185	4696	79210917
Sapansoong	102978	1378.4	9329	13.62	29.71	240185	3660	118260749
Nongjok	153876	1378.4	22528	13.62	29.71	240185	853	23123501
Huykwang	73978	1378.4	4773	13.62	29.71	240185	4850	161466020
Nongkam	173024	1378.4	29521	13.62	29.71	240185	4906	227726092
Laksi	115418	1378.4	20162	13.62	29.71	240185	4992	136015187

Year 2019

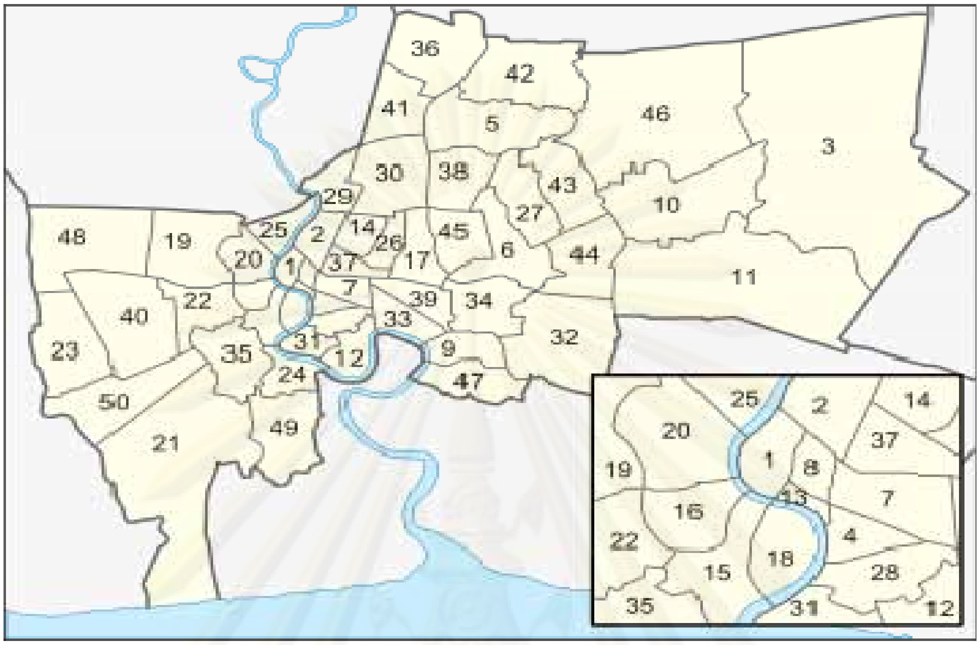
District	x1	x2	x3	x4	x5	x6	x7	x8
Klongsan	50561.82	1368.52	11149.4	13.71752	29.76758	242539.8	8356.1	142228636.8
Klongtoei	86691	1368.52	35631.1	13.71752	29.76758	242539.8	6671.436	171416630.6
Kannayao	91918.6	1368.52	12626.32	13.71752	29.76758	242539.8	3536.194	133207990.6
Klongsamwa	224480.8	1368.52	23971.52	13.71752	29.76758	242539.8	2046.374	248123963
Jatujak	158907	1368.52	12077.02	13.71752	29.76758	242539.8	5250.152	222366981.6
Jomthong	155992.2	1368.52	13830.76	13.71752	29.76758	242539.8	5685.496	231646804.6
Dusit	75613.2	1368.52	9666.52	13.71752	29.76758	242539.8	7089.78	226853430.4
Dindeang	107010.8	1368.52	4326.254	13.71752	29.76758	242539.8	9374.16	275769949.8
Donmaung	183321.2	1368.52	24749.16	13.71752	29.76758	242539.8	8716.66	245936455.8
Talingchan	119111.8	1368.52	8990.76	13.71752	29.76758	242539.8	4039.786	184578093
Tawewatana	90714.2	1368.52	3069.404	13.71752	29.76758	242539.8	1862.842	166548855.6
Toongkru	126162.8	1368.52	11092.6	13.71752	29.76758	242539.8	4725.4	149498868.4
Thonburi	62201.8	1368.52	15543.18	13.71752	29.76758	242539.8	7275.1	208293002
Bangrak	33503.3	1368.52	10149.4	13.71752	29.76758	242539.8	4847.438	221692291.4
Bangken	204208.6	1368.52	34562.44	13.71752	29.76758	242539.8	4848.07	233481887.4
Bangkapi	163649.4	1368.52	10303.58	13.71752	29.76758	242539.8	5743.176	87935213.8
Bangkok-yai	64478.58	1368.52	6892.922	13.71752	29.76758	242539.8	10432.6	267930319.2
Bangkok-noi	89363.6	1368.52	26624.74	13.71752	29.76758	242539.8	7484.58	73691291.6
Bangkuntian	185383.6	1368.52	11028.04	13.71752	29.76758	242539.8	1533.356	206819059
Bangplud	79675.6	1368.52	14462.52	13.71752	29.76758	242539.8	7013.718	156905000.8
Bungkum	157484.8	1368.52	9490.88	13.71752	29.76758	242539.8	6474.632	193388053.8
Bangsue	123489.4	1368.52	11811.56	13.71752	29.76758	242539.8	10697.56	181531838.2
Bangkoleam	79762.8	1368.52	18921.02	13.71752	29.76758	242539.8	7305.922	75726884
Bangkea	210971.2	1368.52	14982.82	13.71752	29.76758	242539.8	4744.866	74466608.6
Bangna	102806.8	1368.52	16003.06	13.71752	29.76758	242539.8	5242.694	76253540.8
Bangbon	119668.8	1368.52	2557.95	13.71752	29.76758	242539.8	3750.878	127335818.8
Patumwan	2754.56	1368.52	8703.098	13.71752	29.76758	242539.8	4456.894	235655960.4
Pomprabsatrupai	36363.98	1368.52	3931.224	13.71752	29.76758	242539.8	18830	168376692.8
Pravet	193334.2	1368.52	7854.06	13.71752	29.76758	242539.8	3682.068	191741844.8
Pranakorn	40727.3	1368.52	5413.6	13.71752	29.76758	242539.8	7356.76	195351801
Prakanong	104549.6	1368.52	10570.28	13.71752	29.76758	242539.8	7466.108	174505453.6
Payathai	64584.64	1368.52	8956.24	13.71752	29.76758	242539.8	6732.002	236027656.4
Pasicharoen	123628.8	1368.52	16459.74	13.71752	29.76758	242539.8	6932.896	81466734
Minburi	169986.2	1368.52	18432.94	13.71752	29.76758	242539.8	2672.266	75959836
Yannawa	82808.62	1368.52	8683.8	13.71752	29.76758	242539.8	4969.26	89244584.6
Ratburana	167357.6	1368.52	6806.748	13.71752	29.76758	242539.8	5719.042	308588857.4
Ratchadevee	61191.74	1368.52	6185.518	13.71752	29.76758	242539.8	12038.98	213718573.8
Ladkrabang	178386.8	1368.52	18510.78	13.71752	29.76758	242539.8	1455.306	75316989.6
Ladprao	138531.6	1368.52	2992.2	13.71752	29.76758	242539.8	6255.84	75146148.6
Watana	80881.32	1368.52	2954	13.71752	29.76758	242539.8	5090.168	229579901.6
Wangthonglang	130632	1368.52	4479.558	13.71752	29.76758	242539.8	7450.724	207154984.6
Samphanthawong	22153.36	1368.52	2062.01	13.71752	29.76758	242539.8	15644.56	113444689.2
Sathorn	71442.1	1368.52	8669.552	13.71752	29.76758	242539.8	7658.96	142252063
Suanlaung	123245	1368.52	14181.18	13.71752	29.76758	242539.8	5204.754	74130189.6
Saimai	213853.8	1368.52	21899.46	13.71752	29.76758	242539.8	4794.15	74521757.2
Sapansoong	105042.6	1368.52	9402.95	13.71752	29.76758	242539.8	3733.408	118019667.8
Nongjok	155476.2	1368.52	23889.98	13.71752	29.76758	242539.8	884.788	224640393.4
Huykwang	73597.28	1368.52	4811.528	13.71752	29.76758	242539.8	4821.842	161940626.8
Nongkam	177461.2	1368.52	31640	13.71752	29.76758	242539.8	5039.37	232452075.6
Laksi	115330.8	1368.52	20673.2	13.71752	29.76758	242539.8	4976.124	136750465

Record of precipitation volume and temperature from 1960-2007 from Nartional Ocenic and Atmospheric Administration.

Year	Precipitation voulme (mm)	Temperature (degree Celsious)	Year	Precipitation voulme (mm)	Temperature (degree Celsious)
1960	1612.2	27.6917	1984	1044.01	28.2333
1961	1640	27.7333	1985	1018.98	28.3250
1962	1376.8	28.2583	1986	993.95	28.5500
1963	1540.5	28.3333	1987	968.92	27.9417
1964	1882	27.9250	1988	943.89	27.8967
1965	1702.8	27.6500	1989	918.86	27.8583
1966	1600	27.7417	1990	893.82	28.1267
1967	892.8	27.0667	1991	868.79	28.1917
1968	1304.5	26.8583	1992	843.76	29.1033
1969	1177.5	26.4667	1993	818.73	28.3333
1970	1915.1	26.7000	1994	793.7	28.8967
1971	1483.2	27.6917	1995	768.67	28.9867
1972	1652.3	27.7333	1996	743.64	29.2000
1973	1089	28.2583	1997	1063.7	29.4000
1974	1312	28.3333	1998	2109.1	29.6000
1975	1377	27.9250	1999	1756.2	28.1000
1976	1160	27.6500	2000	1878.3	28.7600
1977	1041	27.7417	2001	1764.5	29.0000
1978	1236.4	27.0667	2002	1362.5	29.2000
1979	1133.4	26.8583	2003	1372	29.2000
1980	1155	26.4667	2004	1160.4	29.3000
1981	1119.11	27.3917	2005	1651.4	29.1000
1982	1094.08	27.4333	2006	1598.7	29.3000
1983	1069.04	27.9833	2007	1684	29.1000

Reseources: http://docs.lib.noaa.gov/rescue/data_rescue_thailand.html.

<u>Bangkok metropolitan separate to 50 district.</u>



1. Pranakorn 2. Dusit 3. Nong-Jok 4. Bangrak 5. Bangken

6. Bangkapi 7. Patumwan 8. Pomprabsatrupai 9. Prakanong 10. Minburi

11. Ladkrabang 12. Yanawa 13. Sampantawong 14. Phayathai 15.
Thonburi

16. Bangkok-yai 17. Huakwang 18. Klongsan 19. Talingshan 20. Bangkok-noi.

21. Bangkuntien 22. Pasricharoen 23. Nongkam 24. Ratburana 25. Bang-
Plud

25. Bang-Plud 26. Din-Dang 27. Bungkum 28. Sathorn 29.
Bangsue

30. Jatujak 31. Bangkoleam 32. Pravet 33. Klong-Toei. 34. Suan-
Luang

35. Jomthong 36. Donmaung 37. Rachathevee 38. Ladprao

39. Wathana 40. Bangkae 41. Lak-Si 42. Saimai

43. Kanayaw 44. Saphansoong 45. Wangthong-lank 46. Klongsamwa

47. Bangna 48. Thaweewatana 49. Thungkru 50. Bangbon

Biography

Mr.Wanpiya Phiw-ngam was born in Phitsanuloke October 23; 1977.He was graduated from Naresuan University, Phitsanuloke in bachelor degree of civil engineering. He has been worked in few construction public companies, then in year 2007 he admitted to study at international school of engineering, Chulalongkorn University in major infrastructure in civil engineering. At the present he has working at CUEL limited as a project control engineer position.