

**FORECASTING LOW COST HOUSING DEMAND IN URBAN AREA IN  
MALAYSIA USING ARTIFICIAL NEURAL NETWORKS (ANN)**

**NOOR YASMIN ZAINUN  
NUR AINI MOHD ARISH  
AZEANITA SURATKON**

**GERAN FRGS  
NO. VOT 0381**

**UNIVERSITI TUN HUSSEIN ONN MALAYSIA**

## ABSTRACT

The forecasted proportions of urban population to total population in Malaysia are steadily increasing from 26% in 1965 to 70% in 2020. Therefore, there is a need to fully appreciate the legacy of the urbanization of Malaysia by providing affordable housing. The main aim of this study is to focus on developing a model to forecast the demand of low cost housing in urban areas. The study is focused on eight states in Peninsular Malaysia, as most of these states are among the areas predicted to have achieved the highest urbanization level in the country. The states are Kedah, Penang, Perlis, Kelantan, Terengganu, Perak, Pahang and Johor. Monthly time-series data for six to eight years of nine indicators including: population growth; birth rate; child mortality rate; unemployment rate; household income rate; inflation rate; GDP; poverty rate and housing stocks have been used to forecast the demand on low cost housing using Artificial Neural Network (ANN) approach. The data is collected from the Department of Malaysian Statistics, the Ministry of Housing and the Housing Department of the State Secretary. The Principal Component Analysis (PCA) method has been adopted to analyze the data using SPSS 18.0 package. The performance of the Neural Network is evaluated using R squared ( $R^2$ ) and the accuracy of the model is measured using the Mean Absolute Percentage Error (MAPE). Lastly, a user friendly interface is developed using Visual Basic. From the results, it was found that the best Neural Network to forecast the demand on low cost housing in Kedah is 2-16-1, Pahang 2-15-1, Kelantan 2-25-1, Terengganu 2-30-1, Perlis 3-5-1, Pulau Pinang 3-7-1, Johor 3-38-1 and Perak 3-24-1. In conclusion, the evaluation performance of the model through the MAPE value shows that the NN model can forecast the low-cost housing demand 'very good' in Pulau Pinang, Johor, Pahang and Kelantan, where else 'good' in Kedah and Terengganu while in Perlis and Perak it is 'not accurate' due to the lack of data. The study has successfully developed a user friendly interface to retrieve and view all the data easily.

Key words: low-cost housing demand, Principal Component Analysis, Artificial Neural Networks.

# **CONTENTS**

---

Abstract.....	i
Contents.....	ii
List of Figures and Tables.....	vi
List of Symbols.....	xii
List of Appendices.....	xiii
<b>CHAPTER 1: INTRODUCTION.....</b>	<b>1</b>
1.1 BACKGROUND OF THE PROBLEM.....	2
1.2 STATEMENT OF THE PROBLEM.....	4
1.3 AIMS AND OBJECTIVES OF THE STUDY.....	5
1.4 SCOPE OF THE STUDY.....	5
1.5 SIGNIFICANCE OF RESEARCH.....	8
1.6 ORGANIZATION OF THE THESIS.....	8
<b>CHAPTER 2: HOUSING IN MALAYSIA.....</b>	<b>11</b>
2.1 HOUSING.....	11
2.2 HOUSING IN MALAYSIA.....	12
2.2.1 Concept of low cost housing.....	24
2.2.2 Low-cost housing policy.....	27
2.3 IMPACT ON URBANIZATION ON HOUSING.....	28
2.3.1 Urban Poverty.....	32
2.4 DEMANDS ON LOW-COST HOUSING AND INDICATORS.....	34
2.5 SUMMARY.....	40

<b>CHAPTER 3:</b>	<b>FORECASTING HOUSING DEMAND.....</b>	<b>41</b>
3.1	APPLICATION OF ARTIFICIAL NEURAL NETWORKS.....	46
3.1.1	United Kingdom (UK) demand forecasting in private sector.....	46
3.1.2	Singapore construction demand forecasting.....	49
3.1.3	Singapore residential construction demand forecasting.....	50
3.1.4	Private residential construction forecasting in the United States.....	51
3.1.5	Tools for forecasting demand in consumer durables (automobiles).....	52
3.1.6	House price prediction in New Zealand.....	53
3.2	FORECASTING OF LOW-COST HOUSING DEMAND IN URBAN AREAS.....	54
3.3	DEFINITION OF TERMS.....	56
3.4	ARTIFICIAL NEURAL NETWORKS (ANN).....	56
3.4.1	Back-propagation Network.....	60
3.5	ANN STRENGTHS AND WEAKNESSES.....	63
3.6	PRINCIPAL COMPONENT ANALYSIS.....	65
3.7	SUMMARY .....	65
<b>CHAPTER 4:</b>	<b>RESEARCH METHODOLOGY.....</b>	<b>67</b>
4.1	DEVELOPMENT OF NEURAL NETWORK MODEL .....	69
4.2	DATA ANALYSIS.....	69
4.3	DERIVATION OF SIGNIFICANT INDICATORS.....	71
4.4	NETWORK ARCHITECTURE DETERMINATION .....	73
4.5	TRAINING THE NETWORKS.....	74
4.6	TESTING THE NETWORKS.....	76
4.7	DEVELOPMENT OF USER FRIENDLY INTERFACES.....	77
4.8	SUMMARY.....	79

<b>CHAPTER 5:</b>	<b>DERIVATION OF SIGNIFICANT</b>	
	<b>INDICATORS.....</b>	<b>80</b>
5.1	TIME SERIES DATA ON LOW-COST HOUSING DEMAND.....	81
5.2	INDEPENDENT INDICATORS FOR LOW COST HOUSING DEMAND.....	86
5.2.1	Birth Rate.....	90
5.2.2	Population Growth.....	92
5.2.3	Child Mortality Rate.....	95
5.2.4	Poverty Rate.....	97
5.2.5	Income Rate.....	99
5.2.6	Unemployment Rate.....	100
5.2.7	Housing Stock.....	103
5.3	INDICATORS CONFIRMATION IN MALAYSIAN'S HOUSING INDUSTRY.....	105
5.4	SIGNIFICANT INDICATORS.....	107
5.4.1	Significant indicators for Perlis.....	108
5.4.2	Significant indicators for Pahang.....	112
5.4.3	Significant indicators for Johor.....	116
5.4.4	Significant indicators for Terengganu.....	120
5.4.5	Significant indicators for Kelantan.....	124
5.4.6	Significant indicators for Kedah.....	128
5.4.7	Significant indicators for Penang.....	132
5.4.8	Significant indicators for Perak.....	136
5.5	SUMMARY.....	140

<b>CHAPTER 6:</b>	<b>MODEL AND INTERFACE DEVELOPMENT.....</b>	<b>142</b>
6.1	TRAINING AND TESTING DATA.....	143
6.2	CREATING NEURAL NETWORK MODEL.....	143
6.3	VALIDATION.....	151
6.4	INTERFACES DEVELOPMENT.....	156
6.6	SUMMARY.....	161
<b>CHAPTER 7:</b>	<b>CONCLUSIONS AND RECOMMENDATIONS.....</b>	<b>163</b>
7.1	CONCLUSIONS.....	163
	7.1.1: Reviewed Artificial Neural Network (ANN) algorithms for forecasting.....	164
	7.1.2: Established significant indicators for forecasting low-cost housing demand.....	164
	7.1.3: Developed a model using ANN to forecast on low-cost housing demand in urban area in eight states in Peninsular Malaysia; and.....	166
	7.1.4: Developed a user friendly interface.....	168
7.2	LIMITATIONS.....	168
7.3	ADVANTAGES OF THE COMPUTERIZED MODEL.....	168
7.4	RECOMMENDATIONS.....	169
	<b>REFERENCES.....</b>	<b>170</b>
	<b>PAPERS BY THE AUTHOR.....</b>	<b>179</b>

---

## LIST OF FIGURES AND TABLES

Listed in order of appearance.

Figure 1.1:	Map of Peninsular Malaysia
Figure 2.1:	Planned housing units according to house price category during Sixth Malaysia Plan
Figure 2.2:	Completed housing units according to house price category during Sixth Malaysia Plan
Figure 2.3:	Total percentage of planned and completed housing units according to house price category during Sixth Malaysia Plan
Table 2.1:	Public and private sector housing targets and achievements, 2001-2005
Table 2.2:	Housing requirements by state, 2006-2010
Figure 2.4:	Total units and percentage of housing requirements by state, 2006-2010
Table 2.3:	Public and private sector housing targets, 2006-2010
Table 2.4:	Existing housing stock in Kuala Lumpur, 2000
Table 2.5:	Target and achievement housing construction according to price category in Kuala Lumpur, 1996-2000
Table 2.6:	Guidelines for Low-cost Housing Categories
Table 2.7:	House Price and Group Target
Table 2.8:	Urbanization in Peninsular Malaysia 1911-2020
Table 2.9:	Population of Malaysia 1970-2020

Table 2.10:	The distribution of monthly household income in Malaysia in 1980
Table 2.11:	Incidence of poverty by state 1976-1991
Table 2.12:	Summary of Housing Indicators
Table 3.1:	The five most frequently cited articles in the Journal of Computing in Civil Engineering.
Table 3.2:	One quarter ahead forecasting
Table 3.3:	More than one quarters ahead forecasting
Figure 3.1:	The prediction curves of the commercial sector
Table 3.4:	Relative measures of the accuracy of different forecasting technique
Table 3.5:	New automobile price and quantity estimated and forecasting results lag structure parameterized by best neural network
Table 3.6:	New automobile price and quantity estimated and forecasting results lag structure parameterized by best linear model
Table 3.7:	Comparing the out-of-sample forecast evaluation results for Hedonic Price Model and Neural Network Model
Figure 3.2:	Actual and estimated house price in log form (out-of-sample forecast)
Table 3.8:	Comparison MAPE values between Neural Network (NN), nonlinear regression (NLR) and ARIMA (ARI) models
Figure 3.3:	A simplified biological neuron
Figure 3.4:	The basics of an artificial neuron
Figure 3.5:	A simple structure network
Figure 3.6:	Back Propagation Neural Network (BPNN)
Figure 4.1:	A flow chart of research methodology
Table 4.1:	Determination of learning and momentum rate
Figure 4.2:	A flow chart of the workflow process
Figure 5.1:	Time Series Data for Low Cost Housing Demand in Johor
Figure 5.2:	Time Series Data for Low Cost Housing Demand in Terengganu
Figure 5.3:	Time Series Data for Low Cost Housing Demand in Kelantan



Figure 5.4:	Time Series Data for Low Cost Housing Demand in Perlis
Figure 5.5:	Time Series Data for Low Cost Housing Demand in Kedah
Figure 5.6:	Time Series Data for Low Cost Housing Demand in Pahang
Figure 5.7:	Time Series Data for Low Cost Housing Demand in Penang
Figure 5.8:	Time Series Data for Low Cost Housing Demand in Perak
Figure 5.9:	Inflation Rate in Malaysia (2000 – 2007)
Figure 5.10:	Gross Domestic Product in Malaysia (2000 – 2007)
Table 5.1:	Time Series Data for Independent Indicators in Each States (2000 – 2007)
Figure 5.11:	Birth Rate in All Eight States (2000 – 2007)
Figure 5.12:	Population Growth in All Eight States (2000-2007)
Figure 5.13:	Child Mortality Rate in All Eight States (2000-2007)
Figure 5.14:	Poverty Rate in All Eight States (2000-2007)
Figure 5.15:	Mean Income in All Eight States (2000-2007)
Figure 5.16:	Unemployment Rate in All Eight States (2000-2007)
Figure 5.17:	Housing Stock in All Eight States (2000-2007)
Table 5.2:	Number of Respondents for Each Indicators Level
Table 5.3:	Percentage (%) of Respondents for Each Indicators Level
Figure 5.18:	Percentage of Respondents for Each Indicators Level
Table 5.4:	Total Variance for Perlis
Figure 5.19:	Scree Plot for Perlis
Table 5.5:	Rotated Component Matrix for Perlis
Table 5.6:	Component Score Coefficient Matrix for Perlis
Table 5.7:	Total Variance for Pahang
Figure 5.20:	Scree Plot for Pahang
Table 5.8:	Rotated Component Matrix for Pahang
Table 5.9:	Component Score Coefficient Matrix for Pahang
Table 5.10:	Total Variance for Johor
Figure 5.21:	Scree Plot for Johor

Table 5.11:	Rotated Component Matrix for Johor
Table 5.12:	Component Score Coefficient Matrix for Johor
Table 5.13:	Total Variance for Terengganu
Figure 5.22:	Scree Plot for Terengganu
Table 5.14:	Rotated Component Matrix for Terengganu
Table 5.15:	Component Score Coefficient Matrix for Terengganu
Table 5.16:	Total Variance for Kelantan
Figure 5.23:	Scree Plot for Kelantan
Table 5.17:	Rotated Component Matrix for Kelantan
Table 5.18:	Component Score Coefficient Matrix for Kelantan
Table 5.19:	Total Variance for Kedah
Figure 5.24:	Scree Plot for Kedah
Table 5.20:	Rotated Component Matrix for Kedah
Table 5.21:	Component Score Coefficient Matrix for Kedah
Table 5.22:	Total Variance for Penang
Figure 5.25:	Scree Plot for Penang
Table 5.23:	Rotated Component Matrix for Penang
Table 5.24:	Component Score Coefficient Matrix for Penang
Table 5.25:	Total Variance for Perak
Figure 5.26:	Scree Plot for Perak
Table 5.26:	Rotated Component Matrix for Perak
Table 5.27:	Component Score Coefficient Matrix for Perak
Table 5.28:	The Most Significant Indicators in All Eight States
Table 6.1:	Training and testing data set for Perlis, Kedah, Pulau Pinang, Terengganu, Johor, Pahang, Kelantan and Perak
Figure 6.1:	Neural Network topology with 2 inputs nodes
Figure 6.2:	Neural Network topology with 3 inputs nodes
Figure 6.3:	Network performance of Kedah, Terengganu, Pahang and Kelantan
Figure 6.4:	Network performance of Perlis, Pulau Pinang, Johor and Perak

Table 6.2:	Performance of R square with different combination of learning rate and momentum rate for all eight states using their best networks.
Table 6.3:	MAPE value with different combination of learning rate and momentum rate for Kelantan using the best networks.
Table 6.4:	MAPE value with different combination of learning rate and momentum rate for Perak using the best networks.
Table 6.5:	Actual and forecasted low cost housing demand for 6 month ahead at Kedah
Table 6.6:	Actual and forecasted low cost housing demand for 6 month ahead at Terengganu
Table 6.7:	Actual and forecasted low cost housing demand for 6 month ahead at Perlis
Table 6.8:	Actual and forecasted low cost housing demand for 6 month ahead at Pulau Pinang
Table 6.9:	Actual and forecasted low cost housing demand for 6 month ahead at Johor
Table 6.10:	Actual and forecasted low cost housing demand for 6 month ahead at Pahang
Table 6.11:	Actual and forecasted low cost housing demand for 6 month ahead at Kelantan
Table 6.12:	Actual and forecasted low cost housing demand for 6 month ahead at Perak
Figure 6.5:	<i>File</i> Menu
Figure 6.6:	<i>Option</i> Menu
Figure 6.7:	Changing Background
Figure 6.8:	<i>Window</i> Menu
Figure 6.9:	<i>Help</i> Menu
Figure 6.10:	Launch Lochdep Information fom <i>File</i> Menu
Figure 6.11:	Launch Lochdep Information
Table 6.13:	Best Neural Network models with the best $R^2$ for all eight states

Table 6.14:	MAPE values and evaluation results for all eight states
Table 7.1:	The most significant indicators to forecast low cost housing demand for all eight states.
Table 7.2:	Best Neural Network models for all eight states.
Table 7.3:	Evaluation results for all eight states

---

## LIST OF SYMBOLS

$R^2$	=	R square
$\Sigma$	=	symmetric $p \times p$ matrix
$tr(\Sigma)$	=	trace of $\Sigma$
$ \Sigma $	=	determinant of a square matrix $\Sigma$
$\lambda$	=	eigenvalues
$\mathbf{a}$	=	eigenvector
$\mathbf{c}$	=	component correlation vectors
$\mathbf{R}$	=	sample correlation matrix
$ \mathbf{R} $	=	determinant of the correlation matrix
CM	=	coefficient matrix
$x$	=	input
$w$	=	weight
$\theta$	=	internal threshold or offset or bias
$y$	=	actual value
$\hat{y}$	=	predicted value of $y$
$\bar{y}$	=	mean of the $y$ values
$r$	=	Correlation Coefficient $r$ (Pearson's Linear Correlation Coefficient)
$n$	=	the number of patterns
$X$	=	set of actual outputs
$Y$	=	predicted outputs

---

## **LIST OF APPENDICES**

Appendix A:	Map of Malaysia
Appendix B:	Summary of Malaysia Housing Policy
Appendix C:	Principal Component Analysis Items
Appendix D:	Summary of Forecasting Models Using ANN
Appendix E:	Sample of Questionnaire
Appendix F:	Chi-square distribution graph
Appendix G:	User's Guide

---

## CHAPTER

# 1

## INTRODUCTION

It is widely believed that the construction industry is more volatile than other sectors of the economy (Goh, 1998). Accurate predictions of the level of aggregate demand for construction are of vital importance to all sectors of this industry such as developers, builders and consultants. Empirical studies have shown that accuracy performance varies according to the types of forecasting technique and the variables to be forecasted. Hence, there is a need to identify different techniques, in terms of accuracy, in the prediction of needs for facilities.

Under the Seventh Malaysia Plan (1996-2000) and Eight Malaysia Plan (2001-2005), the Malaysian government is committed to provide adequate, affordable and quality housing for all Malaysians, particularly the low income group. This is in line with Istanbul Declaration on Human Settlement and Habitat Agenda (1996) to ensure

adequate shelter for all (Shuid,2004). The total number of housing units targeted was 800,000 units under the Seventh Malaysia Plan and 782,300 units of housing is targeted to be constructed under Eighth Malaysia Plan (Government of Malaysia, 2006).

Unfortunately, in 2004 there were 100,000 of low-cost houses in Selangor, Malaysia overhang (The Sun, 2004). The over construction of the low-cost houses in Selangor had caused millions of loss while at the same time the money could have been used to provide low-cost houses in other states in Malaysia. Based on the Draft of the Kuala Lumpur Structure Plan 2020, Kuala Lumpur still lacks 20,595 units of houses.

Besides the high cost of low-cost houses, one of the other main reasons for these houses remaining unsold is because they were built in undesirable locations (Buang, News Straits Times, 2004). Therefore, there is a vital need to have a model to forecast low-cost housing demand in Malaysia so that it will improve and solve the low cost housing constructions. At the same time, budget, time and manpower can be saved.

## **1.1 BACKGROUND OF THE PROBLEM**

Over the past decade, the rate of growth of the housing construction in Malaysia has been dramatic. Demand on personal housing has also increased especially for low cost housing. Therefore; a housing scheme program called Public Low-Cost Housing (PAKR) was launched to tackle the housing problem for low-income group. Besides PAKR, the government has also introduced two other schemes which are Location and Facilities Scheme Program (SPK) and Housing Loan Scheme Program (SPP) (Sirat et. al, 1999).

The percentage of urban population is currently greater. Due to that, most of the housing including low cost houses is located in the town area (*Biro Rundingan UKM, 1999*). The average of population growth rate during the last two decades was 2.25% with a population recorded in the 1991 census as 17.6 million people. 50.6% of these people



are urban population (Yahya and Abd. Majid, 2002). The census made by the Department of Statistic Malaysia had also shown that the percentage of constructed houses increased fifty-five percent in an eleven-year period starting from 1980 to 1991 (Department of Statistics Malaysia, 1995).

On the supply side, construction is expected to register a positive growth of 3.1% for the next five years due mainly to the impetus provided by public sector projects and the provision of social infrastructure such as schools and low cost housing. Growth in construction sector supply is expected to come from several large public and private infrastructure projects and also the construction of medium and low-cost residential houses (Construction Industry Development Board Malaysia, 2001)

A significant shortage is already expected for low cost housing sub-sector from the year 2001 (William et. al, 1999). It has resulted to the problem of insufficient housing especially for the low-income group. Therefore, during the Seventh Malaysia Plan period, various programs for the development of housing were implemented in the urban and rural areas. During the Eighth Malaysia Plan period, the objective of the housing development programs will be to increase adequately, affordable and quality houses for all income groups. Priority will be given to the development of low-cost and low-medium cost houses (Government of Malaysia, 2006).

However, the distribution based on the type of houses was not in line with the target set during the Plan period which is a total of 800,000 units of houses for construction to meet housing needs. Whereby, the private sector mainly built medium-cost and high-cost houses and this was reflected by the completion of a total of 554,458 units of medium-cost and high-cost houses or 291.8 per cent of the Plan target (Government of Malaysia, 2006).

Consequently, at the end of June 1999, the overall number of unsold residential properties was estimated at 93,600 units. Therefore, the Government and the Real Estate and Housing Developer's Association Malaysia (REHDA) launched several home

ownership campaigns to help reduce the stock overhang (Government of Malaysia, 2006).

On the other hand, the Government is expected to build approximately 43,800 units of low-cost houses through the '*Program Perumahan Rakyat*' during the Ninth Malaysia Plan (2006-2010) (Speech by the Prime Minister, Ninth Malaysia Plan, 2006). Of the 35,000 units which were planned to be built in the Federal Territory of Kuala Lumpur, a total of 34,148 units were under various stages of implementation (Shuid, 2005).

## **1.2 STATEMENT OF THE PROBLEM**

The housing census was first conducted in 1970 simultaneously with population census since the formation of Malaysia in 1963 (Department of Statistics Malaysia, 1995). Since then, the study on housing has been conducted extensively in Malaysia and many researchers have started their effort to study and find solutions for housing problems including Salih (1976), Chander (1977), and Wegelin (1978). Recently, research on forecasting low cost housing demand in urban area was carried out by Yahya and Abd. Majid (2002). His research was done by comparing nonlinear regression, ARIMA models; and Artificial Neural Networks (ANN) in forecasting the demand.

Due to the increase for the demand for low cost houses, it is very significant and vital to select the best method for forecasting the demand. Meanwhile, the number of unit of low cost houses that have been built by private sector is 30% of the total development which is also a requirement imposed by the government. Obviously, by following this requirement, the number of low cost houses to be built does not reflect the actual demand of low cost housing. Henceforth, developing a model as an alternative way to forecast the number of units of low cost houses is therefore timely and imperative for a developing nation.

In view of this, there is an increasing need to objectively identify a forecasting technique which can produce an accurate forecast demand for this vital sector of the economy. However, there has been no research purposely done on the forecast of low cost housing demand model based on ANN. In this study, a computerized model based on Artificial Neural Networks (ANN) will be developed to forecast low-cost housing demand in urban area.

### **1.3 AIMS AND OBJECTIVES OF THE STUDY**

The aim of the study is to develop a computerized forecasting model using Artificial Neural Networks (ANN) technique to forecast low-cost housing demand in urban areas in Malaysia. To achieve this aim, the following objectives have been identified and carried out:

- a) Reviewed Artificial Neural Network (ANN) algorithms for forecasting.
- b) Established significant indicators for forecasting low-cost housing demand.
- c) Developed a model using ANN to forecast on low-cost housing demand in urban area in eight states in Peninsular Malaysia; and
- d) Developed a user friendly interface.

### **1.4 SCOPE OF THE STUDY**

Malaysia's modern urban growth, development and urbanization experiences may be conveniently periodised into three major periods, based on the form, structure and functions of the urban centers. Urbanization began as the founding of urban areas and urban growth during the British colonial rule, roughly covering the period 1887 till 1956. This was followed by urban growth, development and increasing urbanization in the early years of independence, 1957-1969 (Sendut 1965; Yeoh and Hirshman 1980),

and urban explosion and urban areas as growth centers in the export industrialization period, 1970 until present (Sirat et. al., 1999).

It was observed by the government of Malaysia that in the census for year 2000 that the proportion of urban population had increased to 62.0% in 2000 from 50.7% in 1991. The states with very high proportions of urban population in the 2000 Census were: Wilayah Persekutuan Kuala Lumpur (100%), Selangor (87.6%) and Pulau Pinang (80.1%). Conversely the states with low urbanization levels were Kelantan (34.2%), Perlis (34.3%) and Kedah (39.3%).

Figure 1.1 shows all the states in Peninsular Malaysia. There are eleven states in Peninsular Malaysia in addition to the Federal Territory of Kuala Lumpur. Malaysia is situated in the heart of Southeast Asia, which comprises of Peninsular Malaysia and the states of Sabah and Sarawak. Peninsular Malaysia is bordered in the north by Thailand, and Singapore in the south. The Malaysian states of Sabah and Sarawak are located in the northern part of the island of Borneo which is separated by 500 kilometers of the South China Sea from Peninsular Malaysia. For more information refer to the map of Malaysia in Appendix A.



**Figure 1.1: Map of Peninsular Malaysia**

*Source: www.mymalaysiabooks.com, 2011.*

The scopes of this study are in the eight states in peninsular Malaysia and they are; Perlis, Kedah, Pulau Pinang, Perak, Kelantan, Terengganu, Pahang, and Johor. The scopes had been narrowed down to these eight states since the other states do not have enough and complete data to develop the forecasting model.

## **1.5 SIGNIFICANCE OF RESEARCH**

From a comprehensive research finding output, a Neural Network Model developed. This model can be used by relevant government bodies and agencies for predicting the demand of low cost housing in the government's economic planning activities. With the user friendly interface, the current input data can be siphoned to the model, thus giving more ease to the users. The model can also be used remotely for prediction activities.

## **1.6 ORGANIZATION OF THE THESIS**

The thesis contains a total of 7 chapters and 6 appendices. In Chapter 1, the introduction, background of the problem, statement of problem, objectives, scope of the study, significant of research, research methodology framework and organization of the thesis are discussed.

In Chapter 2, a literature review on low cost housing, urbanization and Principal Component Analysis is discussed. The main topics in this chapter are divided into introduction, Housing in Malaysia, Impact of Urbanization on Housing, Demand on Low Cost Housing and Indicators, Principal Component Analysis and Summary while the sub topic are divided into Concept of Low Cost Housing, Housing Policy, Urban Poverty, and Urbanization in Peninsular Malaysia.

The literature review of previous forecasting models using Artificial Neural Network (ANN) technique is discussed in Chapter 3. The main topics of this chapter are;

Definition of Terms, Artificial Neural Networks (ANN), Application of Artificial Neural Networks, Forecasting of Low Cost Housing Demand in Urban Areas and Summary.

The sub topics are; Back-propagation Network, ANN Strengths and Weaknesses, United Kingdom (UK) Demand Forecasting in Private Sector, Singapore Construction Demand Forecasting, Singapore Residential Construction Demand Forecasting, Private Residential Construction Forecasting in the United States (US), Tools for Forecasting Demand in Consumer Durables (automobiles) and House Price Prediction in New Zealand.

Research methodology is presented in Chapter 4. It consist of Selection of research area, Selection of Indicators, Data Collection, Determination of Significant Indicators, Development of Neural Network Model, Network Architecture Determination, Validation, Development of User Friendly Interface and Summary are the main topics. The sub topics are: Confirmation of Indicators in Malaysian Housing Industry, Steps of Performing PCA on the Correlation Matrix, Neural Network Items, Training the Networks, Stop Training Network Criteria and Testing the Networks, and Programming Implementation.

In Chapter 5, the collected data will be analyzed using the Principal Component Analysis. The topics are divided into five main topics. The main topics are; Time Series Data on Low Cost Housing Demand, Independent Indicators for Low Cost Housing Demand, Indicators Confirmation in Malaysian's Housing Industry, Significant Indicators and Summary while the sub topics are; Birth Rate, Population Growth, Child Mortality Rate, Poverty Rate, Income Rate, Unemployment Rate, Housing Stock, Significant Indicators for Perlis, Significant Indicators for Pahang, Significant Indicators for Johor, Significant Indicators for Terengganu, Significant Indicators for Kelantan, Significant Indicators for Kedah, Significant Indicators for Penang, and Significant Indicators for Perak,

In Chapter 6, the development of model was discussed. In this chapter, the topics are divided into Training and Testing Data, Creating Neural Network Model, Validation,

and Summary. Conclusions and recommendations are discussed in Chapter 7. This chapter contains Conclusions, Limitations, Advantages of the Model, and Recommendations.



---

## CHAPTER

# 2

## HOUSING IN MALAYSIA

This topic discusses the Malaysian housing development scenarios, the success and the drawback of government policies and programs in providing shelter to Malaysians. It discusses the demands in line with the population increase, birth rate, child mortality rate, income rate, poverty rate, inflation rate, unemployment rate, GDP, housing stock and other factors. It also mentions the key player for the development program, the overall policy, commitment of federal and state government in the schemes.

### 2.1 HOUSING

A house is a building or structure that has the ability to be occupied for habitation by humans or other creature (Kahn, 2000). The term 'house' includes many kinds of dwellings ranging from rudimentary huts of nomadic tribes to complex structures composed of many systems. The social unit that lives in a house is known as a household.

Affordable housing is a term used to describe dwelling units whose total housing costs for either rented or purchased unit are deemed affordable to those that have a median household income (Basudeb, 2010). In Australia, the National Affordable Housing Summit Group developed their definition of affordable housing as housing which is "reasonably adequate in standard and location for lower or middle income households and does not cost so much that a household is unlikely to be able to meet other basic needs on a sustainable basis. In the United Kingdom affordable housing includes "social rented and intermediate housing, provided to specified eligible households whose needs are not met by the market (Canada Mortgage and Housing Corporation, 2011). Most of the literature on affordable housing refers to a number of forms that exist along a continuum - from emergency shelters, to transitional housing, to non-market rental (also known as social or subsidized housing), to formal and informal rental, indigenous housing and ending with affordable home ownership

Income is the primary factor that determines housing affordability (Chris, 2005). In a market economy the distribution of income is the key determinant of the quantity and quality of housing obtained. Housing is often the single biggest expenditure of low and middle income families. For low and middle income families, their house is also the greatest source of wealth (Chris, 2005).

## **2.2 HOUSING IN MALAYSIA**

Low-cost housing is a popular political agenda worldwide. Housing provision in Malaysia is planned with the cooperation of the government and the private sector. The main objective of the housing policy is to ensure that all Malaysians particularly the low income groups have access to adequate and affordable shelter and related facilities (Ministry of Housing and Local Government Malaysia, 1999). This was concurrent with the Eighth Malaysia Plan of housing program objectives (Government of Malaysia, 2001) in providing adequate, quality and affordable houses to all Malaysians. This policy was then continued in the Ninth Plan period (Government of Malaysia, 2006).

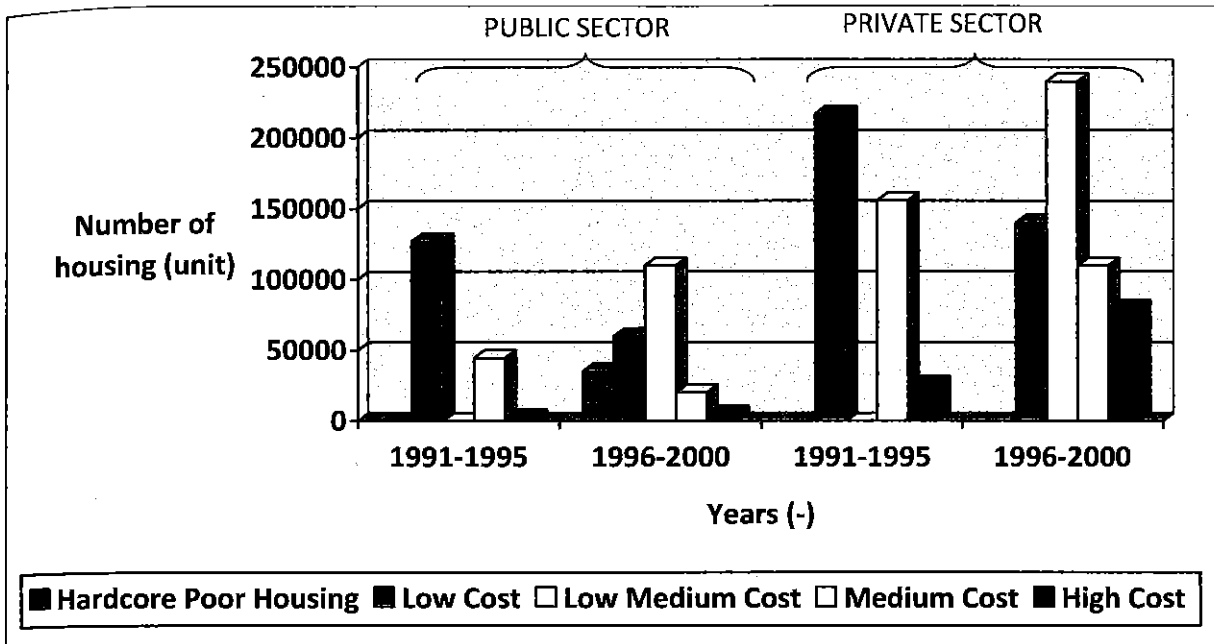
The Government's five-year National Plan has focused on various housing programs in both rural and urban areas with the aim of providing affordable housing. The housing development

is the main sector in expanding the economy of Malaysia. Housing can be categorised into four main groups, namely (1) low cost, (2) low medium cost, (3) medium cost, and (4) high cost housing. To fill up the demand of housing each year, the government comes up with several plans with an aim to give the population affordable housing completely within the convenient infrastructure (Government of Malaysia, 1996).

During the Sixth Malaysia Plan period (1990-1995), a total of 573,000 units of houses were planned for construction all over Malaysia to meet the new requirements and replacement of dilapidated units. The overall achievements of housing construction were very encouraging with the completion of 647,460 units or 113 percent of the planned target (Government of Malaysia, 1996). A total of 261,386 units of low cost-houses or 76 percent of the planned target were completed, with the public sector contributing 46,497 units and 214,889 units from the private sector (Government of Malaysia, 1991).

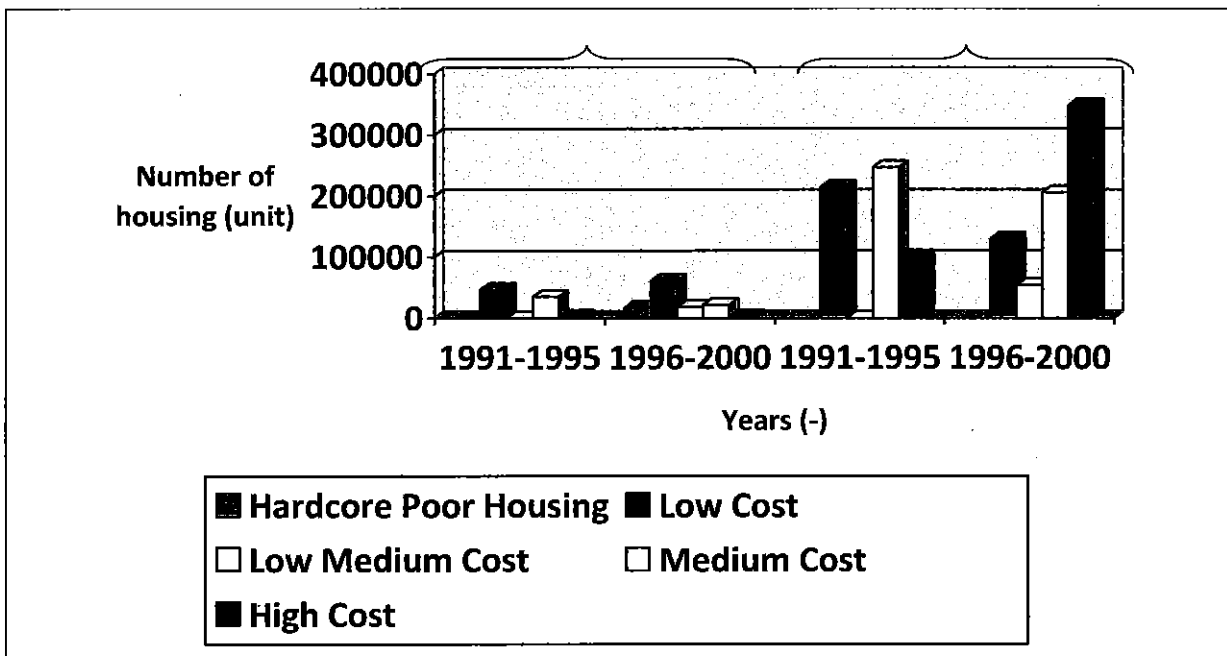
During the Seventh Malaysia Plan Period (1995-2000) a total of 800,000 units of houses were targeted to be constructed, of which about 740,000 units were built to meet the demand of new households, while the remaining 60,000 units were allocated or built for replacing houses (Government of Malaysia, 1996).

The government has been focusing more on medium cost housing during the Seventh Malaysia Plan with a total of 350,000 units or 44% from the total 800,000 units planned (Shuid, 2005). Figure 2.1 to 2.3 shows the planned and completed housing unit according to house price category during the Sixth and Seventh Malaysia Plan. These data have been summarised into a table in Appendix B.



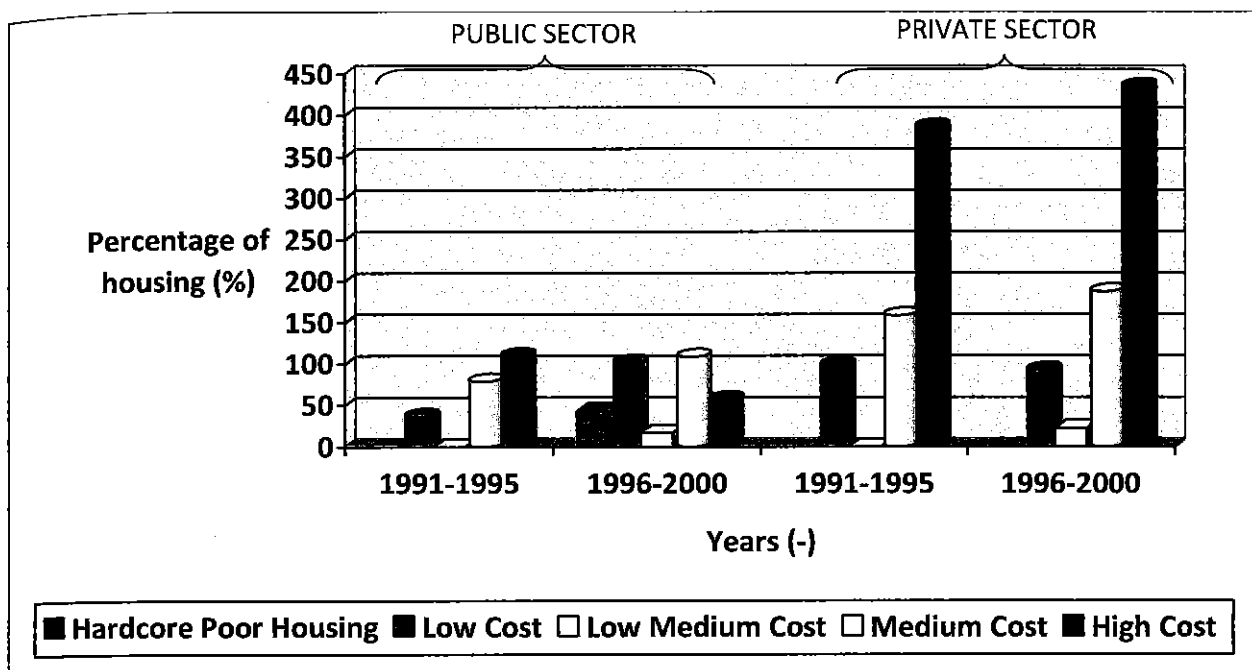
**Figure 2.1: Planned housing units according to house price category during Sixth Malaysia Plan**

*Source: Government of Malaysia, 2001 (Eight Malaysia Plan, 2001-2005)*



**Figure 2.2: Completed housing units according to house price category during Sixth Malaysia Plan**

*Source: Government of Malaysia, 2001 (Eight Malaysia Plan, 2001-2005)*



**Figure 2.3: Total percentage of housing units according to house price category during Sixth Malaysia Plan**

*Source: Government of Malaysia, 2001 (Eight Malaysia Plan, 2001-2005)*

From figure 2.1 to 2.3, it can be seen that although the number of units planned for low medium cost houses are the highest compared to other categories, the achievement is relatively low which is only 17.1% in the public sector and 22.4% in the private sector. During the Seventh Malaysia Plan the construction of medium and high cost housing by the private sector has achieved 187% and 435% respectively of the targeted units. This situation created an oversupply of housing stock for both categories from 1997 to 2000. The Asian economic crisis had a devastating effect on the property scenario in Malaysia, with many unsold properties, mainly from medium and high cost housing.

Meanwhile, another 782,300 units of housing were targeted to be constructed under the Eight Malaysia Plan (Government of Malaysia, 2001). Consequently, the performance of housing development programmes and provisions were encouraging with the number of houses constructed surpassing the Planned Target. A total of 844,043 units were completed with 77.6% constructed by the private sector while the remaining was constructed by the public sector. Table 2.2 shows the housing target and achievements during the Eighth Malaysia Plan.

As part of the Government's efforts to increase the construction of low and low medium cost houses, the *Syarikat Perumahan Negara Malaysia Berhad* (SPNB) has undertaken housing development projects to cater for the housing needs of the population. During the Plan period, SPNB implemented two housing programs: (1) *Program Perumahan Mampu Milik*, (2) *Program Perumahan Mesra Rakyat*, and housing projects for military personnel. In addition, SPNB also undertook the rehabilitation of selected abandoned housing projects, including those of the private sector which were identified by the Ministry of Housing and Local Government (MHLG) (Government of Malaysia, 2006).

**Table 2.1: Public and private sector housing targets and achievements, 2001-2005**

Source: Government of Malaysia, 2006 (Ninth Malaysia Plan, 2006-2010)

Notes: Excluding 13,037 units rehabilitated houses

Program	Housing for the poor			Low cost			Low medium cost			Medium cost			High cost			Total		
	Target (units)	Achieved (units)	% of Target	Target (units)	Achieved (units)	% of Target	Target (units)	Achieved (units)	% of Target	Target (units)	Achieved (units)	% of Target	Target (units)	Achieved (units)	% of Target	Target (units)	Achieved (units)	% of Target
<b>Public sector</b>	<b>16,000</b>	<b>10,016</b>	<b>62.6</b>	<b>192,000</b>	<b>103,219</b>	<b>53.8</b>	<b>37,300</b>	<b>22,826</b>	<b>61.2</b>	<b>46,700</b>	<b>30,098</b>	<b>64.4</b>	<b>20,000</b>	<b>22,510</b>	<b>112.6</b>	<b>312,000</b>	<b>188,669</b>	<b>60.5</b>
Low cost housing	-	-	-	175,000	81,108	46.3	-	-	-	-	-	-	-	-	-	175,000	81,108	46.3
Housing for the hardcore poor (PPRT)	15,000	9,536	63.6	-	-	-	-	-	-	-	-	-	-	-	-	15,000	9,536	63.6
Sites and services	1,000	480	48.0	-	-	-	-	-	-	-	-	-	-	-	-	1,000	480	48.0
Housing by commercial agencies	-	-	-	15,000	16,386	109.2	10,000	15,442	154.4	16,000	9,924	62.0	15,000	5,753	38.4	56,000	47,505	84.8
Housing by land schemes	-	-	-	2,000	5,725	286.3	1,000	695	69.5	-	-	-	-	-	-	3,000	6,420	214.0
Institutional quarters and staff accommodation	-	-	-	-	-	-	26,300	6,689	25.4	30,700	20,174	65.7	5,000	16,757	335.1	62,000	43,620	70.4
<b>Private sector</b>	<b>-</b>	<b>-</b>	<b>-</b>	<b>40,000</b>	<b>97,284</b>	<b>243.2</b>	<b>94,000</b>	<b>61,084</b>	<b>65.0</b>	<b>64,000</b>	<b>222,023</b>	<b>346.9</b>	<b>105,000</b>	<b>274,973</b>	<b>261.9</b>	<b>303,000</b>	<b>655,374</b>	<b>216.3</b>
Private developers	-	-	-	39,000	94,029	241.1	90,000	53,607	59.6	60,000	215,267	358.8	100,000	269,320	269.3	289,000	632,223	218.8
Cooperatives societies	-	-	-	1,000	3,265	326.5	4,000	7,477	186.9	4,000	6,756	168.9	5,000	5,653	113.1	14,000	23,151	165.4
<b>Total</b>	<b>16,000</b>	<b>10,016</b>	<b>62.6</b>	<b>232,000</b>	<b>200,513</b>	<b>86.4</b>	<b>131,300</b>	<b>83,910</b>	<b>63.9</b>	<b>110,700</b>	<b>252,121</b>	<b>227.8</b>	<b>125,000</b>	<b>297,483</b>	<b>238.0</b>	<b>615,000</b>	<b>844,043</b>	<b>137.2</b>

From table 2.1, the overall performance of houses built under low cost housing category was encouraging with 200,513 units completed which are 86.4% of the Plan target. Of this total, 103,219 units (53.8%) were constructed by the public sector. Under the Public Low-cost Housing Program (PLHP) for the low income group, a total of 27,006 low cost houses were constructed involving 70 projects during the Plan period. These projects were implemented by the state government through loans provided by the Federal Government and they were mainly concentrated in small towns and sub-urban areas. These houses were sold to eligible buyers registered under the computerised open registration system which are administrated by the respective state governments. For cities and larger towns, the *Program Perumahan Rakyat Bersepadu* (PPRB) was implemented for the resettlement of squatters. Under this program, 37,241 low cost houses were completed and rented out to those eligible. Out of this total, 24,654 units were built in the Federal Territory of Kuala Lumpur while 12,587 units were built in other major towns throughout the country.

In the low medium cost housing category, a total of 83,910 units were completed, achieving 63.9% of the Plan target. Of this total, the private sector constructed 61,084 units (72.8%). The overall performance in this category was better than the 22.4% of the target achieved during the previous Plan period. On the other hand, the total number of medium and high cost houses constructed by the private sector during the Plan period far exceeded its target. A total number of 222,023 units of medium cost and 274,973 units of high cost houses were constructed. This shows the imbalance of housing construction in Malaysia which leads to high demand pressure for low cost houses.

To ensure an adequate supply of low cost houses for the low income group, any mixed-development projects undertaken by private developers, continued to be guided by the 30% low cost housing policy requirement (Government of Malaysia, 2006). The local income level should be one of the main dominant factors in decision making of housing construction category. By developing low cost and low medium cost housing, it can reduce illegal housing growth on the government's land and also prevent the public from creating other new squatters.



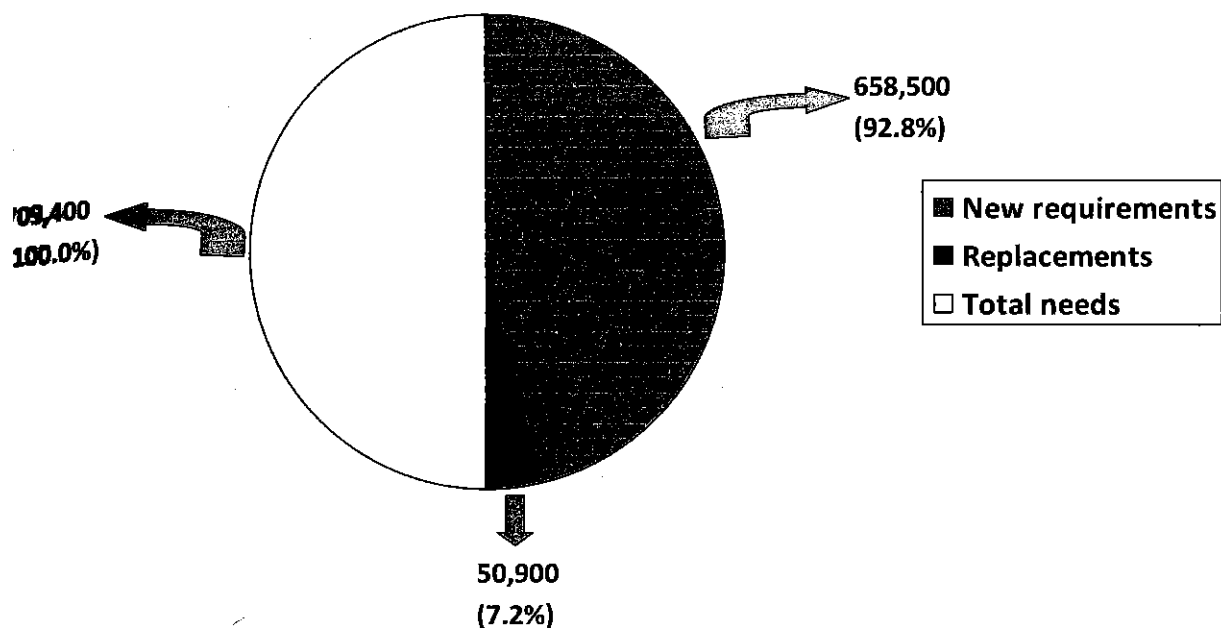
During the Ninth Malaysia Plan, the requirement for new houses was expected to be about 709,400 units of which 19.2% will be in Selangor followed by Johor at 12.9%, Sarawak 9.4% and Perak 8.2%. Table 2.2 shows the housing requirements by state from 2006 to 2010.

**Table 2.2: Housing requirements by state, 2006-2010**

*Source: Government of Malaysia, 2006 (Ninth Malaysia Plan, 2006-2010)*

*Notes: <sup>1</sup>Includes Wilayah Persekutuan Putrajaya*

State	New requirements	Replacements	Total needs
Johor	86,100	5,400	91,500
Kedah	51,800	5,000	56,800
Kelantan	40,600	5,600	46,200
Melaka	19,100	1,700	20,800
Negeri Sembilan	23,000	3,700	26,700
Pahang	41,100	3,300	44,400
Perak	48,600	9,600	58,200
Perlis	6,100	500	6,600
Pulau Pinang	30,900	1,900	32,800
Sabah	50,800	5,300	56,100
Serawak	62,400	4,600	67,000
Selangor <sup>1</sup>	135,200	800	136,000
Terengganu	30,000	2,800	32,800
Federal Territory of Kuala Lumpur	31,800	600	32,400
Federal Territory of Labuan	1,000	100	1,100
<b>Total</b>	<b>658,500</b>	<b>50,900</b>	<b>709,400</b>
<b>%</b>	<b>92.8</b>	<b>7.2</b>	<b>100.0</b>



**Figure 2.4: Total units and percentage of housing requirements by state, 2006-2010**

*Source: Government of Malaysia, 2006 (Ninth Malaysia Plan, 2006-2010)*

*Notes: <sup>1</sup>Includes Wilayah Persekutuan Putrajaya*

Of the total requirement, 92.8% will be for new houses while 7.2% for replacing old ones. The private sector is expected to supply 72.1% of the total requirement. The private sector will provide 38.2% of combination of low and low medium cost houses, as well as houses for the poor while 61.8% of medium and high cost houses. Table 2.3 shows the public and private sector housing targets for 2006 to 2010.

**Table 2.3: Public and private sector housing targets, 2006-2010***Source: Ministry of Housing and Local Government, 2006*

Program	Number of units					Total	
	Housing for the poor	Low cost	Low medium cost	Medium cost	High cost	Number of units	% of total
<b>Public sector</b>	<b>20,000</b>	<b>85,000</b>	<b>37,005</b>	<b>27,100</b>	<b>28,700</b>	<b>197,805</b>	<b>27.9</b>
Low cost housing	-	67,000	-	-	-	67,000	9.5
Hardcore poor housing (PPRT)	20,000	-	-	-	-	20,000	2.8
Housing by commercial agencies	-	13,500	31,005	8,200	4,700	57,405	8.1
Housing by land schemes	-	4,500	500	-	-	5,000	0.7
Institutional quarters staff accommodation	-	-	5,500	18,900	24,000	48,400	6.8
<b>Private sector</b>	-	<b>80,400</b>	<b>48,500</b>	<b>183,600</b>	<b>199,095</b>	<b>511,595</b>	<b>72.1</b>
Private developers	-	77,700	42,400	178,000	194,495	492,595	69.4
Cooperative societies	-	2,700	6,100	5,600	4,600	19,000	2.7
<b>Total</b>	<b>20,000</b>	<b>165,400</b>	<b>85,505</b>	<b>210,700</b>	<b>227,795</b>	<b>709,400</b>	<b>100.0</b>
<b>%</b>	<b>2.8</b>	<b>23.3</b>	<b>12.1</b>	<b>29.7</b>	<b>32.1</b>	<b>100.0</b>	

During the Plan period, the Government will continue to construct low cost houses under the *Program Perumahan Rakyat* (PPR) to ensure adequate houses for the low income group. Greater private sector involvement is encouraged to ensure adequate supply of affordable houses, to meet the needs of the low income group. The private sector is targeted to construct a total of 80,400 low cost houses. The 30% quota requirement for the low cost houses will be reviewed, to encourage housing developers to increase the supply of low medium cost housing component in their mixed development projects (Government of Malaysia, 2006).

The first systematic major collection of statistics on housing in Peninsular Malaysia was undertaken in 1970. Since then, studies on housing have been conducted extensively in Malaysia such as socio-economic considerations of human settlements and housing (Salih,

1976), housing needs versus effective demand in Malaysia 1976-1990 (Chander, 1977), and housing needs in Peninsular Malaysia (Chander, 1974).

The questions of price, affordability and ownership remain as the main problems to the housing sector. Home ownership reflects an inherent human desire for property ownership for economic or non-economic reasons and the sense of security, which it is alleged, to bestow. In this respect, house ownership issues could be viewed as a demand led phenomenon (Saunders, 1990)

Alternatively, home ownership could be viewed as essentially, a supply-led problem and accordingly, the growth of owner-occupation as a response to the problems of housing providers rather than consumers (Malpass and Muril, 1994). But in order to deal effectively with housing problems, a much wider perspective on housing is urgently required (Ball 1983, 1992) embracing the issue of production as well as consumption.

Based on the Draft of the Kuala Lumpur Structure Plan 2020, currently there are 328,205 units of house (excluding temporary houses) as compared to the total household number of 348,800. It means that, Kuala Lumpur still lacks some 20,595 units of houses if the objective of every family to own a house is to be achieved.

The present housing stock according to the price category is at 3.5% for low medium cost housing as compared to percentage or targeted group at 20.5% within the affordability level, associated with this category. There is a clear mismatch between the people's affordability and house category available at the market currently. Table 2.4 shows the existing housing stock in Kuala Lumpur.

**Table 2.4: Existing housing stock in Kuala Lumpur, 2000***Source: Kuala Lumpur City Hall, 2003*

Price category	Unit	%
Low cost	111,906	26.1
Low medium cost	14,993	3.5
Medium cost	61,345	14.3
High cost	184,725	43.1
Temporary house	40,350	9.4
Others	15,489	3.6
<b>Total</b>	<b>428,808</b>	<b>100</b>

The achievement of construction of low medium cost housing in Kuala Lumpur during the Seventh Malaysia Plan was also at the lowest with only 27.3% compared to medium (233.7%) and high cost (749.6%) housing. The construction of low medium cost housing only started in 1998. Table 2.5 shows the target and achievement of housing construction according to the price category in Kuala Lumpur from 1996 to 2000.

**Table 2.5: Target and achievement housing construction according to price category in Kuala Lumpur, 1996-2000***Source: Government of Malaysia, 2001 (Eight Malaysia Plan, 2001-2005)*

Price category	Target		Achievement		%
	Unit	%	Unit	%	
Hard core poor housing	100	0.2	0	0.0	0.0
Low cost	14,000	33.3	4,329	6.0	30.9
Low medium cost	14,000	33.3	3,828	5.3	27.3
Medium cost	8,000	19.0	18,692	26.0	233.7
High cost	6,000	14.2	44,962	62.6	729.4
<b>Total</b>	<b>42,100</b>	<b>100</b>	<b>71,811</b>	<b>100</b>	

In 2003 Selangor, Johor, Perak, Federal Territory Kuala Lumpur and Pulau Pinang dominated the existing housing stock and together contributed 68.9% (2,133,128 units) of the total existing housing stock in Malaysia (Valuation & Property Services Department, 2003). All these states experience a high migration of people because of many vacancies offered in industrial and also a well maintained flow of economy. Residential Property Stock Report in the year 2003 year reported that housing stock in the fourth quarter was increased by 1.3% to 3,237,599 units over the third quarter. Conversely, the units completed in this period decreased from 5.1% in the third quarter to 17.3% in the fourth quarter.

As in a conclusion, housing construction will go on continuously to supply the population needs in this country with a convenient residential area and also a complete infrastructure. To achieve this aim successfully, the link between the government and private sector is important.

### **2.2.1 Concept of low cost housing**

In Malaysia, low cost housing is defined at a ceiling price. Previously, the Ministry of Housing and Local Government has laid down the following guidelines for low cost housing category:

1. The target group consists of households with monthly incomes not exceeding RM750 (157.12 GBP).
2. The type of houses may include flats, terrace or detached houses.
3. The minimum design standard specifies a built-up area of 550-600 square feet, 2 bedrooms, a living-room, a kitchen and a bathroom.

Starting from June 1998, the Ministry of Housing and Local Government have changed the guidelines for low-cost housing category as mentioned below:

1. The housing price is divided into four categories; (1) first category with RM 42,000 (8,798.81 GBP); (2) second category with RM35,000 (7,332.34 GBP); (3) third category with RM30,000 (6,284.86 GBP); and (4) fourth category with RM25,000 (5,237.38 GBP).

---

**REFERENCES**

- Abdul Karim, M. R. (1995). "Housing for the Urban Lower Income Group", United Nations: Public Administration and Finance, New York.
- Anderson, O. D. (1976). "Time Series Analysis and Forecasting: The Box-Jenkins Approach", London and Boston. Butterworths, Malaysia.
- Armstrong, J.S. and Fred, C. (1992). "Error Measures for Generalizing About Forecasting Methods: Empirical Comparisons", *International Journal of Forecasting*, Vol. 8, p. 69-80.
- Ball, M. (1983). "Housing Policy and Economic Power", Methuen, London.
- Ball, M. and Harloe, M. N. (1992). "Rhetorical Barriers to Understanding Housing Provision what the 'provision thesis' is and is Not", *Housing Studies*, Vol. 7, no. 1, p. 3-15.
- Bahkary, N. (2001). "Application of Artificial Neural Network in Bridge Deck Condition Rating", Universiti Teknologi Malaysia, Malaysia.
- Barnea, N. and Yehudit, J. D. (2000). "Computerized Molecular Modeling – The Technology for Enhancing Model Perception among Chemistry Educators and Learners", *New Educational Technologies (NET)*, Vol. 1, p. 109-120.
- Basudeb, B. (2010). "Analysis of Urban Growth and Sprawl from Remote Sensing Data", *Advances in Geographic Information Science*. Springer. p. 23. ISBN ISBN 978-3-642-05298-9.

- Bishop, C.M. (1995). "Neural Networks for Pattern Recognition", Oxford University Press, Oxford.
- Bell, D. and Parr, M. (2003). "Visual Basic.Net for Students", Person Education Limited, England.
- Bowerman, B. L. (1987). "Time Series Forecasting: Unified Concepts and Computer Implementation", 2<sup>nd</sup> ed, Mass: Duxbury Press, Boston.
- Bowerman, B. L. (1979). "Time Series and Forecasting: An Applied Approach", Mass: Duxbury Press, North Scituate.
- Brockwell, P. J. (1994). "ITSM For Windows: A User's Guide to Time Series Modelling and Forecasting", Spring-Verlag, New York.
- Canada Mortgage and Housing Corporation, (2011). "Affordable Housing: What is the common definition of affordability?", Government of Canada. [http://www.cmhc-schl.gc.ca/en/corp/faq/faq\\_002.cfm](http://www.cmhc-schl.gc.ca/en/corp/faq/faq_002.cfm).
- Carpenter, G., Gjaja, M., Gopal, S., and Woodcock, C. (1997). "ART networks in Remote Sensing", *IEEE Transactions on Geoscience and Remote Sensing*, Vol. 35, no. 2, p. 308-325.
- Chander, R. (1974). "Housing Needs in Peninsular Malaysia", Department of Statistics Malaysia, Kuala Lumpur.
- Chander, R. (1977). "Housing Needs versus Effective Demand in Malaysia." Department of Statistics Malaysia, Kuala Lumpur.
- Chatfield, C. (1984). "The Analysis of Time Series: An Introduction", 3<sup>rd</sup> ed, Chapman and Hall Ltd, London.