

Ministry of Higher Education  
and Scientific Research  
University of Diyala  
College of Engineering



# **ARTIFICIAL INTELLIGENT MODELING FOR CONSTRUCTION COST INDICES, ESTIMATION AND PREDICTION**

**A Thesis Submitted to the Council of College of Engineering  
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Requirements for the Degree of Master of Science in Civil  
Engineering**

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بِسْمِ اللّٰهِ الرَّحْمٰنِ الرَّحِیْمِ

فَبَدَأَ بِأَوْعِيَّتِهِمْ قَبْلَ وِعَاءِ أَخِيهِ ثُمَّ اسْتَخْرَجَهَا مِنْ  
وِعَاءِ أَخِيهِ كَذَلِكَ كِدْنَا لِيُوسُفَ مَا كَانَ لِيَأْخُذَ  
أَخَاهُ فِي دِينِ الْمَلِكِ إِلَّا أَنْ يَشَاءَ اللّٰهُ نَرْفَعُ دَرَجَاتٍ مَنْ  
نَشَاءُ وَفَوْقَ كُلِّ ذِي عِلْمٍ عَلِيمٌ

صَدَقَ اللّٰهُ الْعَظِيمَ

القرآن الكريم سورة يوسف، الآية (٧٦)

## *Dedication*

*To my parents who give me the  
support in every step of my life*

*To my brothers and sisters*

*To Everyone I loved deeply in my  
heart*

*Fatima*

## *Acknowledgments*

*I want to thank the Civil Engineering Department for the facilities provided to me.*

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## **Abstract**

There is a time difference between the cost estimation stage of construction projects and the implementation phase. In addition, the project takes a long time to complete it and the cost of materials varying from time to time in the market so cost estimation play important role in success of any construction project at initial stage therefore the research aims to develop one model to predict the total cost of the construction project and develop twenty-five models to estimate the average prices of construction items of the project with high accuracy by using artificial intelligence techniques such as multiple linear regression analysis (MLR), support vector machine (SVM) and artificial neural networks (ANN). The data set used to build the models is 34 construction projects, and these projects were collected from several government departments in Diyala province.

The optimal method based on precision, and enabling to predict the budget of projects was MLR with precision (98.97%) while the optimal method based on correlation factor was ANN with percentage (100%).

The optimal method based on precision, which is able to predict the price rate of land fill work item, construction works under moisture proof layers item, ordinary concrete for walkways item, reinforced concrete lintel item, reinforced concrete slab item, reinforced concrete stairs item, reinforced concrete for the sun bumper item, cement finishing works item, color pigment item and works of placing marble item model was SVM. Price rate of pentellite paints item model was MLR and for excavation the foundation works item, filling with sub-base item, the construction works above moisture proof layers item, construction work of sections item, reinforced concrete foundation item, reinforced concrete columns item, reinforced concrete beams item, plaster finishing works item , plastic finishing works item , Stone packaging item model, ceramic works for

floors item model, ceramic work for walls item, flattening (two opposite layers of lime) and flatting (Tiling) item was ANN. Also, the optimal technique based on correlation factor, it can be used to predict price rate for all items was ANN expect the construction works under moisture proof item model and pentellite layer was MLR.

## Contents

Subject	Page
Dedication	I
Acknowledgements	II
Abstract	III
Contents	V
List of Tables	IX
List of Figures	XIV
List of Abbreviations	XV
<i>Chapter One: Introduction</i>	
1.1 General	1
1.2 Research Justification	2
1.3 Research Hypothesis	2
1.4 Research Aim and Objectives	2
1.5 Research Scope and Limitation	3
1.6 Research Methodology	3
1.7 Research Structure	4
<i>Chapter two: Construction cost estimation, predication and indices</i>	
2.1 Introduction	7
2.2 Cost management	8
2.3 Cost Estimating	8
2.4 Types of construction cost estimating	9
2.5 Purpose of cost estimation	10
2.6 Accuracy of Cost Estimate	10
2.7 Classification of Construction Costs	13
2.8 Construction cost indices	14
2.9 Factor affecting on construction cost	16
2.9.1 Factors related to estimator	16
2.9.2 Factors related to design and project	16
2.9.2.1 Material Costs	17
2.9.2.2 Site Conditions	17
2.9.2.3 Duration	17
2.9.2.4 Changes of design and scope	18
2.9.2.5 Project Size	19
2.9.2.6 Projects kinds	19
2.9.2.7 Client kind	20
2.9.2.8 Methods of tendering	20
2.10 Methods of cost estimation	21
2.10.1 Quntitive and qualitative methods	21
2.10.2 Detailed and preliminary techniques	22

2.11 Intelligent Construction Project Cost prediction Methods	23
2.11.1 Machine Learning (ML) Systems	24
2.11.2 Knowledge-Based Method (KBM)	25
2.11.3 Evolutionary Methods (EM)	26
2.11.4 Agent Based Methods (ABM)	27
2.11.5 Crossbred methods (CM)	27
<i><b>Chapter three: Artificial intelligent techniques</b></i>	
3.1 Introduction	31
3.2 Artificial neural networks (ANNs)	31
3.2.1 Artificial Neural Network Structures	33
3.2.2 Artificial Neural Network operations	34
3.2.3 Activation Function	35
3.2.4 Training process of networks	37
3.2.5 Kinds of Neural Networks	38
3.2.5.1 One -Layer Feed Forward Networks	39
3.2.5.2 Feed Forward Networks	39
3.2.6 Recurrent Networks	41
3.2.7 Advantage of ANN in project management	41
3.2.8 Disadvantage of ANN	42
3.3 Multiple Linear Regression Analysis (MLR)	43
3.4 Support Vector Machines (SVMs)	44
3.4.1 Introduction	44
3.4.2 Support Vector Machine algorithms	44
3.3.3 Support Vector Machine Structure	45
<i><b>Chapter Four: Using Artificial Neural Networks for developing the cost estimation model and construction cost indices models</b></i>	
4.1 Introduction	49
4.2 ANN Model Inputs For (CEM)	49
4.3 ANN Model outputs For (CEM)	50
4.4 Data collection	50
4.5 Program Selection	50
4.6 Developing Network	51
4.7 Model structure	52
4.8 Data Division for ANN Models	53
4.9 ANN (CEM) Final Equations	55
4.10 Validation of the ANN (CEM)	59
4.11 Construction Cost Indices Models (CCIMs)	61
4.11.1 Input and output for (CCIMs)	62
4.11.2 Data division	62
4.11.3 Model structure	63
4.11.4 Excavation the foundation works item Model Equation	63
4.11.5 Land fill model item	64



4.11.6 Filling with sub-base item model	64
4.11.7 Construction works under moisture proof layers item	65
4.11.8 Construction work above moisture proof layer	67
4.11.9 Construction works of sections	67
4.11.10 Ordinary concrete for walkways	68
4.11.11 Reinforced concrete foundation	69
4.11.12 Reinforced concrete column	69
4.11.13 Reinforced concrete lintel	70
4.11.14 Reinforced concrete slabs	71
4.11.15 Reinforced concrete beams	72
4.11.16 Reinforced concrete stair	73
4.11.17 Reinforced concrete for the sun bumper	73
4.11.18 Plaster finishing works	74
4.11.19 Cement finishing work	75
4.11.20 Plastic finishing works	75
4.11.21 Pentellite paints	76
4.11.22 Stone packaging	77
4.11.23 Color pigment	78
4.11.24 Works of placing marble	79
4.11.25 Ceramic works for floor	80
4.11.26 Ceramic works for wall	80
4.11.27 Flattening (two opposite layers of lime)	81
4.11.28 Flattening (Tiling)	82
4.12 Validation of CCIMs	83
<b><i>Chapter five: Using Multiple Linear Regression for developing the cost estimation model and construction cost indices models</i></b>	
5.1 Introduction	85
5.2 Application of MLR	85
5.3 Weighted Least Square regression	86
5.4 Development of (CEM)	86
5.5 Model Validation	89
5.6 Development of CCIMs	91
5.6.1 Statistical measurements for CCIMs	91
5.6.2 Excavation the foundation works item Model	92
5.6.3 Land fill work item	93
5.6.4 Filling with sub-base item model	93
5.6.5 Construction works under moisture proof layers item model	94
5.6.6 Construction work above moisture proof layer model	95
5.6.7 Construction work of section	95
5.6.8 Ordinary concrete for walkways model	96
5.6.9 Reinforced foundation model	96
5.6.10 Reinforced column item model	97

5.6.11 Reinforced lintel item model	98
5.6.12 Reinforced beams model	98
5.6.13 Reinforced slab model	99
5.6.14 Reinforced stair model	99
5.6.15 Reinforced concrete for the sun bumper model	100
5.6.16 Plaster finishing works model	101
5.6.17 Cement finishing works model	101
5.6.18 Plastic finishing works model	102
5.6.19 Pentellite paints model	102
5.6.20 Color packaging model	103
5.6.21 Stone packaging item model	103
5.6.22 Works of placing marble model	104
5.6.23 Ceramic works for floor model	105
5.6.24 Ceramic work for wall model	105
5.6.25 Flattening (two opposite layers of lime)	106
5.6.26 Flattening (Tiling) model	106
5.7 Validation of CCIMs	107
<i>Chapter six: Using support vector machines for developing the cost estimation model and construction cost indices models</i>	
6.1 Introduction	109
6.2 Determination the variables for Support Vector Machines Models	109
6.3 Program Selection	109
6.4 Data Division for CEM	111
6.5 Implementation the techniques in WEKA	112
6.6 SVM Model Equation (CEM)	113
6.7 Validation of the CEM Model	114
6.8 Development of Mathematical Models for CCIMs	115
6.8.1 Data Division for CCIMs	115
6.8.2 Excavation the foundation works item Model Equation	116
6.8.3 Land fill work item	116
6.8.4 Filling with sub-base item model	117
6.8.5 Construction works under moisture proof layers item model	118
6.8.6 Construction work above moisture proof layer	118
6.8.7 Construction works of sections	119
6.8.8 Ordinary concrete for walkways	120
6.8.9 Reinforced foundation	120
6.8.10 Reinforced column	121
6.8.11 Reinforced beams	122
6.8.12 Reinforced lintel	123
6.8.13 Reinforced slabs	123
6.8.14 Reinforced stair	124

6.8.15 Plaster finishing works	124
6.8.16 Cement finishing works	125
6.8.17 Plastic finishing works	125
6.8.18 Pentellite paints	126
6.8.19 Stone packaging	126
6.8.20 Color pigment	127
6.8.21 Works of placing marble	127
6.8.22 Ceramic works for floor	128
6.8.23 Ceramic works for walls	128
6.8.24 Flattening (two opposite layers of lime)	129
6.8.25 Flattening (Tiling)	129
6.9 Validation of CCIMs	129
6.10 Results of cost estimation models of three techniques	131
6.11 choosing the optimal technique	132
<i>Chapter seven: Conclusions and recommendations</i>	
7.1 Conclusions	136
7.2 Recommendations	137
7.3 Proposals for future research	138
7.4 Published Research	138
Reference	139
Appendix	

## List of Tables

Table no.	Title	Page
<b>Chapter Two</b>		
Table (2.1)	Three types of construction cost estimating methods. (Holm et al., 2005)	10
Table (2.2)	Comparison of proposals based on technique and validation	29
Table (2.3)	Comparison of the proposals based on factors related to design and project	30
<b>Chapter Four</b>		
Table (4.1)	Effects No. of Nodes on ANN Performance	52
Table (4.2)	Effect of Transfer Function on ANNs Performance	52
Table (4.3)	Effect of Data Division on Performance of ANNs	48
Table (4.5)	Information of the network for CEM	56
Table (4.6)	Statistical results for inputs and output	51
Table (4.7)	Statistical results for testing data of ANN model	59
Table (4.8)	Errors Classification (%), (Schexnaydr, 2003)	60
Table (4.9)	The information of the network for excavation the foundation works item Model	63
Table (4.10)	The information of the network for land fill model item	64
Table (4.11)	The information of the network for filling with sub-base item model	65
Table (4.12)	The information of the network for Construction works under moisture proof layers item model	65
Table ( 4.13)	The information of the network for Construction work above	67

	moisture proof layer	
Table (4.14)	The information of the network for Construction works of sections	68
Table (4.15)	The information of the network for ordinary concrete for walkways	69
Table (4.16)	The information of the network for reinforced concrete foundation	69
Table (4.17)	The information of the network for Reinforced concrete columns	70
Table (4.18)	The information of the network for reinforced concrete lintel	70
Table (2.19)	The information of the network for reinforced concrete slabs	71
Table (4.20)	The information of the network for reinforced concrete beams	72
Table (4.21)	The information of the network for reinforced concrete stairs	73
Table (4.22)	The information of the network for Reinforced concrete for the sun bumper	73
Table (4.23)	The information of the network for plaster finishing works	74
Table (4.24)	The information of the network for cement finishing works	75
Table (4.25)	The information of the network for plastic finishing works	75
Table (4.26)	The information of the network for pentellite paints	76
Table (4.27)	The information of the network for Stone packaging	77
Table (4.28)	The information of the network for color pigment	78

Table (4.29)	The information of the network for Works of placing marble	79
Table (4.30)	The information of the network for Ceramic works for floors	80
Table (4.31)	The information of the network for Ceramic works for walls	81
Table (4.32)	The information of the network for flattening (two opposite layers of lime)	81
Table (4.33)	The information of the network for Flattening (Tiling)	82
Table (4.34)	The statistic results of CCIMs	83
<b>Chapter Five</b>		
Table (5.1)	Measurements of regression model	87
Table (5.2)	Model summary	89
Table (5.3)	Statistical Measures Results for Regression model	91
Table (5.4)	Summary Statistics of Models	93
Table (5.5)	Coefficients for Excavation the foundation works item Model	93
Table (5.6)	Coefficients for Land fill work item	93
Table (5.7)	Coefficients for Filling with sub-base item model	94
Table (5.8)	Coefficients for Construction works under moisture prove layers item model	94
Table (5.9)	Coefficients for Construction works above moisture proof layers item model	95
Table (5.10)	Coefficients for Construction works section	96
Table (5.11)	Coefficients for Ordinary concrete for walkways model	96
Table (5.12)	Coefficients for reinforced foundation model	97

Table (5.13)	Coefficients for column item model	97
Table (5.14)	Coefficients for lintel reinforced model	98
Table (5.15)	Coefficients for reinforced beams model	99
Table (5.16)	Coefficients for reinforced slabs model	99
Table (5.17)	Coefficients for reinforced stair model	100
Table (5.18)	Coefficients for Reinforced concrete for the sun bumper model	100
Table (5.19)	Coefficients for plaster finishing works model	101
Table (5.20)	Coefficients for Cement finishing works model	102
Table (5.21)	Coefficients for plastic finishing works model	102
Table (5.22)	Coefficients for Pentellite paints model	103
Table (5.23)	Coefficients for color packaging model	103
Table (5.24)	Coefficients for Stone packaging item model	104
Table (5.25)	Coefficients for works of placing marble model	104
Table (5.26)	Coefficients for ceramic works for floor model	105
Table (5.27)	Coefficients for ceramic work for wall model	105
Table (5.28)	Coefficients for Flattening (two opposite layers of lime)	106
Table (5.29)	Coefficients for Flattening (Tiling) item	107
Table (5.30)	The statistics results of CCIMs	107
<b>Chapter six</b>		
Table (6.1)	Effect of data division on CEM	111
Table (6.2)	Effects of select kernel on CEM Model Performance	113
Table (6.3)	Effort of Change the Parameter C on CEM	114
Table (6.4)	The information of support vector machine net works	115
Table (6.5)	Results of the SVM Model	116

Table (6.6)	The information of the network for Excavation the foundation works item Model Equation	117
Table (6.7)	The information of the network for land fill work item	117
Table (6.8)	The information of the network for Filling with sub-base item model	118
Table (6.9)	The information of the network for Construction works under moisture proof layers item model	119
Table (6.10)	The information of the network for Construction work above moisture proof layer	119
Table (6.11)	The information of the network for Construction works of sections	120
Table (6.12)	The information of the network for ordinary concrete for walkways	121
Table (6.13)	The information of the network for Reinforced foundation	121
Table (6.14)	The information of the network for Reinforced column	122
Table (6.15)	The information of the network for Reinforced beams	112
Table (6.16)	The information of the network for reinforced lintel	123
Table (6.17)	The information of the network for Reinforced slabs	123
Table (6.18)	The information of the network for Reinforced stair	124
Table (6.19)	The information of the network for Plaster finishing works	124
Table (6. 20)	The information of the network for Cement finishing works	125
Table (6.21)	The information of the network for Plastic finishing works	125
Table (6.22)	The information of the network for Pentellite	126



	paints	
Table (6.23)	The information of the network for Stone packaging	126
Table (6.24)	The information of the network for Color pigmen	127
Table (6.25)	The information of the network for Works of placing marble	127
Table (6.26)	The information of the network for Ceramic works for floor	128
Table (6.27)	The information of the network for Ceramic works for walls	128
Table (6.28)	The information of the network for Flattening (two opposite layers of lime)	129
Table (6.29)	The information of the network for Flattening (Tiling)	129
Table (5.30)	The statistical measures of CCIMs	130
Table (6.31)	Best Technique Used for Deriving the Model Equation according to AA%	133
Table (6.32)	Best Technique Used for Deriving the Model Equation According Correlation R%	134

## List of Figures

Figures No.	Title	Page
<b>Chapter One</b>		
Figure(1.1)	Research methodology	4
<b>Chapter Two</b>		
Figure (2.1)	Cost Management steps (Stephenson and FAACE, 2015)	7
Figure (2.2)	Relationship between time and estimate accuracy	13
Figure (2.3)	Classification of construction costs	13
Figure (2.4)	Modeled duration –cost envelope for police decision support in small and medium projects	18
<b>Chapter Three</b>		
Figure (3.1)	Work of artificial neural cells and biological cells (AL-Zwainyet al.,2012)	32
Figure (3.2)	Architectural of artificial neural networks(Kimes, 1998)	33
Figure (3.3)	Process of neural network (Shahin, et al., 2008)	35
Figure (3.4)	The types of activation function (Stewart, 2005)	36
Figure (3.5)	The Hyperbolic Tangent Function (Karlik,2011)	37
Figure (3.6)	The Logistic Sigmoid Function (Karlik,2011)	37
Figure (3.7)	Types of learning methods(Pawar, 2007)	38
Figure (3.8)	One-layer feed forward network (Al-Janabi, 2006)	39
Figure (3.9)	Multiple layer Perceptron(Christian, et al., 2000)	40
Figure(3.10)	General Feed Forward networks organization(Principe, et al., 2010)	41
Figure(3.11)	General model of SVM (Petruseva, 2013)	47
Figure(3.12)	Mapping in multidimensional space	48

Figure(3.13)	Margins and support vectors	48
<b>Chapter Four</b>		
Figure (4.1)	Developing neural network in Matlab	51
Figure(4.2)	Effects No. of Nodes on ANN Performance	53
Figure (4.3)	Effect of Data Division on the Performance of the ANNs	55
Figure (4.4)	Architecture of the ANN of CEM	55
<b>Chapter Five</b>		
Figure (5.1)	Prediction versus real total cost	90
<b>Chapter Six</b>		
Figure (6.1)	The software Interface	110
Figure (6.2)	Transfer the file to software	111
Figure (6.3)	Graphing Component of weka Program application	112
Figure (6.4)	Graphing Component of weka Program application	112
Figure (6.5)	Prediction versus real costs for testing dataset	115
Figure (6.6)	Results for CEM of the Techniques	132

## List of Aabbreviation

Abbreviation	Description
Agent- Based methods	ABM
Artificial intelligence	AI
Artificial Neural Network	ANN
Autoregressive	AR
Construction cost indices	CCI
Construction cost indices models	CCIMs
Correlation factor	R
Cost estimation model	CEM
Cost Estimation Relationships	CER
Crossbred methods	CM
Determination factor	R <sup>2</sup>
Engineering News Record	ENR
Evolutional Methods	EM
General feed forward	GFF
Genetic Algorithm	GA
Knowledge- Based methods	KBM
Machine Learning	ML
Mean Absolute Percentage Error	MAPE
Modern econometric methods	MEMs
Multilayer Perceptron	MLP
Multiple Linear Regression Analysis	MLR
Percent of Average Accuracy	AA
Radial basis function networks	RFB

seasonal dummy vector error-correction method	VECM
Sequential minimal optimization	SMO
Statistical Package for Social Science	SPSS
Support Vectors Machines	SVMs
Traditional Econometric Methods	TEMs
Vector error-correction method	VECM
Weighted least squares regression	WLS

*Chapter one**Introduction***1.1 General**

From many decades, the subject of the cost has become of a great importance in the construction industry. Dealing with the cost subject starts from the inception of the idea in the head of the client and continues throughout the life of the project. Cost estimating is one of the most important steps in project management. A cost estimate establishes the base line of the project cost at different stages of development of the project.

Accurate cost estimation at the early stage of a construction project is key factor in a project's success. But it is difficult to quickly and accurately estimate construction costs at the planning stage, when drawings, documentation and the like are still incomplete. As such, various techniques have been applied to accurately estimate construction costs at an early stage, when project information is limited. While the various techniques have their pros and cons, there has been little effort made to determine the best technique in terms of cost estimating performance. From this point the researcher will focus on using the three estimating techniques (regression analysis (RA), artificial neural network (ANN), and support vector machine techniques (SVM)) by performing estimations of construction costs.

## **1.2 Research Justification**

The points below summarize the justifications of this research:

- 1) The existing cost estimation practices is poor or not dependable because of the blurry and incomplete environment of these practices and beside that the owner's project is need to know the accurate cost of his project before starting the construction to provide funding for the project.
- 2) The need of the Iraqi construction sector to apply the new effective techniques to estimate the budget of projects and price rate of project item before the execution stage.
- 3) Developing mathematical prediction models that can help in the planning and assist estimation engineers and contractors in guessing the budget of projects or price rate of projects items with precise, easy and fast process.

## **1.3 Research Hypothesis**

The construction sector in Iraq need to use intelligent prediction models in predicting the price rate of projects items and budget of projects. And especially, it does not establish the mathematical prediction equations to predicting price rates of project items.

## **1.4 Research Aim and Objectives**

Development mathematical prediction models using three techniques such as artificial neural networks (ANN), support vector machine (SVM) and regression analysis (RA) to estimate the final cost of construction project and price rate of items at tendering prepare stage and made comparing between the models in term of accuracy in estimation.

The means that is adopted to reach the aim of the study:

1. Examining the uses of the three techniques in the field of project management.
2. Building and validation the mathematical prediction equations to compute the budget of the construction and cost indices for items of the project.

### **1.5 Research Scope and Limitation**

This research focuses on public sector of construction projects in Diyala province including tendering prepare phase. Many building projects that were implemented between 2005 and 2015 were collected, and some types of these building projects were school buildings and higher education buildings and type of tendering is open tendering.

### **1.6 Research Methodology**

The steps below summarize the methodology used to achieve study objectives:

#### **1. Literature review**

The literature review includes a collection of references that are related to the research topic such as thesis, papers, books, and website sources particularly which are related to artificial intelligence and its application to the estimation costs.

#### **2. Collecting the data**

Historical cost data of 34 projects, Project assignment year and detailed quantities of these projects were gathered.

#### **3. Building the Models**

This stage involves choosing the software, selecting kind of models, and developing models. Furthermore, to execute the models and make



training several times and validate the models. Additionally, this stage contains testing the models and discussing the findings carefully.

#### 4. Validating the models

Finally, at this stage the models that developed by the ANN, SVM and MLR are validated and the best model is found.

Can be summarize the research methodology as shown in Figure (1.1).

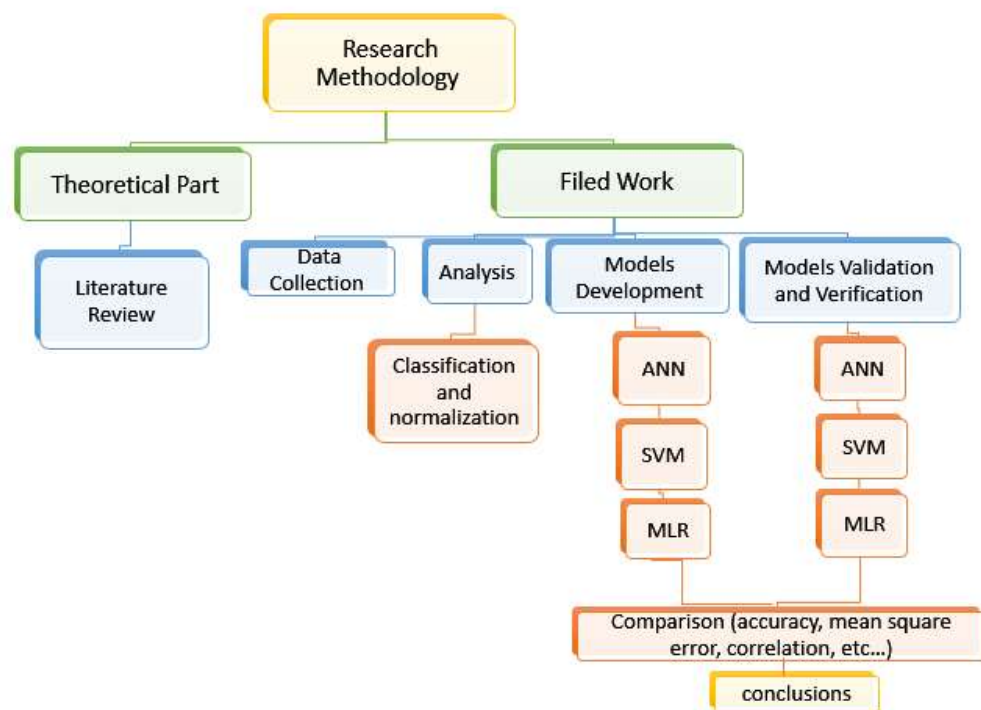


Figure (1.1): Research methodology

#### 1.7 Research structure

The structure of the research involves the following:

#### Chapter one: Introduction

This chapter provides an overview of the research topic in addition to the justification of research, hypothesis, aim and objectives, research methodology and research structure.

**Chapter two: Construction cost estimation, predication and indices**

Chapter two discovers construction projects costs and construction indices costs as well as estimation techniques and methods that are in use for estimating costs of construction projects and price indexes.

**Chapter three: Artificial intelligent techniques**

This chapter offers complete explanation of the techniques used in the research in terms of its kinds, taxonomies, architecture, and evolution.

**Chapter Four: Using Artificial Neural Networks for developing the cost estimation model and construction cost indices models**

This chapter tries to developing and assess the cost estimation model and construction cost indices models by artificial neural networks technique to offer an instrument to help in the guess of the costs of construction over various stages.

**Chapter Five: Using Multiple Linear Regression for developing the cost estimation model and construction cost indices models**

This chapter tries to developing and assess the construction cost estimation model and construction cost indices models by multiple linear regression analysis technique to offer an instrument to guess the costs of construction over various stages.

**Chapter six: Using support vector machines for developing the cost estimation model and construction cost indices models**

This chapter tries to developing and assess the cost estimation model and construction cost indices models by support vector machine technique to offer an instrument to help in the estimation of construction cost over different stages.

**Chapter seven: Conclusions and Recommendations**

In this chapter, some recommendations and conclusions are presented as well as some suggestions for future studies that may be undertaken in the area of costs of constructions.