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Construction Cost Approach Model for Estimating Real Estate Market Value in Sudan

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ABSTRACT: *Sales comparison, capitalization and construction cost are the main methods of valuation, all of them depend on the availability and accuracy of market data, in the absence of stable markets the available data is questionable. In unstable markets cost of construction materials and workmanship are dynamically influenced by dominating market conditions. This paper suggests using a mathematical model based on the construction cost method to estimate the market value of a real estate in inefficient and unstable markets. Considering all discussions about Sudanese current market instability, valuation approaches and valuation uncertainty, it is recommended to use the model to estimate the market value of a real estate in Sudan. With ±5% results precision, statistics classifies the model results as reliable market values The most valuable feature of the model is time-saving. Using the model to generate market value for real estate is significantly less in time than the classical manual method. The model can be used to calculate quantities of construction materials and workmanship. Contractors can use the model to estimate contract value, especially in lump sum contracts. Also, valuation service applicants can use the model to verify values submitted by the valuation firms.*

KEYWORDS - *Construction cost, Cost method, Inefficient market, Real estate valuation, Uncertainty, Unstable market.*

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I. INTRODUCTION

Valuation is known as the process of concluding the price of an asset, in practice, it contains both objectivity and subjectivity. Valuation is often said to be "an art not a science" but this relates to the techniques employed to calculate the value, not to the underlying concept itself [1].

The 2008 global financial crisis was initiated by the collapse of the real estate market and then dramatic consequences occurred. This scenario elaborates how sensitive is the real estate market. In Sudan the real estate assets play an essential role in supporting the national economy; it is the favourite collateral for the banks (lenders) to accept releasing loans to the investors (borrowers). It is the backbone of investment activities between banks and investors, which means the whole process of loan and paying back the loan is dependent on the credibility of the collateral. The credibility of the collateral requires a fair and clear appraisal for the property which consequently requires a scientific methodology for appraisal carried out by an expert and qualified appraiser.

According to the professional practice specified in valuation standards, there are three main approaches to estimate the market value of the real estate. These approaches are comparison sales, construction cost and income approach, each of them will work and gives reliable results in certain market conditions [2-4].

The absence of reliable market data is the result of the inefficient market in Sudan. This paper will suggest a construction cost model for estimating the market value of real estate in such a case.

1.1 Need for Mathematical Modelling for Real Estate Valuation in Sudan

Uncertainty is a real and universal phenomenon in real estate valuation, Sudan is not an exception. Moreover, in Sudan extra uncertainty originated from market instability, high inflation, and severe fluctuation of foreign currency exchange rate. All these economic factors negatively affect the efficiency of input data required for reliable valuation outputs. The degree of reliability will vary according to the level of confidence in the market information. Therefore, there is a need to use methods and models considering uncertainty. The abnormal uncertainty in Sudan, suggests mathematical modelling to minimize the effect of uncertainty in the value conclusion.

1.2 Why Construction Cost Model?

As discussed before the three main valuation methods are:

1. Sales Comparisons
2. Construction Cost
3. Capitalization Method

Both Sales Comparisons and Capitalization methods depend on the availability and accuracy of the market information [5]. Market Information in the case of unstable and inefficient markets are questionable, while the construction cost approach is based on the current cost of construction materials and workmanship which is real-time information directly affected by market conditions, and that makes this information more reliable and trustable.

The following table is a part of research conducted in Poland to compare the applicability of the comparison method and construction method in absence of reliable market data. The table shows the efficiency of the construction cost method in absence of reliable market data [6].

Table 1: Cost Method Applicability

CRITERION OF COMPARISON	MARKET VALUE	COST VALUE
Object of Valuation	Real estate as a project (site or site and developments together) with it is legal attributes	Real estates as objects (Site and improvements separately or improvements only)
Possibility of valuation	When the market exits, and this kind of value is needed	When there is either very limited market or no evidence of sales or this kind of value is needed
Type of market and the main source of information used in valuation	Sales and lease property market (exchange sphere)	Sales property market for land (exchange sphere) and building construction market for improvements
Principle of valuation	Heights and best use of the property	Existing use of the improvements, heights, and best use of the land
Methods of valuation	Comparison, income, cost approaches-IVS, EVS; comparison, income, mixed approaches_ Act of land management (in Poland)	Cost approach (Depreciated Replacement cost)

II. METHODOLOGY

2.1 Model Purpose and Limitations

The model purpose is to provide a rapid reliable real estate market value in the case of material input uncertainty. The model adopted the construction cost method as a valuation method.

The model will consider (1+4) multi-storeys reinforced concrete residential buildings. the researcher chose this type of building because this type is widespread in the city of Khartoum.

This model is designed to provide market value for real estate with the following specifications:

1. Residential building
2. Reinforced concrete building
3. Up to 5 storeys building
4. Located in Khartoum City, Sudan

2.2 Model Variables

The model variables are classified into two categories, variables connected to the real estate and variables related to the market.

1. Variables connected to the real estate:
1. Built area of each floor
2. Plot size (Length * Width)
3. Number of toilets & kitchens
4. Number of gates and doors
5. Building age in years
6. Number of Elevators
7. Number and type of air conditioning units
8. Tiles type for the staircase
9. External works information (if any)
10. Buildings current condition in (%) percentage

11. Expected construction materials waste in (%) percentage
2. Variables connected to the market:
1. Price of the construction materials and workmanship cost at the time of market value estimation.
2. The USD exchange rate at the time of market value estimation.
3. Expected profit in (%) percentage

2.3 Model Philosophy

Generally, buildings can be categorized based on their functions (i.e., residential, public, commercial …), structural systems (i.e., flat slab, slab with beam ...) and grade of finishing materials.

Considering construction materials quantities, workmanship, tools, and equipment needed to construct a building, buildings in the same category will fall in the same range of quantities required for the square meter of built area. The rate factor of each construction item for the square meter of a built area can be estimated for all construction units of the building.

These estimated factors will be the backbone of the mathematical model. Updated market data will be used in the model to develop the market value at the time of valuation.

In the country Sudan, most of the construction materials or their raw materials are imported, cost of construction materials is directly connected in a dynamic way to foreign currency.

A construction cost model considering the effect of local currency exchange rate on construction materials as a driven variable and considering other variables of the unstable market will increase the credibility of the estimated market value of a real estate. The following figure explains the philosophy of the proposed construction cost model and its role within the whole process of valuation in the case of an inefficient market.

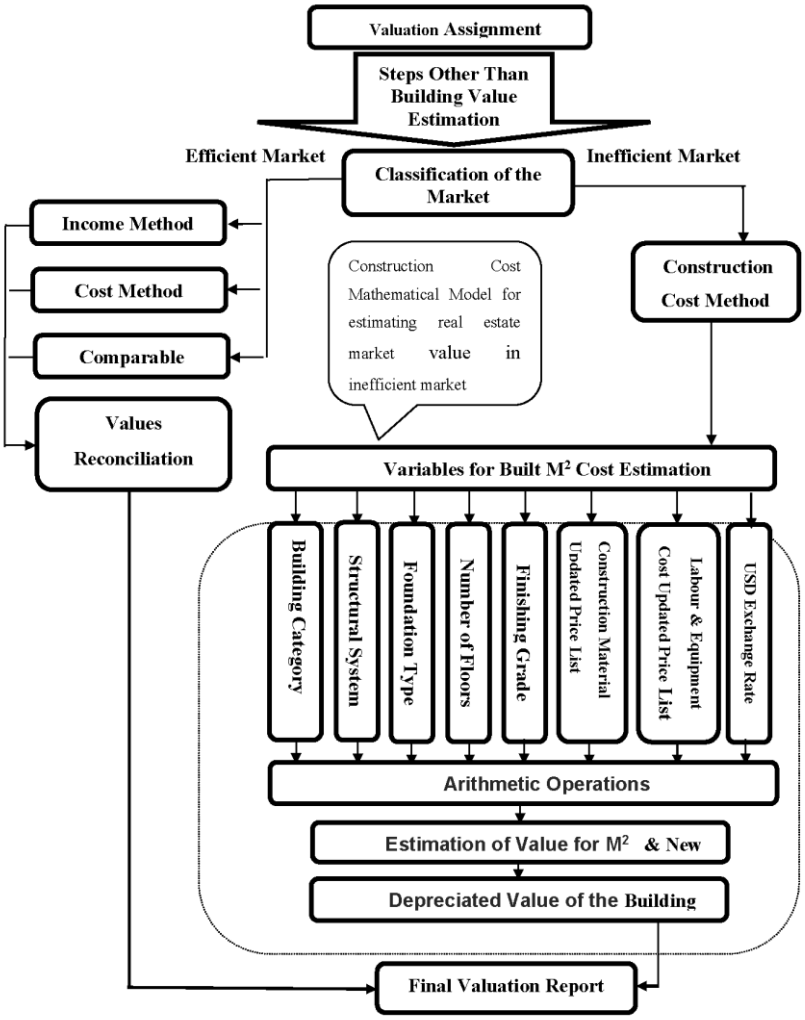

Figure 1: Model Philosophy

1.3 Model Structure

The model is a spreadsheets model using MS Excel 2016. The model is composed of three main sections; each section has a different function. These sections are:

Section 1: Input Section, facilitates entering all information about the real estate, materials prices, workmanship costs and USD exchange rate values.
Section 2: Processing Section, this part is responsible for all necessary calculations using predesigned equations and predetermined factors and variables.
Section 3: Output Section, this part displays output, estimated quantities and values in an organized manner

1.3.1 Section 1: Input Section

This section consists of the following sheets:

1. Real Estate Data, USD Exchange Rate Information and summary of the estimated market value of the subject real estate.
2. Factors for Construction Item / Built Area Factor
3. Quantity for each construction item for a square meter of built area.
4. Updated Price List for Construction Materials & Workmanship

1.3.1.1 Factors for Construction Item / Built Area Factor

Factors are related to each construction item e.g., excavation, backfilling, concrete works, masonry works, finishing works, etc.
There are two types of factors:

1. Quantities Breakdown factors are item and element factors, those factors are applicable for items that could be directly estimated considering the relation between required materials quantities and the built area of the real estate.
2. Flat / fixed rate factors are suitable for items not linearly connected to the built area, namely electrical, water supply and sewage networks.

1.3.1.2 The Calculation for Breakdown Factors

Item factor is the quantity of that item required for one square meter of the built area. It is the mathematical relation between a specific construction item and the built area for a building.
To estimate those factors, first, the researcher studied 12 five-storeys residential buildings drawings sets. Secondly, he created the bill of quantities for sub-structure, ground floor and typical floors, and then he calculated the built area for the ground floor and all typical floors.
To estimate a specific construction item factor for a certain floor, the total quantity of that item divided by the built area of the subject floor. Equation (1):

$$\text{Item Factor} = \frac{\text{Total Item Quantity}}{\text{Total Floor Built Area}}$$

For instance, calculations suggest the factor of 11 m^2/ column, which means, each 11 m^2 of the built area require one column (Table 2).

Table 2 Columns Factor

Built Area M^2	No. of Columns	M^2/No. of Columns	Ratio (Factor)
265	22	12.04545455	12
230	21	10.95238095	11
263	23	11.43478261	11
375	33	11.36363636	11
Say Built Area / No. of columns		=	11

Table (3) shows the items factors as estimated by the study.

Table 3: Construction Items Factors

#	Construction Item	Factor	Unit
1	Reinforced concrete foundations and columns	11	m2 for col.
2	Concrete masonry walls – Ground Floor	2.5	m2/m2
3	Concrete masonry walls – Typical Floor	2.1	m2/m2
4	Concrete masonry walls - Average	2.3	m2/m2
5	Plaster works for walls – Ground Floor	6	m2/m2
6	Plaster works for walls – Typical Floor	5.3	m2/m2
7	Plaster works for walls - Average	5.6	m2/m2
8	Plaster works for ceilings	1	m2/m2
9	Painting works for walls – Ground Floor	6	m2/m2
10	Painting works for walls – Typical Floor	5.3	m2/m2
11	Painting works for walls - Average	5.6	m2/m2
12	Painting works for ceilings	1	m2/m2
13	Tiles for walls (kitchens & toilets) - GF	0.74	m2/m2
14	Tiles for walls (kitchens & toilets) - Typical Floor	0.68	m2/m2
15	Tiles for walls (kitchens & toilets) - Average	0.71	m2/m2
16	Tiles for floors	1	m2/m2
17	Gypsum decoration works – Ground Floor	2	m/m2
18	Gypsum decoration works – Typical Floor	1.7	m/m2
19	Gypsum decoration works - Average	1.8	m/m2
20	Windows works – Ground Floor	0.1	m2/m2
21	Windows works – Typical Floor	0.11	m2/m2
22	Windows works - Average	0.1	m2/m2
23	CMU Boundary wall works / meter length	2.5	m2/m
24	Boundary wall plaster / meter length	5	m2/m
25	Boundary wall painting / meter length	5	m2/m

1.3.2 Section 2: Processing Section

This Section is responsible for all necessary calculations using preformulated and predetermined factors and variables. It is a protected file, and the user cannot change its contents, or reformulate any pre-entered values.

This section of the model uses all factors and values that the user entered in section 1 to generate quantities for the required construction materials and workforce cost estimation, this is the first step and the second step is to multiply these quantities by the unit rate mentioned in updates list price. The summation of the multiplication results is the construction cost of the building.

The real estate market value is the summation of the construction cost and the value of the land. Equation (2):

$$\text{Real estate market value} = \text{Construction cost} + \text{Land value}$$

The processing section comprises the following spreadsheets:

1. Materials quantity for sub-structure and ground floor
2. Materials quantity for the first floor
3. Materials quantity for the second floor
4. Materials quantity for the third floor
5. Materials quantity for the fourth floor
6. Materials quantity for annexe
7. Materials quantity for boundary wall
8. Materials cost for sub-structure and ground floor
9. Materials cost for the first floor
10. Materials cost for the second floor
11. Materials cost for the third floor
12. Materials cost for the fourth floor
13. Materials cost for annexe
14. Materials cost for boundary wall
15. Workmanship cost for sub-structure and ground floor
16. Workmanship cost for the first floor
17. Workmanship cost for the second floor
18. Workmanship cost for the third floor
19. Workmanship cost for the fourth floor
20. Workmanship cost for annexe
21. Workmanship cost for boundary wall

1.3.2.1 Materials quantity calculation Sheet

Mathematical operation: For a specific construction item includes:

Equation (3): Item Cost in SDG = Item Total Quantity * Unit Cost

Equation (4): Item Cost in USD = Item Total Quantity * Unit Cost * Exchange rate

1.3.2.2 Workmanship cost calculation Sheet

Mathematical operation: For a specific construction item includes:

Equation (5): Item Workmanship Cost in SDG = Item Total Quantity * Unit Cost

Equation (6): Item Workmanship Cost in USD = Item Total Quantity * Unit Cost * Exchange rate

1.3.2.3 Floor cost calculation Sheet

Mathematical operation: For a specific floor, Equation (7):

Construction cost of the floor = Materials Cost + Workmanship Cost

1.3.3 Section 3: Output Section

This part of the model displays the outputs, estimated quantities and values in an organized manner. It includes in detail all cost calculation results for each construction item, the result of the summation of these costs is the total construction cost of the building.
This section contains the following sheets:

1. Sub-structure and ground floor cost summary
2. First-floor cost summary
3. Second-floor cost summary
4. Third-floor cost summary
5. Fourth-floor cost summary
6. Annexe cost summary
7. Boundary Wall cost summary
8. Building cost summary
9. Land Valuation
10. Real estate market value

Table 4: Floor cost calculation Sheet - Sample

Item	SDG	USD
Engineering & Approval Fees	x	x
Materials Cost	x	x
Workmanship Cost	x	x
Sub -Total	x	x
Sub -Total	x	x
Total Cost	x	x

Table 5: Building Cost Summary and Value - Sample

#	Item	Area M2	Cost SDG	Cost USD
1	Ground Floor	x	x	x
2	First Floor	x	x	x
3	Second Floor	x	x	x
4	Third Floor	x	x	x
5	Fourth Floor	x	x	x
6	External Works		x	x
	Total Estimated Buildings Cost		x	x

Profit %	x	x
Profit Amount	x	x
New Constructed Buildings Value	x	x
Current Buildings conditions %	x	x
Current Constructed Buildings Value	x	x

1.4 Land Valuation

The market value of a real estate is the algebraic sum of the land value and the cost of construction of the buildings and development. Therefore, it is of the essence to estimate reliable market value for the plot on which the buildings were constructed.

The basic method of land value estimation is the comparable sales approach. In brief, it estimates the market value of the subject land depending on the selling price and features of sold plots on the zone of the subject plot. The valuer analyses the feature of all comparable sales and makes the necessary adjustment to develop the market value of the plot under consideration.

The next table represents the matrix applied for the comparable sales method.

Table 6: Land Valuation

Date	**Plot #**	**Block #**	**Area M2**	**Neighborhood**	**City**	**Owner**	
04/02/22	0	0	0		0	0	
Characteristics	Normal	$ Ex. Rate	450	Currency	SDG		
Comparable #	Subject Land	1	2	3	4	5	6
Characteristics	Excellent	Excellent			Normal		
Area M2	400	500	400	450	380	420	400
Sell Value	-	0	0	0	0	0	0
M2 Price	-	0	0	0	0	0	0
Today	04/02/2022	04/02/2022	04/02/2022	04/02/2022	04/02/2022	04/02/2022	04/02/2022
Sell Date	04/02/2022	16/03/2021	21/02/2021	05/06/2021	08/07/2021	12/12/2020	1/1/2021
Time Lag	0	10	11	7	6	13	5
$ Ex. Rate	450	410	400	420	450	380	390
$ Ex. Rate Diff.	0	40	50	30	0	70	60
$ Ex. Rate Diff. %	0.00%	9.76%	12.50%	7.14%	0.00%	18.42%	15.38%
M2 Adjustments							
Sell Time Adjust		0	0	0	0	0	0
Average		0			0		
Subject Land Estimated Market Value							
Characteristics		If Excellent			If Normal		
M2 Estimated Value		0			0		
Plot Estimated Value		0					
Plot Estimated Value Rounded		0					

1.5 Real Estate Market Value Report

The main objective of the model is to find out the market value of the subject real estate, after finish entering input information, the model automatically develops the targeted value. The following table represents the final estimated market value of the real estate including separated values of the buildings and the land.

Table 7: Real Estate Market Value

Item	**SDG**	**USD**
Buildings Value	0	0
Land Value	0	0
Real Estate	0	0

1.6 USING the Model

The model is designed to be simple and easy to use, the user only needs to enter data into two spreadsheets:

1. Real estate information and the USD exchange rate.
2. Updated price list of construction materials

After the user enters the input information, the model automatically generates the construction materials quantity list and calculates the cost of the materials and workmanship.

The following chart elaborates the process followed by the model to conclude the market value of the subject real estate.

Table 8: Model Steps

#	Operator	Process	Sheet
1	User	Enter real estate information and current USD exchange rate	Real estate data & Ex-Rate
2	User	Enter updated prices for construction materials and workmanship costs	Updated Prices
3	Model	Model calculates construction items quantities for each floor using pre-determined factors	QTY - Floor
4	Model	Model calculates construction cost for all items of the real estate	Material Cost Workmanship Cost
5	Model	Model Summarizes construction cost for each floor	Floor - Value
6	Model	Model calculates the market value of the real estate	Real estate Market Value
7	User	User prints market value report	Computer Command

1.7 Model Testing

The researcher conducted the model test following the next steps:

1. Randomly selected five real estates that recently their market value was estimated. Those selected real estates met the specification for which the model is designed.
2. The selected real estates for the test were:

a. Residential Buildings
b. Reinforced Concrete skeleton
c. In the state of Khartoum
d. Their market value was estimated in the last three months

3. Using drawing/bill of quantities of selected real estate to specify the required data to run the model.
4. Update the model price list of the materials and workmanship.
5. Run the model to calculate the market value of the selected real estates.
6. Compare the model results with the reported values in the valuation reports of the selected real estates.
7. Report the comparison result and estimate the degree of confidence in the model results.

The researcher selected five real estates based on the above-mentioned criteria. The following table represents all information for real estates used in the test of the model.

Table 9: Data for Model Test

#	Test No.	Land Information (M2, M)			Floor No.	Floor Built Area M2					Condi.
		Area	Length	Width		GF	1st F	2nd F	3th F	4th F	%
1	Test 1	500	25	20	5	350	380	380	340	320	90
2	Test 2	500	25	20	2	310	330	0	0	0	80
3	Test 3	400	20	20	3	300	330	315	0	0	85
4	Test 4	300	20	15	1	225	0	0	0	0	95
5	Test 5	300	20	15	3	210	210	235	0	0	70

1.7.1 Test Results

Table (10) shows both values, model's generated values and manually calculated, also it shows the differences between them in term of SDG amount and percentage. The real estate market values generated by the model are relatively close to those manually calculated. The table also shows the difference between the two values in percentage. Some model generated market values are less than manually calculated, while others exceed manually calculated ones. The fewer values were indicated in (-) negative signs while exceeding values indicated in (+) positive signs. the maximum percentage of the negative values is (-8.34%), and for positive value is (7.76 %)

Table 10: Model Results

#	Test #	Model Value SDG	Manual Value SDG	Difference	
				SDG	%
1	Test1	585,312,878.19	622,187,589.51	-36,874,711.33	-5.93%
2	Test2	261,327,945.64	242,512,333.55	18,815,612.09	7.76%
3	Test3	305,775,799.42	303,329,593.03	2,446,206.40	0.81%
4	Test4	248,383,925.11	270,986,862.30	-22,602,937.19	-8.34%
5	Test5	212,027,247.81	219,236,174.23	-7,208,926.43	-3.29%

1.7.2 Model Precision

For practical use of the model, the model precision should be estimated. Calculation of the arithmetic mean for lesser and exceeding model-generated values sets up the range of the expected market value of the subject real estate.

To calculate the arithmetic mean of Model Generated Values, Equation (8)

$$\bar{A} = \sum A / n$$

Where: $\bar{A}$ = Arithmetic mean, A = Model generated values, n = Number of generated values, $\sum A$ = Sum for generated values.

Mean for the percentage of fewer values = $((-5.93\%) + (-8.34\%) + (-3.29\%)) \div 3 = -5.85\%$

Mean for the percentage of exceeding values = $(7.76\% + 0.81\%) \div 2 = 4.28\%$

Accordingly, the real estate market value generated by the model could be less than manually calculated by 5.85% and or exceed by 4.28, for approximation let us round both values to 5%.

Bear in mind that the valuation process is logical value opinion. Therefore, for practical use of the model, the upper value of market value could be + 5% more than model generated value and lower value could be less by -5%, accordingly, we can conclude:

The Model Precision = ±5%

III. CONCLUSIONS

I. Mathematical models can be used in the valuation process.
II. Mathematical models can estimate assets market values with acceptable accuracy.
III. Mathematical models are time-saver compared to manual calculation.

IV. RECOMMENDATIONS

I. Considering all discussions about Sudanese current market instability, valuation approaches and valuation uncertainty, it is recommended to use the model to estimate the market value of the real estate in Sudan. With ±5% results precision, statistics classifies the model results as reliable market values.

II. In sum, the most valuable feature of the model is time-saving. Using the model to generate market value for real estate is significantly less than the classical manual method.

III. The model can be used to calculate quantities of construction materials and workmanship for the category of buildings that the model supports.

IV. Also, contractors can depend on the model to estimate contract value, especially in lump sum contracts.

V. Valuation service applicants can use the model values submitted by the valuation firms.

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