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Steady Resource Selection Model for Housing Projects in Nigeria

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Abstract: *One of the primary indicators of any country's level of development is the volume of decent housing stock provided for her citizenry. This could be done by government agencies and the private investors as noticed in many developing countries. Interest of governments of developing countries in this respect is high to attract support from both the public and other development partners. Events of the past show that, housing delivery is pioneered by host governments and their agencies alone in most. The situation is not different in Nigeria, with over 80million in search of decent accommodation. The direct interventionist policy of the Nigerian government have been restricted to the initiation of policy guidelines, leaving the on-site assembly of project resources and its attendant challenges to the direct initiative of developers. Available data shows that a total of NGN4.5billion was spent between the first and fourth development plans with forest of uncompleted projects. The existence of numerous slums in our cities and overcrowding in many homes tells the story that decent accommodation is expensive to provide and beyond the reach of the low-income group. The singular focus of government in initiating policy guidelines and the inability of those who manages the production process of housing units to establish the optimum resource requirement and utilization in the construction process have added more injury to the high cost of housing production. This paper is therefore aimed at determining the resource selection criteria that will optimize resources for housing delivery in Nigeria.*

Keywords: *housing, leveling, optimization, project, smoothening.*

I. Introduction

One of the cardinal objectives of housing policy initiative in Nigeria and indeed other developing countries is to provide her citizenry with decent and affordable accommodation. A review of the Nigerian sub-sector would be necessary to have a glimpse of the success rate and challenges of affordable housing delivery. This review will consider some policy initiatives and actions taken by government from colonial era to the establishment of the National Housing Fund.

1.1 Colonial Era

During the colonial era, the public action in housing was confined to layouts and construction of government reserved areas - GRAs. These reserved areas were exclusive meant for the colonial masters, who were only interested in the exportable profits and not the housing challenges faced by the teeming Nigerians. This was evident in the merger provision made for the housing sub-sector in the initial development plan.

1.2 First National Development Plan 1967-1968

Housing activities in the first national development which span 1962-1968 was little and savored of colonial legacy. The emphasis of government was on the provision of senior staff housing which led to setting up regional housing corporations in Kaduna-northern Nigeria, Enugu-eastern Nigeria, Ibadan-western Nigeria and Benin City-mid-western Nigeria.

1.3 Second National Development Plan 1970-1974

As it was in the first national development plan, housing and town planning were taken together in the second national development 1970-1974. This period coincided with the oil boom and sharp increase in government revenue. In the face of up-surge of the revenue profile, the federal government granted a loan of NGN6milion to the Nigerian Building Society in 1972, to expand the credit facilities to the low income group in the country. The government took a further bold step in setting up the Federal Housing Authority and allocated an initial sum of NGN5million for direct construction of houses in the then twelve states. This historically marked the beginning of government's direct participation in housing delivery.

1.4 Third National Development Plan 1975-1980

The period of the third national development plan 1975-1980 saw much greater attention in sphere of public housing than earlier attempts by government. As table below shows, the sum of NGN2million was earmarked for the direct provision of two hundred and two housing units for low and medium income groups in Nigeria. The period also witnessed the construction of many federal and state low cost housing estates and emergence state housing corporations' medium income housing estates. It was during this plan period that the Building Society was acquired by the Federal Mortgage Bank of Nigeria and was given an initial capital of NGN150million to encourage private participation in housing delivery. The government also set up several rent tribunals and enacted the Land Use Decree.

1.5 Fourth National Development Plan 1980-1985

This period witnessed high public awareness in housing delivery. Expectedly, housing featured prominently in the manifestos of the then five political parties and the Federal Ministry of Housing and Environment was created and the Nigeria Housing Policy was formulated in 1981. The key points of the policy include:

a. To improve and increase the quantity and quality of housing stock in Nigeria.
b. To give attention to the concept of affordability in housing provision
c. To aid self help housing programmes.
d. To encourage owner occupation by expanding credit facilities.
e. To mobilize both government and private sector financing into housing.

The Nigerian government also earmarked NGN2.645billion for execution of housing programme within the planned period as contained below.

1.6 National Housing Fund

The most recent of these policies is the National Housing Fund as contained in Decree 3 of 1992. The policy requires banks, insurance companies and allied financial institutions to compulsorily contribute 10% of their loan-able funds and advances for on-lending to primary mortgage institutions. It stipulates a mandatory monthly contribution of 2.5% of the basic income of every Nigerian earning a minimum of NGN3,000.00 per annum into the fund, which is managed by the Federal Mortgage Bank of Nigeria.

II. Literature Review

The target of United Nation Commission for Human Settlements at the global level, to ensure the provision of decent accommodation for the over 750million homeless people in developing countries by the year 2000 was not met due to myriad of problems. Some of the reasons advanced for this abysmal success rate include high cost of housing construction, inadequate funds, ubiquitous land tenure system and the interventionist policies of the governments of these countries. Andawei (2001) in his contribution noted that the inability of performing organizations to determine the best resource combination at any given point in time of the project life also the high cost of housing production. The application of optimal resource selection model during the pre and post-contract stages of the project is required to minimize budget and schedule slips noticed with many housing projects.

2.1 Scientific Approach

This resource optimization model has its origin from scientific management. Scientific management has the orientation of scientific analysis of work methods and the development of management principles and practices. They aimed at efficiency and productivity through the reduction of unit cost and increase in output per worker, improved working condition, reduction of physical efforts and the development of the science of work (Jaja and Zeb-Obipi, 1999). One dominant factor in management of resources is the scientific approach in problem solving. It involves the definition and analysis of work, measurement of facts, experimentation, development of work methods and techniques.

These processes in their opinion, will meet the objective of firms which is to achieve optimum efficiency in production, as the survival of the firm in a competitive world like ours, depends largely on their ability to deliver goods and services at a competitive cost. Managers, therefore deals more with physical relation between inputs and outputs in the production chain, which ultimately produces the best input combination to achieve a given output level of a production system for which housing in one.

2.2 Housing Project Criteria

The housing production process which involves series of processes requires the utilization of machines, men of various skills, materials and time. This transformation process which primarily utilizes raw materials shares the novel characteristic of a project being managed by project team members. The primary focus of these project team members is to develop selection models to deal with these dynamic and expected project surprises at both the planning and execution stages of these projects to achieve set budget and time which is the baseline of every project success. Though it appears to be very challenging to always complete projects within the planned completion period, such delayed completion have multiplier effect on the cost and other project parameters. In the words of Franklin(1780) to tradesmen: "that every team member is aware that time is money. If the planned time-scale is exceeded, the original cost estimates and budgets are almost certain to be exceeded too. A project costs money during every day of its existence, living or non-living, weekday or weekend." The knowledge of the effect of project time variance on other cost parameters and how cost behaves over time throughout the project life is therefore remains fundamental to success of housing project delivery. Project resources are scarce and can be optimally utilized only when they are available in the right proportion at any given point in time by proper resource planning, allocation, monitoring and control by the project team (Harris and McCaffer 1985).

In their separate arguments, Mazda(2000), Andawei(2001) contended that project time and cost which are the basic project success factors can no longer be open-ended. They then suggested the adoption of traditional procedures to achieve the cost and time needs of these acyclic projects through the use of bills of quantities, two-stage tendering and other cost control mechanisms. They noted that the Nigerian construction environment has exacerbates this situation as project team members are faced with frequent changes in the monetary and fiscal policies, inadequate data and records on productivity levels, imprecise project objectives and uncertain expertise of team members, which accounts for present level of performance of the housing sub-sector.

In agreeing with the above assertion, Spinner(1997) contended that the complexities introduced in the construction industry by technological innovations have made job coordination and resource allocation with traditional methods more difficult, which has made the adoption of better and more efficient techniques in resource planning imperative. Despite the existence of this revenue enhancing approach, it is obvious that its prolonged application in housing production can no longer stand due to the discovery by stakeholders in the housing sub-sector of more sophisticated resource scheduling models that maximizes project resource usage.

2.3 Resource Scheduling

Resource scheduling is the process of allocating resource available capacities to jobs and activities. It is the process that helps the team members to determine and make available the resource requirements of the various project activities within pre-determined constraints. The purpose of resource scheduling is to ensure that available capacity of project resources are efficiently used to achieve the objective of the activity and the organization at a broader scale. In practice, resource scheduling results in to a time-based plan which allows the determination of and allocation of resources within the limitations in the best manner. Rogers(1985) opined that the resource schedule that guarantees efficiency is the one that can maintain a high utilization of labour, plant, materials and time. Popescu and Charoenngam(1995) see resource scheduling to be more than resource allocation. They argued that the assumption of unlimited resource availability by some concepts like network techniques, can no longer hold as the constraining indices of the different resource categories are not the same at all points of the project. They instead considered resource availability at the required quantity and time in the project life critical. They concluded by recommending resource levelling and smoothening as the alternative solution for resource and time constrained situations respectively. While I agree totally with their view on the open-ended resource availability assumption of network techniques, I do not completely share the opinion that resource leveling and smoothening techniques as the ultimately solution to the resource dis-equilibrium, but can enhance resource efficiency level which forms the core of this paper.

The basic approach to all scheduling techniques is to form a network of activities and events relationship that pictorially portrays the sequential logic of activities in the project. In supporting this widely held view, Kenzer (1995) and Udosen (1997) considered network as one of the most acceptable and powerful tool for project planning and control as it provides a consistent framework for planning, allocating, monitoring and controlling project resources. Secondly, it shows the activity interdependence and defines the critical activities in any given project and helps to identify floats of project activities.

2.4 Resource Management

For the project implementation to proceed efficiently and as scheduled, the project team members must source for the right type of resources, quantities planned for each activity as at the time of execution. While this process appears to be simple and straightforward the resources' need may fluctuate from time to time thus necessitating hiring and or layoffs to fit in nicely with the daily resource demand. According to Akpan and Chizea(2013), this is not always practically feasible. Even if this could be possible with labour, it may not be possible with fixed assets jointly used in the project execution, they asserted. They further contended that the allocation of resources to a project invariably poses two fundamental problems to the project manager.

Firstly, the determination of maximum level of resources during each time period and secondly is the problem associated with excessive resource demand at certain periods and very low demand almost immediately following a high demand. They identified some of the resource allocation problems and the accompanying scheduling bottlenecks such as when there is excessive fluctuation in resource demand, when resource availability is limited and when resource availability is not a limiting factor.

They further recommended that under excessive resource fluctuation, the project team should endeavour to maintain a steady demand level on available resources so as to avoid inefficiency and wastage inherent in high turnover of resources that accompany excessively high demand at certain periods with low demand immediately following.

When resources are in limited supply, the project team in an attempt to maintaining a steady resource level, should minimize the inevitable increase in project duration, cost due to overheads and possible cost penalties that could result from project delay. Thirdly when resource availability is not a limiting factor, concerted efforts should be made by the project team to stay within the project budget and minimize the cost of idle resources.

2.5 Determination of the Steady Resource Demand Level

From the foregoing though Akpan and Chizea(2013) tried to identify some of the key challenges in making supply and demand decisions of project resources, they were unable to give an outright solution. Some of the key issues raised by them which is evident in every resource decision making is the issue of providing the optimum level or steady level of resources to avoid shortage as well as idle time, which this paper intend to address.

Firstly, when the resource demand is more than the resource supply, it will result to resource shortage. The affected project activities have to wait until the resources are made available. The implication on the project is that, the entire project has to wait until when the resources are made available. Worst still if it is an activity that is vulnerable and must to be completed. The total cost to the project resulting from this shortage, amongst others, will include idle time of the waiting resources, likely extension of project completion time and its attendant penalties. Similarly when the resource supply is in excess of demand, the additional idle resources will be counted as additional cost to the project. The question how do one maintain an optimum resource level that would be economical. I considered two key optimization techniques **-** the greatest resource utilization and the minimum slack heuristics in attempting to solve this daunting resource selection challenge.

2.5.1 Greatest resource demand

This heuristics assigns priority on activities on the basis of total resource requirements, with priority given to the activities with the greatest resource demand. The activity priority is computed as

$$\text{priority} = dj \sum_{i=1}^{n} \text{ri, j}$$

dj = duration of activity j
rij = per period requirement of resource i by activity j
n = number of resource types

2.5.2 Minimum slack first

In this heuristics, activities are ordered by the amount of least slack going first. In this regard resources would be devoted to critical or near critical activities, delaying those with greater slack. Delay of any activity uses some of its slack, as the activity will have a better chance of receiving resources in the next allocation.

2.5.3 General heuristic features:

As scheduling heuristic operates, irrespective of the priority rule, one or two events will occur. The routine will run out of activities for the current period before all activities are scheduled or it will run out of resources before all activities are scheduled. If the former occurs, the excess resources are left idle or assigned elsewhere in the project organization. On the other hand if one or two of the resources are exhausted, activities requiring these resources are slowed down or delayed until the next period when resources are re allocated. The main problem facing the project manager under this situation is to find a schedule that satisfies the sequence constraint and minimizing the overall duration of the entire project within the resource ceiling. The resulting optimal resource schedule should be able to indicate when to start any activity and at what level of resources it should maintain while it is alive.

Work of Fendley(1968) focused on the best heuristics for resource scheduling. While their findings vary somewhat because of their different assumptions, the minimum slack rule was found to be the best. The choice according to them was based on the fact that minimum slack heuristic results to minimum project schedule slippage, the best utilization of facilities and minimum total system occupancy time. These results and works of other authors so far have increased the range of uncertainty in the choice of heuristics that should be considered generally suitable and optimal. In an effort to narrow the region of choice the idea of random activity selection was proposed by Akpan(2000).

III. Methodology

This paper adopted a steady resource level model to establish the resource equilibrium. The model has twelve procedural steps:

1. Draw a network diagram of the project
2. Compute all the critical indices - the earliest and latest times of all the activities
3. Determine the longest - critical path and all the critical activities
4. Prepare a resource demand table for all the activities and allocate resources
5. Determine the total resource demand per time period - daily, weekly or monthly.
6. Compare the total resource demand with the resource availability.
7. Compute the cost of hiring additional resources to meet up the resource demand
8. Level the resources of all the activities within the limits of resource availability
9. Re-determine the new project duration after the resource leveling
10. Compute the cost of delayed completion.
11. Compare the cost of delayed and the cost of hiring additional resources
12. Make your resource allocation decision.

Two sample projects were used to demonstrate the steady resource level model. The project details as shown below.

Case 1

Resource considered for allocation is A-Labour

Resource ceiling: 7units each

Table 3.1 Project Network details for case 1

Activity	Duration	Resource Demand
		A
1-2	2	3
2-3	3	3
3-4	2	4
4-5	2	3
4-6	3	4
4-7	2	3
5-7	2	4
6-7	3	4
7-8	3	4
8-9	4	3

Case 2

Resource considered for allocation is A-Labour

Resource ceiling: 6units each

Table 3.2 Project Network details for case 2

Activity	Duration	Resource Demand
		A
1-2	3	3
2-3	3	4
3-4	3	3
4-5	3	4
4-6	2	3
5-7	2	3
6-7	3	3
7-8	3	3

Table 3.3 Resource demand for case 1

Activity	ACTIVITY DURATION (weeks)																					
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
1-2	3	3																				
2-3			3	3	3																	
3-4						4	4															
4-5								3	3													
4-6								4	4	4												
4-7											3	3										
5-7											4	4										
6-7											4	4	4									
7-8														4	4	4						
8-9																	3	3	3	3		
Total Resource Demand	3	3	3	3	3	4	4	7	7	4	11	11	4	4	4	4	3	3	3	3		

Table 3.4 Steady resource level for case 2

Activity	RESOURCE DEMAND / DURATION																					
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
1-2	3	3																				
2-3			3	3	3																	
3-4						4	4															
4-5								3	3													
4-6								4	4	4												
4-7											3	3										
5-7											4	4										
6-7													4	4	4							
7-8																4	4	4				
8-9																			3	3	3	3
Total Resource Demand	3	3	3	3	3	4	4	7	7	4	7	7	4	4	4	4	4	4	3	3	3	3

Table 3.6 Resource demand for case 2

Activity	ACTIVITY DURATION (weeks)																					
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
1-2	3	3	3																			
2-3				4	4	4																
3-4							3	3	3													
4-5										4	4	4										
4-6										3	3											
5-7													3	3								
6-7												3	3	3								
7-8															3	3	3					
Total	3	3	3	4	4	4	3	3	3	7	7	7	6	6	3	3	3					

Table 3.7 Steady resource level for case 2

Activity	ACTIVITY DURATION (weeks)																					
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
1-2	3	3	3																			
2-3				4	4	4																
3-4							3	3	3													
4-5										4	4	4										
4-6													3	3								
5-7																3	3					
6-7															3	3	3					
7-8																		3	3	3		
Total	3	3	3	4	4	4	3	3	3	4	4	4	3	3	3	6	6	3	3	3		

IV. Discussion Of Results

Assuming that in each of the cases, the cost of hiring one unit of resource A is $1,600 per 40hour-week and the cost of delayed completion is $4,500 per week for both cases. The best resource decision to take can be established using the above model.

Case 1

In meeting the contract duration of twenty weeks as shown in TABLE 3.3, the resource needs of week eleven and twelve is eleven units while the available resource ceiling is seven. If we must meet the original project duration we must as a matter of necessity hire additional four units of resources A for at least weeks 11 and 12, which will cost $12,800. Alternatively the project can be extended by another two weeks and maintain the original resource ceiling of 7units throughout the project. This will attract an additional sum of $9,000 as cost of delayed completion. The optimal resource decision in this case is to maintain the resource ceiling of 7units and extend the project by two weeks.

Case 2

In meeting the contract duration of seventeen weeks as shown in TABLE 3.6, the resource needs of week ten to twelve is seven units while the available resource ceiling is six. If we must meet the original project duration we have to as a matter of necessity hire additional one unit of resource A for at least weeks 10, 11 and12, which will cost $4,800. Alternatively the project can be extended by another four weeks and maintain the original resource ceiling of 6units throughout the project. This will attract an additional sum of $13,500 as cost of delayed completion. In this case extending the project by three weeks is not the optimal decision. The best thing to do is to hire additional one unit of resource A to the three week period.

V. Conclusion

Project resource demand and supply decision making have been beclouded with uncertainties over the years. Several models have been developed in recent times to correctly predict the meeting point of resource demand and supply chains in the housing project delivery process. The use of Steady Resource Level model, in my opinion will help project managers in the housing and other sectors dealing with resource combination of non-acyclic projects to make a more rational resource decisions at any given activity node point.

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