The Impact of Architectural Designs and Practices on the Cost of Housing in Tanzania

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Abstract: *This research highlights and discusses various aspects of architecture and common practices done by housing inhabitants, professionals and developers. It exposes positive and negative contributions on how these three actors increases or decreases total housing costs. Resources are limited in the world especially in the developing countries. The little which is available must be utilized in the most economical manner. Land is the most treasured resource in housing development hence should be planned and managed optimally. Decisions that are done at housing design and construction stages have a direct cost impact. The main research methodology employed to gather information and data for this research was multiple case studies conducted in Dar es Salaam – Tanzania. Bad viz-a-viz good designs and practices were examined by the aid of literature review and fieldwork. Major data collection tools were internet surfing, literature review, sketching, and photographic registration. This study has found out that different building shapes and layouts have different construction cost despite the fact they have same floor areas. A square layout is cheaper than a rectangular layout; and high-rise block of apartments is cheaper than low-rise residential house development. It is also evident that prefab modular building techniques saves construction time and construction cost. Prefab modular buildings are cheaper than conventional buildings. Architects, Engineers, Spatial planners and building developers have to do thorough site investigation so as to achieve sound designs that conform to natural features such as sloping terrain and environmental aspects to minimize uneconomical design proposals. Poor structural design and inadequate landscape considerations that increases building maintenance cost and hence high total housing cost should be monitored and discouraged. Housing developers and professionals must be cost-conscious to all professional decision that they make during design, construction and habitations stages.*

Keywords: ***Housing cost, architectural designs and practices***

1. INTRODUCTION

UN-Habitat estimates that half of Africa's population will be urban dwellers by the year 2030 but with inadequate housing, widened social and spatial marginalization, wide-spread growth of informal settlements and difficulties in managing urban expansions and social services [1]. [2] ascertain that urban and regional planning is concerned with the management of change in the built and natural environment to ensure sustainable utilization of resources for social and economic development. The World Bank [3] data shows that cities infrastructural services on fresh urban development schemes cost 20% of the total investment.

It is argued that the type of the layout of a building influences housing cost. [4] underscores that design variable such as the shape, size; number of floors, height, and circulation space of a building has a great influence of the housing cost. For instance, the square layout is cheaper than a rectangular layout.

The type of construction techniques employed has a significant impact on the housing cost. Prefab modular construction techniques can reduce construction time, housing cost and can assist low income people to afford housing. [5] explains that prefab modular construction can save up to 50% of the normal construction time and saves up to 30% of the cost of conventional building. For instance, the world's tallest prefab modular building, the Brooklyn 32 storey residential tower in New York used 75% of the typical construction time in 2012 of which 60% of its construction was done off-site [5].

Buildings including residential are expensive and valuable assets and require maintenance which contributes to the total housing cost. [6] defines maintenance as a process, activities, procedures and services which are applied to building to preserve, repair and care its fabrics and facilities at all of its life time. However, there is no building which is maintenance free. [7] and [8] explain that proper housing design, construction techniques and workmanship minimizes housing maintenance cost. Maintenance is important and practiced after the building is commissioned. However, it is a common practice in Tanzania to ignore periodic building maintenance which results into huge cost of repair works or even to the extent of demolition [9].

Maintenance is important not only to internal walls but also external walls of the building which faces challenges of weather and green landscape. Green spaces are useful in residential premises and offers opportunities for people of all ages to interact relax, breath fresh air in both urban and rural contexts [10]. Greening at all levels of the city, from block level, plot level and house level is crucial and

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important to humankind. [11] showed that urban green spaces have tangible, socio-cultural, environmental and social benefits in many countries of sub-Saharan Africa as a unifier of the people. However, if greening is not properly considered in relation to its proximity to external walls, structural failures may occur and may require high housing maintenance costs.

Detailed academic debate of these aspects of building design layouts, prefab modular designs, design considerations on sloppy terrain sites, building maintenance is presented and discussed in this paper to provide knowledge on how these aspects influence the total housing cost from the design to occupation stage.

2. SIGNIFICANCE OF THE RESEARCH

There is too little housing resources in developing countries that we are all compelled to be concerned and responsible to control. Housing is one of basic needs to all humankind. It is important therefore to ensure all decisions made by housing developers, professional and inhabitants are sound, economical and viable. This paper contributes knowledge to the existing body of knowledge on the subject. It is an eye opener to all housing actors to make rational and informed decisions so as to maximize effective use of available little housing resources on infrastructural services, building construction techniques and materials and reduce maintenance cost of buildings to the minimum.

3. METHODOLOGY

This is a social science research requiring exploration of the impact of architectural designs and practices on the total cost of housing. It is a qualitative inquiry based on critical synthesis of people's resources, opinions and views as expressed by [12]. A scientific research is how systematic and honestly it was carried and reported [13]. Multiple case studies were selected to be suitable method of collecting authentic information and data because of multiple research variables namely, architectural designs, spatial planning, inhabitants' practices and building maintenance. [14] questioned: How many cases are enough to be able to generalize the reliability and validity of the research data and findings? The answer is: Each research variable must have independent case study to address that particular research inquiry. Each of the above mentioned research variable was given sufficient time and appropriate data collection tools were used.

Collected data and information were categorized into different classes and groups as initial stage of research analysis and finally documented and reported into this manuscript. Provided discussion, research findings, conclusions and recommendations can be generalized to similar contexts in other parts of the world.

4. RESULTS AND DISCUSSION

4.1 Urban Plot Layout as Aspect of Housing Cost

Spatial planning at the level of the plot can significantly influence the cost of housing because all infrastructural services are placed along access roads. Hence, a plot layout with its longest side facing the access road as shown in figure 1 (exaggerated to clarify the point) is certainly more expensive to housing development to both public and private developers than in figure 2 because the former occupies more running meters of infrastructural services such as access road, water supply, electricity, sewerage pipes and so forth. [15] explains that urban development schemes are implemented in accordance to infrastructure planning to guide proper growth of towns and cities. Furthermore, figure 3 which is a stand-alone housing unit costs the housing developer more than when the same plot accommodate six (6) row housing units or twenty four (24) row housing units when the plot area is doubled (figure 4). Low density plots are therefore more expensive to service compared to cost of servicing high density plots which can accommodate relatively more inhabitants. [16] underscores that one approach of reducing construction cost in housing is to reduce the width of plots so as to increase the number of inhabitants in a planned neighbourhood area. This approach reduces the cost of land, discourage housing sprawl, and minimizes cost of infrastructural services. [17] indicate that there is cost reduction in housing when the community is collectively serviced in close locations than when they are widely located. The concept of proper neighbourhood spatial planning with minimum plot sizes (especially on width) maximizes the number of plots and inhabitants who benefit limited resources allocated for infrastructural services.

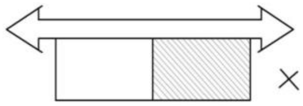

Fig. 1: Poor Housing Plot Layout
Source: Author

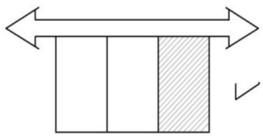

Fig 2: Good Housing Plot layout
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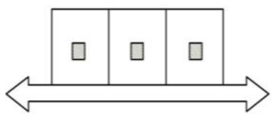

Fig. 3: Stand-alone Housing Unit
Source: Author

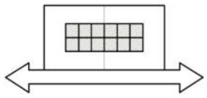

Fig. 4: Multiple Housing Unit
Source: Author

The concept of economical plot layout which is based on narrow width of plots at a neighbourhood level is equally meaningful and viable at a city level. Urban design and planning encourages high-rise cities than low-rise cities on the same argument that it is easy to service many city inhabitants dwelling in high-rise vertical development than to service the same number of city inhabitants dwelling in a low-rise horizontal development on larger city area coverage. This scenario is explained by figure 5 which is a private developed high-rise block of apartments at Muhimbili-Upanga and figure 6 is public high-rise police barracks at Kilwa Road both in Dar es Salaam Tanzania. [18] emphasize this concept by citing Hyderabad City that only multi-storey buildings are permitted to maximize the value of the land and market economy. [19] indicate that human settlement policy in Tanzania requires the government to ensure the land is used efficiently and effectively by encouraging and stimulating vertical development than horizontal urban sprawl which is always expensive to service. Figure 7 is a neighbourhood plan and figure 8 an aerial view of Iyumbu National Housing Corporation (NHC) housing scheme in Dodoma, the new capital of the United Republic of Tanzania. This scheme is an expensive public investment when compared with a high-rise block of flats to accommodate the same number of inhabitants. The law in Tanzania allows buying an apartment and getting a certificate of occupancy of that particular apartment in a block of apartments. It is logical to argue that horizontal housing development exampled by figures 7 and 8 is expensive and uneconomical. If all soldiers and their families of Kilwa-road police high-rise barracks were to be accommodated in a low-rise barracks that particular housing scheme would have been very expensive in terms of required land, infrastructural services and construction costs.

The proposed Kawe satellite city (figure 9) in Dar es Salaam – Tanzania emanate from this understanding of *going up* as opposed to *going horizontal*. Kawe city proposal is at its infant stage of implementation but facing several challenges exist towards its realization. Generally, major problems in building construction projects of this magnitude are infrastructural planning and provisions. [20] underscores that infrastructure planning in developing countries is not accorded the weight it deserve in project formulations and implementations. Infrastructural services are poor, outdated and inadequately funded. Furthermore, this research argue that the third dimension, namely *height* and fourth dimension *time* are extremely important for an investor, particularly housing investor because these dimensions can preliminarily provide: quick futuristic understanding of city morphology volumetrically, predictions of payback period and possibilities of the break even of the investment.

Figure 5: Private Muhimbili-Upanga High-Rise Apartments in Dar es Salaam Tanzania
Source: 2018 Field Survey

Figure 6: Public High-Rise Police Barracks at Kilwa Road Dar es Salaam Tanzania
Source: 2018 Field Survey

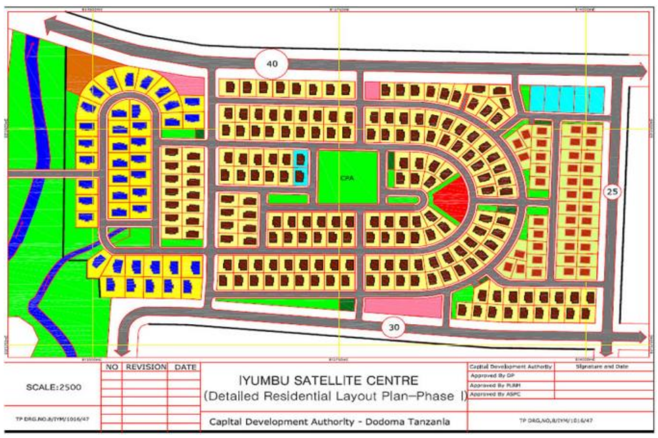

Fig. 7: Iyumbu Neighbourhood Plan – Dodoma Tanzania
Source: [21]

Fig. 8: Iyumbu Neighbourhood Aerial View - Dodoma Tanzania
Source: NHC 2018

Figure 9: Proposed Kawe High-rise Satellite City

4.2 Building Design Layout as an Aspect of Housing Cost

[22] underscores that housing typology and design type has a direct influence on the total housing cost. Architectural design of a buildings may increase or decrease housing cost in many ways. The first simple example is the shape of the house. Abstract cost estimation indicate that, a square designed residential house (schematically shown on figure 10) is cheaper than a rectangular designed residential house of the same floor area (figure 11) as proved mathematically on table 1. The unit cost comparison between residential house alternative A (square or almost square) is cheaper than alternative B (rectangular house) by 84,000TShs. This unit cost variance is calculated and obtained from the differences of perimeters, areas of external walls with assumption that the openings occupies 20% and the actual areas of openings.

Poor location of toilets in a residential house (figure 12) may increase housing cost related to water inlet and outlet pipe layouts as compared to good location of toilets (figure 13).

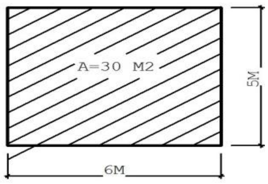

Figure 10: A Square Residential House (30^2)
Source: Author

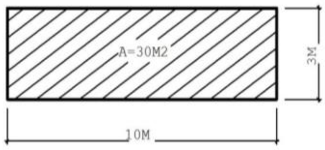

Figure 11: A Rectangular Residential House (30^2)
Source: Author

Table 1: Unit Cost Comparison between Square and Rectangular Designed Residential House

Alternative A: Square House (Height 2.5m)			**Alternative B: Rectangular House** (Height 2.5m)		
Item	Unit Rate (TShs)	Total Cost (TShs)	Item	Unit Rate (TShs)	Total Cost (TSh s)
Floor Area 5x6 = 30m²	7,600	228,00 0	Floor Area 3x10 = 30m²	7,600	228, 000
Perimeter of strip Foundation 2(5+6) = 22m	8,000	176,00 0	Perimeter of strip Foundatio n 2(3+10) = 26m	8,000	208, 000
Area of External Walls 11x2.5x2x80 % = 44m²	6,000	264,00 0	Area of External Walls 13x2.5x2x 80% = 52m²	6,000	312, 000
Area of Openings in ditto 11x2.5x2x20 % =11m²	2,400	26,400	Area of Openings in ditto 13x2.5x2x 20% =13m²	2,400	31,2 00
		694,40 0			**779, 200**

Source: Author
Exchange rate: 1 USD = 2,233TShs

Figure 12: Poor Location of Toilets in a Residential House
Source: Author

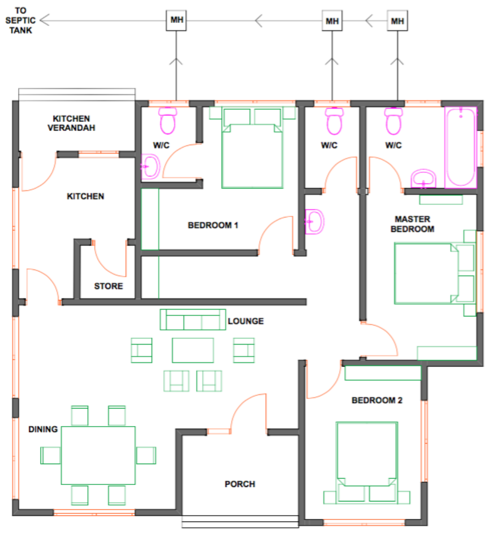

Figure 13: Good Location of Toilets in a Residential House
Source: Author

4.3 Prefab Modular Designs and Construction on Housing Cost

The levels of technique applied to a certain construction activity can increase or reduce construction cost on housing delivery. When the level of professional expertise needed is high, this means that the cost implication is also high since it will require only the skilled labor to perform a particular task. Furthermore the production chain for different building elements and components has an implication on housing cost. If construction chain involves many steps implies that it is labour intensive and there is a likelihood of unnecessary waste of building materials hence increased construction cost. Modular construction can attain 90% reduction in material waste of the conversional construction techniques. Simple building materials which are modulated in multiples of module "M" (figure 14) include bricks, floor tiles and roofing tiles (figure 15 and 16). For example the modular construction that is sometimes referred as prefabricated construction, is cost-effective technique of which different building elements such as columns and beams (figure 17); portal frames and trusses (figure 18) are prefabricated off site and brought to the site for installation into the required buildings.

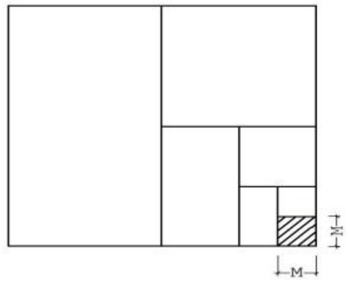

Fig. 14: Modular Unit "M"
Source: Author

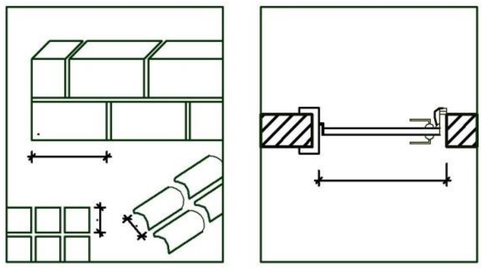

Fig. 15 and 16: Modulated Bricks, Floor Tiles, Roofing Tiles and Door Opening
Source: Author

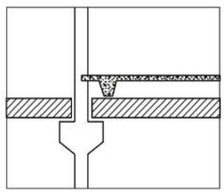

Fig 17: Modulated Column, Beams and Floor Slab
Source: Author

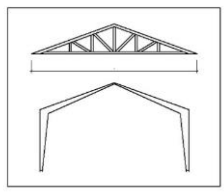

Fig 18: Portal Frames and Trusses
Source: Author

This construction technique facilitates and simplifies erection process due to the fact that completed building elements and components are brought to the site ready to be installed. Architects must provide modulated layout plans as exampled by figure 19 and construction sections such as figure 20 which are in multiple of 300mm module "M". Furthermore fittings such as cookers, refrigerators, sinks, cupboard and worktops (figure 21) in the kitchen must be designed and manufactured in the multiple of module "M" to ensure that they fit well and maximize functional space use in a modulated kitchen.

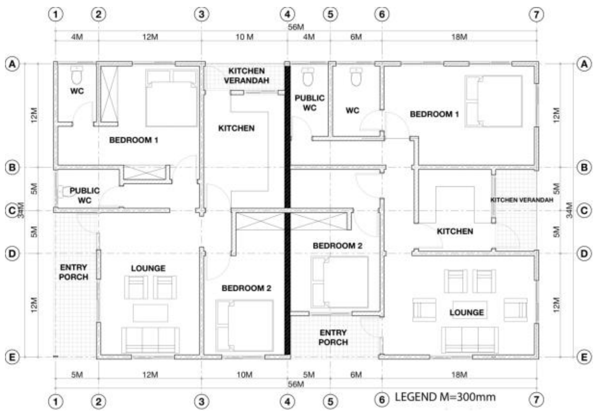

Fig. 19: Modulated Semi-detached Floor Plan
Source: Author

Fig. 20: Section of Modulated Plan (Fig. 19)
Source: Author

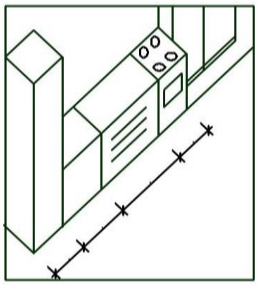

Figure 21: Kitchen Fittings Designed, Manufactured and Fitted in Module "M" in a Modulated Kitchen

The construction period and cost is therefore reduced. Several activities can be carried out in a parallel manner. For instance, when prefabrication is taking place in the factory (figure 22), installation of the finished components can continue at the same time. Modular or prefabricated construction can take half the time of the regular construction period of the normal in-situ site works. Modular construction elements and components are usually done and assembled indoor. Production of modular building elements and components is not affected by bad weather conditions such as heavy rainfall, strong winds and high or low temperatures.

These practices of indoor production of building components and elements has a cost reduction effect compared to when the construction activities are carried out on site and always stopped to proceed because of bad weather. Furthermore, because building components and elements are assembled to a particular exact size, modular coordinated construction has made it possible to optimize construction materials purchases and usage while minimizing onsite material wastes.

Modular buildings are constructed by assembling different building elements off-site. The assembled units and materials can be dis-assembled and reused in other construction activities (including constructing other building) with reduced labour force compared to when building components and elements are prepared on site. Rooms can be produced in a factory, then transported to a housing site and assembled into a complete house. These rooms are mechanically lifted up by cranes to its appropriate location into a modular coordinated designed house as shown in figure 23 and are bolted accordingly. Figure 24 is a floor plan for a prefab-modular one bedroom cell with a possibility of flexible space use. The brown shaded space is used as a dining during the day and bedroom during the night.

Figure 22: Modular One Bed-roomed Apartment Manufactured in a Factory
Source: Cohen 2016

Figure 23: Modulated Factory Rooms installed on Site in New York
Source: Cohen 2016

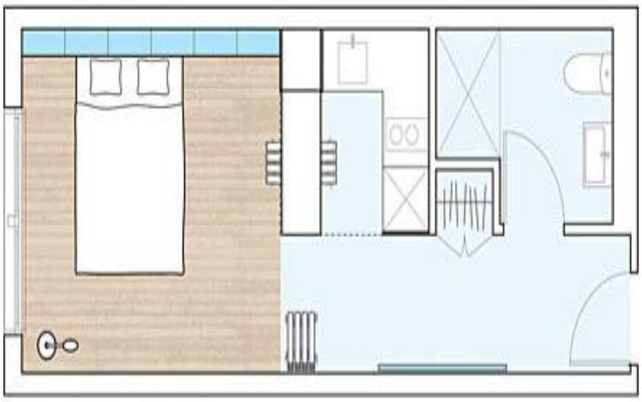

Figure 24: Flexible Space-use Flexibility: Dining during the day, Bedroom during the Night

4.4 Architectural and Structural Design Cost Influence on Sloping Terrain

Housing construction on sloping terrain sites may turn out to be very expensive and environmentally unpleasant if not well considered at the design stage. Thorough site consideration and evaluation before housing developer commits himself/herself to housing construction project is very important as the decision may reduce or increase housing construction cost exorbitantly [23]. Site leveling by cutting the hilly part and filling the lower part of the site is a common practice by most of housing designers and developers. This is a practice commonly known *as cut and fill* of slopping sites. It is a concept which is environmentally unfriendly as it destroys the natural land form, disturbs natural ecology especially the soil strata, expensive construction undertakings, and doesn't ensure even settlement of the building. Figure 25 vividly show destruction of natural land form whereby the housing developer and designer have failed to conceptualize best design options and approaches that could take-care of the sloping characteristics of the natural land form. The failure of proper *design by nature* has resulted to extra-ordinary massive and expensive foundation. The foundation height of figure 25 is proportionally higher than the height of this habitable storey structure. Implying therefore, the designer could have provide four storey part structure on the lower side of the site to compromise with two storey part structure on the upper side of the site. Ultimately, the housing developer and designer were compelled to introduce massive retaining foundation walls and huge stair-steps to be able to access part structure on the higher site level. Furthermore, structural failures are likely to occur to these kinds of structures and in a worse scenario they may collapse when subjected to unfavourable natural forces; weather calamities such as heavy rains; and unconsidered dead loads when occupied by residents.

Figure 25: Poor Architectural and Structural Design Considerations on Housing Cost
Source: 2018 Field Survey in Dar es Salaam

Moreover, housing construction cost on sloping terrain can be reduced by various architectural design considerations in a reversed order of what was conceived and applied at the design and construction stages for figure 25. *Cut and fill* concept is not recommended though the site is sloppy The natural landform whether sloppy or not is considered as blessing in disguise and hence maintained and integrated in design concepts. Figure 26 is the floor plan for the part structure with its foundation resting on the lower ground level. The lower part structure with a normal foundation height is designed strategically to allow its monolithic reinforced concrete slab roof to extend to the upper ground floor plan level (figure 27) to create a second part structure resting on the higher ground level. The Computer Architectural Aided Design (CAAD) comprising three dimensional (3D) structure (figure 28) has carefully considered and generated the left part structure to be single storey and the right part structure to be a double storey housing unit. The CAAD generated designs (figures 26 – 28) have integrated sloping terrain features at the design stage and later realized it physically on the earmarked sloping terrain site as shown on figure 29. A gentle external stair case is introduced to connect the lower and the upper part of this building. Furthermore, an internal stair case is provided to allow smooth, coherent and functional internal communication and movement between the two ground levels of this housing unit architectural design of residential house shown in figure 29 is more cost conscious than in figure 25.

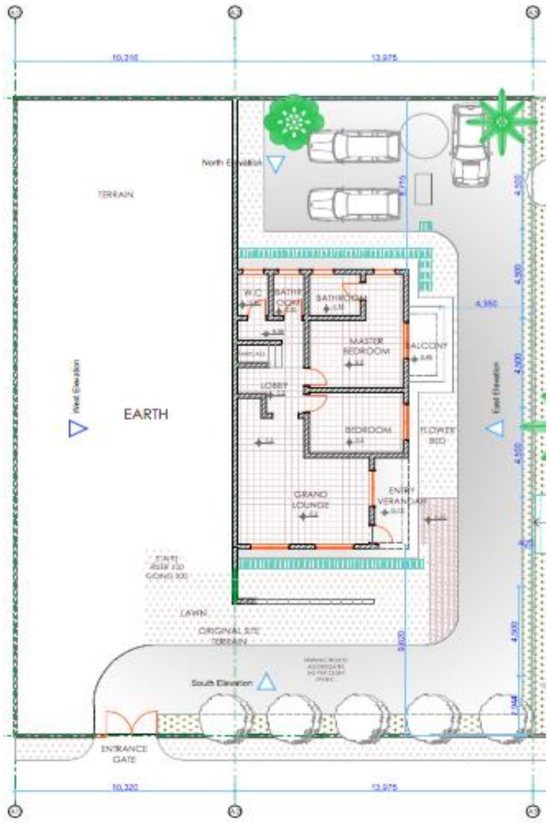

Figure 26: Lower Ground Level Floor Plan
Drawn by: Innocent Lucas (2017 - Architecture Student Ardhi University)

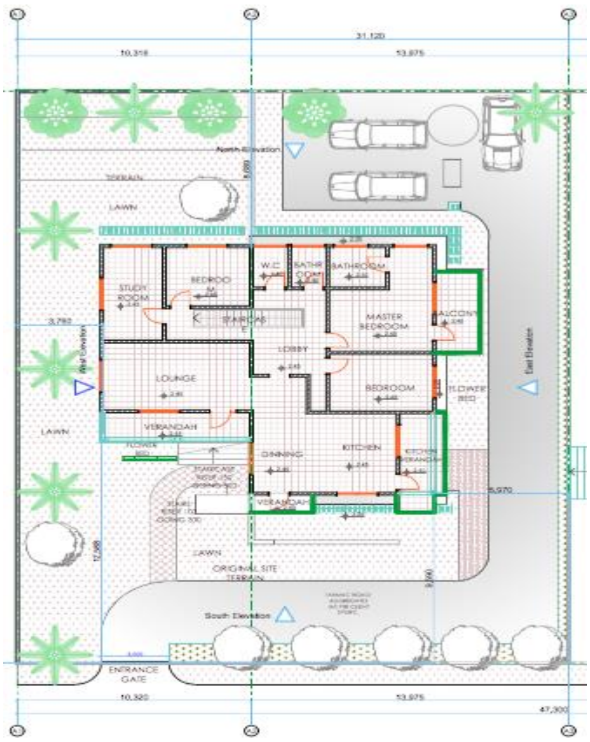

Figure 27: Upper Ground Level Floor Plan
Drawn by: Innocent Lucas (2017 - Architecture Student Ardhi University)

Figure 28: Three Dimensional (3D) Image
Drawn by: Innocent Lucas (2017 - Architecture Student Ardhi University)

Figure 29: Built Residential House on a Sloping Terrain
Source: 2018 Field Survey – Dar es Salaam

4.5 Effect of Structural Design on Housing Maintenance Cost

Professionals in the construction industry have significant influence on housing cost from their decisions they make. This include what they provide on space dimensions, building element dimensions and specification of building materials The number and sizes of structural members are designed by a structural engineer to carry dead and live loads of a structure. Figure 30 is a residential building structure which is under construction but it is overdesigned with (500mm diameter size column) and over provided nine columns which are basically intended to only carry the roof! A good structural engineer could have provided structurally sound design and in turn reduce the construction cost of this residential house. Notably, in most cases housing developers are not aware of what professionals design and specify. Over designed and provision of these huge columns is certainly not accepted by an informed housing developer because construction cost increases substantially!

Figure 30: Over-designed Reinforced Concrete Double Columns of a Two Storey Residential House
Source: 2018 Field Survey in Mbweni-Dar es Salaam

A second bad practice is the situation whereby a housing developer decides to put dead loads such as water tanks on top of a roof slab of a verandah of residential house which was not initially designed to carry dead loads. However, it is a common practice in developing countries to carelessly put an overhead water storage tank on a roof slabs because of unreliable water supply systems. It is recommended to ask for structural engineer's expertise so that structural members such as columns, beams and slabs are properly designed to avoid wall structural failures as observed in figure 31. Maintenance of these structural failures has an impact on an increased housing cost. The best practice is to design, construct a stand-alone tower of concrete or steel structure to carry the water storage tank as shown in 32

Figure 31: Loading Water Tank without Proper Structural Designs may Results onto Wall Structural failure
Source: 2018 Field Survey in Mbweni-Dar es Salaam

Figure 32: Good Practice: A Stand-alone Water Storage Concrete Tower Structure
Source: 2018 Field Survey in Mbweni-Dar es Salaam

4.6 Effect of Landscape Architecture on Housing Maintenance Cost

Green gardens at the level of residential plot are ornamental and improve environmental conditions. Green spaces enhance cultural life by providing venues for local festivals and provide safe play grounds for children [24]. The opposite of greening with green plants, shrubs, and or flowers is browning which works with pavements, concrete artworks, stones, and or aggregates in landscape architecture which provides viable solutions in the place of greening close to the external walls.

The bad landscape architecture and practices in housing is detrimental and increases the cost of housing maintenance including repairing structural failures and re-painting frequently. Planting flowers close to external walls of a residential house (figures 33 & 34) can cause structural failures because of unequal settlements of the house structure during watering. The growth of algae over the wall as noticed in figure 34 harms the structural viability of walls. According to [25], structural wall failures may happen because of inadequate wall protection against moisture penetration or inferior wall materials. This bad practice increases housing maintenance costs. Figures 35 & 36 shows good practices where brown landscape architecture provides concrete artwork and flower pots.

Figures 33: Poor Landscape Architecture Providing Flowers Close to External Walls
Source: 2018 Field Survey in Mbweni-Dar es Salaam

Figure 34: Growth of algae as Result of Poor Green Landscape Architecture Close to External Walls
Source: 2018 Field Survey in Mbweni-Dar es Salaam

Figure 35: Good Practice: Aggregates, Concrete Artworks as Brown Landscape Architecture Elements
Source: 2018 Field Survey in Mbweni - Dar es Salaam

Figure 36: Good Practice: Flower pots and Pavements as Brown Landscape Architecture Elements
Source: 2018 Field Survey in Mbweni - Dar es Salaam

5. CONCLUSIONS

The research has found out that there is a huge impact on the total housing cost emanating from decisions that are made by housing developers, professionals and inhabitants. Architects, Engineers, Spatial planners are the key professionals in the housing sector that they can assist housing developers in making informed decisions at early stages in project formulation, site selection and desires of what kind of housing project they aim at. Informed developer's decision provides proper management and expenditure of limited financial resources. On the other hand, key professionals have to make design and planning decisions that are cost conscious. Professionals should not take advantage of housing developers' ignorance on professional decisions and specifications. Professional fantasies at the cost of housing developer should stop. For instance provision of huge foundation as shown in figure 25 and the 500mm diameter double columns in figure 29 is uneconomical, unprofessional and certainly not wise decisions.

Inhabitants' bad practices such as deciding to put a water storage tank on a roof slab which is not designed to carry such dead loads or garden greening up to the edge of external walls should be discouraged to avoid unnecessary building maintenance cost. Professional decisions on what type of construction techniques and or building materials to be applied is important to be given thorough professional consideration because it has serious impact on the overall housing cost. Prefab modular construction techniques are highly recommended as it saves construction time to up to 50% and 30% of the construction cost of the conventional construction. Furthermore, shapes of building generated by architectural design concepts must put in consideration the best use of limited financial and building material resources with the aim of lowering total construction cost. Observed and proved that square buildings are cheaper than rectangular buildings and high-rise block of apartments are cheaper than low-rise residential buildings in terms of shared infrastructural services. Public and private housing developers are therefore encouraged and recommended to construct high-rise block of apartments than horizontal single storey houses.

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