# Feasibility Analysis of Timber Houses in Mozambique

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# ABSTRACT

Housing quality and costs have been a major concern for a large number of people both in urban and rural areas. Most people live in sub-standard houses, mostly mud/grass materials, because they are poor and cannot afford building decent ones. Efforts have been made in order to find alternative cost-effective and improved building solutions to mitigate the problem. The solutions under investigation focus on grassroots technologies with focus on low-cost construction materials and technologies that can be easily absorbed and used by communities to improve their living standards. One of such studies is the employment of timber in the construction of houses in contrast with conventional cement blocks and bricks which are very costly for the majority of people. Timber is a renewable and available material in most regions of the country. Evidences suggest that there are approximately 300 wood species and only 30% of them are being exploited in Mozambique. Low grade species can be used for the purpose and preliminary results indicate that cost and quality benefits can be achieved with timber buildings. Further research is required in order to examine appropriate low-cost technologies to be disseminated as well as the economic side of these solutions in detail.

Keywords: Feasibility; Low-cost housing; Sustainability; Timber.

#### **1.0 INTRODUCTION**

High costs of construction have been a major concern for potential clients of the industry with particular emphasis on households. The materials vastly employed in conventional construction include cement blocks, bricks, cement, steel, ceramic tiles, plastics, glass and various metals. Most of these materials have to be imported from abroad which significantly increases construction costs. A large proportion of building and infrastructure costs (approximately 60%) in Mozambique are attributed to construction materials.

Efforts to find alternative options that could help increase affordability have been in place but little has been achieved so far. Indeed, a large number of low-cost housing research projects have been implemented. Some results are encouraging in terms of affordability and quality but the fact that most people live below the poverty line (less than 1,0 USD a day) makes the problem much more difficult.

One of the low-cost housing solutions is the use of soil-cement to manufacture blocks for walls and floors. Others include firing clay to produce better quality bricks or highly compressed earth in order to achieve the same objectives. Although they help to reduce construction costs, it should be recognized that they are still significant costs for the average individuals with low incomes in developing areas. As a result, there are still large numbers of people living in sub-standard houses. The vast majority of poor people in the countryside have relied on mud houses covered with straw or grass. As such, search for affordable construction materials and technologies have gained momentum in recent years.

Wood appears to be a viable solution since it is available in most rural areas, can be easily shaped to suit construction needs and is renewable. There are hardly evidences that show work on wood utilization for building construction in Mozambique. The only examples come from the past where low-cost mixed buildings (timber-metal sheets) were erected in the outskirts of the main cities.

#### **2.0 OBJECTIVE**

This research aims to assess the financial feasibility of wood utilization in low-cost building construction. It is part of a larger study aimed to evaluate the economic and technical feasibility of wood utilization for the construction of buildings and infrastructures in Mozambique.

#### **3.0 METHODOLOGY**

The research adopted various methods and techniques to achieve the objectives, which included literature review, direct observation, discussions with construction professionals, and wood market survey. Evaluation of current timber construction practices in Mozambique, the region and worldwide was undertaken. Timber applications in building construction were assessed and specific technologies identified. The suitability of different wood species for construction was investigated, as well. Timber buildings costs were estimated. These costs were compared to construction costs of same size/form conventional and indigenous buildings. Focus was on the wood species with potential for building construction.

#### 4.0 FORESTRY RESOURCES

Mozambique has a total area of 80 million hectares of which approximately 78% is covered by natural vegetation according to recent studies (Nhancale *et al*, 2009). It is likely that the situation has changed since then. Vegetation is not uniform and has various types such as high forest, thicket, wood grassland, low forest and others. Forests with potential for wood supply amount to approximately 19,7 million hectares, that is 24% of the total surface. These forests are concentrated in the central and northern regions of the country, namely Sofala, Zambézia, Nampula, Cabo-Delgado and Niassa provinces. There are no definitive field data on the forest growth but studies based on rainfall patterns indicated that there are three specific regions in this regard. The south of the country has some growth potential of 0,70 m<sup>3</sup>/hectare per year; Centre – 1,61 m<sup>3</sup> /hectare per year and North – 1,36 m<sup>3</sup>/hectare per year. At the national level, it is estimated that 1.195 million m<sup>3</sup> of 25 cm diameter wood and 500 thousand m<sup>3</sup> of 45 cm diameter wood are added to the stock of wood. The annual wood growth, on average, is estimated to be 503 million m<sup>3</sup> (Marzoli, 2007).

The numbers here provide an indication of the existing potential of forests where wood resources can be extracted around the country. At the same time, the demand for both domestic and international markets has been tremendous in recent years. The internal demand is driven by the solid economic growth over the last ten years whereas international demand is associated with Chinese markets (Nhancale *et al*, 2009) to which over 80% of the exported logs were sold.

The increasing demand has pushed prices and forests have been under severe pressure with more operators joining the industry. This indicates the importance of determining sustainable levels of resources exploitation and relevant authorities have management plans and tools for the purpose. Regardless of good forest management, natural inventory is limited and at some point can be exhausted. That is why effective management should include a component of replacement particularly for those species with high growth cycles. In total, there are approximately 350 wood species and only about 35 are commercially exploited. On average the quantity of wood extracted per ha is 32 m<sup>3</sup>. Productive forests in this context refer to the exploitation of wood for different uses.

### 5.0 WOOD WITH POTENTIAL UTILIZATION IN BUILDING CONSTRUCTION

It is obvious that first grade wood species cannot be used in building constructions due to economic reasons and only some lower grade ones can be employed. There are three main species with huge utilization potential namely pine, eucalyptus and "messassa". Of these pine and eucalyptus are the most common, mainly because the knowledge associated with their farming and processing is strong and vast. There is, however, much research work to find ways for better processing and properties improvement of these species.

### 6.0 TIMBER BUILDINGS TECHNOLOGIES

There are various forms in which timber buildings can be erected (APA, 2009). Most of the buildings follow platform construction pattern where the vertical wall studs are built one storey at a time and the floor below provides the platform to build the next level of wall that will in turn support the floor above. The walls span vertically between the sole at a floor level and the top plates at the floor or roof level above. Another construction form is the balloon-type where vertical studs are continuous for the entire height of the building and the floor framing is supported on brackets off the face of the wall studs.

Framing is based around structural members, studs, which provide a stable frame to which interior and exterior wall coverings are attached, and covered by a roof comprising horizontal ceiling joists and sloping rafters. The roof is usually covered by various sheathing materials to give weather resistance. The components are commonly grouped to form structural systems which are essentially three, namely roof framing, floor framing and wall framing.

New technological developments have enabled the emergence of light-frame structures which use rigid panels in various forms such as ply-wood and oriented strand boards. These panels provide enough strength to the walls and bracing is not required in the same fashion as in the past. However, some sort of bracing might be required in the roof structures depending on the specific circumstances or building regulations.Platform framing or light-weight construction is the most common construction technique of buildings around the world. This is so due to many advantages associated with the technique which include constructability, productivity, technical integrity and materials economics.

### 7.0 TIMBER CONSTRUCTION COSTS

Two typical residential building designs were considered for cost analysis. The first consists of two divisions (common room and a bedroom  $-35 \text{ m}^2$ ) and the second has four divisions (dining room, sitting room, bathroom and two bedrooms  $-80 \text{ m}^2$ ). These two designs (in terms of size) were considered as representative of typical houses in Mozambique, particularly in rural areas and city outskirts. Cost estimation of the buildings is based on the cost of the inputs, namely labour, materials and equipment/tools. It is assumed that construction is undertaken by artisans and not by construction firms. This is the common practice in the country, as most households cannot afford the costs charged by construction firms.

The main building elements are studs, planks for wall panels and roofs (corrugated sheets or timber planks). Floors will consist of mortar on top of well compacted soils. Floors can also be formed by timber planks laid on beams and poles or planks on compacted soils. The costs of wood and timber were obtained through market survey at the sources and in different regions of the country and South Africa. Pine is mainly grown in Manica province, some 1300 km away from Maputo. However, a large amount of pine is also imported from South Africa. In order to ascertain the magnitude of timber building costs a comparison was conducted with two types of buildings namely rudimental reed houses and conventional cement/sand block houses. The results are depicted in following sections.



Figure 1: House categories

Figure 1 shows the percentages of house types in Mozambique. It is evident that most of the houses are substandard. There are various construction materials in use for building being the main grass/palm leaves for roof, palm leaves/mud/stakes/reeds/mud blocks for walls and mud blocks for floors. These data is in line with demographic statistics where approximately 80% of population lives in rural areas.



Figure 2: Prices of logs and sawn wood in Nampula and Maputo

Figure 2 depicts the prices of logs and timber in two cities namely Nampula and Maputo. Nampula, located some 1900 km North of Maputo, is one of the main sources of wood in Mozambique, but Maputo is by far the largest market. The costs of transport and commercial margin are the main causes of staggering wood prices in Maputo. The high demand in Maputo pushes prices significantly. The prices of logs are approximately 70% higher in Maputo, whereas the prices of sawn wood are 76% higher. Data indicates that in the prevailing conditions where the industry is incipient the economics of wood are largely influenced by the sources of harvest. Almost all wood is cut in rural areas and transported to urban centres. As such, the prices in the primary sources, the forest, are even lower than those depicted for Nampula, for example.



Figure 3 : Prices of pine timber according to origin

The same applies to imported wood products. South Africa has been the main source of pine timber supply to the Mozambican market, despite the fact that there is some local pine production in Manica province (IFLOMA Ltd)). Most retails have for so long relied on foreign supplies and it is not easy to break the ties. It is likely that in the future the situation will change with the emergence of new pine farms in the country, particularly in Niassa province (Chikweti Forests). The investments in pine farming will help to consolidate the industry and mass production with associated economy of scale can flourish. As illustrated in figure 3, pine imports are costly compared to local products being the main reasons transport costs, charges (import duties, VAT, etc) and commercial margins.



Figure 4: Construction costs across house type and size and cost per sqm.

A comparative construction cost analysis among different building types was conducted to verify the implication of construction materials and technologies. In figure 4a six cases, timber one, timber two, masonry, reed and earth were considered. Timber one/masonry one and timber two/masonry two refer to timber buildings with 35 m<sup>2</sup> and 80 m<sup>2</sup>, respectively. Local timber costs were used in the analysis. Masonry refers to conventional house made of cement blocks and concrete structural elements. Reed and earth are houses made of reed and mud respectively. All designs do not include wet services, electrical reticulation and finishes for simplicity sake. All houses, except earth, have mortar floor and corrugated sheets on the roof. Reed category is covered with grass.

The cost of "masonry one" is 23% more than "timber one", whereas "masonry two" costs 1.3 more than "masonry one". The cost differences reflect some savings obtained from employing

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timber instead of conventional materials when local pine is used. Figure 4b depicts construction costs per m<sup>2</sup> using local pine, imported pine, masonry and reed. Higher costs of imported pine are also evident from unit costs analysis. Indeed, imported pine drives construction costs to more than 43% of those derived from using local material. Furthermore, timber constructions lead to labour resources reduction and time gains which contributes to additional cost savings. Masonry costs more than timber, which reflects the incorporation of expensive materials such as cement and steel as well as the skills required to assemble these. It is obvious that reed category is the cheapest as almost all materials are obtained from woodlands and owners build their houses. The cost estimate attached to that category reflects the economic value of the materials and the added value in producing the houses.



Figure 5: Contribution of components to the total cost

In order to show the weight of the building components in the total cost structure the main elements were highlighted. Walls account for approximately 32% of the total cost, followed by roof, floor and foundations. The remaining portion is attributed to finishes, accessories, labour and others. The relative cost of walls means that change in this category may have a significant influence in the cost structure. The average exchange rate is 1 USD = 35 MZM.

Timber preservation was one of the main concerns over the years. However, there are now very robust and cost-effective treatment strategies against termites, decay and borers. Commercial timber is industrially treated before it is sold. As such the prices and referred to incorporate treatment costs. Timber treatment helps to extend its life significantly. In terms of maintenance timber need to be protected against factors such as humidity, ultraviolet light, abrasion and temperature for which a variety of products are available. Initial treatment, adequate design and construction are very important for timber life cycle. If these are properly conducted the costs associated with maintenance becomes minimum.

# **8.0 CONCLUSIONS**

Timber buildings can be an alternative to conventional constructions which are costly to most people and have huge impacts on the environment. Before that becomes a reality work has to be done in order to create conducive climate in terms of wood farming, processing and supply to prospective markets. Low-cost technologies can be developed to produce standard timber products for rural poor communities. Location is an important factor on the cost of timber, mainly due to the high costs of transport and high demand pressures. Initiatives such as pine farming taking place in some regions (there is a 70.000 hectare project in Niassa) will certainly bring about structural changes in the timber industry with impact on supply and processing.

A cost feasibility analysis of timber buildings was conducted so as to ascertain the extent to which they are affordable. The main conclusion was that the timber buildings with the

specified technology have lower construction costs than current conventional buildings. The magnitude of the difference when imported timber is used is approximately 20%, which is substantial. When using local timber the difference increases to approximately 40%. The imports of timber have, indeed, led to increased costs. Imports add charges that are passed on to the final consumers. In the case of local (country) timber, which is produced in small quantities, the cost of transport and commercial margins tend to have significant impacts on the cost. Large scale pine farming would bring significant economies of scale with the associated cost benefits. It would also be possible to design standard products thus boosting construction timber industry segment. Log mills can process softwood into swan timber products such as structural timber, shutter boards, laminates, plywood panels, and studs. Despite lower costs compared to timber buildings, traditional reed/mud/grass houses are very precarious and prone to weather agents. The impact of timber construction would be an upgrade from substandard housing to more decent houses. Apart from the cost benefits, timber buildings can perform very well in terms of durability, weather exclusion, comfort and appearance. To improve timber performance it can be treated in various ways such as cooper chrome arsenate and water repellent wax.

Further research work is needed in order to conduct cost analysis in different regions and to study appropriate technical solutions that can lead to optimal solutions.

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