Bamboo as a building material for meeting East Africa's housing needs: a value chain case study from Ethiopia

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Abstract – This paper assesses the potential of bamboo building materials to meet East Africa's urgent housing needs, with special reference to Ethiopia. The paper is based on a one-month field study of Ethiopia conducted in early 2011, where we investigated local bamboo value chains and their sustainability through a series of interviews, questionnaires, and site visits with local bamboo stakeholders. From the study, we found that many rural communities use bamboo extensively as a building material with widespread applications in wall, roof, ceiling, structural work and scaffolding systems. Ethiopia has a rich diversity of traditional bamboo housing designs, practices and skills. However, we also found that the sustainability of Ethiopian bamboo architecture is under threat from modernization, decreasing availability of bamboo resources, increased rural populations, and lack of adequate processing skills and modern designs. Despite these challenges, our economic analysis indicates that using bamboo for the development of tourist lodges and, or, low-income urban housing offer a financially viable means of developing the bamboo construction sector. Therefore, to ensure sustainable development of bamboo-based construction, we recommend that Ethiopian Government, with assistance from international development agencies, should 1) continue to integrate bamboo with local building materials and promote a broader range of bamboo construction projects through its urban and rural housing development programmes, 2) prepare building codes and product standards for bamboo housing and construction products, and 3) develop clear conservation and utilization policies for bamboo resources.

Keywords: Bamboo housing, value chains, Ethiopia

1. Introduction

1.1 Housing Shortages in East Africa and Ethiopia

In East Africa, in recent decades, the supply of houses in rural and urban areas has failed to keep up with growing demand. This has led to chronic shortages of safe and affordable housing across the region, with slums emerging as a dominant and distinct type of settlement in many cities (UN-Habitat, 2010). Therefore, there is now an urgent need to identify sustainable building materials to meet the continent’s demand for housing. In this paper, we use the Brundtland Report definition of sustainability as *meeting the needs of present generations without compromising the ability of future generations to meet their own needs* (WCED, 1987), while sustainable building materials are defined as being materials that are low in toxicity, possible to maintain without having adverse affects on health, renewable, recyclable, energy and resource efficient, locally available, and affordable (Froeschle, 1999).

In Ethiopia, the housing situation mirrors regional trends, with severe shortages of housing being a recurrent problem across the country. Available literature reveals that 85% of Ethiopia’s urban population lives in unhygienic and confined housing conditions (World Bank, 1998; UN-

Habitat, 2002; UN-habitat, 2006). Given population growth of 2.8% per year and accelerated migration to urban centers of 6% per year, the demand for affordable and decent housing is set to increase rapidly in the coming years (Haregewoin, 2007).

To meet this demand, the Ethiopian Federal Government is now implementing an *Integrated Housing Development Program* (IHDP) that is mainly focusing on providing concrete-built condominium houses for low and medium-income families in urban areas. In rural areas, especially in extremely marginalized and poor places, most Regional governments are now also implementing the Rural Clustered Village Settlement Programme. Under this programmes the use of local natural resources, particularly bamboo, is being promoted. This new village policy makes the provision of basic services like education, security, water, electricity and agricultural extension services easy and economical to Regional governments. Due to these developments, the need for a sustainable building material is especially high in Ethiopia; with forest cover accounting for less than 3% of Ethiopia's total area (FAO, 2010), timber is scarce, while other non-renewable building materials, such as concrete, are relatively expensive and often have high environmental impacts.

1.2 Bamboo Building Materials as a Potential Solution to East African Housing Needs

Bamboo, a native, renewable East African forest resource, could be one alternative source of sustainable building material that can help the region meet its housing needs. Decades of research by bamboo practitioners has validated that, when treated and used properly, bamboo is a sound structural and engineering material (Janssen, 2000), which, due to its strength, flexibility and versatility, is a suitable material for use in housing. Recently, the International Network for Bamboo and Rattan (INBAR), the world's only intergovernmental organisation dedicated to the sustainable development of bamboo and rattan, and Chinese partners have also demonstrated that laminated bamboo can be used in structural applications, presenting new opportunities to standardise bamboo-based construction and produce modern modular housing designs that are potentially suitable for East African markets (Xiao et al., 2009 and Xiao et al. 2010).

Bamboo species grow naturally on the mountains and highlands of Eastern African Countries and in the medium lowlands of other African countries (KEFRI, 2007). Bamboo is one of the most economically important Non-Timber Forest Products (NTFPs) in the region, with its renewability and accessibility to the rural poor meaning it has traditionally made significant contributions to rural livelihood and employment (Ensermu et al, 2000).

In Ethiopia, there are over 850,000 hectares of native lowland bamboo (*Oxytenanthera abyssinica*) and over 130,000 hectares of highland bamboo (*Arundinaria alpina K. Schumach*) (Luso consult, 1997). Due to lack of alternative construction materials in lowland areas, lowland bamboo is commonly used as a dominant building material in houses and construction of fences, while it is also used widely as fodder for cattle, food for people, and a biomass energy source (Luso consult, 1997, Ensermu et al, 2000).

1.3 The Current Status of Bamboo Construction in East Africa and Ethiopia

Although bamboo has traditionally played an important role in the rural economies of East Africa, due to indiscriminate clearing of natural forests and the lack of government policies to support development, bamboo resources have diminished rapidly across East Africa, with subsequent erosion in the status of the resource (KEFRI, 2007).

In Ethiopia, the most recent national bamboo resource inventory reported a 15% decrease in bamboo coverage from 1980 to 1997 (Luso consult, 1997), with a primary cause being a lack of clear bamboo conservation and utilization policies. The Forest Development, Conservation and Utilization Proclamation No. 542/2007 of Ethiopia has no explicit statements on bamboo, while inefficient utilization and neglect of bamboo resources is compounded by insecurity of land tenure rights and a lack of economic incentives to value them as useful commodities (Federal Government of Ethiopia, 2007).

In recent years, to address this issue and realize bamboo’s potential to solve building material shortages in East Africa, INBAR has been leading research and development activities to set up a bamboo housing industry in Ethiopia and adjacent East African countries. The International Development Research Centre (IDRC), Ottawa, Canada has supported this work through a two-year project entitled “Development and Promotion of Bamboo Housing Technology in East Africa”. A value chain and sustainability study of Ethiopia’s bamboo construction sector, the results of which are disseminated in this paper, formed a central tenant of this project.

1.4 Current Research Needs and Policy gaps

While bamboo has considerable potential for meeting regional housing needs in East Africa, several questions remain over whether bamboo is able to meet housing needs at the larger scales, necessitated by the current housing crisis, in a sustainable, economic, and technically viable way. This paper, which also draws on wider experiences from INBAR’s IDRC-funded work, aims to address how a sustainable supply chain of bamboo raw materials for processing and a larger-scale, economically viable bamboo housing industry can be established in Ethiopia.

1.5 Paper Objectives

This paper synthesizes the lessons learned from INBAR's IDRC–funded project with the following objectives:

1. To assess the sustainability of a bamboo housing sector in Ethiopia in terms of socio-economic, environmental and technical aspects;
2. To assess existing bamboo value chains in Ethiopia and recommend how a sustainable and integrated value chain for housing can be developed

2. Methods

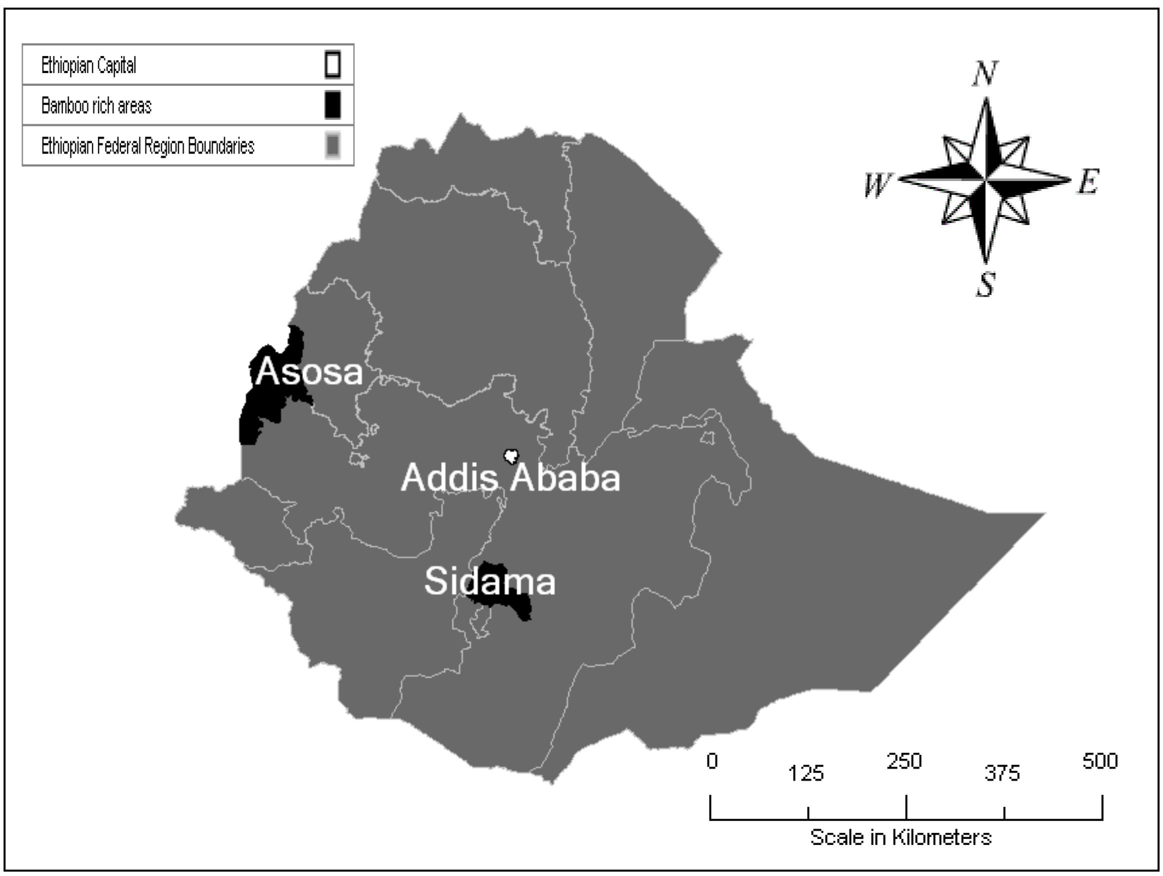
2.1 Study Area

In Ethiopia, challenges to developing a sustainable housing sector are highly diverse; reflecting many of the issues faced across the East Africa region. Firstly, Ethiopia has a large population of 77.1 million, with an estimated annual growth rate of 2.8% (Census result, 2007). Secondly, despite engaging in economic reform since the 1990s, the country remains highly poor. Based on a poverty line of USD1 per day, an estimated 66.3% of Ethiopian households are poor (World Bank, 2005). Finally, Ethiopia is almost unique in Africa in having virtually no large private sector business. Our field work indicated that many previous government-owned properties have been transferred to State enterprises. Furthermore, no foreign banks are allowed and it is almost impossible to obtain start-up loans for small and medium businesses. Although the Ethiopian constitution defines the right to own land as belonging only to "the state and the people", citizens may only lease land for up to 99 years, and are unable to mortgage, sell, or own it.

Within this context, bamboo construction in Ethiopia has remained predominantly rural and informal in nature (table 1). The main bamboo growing areas in the country are in the Southern and Western regions, especially in Asosa, located in the Western federal District of Benshangul Gumuz and Sidama, located in the Southern Nations Nationalities and People's Region (map 1)

Application	National percentage of houses with bamboo material	Rural percentage of houses with bamboo material
Bamboo Walling	2.51	3.03
Bamboo Roofing	3.37	4.1
Bamboo floor	1.30	1.30
Bamboo Ceiling	0.05	-

Table 1: Use of bamboo/reed material in Ethiopian home construction, (Source: Analyzed from Federal Government of Ethiopia, Population and Housing Census, 2008)



Map 1: Map of Ethiopia showing bamboo rich growing areas and location of the Capital, (Source: DIVA-GIS 2011)

2.2 Data Collection

We collected and verified necessary information for this study from primary and secondary sources and interactions with stakeholders and informants from private sector, government and non-government agencies. We carried out Interviews and consultations at all levels of the value chain, targeting bamboo farmers, buyers, suppliers, producers, processors, traders, architects, civil and structural engineers, building experts, government and non–governmental agencies with bamboo housing and, or, construction related activities in Ethiopia. Furthermore, we also visited the main Bamboo growing areas in the South and Western parts of the Country. Finally, during our site visits, we consulted with bamboo-based industries in different locations in Ethiopia's main cities, such as Addis Ababa, Hawasah, and Assosa.

2.3 Data Analysis

The scope of the study upon which this paper is framed was to investigate the sustainability of bamboo value chains in Ethiopia's main Lowland and Highland bamboo producing areas based on socio-economic, environmental and technological indicators and assessment. To achieve this, we undertook detailed case studies of traditional bamboo architecture from Assosa area, which is located in the West and borders the Republics of Sudan and South Sudan, and Sidama area, which is located in the South in the Southern Nations Nationalities and Peoples Region (SNNPR) of Ethiopia. Sidama's capital city is Hawassa in the Hulla-Agresalem location. These case studies were cross-referenced against modern bamboo structures, built using laminated bamboo, which are currently being introduced through an INBAR-supervised project in the country.

In addition to the case studies, we also conducted a financial analysis of four potential socially acceptable forms of bamboo housing investment scenarios; for very low income housing, low-income housing, low to medium-income, and recreational bamboo lodge/hotels. For each scenario we calculated an Internal Rate of Return (IRR) for the property investment. The IRR of an investment is the discount rate at which the Net Present Value of costs (negative cash flows) of the investment equals the Net Present Value of the benefits (positive cash flows) of the investment. Therefore, IRR is the rate at which the project NPV equals 0. It also provides the expected return rate of the project, assuming certain conditions are met. In other words, if C(n) is the cash flow for each period, then

$$NPV = C(0) + C(1)/(1+r) + C(2)/(1+r)^2 + \ldots + C(n)/(1+r)^n$$

We calculated IRR in Microsoft Excel, which can run iterations to calculate IRR by setting NPV = 0 and solving for “r” above.

Based on the current state of the Ethiopian economy, we adopted various assumptions to assess the economic viability of investing in bamboo housing. For example, we used a one unit house scenario, as this allows results to be extended to as many units as the capital can allow. We also assumed a discount rate of 8%, which is the average 2011 lending interest rate in Ethiopia. All cash flows were adjusted with an inflation rate of 7%. These rates were obtained from the Bank of Ethiopia. The operation costs have been assumed to be 4.5%, which is a commonly used rate in property investments. This category includes all the operational expenses that are incurred on an ongoing basis. These include rates, property management fees, levies, repairs & maintenance and insurance premiums. An annual increase percentage of the same has been included in order to adjust the initial operating expense amounts for future periods.

In the analysis, the initial investment is the fixed cost, as it includes all the cost for building one unit until it is ready for occupation, while the operational cost gives us the variable costs on an annual basis. The life span of each of the different types of houses has been assumed to be 40 years. Total estimated costs of each house-type were based on information from local people.

Finally, based on field interviews and field observations we mapped Ethiopia's existing bamboo value chains in high and lowland areas and conducted a SWOT (Strength Weakness Opportunities and Threats) analysis. The main aim of the SWOT analysis was to identify how a sustainable and integrated value chain for housing can be developed

3. RESULTS AND DISCUSSIONS

3.1 Sustainability of Bamboo Housing Architecture

Based on detailed case studies from rural and urban areas, this section introduces our findings on the designs, practices, skills and sustainability of traditional and modern architecture used by poor communities in Ethiopia. This has been analyzed and discussed under three case studies:

- *Amhara house Traditional house: Case Study for Lowland Bamboo Housing*
- *Sidame house Traditional house: Case Study for Highland Bamboo Housing*
- *Modern-Traditional Bamboo House: Case Study for Engineered Bamboo*

Amhara Traditional Bamboo House: Case Study for Lowland Bamboo Housing

The Amhara Bamboo House is a traditional style of architecture with Islamic influences; the predominant religion among local peasant associations, which are locally known as *Kebeles*. These concentric houses are supported by a center post that carries the weight of a thatched roof made from reed. The roof is further reinforced by four bamboo members that are tucked into the woven wall at the ring beam level and also jut out of the thatched roof. The walls comprise of structural bamboo poles that end up in the ground and bamboo infill that is woven around these members. The front of the house is sometimes plastered with mud for purposes of beautification and protection. Ropes made from one year old bamboos, which are flexible and soft, are used for joinery. The roof eve is purposefully designed at a very low level as a means of protecting the house against strong winds. It also protects the bamboo walls from rain. The eve is also used as a resting shade area during the day, as well as a firewood store.

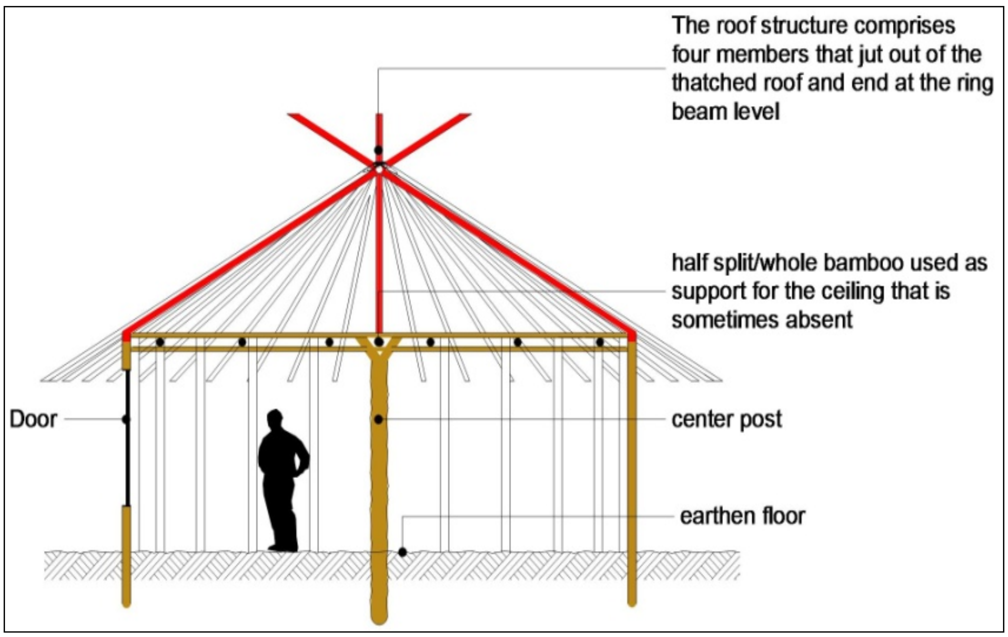


Figure 1*: Amhara bamboo house Structural Design Details*

From the layout plan in Figure 2, one can see that there is clear separation of spaces, which could be inspired by the Islam religion. There are separate houses for older girls, older boys and also for cooking. Men can marry many wives; each wife gets her own house but their children stay together in one house. From field observations and interviews, the authors found that men are solely responsible for house construction, while women carry out repair and maintenance work in addition to the other tasks, such as farming, cooking and mining of clay, sand and stones.

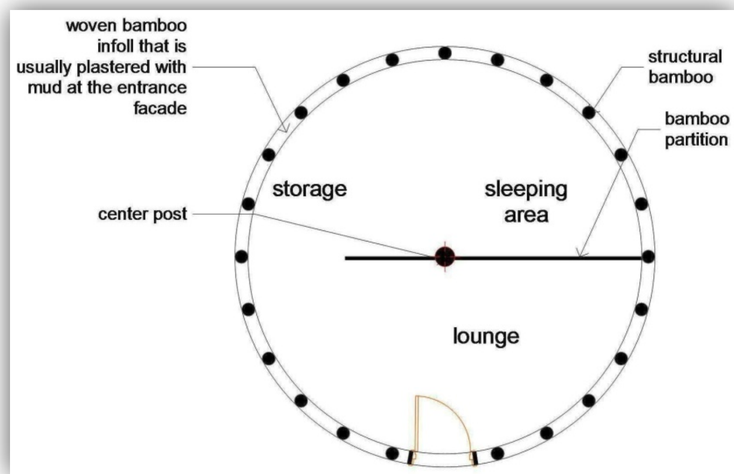


Figure 2: Typical Amhara Bamboo House Layout Plan

Construction of each standard house of averagely of 8m diameter consumes an average of 300 bamboo culms. However, the final number of culms depends on the size of the house under construction. The wall structure consumes about 30-50 culms, while 120-150 culms are used for weaving between the wall structures, installing upright standing culms. Finally, roughly 100 culms are used for the roof. Bamboo is used both for structure and as a filling material, usually woven around the structure. Grass thatch is used for roofing.

The construction is carried out by local people using traditional skill passed from one generation to another. Some of the houses have open plans whilst others have been partitioned. An average of 6 adult men need a construction period of about 12 days; where 5 days are used to collect and prepare the construction materials and the remaining 7 days are used in building the house. The house lasts about 20 to 30 years depending on the quality and age of bamboo used. Mature bamboo harvested after 6-7 years lasts longer than immature ones.

Bamboo for rural housing construction is available for free to community members upon request from the *Kebele* (village) Chairman. However, some substantial cost (depending on the distance) is incurred in transporting the poles from the bamboo forests to the construction sites. Due to increased demand and scarcity of mature bamboo poles, local communities interviewed during our filed study reported that the transport distance has been increasing. While traditionally local people transported bamboo by hand, due to the longer distances, they now have to use of vehicles and animals.

Finally, in addition to the threat to sustainability posed by depletion of local resources, the authors found that termites and weevils were also reported as presenting major challenges to these houses structural integrity. Boring beetles are also attracted to immature bamboo poles because they have a lot of starch. To ensure durability, the local housing artisans take precaution by preparing a good or very strong base that termites are unable to penetrate through. Salt solution is also sprayed around the house during construction in order to control beetle attacks on the bamboo.

Sidama House: Case Study for Highland Bamboo Housing

This type of house is commonly found in the Southern Nations Nationalities and Peoples Region (SNNPR) of Ethiopia whose capital city is Hawassa. The people in this region have access to natural forest highland bamboo, but private bamboo farming is also traditionally practiced. The architecture of this people is a unique beehive shaped structure that is finished by fixing a layer of undifferentiated woven bamboo onto the structure. Partitions are also made of woven bamboo. Most of the houses have two entrances, a back and front entrance. The back entrance is meant for use by the cattle and sheep while the front entrance is used by people (Figures 3).

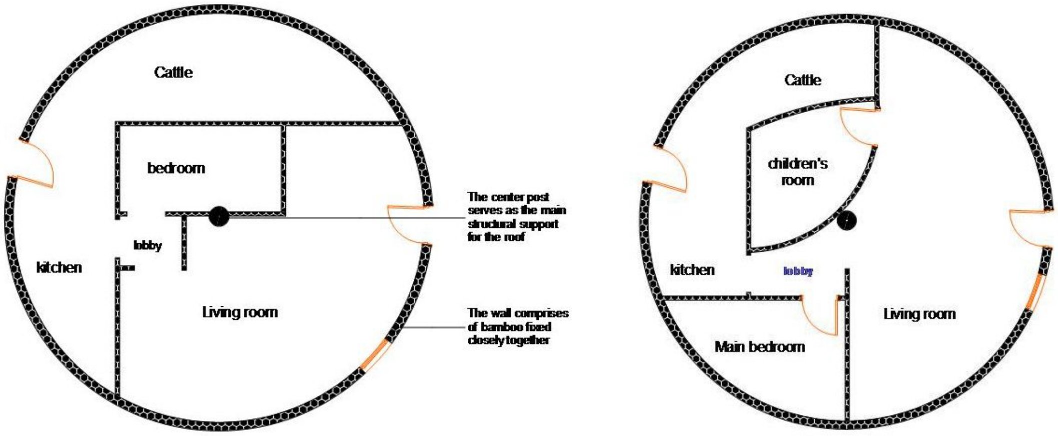


Figure **3**: Sidama House Layout Plans

The highly advanced traditional skill of building is inherited and passed down within the family from fathers to sons to grandchildren. The resulting bamboo house can last up to forty (40) years, but the woven outer layer is usually replaced after about 15-20 years.

The materials used include:

- Bamboo poles of at least 7 years old
- Ropes for joinery, usually made from the stem of false banana, a staple plant in most parts of Ethiopia, including the S*idama* area.
- Bamboo sheaths are used to line the roof's inner core as a means of moisture exclusion
- Center post (usually made from *eucalyptus*); it carries the weight of the building i.e. it is the main structural element in the house
- Nylon ropes are used for decorative purposes; this is a recent addition that has happened with modernization. False banana ropes were are also used for decorative purposes in some houses we visited during the study.
- Clear varnish paint is applied to enhance quality and general outlook. This is also a recent addition used in restaurants and guest houses to enhance visual aesthetics.

The building process starts by selecting a suitable site for construction, with a circle drawn on the ground marking the house perimeter. The vertical wall elements and the center post are erected, the roof is then fixed and the finishing done. In rural areas, roughly 10 men are involved in material collection, site preparation, construction, and finishing. The process of cutting, splitting, erecting and net making is highly labour intensive. A standard Sidama house has a diameter of 10 meters and takes about one month to complete. A total of 800-1000 culms for one main standard family structure are required for one unit house. In urban areas, like Addis Ababa, where similar structures are constructed for tourism purposes, such as luxury traditional bars, hotels, and entertainment centers, their sizes and costs vary from place to place depending on availability of bamboo materials and traditional skill. Generally, costs are higher in towns compared to rural areas; a standard Sidama house costs has almost no costs, as all materials are free from private bamboo farms, while communal labour is also *gratis*. In urban areas, one unit usually costs up to 75,000 Birr (equivalent to US$4,375 at the time of paper submission), with labour accounting for about 35% of total costs.

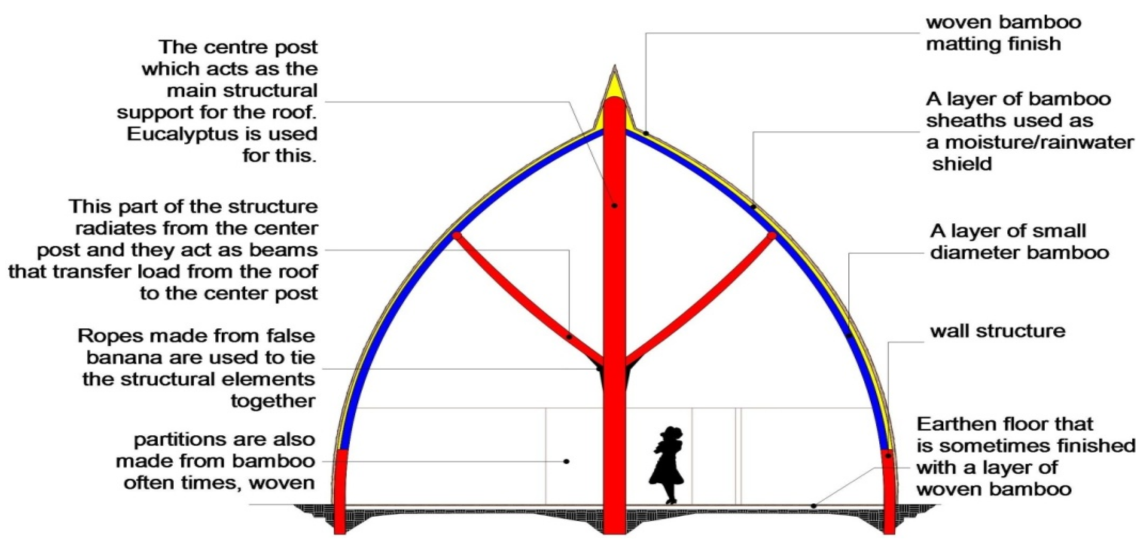


Figure 4: A section showing the construction elements of the Sidama house

Due to modernization, we observed that there have been some modifications and special improvements to *Sidama* houses. These include the introduction of a concrete plinth and wooden doors, as is the case with the *Aregash* lodge pictured in the Figure 5.

Figure 5: Modified Sidame Housing Architecture, (Source: Authors, 2011)

Analysis of qualitative information from most interviews and field observations, we found that the following are major sustainability challenges for the *Sidama* style of house design:-

i. *Poor ventilation due to inadequate or non-existent window openings*: During the day, air circulation is good because the doors are open, the animals are out for pasture, and the people are also out attending to various duties. However, at night, there is a lot of stuffy air from the animals and the owners of the house. Furthermore, since most cooking is done at night, the houses are also filled with smoke.

ii. *Day lighting:* As illustrated in the layout plans, most of the rooms in this house lack an opening to the outside, making houses very dark during the day. This is made worse by blackening from smoke. The lack of window openings are due to the following reasons:

    a. Rudimentary building technology and lack of exposure to new modern housing technologies

b. It is a strategy to cut down the cost

c. retaining smoke from cooking acts as a means of bamboo preservation

d. It is also a social strategy to enhance security and privacy

iii. Termite attack: this is especially common for immature bamboo poles

iv. *Fire:* sometimes, the kitchen is put outside the house to mitigate against this risk

v. Non-effective water exclusion system

To preserve bamboo, *Sidama* communities rely on smoke that comes from the cooking area. The community is also very keen in selecting only mature bamboo of over 7 years for long-lasting and durable houses. Most of the traditional houses had no ventilation, but in recent constructions; windows have been added to the elevation of the house.

Modern-Traditional Bamboo House: Case Study for Engineered Bamboo

Most communities are now shifting away from traditional bamboo houses to modern structure due to a combination of factors, such as increased incomes, continued maintenance costs associated with traditional bamboo houses, new influences from abroad, rising scarcity and price of bamboo poles, and the growing influence of construction technologies being promoted by development agencies and NGOs. Within this context, INBAR and its partners work in Ethiopia are introducing new lamination technology for bamboo, which will allow local enterprises to produce bamboo plywood and laminated lumber. In 2012, a processing plant will be established in Addis Ababa with an annual production capacity of 2,970m^3 for 12mm thick plywood panels. An agreement has been reached with the Addis Ababa Housing Authority to use these panels as wall partitions in their new urban condominium housing built under IHDP.

3.2 Social, Financial and Economic analysis of investments in bamboo housing

In urban areas, we selected four scenarios based on common housing designs of $20M^2$ preferred by most Ethiopians and tourists for detailed financial and economic viability analysis. The four scenarios and our findings are given below.

Investment in "very low income" housing in urban areas: This house when complete has an iron roof, mud-walls and floor (see Figure below). In the first scenario, an investment of 75,000 Birr (equivalent to US$4,375 at the time of paper submission) has been assumed for a complete single unit, which attracts a monthly rent of 300 Birr. The annual rent has also been adjusted for inflation at the average rate of 7 per cent on a year to year basis. Using a period of 40 years and applying all the aforementioned assumptions in scenario one, the project has been found to be unviable because it has an IRR of 5.51 percent and the investor will not get back his/her capital.

Investment in "low income" housing in urban areas: In scenario two, financial viability has been undertaken for an investment in a single unit house of 30,000 Birr (see Plate below) which attracts a monthly rent of 1000 Birr. This is semi-permanent house is made of an iron roof, cheap walls made of bamboo mats and mud in some sections (see Figure below). The floor is made of mud. Using a project period of 40 years and having similar assumption like the other three cases, the project yields an IRR of 42.79 percent and a payback period of 4 years, which confirms its financial viability.

Investment in "low medium income" houses in urban areas: In Scenario three, an investment of 75,000 Birr in a one unit house (see Figure below) which attracts a monthly rent of 1000 Birr has been calculated. This design is new and is made of an iron roof, mud walls smeared with some special clays and also lower-half part cheaply painted with colour of one's choice. The annual rent has been adjusted for inflation at the average rate of 7 per cent on a year to year basis. The life span of the house has been taken to be 40 years. Based on assumptions of a discount rate of 8 percent and additional annual operation cost of 4.5 percent, this project gives an IRR of 19.07 percent and a payback period of 10 years, which confirms its financial viability.

Investment in a recreational bamboo lodge/ hotel: This design is an improved Sidama house with a concrete floor and good-finishing of wood for doors and windows (see Figure below). In this scenario four, an investment in a recreational Bamboo house of 225,000 Birr per unit has been assumed. A single unit attracts 12,750 Birr per month. The annual rent has also been adjusted for inflation at the average rate of 7 per cent on a year to year basis. Using a maximum period of 40 years that a bamboo house will require full demolition and replacement, as a common assumption to all scenarios, the investment has an IRR of 70.67 percent and a payback period of 2 years hence the project is viable.

From the above analysis, we found that scenario two and four provide housing investors with the fastest and highest return of their money, with all investments recouped after 2-4 years.

Figure 6: *Selected Sample Houses (with complete finishing) for scenarios 1-4 (in that order), (Source: Authors, 2011)*

3.3 Bamboo market value chain analysis

Our field survey case studies in Sidama and Assosa areas showed that there are a number of key stakeholders in both highland and lowland Bamboo market value chains, as depicted in figures 7 and 8 respectively. In figures 7 and 8, we show the position of existing actors in the value chain, with an estimate of the percentage value additions that is active at each value chain stage.

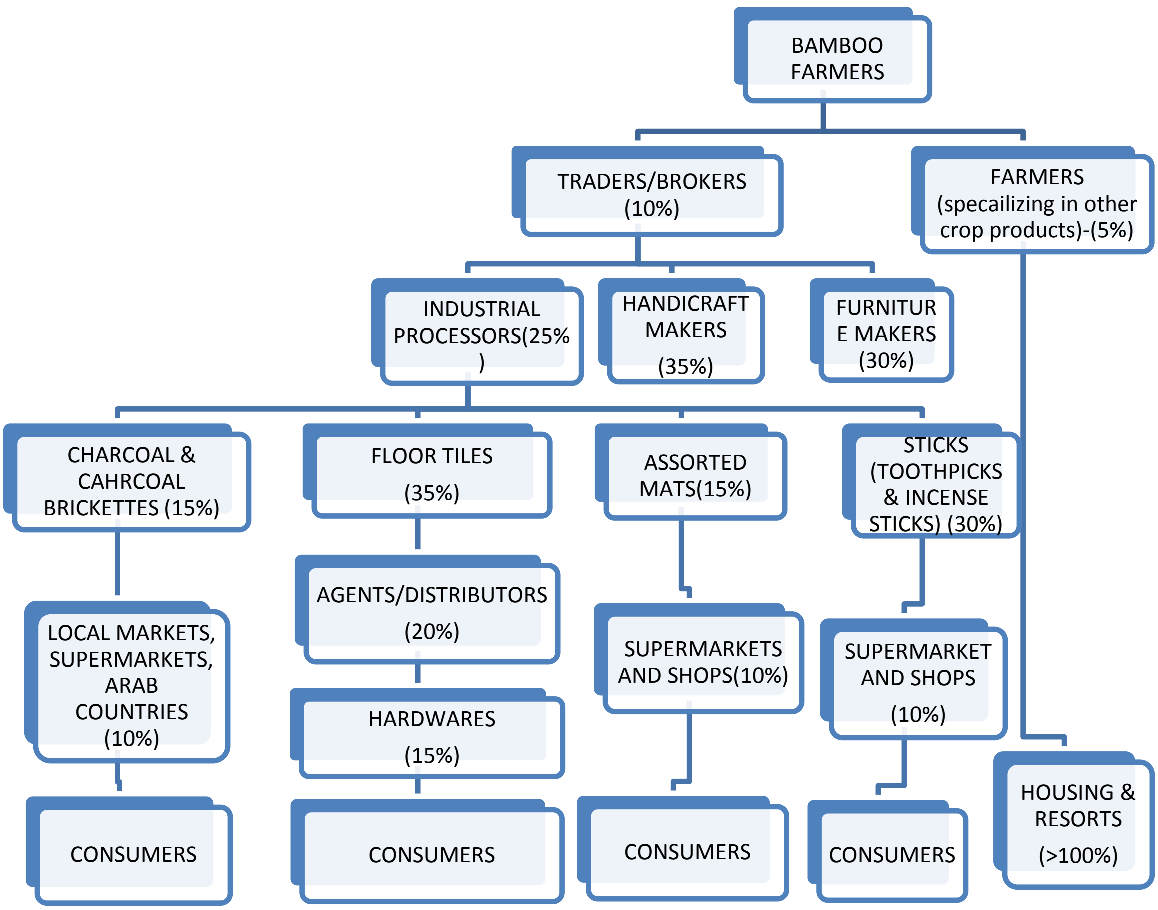


Figure 7: Highland Bamboo value chain: Case study from Sidama area, (Source: Authors)

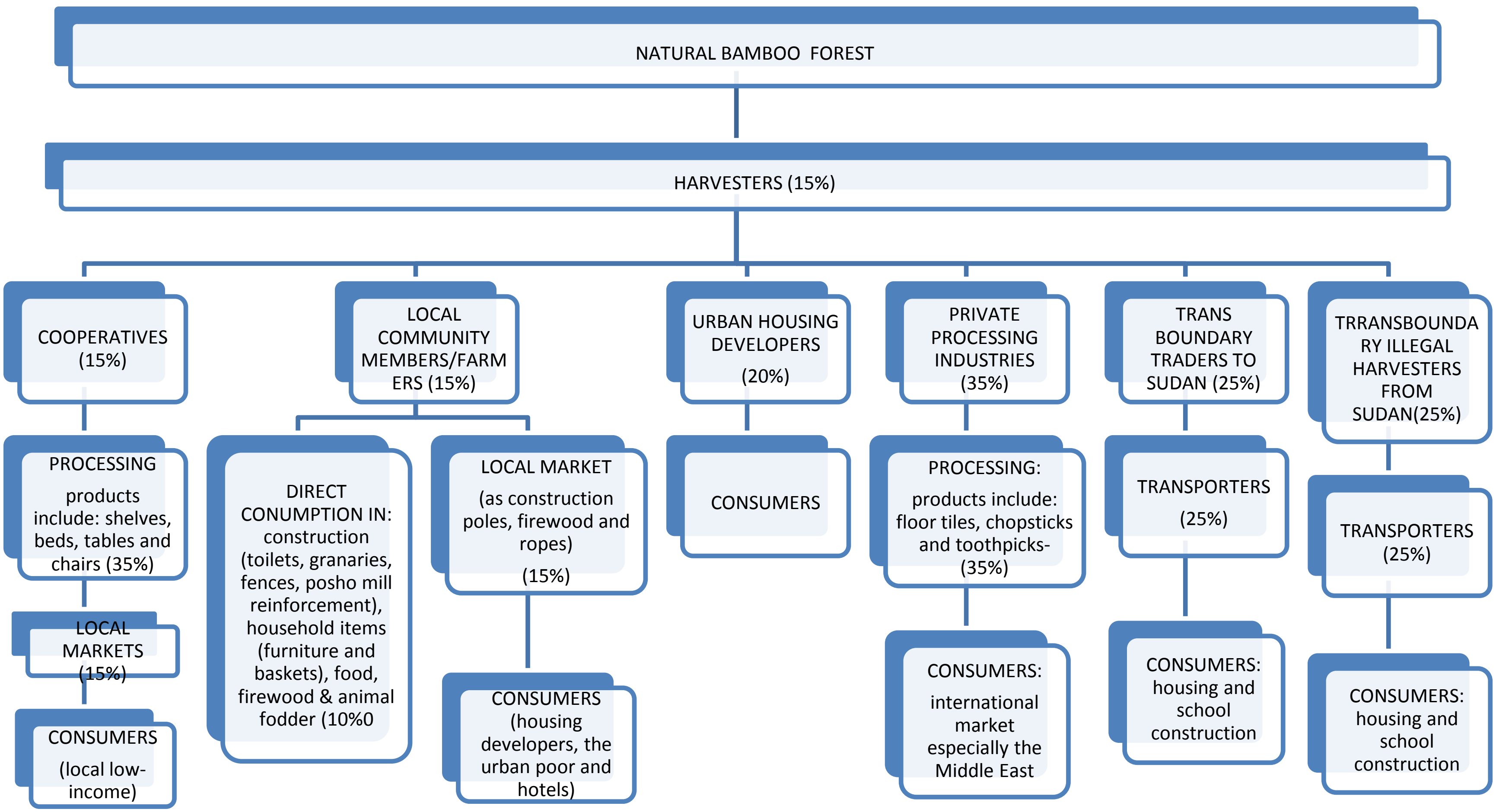


Figure 8: Lowland Bamboo value chain: Case study from Assosa area, (Source: Authors)

The cost of highland bamboo in the city is summarised in the Tables 2 & 3 below. This clearly indicates that bamboo poles of all sizes are far cheaper in Addis Ababa than Eucalyptus, hence providing big potential opportunities for the bamboo housing sector.

Category/ Grade	Circumference(cm)	Standard Length(m)	Average Price per pole (Birr)	Average Price per M (Birr)
1-Large	Over 20	15	32.50	2.20
2-Medium	16-20	15	25.00	1.70
3-Small	10-15	15	20.00	1.30
4- Very small	7-9	15	13.50	0.90

Table 2: Cost of bamboo culms in Addis city, Source: (Authors' Survey, 2011)

Category/ Grade	Average Diameter (cm)	Length (m)	Price per pole(Birr)	Price per M (Birr)
5-Very small	6	4	11	2.75
4-Small	8	4	14	3.50
3-Medium	10	8	26	3.25
2-Large	12	8	38	4.75
1-Very Large	14	3	30	10.0

Table 3: Eucalyptus prices in Addis Ababa, Source: (Authors' Survey, 2011)

Although bamboo is relatively cheap compared with eucalyptus, entrepreneurs in Addis Ababa pay very highly for culms compared with prices in Asossa and Sidama because of:

i. The high taxation imposed by the Federal Government. For example, from Sidama to Addis (approx 400Km), bamboo transporters go through three check points where they pay some levies / culm making a 5Birr culm in Sidama to cost as much as 36Birr in Addis. The traders pays 0.5Birr, lowered from the initial 1.5Birr per culm as tax to the Ministry of Agriculture at every check point.

ii. Transportation cost/ fuel from the point of harvesting to the point of use in the City is very high. For example, they pays 8Birr per culm for transportation from Injibara to Addis Ababa (150Km) and this doubles its price 18Birr at farm gate to about 36 birr in Addis

iii. High labour cost of loading and offloading.

iv. There is reduced bamboo supply during harvesting of other food crops

3.4 SWOT Analysis of Bamboo Applications in the Low Income Housing Sector

Based on our assessment of the bamboo housing sector, we conducted a SWOT analysis. In our analysis we found that bamboo's inherent widespread use in rural construction and potential opportunities for incorporating bamboo into existing government housing policy instruments provide good entry points for developing a housing sector. However, we also note that the current weak nature of bamboo processing skills the informal and non-standardized nature of production need to be overcome to maximize bamboo's potential in construction. Finally, the threat of continued lack of incentives for conserving and utilizing bamboo remains strong. The results of our SWOT analysis are summarized in table 4.

	Positive	Negative
Internal	*Strengths:* • Government already developing bamboo as a construction material • Strong local skill in traditional bamboo construction • Modern engineered bamboo supply chain already being established in Addis Ababa • bamboo is much cheaper than eucalyptus, sand and steel reinforcement bars • Bamboo is cooler than concrete structures • Large availability of bamboo resources in the country	*Weaknesses:* • No bamboo conservation and utilization policies in place • Lack of modern processing skills and building designs • Lack of financing available to bamboo producers to cover capital investments • No building codes/construction product standards for bamboo • less security against burglary than concrete • durability of bamboo often poor due to lack of proper preservation and treatment • Bamboo resources not evenly distributed across the country • No insurance for bamboo home
External	*Opportunities:* • *Rural Clustered Village Settlement Programme* can be targeted for rural markets • Bamboo constructions products can be introduced to urban housing markets through the *Integrated Housing Development Program* • New research in Addis Ababa University recommends replacing steel with bamboo for reinforcement in the ground floor slabs of buildings and also in reinforcing manhole covers • Bamboo can be a good replacement for expensive timber scaffolding • Bamboo sought after material by the rich • Market for construction in new Republic of Southern Sudan	*Threats:* • Gregarious flowering, which occurs roughly every 50 years, disrupts supply of bamboo • Depletion of bamboo resources due to over-utilization and land reclamation for settlements and farming • Negative local perceptions of bamboo as a low-cost, poor building material

Table 4: SWOT Analysis of Bamboo Applications in the Low Income Housing Sector, Source: (Authors)

Conclusions and Recommendations

As discussed above the Ethiopian Government policy and the people's cultural perceptions encourage and only prefer permanent concrete houses for residential purposes. This is mainly due to bamboo construction perceived negative characteristics and weaknesses. Therefore, due to these trends, bamboo housing has limited potential to develop in the retail market for the majority of urban people. Furthermore, future housing investments will continue to be influenced by the long-term policy of developing apartment and storey buildings in cities and rural towns through programmes, such as the IHDP. However, our study showed that bamboo does have very high potential in the rental market for low-income groups and for recreational structures, such as tourism lodges and bungalows. The potential of manufacturing bamboo housing materials, such as floor tiles and mats also requires detailed investigation.

Based on our findings, we recommend that the Ethiopian Government and bamboo sector, with support from International bodies, such as INBAR, should work closely with local builders to improve traditional architecture. This could be targeted through the Rural Clustered Village Settlements program which provides opportunities to improve rural poor housing in Ethiopia through humanitarian programmes. It is also recommended that bamboo should be promoted for flooring, ceiling, walling and partitioning in low-cost housing schemes. The integration of bamboo plywood panels as wall partitions in Addis Ababa IHDP condominium housing in 2012 will provide a good example for this approach. Relevant Government Ministries, with support from INBAR and its partners, should also assist in building capacity by developing a local bamboo building code and then create sustainable partnerships with key actors to ensure smooth flow of materials within the various product chains. Finally, a thorough and thought-out strategy that will provide incentives to protect and use natural bamboo forests on a sustainable basis, and to establish bamboo plantations, wherever they could have both an environmental protection and production function, is urgently required.

Acknowledgments

This work was carried out with aid of a grant from the International Development Research Centre (IDRC), Ottawa, Canada. We, the authors, would also like to acknowledge the technical support we received from Sylvia Misreave Essendi, Tesfaye Hunde, Biruk Kebede, Girma Deriba, Yaregal Mesker and Melaku Tadesse during the completion of this study. However, the content herein is attributed to the authors and not supporting institutions or individuals.

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