KNOWLEDGE PARTNERSHIP PROGRAMME

South-South Technology Transfer

Low Carbon Building Technologies

Market Assessment Report, Malawi

Technology and Action For Rural Advancement, New Delhi

Submitted to

Department for International Development (DFID)

IPE Global (P) Ltd.

September 2014

SOUTH-SOUTH TECHNOLOGY TRANSFER
LOW CARBON BUILDING TECHNOLOGIES

MARKET ASSESSMENT REPORT
MALAWI

AUGUST 2014

TARA
A Development Alternatives Group Enterprise

IPE GLOBAL
Expanding Horizons. Enriching Lives.

UKaid
from the British people

"*This material has been funded by UK aid from UK Government's Department for International Development under the Knowledge Partnership Programme (KPP). However the views expressed do not necessarily reflect the UK Government's official policies".*

Feasibility study undertaken by:
Technology and Action For Rural Advancement, India

Supported in Malawi by:
Centre for Community Organization and Development, Lilongwe, Malawi
Enterprise Development Holdings, Lilongwe, Malawi
Eco Bricks Limited, Selima, Malawi
Indian High Commission at Malawi
Deutsche Gesellschaft fur Internationale Zusammenarbeit (GIZ) GmbH, Malawi

ACKNOWLEDGEMENT

It would not have been possible for the project team of Technology and Action for Rural Advancement (TARA), Development Alternatives Group; to undertake the feasibility study for introducing energy efficient and environment friendly building material technologies in Malawi without the active involvement and assistance of a number of individuals and organizations.

The Feasibility team would, in particular, like to acknowledge the unflinching support given by all the staff and management of Centre for Community Organization and Development (CCODE), Lilongwe, Malawi; Eco Brick Limited, Selima and Enterprise Development Holdings, Lilongwe, Malawi. We would like to express our sincere thanks to Peter Schramm, Siku Nkhoma, Cynthia Phiri and Wonderful Hunga, for supporting us beyond means to undertake the assessment study. Their constant aspiration of supporting Malawi to explore efficient construction through building material production inspired the team to achieve the same.

The team gratefully acknowledges the support from various Departments and Ministries, Government of Malawi especially. National Construction Industry Council, Ministry of Land, Housing and Urban Development, Ministry of Natural Resources, Energy and Environment for their interest shown in the feasibility study. Their interest to take out time and discuss possible means of cooperation with the implementation team shows their keen support for dissemination of cleaner building material production technologies for Malawi.

At the end and certainly not because they were the least important, TARA would like to highlight the crucial role played by building material manufacturers of Malawi in helping us understand the current situation, identify key issues, estimate the immense potential for modernization of the brick sector and chart out the way forward. The openness and alacrity with which they shared information and ideas was truly remarkable.

Last but not the least, TARA gratefully acknowledges the support provided by Department of International Development, India and IPE Global, New Delhi for the assessment study undertaken.

We do hope that the feasibility study will encourage the introduction of new and sustainable building material technologies in Malawi to build up resilience to cope with environmental effects in future.

Technology and Action for Rural Advancement

FOREWORD

Given the strong South-South Cooperation development dialogue and India's long standing presence in assisting development in various regions of the world, DFID has identified a new model for increased cooperation support to India. The Knowledge Partnership Programme aims to step up collaboration around ideas, knowledge, evidence, accountability, technology and innovation, impacting the delivery of global public goods and services and leverage Indian experiences to reduce poverty in LDCs.

Development Alternatives Group has been working for the last 3 decades in developing energy efficient and environment friendly technologies creating sustainable livelihoods. Technologies developed, tried and tested has been transferred to many countries in South Asia and Africa. Thus DA Group has acquired capabilities of re-engineering, home-grown technologies to suit the developmental needs for South-South countries. In light of this, the Development Alternatives Group is working a South-South technology transfer assignment for green building material technologies to Malawi.

The Centre for Community Organization and Development (CCODE) is a non-govt. organization which works in alliance with Malawi Homeless People's Federation to provide affordable housing to all. Over the last decade the construction of houses has been costly and thereby not affordable at all for the homeless. This has been mainly due to irregular shape and poor quality bricks, the use of which consumes high cement from large mortar joints and plastering. Over the last decade CCODE has been looking at low cost technologies to produce good and affordable quality building material so that the homeless can live in safer and better conditions.

This assessment conducted by the DA Group in collaboration with Centre of Community Organization and Development (CCODE), examined the feasibility of introducing green building material production techniques and methods like the Vertical Shaft Brick Kiln, Micro Concrete Roofing Tiles, RCC Door and Window Frames etc. in Malawi. It showed that all pre-requisites to transfer this technology to Malawi exists and the project would have the support of most institutions in the Malawian housing sector. These low carbon building technologies within the portfolio of DA Group have potential to deal with the dual challenge of mitigating GHG emissions while catering to the housing demand through livelihood creation for poverty alleviation.

LIST OF ACRONYMS AND ABBREVIATIONS

CCODE	Centre for Community Organization And Development
DA	Development Alternatives
DEA	Department of Environmental Affairs
DFID	Department for International Development
GDP	Gross Domestic Product
GoM	Government of Malawi
GoI	Government of India
IPEG	IPE Global, New Delhi, India
ILLOVO	Illovo Sugar (Malawi) Limited
INR	Indian Rupee
MBS	Malawi Bureau of Standards
MFIs	Micro-finance Institutions
MHC	Malawi Housing Corporation
MIPA	Malawi Investment Promotion Agency
MITPSD	Ministry Of Industry, Trade And Private Sector Development
MWK	Malawian Kwacha
MLHUD	Ministry of Lands, Housing And Urban Development
MNREE	Ministry of Natural Resource, Energy And Environment
NCIC	National Construction Industry Council of Malawi
TARA	Technology And Action For Rural Advancement
TEVETA	Technical Entrepreneurial, Vocational Education And Training Authority
VSBK	Vertical Shaft Brick Kiln

TABLE OF CONTENTS

1. MALAWI – A BRIEF PROFILE

1.1. Development and growth

The Republic of Malawi is a land locked country situated in Southern Africa. It is bordered by Zambia, Mozambique and Tanzania. Measuring 48,000 square miles, it is a relatively small and densely populated with limited mineral resources. On the unique geographical treasures of Malawi is the Lake Malawi the 3rd. largest fresh water lake in Africa. Part of the Great African Rift Valley, Lake Malawi is around 587 km and 84 km at its longest and widest point. With a population of over 15 million and an average annual per capita income of USD 268 (at current USD), it is among the poorest countries in the world (World Bank, 2012). The economy is predominately agricultural and is dependent on substantial international assistance. In 2012, Malawi received official development assistance and official aid to the tune of USD 1.174 billion (current US$, World Bank, 2012).

The Human Development Index, 2013 is 0.418, ranking Malawi at 170 out of 187 countries. 66.7% of the population live in multidimensional poverty (MPI 'head count', 2010) while an additional 23.4% were vulnerable to multiple deprivations, leading to an MPI value[1] of 0.334. Life expectancy of 54.8 years with an average of 4.2 years of schooling put Malawi below the average for both Sub-Saharan Africa and other Low HDI countries. While Malawi has shown signs of development, this development has been very unequal. HDI when adjusted for inequality falls to 0.287 and the 2004 Gini coefficient is just 39.0. In addition Malawi has a Gender Inequality Index (GII) value of 0.573, ranking it 124 out of 148 countries reflecting gender-based inequalities in three dimensions – reproductive health, empowerment, and economic activity.

As of 2014, Malawi ranked 128 out of 178 countries on the Environmental Performance Index with a score of 40.06. In 2010, it had a total emission of 1,239 ktonnes CO_2 emissions with a per capita figure of 0.1 metric tons CO_2 emissions. (World Bank, 2012). Malawi is one of the countries with the smallest Ecological Footprints, under 0.5 global hectares (1¼ acres) which is generally too small to meet basic requirements for food, shelter, infrastructure and sanitation (Global Footprint Network, 2009).

In 2012, Malawi managed to attract Foreign Direct Investment worth US$1.2 billion representing 22 percent of the FDI flows to Southern Africa. With reference to Malawi

[1] Share of the population that is multi-dimensionally poor adjusted by the intensity of deprivations.

Investment and Trade Centre records for investment pledges for the year 2012, FDI significantly rose by 18% from US$987,458,231 recorded for 2011 to US$1,161,432,000. This is a reflection of the improved business environment which attracted more investors from within and outside Africa. This upward trend commencing from 2011 was a diversion from the collapsing investment figures traced from 2008 to 2010. Infrastructure and Energy sectors shared 62% and 33% of the 2012 total investment respectively with tourism, services and agro-processing having minimal contribution. Concerning the origin of the investors, China and the United Kingdom shared 46% equally while the rest of the investors which include South Africa, India, Pakistan and local investors, were less than 4% of the total investors. Despite the hike in FDI in 2012, the year's employment levels (at 4,366) were relatively lower than those of 2011 (at 12,847).

Foreign Direct Investment in 2013 and beyond is expected to show a positive growth from the current trend that is benefiting from the investment friendly economic reforms. The current government has liberalized the exchange rate and devalued the Kwacha which should ensure availability of foreign exchange for investment. Restored good relations with the donor community are also expected to boost confidence in investors. The Economic Recovery Plan is expected to put Malawi's economy back on track which subsequently should make investing in Malawi more secure. Furthermore, the One-Stop investment facilitation anticipated to commence this year is a likely determinant to increased investment.

This it is seen that the Government of Malawi is planning to open up the infrastructure sector in the next decades and create favourable investment opportunities. This is expected to create a large demand on the building and allied materials. Moreover increasing urbanization will place a high demand on housing and related infrastructure. Thus there will be rapid increasing demand of building materials and technologies creating high interest for investment and profitable business.

1.2. Urbanization and housing

The capital city of Lilongwe is Malawi's largest city. Other large urban centres include Blantyre, Mzuzu, Zomba and Karonga. Currently just over 15% of the population is urban, which is growing at an annual rate of 4.2% (CIA, 2013). Projections suggest that, by 2025, almost 30% and by 2050, 50% of Malawi's population will be urbanised (UN DESA, 2007). The average annual increase of 5.2% in the urban

Figure 1: Traditional rural housing in Malawi

population in Malawi during the period 2005-10 is amongst the highest in the world.

Approximately one in four urban residents officially live in poverty, one-third in Mzuzu, constituting 6% of all the poor people in the country (Integrated Household Survey, Government of Malawi 2005). The richest 20% of urban households consume 40 times as much as the poorest 20% of rural households and 13 times as much as the poorest 20% of urban households (World Bank, 2003).

Population growth patterns of Malawi's major urban centres indicate there will be 203,600 additional households by 2020 that, with an additional 25 per cent for the secondary urban centres, leads to a total demand for new dwellings of 254,500 by 2020. The Malawi Urban Housing Sector Profile 2010 reveals that with the current rate of urbanization 21,000 housing units are required annually to meet the urban housing needs over the next 10 years. In Malawi, formal housing delivery systems account for less than 20% of the demand and target middle and high income people. As a result, between 70-90% of the urban population who cannot afford a decent living condition are forced to live in informal settlements – resulting in insecure tenure, poor quality of housing and overcrowding (Habitat NI, N.D)[2]. This type of living conditions often creates human stress leading to restlessness and unlawful activities.

The Malawian government has retained a high profile in the housing sector despite never adopting a national housing policy. The draft National Housing Policy recognises that housing provision is potentially a major contributor to national economic development through its direct, and multiplier effects in job creation (Government of Malawi, 2007). NSO data reveals that building and construction is

Figure 2: Typical Urban House in Malawi

[2] http://www.habitatni.co.uk/docs/malawi.pdf

fourth among the nine major businesses in the country. It follows agriculture, mining and manufacturing in terms of contribution to GDP and growth. An annual increase in funding for construction works from MWK 11.9 million in 2003 to MWK 20.4 million in 2009 (at constant 2002 prices) was observed, highlighting the growth in the building sector. According to the IHS, 3.9 % of the urban workforce is employed in construction.

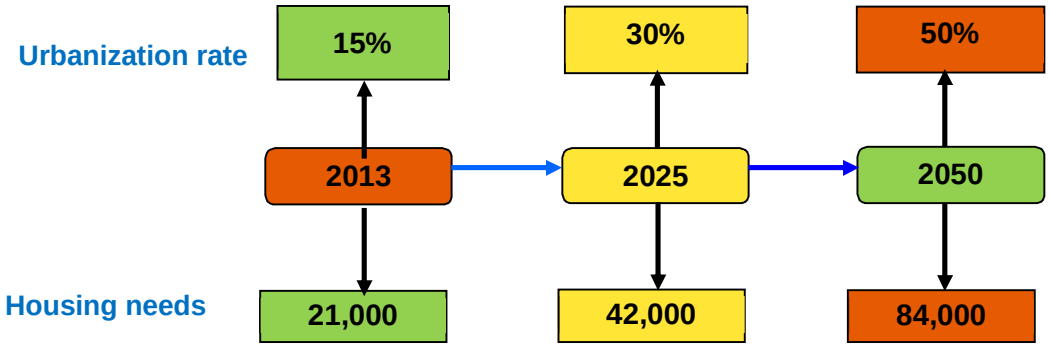


Figure 3: Urbanization rate and corresponding housing needs.

Note: This prediction is only for urban and does not account rural houses and other infrastructural needs

The last few years, Malawi has seen an improvement in its development and poverty indices. As the country moves towards growth and development, people will have disposable incomes and will invest in essentials like housing. The housing demand is already evident and this will only grow. Building materials are estimated to contribute to about 60% of the cost of housing as well as the major chunk of the emissions from the sector. Thus investing in technologies for production of clear and better quality building material is imperative to enable the sector to grow in a sustainable manner.

2. MALAWI HOUSING

2.1. The Informal sector

In Malawi market, competition in the housing sector is limited and operates under a weak institutional framework. Taking advantage of this, the informal sector plays a vital role in Malawi's urban housing though difficult to quantify. In fact one of the biggest informal housing sector is in Likuni, on the outskirts of Lilongwe. The pre and post-independence administrations set up the Traditional Housing Areas[3] and successfully recruited the informal construction sector's energies to develop an

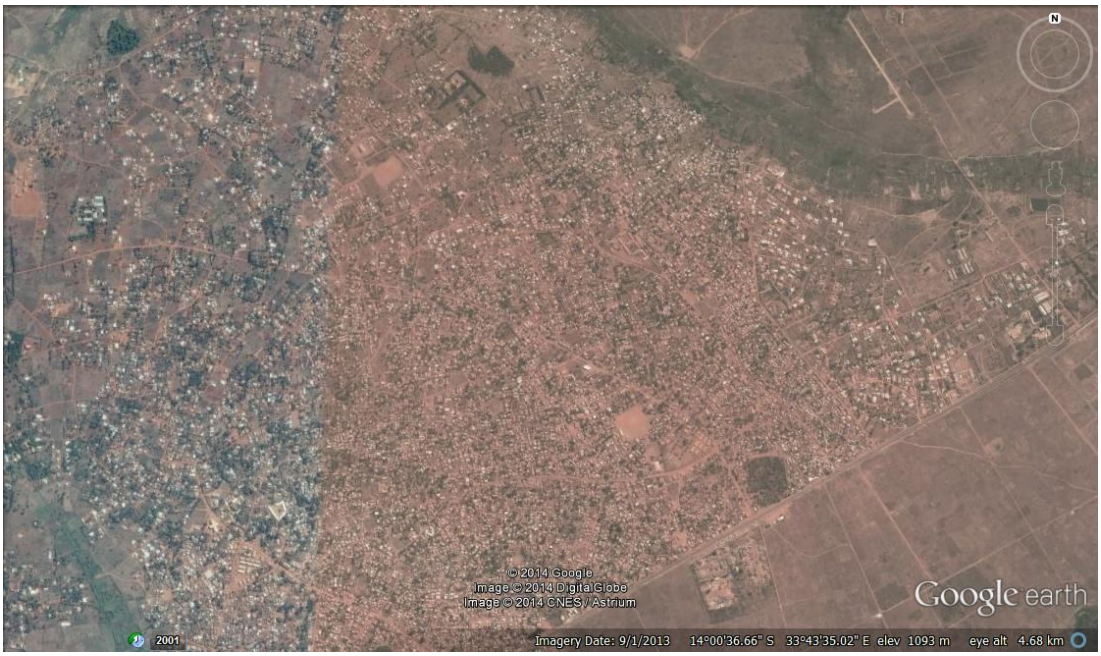


Figure 4: One of the largest informal settlements in Malawi situated in Likuni on the out skirts of Lilongwe, Malawi

affordable urban environment. Unfortunately, this has withered away and the informal sector co- operates with the formal sector in overlapping systems, but with little government acknowledgement or assistance through policy (UN-Habitat, 2010).

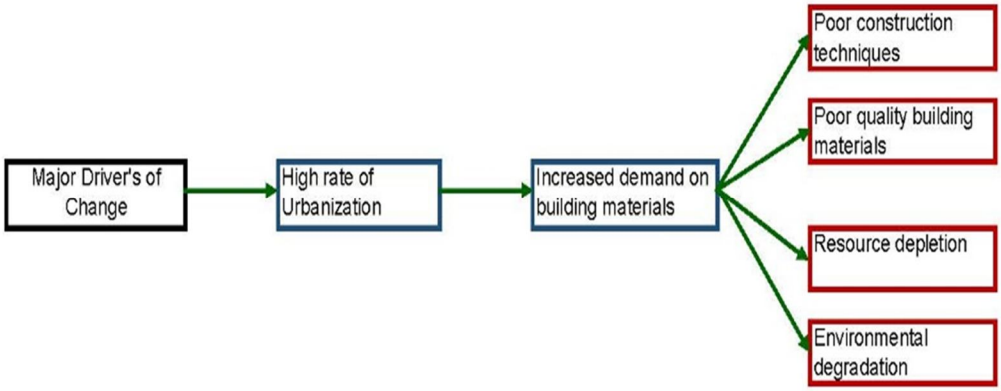
2.2. Drivers of change

This high rate of urbanization puts tremendous pressure on the entire building material sector. With constraints in supply of material and demand far outstripping supply, both the quality of material and the application (house) has degraded to an alarming extent. This has resulted in poor quality and increasing construction costs. The current state of housing has put an immense pressure on the low cost housing sector. Most often it has reached beyond the means of common beneficiaries. Thus there is a need to bring about change in the business as usual scenario.

[3] Traditional Housing Areas (THAs) are the official way of supplying housing to the low-income majority in urban areas. They are provided serviced plots in the "sites and services" tradition, but with relatively tolerant standards for the construction of the dwellings in response to the poverty of the plot holders.

The prime driver for change is the rising concern on resource scarcity voiced by both the Malawian Government and the building material industry. As wood is the prime source of energy (both domestic and for brick firing), there is immense pressure of deforestation on the fast depleting forests. Thus, the two major concerns in the Malawi brick sector are increased deforestation due to use of fuelwood and poor brick quality resulting in poor construction quality.

Another major driver is the demand for quality building material that can contribute to a reduced cost of construction. One of the largest contributors to the cost of construction are the cost of cement from high mortar joints. These costs can be reduced for example in walls through standardized and good quality bricks from better construction and reduced use of cement mortar, Estimates peg reductions at about 25-30% from current conventional costs. Construction with traditional bricks, is



approximately 70% more than similar construction with good quality bricks. Thus use of quality bricks can drastically bring down the cost of construction of a low cost housing.

Poor quality housing coupled with the increasing deforestation in the country, has prompted the Government of Malawi to take notice of the situation and explore alternatives. During the course of the assessment, several meetings were conducted in Lilongwe, Malawi. The Department of Energy Affairs, Department of Environment Affairs, and National Construction Industry Council etc. have expressed a keen interest in promotion of such building materials from India.

The project intervention will introduce new technologies for building material production that will deal with this dual challenge of proving quality housing to communities while mitigating environmental damage caused. A further dissemination is required to enable the technologies introduced to have large scale impacts on suitable development indicators of environment, economics and social well-being.

3. THE HOUSE

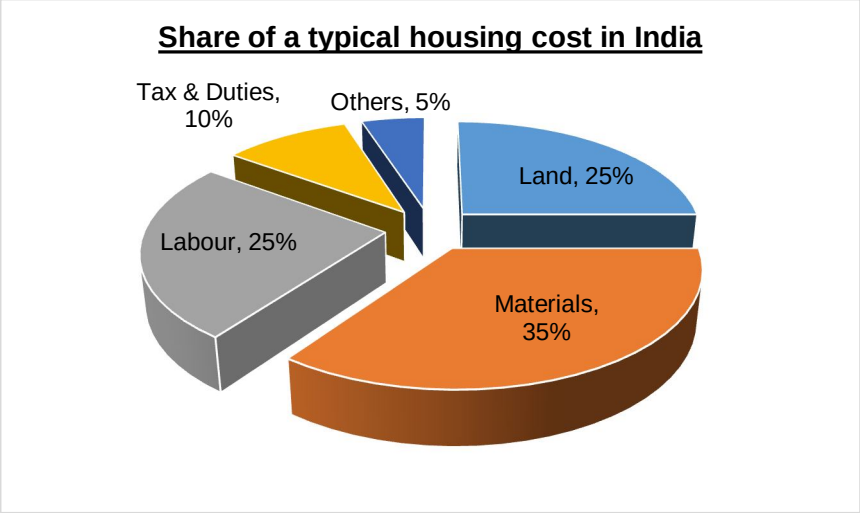
3.1. Analysis

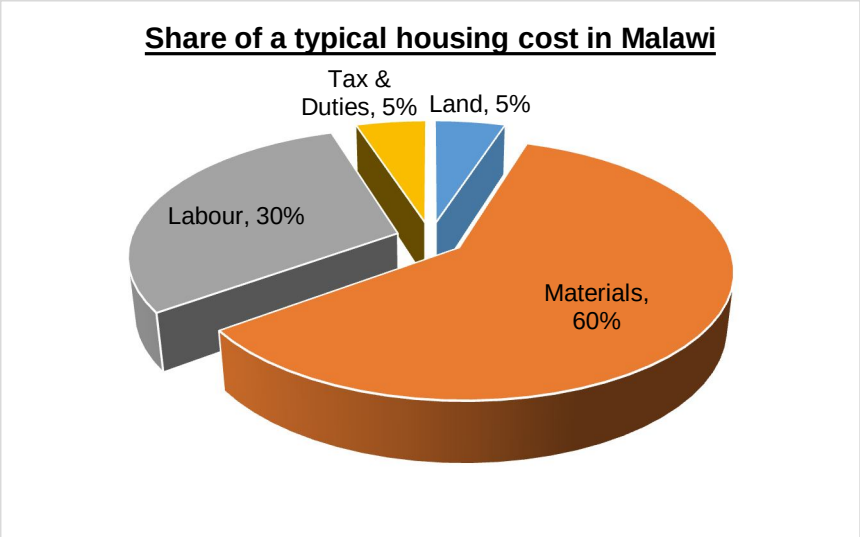
Housing is a very personal and an important part in the lives of people in Malawi. Housing in Malawi ranges from traditional thatched huts to elaborate multi-roomed dwellings with running water and satellite television. Most rural homes are made of unbaked brick (adobe's) and grass thatched roofs. As we move towards urban spaces baked-brick homes with metal roofs begin to make an appearance. Only a third of current urban housing is built of permanent materials It is important that the Malawian cities do not simply extend the current networks and technologies as different ones are available and may be more appropriate and sustainable (UN Habitat, 2010).

Figure 5: Traditinal dwelling in Malawi in semi-urban areas

Traditionally, government agencies like the Malawi Housing Cooperation (MHC) provide the infrastructure for housing, but they are not necessarily fulfilling expectations. Their pace of delivery is slow and quality less than expectations. They are now more or less defunct for want of able administration and capital infusion. Small-scale private and household sector initiatives provide most of the dwellings, while there is an increasing focus on a few civil sector actors especially for creating a sustainable affordable housing stock for both owning and rent. Compared to other Asian, European countries, the housing sector is not looked at as a good business proposition by private players and housing companies. The market is small and credit rates from banks very high making business unviable in large scale.

Even with this slower-than-expectation pace of delivery of houses the building material scenario is quite different than in India.





It is apparent from the above representation that building material costs occupy the highest share of a house cost in Malawi. This is since land is available at much cheaper rates compared to India. However for Malawi the scenario is different in rural areas where land are owned and need not be purchased.

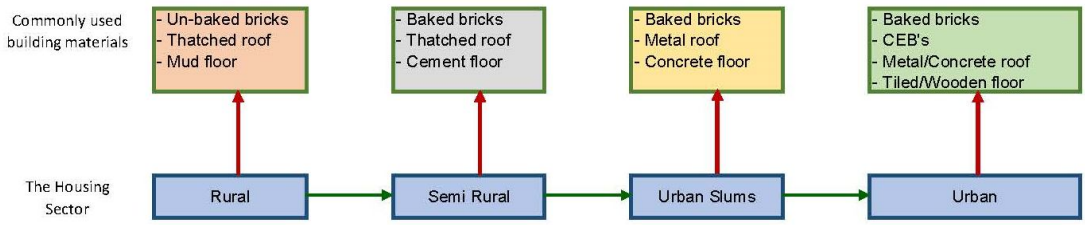
The price difference between the formal sector building (~MWK 1.7 million for a 40m^2 dwelling) and the informal sector (~MWK 30,000 for a 40m^2 dwelling) is almost 60-fold. The median household consumption of about MWK 195,111 (USD 1,400) per year leads to a need for most housing to cost around MWK 976,000 (USD 6,970), including plot and servicing The annual need for 21,000 dwellings costing around MWK 976,000 each generates a need for MWK 20.5 billion (USD 146 million) per annum of housing investment against a current government housing budget for Malawi of MWK 949 million (USD 6.8 million) (UN Habitat, 2010).

The figures below gives an idea of the quality of construction of houses in Malawi. Typically an average quality of construction in India would require low cement and sand compared to bricks. In case of Malawi this is entirely different. The high proportion of cement and mortar cost is indicative of poor construction practices. Another factor of high mortar costs is due to the poor quality of building materials being used in terms of shape and size. To make a uniform quality wall, with irregular brick shape and sizes the mortar consumption is extremely high.

Thus there is ample scope of improving both the quality of building materials and also the construction practices concurrently to achieve a quality house at an affordable cost.

Figure 6: A typical construction quality in Malawi

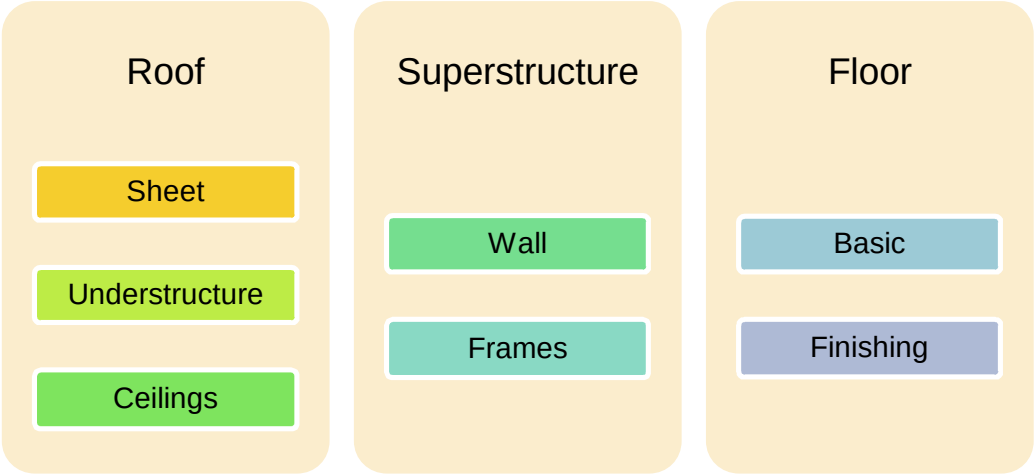
The informal sector dominates the construction and housing industry in Malawi, as is the case in many developing countries. There is a small formal sector that caters to



some of the demand. These are generally large public private partnerships. The Guonji Dream Town project of the MHC in partnership with Chinese companies is the only example being executed presently. Here the construction is being undertaken by the MHC, while the project is primarily financed through the Chinese. However this is also mainly for use by Chinese expats and workers serving in Lilongwe, Malawi.

With respect to materials, steel and cement are sourced from the formal sector, but most other materials e.g. bricks come from the informal manufactures. The informal sector makes use of labour-intensive, local technologies and materials costing very little or nothing (e.g. adobe bricks made from the site soil). There is a strong tradition of manufacturing and building with burnt bricks, and similar materials available locally. Cement products like tiles, grills, sills are available along the major roads leading into the urban centres. This is a typical small scale household production system followed in most part of Africa. However the quality of these products are extremely variable. The high-end housing segment uses mainly imported materials.

For the purpose of the assessment, we looked at the house in terms of three elements i.e. the Roof, the Superstructure and the Floor. Each was then further divided on the basis of the material used. The observations and analysis has been presented below in a similar fashion.



3.2. Assessment

3.2.1. Roof and roofing materials

Houses in Malawi predominantly have sloping roofs, as it is the preferred choice of people not only in Malawi but in majority of Africa. However internally they aesthetically demand flat ceilings especially in urban areas. Thus the assessment looks at the Roof in these two parts.

In rural areas grass thatch is most common material used. These need to be replaced or repaired annually thus adding to maintenance costs and effort. However this is also an inexpensive option, most often undertaken by family and friends without hiring external experts. As income levels rise, people aspire to move beyond thatch to a more permanent roof. The permanent roof is also seen the first step towards a better quality of life through housing. Thus households are increasingly moving towards steel sheets. There was also observed some isolated presence of asbestos roofing sheets in some of the older constructions.

Figure 7: Thatched roof in rural settings

In urban areas, steel sheets are the most common roofing material used. They account for about 80-90% of the market. All steel is imported since there are no steel producing factories in Malawi. Most of the import is from South Africa – especially for the large companies like MACsteel and Safintra. There are also a fair number of smaller retailers who import the sheets into Malawi from South Africa and other neighbouring countries. This informal sector accounts for 60-40% of the market based on estimates by different stakeholders in the industry.

While the metal is mined and refined abroad, the profiling does take place within Malawi. There are various profiles of steel sheets available. The most common ones are corrugated sheets. These were among the first steel sheets introduced in the country. They cater primarily to the low income households. This is the first step in the move towards the permanent roof and subsequently house.

Figure 8: Concrete tiles roof in peri-urban settings

About 50-70% of the market is occupied by them. As the prices of the profiles increases, the market share decreases both in terms of volumes and amount, while the socio-economic status of the target consumer increases.

Figure 9: Corrugated metal sheet roof in urban areas

Middle income household prefer IBR (inverted box rib) profiles accounting for 20-30%. While the bold angular appearance of this profile makes it a very attractive choice, it provides optimum load span consistency. The deep and broad flutes of the IBR profile also ensures excellent drainage capacity. The IBR profile can furthermore be factory cranked, curved and bull-nosed to a wide range of radii to suit specific requirement thus offering variety to the consumer. The remaining 10-20% is filled in by Tile profiles catering to the high incomes households. They mimic the aesthetics of tiles while

providing the ease of installation of steel sheets. Each of these categories also have an option for introducing colours in the products, of course at a premium cost.

Figure 10: Clay tiles roof in urban areas

Figure 11: Cement based decorative tiles in urban areas

Materials	Cost (m^2)	Life years	Response to hazards	Availability	Trend over last 5 years	Ease of Use	Raw Material Concerns	Production Concerns	Marketing Concerns	Quality Perception
Steel	5000	25	Med	High	Up	High	Cost	None	None	High
Tiles Concrete	4000	10	Low	Med-Low	Down	Low	Cement cost	Weight / installation	Cost / quality	Low-Med
Precast Concrete		60	High	-	-	Low	Cement cost		Cost / trust	High-Med

A small market share of about 10% is occupied by cement tiles. While there is a very strong aesthetic appeal and aspiration for tiles, the challenges with implementation have retarded its growth. They were used for a while after Independence; however

have increasingly lost favour to steel sheets. The biggest problem with cement tiles is the installation. With no availability of skilled labour, poor installation leads to leaks and lack of insulation, compromising on the quality of comfort. The informal sector is more prominent in this space, with very few companies investing due to lack of skill among carpenters. Some outfits import skilled labour from Mozambique, to ensure quality roofing delivery. However this is still not a common trend. Besides tiles, there is negligible use and demand of cement based roofs both cast in situ and pre-cast. There is a reluctance among developers to consider cement based technologies due to the high costs and lack of skill and expertise in executing these technologies.

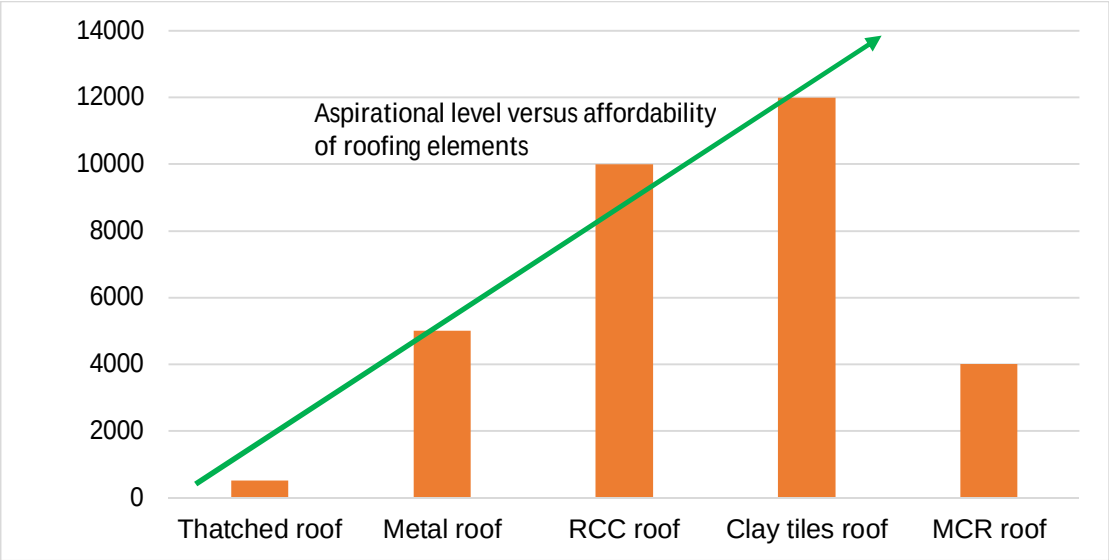


Figure 12: Procurement cost of various types of roofing materials showing cost versus aspirational levels.

In order to support the desired sloping roofs, an under structure needs to be erected. The most commonly used material for this is timber. There are various concerns that are raised due to the use of timber. It increases the pressure on deforestation and with the expected demand for housing, this will have serious consequences. Also if the timber is not adequately treated which is often the case, the quality of the construction suffers. Industrial construction has shifted to steel under-structures, however this is not seen in residential homes due to the costs involved. Industry watchers do predict that the shift to hollow steel purlins will take place in the next 5 years with good quality timber becoming scarce and expensive. There is also a latent movement towards newer lighter materials to fill this space.

In addition to the roof, most houses have flat false ceilings. These are made of boards. Depending on the affordability of the household, the range various from plywood ceilings to the much more expensive gypsum boards used in luxury homes.

3.2.2. Superstructure and walling materials

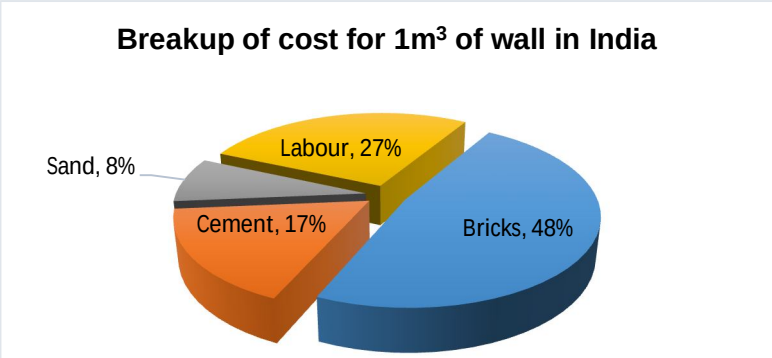
The superstructure consists of the envelop of the building. Besides the wall, we have also looked at the frames for doors and windows.

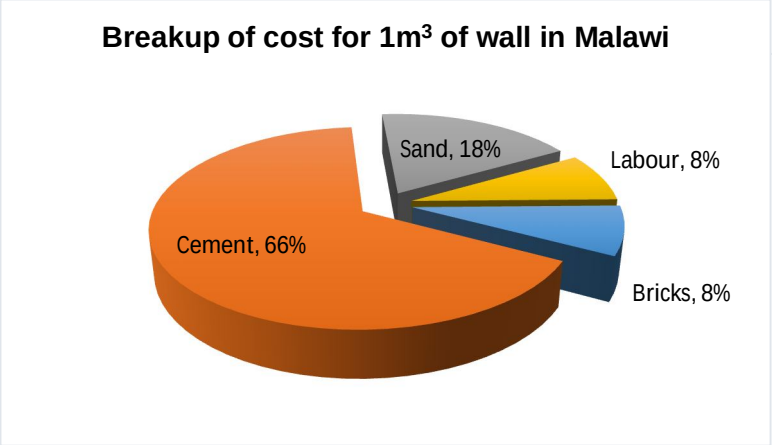
3.2.2.1. Wall and related materials

A low cost house will require an estimated 20,000 burnt bricks while a high income house will require an estimated 150,000 to 300,000 including bricks for fencing around the house. Thus on an average 85,000 burnt bricks will be required for the construction of a single house. Therefore to meet the demand of 21,000 housing units needed each year, a minimum of 1.7 billion burnt bricks are required every year.

The main walling material in Malawi in urban settings is “burnt clay bricks”, especially for owner drive housing. While bare minimum of the housing sector in urban areas only. If the requirement of rural areas including infrastructure requirements of public investment is calculated then the estimate Adobe or Sun-dried bricks are the most common rural walling material. Both materials are produced locally, often by the homeowners themselves or by small teams of 1-4 brick manufacturers.

Currently, brick production in Malawi is highly decentralized and unorganized. The entire Malawi brick industry uses open clamps for firing. With no control on raw materials and process the product is extremely poor compared to the standards in other countries. Due to poor quality of green bricks, clamps are not stacked high enough. There is no control over the firing process in the clamps. Fuel used in firing bricks in Malawi is fuelwood. It is estimated that around 850,000 tonnes of fuelwood will be required to produce around 1.7 billion bricks if alternate technologies are not adopted. At this rate of fuel wood consumption, the entire country will be deforested within 25-30 years only from the brick industry. No waste materials are used in green brick making for use as body fuel. Besides fuelwood, fuel in the form of leafy biomass is also used to provide additional energy. However the quantity and quality is not suitable to provide additional heat to uniformly fire the upper layers of the clamp





The quality of brick is very poor. There is no consistency in shape, size and colour. This drastically impacts the quality of construction and the standard of living. The poor quality leads to use of excessive mortar, increasing the cost of construction.

From the analysis of the cost of a wall (refer to pie-diagrams) it is seen that in India majority of the cost is of the bricks with cement and labour having equal share. However the scenario is just the opposite in Malawi. Maximum cost of a wall in Malawi is from the cement. This is due to the large and thick mortar joints and extra cement consumed to make a uniform plastering.

Thus if the various stakeholders can concentrate on reducing the cost of cement in construction, then the overall cost of a wall will be drastically reduced. This can be done by use of good quality and uniform bricks. Thus the Vertical Shaft Brick Kiln will be a useful technology to adopt in Malawi for production of uniform and good quality bricks. Even if the bricks are priced at a higher cost compared to normal clamp bricks, still the cost of wall made with these bricks will be cheaper.

Use of alternate materials is sparse, limited only to subsidized construction activities. Funder driver construction opts prefer the use of Stabilized Soil Blocks (SSBs). This is also the material of choice for the MHC, as they move away from the use of burnt bricks. These blocks are produced manually on site with simple machines. Current production systems do retard the chances of this material helping plug the vase housing gap. The reason for the preference is the large scale environmental damage and deforestation on account of firing clay bricks. The recognition of this impact has led funding agencies to promote the cleaner SSBs.

Materials	Cost	Cost for $1m^2$	Availability	Trend over last 5 years	Raw Material Concerns	Production Process Concerns	New Skill requirement	Marketing Concerns	Quality (Perception)
Burnt Brick	6	3837	High	Stable	None	Wood Fired	Low	None	Low
SSB	80	3629	Med	Up	None	Quality	Low	Cost	High
HCB	400	4306	Low-Med	Up	Cement cost	Manual	Low	Cost	High
VSBK	25	4270	Low	-	Coal	New	Low	None	High
Hydraform	150	6238	Low-Med	Up	Cement cost	Manual	Med	Cost	High

There is a slow but steady shift over the last 2-3 years towards the use of concrete blocks. This has been spurred on by the proliferation of developer led construction. The local availability of stone and quarry dust and aggregate has encouraged entrepreneurs to come up with these products. Though cement is expensive developers are increasing choosing this over burnt bricks for quality reasons. This is still however a trend restricted to high end housing and institutional buildings.

The manufacturing of these concrete blocks is split between the formal and informal sector. There is limited evidence of larger companies supplying machine made blocks. Large developers also manufacture their own blocks using hydraulic or manual machines. Concrete blocks are increasingly being manufactures by informal vendors who hawk their wares on the street sides. The quality of the product is a concern

especially for the informal street vendors as the process if manual and the compaction and compression forces are not uniform.

3.2.2.2. Reinforced Concrete Frame

Frames though a small part of the house are very important. Traditionally, wooden frames are used in Malawi. These are the cheapest available option especially when the wood is untreated. However the life of these frames is not very long. They start rotting and decaying within a matter of 3-5 years. Treated wood frames have a much longer life but are also more scarce and expensive.

In urban spaces, steel frames have dominated the market. The frames in the informal sector are much cheaper and comparable in cost to good quality treated wooden frames. But most good quality steel frames are very expensive. Steel frames are available along most major roads leading into the urban centres. Small welding and fabrication units have sprung up to cater to the growing demand.

While window frames have almost completely made the transition, people still prefer wooden frames for doors. Steel door frames give a prison like feel and the aesthetics of the wooden door are appreciated.

Materials	Cost MK	Availability	Trend over last 5 years	Ease of Use	Raw Material Concerns	Production Process Concerns	New Skill requirement	Marketing Concerns	Quality (Perception)
Wood	12000	Med-Low	Down	High	None	Wood Fired	Low	None	Low
Steel	23000	High	Up	High	None	-	Low	Cost	High
Concrete	10000	-	-	High	Cement cost	Technology	Low	-	High

The idea of concrete door and window frames was introduced to both users and developers. Though they had not heard or seen it before, there was limited reluctance for the approach. The cost was the major concern.

3.2.3. Floor and associated products

The floor of the house receives the least attention when upgrading from a temporary to a permanent home. Most rural homes have mud floors. As economic and aspiration levels rise there is a movement towards screed concrete flooring. Current in urban areas, this is the most common material. In order to enhance aesthetics sometimes colour is added in to the concrete while laying the floors.

The next step in the aspiration hierarchy is tiles. These can be concrete, ceramic and wood in increasing order of magnitude of prices. Concrete tiles are manufactured by few large units, but are most commonly locally produced and sold on street sides, Ceramic tiles are generally imported from India and China. This is fast becoming a middle class market demand. There is also some instance of tiles being imported from Italy, but these cater to a very high end niche market. Wood tiles are imported generally from South Africa and neighbouring countries.

While internally concrete dominates in form of screed, external pathways are made of concrete pavers. While this is not a market for affordable housing, high end construction makes use of them. These again are supplied by both formal and informal setups.

Figure 12: Various types of flooring and other materials produced manually in Malawi

3.2.4. Construction quality

The construction quality found in Malawi is mixed in quality. There are masons who can do a much better job of construction. However the general tendency is to cover up the construction by either thick pointing or by plastering, both of which are expensive. This is a general habit of masons and cannot be changed immediately. The reason of poor construction quality might be due to poor quality and irregular shape of bricks. However even if good quality bricks are made available from improved technologies, quite a substantial and continued effort needs to be done on training and capacity building of mason's, helpers and engineers on better construction practices.

4. MARKET ASSESSMENT OF BUILDING MATERIALS

An estimate of the quantity of building materials required in Malawi has been calculated based on the requirement of housing in urban areas only. These are the minimum requirement during the stated period since additional building materials from rural areas and infrastructure has not been considered. To estimate the market it is assumed that the walls will be made of bricks and roof with MCR tiles. The floor of the rooms might be made with paving blocks.

Table 1: Requirement of building materials in Malawi

Sl.	Materials	Year		
		2013	2025	2050
1.	Roofing materials			
1a.	MCR Tiles	3 million	6 million	12 million
2.	Walling materials			
2a.	Burnt clay bricks	1.7 billion	3.5 billion	7 billion
2b.	RCC Door frames	0.2 million	0.4 million	0.8 million
3.	Flooring materials			
3b.	Paving blocks	8 million	16 million	32 million

***Note**: For all materials requirements are based from urban needs only. Rural and infrastructural requirements have not been considered.*

Presently all the materials are being produced from either local materials or imported. To produce the above building materials, following are the number of technologies required in the future.

Table 2: Requirement of technologies for production of building materials given Table 1 for Malawi

Sl.	Materials	Year		
		2013	2025	2050
1.	Roofing materials			
1a.	TARA Micron	50	100	200
2.	Walling materials			
2a.	Vertical shaft brick kiln	600	1200	2400
2b.	TARA Green Cast	20	40	70
3.	Flooring materials			
3b.	TARA Green Cast	30	60	120

In the above estimations, it is assumed that the building materials will be produced from the technologies mentioned below.

- Micro-concrete roofing tiles - TARA Micron
- Burnt clay bricks - Vertical Shaft Brick Kiln
- RCC door frames - TARA Green Cast
- Paving blocks - TARA Green Cast

Capacity of production of various technologies based on yearly (250 days per year) production:

1. TARA Micron - 60,000 tiles per year
2. Vertical Shaft Brick Kiln - 25,00,000 per year
3. Green cast (door frame) - 12,500 per year
4. Green cast (paving block) - 2,50,000 per year

Thus it is seen from Table 2 that the requirement of technologies over the near future are large and makes business sense for undertaking and demonstrating technology transfer programme.

5. BUSINESS ECONOMICS

Although no detailed business economics was studied in Malawi however financial feasibility of both products and technologies were estimated.

MCR Tiles – TARA Micron

Comparison of the production cost of the various products suggested that in case of MCR tiles it is cheaper in comparison to roof with metal sheet. For a m^2 of roof metal sheet cost is MK 5000 and MCR is MK 4000. The cost of the MCR tiles is based on raw material cost, labour required and overheads including investment in machine and working capital.

Burnt Bricks - Vertical Shaft Brick Kiln

The price at which bricks were being sold in Malawi ranged from MWK 5 to MWK 6 per brick. Apart from the normal spread in pricing on account of variation in rates at which entrepreneurs are selling bricks to customers, there is only one main factor that determine price:

- Quality:

  Good quality bricks are in high demand for high end and Government construction since traditionally people prefer exposed brick work. Thus even a 5 times price escalation is not an issue provided the bricks are of good shape and quality. This high price is also somewhat offset from the reduced cement costs from thinner mortar joints.

There is sufficient evidence to indicate that the brick market in Malawi is robust enough to encourage higher pricing if quality bricks are being produced. This will result in relatively predictable revenue for brick makers which will increase over time with demand. Input costs are also likely to be stable and increase gradually in pace with general inflation.

Adoption of VSBK technology would result in savings of 850,000 – 1,000,000 tonnes of wood per year in Malawi.

The economic feasibility of VSBK Technology in Malawi is predicated upon its viability in the urban areas of Lilongwe and Blantyre. No absolute prediction can be made at this stage by comparing the VSBK Technology Package against existing brick production technologies i.e. the traditional clamps. Once pilot kilns are operational more definite figures can be calculated. Thus the table gives an idea on the scale of operation of a single and a double shaft VSBK.

Key economic parameters used to make the analysis are: Scale of operation, Investment, Annual Expenditure, Annual Revenue and Overall Business Performance. Given that the VSBK is modular in nature, two sizes – a 1-shaft VSBK and a 2-shaft VSBK are being recommended.

Table 3: Scale of operation

Parameters	VSBK 1 - shaft	VSBK 2 - shaft
Daily output (bricks)	4,500	9,000
Days of operation	300	300
Annual capacity (bricks)	1,350,000	2,700,000
Capacity utilization	90 %	90 %
Annual production (bricks)	1,215,000	2,430,000

It is evident that VSBK technology is suitable for small to medium scales of brick manufacturing. It matches the capacity expectations of most entrepreneurs and is modular. If there are constraints in capital investment or uncertainty in volumes that can be marketed, an entrepreneur can start with a single-shaft VSBK and add shafts as his business grows. Moreover the flexibility of the VSBK can meet any production capacity. For smaller production requirement the shaft size can be changed to suit the requirement.

Door frames and paving block – TARA Green Cast

The TARA Green Cast technology is suitable for producing both door and window frames and paving blocks. The vibrating table being used for production is common to both the technologies. The production capacity is dependent on the capability of investment to be made. The variable investment is from the number of moulds of frames and blocks. At present the investment cannot be calculated since the equipments are being imported from India. Once they are produced in Malawi then the actual investment can be calculated. However basic production cost calculated show that the RCC door and window frames are much cheaper than existing products.

6. STAKEHOLDER ANALYSIS

The housing and infrastructure sector in Malawi, the prime users of building and construction materials has a small set of direct stakeholders. The three main sets are the Government, the private sector and the home owners.

6.1. Government

The housing sector currently is dominated by the Government. Even with the advent of private players in the arena, the Malawi Housing Corporation remains the single largest player in housing development and construction. The government plays a largely regulatory role, with MHG taking on the execution responsibility. In the overall construction space however it occupies only a 10-20% share. Most residential construction is carried out by home owners themselves.

Agencies like TEVETA (Technical, Entrepreneurial and Vocational Education and Training Authority) are involved in capacity building and skill up gradation of masons and other construction workers.

While housing is apriority area for the government, there are no dedicated schemes or plans to meet the deficit or take the programme further. They recognize the need to introduce cleaner production technologies for building materials especially bricks due to the increasing pressure of natural resources like wood and timber. Thus the technology transfer programme proposal was met with a lot of encouragement from departments as diverse as Energy Affairs, Environmental Affairs and Housing.

However beyond just the technology transfer for production technologies, there is a need to work on policy level interventions to introduce codes and standards for the newly introduced materials. There is also needed a policy push to move away from the traditional low quality high energy building material towards cleaner low carbon options among the users.

6.2. Private Sector

The private sector in increasingly becoming an important part of the construction value chain in Malawi. Moving away from just being material or service providers, they are now taking on the role of developers.

Material and Service Providers

The building material market is completely dominated by the private sector. The important distinction here is between the formal and the informal sector. There are a few large companies that provide materials especially for roofing and flooring. However almost the entire walling and about 60% of the other product market is accounted for with the informal sector.

The informal sector has various scales of operation starting from a two member team having set up their enterprise on a busy highway. The largest concern with the informal sector is the quality of the product manufactured as there is no control over

material use and composition. In addition the process is completely manual introducing aspects of variability in the product range. Cement based products are manufactured without vibration or compaction severely impacting the quality.

This recognition is present among the entrepreneurs but they are unable to adopt mechanized production due to the lack of access to both information and technology. They however expressed interest in adopting simple mechanized devices is easily available. The barrier of access to finance however remains.

Also important are the construction service providers who use these materials. While adept at using the available materials and making the best of it, there is a server dearth of skilled labour who can take on new technology applications. Hence the need for capacity building and agencies like TEVETA is imperative.

Developers

Private developers are mushrooming in urban areas like Lilongwe and Blantyre. Moving away from the traditional housing practices of owner driver construction, they are providing already constructed homes. Majority of these however deal with higher to middle income groups. Public private partnerships enable the smooth functioning of these developers, with the government playing the role of a facilitator.

With respect to the materials and technologies used however, there is still a resistance to try out new innovations. While the transition from burnt bricks to concrete blocks for walling is being made, they are reluctant to experiment with roofing technologies. The only difference is the cost and quality of material used. For e.g. Harvey tiles will be used instead of corrugated sheets.

This is however a stakeholder group that is fast gaining influence in the sector and it is important to seed them with innovations at this time.

Financial Agencies

Access to finance is one of the largest barriers to industry in Malawi. This also applies to the construction sector. With interest rates exceeding 30%, it is difficult for entrepreneurs to invest capital in their businesses. In addition the risk taking ability of local entrepreneurs is not very high.

Most businesses in the country are owned by ex-pats who invest equity. This is not a luxury afforded to many local entrepreneurs. Thus in order to ensure the widespread adoption of new technologies among new entrepreneurs, it is imperative to improve access to finance.

6.3. Home Owners

The home owners play an important role in the sector as they are the largest consumers of building materials. However they have limited say in the quality and pricing of products. The options range between low cost-low quality and high cost-high quality products, often making quality affordable housing a dream. They unfortunately have very little say in this as the market is controlled from the supply

side. Introduction of new technologies and new players in the market will help the market grow and let the consumer have better decision control over their choices.

6.4. International Cooperation

Besides the Government of Malawi, there is also interest among the international multi and bi lateral community to work on the housing concerns in Malawi. A priority geography for many agencies, Malawi with its rapid urbanisation rate has incited interest in its housing and construction sector. This set of stakeholders is also responsible for introducing materials like SSBs and Concrete Blocks. However high costs of these materials keep most other users at bay.

7. POLICY IMPERATIVES

Most of the Government bodies in Malawi are well aware of the fact that the building material sector needs to change, especially the burnt brick sector. The major concerns expressed by most of the Government Departments visited are the use of wood and quality of the bricks being produced. In general it was felt that there is a strong knowledge gap between the current situation and the present technologies being adopted in other countries. Although a concern was raised with the use of coal in brick making (technical issues), however the same was mainly due to lack of knowledge about possibilities.

It was also pointed out that presently there is a growing interest by the private sector in investment in the building material sector especially in making eco-concrete products. However due to lack of technical support, the quality being produced are not upto national working standards. It was requested that quality control labs and capacity building be supported by India. This is especially for transferring knowledge and should be anchored within Malawian Universities and Technical Institutes.

It was also communicated that there was a move by the Cabinet, Government of Malawi on banning the use of wood in making of burnt clay bricks. However the major questions raised were the alternative options available that Malawi needs to adopt. Since no option was suitably presented, thus the ban was deferred. Thus there is a positive mindset in improving the industry. However adequate information and means should be made available by the civil societies and entrepreneurs working on introducing cleaner production technologies to provide an alternative to the current type of building material production.

In 2012 a proposal was submitted to the Cabinet to ban burnt clay bricks.

8. RECOMMENDATIONS

Based on the observations in the field and the interactions with stakeholders, the team recommends the adoption of some green building materials.

Summary of presently used building materials and alternatives suggested:

Sectors	Building materials presently used	Alternative proposed	Benefits
Roof	• Thatched materials • Metal sheet roof with false ceiling • Concrete flat roof • Tiled roof with false ceiling • Concrete sloping roof with decorative tiles	• Micro concrete roofs with and without false ceilings • Flat roof with filler materials • Planks and joists • Funicular shells	• Low cost, versatile, load bearing, easy to produce • Low construction time • Low material consumption • Durable and aesthetically pleasing
Wall	• Adode bricks • Burnt clay bricks fired in clamps • Stabilized soil blocks • Concrete Blocks	• Vertical Shaft Brick Kiln for burnt bricks • Mechanized Concrete Blocks	• Better quality of product • Less use of mortar • Durable and aesthetically pleasing
Frames	• Wood • Steel	• Reinforced Cement Concrete	• Durable as compared to wood • Less construction time but fits into existing practices • Less cost, easy to produce, versatile
Floor	• Skreed Concrete • Tiles • Pavers for roads	• Semi-mechanized medium and heavy duty pavers	• Low cost • Versatile and easy to produce • Durable and aesthetically pleasing

Roof

The aspiration of the home owner towards a tiled look is the major driver in this element. The lack of appropriate technology helps fuel the common perception of low quality in this technology option. Lack of adequate skill in installation and the monopoly of the steel industry are other barriers.

Technologies like the TARA MCR technology enable the local production of concrete tiles using cement and available stone dust to produce low cost, high quality aesthetically appealing roofing tiles. This is a technology that can be transferred profitably in the short term. Care however needs to be taken in simultaneously transferring skills needs to install the roof.

Malawi however is seeing a slow trend towards multiple storied structures. Sloping roofs will have to make way for flat roofs. In the medium term, options for precast flat roof construction options should be explored. There are available options like precast ferrocement members, planks and joists, etc. However, this needs a change in mindsets from the aesthetic appeal of the sloping roof as well as confidence and skill building in concrete based construction techniques.

Superstructure

The recognition of the low quality afforded by the existing burnt bricks and the excessive amounts of cement mortar required to compensate is the prime mover for the sector. The government supports a move away due to environmental considerations. New products like SSBs and concrete blocks provide evidence to this fact, they are however held back by the high costs.

The Vertical Shaft Brick Kiln (VSBK) is a great opportunity to overcome these barriers. There is a lot of traction from the Government of Malawi for the technology as well as interest expressed from entrepreneurs willing to invest in the technology. The large affordable housing market can absorb the supply very quickly, creating an existing market for the new product.

Concrete blocks also afford a lot of potential. There has been some informal technology transfer from neighbouring countries. Caution however to the quality of products manufactured.

For the frames, there is opportunity available in the precast RCC door and window frames. Manufactured on a vibrating table, they require little energy to produce a quality and affordable product. They offer a cost advantage over the steel and quality advantage over the wood frames while enabling livelihoods to be created through the units set up.

Floor

There are very few products available to cater to this housing element. However with increasing aspirations there is a market opening up. A Medium term option could be to look at cement based pavers and tiles. The availability of aggregate and stone dust make this an interesting opportunity.

Concrete products

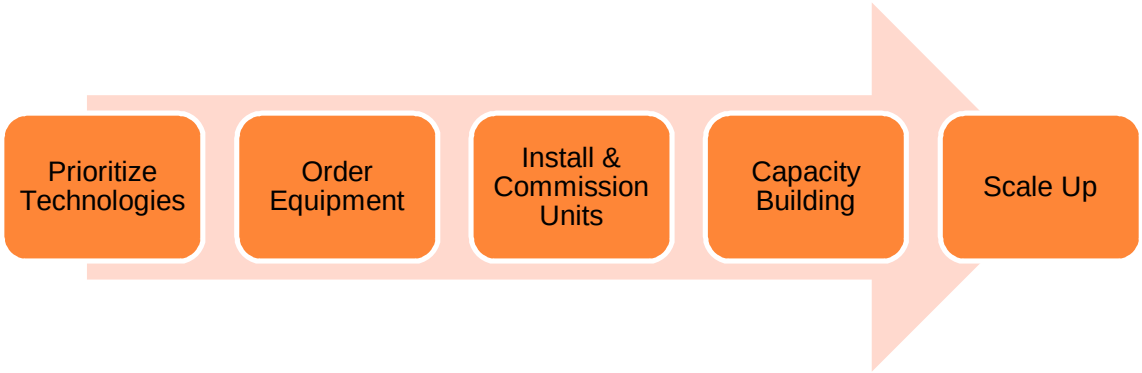
There is an increasing market for concrete products like window grills and sills, decorative elements, etc. This demand is currently being met by the informal sector with suspect quality parameters. The vibrating table affords the opportunity of diversifying the product portfolio to include other elements based on demand.

A summary of recommendations presents the following view

SHORT TERM	• VSBK • Precast Frames • MCR
MEDIUM TERM	• Concrete Pavers • Precast Roofs

9. WAY FORWARD

The increasing housing demand exerts pressure in the current building materials market both formal and informal. The formal market is small and cannot meet he demands of the people. The informal market has a cost and convenience advantage but suffers on account of quality due to the lack of mechanisation. There is a gap that small scale units can fill. There is very limited evidence of this happening as the entrepreneurial ecosystem is not well developed. Thus the technology transfer needs to be integrated with elements of capacity building and hand holding for the enterprises.



The next steps for the local partners becomes to prioritize technologies based on the feasibility study to enable the installation of pilot enterprises. These will then become demonstration grounds for further scale up.

Strengthening the Value Chain

While the current environment is conducive to the introduction of new technologies and the need for such transfer is ripe, this is just the beginning. The technology transfer programme is observing positive sings in terms of acceptance among the government and support from bi-lateral agencies. However, in order to achieve impact at scale it is important to tie up the technology transfer initiative with support particularly from the policy and finance end.

Policy support in the form of codes and regulations for new materials is one of the first steps in mainstreaming these technologies. Policy research also needs to explore and understand how these materials and technologies can be incentivized for the users through fiscal and regulatory measures. Till the market is mature enough to innovate, policy needs to provide support to new technologies and developments. This area currently lies in vacuum.

Another aspect is building capacities of local people to take on these technologies. This needs to be done at various levels ranging from establishing new entrepreneurs to workers at the enterprise as well as masons during construction. The lack of skilled workforce can be met through introducing vocational training courses. This skilled workforce is a key ingredient in promoting the technologies and achieving scale.

Finance as an enabler cannot be ignored. While the technology transfer has been met with positivity, the impact of the initiative will be seen only when more and more entrepreneurs adopt the technology. The current financial landscape defies this

movement. The lack of access of capital and the limited risk taking ability of locals is a deadly mix to retard the good progress the pilot has made. Thus it is important to seed and provide hand holding support to the first set of enterprises that will be created. There is a need to move beyond the first enterprise to create a critical mass of enterprises to demonstrate the potential for change both for the entrepreneur and the local economy.

A longer term support program is imperative to achieve scale and impact that the technology transfer pilot envisions. With the backdrop of these assumptions, we can chart a course of widespread impact in the lives of the local Malawi home owners and entrepreneurs.

10. TECHNOLOGY PROFILES

TARA EcoKiln

EcoKiln technology for highly energy efficient firing of clay bricks

TARA EcoKiln brick firing plant is certified as the world's most energy and fuel efficient firing system for clay bricks. TARA EcoKiln has modular construction with one or more rectangular shafts (in multiples of two) that can meet any capacity of brick production. TARA enterprises run two, four and six shaft EcoKiln with technology provided by TARA Machines.

TARA Machines provides a comprehensive package of services to its clients; soil testing, kiln design, construction, installation & commissioning, machine supply and training.

TARA EcoKiln Package Specifications

S. No.	Specifications	TARA EcoKiln
1	Production Capacity	10000 bricks/ day
2	Energy / fuel saving	Saving of upto 50%
3	Construction Period	With in 45 days
4	Manpower	30 operators
5	Electrical Power	15 KVA
6	Operation Period	240 days per year
	Accessories	
7	Screw jack	2 Nos.
8	Trolleys	4 Nos.
9	Conveyor system	1 Nos.

TARA EcoKiln, Balangir, Orissa

TARA BrickMek

Soft clay moulding technology for high quality green bricks

TARA BrickMek Moulding Machine is designed to optimize manpower while producing high quality bricks with good control on brick size and finish.

TARA Machines provides a service package which includes soil testing, custom designed moulds, nachines & accessories, machine commissioning & training of operators.

TARA BrickMek Package Specifications

S. No.	Specifications	TARA Brick-Mek
1	Rated Production Capacity	1440 bricks/ Hour
2	Electrical Power	3-phase (7.5+1 HP motors)
3	Brick moulds	24 nos. of Stainless Steel moulds
4	Mould Shifting Trolley	03 nos. (Manually operated)
5	Manpower	10 - 12 people
6	Feeding of Raw Material	Through conveyor (Optional)

TARA BrickMek in operation

Special Features:

- Premium on high quality bricks made with TARA Brick Mek Machine.
- Extended brick season due to uninterrupted moulding of green bricks.
- Fuel saving realized through consistent mixing of soil with carbon rich materials like sponge iron waste.
- Reliable operation and low maintenance.

TARA GreenCast Frames

Eco Concrete Technology for high quality concrete Door & Window Frames

TARA Green Cast Frames Technology provides a cutting edge solution for manufacturing of high quality, long lasting and affordable Concrete Door and Window Frames using reinforced cement concrete. The production system consists of specialized rubber moulds, which are placed inside a GI channels. A series of GI channels are mounted on the vibrating table; fitted with vibration mechanism to achieve uniform compaction and high quality surface finish. Two sets of door frames can be manufactured in every production cycle.

With a judicious investment in moulds, this technology offers flexibility in quantum as per local market requirement and option of other concrete products like GreenCast Floors.

TARA GreenCast Frames Package Specification

Specifications	TARA GreenCast Frames
Vibrating Table (L x W)	3.15 x 0.78 meter operated with 2HP, 2800 RPM, 3 Phase
Color Pan Mixer	150 kg / Charge operated with 3 HP, 1440 RPM, 3 Phase
Moulds	PVC Moulds in diverse range of interlocking shapes; choice of thickness for medium and decorative pavers
Production Capacity	1000 pavers / day
Manpower	5 - 6

TARA GreenCast Frames Machine

Door and Window Frames

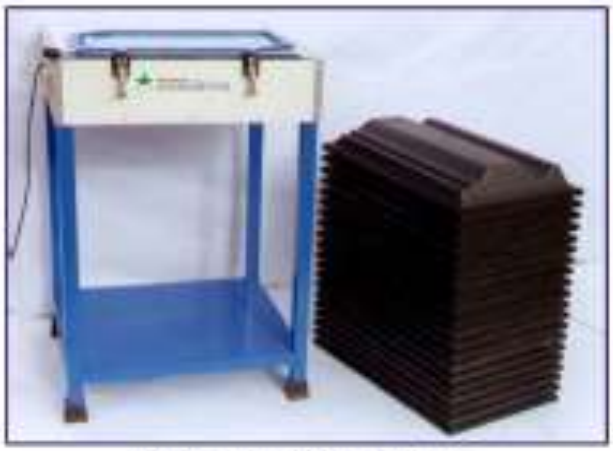
TARA Micron

Eco concrete technology for roofing tiles & decorative pavers

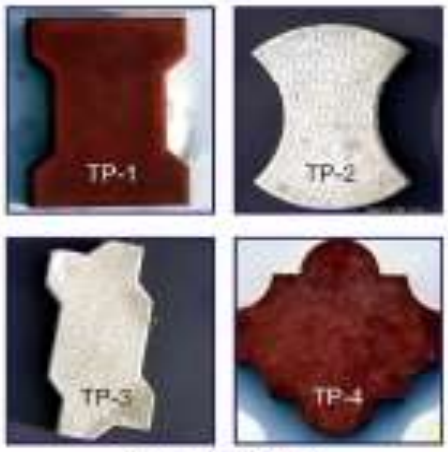
TARA Micron machine produces cost effective, aesthetic and durable roofing products. The technology drives highly profitable businesses in both rural and urban markets. The micro concrete tiles are made on the TARA Micron machine; suitable HIP moulds and a full set of accessories complete the technology package. Specialized rubber moulds for decorative pavers are also available.

TARA Micron Package Specifications

S. No.	Specifications	TARA Micron
1	Vibrating Table (L×W)	540 × 315 mm
2	Roof Tile Moulds	Pan / Roman HIP injection moulds
3	Decorative Paver Moulds	Various Types
4	Quality Assurance Tools	• Bending test jig • Alignment tool
5	Electrical Power	1/4 HP, Single Phase
6	Production Capacity	250 Tiles / Pavers per day
7	Manpower	3 - 4



TARA Mircon with tile moulds



Decorative Pavers