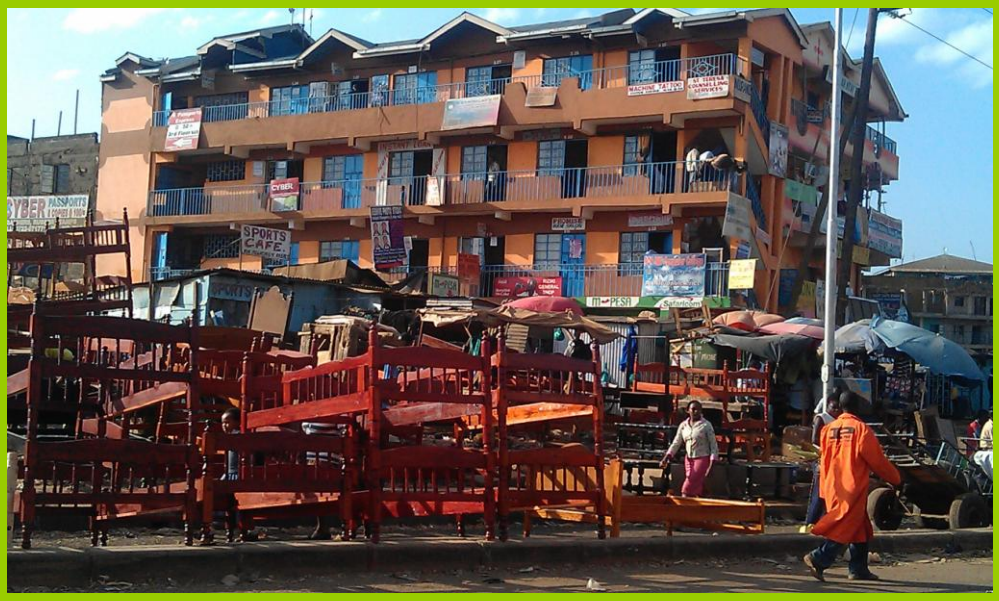
Addressing Climate Change with Low-Cost Green Housing



Final Report

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EXECUTIVE SUMMARY

The primary purpose of this report is to present findings from a rapid assessment of 'green affordable housing' conducted in Nairobi, Kenya between February and May 2012, including an intensive field visit to Nairobi. This effort should be viewed as *preparatory work* with the objective of promoting green technologies and materials in the housing sector to reduce the negative impact of the housing construction industry on the environment and climate change and make good quality environment-friendly housing more affordable to the average household.

The current report is, therefore, a summary of rapid assessment that seeks to:

- Identify green technologies' that exist in Kenya (or more broadly the SSA region) or can be developed, that are both economically viable and socially acceptable.
- Identify the challenges – technical, institutional, economic, financial, cultural or other – faced in getting affordable 'green' into the mainstream housing construction industry.
- Provide recommendations for reform and the development of supporting financial tools.
- Provide benchmarks for the cost of various materials and technology options.

In the context of this assessment the terms 'green' and 'affordable' were more clearly defined as follows:

- '*Green'*: During discussions 'green' was described in line with IFC's 20-20-20 approach, i.e. 20% reduction over the baseline in Carbon emissions, water & energy consumption.
- *'Affordable'*: Affordable was described in terms of what a 'modest income' household - defined as one with a monthly household income of 23,000-60,000 Kenyan Shillings (KSh) - would purchase.

Nairobi is growing rapidly and there is currently a lot of new housing being built in Nairobi and surrounding areas. However, as much as 80% of the people in Nairobi are in the 'modest income' group and unable to afford to buy anything currently on sale in the housing market. As a result a majority of people live within rented accommodation. The exact scale of the housing shortfall is not fully confirmed although it is in excess of 100,000 dwelling units per annum. Households in Nairobi pay a substantial proportion of their limited income for energy and water and often these are from unsustainable sources such as charcoal, diesel and paraffin.

Builders and developers in the region explain that they face a number of barriers which prevent them from being able to deliver housing in the affordable sector. These range from high costs and difficulties of obtaining land, low-cost credit and restrictive regulations that limit the use of alternative cheaper building material and maximize the development of expensive land due to zoning and bye-law restrictions. In 2007 Government of Kenya identified a set of incentives to encourage developers to enter the affordable/low-income housing sector but Developers say this has had little impact. It is widely believed that there is a dearth of low-cost appropriate technology in Kenya. This is not true as many countries in the region have taken up Kenyan developed technologies for decades to reduce the cost and environmental footprint of their buildings.

Meanwhile the current infrastructure boom in and around Nairobi is consuming enormous amounts of quarried stone, timber, and river sand. It is not clear how well—or if at all—the production and

supply chains for these commodities are being managed. Kenya has experienced a shortage of timber for many years. The forest cover has been severely depleted. So much so that today much of the timber used for construction is being imported from Tanzania, Uganda, and the Democratic Republic of Congo. The rapid development is also negatively impacting upon Kenya's natural heritage for instance the disruption of migratory routes and horticulture farms.

Our assessment identifies that substantial savings in cost, embodied Carbon, electricity and water consumption are possible in housing currently being built in Kenya making it more green and affordable:

- The current Nairobi climate is ideal for the design of energy efficient housing. A well-designed building i.e. orientation and careful position of openings and selecting building materials will minimise the requirement of lighting and heating in the house saving electricity or other fuels. Currently there is no need for any air-conditioning in Nairobi housing but it shouldn't be forgotten that unchecked construction and poor urban design can often result in higher than normal temperatures so people resort to energy consuming air-conditioning.
- The construction technology most prevalent in Nairobi for multi-dwelling housing is the reinforced cement concrete (RCC) frame with in-fill stone walls. The intermediary slabs, columns and roofing (constituting the structure of the building), door and window frames, and external/internal walls present the highest potential for savings in embodied energy i.e.: energy used in the production and transport of materials. The table below gives more details.

Building Component	Potential for savings in embodied energy and Carbon emissions
Structure (columns, intermediary slabs)	Potential is high. Field observations and discussion with local developers highlighted that many structures are over-specified, possibly to compensate for poor construction quality and supervision. Also leaner structures will be adequately suitable for domestic uses. Roofing and walling that is lighter in weight (as compared to current practice) will also enable the structure to be made leaner and reduce embodied Carbon.
Roofing	Potential is high. Lightweight alternatives are available in Kenya for roof covering and supporting under-structure.
Walling	Potential is high. Thinner and lighter walls (compared with current practice of using 200mm thick stone walls)
Door and Window Frames	Moderate to high potential. For instance by introducing wood-plastic frames and replacing steel [although currently these are all imported] Also people will be reluctant to do away entirely with steel bars and heavy doors for security reasons.
Boundary Walling	High potential. Nairobi has many examples of sturdy boundary fencing that uses robust green hedging that cannot be easily breached.

Building Component	Potential for savings in embodied energy and Carbon emissions
Foundations	Potential is high as over-specification of foundation is common in response to Black Cotton Soil (BCS) Another alternative will be to select sites carefully to minimize the weight and the huge expense of foundations.
Construction Waste	Potential is High. From current observations improved site management and better use of extracts from the site itself [soil, stone] into the construction will reduce embodied energy from transportation and disposal.

In meeting the 'green' targets here's a measure of what is possible from current observations:

	Possible Savings
Carbon	Optimised building specification and improved site management alone can save in excess of 20%.
Energy	Climate allows excellent energy efficient design. Using efficient appliances and fixtures, solar water heating along with optimised materials specification will reduce both embodied and operational energy consumption in excess of 20%.
Water	Using water saving fixtures (at no additional cost) will be sufficient to exceed the 20% savings target.

The advent of international firms as well as local housing co-operatives (who have more than a quarter of Kenyans as members) offer several valuable models to bring efficiency, competition and reduced transaction costs into housing. When combined with green technology and appropriate design specifications the possibilities for 'affordable green housing' will increase substantially.

We sensed considerable enthusiasm within the Ministry of Housing for the 'green affordable housing' initiative. The World Bank representative flagged that KISIP (particularly component 4) as suitable to accommodate further initiatives on 'affordable green housing' related efforts.

With general elections looming in late 2012 or early 2013 the political and institutional landscaping may change in the near future. This can bring considerable opportunity. Affordable green housing is an issue for more than 80% of the population in Kenya and carries substantial democratic weight considering the rapid rise in the costs of utilities. With this in mind any forthcoming changes to the structure and mandate of Ministry of Housing and Ministry of Public Works should be seen as an opportunity to improve the status and acceptability of alternative building technologies, optimised space standards and access to land.

1. OVERVIEW

1.1 The primary purpose of this report is to present findings from a rapid assessment of 'green affordable housing' conducted in Nairobi, Kenya between February and May 2012, including an intensive field visit to Nairobi. This effort should be viewed as *preparatory work* with the objective of promoting green technologies and materials in the housing sector to:

- reduce the negative impact of the housing construction industry on the environment and climate change, and
- make good quality environment-friendly housing more affordable to the average household.

1.2 This preparatory work will likely contribute to a guidance document for future activities in the 'green affordable housing' sector for Kenya (see *Terms of Reference* - Appendix 4). The current report is, therefore, a summary of rapid assessment that seeks to:

- Identify green technologies' that exist in Kenya (or more broadly the SSA region) or can be developed, that are both economically viable and socially acceptable.

- Identify the challenges – technical, institutional, economic, financial, cultural or other - faced in getting affordable 'green' into the mainstream housing construction industry.

- Provide recommendations for reform and the development of supporting financial tools.

- Provide benchmarks for the cost of various materials and technology options.

- Recommend immediate next steps.

2. APPROACH & PROGRESS

2.1 The assessment is being carried out through consultation and desk-review using the field visit as an opportunity to identify 'as-built' examples that can set the benchmark for cost and carbon/energy/water abatement analysis and other detailed work that may need to be carried out in the future. The assessment included the following:

- *Desk-review* – review of existing documentation and 'obvious' literature; identification of key stakeholders (local, regional and international).
- *Stakeholder Interviews* – semi-structured discussions with an exhaustive list of stakeholders [including but not limited to Ministry of Housing; Housing developers; Housing financiers; Professional bodies; UN/World Bank; Material Suppliers]. See *Appendix 3* for people consulted during the visit.
- *Project-visits:* site visits to 4-5 projects identified through desk-review and stakeholder referrals. See *Appendix 2* for sites visited.
- *Observations and recommendations*

Further, the terms 'green' and 'affordable' were more clearly defined in the context of this housing assessment in Kenya:

- *Definition of 'Green'*: During discussions 'green' was described in line with IFC's 20-20-20 approach, i.e. 20% reduction over the baseline in Carbon emissions, water & energy consumption.
- *Definition of 'Affordable'*: Affordable was described in terms of what a 'modest income' household - defined as one with a monthly household income of 23,000-60,000 Kenyan Shillings (KSh) - would purchase.

3. OBSERVATIONS

Introduction

The following observations and recommendations are made after an exhaustive series of interviews with government officials, financiers, materials manufacturers, developers, contractors and home owners. The interviews were followed up with several site visits to verify the information gathered.



Images 1 (Left to Right): (L) Urban sprawl is characteristic of Nairobi's current growth with development extending along all major roads going out of Nairobi. The spread of real estate is clearly and rapidly impacting the natural environment, and also transforming livelihoods and land-uses such as agriculture. In many instances, new roads have split historic migratory routes for Kenya's wildlife which brings the country its vital tourism dollars. (M) There is a lot of housing being built in Nairobi and surrounding areas. However according to NACHU,[1] as much as 80% of the people in Nairobi are in the 'modest income' group and unable to afford to buy anything currently on sale in the housing market. This document does not report on the exact scale of the housing shortfall, although a figure of 150,000 per annum appears recurrently in publications. (R) On first observation, it appears that many of the newly constructed buildings across Nairobi could be easily built more cost-effectively by avoiding wasteful design, construction, operations and maintenance. Further, there is extensive potential to bring about significant savings in maintenance and operations through more efficient design.

Overview

Nairobi as a city has many commercial developments with internationally acceptable design and construction standards. However, behind this impressive façade also lies an enormous industry that has a vast potential to improve across all its constituent components: design, engineering, construction, day-to-day usage and maintenance. Nairobi's situation is generally mirrored across Kenya's other major urban centres.[2]

By far the biggest consumers of construction materials are the thousands of Kenyan households who are either incrementally building new homes or extending and improving their existing homes.[3] For this, they invariably employ poorly qualified draughtsman to act as architect, engineer and project coordinator, or rely on a family artisan (*fundi*) to provide technical knowledge in design and choice of material.

Based on the information gathered from the interviews, lack of building quality control is a matter of significant concern as it is possible to avoid adherence to building regulations and standards. Current construction standards, particularly with reference to the average house being constructed in the city, appear to be out-of-date.[4]

[1] NACHU – National Association of Co-operative Housing Unions

[2] Various Discussions and own observations of ongoing design and construction.

[3] Discussion with Bamburi cement (LaFarge Group) on their core customers.

[4] The discussions pointed out that the city building codes are based on extremely high design specifications, which are adhered to without regard to cost-effectiveness or value for money. This conflicts with infrastructure shortfall in many sectors including housing and education where maximum amount of infrastructure needs to be provided cost-effectively.

This apparent ad-hoc manner of developing the cities' infrastructure specially the housing market, both on the commercial and individual housing developments, is not sustainable with respect to the environment. The current enormous take-up of land in and around Nairobi for real-estate development seems to be having detrimental effects on the long established economies such as small farms and agriculture i.e. coffee growing or horticulture. The implementation of sustainable physical planning measures appears amiss and is discussed further in this report in detail.

This issue of environmental sustainability - or lack thereof - assumes even more importance in Kenya in light of the fact that the country has developed and proven the viability of several alternative construction materials that have been tested over several decades. And while neighbouring countries[5] have willingly embraced these technologies from Kenya, there has ironically not been much uptake of these methods and systems in the more recent - and on-going - upsurge in construction practice in Kenya.

From the point of view of building energy efficient into construction, Nairobi has two inherent advantages: one, good location (close to equator) and altitude that creates a climate highly suitable for energy efficient buildings. This is evident from the fact that mechanical air-conditioning in Nairobi is largely confined to big commercial complexes. Few, if any, homes require or have such facilities. However, the rapid disappearance of greenery in the city and concretization of its open spaces are having a detrimental effect on the micro-climate. With this trend, it is likely that within ten years air-conditioning may become the norm owing to the heat-island effect.

A variety of energy sources are used in a typical Nairobi household, ranging from charcoal (for heating water, and cooking), paraffin (for lighting, heating water, cooking), diesel (for generators), and grid-electricity (for heating water, cooking, lighting and appliances). The substantial cost of energy poses a real cost constraint to most resident households.

Many zero-cost and low-cost measures[6] are equally applicable to Nairobi's construction practices to reduce (embodied) carbon, energy and water consumption by 20% or more from current (baseline) levels. As mentioned earlier, since buildings do not require mechanical air-conditioning, the energy used for the operation of buildings - in particular, housing - is minimal. It is the embodied energy within building materials that is of greater concern, given that most conventional materials are characterized by intensive energy consumption during the production process, and for their transportation. This is further exacerbated by the over specification of building materials and substantial construction waste observed during the field visit.

[5] For instance widespread use of Cement Stabilised Mud Blocks in Malawi entirely using Kenyan training skills and technology.
[6] See Appendix 6: Cost effective measures identified in India study.



Images 2 (Left to Right): (L) Nearly all buildings in Nairobi now use stone from the local quarries as the main walling material. Cheaper/more environment friendly alternatives are available but not widely known or accepted. Stone is the preferred material of choice because it is readily available, approved within building regulations, and seen as synonymous with a high standard of living and 'secure' walling material protecting the building user from intrusion. However, given the pace at which stone is being used, it is likely to run out eventually. (M) Charcoal and paraffin are the preferred fuel to heat water and cook in Nairobi households. Often the modest income groups spend a substantial part of their income in domestic energy consumption. (R) Nairobi's existing water supply comes predominantly from bore wells; rapid urbanization is already adversely impacting ground water availability. In developments further outside of the city, water availability is highly dependent on the use of expensive fuel (diesel for instance) for pumping as well as transporting water using pick-up trucks.

3.1 BUILDING TECHNOLOGY ISSUES

Social acceptability of materials

The social acceptability of alternative materials particularly centres around their suitability for house walling, openings and overall boundary security. Security and a robust aesthetic are of high significance in urban housing. They embody several established social values such as modernity, social status, need for security against intruders. As a result many desirable Nairobi developments are characterized by high boundary walls, electric fencing in some instances, security guards, steel barriers in openings and heavy walling material predominantly stone.

Take walling material, for instance. Stabilised Soil Block (SSB) technology, originally developed in Kenya, is a popular material of choice for walls in East Africa (Malawi, Southern Sudan, Darfur, Uganda). In contrast, SSB has struggled to find a foothold in Kenya despite being successfully tested in several buildings. This is because of several reasons:

- The average Kenyan remains extremely conservative when selecting materials from which to build the family home.
- There is also no evidence of mainstream architects using or promoting any form of alternative or 'green' walling materials.
- The social mind set remains firmly fixed on 200mm thick quarried stone walling even though a 150mm thickness will be sufficient in most cases. A saving of 25% (material and embodied carbon is obvious here but social barriers override the economic or energy savings.

Developers appear to be open to the possibility of using the SSB technology. It has also now been taken up as one of the select technologies by Ministry of Housing's (MoH) alternative technology programme. MoH has recently made significant investment in procuring 130 'HydroForm' SSB presses from South Africa. These are more expensive than the locally manufactured 'Makiga' presses. This is difficult to understand as neighbouring countries, Malawi, Uganda, Sudan and South Sudan have purchased the Kenyan equipment in their thousands. Currently, the 'Hydroform'

machines are made available to individual home builders free of cost. Unfortunately, there is little technical support provided on their usage (appropriate design, for example) or in the preparation of the raw material (the mix, proportions etc.); this runs the risk of the material being used improperly, and its reputation being compromised. For instance, 'green' minded home builders are constructing their homes using designs and specifications geared to stone or concrete block construction, without adapting them to SSB. This poses a high risk in terms of the stability of the structure.

Preliminary Alternative Technology Possibilities

The construction technology most prevalent in Nairobi is the reinforced cement concrete (RCC) frame with in-fill walls, which also used globally. The intermediary slabs, columns and roofing (constituting the structure of the building), door and window frames, and external/internal walls - largely made of RCC - present the highest potential for savings in embodied energy. The reasons for this are indicated in the table below:

Building Component	Potential for savings in embodied energy
Structure (columns, intermediary slabs)	Potential is high. Field observations and discussion with local developers highlighted that many structures are overs-specified, possibly to compensate for poor construction quality. Also leaner structures will be adequately suitable for domestic uses. Roofing and walling that is lighter in weight (as compared to current practice) will also allow enable the structure to be made leaner and reduce embodied Carbon.
Roofing	Potential is high. Lightweight alternatives are available in Kenya for roofing and supporting under-structure structure.
Walling	Potential is high. Thinner and lighter walls (compared with current practice of using 200mm thick stone walls)
Door and Window Frames	Moderate to high potential. For instance by introducing wood-plastic frames and replacing steel [although currently these are all imported] Also people will be reluctant to do away entirely with steel bars and heavy doors for security reasons.
Boundary Walling	High potential. Nairobi has several examples of sturdy boundary fencing that uses robust hedging that cannot be cut through with ease.
Foundations	Potential is high as over-specification of foundation is common in response to Black Cotton Soil (BCS) Another alternative will be to select sites carefully to minimize the weight and the huge expense[7] of foundations.
Construction Waste	Potential is High. From current observations improved site management and better use of extracts from the site itself [soil, stone] into the construction will reduce embodied energy from transportation and disposal.

Hollow concrete blocks, quarry dust cement blocks, Stabilised Soil Blocks (SSB) and rammed earth walling systems are likely to perform extremely well on the carbon savings index, potentially making

[7] From the study of the RUIRU project Bills of Quantities we know that site works and foundations can be 40-50% of the whole construction cost including safe disposal of BCS to designated sites.

significant savings over the predominant quarried stone walling. However, all such technologies would require concerted interventions for acceptability and scale-up. All mentioned technologies have been around for years, but have been generally confined to select low-cost social infrastructure projects. CSSB for instance, has already been approved by the Kenyan Bureau of Standards for the last twenty-years but is still totally ignored and in some instances actively discouraged by official departments[8].

Kenyan buildings generally utilise corrugated iron for roofing. Improved production methods and newer specifications of this material (such as stone/sand coated light gauge sheets) are currently making it acceptable to the high-end commercial market and replacing heavy clay tiles. The new roof covering is aesthetically pleasing and light weight thus enabling small profile roof frame (trusses) to be used, greatly reducing the required timber. However these are imported. Greater usage of light-weight roofing insulation would significantly improve the thermal comfort of users. Currently fabricated steel and glass windows predominate but PVC and plastic windows, doors and frames are gaining in popularity but as yet these are all imported into the country. In comparison to steel doors/window frames however these may be preferred (social acceptability permitting) as steel is imported as well.

Kenya is a net importer of construction timber. However, virtually all roofing supports constitute large sections i.e. 200mmx50mm and 100mmx50mm. Few, if any, construction professionals are exploring the possibility of using smaller section timber frames, or the alternatively, the use of angle-iron roof frames.[9]

Images 3 (Left to Right): (L) New lightweight sheeting is replacing heavier clay tiles and the need for heavier trusses in wood or steel. Although smaller sections are still not being used in the understructure. (M) Door and window frames continue to be in steel with bars to safeguard from theft. The need to feel secure forms an important part of the design, construction and operations of buildings. While it may be hard to persuade people to do away with these entirely some robust alternatives are available such as the green hedge fencing seen all across Nairobi which is extremely difficult to cut through. (R) Another key problem with Nairobi sites is the enormous expenditure involved in preparing sites with black cotton soil (BCS) and its disposal once the construction has started. Preparing ground and foundations can sometimes cost more than the superstructure, in many instances up to 40-50% of the overall construction cost (excluding siteworks). Mounds of BCS can be found all over Nairobi just abandoned or awaiting suitable disposal. On smaller sites, the stone underneath can be utilized for foundation and walling material with potential savings for construction purposes saving both fuel and transport costs.

Lower Cost options

In addition to the technologies identified above, a number of cost neutral initiatives are also applicable in Nairobi's context.

[8] As previously mentioned there is now renewed interest though. Ministry of Housing ABMT programme does recognise and promote many of these materials on developments across Kenya. These programmes will be more effective and sustainable with suitable technical support.

[9] In one instance, within a NACHU development in RUIRU, light gauge sections supported lightweight roofing sheets which is a step in the right direction.

- Rationalised designs (including passive design – site planning, building orientation, and so on) can provide energy savings and higher levels of thermal comfort ... passive solar features and design for thermal comfort, day lighting and natural ventilation would all contribute to the carbon savings index.
- Good oversight and enforcement of engineering standards, and enhanced quality assurance during the construction process would significantly reduce the usage and cost of fuel, steel, cement, aggregate, and their associated transportation costs.
- Greater usage of rain-water harvesting systems, re- cycling of 'grey' water and water-efficient fixtures would all reduce water consumption.
- Like-wise energy-efficient house-hold equipment and fixtures would reduce the growing call-down on energy supplies.

Solar water heaters – Are currently approximately five times the cost of conventional electric water heaters (immersion/*geysers*) but have an expected payback period of approximately 8-10 years. As hot water consumption is low, more effort to popularise smaller low-cost solar water heaters would significantly reduce the indiscriminate cutting of trees to make charcoal which is used to heat water.

Environmental Impact Interventions

Stone & Timber: The current infrastructure boom in and around Nairobi is consuming enormous amounts of quarried stone, timber, and river sand. It is not clear how well—or if at all—the production and supply chains for these commodities are being managed. Kenya has experienced a shortage of timber for many years. The forest cover has been severely depleted. So much so that today much of the timber used for construction is being imported from Tanzania, Uganda, and the Democratic Republic of Congo.

There is clear visual evidence that dust created by the stone quarries located in the northern environs of Nairobi is damaging the surrounding agricultural activities especially the coffee plantations. Furthermore, as the stone is extracted from the ground large quarries are being formed. It is not clear as to how these will be managed when the stone deposits are depleted.

Sand: A constant stream of poorly maintained trucks transport river sand from the Machakos district east of Nairobi. The Nairobi based construction industry is reliant on sand being transported from the Machokos district, some 60 kilometres north-east of the city. The current mass extraction and the condition of the fleets of poorly maintained trucks transporting the material is cause for considerable environmental concern. As such this practice requires tight control.

Much of Nairobi sits on 'black-cotton' soil, which is notorious for its high clay content, which causes excessive shrinkage during periods of drought, and swelling during the wet seasons. The variances between contraction and expansion are often great enough to cause serious structural damage to the buildings. Developers typically strip this poor soil prior to commencing construction. The extracted poor soil is being dumped on vacant plots around the city. Unless this practice is managed then Nairobi is going to inherit enormous problems in the future i.e. BCS will not absorb heavy rainfalls. Stockpiling of large amounts of BCS along major roads can, during the rainy seasons, be the cause of major flooding. Furthermore, for much of the year, quite strong winds blow through the region. This will constantly carry clouds of the small granules of dry BCS into the housing estates causing health problems i.e. respiratory and eye issues.

Audit on comparative cost of technology reduced specifications

In March 2012[10] estimates were developed on construction costs in Nairobi comparing various technologies. Below is a comparison of costs for various 150mm thick walling options for a single storey two-bedroom house with a floor area of 70 m2 built with concrete foundations, concrete floor, 30 gauge roofing sheets on timber frames, steel and glass doors and windows. Price includes transport and labour. The general finish is in line with what the majority of mid to low income earners would aspire to.

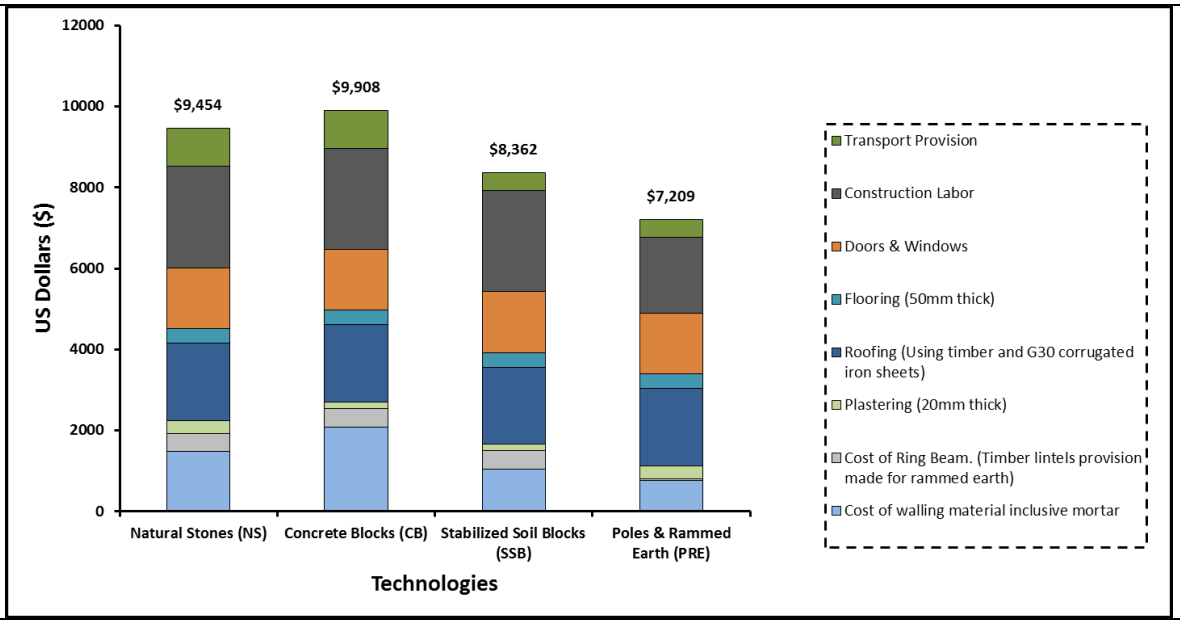

Figure 1 (above) Comparison of costs using different walling technologies - 150mm thick walls are compared. Most Nairobi buildings use 200mm thick walls so savings can be as high as 37%. Multi-story urban walkups are coming out to a higher range of 200-400 USD/sq.m. Amongst these the buildings built recently by Chinese contractors come out the cheapest.

Given the large geographic spread and geological diversity of Kenya in general it is a difficult task to provide 100% accurate costs for any form of physical infrastructure without doing site specific planning and costing which is not feasible under current scope.

As observed before not only are certain technologies cheaper, there is tremendous scope for optimizing the specifications. While PWD currently does not accept alternatives easily, there are already examples within Kenya (such as Ministry of Education school infrastructure programme) that has deployed optimized specification for foundations, roofs, walling to make it possible for a large number of buildings to be built at lower cost without compromising health and safety standards.

Over-specification comes not just in the form of quantities of building material used but also in terms of space standards. In Nairobi, a typical 2-bedroom dwelling could be in excess of 100 sq.m. a generous allowance of space which is likely to shrink as pressure on land and demand for housing in Nairobi goes up.

[10] Costs based on discussion with COMAC a Building Construction Management and Consulting agency specialising in cost-effective construction technologies. They are based in Nairobi and have worked on infrastructure projects in Darfur, South Sudan and Malawi for clients including USAID and UN Habitat.

Cost savings from alternative construction procurement

Modest income housing can benefit from exploring alternative models of procurement and construction management. Organizations such as Habitat for Humanity have been known to deploy 'sweat equity' in keeping construction costs within budget. There is also evidence from work in India and SSA that community-led monitoring (with training) can result in minimizing wastefulness during the construction process savings can be as high as 15-20% of the construction budget. Similar work is being undertaken in Ghana to make housing investments viable through reduced specifications and minimizing construction waste.

The predominant PWD implementation process relies on the projects being implemented through National Competitive Bidding (NCB) which means Full Contracting procedures with the contractor providing all labour and materials. Prices for such contract systems are determined through the 'District Term Contract' rates. These generally inflate the price of materials by as much as 30 to 45%. Also as the contract process is opened to Nationally-based contractors these add considerable overheads to their 'competitive' bids as they are aware that they will only be bidding against other Nationally-registered contractors. Overall, such a system inflates the cost of physical infrastructure by as much as 2 or even 2.5 times.

Our discussions with developers revealed that their suppliers and contractors realize the importance of competitive pricing. They are also learning from management practice(s) from Chinese firms operating in Nairobi and have managed to lower the costs of delivery down. Some developers believe competition is good for the Kenyan developers market with a view to reducing cost.

A third model is the community-based model. In Kenya the Ministry of Education (MoE) has developed a system of providing (educational) infrastructure through 'Community Contracting'. Briefly, this means that selected communities, with guidance from MoE, prepares their 5-Year Infrastructure Development Plan. When this is approved by MoE a series of annual School Infrastructure Improvement Grants are disbursed directly into the school's bank account. Then, the school and community, through a competitive tendering process, employ a local contractor and procure all required materials at market rates. They supervise and quality control the construction process until project completion, and MoE provides technical support through specially prepared manuals and specialist technical support through recognised GoK departments. Costs can be as low as half of the PWD procurement system.

Climate, user comfort and building design

The current Nairobi climate is ideal for the design of energy efficient housing. A psychometric chart (below) modelled for Nairobi weather demonstrates minimal requirement for mechanical methods of cooling or heating. A well-designed building i.e. careful position of openings and selecting building materials will minimise the requirement of lighting and heating in the house using electricity or other fuels.

Further, modelling demonstrates that by reducing the thickness of walls (down to 150mm) from currently practiced 200mm, and adding lightweight insulation will enhance user comfort during lower temperatures. This will bring about:

- reduction in embodied energy from the reduction in building material utilized
- reduction in operational energy for heating domestic spaces in cooler weather

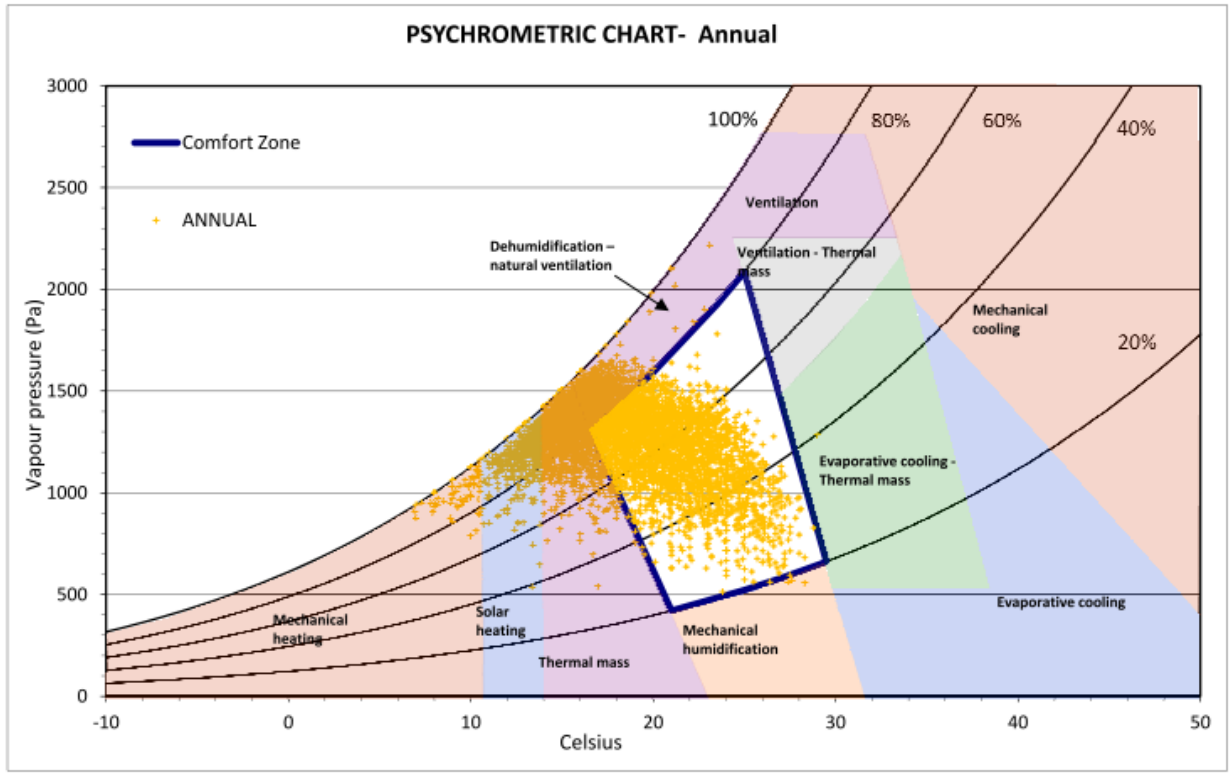

Figure 2: A psychometric chart[11] modelled for Nairobi weather identifying thermal mass and solar heating as the key measures that will improve comfort for users.

Benchmarking

The consultants visited a number of housing sites that may be used for benchmarking future work on affordable green housing in the Nairobi region. Where possible data on construction costs was obtained or noted for these sites.

Images 4 (Clockwise from top left): Great wall housing – Beijing Road/ Mombasa Road; High-rise Tenements – Manyaja Road; NACHU housing – Ruiru; Private house - Syokimau; Greenspan housing - Donholm; NACHU housing - Mlolongo.

[11] A graph each point of which represents a specific conditions in a location with regard to temperature (horizontal scale) and absolute humidity (vertical scale); other characteristics of the weather system that determine the comfort levels of people, such as relative humidity, wet bulb temperature, and latent heat of vaporization, are indicated by curved lines on the Psychrometric Chart. It is used to plot and assess the annual hourly weather conditions of a location. Once plotted it is easier to estimate what design interventions in the building will enhance the comfort of people using it.

3.2 FINANCE & STAKEHOLDER ISSUES

Affordability amongst the modest income group in Kenya

According to NACHU 80% of the Nairobi's households are in a 'modest' income group, earning between 23,000-60,000 KSh per month (excluding subsistence from small farm or poultry). In order to get a measure of typical household spending some families in the modest and low income range were interviewed as part of this study. This is valuable information that sheds light on the amount of disposable income and the affordability levels of these households with respect to housing. [To provide some context, the cheapest 2-bedroom dwelling currently on the market is priced at 3.5-4.5 million KSh.]

Its fair to say that a majority of people live in rental housing with rentals varying from 11,000-25,000 KSh per month[12] (excluding transport and utilities) From field visit discussions we understand that currently there is a considerable amount of rentable accommodation within the affordable market place. Up to seven storey buildings with rentable accommodation are visible throughout the city. But it was difficult to ascertain the actual numbers of units or the rent bands.

The modest income[13] group spends a majority of their income on groceries, rent and utilities often paying even more for services (per unit) like water and energy than wealthier families.[14] Accordingly, any savings in energy and water will make a substantial difference to their quality of life, and potentially also contribute towards housing affordability.

NACHU provide 'Nyumba' (or building) loans to many of their 10 million members across Kenya. Although they offer loans upto KSh 2.5 million, a typical loan is about KSh 1.25 million with a repayment period of 5-10 years. This gives a measure of the loans that typically people will be able to afford. The repayment is about 20-22,000 KSh per month[15]. In comparison, if a family were to take out a loan at commercial rate[16] in order to purchase the cheapest 2-bed house currently known to be selling on market they will be required to pay in the region of 63,000 KSh per month. Such repayments will be above the capacity of any modest income family to repay. [As illustrated in Fig. 3 below]

[12] Renting rooms can vary from 1,000 to 15,000 Ksh per month.
[13] Discussion with NACHU.
[14] We captured some illustrations of monthly spending by talking to typical modest and low income families. Again this needs to be verified. Currently the opportunity is to set this within the household surveys.
[15] At 13% interest rate on a loan of 1.25 m KSh over a 10-year term. It is not possible to establish at this point in time if NACHU loans are backed up by a subsidy. This will require further detailed investigation of their model.
[16] At 22% assuming 10% deposit

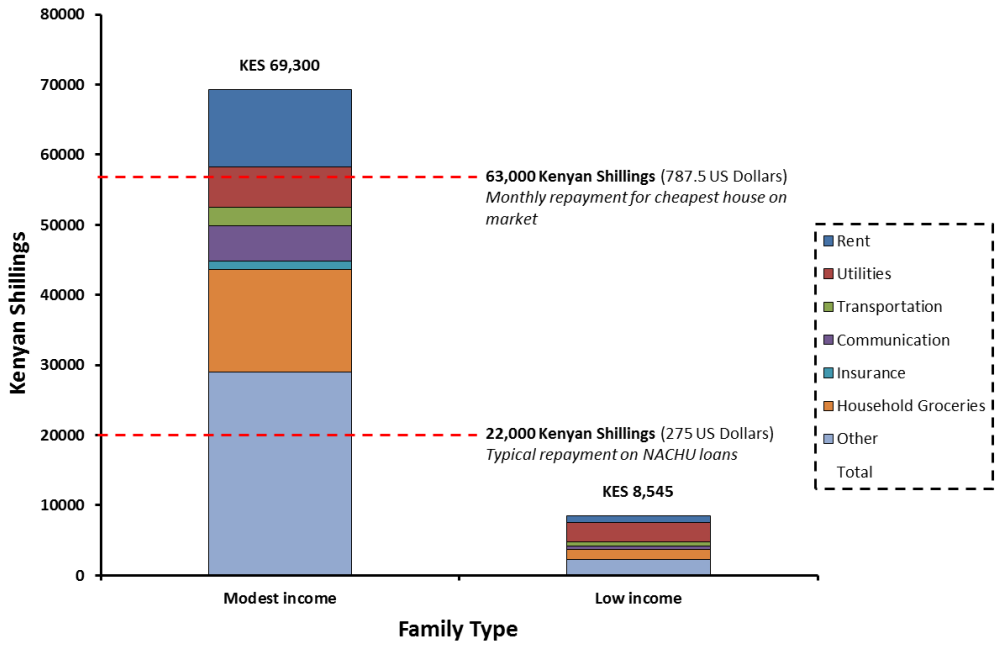

Figure 3 illustrates estimated monthly Expenditure by low income and modest income families including their monthly rents. The monthly repayments of 63,000 Ksh to purchase the cheapest 2-Bed currently on the market selling at 4.5 million KSh will be well beyond the ability of a typical modest income family. The figure also provides a comparison with 22,000 Ksh monthly repayment (on a 1.25 million KSh loan) that NACHU members can typically afford to pay each month against a loan for housebuilding or house improvements.

Housing Developers issues, incentives and opportunities

Housing developers interviewed during this study expressed concern on the volatility of land prices, construction, borrowing and bureaucratic procedures, but are willing to enter the affordable housing market if steps are taken to address some of these issues. Moving forward, the prospects of a broader market base, savings in development costs, and avoiding penalties resulting from environmental problems in the future appear to be appealing to them. Currently, they view the environment as an opportunity to position themselves favourably in the market as 'green developers'. Although among those interviewed, most were not aware of Kenya's commitment towards 'UNFCCC article 6'[17] and the resulting compliance requirements they will have to deal with in the very near future as this regulation comes into effect as the true extent of water, energy and environmental impact from housing becomes widely appreciated by NEMA[18].

Based on discussions with developers, these estimated ratio of cost of building construction to cost of on-site infrastructure and land to profit margins is in the region of 2.5:1:1 for a typical dwelling costing 4.5 million KSh. This opens up several possibilities to explore measures in each of these three areas could affect the overall cost of such a dwelling unit.

In order to address developers' issues and remove barriers to their entry into the low-income (or possibly modest income) housing sector, MoH proposed a series of incentives in January 2007. MoH proposed five clusters of incentives for infrastructure development:

[17] UN convention on climate change. The objective of Article 6 is to join the international community in combating the problem of climate change in the stabilization of greenhouse gases in the atmosphere at a level that will prevent dangerous anthropogenic interference with the climate system.
[18] Co-ordinates climate change mitigation/ adaptation strategy in Kenya.

- budget allocation for infrastructure through public and private partnerships,
- concessions to foreign investors,
- a 10-year tax holidays for developers for projects with a minimum 100 housing units,
- an investment deduction on investment in new technologies, and
- tax deductions for expenditure on social infrastructure.

The incentives were all expected to be implemented in the financial year 2007/2008 and required action from the Ministry of Finance (MoF), Ministry of Housing and, in some cases, local authorities and private sector bodies. In 2007, these initiatives were widely advertised by GoK and external agencies. UN-HABITAT reported on the pledges made by GoK during their 21st session of the Governing Council (UN- HABITAT, 2007). However, during the UN-HABITAT 22nd session inaugural speech, the Kenyan Vice President acknowledged that the implementation of incentives 'has been much slower than anticipated' but they 'hope to get there soon' (UN-HABITAT, 2009, p9). A major barrier to implementation of incentives has been the slow response of GoK Ministries.

The slow pace at which GoK has been implementing the incentives is further evidenced by their annual sector reports produced by the MoF. A physical infrastructure report released in 2010 (MoF, 2010) states that emerging issues in the housing sector are lack of comprehensive legislation, inadequate public and private sector investments, high cost of building materials, and low level funding by government for housing development. The housing incentives proposed in 2007 were meant to address these challenges but clearly the one-year time frame, as well as the large number of activities to be undertaken for implementation, was too ambitious. All Africa, a news website, comments that from the 2007 proposals, only token incentives have been implemented (Ayieko, 2012). Private developers have told government that the incentives provided so far have been inadequate in supporting development in the affordable housing market.

In the 2011 and 2012 MoF reports, again, the major challenges are lack of housing sector legislation, low government funding and high material cost, as well as the lack of appropriate building material and technology. One possible reason is the lack of staffing, in particular at local government level, as the 2011 report suggests.

These reports paint a picture of well-intended policy faced poor implementation and management. The Kenyan Joint Assistance Strategy (USAID, 2007) identifies lack of institutional capacity as a major constraint for Kenya. Whilst Kenya has a large number of highly trained and qualified civil servants, the overall effectiveness is limited by years of mismanagement and weak communication between government ministries leading to considerable delays in programme implementation.

The long delays in implementation have also affected housing developers looking to introduce new lost cost technology. Makiga Engineering Services manufactures machinery that produces Stabilised Soil Blocks and Micro Concrete Roof Tiles, both of which are building materials which are low cost and utilise local site materials. Research at Kyoto University, Japan, suggests that this technology could reduce housing cost[19] (Karani, 2010). However, Makiga is facing challenges in using this material in Kenya because it is cheap and as a result perceived as not up to standard for urban use. Its machinery is widely used in other African countries notably on UN and USAID funded projects. In 2010, Makiga was still lobbying for change to building codes so their products can be used in urban areas.

[19] A specific number is not given but we know from field visit that up to 40% cost reduction is possible as compared to standard 200mm thick stone walling.

It seems that the incentives introduced in by GoK in 2007 to promote development of affordable housing are still very much the means by which the government believes they can encourage the development of infrastructure. The *Appropriate Building Material and Technology programme* mandated to research and advise the MoH on the viability and effectiveness of alternative construction materials and championed by the Ministry of Housing in 2012 is an extension of this. Clearly (as observed in section 3.1) low cost/green interventions in the construction industry is not a barrier for developers as plenty of proven choice is available.

Housing co-operatives and savings groups in Kenya

NACHU is a Kenyan institution for all housing co-operatives in Kenya. Established in 1979 as a one-stop shop to provide training, technical and financial services for Kenyans for shelter and livelihood improvement, its membership is now an impressive 10 million persons (a quarter of Kenya's population) many of whom are from the modest, middle and low income groups. NACHU is surprisingly featured very little in the literature on Affordable Housing in Kenya, but its significance and potential as a major player in the affordable housing sector needs to be recognized.

NACHU, through partnership with S&L[20], offers affordable housing loans to its members for housing construction and improvements of up to 2.5 million KSh (see table below for typical borrowing profile). We understand from discussion that the loan default rate is less than 3%. It offers insurance, technical support and supervision on projects and working with pre-vetted contractors. Understanding and verifying the NACHU model will add more ammunition to the financial instruments and delivery mechanisms being considered for affordable housing in Kenya.

Loan for	Housing construction or improvement
Loan limit	2.5 million KSh
Typical size of loan	1.25 million Ksh
Typical repayment term	5-10 years
Typical monthly repayment	20-22,000 KSh
Interest Rate	13% (needs further verification, may be applicable to specific products only)

International investors and Kenya affordable housing

Kenya is potentially very attractive to international investors looking towards Africa. Kenya is one of the largest economies in the region and in 2010 had a GDP of approximately $66 billion and population of 40.9 million. The capital, Nairobi, is the largest city between Johannesburg and Cairo and is the main transport hub in central and Eastern Africa. The country has a liberalised economy with no exchange or price controls, and there are no restrictions on domestic and foreign borrowing by residents and non-residents. The Nairobi Stock Exchange is one of the most developed stock markets in Central and Eastern Africa.[21] According to *Standard and Poor*, Kenya credit rating for local and foreign currency is 'B+'. Investors use the rating to assess credit risk and to compare different issuers and debt issues when making investment decisions.[22] The 'B+' rating reflects that the country is vulnerable to adverse business, financial and economic conditions but has the capacity to meet financial commitments.[23]

In 2008, the Ministry of State Planning published a paper on key investment opportunities in Kenya. These opportunities included: tourism, agriculture, transport and infrastructure, manufacturing,

[20] Savings & Loan (S&L) is part of the KCB (Kenya Commercial Bank). We understand NACHU is able to borrow and lend money at rates well below the current commercial rate, however details of this model need to be better understood and currently not fully documented in the on-going discussion on affordable shelter.
[21] A Summary of Key Investment Opportunities in Kenya, Macro Planning Directorate, 2008
[22] http://img.en25.com/Web/StandardandPoors/SP_CreditRatingsGuide.pdf
[23] http://www.standardandpoors.com/ratings/definitions-and-faqs/en/us

communications, energy, building and construction and pharmaceuticals sectors.[24] Investment opportunities have been identified in the construction of commercial, industrial and residential buildings, including low cost housing.[25] Indeed, for a number of years now tourism has been frequently targeted, where spot targeted property investments have been carried out in areas close to game reserves and along the Indian Ocean coastline. In addition to this, there is also now an increasing focus on second homes and retirement sectors some of them likely based in Nairobi.[26]

Construction practices and technology sourced from China and sourced through Chinese suppliers is making a visible impact in Nairobi from buildings to super-highway roads. To the extent that their housing scheme 'Great Wall' on Beijing Road is acknowledged amongst the developers as one of the most cost efficient. This is to a large extent shaking up the local practices and providing a sense of much needed competition which could reduce margins and bring prices down.

In spite of this international investment in housing has been minimal and sporadic. Two main reasons are identified for this. The first is business conditions, limited infrastructure set up for active private sector participation for lower middle and low income groups. The short fall of suitable housing for the burgeoning lower to middle income earners could offer lucrative business opportunities to foreign investors such as Kenyan diaspora. The entry of international housing groups from China and India is beginning to [27] raise the sense of competition amongst the local developers and they are eager to facilitate partnerships. Second, Kenya is still perceived as a volatile place and political uncertainty, security risk, bureaucratic delays and corruption discourages international investors. Despite these outward perceptions Nairobi and other parts of Kenya are growing fast and if investors around the world can be made aware of the real capital growth opportunities, there could be a large inflow of investments.[28]

State of Planning Strategy and Governance in Nairobi: Current situation and challenges

Before the development of the National Land Policy in 2007, Kenya has not had any clearly defined National Land Policy since independence. Urban and regional planning is poor across Kenya and in Nairobi. Nationally, and not unlike most other developing countries, physical planning is beset by a complex institutional arrangement where plan formulation is undertaken by Central government whereas implementation is the responsibility of Local government. This has led to physical development plans not being informed by the local needs and therefore not addressing local realities.

In our observations around Nairobi and the fast growing areas around it (Thika, Athi river) it seems that no overall land usage plan is being adhered to for the areas currently under mass development on the immediate outskirts of Nairobi. Currently herds of freely Zebra mingle with new housing estates, industry, office blocks, quarries, super-highways, horticultural farms and coffee plantations. Currently Nairobi does not have a Physical Development Plan that will identify clear locations for affordable housing to come up. Some space programming estimates are required urgently on where and how this dynamic growth within and outside the city with so many different land-uses will fit together with minimum impact on the natural economy (fauna, coffee, horticulture) and living environment of Nairobi.

In 2008, the Government of Kenya produced the Nairobi Metropolitan Development Plan otherwise known as the Nairobi Metro 2030: A World Class African Metropolis[29]. This key strategy document

[24] A Summary of Key Investment Opportunities in Kenya, Macro Planning Directorate, 2008
[25] http://www.africa-do-business.com/kenya.html
[26] http://www.escapeartist.com/efam/78/Kenya_Property_Investment_Guide.html
[27] Strategic Plan, 2008 - 2013, Ministry Of Housing, Kenya
[28] http://www.escapeartist.com/efam/78/Kenya_Property_Investment_Guide.html
[29] Available at: http://www.tatucity.com/DynamicData/Downloads/NM_Vision_2030.pdf

aims to provide a framework for facilitating economic development, developing infrastructure and transport and housing, sustainable urban growth and social infrastructure, safe and disaster averse neighbourhoods, etc. It dovetails into the overarching principles set out in the *Kenya Vision 2030* [30] and acts as a Sustainable Development Framework for the region.

Under this development plan, the boundaries of the city (Nairobi Metropolitan Area) will be expanded to include adjoining towns and municipalities. The plan's other goals include:

- Replace informal settlements with affordable low cost housing;
- Develop and enforce planning and zoning regulations;
- Prepare a spatial plan for the Metropolitan Area;
- Develop efficient water supply and waste management infrastructure;

However, these vision strategies do not provide the detailed land use zoning and policy that can help developers. The importance of land zoning to the development of green housing was discussed extensively during the consultant's trip to Nairobi[31]. Nairobi has areas specifically zoned for the development of sustainable housing, thus socially interested developers can compete with standard commercial housing developers. Currently zoning is a huge limitation on making housing affordable and green. Discussions with developers reveal that they need to maximize the land developable area to consider affordable housing on it. However zoning and planning bye-laws prevent them from doing so. Nairobi zoning and planning rules demand 60:40 development of sites, i.e. 60% of the site can be covered by building footprints leaving 40% for parking, roads and the like. As a result development efficiency is low and housing within city is expensive or if affordable will need to be several tens of miles out of the town.

Image 5: Zoning regulations can impact on housing affordability Car parking space is mandatory on some sites even if not entirely necessary to its users. Such rules make it difficult to maximize development potential of land making development costlier. On the other hand it is easily observable that nearly all affordable dwellings have some measure of commercial uses built into them (above left side of image). The same is true for a large number of multi-storey rental housing seen across Nairobi. They all have shops at the ground floor that enhances the return from the building. This practice is in line with good practice elsewhere globally [See Max Lock Centre (London), 'Good Practice in Core Area Development']

It is worth mentioning here that currently there is a general lack of policy, regulation and guidance on the inclusion on green building design and use of sustainable building materials in design and construction[32]. As a result there are neither incentives nor disincentives related to housing developments. Green is often perceived as an expensive addition which could not be further from the truth considering previous observations on Nairobi climate and availability of zero/low-cost options.

[30] Available at: http://www.vision2030.go.ke/
[31] Field trip during week commencing 26th March 2012
[32] Physical Planning website: www.lands.go.ke

Emerging Green Equity and Disincentives in Kenya

Kenya is a signatory to Article 6 of the UNFCCC[33] and there is an established institutional structure to mainstream the efforts within Kenya. The National Environment Management authority (NEMA) manages the Inter-ministerial committee on environment (IMCE) with representatives from all ministries.

There are several Country wide initiatives that aim to mainstream green economic development, notably the Greening Kenya initiative (GKI)[34] - which promotes the need for the development of a Low Carbon development Policy as well as incentives like green economic zones. However, the initiative makes no mention of green construction and housing. The National Climate Change Response Strategy is another high level strategy. While energy and water feature prominently, the document is not sufficiently specific in mentioning housing construction and green housing concept.

At the Nairobi city level the Nairobi City Council (NCC) through the City Planning Department has embarked on the promotion of Green Buildings/Architecture within Nairobi. In so doing the Council is now a partner in implementing the UNEP Urban Program - Sustainable Buildings Policies in Developing Countries (SPOD)[35].In order to encourage environmentally friendly buildings the Council, through the Planning Department, is undertaking the following:

a) Planning Policy and Building Bye-Laws; Reviewing and appraising all the relevant policies and Building Bye-Laws that are currently used to regulate approval of Public and other Buildings. NCC is engaging all key stakeholders in the built-environment to reach consensus formulation of responsive policy and regulatory framework that promotes green building technologies.
b) Promoting Development Applications that integrate Green Architecture in the proposal; for instance, this entails the provision of solar energy integrated with national grid, enhanced open/recreational spaces, rain water harvesting and use, surface water drainage and collection for to water greenery.
c) Development Control; NCC has embarked on design dissemination, publicisation and mainstreaming of the new policies and regulations supporting green building design & development.

It will be fair to say that currently there are neither incentives nor disincentives or compliance issues related to green affordable housing. However developers are very likely to see changes in this area in the near future as the true scale of the environmental impact (GHG, water, energy) of housing emerges.

Viability of affordable green housing

Most stakeholders we talked to were willing to come to the table and look for solutions and close the affordability gap provided the general and regulatory conditions for doing business were improved. The World Bank suggested that affordable green housing can be an important component of the KISIP[36] Component 4 – *Urban development*. This was confirmed during the enthusiastic response received from the meeting at Ministry of Housing.

[33] UN convention on climate change. The objective of Article 6 is to join the international community in combating the problem of climate change in the stabilization of greenhouse gases in the atmosphere at a level that will prevent dangerous anthropogenic interference with the climate system.
[34] http://www.oecd.org/dataoecd/7/34/48329051.pdf,
[35] World Bank Institute conference on urban development. Paper by Patrick Akivaga of the City Planning Dept. Available here: http://wbi.worldbank.org/wbi/Data/wbi/wbicms/files/drupal-acquia/wbi/Patrick%20Analo.pdf
[36] Kenya Informal Settlements Improvement Project (KISIP)

What is required now is a better investigation of the strategic city-wide programming and financial framework within which such housing can be realistically delivered in Nairobi and other towns of Kenya.

Image 6: Consultants met with 'Mwamko' members and conducted a programming and affordability discussion at the site of the proposed low/middle-income housing at Ngundu. Any financial architecture for affordable green housing needs to recognize that high costs of services can translate into savings and subsistence (poultry, planting) is vital to the maintenance of the housing fabric within the low and modest income groups.

The analysis from discussions and review of current literature suggests that the gap between what the modest income families can afford and what is currently available in the market may be overstated.

It is possible to introduce a number of efficiencies with respect the cost of buildings, the cost of land and site preparation, the cost of financing. Approval of alternative technologies, verifying the physical development plan and changes in zoning may take considerable time, but optimizing building specifications and reducing wastage can be achieved with voluntary initiative.

In meeting the 'green' targets here is a measure of what is likely possible from current observations:

	Possible Savings
Carbon	Optimised building specification and improved site management alone can save in excess of 20%.
Energy	Climate allows excellent energy efficient design. Using efficient appliances and fixtures, solar water heating along with optimised materials specification will reduce both embodied and operational energy consumption in excess of 20%.
Water	Using water saving fixtures (at no additional cost) will be sufficient to exceed the 20% savings target.

On the next page is an outline SLOB analysis that identifies some key/priority issues emerging from stakeholder discussion and this visit. SLOB stands for Strengths, Limitations, Opportunities and Barriers. This should potentially set the agenda for Ministry of Housing and World Bank to progress the initiatives on affordable green housing in Kenya.

Some Key Numbers from observations[37]

Minimum priced 2 bed flat reported selling on market [circa 50sq.m.]	**3.5-4.5 million KSh** [circa 44,000-56,000 USD]
Cost of construction [multi-story flats] [Building only, including basic finishes. Site-wide works and infrastructure excluded]	**15,000-33,000 KSh/ sq.m.** [circa 200-400 USD/sq.m.]
Earnings in the modest income group [assume 80% of people in Nairobi]	**23,000-60,000 KSh/m** [circa 275-700 UDS/m]
Cost of land [Lower is for Ngundu, 25 Km from City Centre]	**3.5-10 million KSh/ acre** [circa 42,000-12,000 USD/ acre]
Exchange Rate(s) [checked 09 April 2012]	1 USD=83KES [2012] 1 USD=84KES [2011] 1 USD=68KES [2007] 1 USD=78KES [2002]
Cost of borrowing [Commercial] Average reported	22%
Lowest cost of borrowing reported [NACHU] On selected and limited products [needs further investigation to understand if any subsidies are present. Due to the sheer spread of NACHU membership i.e: one in four Kenyans the transaction costs are likely to be competitive and low.]	13%

[37] Note these numbers are from anecdotal discussions with stakeholders and should be independently confirmed. They should be used as a rough guide only and not for modelling or transactions.

SLOB Grid for Observations

STRENGTHS	LIMITATIONS
• Established locally available cost-effective technologies that can reduce Carbon emissions, water and energy consumption. • Excellent climate for energy efficient housing (Nairobi) • Established rental market in place • Developers have already identified preliminary incentives in order to enter the modest income market • Established housing co-operatives with a sizeable membership nationally. Model that should be understood better • Kenyans keen to buy	• People with modest incomes have limited disposable income and find it difficult to prove additional income from subsistence activities. High levels of debt. • Over-specification and waste in design and construction, operation and maintenance of assets and infrastructure. • Alternative materials not recognized by building regulations and insurance. • Urban sprawl and rapid rate of growth. • Adverse land-use impacts from real-estate sprawl. [31]
BARRIERS	**OPPORTUNITIES (AGENDA)**
• Outdated and costly procedures resulting from current planning or building and zoning regulations. They do not recognize innovative alternatives. • Worry about 'aesthetics and social acceptability' of differing technologies. • Volatility and risk in market from foreign exchange rate fluctuations. Price of imported material is volatile. • High cost of borrowing further exacerbated by complex procedures. • Adverse perception amongst international investors of security situation in Kenya.	• Housing may be more affordable than previously estimated as significant savings are possible from appropriate design, delivery, construction and operations. • Broaden stakeholder to include co-operatives, savings groups, diaspora, and international investors (including China). Viable solutions possible from stakeholder consensus. • Mix of time-bound incentives, voluntary & compliance measures for developers and professionals. Highlight the benefits of a broader market base, market leadership and avoiding future environmental levies and disincentives. • National compliance with Article 6 of UNFCCC. • Decentralised development reducing the cost and pressure of land in and around Nairobi.

4. DEFINING A SCOPE AND APPROACH FOR FURTHER WORK

The overall outcome of this piece of work is to define 'if a detailed assessment of the type undertaken in India should take place in Kenya'.

One of the key departures we propose from the India study is that instead of mapping a large number of possible building technologies it may be more helpful to set a **design and performance specification** for affordable housing in Kenya. One of the key departures we propose from the India study is that instead of mapping a large number of possible building technologies it may be more helpful to prepare a well-defined 'Design and Performance Standards' for affordable housing in Kenya. Any number of innovative technology options (current or future) can filter through this framework. These specifications will include but not be limited to: location; land use; space standards; design detailing; and fabric of the buildings, all of them with the intention to exceed the 20-20-20 framework and to minimise environmental impact when the housing development is implemented to scale and spread. The Design and Performance Specifications will become the basis for a future reformed 'Building Code' and 'Green Rating System' to be mainstreamed in Kenya.

Physical plan and Environmental impact There is evidently little documentation on how much (and where) suitable land is available to place affordable housing. A physical development plan is required urgently. The volumes of (green) material required and how these supply chains will be managed with minimum impact on the environment needs to be set out.

New stakeholders and business models Important lessons can be learnt from what is already making housing more affordable. The two examples we have identified are the NACHU and the Chinese investment[38] in Nairobi. While there is a lot of room for improvement, these models are bringing new practice into Nairobi such as affordable credit, efficient technical and project management. These models need to be better understood and included in the on-going efforts on affordable housing.

International investment in Kenya We discussed this issue with both developers and international investors with good knowledge of doing business in Kenya. Cost (and volatility) of available funds is an important issue holding back investments into affordable housing. Further work is required on what infrastructure and communication needs to be put into place to make Kenya an attractive option for investors/diaspora who could potentially bring lower cost funding into the Kenyan housing market.

Developers' costs (and true scale of financing gap) need to be better audited and understood before practical suggestions can be made about priority incentives. In previous sections we have already demonstrated that substantial cost savings are possible from optimizing building design and material specification. In addition developers are paying a substantial cost towards unsuitable regulations, process, bureaucracy and the time it takes to get things done. The high cost of borrowing only makes it much worse. Without reform in this area developers will continue to find affordable housing does not give enough reward after all the hard work. Cost reductions need to be accurately established so that the true size of the gap between cost and affordability of housing can be determined. Perceived competition from international developers such as from China is creating a sense of competition which is likely to encourage reduction in margins.

[38] Construction practices and technology sourced from China and sourced through Chinese suppliers is making a visible impact in Nairobi. To the extent that their housing scheme 'Great Wall' on Beijing Road is acknowledged amongst the developers as one of the most cost efficient.

The Ministry of finance identifies lack of affordable technology as a key barrier to bringing more developers into affordable housing. This study concludes that affordable technology is available in Kenya. Combined with better procurement and less waste during construction and operations this can only be an opportunity for developers to cut costs without cutting quality. The Ministry of finance identifies lack of affordable technology as a key barrier to bringing more developers into affordable housing. We believe that affordable technology is available in Kenya. Combined with better procurement and less waste during construction and operations this can only be an opportunity for developers to cut costs without cutting quality.

The table below captures some measures that have come out of this preparatory work and the extent to which they can be useful in reducing the financing gap.

Aspect	Measure(s)	Cost & Impact
Building Technology & Design	Optimised space planning and standards; design with local climate in mind; optimal design specification to minimize material and maintenance requirement; avoiding waste during construction; green technologies for hot water and water treatment.	Mostly zero cost options will in fact reduce cost burden on developer. Estimated a minimum of 20% cost reduction. In excess of 20% reduction in Embodied Carbon, water consumption and energy consumption.
Land, fiscal & Institutional	Reforming zoning and planning requirements to optimise land development; Audit and optimize cost of regulatory compliance and development processes.	These require the cost of underlying work to reform these processes. Estimated a modest reduction of 10% reduction in cost to developer.
Developer & Investor	More competition (such as the Chinese are bringing in); lower cost investment from overseas; package of incentives combined with regulations.	Incentives should not subsidise profit margins. In return for incentives developers may be willing to work with somewhat reduced margins32 if they see other co- benefits e.g.: broader market base.
Modest income Family	Additional income from rent; Behaviour change in using energy/water and resource-efficient appliances.	At no cost these measures can provide additional income and savings to families improving affordability of mortgage repayment. A modest estimate will be 12,000 KSh additional per month.

The diagram below is an indication of how the application of above measures and even modest assumptions on their impact can bring down the costs of delivering housing.

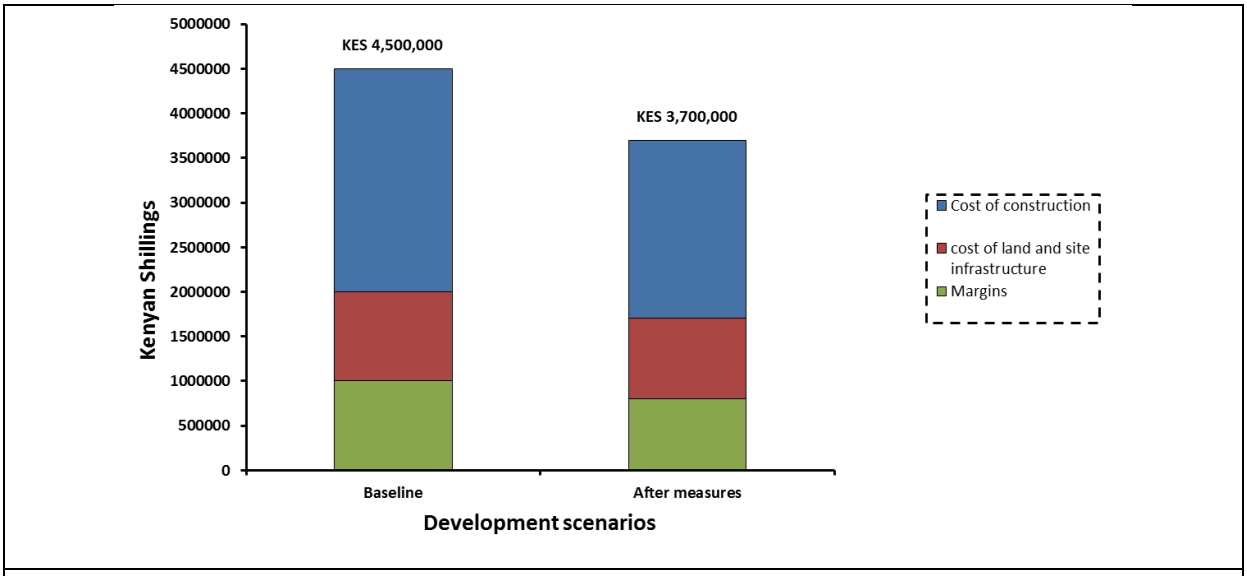

Figure 4: Comparison of market price of a unit after measures are applied and only a modest impact is estimated.

To close the gap further ways to improve income prospects should be designed within the housing for the modest income group. Some options include rentable space designed within housing (sub-letting parts of the house is common in Nairobi) or saving on utility bills by using greener options for hot water and lighting. The diagram below is an indication of how the application of above measures and even modest assumptions on their impact can reduce the development cost of housing and increase the income of modest income groups thus reducing the gap. In figure below 'A' indicates income supplemented through rent, utility savings and other measures.

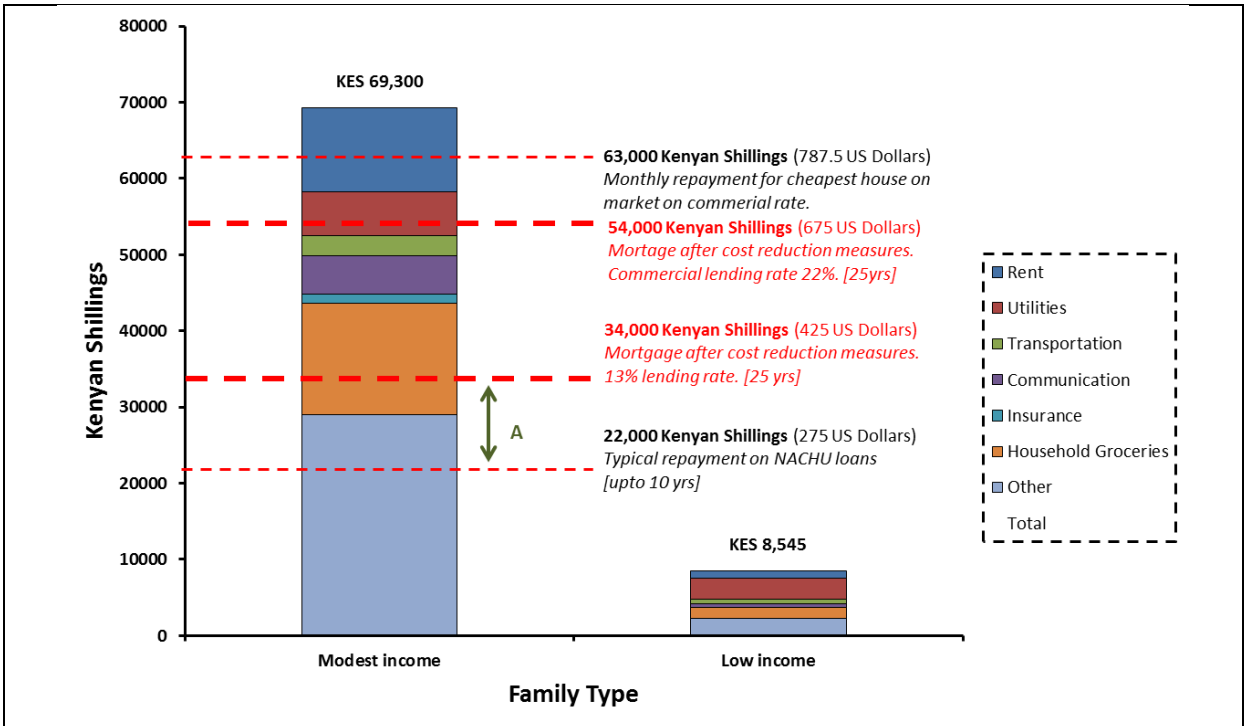

Figure 5: Comparison of financing gap for a modest income family after measures have been applied to reduce developers' costs and 'A' supplement incomes.

The table below provides a summary from Figures 3 and 5 of the closing gap between monthly repayments and income available towards repayments.

	BASELINE	After Reduction in construction costs, savings from use of green technology and income generation [at Commercial Rate of interest 22%]	After Reduction in construction costs, savings from use of green technology and income generation [at affordable Rate of interest 13%]
(M) Mortgage Repayment (p/month)	63,000	54,000	34,000
(I) Income towards repayment	11,000	16,000	16,000
Gap [M-I]	52,000	38,000	18,000
Notes	Loan of 3.5 million KSh for 25 yrs. At 22%	Loan of 3 million KSh for 25 yrs. At 22%	Loan of 3 million KSh for 25 yrs. At 13%

5. CONCLUSIONS

Nairobi is growing rapidly and there is currently a lot of new housing being built in Nairobi and surrounding areas. However, as much as 80% of the people in Nairobi are in the 'modest income' group and unable to afford to buy anything currently on sale in the housing market. As a result a substantial number of people live within rented accommodation. The exact scale of the housing shortfall is not fully confirmed although it is in excess of 100,000 dwelling units per annum. Households in Nairobi pay a substantial proportion of their limited income for energy and water and often these are from unsustainable sources such as charcoal, diesel and paraffin.

Builders and developers in the region explain that they face a number of barriers which prevent them from being able to deliver housing in the affordable sector. These range from high costs and difficulties of obtaining land, low-cost credit and restrictive regulations that limit the use of alternative cheaper building material and maximize the development of expensive land due to zoning and bye-law restrictions. In 2007 Government of Kenya identified a set of incentives to encourage developers to enter the affordable/low-income housing sector but Developers say this has had little impact. It is widely believed that there is a dearth of low-cost appropriate technology in Kenya. This is not true as many countries in the region have taken up Kenyan developed technologies for decades to reduce the cost and environmental footprint of their buildings.

Meanwhile the current infrastructure boom in and around Nairobi is consuming enormous amounts of quarried stone, timber, and river sand. It is not clear how well—or if at all—the production and supply chains for these commodities are being managed. Kenya has experienced a shortage of timber for many years. The forest cover has been severely depleted. So much so that today much of the timber used for construction is being imported from Tanzania, Uganda, and the Democratic Republic of Congo. The rapid development is also negatively impacting upon Kenya's natural heritage for instance the disruption of migratory routes and horticulture farms that contribute significantly towards the Kenyan economy and the income of its people.

Our assessment identifies that substantial savings in cost, embodied Carbon, electricity & water consumption are possible in housing currently being built in Kenya making it more green and affordable:

- The current Nairobi climate is ideal for the design of energy efficient housing.
- The construction technology most prevalent in Nairobi for multi-dwelling housing is the reinforced cement concrete (RCC) frame with in-fill stone walls. The intermediary slabs, columns and roofing (constituting the structure of the building), door and window frames, and external/internal walls present the highest potential for savings in embodied energy ie: energy used in the production and transport of materials.
- It is possible to introduce a number of efficiencies with respect the cost of buildings, the cost of land and site preparation, the cost of financing. Approval of alternative technologies, verifying the physical development plan and changes in zoning may take considerable time, but optimizing building specifications and reducing wastage can be achieved with voluntary initiative. The entry of international developers is bringing further competition and design/construction management techniques that will enable reduced development cost.

Most stakeholders we talked to were willing to come to the table and look for solutions and close the affordability gap provided the general and regulatory conditions for doing business were improved and affordable credit was available. The World Bank suggested that affordable green housing can be

an important component of the KISIP[39] Component 4 – *Urban development*. This was confirmed during the enthusiastic response received from the meeting at Ministry of Housing.

What is required now is a better investigation of the strategic city-wide programming and financial framework within which such housing can be realistically delivered in Nairobi and other towns of Kenya. The analysis from discussions and review of current literature suggests that the gap between what the modest income families can afford and what is currently available in the market can be reduced significantly.

[39] Kenya Informal Settlements Improvement Project (KISIP)

6. NEXT STEPS

We sensed considerable enthusiasm within the Ministry of Housing on the 'green affordable housing' initiative. The World Bank representative flagged that KISIP (particularly component 4) as suitable to accommodate further initiatives on 'affordable green housing' related efforts. Following discussions during the visit and subsequent analysis we believe that the following simple steps can be undertaken quickly. The political and institutional landscaping may change in the near future. This can bring considerable uncertainty. At the same time it also brings opportunity. Affordable green housing an issue for more than 80% of the population in Kenya and carries substantial democratic weight considering the rapid rise in the costs of utilities. With this in mind any forthcoming changes to the structure and mandate of Ministry of Housing and Ministry of Public Works should be seen as an opportunity to improve the status and acceptability of alternative building technologies, optimized space standards and access to land.

A Kenya Affordable Green Housing charrett: Much of the gaps can be filled within a problem solving environment. The most cost-effective way to do this is probably within the remit of KISIP to organize a high-level charrett (problem solving or design exercise) that brings together invited and well informed stakeholders to brainstorm and offer solutions to confirm that the financing gap is indeed more manageable than previously thought and how it might be filled. It is important that local organisations such as NACHU, international investors and NEMA are brought to the same table to present lessons from their approach.

Scope and terms of detailed assessment towards guidelines: Write a terms of reference for the detailed assessment in Kenya and production of affordable housing guidelines. The ToR will include work that cannot be completed rapidly in a discussion environment. It may include: specification for environmental impact study; performance and design specification for affordable housing in Kenya; specification on conducting an audit of developers costs (useful for above charrett); specification on baseline development related to modest income households [income, spending, use of building materials, energy and water]; forthcoming regulation and green-funds relevant to housing developers in a 5-10 year timescale; detailed quantification of green measures in housing.

Annex 1: Key references collected during Kenya visit

AUTHOR	YEAR	NAME
IFC/ World Bank/ National Housing Bank	2011	Green Interventions for Affordable Housing
Mwangi S	2012	Low Cost Housing Technologies Cost Comparisons
S&L	2012	S&L Mortgages
Wally S et al.	2011	Developing Kenya's Mortgage Market
NACHU	2011	Bills of quantities: Proposed faith foundation housing project at Ruiru
PIPAL	2011	Nairobi Affordable Housing
NEMA	2005	Kenya's capacity needs to implement Article 6 of the UNFCCC
Habitat for Humanity	2012	Costing Schedule: quarry stone house
Housing Finance	2011	Annual Report & financial statements 2011
SBS	2012	Portfolio
NACHU	2012	NACHU products & Services
NACHU	2012	NACHU loans and requirements
COMAC	2012	Quality Affordable Housing
Ministry of Housing	2007	Ministry of Housing private sector incentives
UN-HABITAT	2009	Low cost sustainable building materials and construction technologies
Ministry of Housing	2012	Appropriate Building Material & Technology (ABMT) programme

Annex 2: Sites visited

Name of development	Location	Nature
Private home of Mr. and Mrs Githua	Mlulongo – 20km east of Nairobi city centre	Constructed with CSSB – Equipment loaned from Min of Housing – HydraForm system imported from South Africa.
Githua Cement Products	Mlulongo – 20 km east of Nairobi city centre	Cement Floor tiles, stair-balustrades, paving slabs, ferro-cement garden furniture and decorations
Greenspan Developer's 'Donholm' Housing Estate	Embakasi – 15 kms east of Nairobi city centre	High-end market development. 4 bedroom houses selling at Ksh9.5 million and 3 bedroom apartments selling at Ksh 5.3 million. Marketed as a 'green' development. Only visible signs solar water heaters and apparently all ground drains are diverted back into bore-hole.
Sustainable Materials Research and Technology Centre (SMARTEC), Jomo Kenyatta University	Ruiru - 30 kms north of Nairobi city centre	CSSB and Rammed Earth Technologies – All based on Kenyan developed equipment
Stone Quarry	Ruiru – 30 kms north of Nairobi	Machine cut granite stone for wall building – Quarry dust used as a sand substitute and for cement block making.
NACHU Middle Income Housing Development	Ruiru – 30 Kms north of Nairobi City centre	30 houses being constructed by a cooperative. 2 bedroom with 3rd bedroom for rental income. Retail price Ksh 3.5 million per unit.
Great Wall Housing Development	Mlulongo – 15 Kms east of Nairobi city centre	Huge Chinese mixed housing and retail development. No access.
NACHU High Income Housing Development	Mlulongo – 20 kms east of Nairobi city centre	40, 3 bedroom houses being built by a cooperative. Retail price Ksh 7.4 million per unit

Annex 3: Interviewees

Raymond Chisholm	America East Africa Corporation	Nairobi
Jacqueline Akinyi Jakaila Chisholm	America East Africa Corporation	Nairobi
Irfan Keshavjee	Karibu Homes	Nairobi
Diana Ortizzuluaga	World Bank	Nairobi
Wendy Ayres	World Bank	Nairobi
Lucy Kibinu	Savings & Loans	Nairobi
Milicent Omondi	Savings & Loans	Nairobi
Joram Kiarie	Savings & Loans	Nairobi
Solomon Mwangi	COMAC	Nairobi
Mary Mathenge	NACHU	Nairobi
Stanley K Ndung'u	NACHU	Nairobi
D B Busuru	NACHU	Nairobi
Daniel Migui	NACHU	Nairobi
Ravi Ruparel	Independent	Nairobi
Seeta Shah	Pipal	Nairobi
Ashna Mathema	World Bank	Washington DC
Andrey Milyutin	World Bank	Washington DC
Joel Mbabazi Kiberu	Mentor group Limited	Nairobi
Sosi Vincent	Mentor group Limited	Nairobi
Grace Wakaba	International Valuers	Nairobi
Asa Forsman	HiFab	Nairobi
Theresia Munyua	KISIP - Ministry of Housing	Nairobi
Michael Nthiani	KISIP - Ministry of Housing	Nairobi
Mr. Kusienya	Programme co-ordinator KISIP	Nairobi
Gladys Juma	KISIP - Ministry of Housing	Nairobi
Loise N Kinyanjvi	KISIP - Ministry of Housing	Nairobi
Fridah Nalianya	KISIP - Ministry of Housing	Nairobi
Henry Niwakulila	KISIP - Ministry of Housing	Nairobi
Electine Nanzala	KISIP - Ministry of Housing	Nairobi
Njeri Cerere	KISIP - Ministry of Housing	Nairobi
Mary Mueni Muua	Bamburi Cement	Nairobi
Baroness Lynda Chalker	AfricaMatters	London
Laila Macharia	Scion REAL	Nairobi
Michael Mutter	ASI	Abuja
Dr. Michael Theis	Max Lock Centre	Kaduna
Jacob Mwangi	Architectural Association of Kenya	Nairobi
Shirish Shah	Greenspan Housing	Nairobi
Prof. Syagga	Unable to connect	Nairobi
Simon Nyabwengi	Habitat for Humanity	Nairobi
Beryl Okumu	Greenspan Housing	Nairobi
Mrs& Mr. Joshua Gitau	Materials Supplier	Nairobi
Roger Bonner	Independent	Bristol
Mark Gathimieri	Stone Quarry Manager - Ruiru	Nairobi

Kariuki Kevin Kihara	Housing Finance	Nairobi
James Gichatha	Housing Finance	Nairobi
Sophia Mwanza	Mwamko	Nairobi
Valerie kent	Mwamko	Nairobi
Abdi Issac	Mwamko	Nairobi
Simon Walley	Email contact only	Washington DC
Charles Maina	Nairobi SME owner	Nairobi

Annex 4: India Study: Green Technology Outcomes

Affordable green technologies

A comprehensive set of technologies were examined and rated by applying screening criteria to short-list 10 key technologies with most significant environmental impact. Wall systems, roofing, and woodwork for door and window frames account for 60% of the entire construction cost. As a result, a greater emphasis was placed on these components while compiling a list of technologies. The screening parameters used to shortlist technologies were first cost, embodied energy, operational energy, water efficiency (during construction), and cost of scalability and replicability.

The alternatives to brick walls like CSEB, fly ash brick wall or SIP all have a lower embodied energy as well as better thermal insulation, leading to enhanced comfort and energy savings in operation.
There are many other alternatives that meet the criteria, including the Aerated Autoclaved Concrete (AAC) block wall and Cellular Lightweight Concrete (CLC) block. In general, any non-fired material will have a lower embodied energy compared to a fired brick and is a good replacement option.

Roof alternatives that reduce the use of cement and steel also have lower embodied energy, and if the replacement has better thermal insulation, the result can be enhanced comfort as well as energy savings and reduced greenhouse gas emissions.

Other important green building materials include insulated and reflective roofs, which reduce the heat gain into the building and reduce energy use and alternative frame materials for doors and windows. The reinforced concrete frame (RC) and wood plastic composites offer better performance and contain lower embodied energy compared to the traditional steel frames.

In addition to the technologies identified under the 'short-list', two tiers of cost neutral initiatives also have been identified which present opportunities for implementation as general policies. It is noteworthy that cost neutral initiatives are mostly aimed at reducing the carbon footprint from operational energy use, whereas the short-listed technologies are aimed more toward reducing embodied energy use.

The Tier I cost neutral items are must–dos with low environmental and first costs:

- Energy-efficient fans and water pumping systems [Applicable]
- Natural methods of decentralized water treatment systems [Applicable]
- Passive solar features and design for thermal comfort, day lighting and natural ventilation [Applicable]
- Water-efficient fixtures [Applicable]

The Tier II items should be incorporated as far as possible because their relatively higher costs are accompanied by major environmental benefits and short pay back periods. These include:

- Efficient lighting - 1.5 to 2 times the cost of regular fixtures but with a payback period as low as 4-6 months [Applicable]
- Solar water heaters - 5 times the cost of electric water heaters (geysers)with a payback period of 4-5 years [Applicable]
- Rain water harvesting and storage systems with a payback period of 3 years (considering tanker water @ Rs 75 per kl) [Applicable]

Quantifying energy and water savings through low-cost green building technologies

In order to quantify the embodied energy and operational energy savings by implementing green building materials and technologies, a base case was developed and then simulated for both Delhi (Composite Climatic Zone) and Mumbai (Warm and Humid Climatic Zone).

Overall, building materials constitute approximately 60% of the total embodied energy in homes constructed in India. The base case indicated that in a typical low-mid rise building, almost 45% of the embodied energy lies in the RCC roof, intermediates slabs, and structural frame. The external and internal walls comprise another 45%. Over 90% of the embodied energy in a housing project, therefore, is in these two categories.

In the case of operational energy, the combined share of cooling and lighting equipment alone, contribute to over 60% of the total electricity consumption.

Efficient building design using building technology that reduces overall heat gain, maximizes day lighting, and uses efficient cooling, lighting and water heating equipment has immense potential to reduce operational energy consumption in affordable housing.

Savings of more than 30% can be achieved in the embodied energy of a typical apartment by using affordable green building materials.

Operational energy savings of up to 40% can be achieved by incorporating green–building materials, passive design strategies and energy efficient appliances.

In a typical household with 150 liters of water use per person[40], over 32 liters can be saved by using dual flush toilets. This translates to over **46,000 liters of water** saved per household per year.

The 20-20-20 model

The above analysis shows that IFC-recommended model for green buildings– the 20-20-20 model [i.e., 20% energy, 20% water and 20% materials efficiency] - is technically achievable in the low income housing context.

[40] National building Code of India 2005 (NBC 2005)

Annex 5: Further References

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