

## Sustainable Housing and Building Materials for Low-income Households

Bredenoord J\*

International Urban Planner/Housing Researcher, Housing Research Group, The Netherlands

### Abstract

The access to affordable housing in the Global South is very limited for millions. Many households have chosen for incremental self-construction; herewith sustainability does not have the highest priority. The main question is whether affordable housing for the urban poor and the need for sustainable housing and urban development can be combined. Transference of knowledge to (self) builders is a key issue, as is the role of assistance in self-help housing. It is argued in this paper that sustainable goals for low-cost housing and applications are achievable. Measures concerning the physical development of neighbourhoods, such as urban density and connectivity are equally as important as measures concerning community development. The latter include support for community-based organizations, small housing cooperatives (or similar forms of cooperation) and individual households – or small groups – that build and improve their houses incrementally. Adequate planning and social organization and cooperation are preconditions for achieving sustainability in incremental housing.

**Keywords:** Sustainable housing, Sustainable building techniques, Building materials, Low-cost housing, Incremental housing, Urban planning, Community participation, Housing and planning.

### Introduction

Given the enormous and on-going urban growth occurring in the countries of the Global South, and the increasing numbers of poor households living in sub-standard housing, this paper searches for sustainable housing solutions and their subsequent applications for low-income households. A distinction can be made between self-help incremental housing on the one hand and institutional housing on the other. Institutional housing usually refers to 'social or public housing' organized by governmental corporations, project developers and other private enterprises. Here, housing is offered to consumers (renters or buyers), which is organized in a 'top-down' manner. In contrast, self-help housing is principally organized in a 'bottom-up' manner, and can be formalized and assisted by the government or NGOs. Self-help or self-managed housing – the house production method of millions of households worldwide – may also lead towards informal cities, but not always. This paper focuses on, among other things, assisted self-help housing. Local governments might strive for higher urban densities, and the preventing of urban sprawl. Concerning housing, it is equally important to support (the establishment of) small housing cooperatives (or similar forms of cooperation) and individual households that build and improve their houses incrementally.

I discuss some requirements and solutions concerning sustainable housing, and some applications that are particularly affordable for low-income households. In addition to the physical targets concerning sustainability, the concept of sustainability has also a very important social component. The upgrading of neighbourhoods – sometimes even slums – can be accomplished by local governments in cooperation with the residents. This can be called sustainable urban planning and requires support for community-based organizations and small groups of residents. Residents will ask for improvement of the living environment (habitat), e.g. of roads, playgrounds, parks, etc. But they also will ask for improved connectivity with the city centres.

The central question in this paper is: Can the self-help methods employed by poor urban households to attain affordable housing contribute to improving the quality of housing and sustainability of neighbourhoods and cities? An additional question is: What physical and social conditions can (local) governments create to facilitate the development of affordable and sustainable housing?

The paper is organized into five parts. The first section addresses why low-income households need affordable and sustainable housing. The next two sections outline the preconditions necessary for sustainable urban planning and the sustainable housing. The fourth section outlines sustainable building materials for low-cost housing. The last covers aspects of social sustainability and this is followed by the conclusions.

### The need for sustainable urban housing

Over the past few decades, many countries in Africa, Asia and Latin America have seen significant increases in their populations, resulting in housing shortages. The deficits have both quantitative and qualitative components and they are most notable in the cities. According to UN estimates, the urban population of the developing world alone will increase from 2.7 billion in the year 2011 to 5.1 billion by 2050 [1]. Consequently, millions of new and upgraded houses will have to be provided in order to accommodate a rapidly growing urban population. However, most low-income households have limited access to affordable housing, and therefore it is apparent that housing shortages cannot be solved without focusing on sustainable low-cost housing.

The poverty levels vary from country to country. Poverty often results in low-quality and overcrowded housing that lacks of various services and infrastructures. Self-help housing, which is mostly practiced incrementally, is also often a result of poverty [2,3]. Self-help housing is an individual housing provision system, largely completed in a step-by-step construction process. Urban growth in developing countries demands high-capacity housing delivery systems for low-income groups. This often occurs through self-help housing and social (i.e. institutional) housing, the latter making use of public

\*Corresponding author: Bredenoord J, International Urban Planner/Housing Researcher, Housing Research Group, Utrecht, NL. Amerikaring 263823 HT Amersfoort, The Netherlands, Tel: +31 6 22446251; E-mail: [janbredenoord@planet.nl](mailto:janbredenoord@planet.nl)

Received February 01, 2016; Accepted February 23, 2016; Published March 15, 2016

Citation: Bredenoord J (2016) Sustainable Housing and Building Materials for Low-income Households. J Archit Eng Tech 5: 158. doi:10.4172/2168-9717.1000158

Copyright: © 2016 Bredenoord J. This is an open-access article distributed under the terms of the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original author and source are credited.

assistance through *inter alia* housing finance mechanisms, land-for-housing schemes and housing projects. While self-help housing is still widespread, families now 'self-construct' less often than they did in the past, especially if they can afford to contract out parts of the construction work to professional construction workers. Self-help or self-managed housing is based upon the decisions of individual households who determine the building quality and construction pace [4,5]. Due to its prominence, self-managed housing in developing countries is a phenomenon of great importance and thus should be facilitated by formal housing policies [6]. Individual housing projects are realized at the local level, through the involvement of residents, municipal organizations, building companies, housing cooperatives and banks. As housing shortage is a problem of great proportions, housing – including self-building – is a promising source of employment generation” [7] (Figure 1).

Worldwide, many households have chosen for incremental self-help housing. However, issues of sustainability are not given the highest priority. This is probably a consequence of household financial limitations combined with a lack of support and knowledge. The official visions on 'sustainable development' put forth by global institutions such as the UN and World Bank have altered in the course of time, but initially only two themes dominated: one centred on the conservation of nature and natural resources and the other on macro-economic progress. At the end of the 1990s, 'sustainable development' was connected to human settlements and housing [8]. With regard to sustainable housing, Choguill [9] describes a vision for all phases of planning as well as for the construction and maintenance of houses. Five policy elements can be mentioned:

- 1) Involving local communities with urban planning and housing;
- 2) Providing self-builders and building companies with access to good quality and affordable building materials;
- 3) Developing building standards, for example in earthquake-prone areas, for the prevention of fires, and for the protection of health through water and sanitation, etc.;
- 4) Providing sufficient financing mechanisms; and
- 5) Making sufficient land available.

Sufficient conventional housing financing is not available to meet the projected demand for urban infrastructure and housing [10], but micro-finance is rapidly becoming more available and popular and this type of financing fits better with incremental house building. Moreover, one fundamental problem is the lack of affordable land for housing.



Figure 1: The slopes of Medellín, Colombia.

The policy points mentioned above make a strong connection between housing sustainability and affordability. But sustainable housing is a relatively new concept that has only been marginally introduced in many developing countries. Additional criteria for housing and planning involve: economy, environment, local social structures and organizing capacity; see for example Ebsen and Rambøll [11] and Chen, et al. [12]. The latter authors also state that houses should be made energy efficient through improved design and construction such as better insulation and reduced wind infiltration, the use of solar energy for electricity production and water heating, as well as solar shading and natural ventilation for summer cooling. Countries vulnerable to seismic activity need earthquake-proof building designs; this normally requires professional help and cannot be managed by self-builders alone.

Local context always plays an important role in devising appropriate sustainable housing solutions, e.g. concerning the climate, the conditions of the soil and the subsoil, the land tenure, the quality of local governance, the availability of finance, the local knowledge regarding construction, and the way local communities can be involved. To promote sustainable housing, governments need to use environmentally-friendly construction techniques and new technologies for construction, and to make use of existing local resources in order to reduce the negative impact on the environment. Miranda [13] mentions some technical aspects for consideration such as the origin, quality, cost and local suitability of building materials, and social aspects such as the health of residents. Avoiding illnesses and health risks is crucial for resident health, for example through the combat against asbestos and other toxic materials as well as by providing houses with good ventilation and proper cooking devices.

Clearly, low-income families need affordable housing, and sustainable housing can play an important role in filling that need. However, taking sustainability measures cannot be the sole responsibility of poor households in developing countries. Consequently, the use of sustainable housing solutions must be stimulated and facilitated by governments, NGOs, and corporations, which creates a new challenge for practitioners and self-building residents. Herewith, the development of appropriate construction technologies and the transference of knowledge to (groups of) homebuilders are of significance.

### Sustainable urban development, a precondition for housing

Good urban planning is a vital requirement for sustainable development connected to housing. Planning occurs at two levels: the city (municipal) level and the neighbourhood or project level. At the city level, planning activities include for example the development of the city's vision for urban housing and the functions of the neighbourhoods, the provision of urban land for housing, public transportation systems and bicycle paths, as well as amenities and services. Aspects of sustainability planning at the neighbourhood or project level include *inter alia* efficient and cost-effective land-use, higher densities and stacked construction of housing. Briefly, the governmental goals for sustainable urban design must at least include the following: first, the search for higher urban housing densities [14]; and second, the connectivity of neighbourhoods to the city centre and industrial and commercial urban areas. Besides these goals, the municipal government must take care of public services for which the inhabitants cannot be solely responsible, such as the realization of green areas, social facilities, schools, and security for the residents. Another important public task is construction quality control, which is often not available in informal areas.

Although this overview is far from complete, it illustrates the extensiveness of sustainable urban development issues. From a purely technical point of view, designing sustainable urban expansion plans is not too difficult. Making good connections to the city centres for example by realizing bicycle paths and bus facilities may provide suitable alternatives for private motorized traffic. However, creating new green areas in or near existent urban slums is challenging because these areas are not always seen as beneficial for the land exploitation. Furthermore, the issues of providing drinking water (e.g. by collecting rain water), infiltrating of rain water into the subsoil to reduce run-off, and treating sewage water must be attended too. In general, the coordinating and steering roles of local governments regarding low-cost housing must be developed. Moreover, urban planning and management could be developed through education and specialized trainings. The development of municipal planning strategies and its instruments was stimulated by the Urban Management Program between 1986 and 2006; a joint undertaking of the UNDP, UN-Habitat and the World Bank. Currently, comparable programmes are being organized within the world regions, but the residents building their houses have to deal primarily with their own national governments (legislation, housing policy, subsidies, etc.) and then with their municipality (housing and planning policies, infrastructure services, etc.).

Research on best practices concerning the achievement of higher densities in cities is needed. Many housing and planning specialists are convinced that this is a major goal for sustainable housing and urban planning. But the densification of self-help housing areas has its limits. Households have shown to be able to incrementally build up to 3 - 4 storeys, among others in Lima, Peru, on plots of 90 square meters (Figure 2).

The average household has proven to be able to build a one or two-storey house. According to calculations by Bredenoord and Van Lindert [4], there is a rather strong relationship between housing densities and the plot sizes. According to this source, minimal plot sizes (e.g. 50 square meters or less) do not result in higher densities. Examples of 3-storey self-help housing structures can be found in Chile with a series of projects of Elemental Architects [15]. The projects offer a building structure that allows individuals to finish the dwelling themselves. It is a good example of support for incremental housing. There are similar housing projects in other countries. Some of these projects offer cell housing - which can be enlarged later by the residents within a frame - allowing the residents to expand and improve their property incrementally. User-initiated transformations and expansions within public housing complexes are often made informally, because



Figure 2: Individual self-help housing in Peru.

they are not designed in a way that allows for such changes. In housing complexes in Manaus, Brazil, it was found that the projects and the policy do not support the occurring practice of incremental expansions. The large number of - illegal - extensions revealed that there is a certain demand among the residents for incremental housing. Thus, the design for housing and the built environment should contain solutions for incremental finishing of homes [16].

Urban planning is a basic task of local government. In order to connect urban planning with the demands of populations, local groups of residents should be directly involved in planning processes. Urban planners, including architects, civil engineers and other specialists, might develop new working methods to share their skills directly with local households regarding, for example, developing community action plans and establishing housing cooperatives. Co-operation between the various stakeholders will lead to new working methods concerning participatory planning and housing. Another concern is the offering of assistance for self-builders, for example by community architects and construction aid workers. House design assistance for the self-building process in the region of Campinas, Brazil is an example [17]. Ismael [18] describes the technical training resource centre (TTRC) that was set up by a young trainee of the Orangi Pilot Project-Research and Training Institute (OPP-RTI) to support better quality housing and infrastructure provision in the *kaatchi abadis* (informal settlements) of Karachi, Pakistan. The Community Architect Program was created in Cuba in 1994 to support self-help housing construction. Community architects have used participatory techniques to provide technical advice to residents who wish to build, expand or renovate their homes. This has been done by more than one thousand community architects in Cuba [19].

In 2010 in Nairobi, Kenya, an international workshop of young planning professionals resulted in additional recommendations. This workshop, jointly organized by UN Habitat, the Government of Kenya, the city council of Nairobi, the Architectural Association of Kenya, the University of Nairobi and ISOCARP, the International Society of City and Regional Planners, focused on Kibera, one of the largest informal cities in East Africa. The young planning professionals recommended, after many site visits and conversations with the people living in Kibera, that planning, investments and the construction of urban networks and basic infrastructure should be considered as important as planning, investments and the construction of low-cost housing. Enhancing environmental sustainability, community development and creating economic opportunities should be integrated into the planning and upgrading of informal settlements [20].

Sooner or later, the challenges for sustainable planning mentioned above must be translated into practical organizational, social and technical policies and practices that lead to improved urban areas and neighbourhoods. Below, attention is given to some social and technical measures and services that are important for the quality of the physical environment of homes. Organizing the participation of inhabitants and groups of residents, and developing and managing technical infrastructures are core tasks of local administrations. The challenge is the greatest in the upgrading of existing districts and neighbourhoods, including the upgrading of slums. The planning and facilitation of infrastructures and services in these areas can be done by making socio-economic and spatial/technical profiles (Figure 3).

### Socio-economic profiling of urban areas

With extensions and improvements of urban residential areas, an analysis of the socio-economic structure is useful for the understanding



Figure 3: Nairobi (Kenya) Kibera suburb with self-help housing.



Figure 4: Cable car track in Medellin, Colombia.



Figure 5: Separate waste collection in Medellin, Colombia.

of opportunities and threats. Improvement of living and working conditions of residents and business owners hinges on the cooperation between local government, residents, local entrepreneurs, and other stakeholders. Trust between the various stakeholders is crucial. A process of cooperation can begin with participatory surveys of needs, problems, priorities and the like. The joint making of basic maps is another effective trust-building activity. Several models of participatory spatial planning are used in (in)formal settlements, among others in Asian and African cities. Examples can be found in India, Uganda, and South Africa. Slum/Shack Dwellers International (SDI) is successful in promoting such participatory local communities. National SDI federations work with communities to count households, map settlements, and survey at the household level to develop a detailed

socio-economic profile of the settlement, as a start for development and upgrading processes for example in Malawi [21]. Similar work has been done in many other countries. In Uganda, the World Bank funded Uganda Support to Municipal Infrastructure Development and settlement profiling was conducted in the City of Kampala. Here they worked with focus groups [22]. At the neighbourhood level, the NGO ACTogether [23] investigated the social and physical situation in some areas with backlogs in the City of Jinja, Uganda, and they used the knowledge of the residents.

### Spatial and technical profiling of urban areas

When urban areas are expanded or upgraded, the improvement of infrastructures and services is always of outmost importance for the residents. Local governments have crucial tasks here, and spatial planning is one of their main instruments. It is known that in many cities in the global South, the provision of these infrastructures and services is very inadequate. Roads can still be unpaved, drainage is not working, drinking water supply and sewerage are (still) missing or are inadequate, electricity connections are missing or illegal and dangerous and garbage collection is not yet organized. These are the imaginable backlogs in urban slum areas. Of course many neighbourhoods are in a process of improvement but that can take a long time. The infrastructures must be identified and mapped systematically which should lead to the determination of a spatial/technical profile of an area. Then, spatial and infrastructural plans can be made, preferably using the knowledge of the inhabitants. Instruments include urban development plans, area development plans, and plans for the improvement of technical infrastructure with a corresponding strategy for co-funding. The local government and the utilities are the main co-actors. They have both their public infrastructure management systems, which need to be geared to one another, to come to co-dependent infrastructure management systems. Developing such systems is therefore a scientific, technical and political challenge. On the city level it can be done with systems and models for decision making on maintenance and management of individual infrastructures. Below I mention two cities, to show the importance of infrastructure and service policies and practices.

The city of León, Nicaragua (200,000 inhabitants) has a traditional sewer system with pipes in the historical city leading towards a liquid field. In urban expansions from 1980 to 2000 the sewer system was not expanded and households had to choose between latrines and septic tanks. In the south-eastern urban expansion part of the city an advanced sewer system was developed after 2006, but this serves only the district. Consequently, this city needs urgently a better municipal sewer (management) system. The question here is: Are the future solutions individual or collective, and on which level of planning are they? The city of Medellin, Colombia (2.45 million inhabitants) has a more advanced sewer system with treatment plants for domestic waste water. Furthermore, it has a several adequate infrastructures and services, including a high-quality metropolitan transport system with additional cable car tracks, and an advanced system for separate waste collection. Both systems are becoming active in informal areas too [24] (Figures 4 and 5).

Mukherjee et al. [25] introduced an integrative network-based approach to modelling co-dependent infrastructure systems and simulations. It has been used on a city and district level in the USA, on crucial urban infrastructures, and in areas affected by severe flooding along the Mississippi River. These systems can be used in cities in developing countries too, in order to provide adequate facility system management, such as sewer collection systems and solid waste management. Each system needs its own specialized plan

and programme. On the level of neighbourhoods and districts, it is better to have integrative descriptions and management of all technical infrastructures and services within the framework of an integrated area improvement plan. However, facility system management will be necessary here also.

### Final remarks on urban planning

Sustainable spatial planning can also anticipate the effects of climate changes and of possible natural disasters, such as earthquakes and volcanic eruptions. In earthquake-prone regions, houses must be built to be earthquake resistant. One must prevent new residential zones from being built in areas threatened by rising sea levels, flooding by rivers, extreme storms and heavy rainfall. Existing urban areas can sometimes be protected against floods, for example by building dikes. Heavy downpours must be collected temporarily in reservoirs or ponds, and there should be a drainage system. For each region, all threats – and chances - of a disaster must be taken into account. This leads to the establishment of spatial zoning in local planning instruments. Safety for residents and businesses must always come first. Local government plans also include regulations for the construction of houses and other buildings. In some areas, homes are built on stilts, for example in the Mekong Delta in Vietnam [26]. One can also find floating homes there. In other areas, houses must be able to resist severe storms or earthquakes. This means extra technical requirements and costs regarding building structures and materials.

It is challenging to introduce participatory urban planning and management as a precondition for sustainable, low-cost housing. Planners, architects, civil engineers, and other specialists – including young professionals and aid workers – can develop new ways of operating within integral planning processes.

### Sustainable housing, measures and costs

While the costs related to sustainable house construction vary from country to country and region to region, the prices of housing plots are generally higher in metropolitan areas. If families can obtain subsidies or donations, the costs for them are lower. Simple housing is priced between US\$ 1,000 and US\$ 10,000 for a plot. Including the costs of building materials, labour and land, a decent house on a small plot may fetch roughly US\$ 10,000. However, in large cities the plot of land alone can cost US\$ 10,000 or more, which is a very large investment for a poor household. In this case, if very low-income households have to pay for instance more than US\$ 100 monthly, one cannot speak of affordable housing. Such a costly monthly payment is a burden for hundreds of millions of families. Sustainable house building depends on local climate conditions (such as tropical, subtropical, continental, etc.). Sullivan and Ward [27] have explored potential ways in which contemporary sustainable housing applications and their costs may be integrated into the existing housing stock in low-income and informal settlements in the United States and Latin-America. They document a range of sustainable housing applications as a baseline for discussion and evaluation of the potential application to lower-income segments of the housing market in both developed and developing countries. A fundamental barrier to sustainability in these communities is usually poverty. In Table 1, intervention categories are presented. Source: Author's compilation from Bredenoord & Van Lindert [4] and Sullivan & Ward [27].

Every climate and urban situation has its particular potential and limitations. Policies for (social) housing might contain specific points of departure for sustainable housing applicable in a certain region. Sustainability aspects of housing are highlighted and discussed in

Type or quality indication of the house	Examples of measures; (partly derived from Sullivan and Ward, 2012)	Level of costs of measures for sustainability (acc. to the author)	Applicable to low-cost housing
(I) Plot and core house or starter house	Day lighting, Solar bottle bulbs Natural ventilation (TRO) Shading with trees	Very cheap	Applicable at all times
(II) Small family house	Energy-saving bulbs Simple water-sparing measures Foil/reflective film in windows	Cheap	Applicable at all times
(III) Small family house enlarged	Weather-stripping (cold climates) Overhang and/or house orientation (tropical/ resp. cold climate)	Rather cheap	Applicable
(IV) Family house enlarged	Composting toilet Foam/Rigid board insulation Mechanical shading devices	Relatively expensive	In the tropics (comfort); in cold climates (lowering heating costs)
(V) Family house up to middle class	Loose fill insulation Solar assisted composting toilet Simple septic tank	Expensive	Recommendable in continental climates
(VI) Family house middle class	Comprehensive passive solar design Rooftop P/V system New septic system	Very expensive	Too expensive for low-cost housing in initial phase

Table 1: Scope of sustainable interventions related to low-cost housing.

various recent reference books of UN-Habitat [28,29,30]. At the state level, one can find interesting policy documents on sustainable housing, such as 'Sustainable Housing in Mexico' [31] is quite promising. Kessler [32] discusses an array of activities in which self-help actions and community participation can play significant roles. He states that the use of new building materials might stimulate the climate-friendly industry, which minimizes the amount of energy consumed in the manufacturing of building materials. Below is a compilation of measures to be taken at different levels: urban planning, house construction and human behaviour. This overview indicates possible technical demands, but it is not comprehensive. It must be said that each climatic circumstance demands its own sustainability measures and technical features for house construction.

Measures concerning the location of housing and urban development aspects

- Ventilating and insulating as well as backward sun-orientation of houses in tropical climates
- Using passive solar energy and insulation of 'back' at north orientation
- Orientating building such that heat-islands in tropical climates will be minimized
- Making possible the assembly of solar panels and collectors on roofs later
- Designing for tree-lined streets in order to lower environmental temperatures
- Designing for neighbourhood parks, playing grounds and footpaths for community leisure

- Designing adequately-sized housing plots (not too big or too small)
- Designing individual sanitation solutions that are environmentally acceptable
- Using septic tanks or a collective sewer solution for urban situations
- Building homes around collective courtyards to stimulate community interaction
- Designing city gardens for leisure and growing vegetables
- Designing houses with space for commerce and workshops and connections to main roads

#### Measures concerning house construction

- Using reliable, local construction materials
- Insulating walls and roofing; this will increase costs in a continental climate
- Using natural ventilation in the house; this will lower costs cooling in the tropics
- Overhanging roofs by way of verandas
- Painting outside walls with reflective paint and installing reflective window film
- Using small-scale solar panels and/or collectors; this can be effective, but expensive
- Using comprehensive passive solar design in moderate sea and continental climates
- Using strategic shading of trees and plants in tropical climates
- Using locally-produced and recyclable building materials

#### Measures within the dwelling, connected to human behaviour

- Using day lighting and energy-saving bulbs; solar bottle bulbs are particularly inexpensive
- Weather-stripping houses in moderate coastal and continental climates is relatively inexpensive
- Insulating houses in both moderate coastal and continental climates is expensive, but cost-effective at reducing heating costs
- Cooking with gas instead of wood; costs of gas and gas cylinder

- Using solar cookers; often practiced in Africa, this is very cost-effective
- Using water-saving measures in showers and toilets

### Sustainable building materials

Usually, conventional building materials such as iron, cement and concrete are not produced in sustainable ways. The production and transport of such materials lead to relatively high levels of greenhouse gas emission. Alternatively, there are also locally produced and used building materials that do not cause substantial CO<sub>2</sub> emissions. Moreover, they create local employment and promote local craftsmanship, which can be truly sustainable. This section discusses some examples of sustainable building materials including bamboo and wood, as well as earth and adobe blocks. With these materials, new technologies based on traditional building methods can be developed for the production of housing that at the same time is sustainable and affordable for the urban poor.

**Bamboo and wood:** Bamboo is a very promising building material for house construction. In various countries in Latin America and Asia, bamboo housing is a mainly rural phenomenon, based on local production and processing of the raw material [33-37]. If bamboo housing were to also become accepted by city dwellers, there would be a need to develop bamboo plantations that might provide the urban housing markets with bamboo for construction. Based on a bamboo housing study for Guayaquil, Ecuador, architect Simon Velez calls bamboo 'vegetable steel' [38]; however, "... gradually after the site has been hardened, the squatters' house is transformed into a concrete house". This is because the residents eventually prefer a house built with bricks (brick houses have higher status than bamboo houses; many households say that bamboo is 'the poor man's construction material'). Although so far the use of bamboo as a construction material in urban settlements is still limited. But the material is durable and can even be earthquake resistant. Technological improvements are possible as can be seen with new corner joints (Figure 6). Bamboo can be used for many purposes, such as for dividing walls, floors, ceilings, roofs, pillars, and window frames. It is also used on construction sites as scaffoldings [39]. The use of bamboo as a major construction material in dense urban areas, however, is not to be expected.

Using wood in house construction is comparable to using bamboo, but it is easier to handle. The use of wood in construction is also customary worldwide. Although wood is a very good construction material, it is not always locally available. One must take into account transportation costs and the re-planting of trees in the area where the wood was harvested. The use of wood as a building material can be ecologically responsible only if the trees are replanted.

**Compressed Earth Blocks:** Traditional building materials such as loam and adobe can be used in new ways, such as with uniform rectangular Compressed Earth Blocks (CEB) and the Interlocking Stabilized Soil Block (ISSB) system. In both systems the use of cement is minimized. As a professional mix-preparation is necessary, a field-lab and training of the labour force are required. ISSB blocks are used for the construction of buildings, latrines, septic tanks and water tanks [40]. Appropriate earth technologies are being used e.g. in Uganda, Mexico and India. Due to their huge mass, walls made from CEB have excellent thermal performance, reducing heating and cooling costs. If constructed well, buildings made with CEB can be sustainable and durable. This implies that technological improvements can be used small-scale and at the local level, potentially contributing to local



Figure 6: New bamboo corner joints suitable for housing.



Figure 7: Members housing cooperative 'Juntando Manos' in León, Nicaragua.

economic development.

**Adobe blocks:** Adobe bricks are made from a mixture of clay-based soil, straw and water. Wet adobe is formed into bricks and then laid out to dry in the sun for several days. They are used for the construction of walls, with wet adobe serving as the mortar. Methods of construction vary considerably by climate. Most homes have a thin coating of adobe on the outside to create a smooth surface, which can be painted. Adobe is applicable in rural areas but in urbanizing areas – with higher densities – the use of this sustainable material is usually not appropriate.

The applicability of the above-mentioned building materials in urban settings where the majority of the world's population will live in the future demands more attention. Currently, the use of such sustainable and affordable construction materials in high-density urban areas is not very common. Despite the advantages outlined above, city-dwellers do not want to live in houses that in their perception may consist of modest building materials. Therefore, there are probably far more opportunities for the application of the described sustainable building materials in rural areas, villages and small towns than in dense cities.

## Social sustainability and housing

The development of new urban residential areas is an organizational and technical challenge and new residents must be involved in planning and housing issues as soon as possible. Social sustainability is also an issue in existing settlements and urban neighbourhoods and governments should facilitate the establishment of durable, self-reliant communities. Self-reliant, local communities make eventually fewer claims on public forms of support and governments should make use of the power of local communities and support them where necessary. Community potential has been recognized by the World Bank, whereby community-based organizations (CBOs) are included in projects and residents are seen as the most important stakeholders in living and working areas. Until 2010 international institutions such as UN-Habitat, the World Bank and Cities Alliance were mainly focusing on the improvement of slums – neighbourhoods – which meant for example improving roads, sewerage, parks and playgrounds. A good example is the extensive and successful Kampung Improvement Program in Indonesia, which was supported by the UNDP/World Bank. This program focused exclusively on the improvement of the living environment (scaling up of upgrading through participatory development), while house building was seen as an individual responsibility of individual households. Since 2010, however, these international aid organizations have broadened their focus and are working on new policies, including those that facilitate individual and collective construction of homes. One of their priorities

is the encouragement and facilitation of self-help incremental housing. This is because aid organizations have seen that this is an important housing production method of the urban poor. Of course this shift in focus also concerns sustainability goals such as the production and application of sustainable and durable building materials and building techniques.

Private construction activities are usually paid for out of the household's own savings or with family loans. Residents need to receive financial support with the incremental house construction from family members and friends [4]. If there is a collective method of residential building, (future) residents will join together and help each other. This may then lead to the establishment of housing cooperatives whereby a group of residents collectively builds a housing project. The interests of the residents determine how the homes are built, e.g. by contracting out the entire work, or by carrying out a part of the construction themselves in order to save on labour costs. While housing cooperatives have no fixed organizational form, they may be tied to national legislation [41]. Cooperatives can also be set up for other (economic) activities, such as trade, services, transportation, production, etc. In recent years much attention has been placed on cooperatives; 2012 was even the International Year of Cooperatives, supported by the United Nations. There are also 'save and build groups', a comparable cooperative concept successfully promoted by the NGO Habitat for Humanity, as well as housing cooperatives that work with common ownership of land and homes, and housing cooperatives that work with individually-owned properties (Figure 7).

Cooperative organizational models and community-based organizations go along with the development of local communities. All are usually organized for the promotion of the neighbourhood's interests; forms can co-exist and its interests may overlap. Thus, mutual cooperation concerning residential building leads to social cohesion. Nevertheless, organizational, legal and technical knowledge is required. This knowledge is often not available within newly established groups of residents. Therefore local governments and NGOs often support the establishment and capacity development of cooperatives.

Social development may help improve the quality of housing and the environment, and leads to a motivated demand for technical and organizational knowledge and support for sustainable house building. In the past, assistance for self-help housing was given, namely with the provision of plots prepared for individual house construction, via 'sites-and-services programmes'. Other forms of assistance included loans with pay-off arrangements, assistance regarding construction plans and building permits, assistance with the purchase of building materials, and technical supervision.

## Conclusion

This paper focuses on aspects of sustainable urban housing, with special attention to affordable housing for low-income households. The combination of realizing 'affordable housing for (and by) the urban poor' and the 'need for sustainable urban house construction' is not easy. In many less developed countries the ability of institutional housing programmes to provide adequate housing for the urban poor is still very limited. In other countries institutional housing delivery capacity is entirely lacking and households have to build, expand and improve their houses themselves, or have it done by others, which is called self-managed incremental housing. This lack of capacity can lead continuously towards (the growth of) informal self-help settlements with self-help house building and home improvement, which is still and probably will continue to be the norm [27].

Some sustainable applications and measures for affordable housing are achievable for low-income households, but sustainability issues are not yet central to the decision-making of the poor. In this paper I have argued that low-income households can contribute to sustainable urban development and housing, provided that the right conditions are met. For example, there must be adequate urban planning, households and local communities must gain the appropriate knowledge and skills, and sustainable building materials must be made available. If assisted self-help housing and training programmes for self-builders become available, the use of sustainable building materials and applications can be stimulated and guided on the building sites.

It is crucial to involve the local communities when sustainable construction techniques and building materials are being applied. Firstly the objective of such applications should be improving the living environment in neighbourhoods (e.g. slums) partly through cooperation between a local authority and a residents' group. Secondly, there is the individual or collective house building itself, which demands other forms of cooperation between households and aid organizations. Households often build their houses themselves, involving family members, or build collectively, mostly in small groups, possibly known as housing cooperatives. Technical, organizational and financial assistance can be provided to these households by the local government, NGOs and in some cases by corporations, for example producers and sellers of building materials. As it is much more efficient to provide technical assistance for house construction and improvement to small cooperatives and/or family groups, this is preferred over working with (many) individual households. Therefore social organization is important. The local government and NGOs can promote the fact that technical assistance can be very beneficial for individual households and for cooperatives. Assistance for self-help housing, however, is not present in all regions and countries. Eventually the level of community building and mutual cooperation will significantly determine to what extent the habitat and housing is actually upgraded.

Adequate urban planning is indispensable for steering and facilitating sustainable housing. Local governments in particular have responsibilities toward this end, for example through their planning instruments, incentives for sustainable housing and attempts at organizing a stakeholder approach. The question is whether local authorities are properly equipped for their tasks regarding sustainable housing. The author suggests that further development of facility system management on urban infrastructures, such as roads, drainage, sewerage, drinking water, electricity provision is necessary and possible. Linkages between cities (North to South) can help transfer knowledge on co-dependent infrastructure systems. This can be done on two levels: the city level and the district/neighbourhood level.

Other local actors, such as NGOs and private organizations, can help develop knowledge on sustainable house building and sustainable building materials among individual households and groups of residents. The establishment of housing cooperatives in numerous countries is promising, but so far cooperatives have not been developed on a large scale.

The use of sustainable and locally suitable building materials, such as bamboo, wood, compressed earth blocks and adobe blocks can be very promising concerning sustainability. Local building traditions must be combined with new low-tech and low-cost technologies. In general, people do not want to use building materials that are associated with poverty. Due to availability and affordability, the building of houses with cement blocks is widely accepted. When using concrete blocks, one should try to produce the blocks locally, with local materials

and local labour. It seems that bringing traditional building methods and new technologies and insights to cities is far from easy. Household involvement with sustainable house construction demands transference of knowledge and the introduction of additional new technologies.

Social sustainability in housing is of utmost importance and demands at least four measures: first, the involvement of residents in housing and urban development projects; second, the stimulation and facilitation of community-based initiatives; third, the involvement of community-based organizations with respect to the improvement of neighbourhood living conditions; and fourth, the establishment of save-and-build groups and housing cooperatives.

## References

1. UN (2012) World Urbanization Prospects. The 2011 Revision. Highlight, New York. UN Department of Economics and Social Affairs, Population Division.
2. Greene M, Rojas E (2008) Incremental construction: a strategy to facilitate access to housing. *Environment and Urbanization* 20: 89-108.
3. Wakely P, Riley E (2011) The case for incremental housing. Cities Alliance Policy Research and Working, Alliance, Washington DC, USA.
4. Bredenoord J, van Lindert P (2010) Pro-poor housing policies: Rethinking the potential of assisted self-help housing. *Habitat International* 34: 278-288.
5. Bredenoord J, van Lindert P (2014) Backing the self-builders; assisted self-help housing as a sustainable housing provision strategy. In: Bredenoord J, van Lindert P and Smets P (eds.) *Affordable Housing in the Urban Global South, seeking sustainable solutions*. London / New York: Routledge.
6. Connolly P (2006) Housing policy or policy construction? In: *Housing in Mexico: building analysis and proposals*. Mexico City: Center for Social Studies and Public Opinion. Chamber of Deputies / SIX Legislatura.
7. Ergüden S (2001) Low-cost Housing: Policies and Constraints in developing Countries. International Conference on Spatial Information for Sustainable Development. Nairobi, Kenya: 2-5.
8. Choguill C (1999) Sustainable human settlements: Some second thoughts. In: Foo AF and B Yuen (eds.) *Sustainable cities in the 21st century* pp: 131-142.
9. Choguill CL (2006) The search for policies to support sustainable housing. *Habitat International*: 143-149.
10. UN-Habitat (2005) *Financing urban shelter, global report on human settlements*. Earthscan, London.
11. Ebsen C, Rambøll B (2000) International review of sustainable low-cost housing projects. Aarhus, Denmark: Danish International Human Settlements Service.
12. Chen Q, Glicksman L, Lin J, Scott A (2007) Sustainable Urban Housing in China. *Journal of Harbin Institute of Technology* 14s: 6-9.
13. Miranda L (2009) Promoting Sustainable Construction in Peru, in: *Contributions to Sustainable construction in Peru*. Lima: Cities for Life Forum.
14. Burgess R (2004) The Compact City Debate: A Global Perspective. In: M. Jenks and R. Burgess (eds.) *Compact Cities: Sustainable Urban Forms for Developing Countries*. London: Taylor & Francis.
15. Aravena A, Iacobelli A (2012) *ELEMENTAL; Manual de Vivienda Incremental y Diseño Participativo*. Ostfildern, Germany: Hatje Cantz Verlag.
16. Harper C, Portugal V, Shaikley C (2013) Incremental expansion: examining user-initiated transformations in government housing in Manaus.
17. Kowaltowski D, Pina S, Ruschel R, Labaki L, Bertolli S (2005) A house design assistance program for the self-building process of the region of Campinas, Brazil: Evaluation through a case study. *Habitat International* 29: 95-111.
18. Ismail A (2011) The Technical Training Resource Centre (TTRC): building community architects. *Environment and Urbanization* 23: 183-193.
19. Valladares A (2013) The community architect program: implementing participation-in-design to improve housing conditions in Cuba. *Habitat International* 38: 18-24.
20. Kropman N, Dubbeling M (2013) Integrating urban Communities for sustainable cities, Young Planning Professionals Workshop (YPP) of the International



- Society of City and Regional Planners (ISOCARP), 46<sup>th</sup> ISOCARP Planning Congress, pp 12-40. Nairobi: ISOCARP.
21. SDI (2012) Community Planning Studios Programme. Malawi Studios.
  22. Beukes A (2014) Know Your City: community profiling of informal settlements. In IIED Briefing.
  23. ACTogether (2012) Jinja slums: Enumeration report 2012. Kampala: ACTogether.
  24. The Metropolitan Area of the Aburrá Valley (2008) Guide to the Integrated Waste Management. Medellín.. Medellín.
  25. Mukherjee A, Johnson D, Jin Y, Kieckhafer R (2010) Using Situational Simulations to Support decision Making in Co-dependent Infrastructure Systems. International Journal of Critical Infrastructure 6: 52-72.
  26. Janssen J, van Keulen W (2015) Living with the Mekong. Climate change and urban development in Ho Chi Min City and the Mekong Delta. Wageningen: Uitgeverij Blauwdruk.
  27. Sullivan E, Ward PM (2012) Sustainable Housing Applications and Policies for Low-income Self-Build and Housing Rehab. Habitat International 36: 312-323.
  28. Golubchikov O, Badyina A (2012) Sustainable Housing for Sustainable Cities, A Policy Framework for Developing Countries. Nairobi: UN-Habitat.
  29. Hannula E, Lalande C (2012) Going Green: A handbook of Sustainable Housing Practices in developing countries. Nairobi: UN-Habitat.
  30. Majale M (2012) Enabling Shelter strategies: design and implementation guide for policy makers. Quick Policy Nairobi: UN-Habitat.
  31. Federal Government of Mexico (2011) Sustainable Housing in Mexico. Mexico City: SHF, INFONAVIT and CONAVI.
  32. Kessler E (2014) The resilience of self-built housing to natural hazards. In: Bredenoord J, Van Lindert P and Smets P (eds.) Affordable Housing in the Urban Global South, seeking sustainable solutions. Routledge, London / New York.
  33. Gutiérrez J (2000) Structural Adequacy of Traditional Bamboo Housing in Latin America. National Laboratory for Materials and Structural Models, Civil Engineering Department, University of Costa Rica.
  34. INBAR, International Network for Bamboo and Rattan. Bamboo in construction, an introduction. Webpage INBAR.
  35. Rodríguez N, Dill W, Bidegaray P, Botero R (2006) Utilización del Bambú, como una Alternativa Sostenible de Construcción de Viviendas en la Zona Atlántica de Costa Rica. Tierra Tropical 2: 77-85.
  36. Janssen J (2000) Designing and Building with Bamboo. Eindhoven, Netherlands: Technical University. Webpage INBAR.
  37. De Vries S (2002) Bamboo Construction Technology for Housing in Bangladesh. Opportunities and constraints of applying Latin American bamboo construction technologies for housing in selected rural villages of the Chittagong hill Tracts, Bangladesh. (M.Sc-thesis) Eindhoven, Netherlands. University of Technology.
  38. Livingston M (2009) Bamboo housing and the Mangrove of Guayaquil. Tennessee: Institute of tropical architecture, University of Tennessee.
  39. SICCMA (2011) Sustainable Building Practices for Low Cost Housing. Implications for Climate Change Mitigation and Adaptation in Developing Countries. Nairobi: UN-Habitat.
  40. Pérez-Peña AM (2009) With UN-Habitat. Interlocking Stabilized Soil Blocks. Appropriate earth technologies in Uganda. Nairobi, Kenya.
  41. Ganapati S (2014) Housing cooperatives in the developing world. In: Bredenoord J, Van Lindert P and Smets P (eds.) Affordable Housing in the Urban Global South. Seeking Sustainable Solution, London: Earthscan/ Routledge: 102-116.

**Citation:** Bredenoord J (2016) Sustainable Housing and Building Materials for Low-income Households. J Archit Eng Tech 5: 158. doi:[10.4172/2168-9717.1000158](https://doi.org/10.4172/2168-9717.1000158)

### OMICS International: Publication Benefits & Features

#### Unique features:

- Increased global visibility of articles through worldwide distribution and indexing
- Showcasing recent research output in a timely and updated manner
- Special issues on the current trends of scientific research

#### Special features:

- 700 Open Access Journals
- 50,000 editorial team
- Indexing at major indexing services
- Rapid review process
- Quality and quick editorial, review and publication processing
- Indexing at PubMed (partial), Scopus, DOAJ, EBSCO, Index Copernicus and Google Scholar etc
- Sharing Option: Social Networking Enabled
- Authors, Reviewers and Editors rewarded with online Scientific Credits
- Better discount for your subsequent articles

Submit your manuscript at: <http://www.omicsonline.org/submission/>