



Indicator based sustainability assessment tool for affordable housing construction technologies

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ABSTRACT

With the growing worldwide demand for affordable housing and the importance of supporting and stimulating sustainable development, the need for sustainable solutions in the affordable housing sector is at a peak. The present paper screened about 75 construction technologies and assessed 46 of them. The present paper presents the first results of a step wise approach to identify, assess and recommend most promising technologies for affordable housing projects. A database was developed to store detailed technical information about each of the technologies. A grading and ranking scheme was developed to identify the most promising construction technologies from a sustainability perspective. The main challenges for affordable housing production and most relevant assessment indicators were identified from the literature, interviews and meetings with experts. An indicator based assessment system was developed by cross-referencing the identified eight challenges with ten selected indicators. The final ranking demonstrated that a wide variety of technologies perform strongly overall, and these range from bio-based materials, such as bamboo and timber, to industrialized technologies, such as concrete. Moreover, the possibilities for improvement are vast, and the option of combining different technologies seems to be the most promising approach.

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1. Introduction

Housing is one of the most basic human needs and is a key component in the sustainable development of a community (Dumreicher and Kolb, 2008). In general, sustainable development is divided into three interacting sectors: economic, environmental, and social (Keiner, 2005). From a social perspective, housing not only offers shelter but also gives a sense of a secure future and strengthens local communities (Arman et al., 2009). On the other hand, the housing sector is responsible for a great deal of greenhouse gas emissions, energy and material use, waste production, and changes in land-use dynamics (U.E. UN Habitat, 2008). Finally, from an economic perspective, houses are among the major investments that people make in their lifetimes (Maliene and Malys, 2009), and the housing sector is related to 10% of the global gross domestic product and 7% of global jobs (UN Habitat, 2009).

The worldwide demand for affordable housing has grown in recent decades and is expected to continue to grow (Wood, 2007). Moreover, the affordable housing sector has been regarded as one of the less penetrated markets by private companies (World Bank,

2006). Thus, the affordable housing sector provides a wide range of opportunities for development along with a series of challenges to be overcome (Wherever, 2008). Several challenges to affordable housing have been put forth in the literature. The following eight are highlighted as key challenges: scarcity of resources; lack of sufficient funds; shortage due to urgency of demand; shortage of skilled labour; quality control; wastage due to inefficiency; lack of added value creation; and quality and location.

Due to the inherent complexity of the affordable housing problem, it was proposed to have a step wise approach. The first step, from which this paper presents the results, comprehends three parts, first a global screening of construction technologies used in affordable housing programs; second the development of an indicator based assessment system; and third a technology's assessment and ranking. Further steps will consider the development of life cycle assessments for most promising technologies, considering local factors. The final step will be a final selection process, carried out with specific communities and organizations interested in developing affordable and sustainable housing projects, to finalize with its implementation in form of a pilot project. Therefore, the goal of this paper is to identify construction technologies that will be able to sustainably provide shelter to low and lowest income communities in urban areas of emerging economies countries. To identify these technologies an indicator based assessment system was developed. The indicators can be clustered into the three main categories identified by the World Commission

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on Environment and Development: Economic, Environmental and Societal (W.C.o.E.a.D., 1987). The highest-ranking technologies are presented and studied in detail in Section 6 of this paper.

1.1. The definition of affordable housing

The concept of affordable housing is diverse and complex but can be generally described in economic terms (Wherever, 2008). An affordable house can be defined as a house that a family group can acquire within a given period, which generally ranges from 15 to 30 years. This period is directly connected to the acquisition capacity of the group and the financial support that they can obtain in terms of loans, credits and subsidies (UN Habitat, 2009). Because an affordable house is such a long-term investment, it should provide added value to its owners in terms of comfort, quality and lifespan (Jenkins et al., 2007). In this sense, affordable housing, as discussed in this paper, is different from the concept of relief shelter and considers the social effects of long-term habitation. Affordable housing is defined in this paper as housing that costs less than 200 USD/m² to produce, including the costs associated with construction and finishing details.

1.2. The need for sustainable affordable housing

When analysing global development scenarios, the building sector is obviously of high social and economic importance in developing and the least-developed countries. The tendency towards urbanization in these countries is well documented, and it is expected that 70% of the world's population will be living in cities by 2050 (World Bank, 2006). This trend is primarily driven by the perception of cities as centres of wealth and prosperity that attract people from rural areas in search of better futures (Dumreicher and Kolb, 2008).

This increase in the global urban population will inevitably result in a very sharp increase in the demand for housing. Unfortunately, the current housing sector cannot cope with the demand for living space (Jenkins et al., 2007). This gap between demand and supply creates a very complex problem, driving the housing sector towards less efficient and more-expensive solutions and new city dwellers towards informal (and often illegal) independent construction of dwellings (Arman et al., 2009). Independent construction has become a widespread phenomenon in emerging economy countries. It has driven a corresponding sense of urgency to develop socially responsible housing solutions (Erguden, 2001) that do not unnecessarily impact the environment and that can be acquired by low-income family groups in a reasonable period.

The building sector is regarded by many authors as the primary consumer of resources and energy in the modern environment (Kavgic et al., 2010). Therefore, it is of great importance to develop technologies to reduce negative environmental impacts and to assess (Ali and Al Nsairat, 2009) the potential and performance of traditional and novel ideas. Furthermore, the development of sustainable housing projects should aim to reduce the energy and material flows in their whole life cycle, starting on its planning and design phases, considering their construction and use and their final renovation or demolition (Arslan, 2007). To identify the best solution, a consistent set of indicators must be developed (Yao, 2005) that encompass all the aspects of sustainability. Furthermore, the assessment of sustainable construction technologies and solutions requires the development of comparison schemes and benchmarks that will highlight the challenges and opportunities (Monahan and Powell, 2011) of each technology.

1.3. Key challenges of affordable housing

The development of affordable housing project as is in itself a very complex challenge. The first step in the technologies

assessment process was to identify, which are the main challenges for the execution of such projects. These challenges were identified on the literature and through interviews with organizations like UN habitat, HILTI Foundation and UNESCAP. The proposed challenges do not claim to show the whole variety of difficulties that can occur when providing newly constructed affordable houses but to highlight the most commonly occurring. The identified challenges were used to configure a matrix that relates the main challenges with the proposed indicators. The challenges are described on the following sections.

1.3.1. Scarcity of resources

The consumption of resources increases tremendously by the rapid urban growth and changing living standards in emerging economies. Already today shrinking resources and upcoming scarcities are a main issue. In case of the housing deficit this challenge means to look favourably upon the improvement of existing methods and the establishment of innovative technologies acting as drivers for higher efficiency or resource substitution. Financial and technical capabilities of municipalities have to be strengthened and private sector has to serve all income groups. From the construction point of view this means: producing good quality construction materials, increasing its efficiency and reducing its embodied energy.

1.3.2. Lack of sufficient funds

The income of households in vulnerable conditions and/or informal settlements is usually one of the lowest on given countries. The marginal income of the target group has to be considered as a key limitation when thinking about construction technologies. Even though this project intends to highlight technologies that are able to produce sound results over the whole life cycle, the initial construction costs are a key driver for the implementation of a concept for this market segment. Being cost efficient is therefore assessed as key challenge for all technologies presented in this research. As the income is typically not only low but also irregular, the credibility of the dwellers is predominantly insufficient for the loan taking procedure in conventional credit institutes.

1.3.3. Time shortage due to urgency of demand

The rapid urban growth asks for fast solutions however the huge housing demand requires large volumes to be managed. Bureaucratic and legal burdens frequently lead to longer time spans than needed. A clear lack of effective implementation strategies is a major challenge that has to be tackled by the improvement of the interface between policy instruments and reality. A lot has been done in policy framework but its implementations is still lacking behind.

1.3.4. Shortage of skilled labour

One important role of housing production is the generation of new jobs, particularly for unskilled labour. Thus, technologies that require a high skill level will face significant problem in finding skilled and trained works among the members of the target communities. Thus, technologies that require the lowest level of both skill and training will have priority.

1.3.5. Quality control

Beside the significantly difficult access to finance funds, the quality of the final products is one of the most relevant challenges. It does not only affect the performance of the house but also its technical useful life. Thus, is of great relevance to control and assure the quality of materials, and end products as well as the proper utilization on site.

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