Appropriateness is a moving target
The re-invention of local construction technologies and materials in Ethiopia

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Abstract

Urbanization is a generally positive factor in overall poverty reduction but it needs careful urban planning and innovative housing design that makes better use of local resources and practices. Efforts to do so have largely failed in the fast growing cities of Africa. Rather than enhancing the value of existing local resources and practices by combining them with innovative new designs and technologies, governments tend to prefer foreign contractors that import most of their materials to construct energy-intensive and expensive high-rise buildings. This paper uses the case of the SUDU (Sustainable Urban Dwelling Unit) to illustrate how things could be done differently in the case of Addis Ababa.

1. Introduction

Africa is urbanizing faster than any other continent and, at the same time, it is least prepared to accommodate the large number of new residents that arrive every year. This is particularly true for Ethiopia and its capital Addis Ababa [1, 2].

Ethiopia will be confronted with an additional 45 million people within the next 15 years with the basic needs of food, water, safety, and also shelter in not yet existing, or already overstressed, mostly urban settlements. The decades to come will certainly be formative in the further long-term development of the country. Given this challenge, Ethiopia has to invent its own modes of 21st century urbanization rather than relying on outdated models of the so-called developed world. It has to re-invent its indigenous building methods, construction technologies, material use and reduce its dependence on imported materials, if it wants to escape its satellization role in the process of economic globalization [3].

What are the methods, instruments, and ideas that will be needed to structure the necessary development? The capital of Ethiopia, Addis Ababa, is a dynamic urban large-scale laboratory where urban phenomena of growth, expansion, and densification can be experienced and investigated first hand.

Currently, with a population of around 2.8 million people, and 78 ethnic groups, Addis Ababa is the undisputed metropolis of the country. This will remain so for the coming years, as experts predict the population will reach 6 to 8 million people by 2025. So far the city is ill-prepared for this looming migration from the rural areas. Most crucial questions related to urban density, care, safety, social coherence, economic development, and, above all, ecology are hardly addressed. Appropriate building materials and techniques, local participation in the design and implementation of new urban settlements and a supportive urban infrastructure are of crucial importance. Yet, newer developments in Addis Ababa show the contrary: it has been infected with the so-called 'Dubai Fever'. It is the desire to copy or import an image of economic growth and link it with political power. Glass and steel towers are a manifestation for this development and are meant to give a modern look to the city [3].

2. The Dubai Fever

The Dubai Fever, manifested in seductive flashy high-gloss magazines, reached all African cities and with it also Addis Ababa. A city, where more than 60% of the population lives below the poverty line and where power cuts are the rule rather than the exception. The copy and paste of architectural role models brings huge problems with it. Instead of using locally available material, more than 80% of construction material in Ethiopia is imported, mostly from East Asia like cement steel and glass. Capital and foreign currency, which would otherwise be needed to invest in the sustainable growth of local markets, is spent for foreign contractors, mostly keeping the country out of the value chain process. Most big construction sites are run and managed by foreign experts, Ethiopians are mostly seen in lower daily laborer ranks.

But the glass towers have also a big impact on the energy consumption of the city and with it on the ecological footprint of the whole country. Instead of designing and building in accordance with the ideal climatic conditions, which fall between 10° Celsius minimum and 30° Celsius maximum, the glass facades require technical cooling systems, using one of the goods Ethiopia doesn't have in abundance: energy [3].

3. The Grand Housing Project

Ethiopia needs to develop regulations and visions, on how to make better use of its rich culture and its reliable resources such as natural stones, loam brick technology or rammed earth techniques. The population increase of 20% over the last decade in Addis Ababa has dramatically shown the need for such a reconsideration of locally available techniques and materials, next to imported design and construction models. As a first "solution" for the desolate housing situation, the Low Cost Housing Technology (LCH) was developed

with German support. In 2002, it was introduced into the local construction sector – with visible results. Over 40,000 accommodation units for approximately 200,000 persons have been built. At the same time, almost 40,000 jobs were created in the local construction sector, which is mostly organised in the form of small business enterprises. Based on the LCH-principle, the government is trying to promote this development with the recently launched "Addis Ababa Grand Housing Program" – an ambitious project aimed at the construction of further 50,000 accommodation units per year until 2014. But again, the construction technologies used for the program are based on a concrete pillar and slab system. Enormous amounts of cement and gravel are used on construction sites, hollow cement blocks are meant to fill the structures. The underlying principles were developed in the re-building period of post-war Germany but can they be applied to Ethiopia or even whole Africa?

4. The cost of ignoring local people and resources

On closer examination, these kinds of measures such as the Grand Housing Project reveal several shortcomings. The much praised top-down strategy of generating houses, infrastructures as well as jobs for the poorest within one individual program and one construction methodology proves to be an economic pseudo-cycle. When the resources of the local economy go mostly into a foreigner-led superheated construction sector, the question must be asked: Who can afford to build these structures in the future, moving from a government owned program to a private one? It would be considerably more promising and sustainable to develop diverse economic and also construction models, which would allow dealing with poverty and infrastructure problems of one's own accord. It would also be preferable to apply techniques and knowledge, which originate from local habits, materials and cultures and not necessarily from a global market. The use of prefabricated cement materials and mass production of them (or rather: mass importation) has been implemented in the production of housing in the Grand Housing Project in order to facilitate and shorten the construction time. However, the construction projects had to face many unpredictable problems such as shortage of materials, improper use of both material and technology, and unskilled manpower that led to very costly delays. These problems are likely to manifest themselves again in the operation and maintenance of the buildings because the local people were just asked to execute orders. They were not involved as experts of local knowledge and materials or trained in how to maintain the buildings.

The use of eucalyptus trees as a support for the formworks, used in the precast beams that hold the ribbed slab blocks and are usually also used as scaffold, were initially seen as a local solution. Yet, it is not a sustainable solution. An average of 800 eucalyptus tree logs were consumed by building a single block of the Grand Housing Project. For the 60,000 housing units completed so far, taking an average of 30 units per block structure, 1.6 million eucalyptus trees have been consumed so far. The large-scale consumption of trees for such purposes is likely to aggravate the already fragile environmental conditions in Ethiopia a country that is struggling against poverty and unpredictable climate change. Here, alternative techniques and methods have to be applied in order to achieve sustainable construction.

5. Integrative Thinking in Building, Architecture and Urban Planning

Sustainability requires an integrative approach that includes various disciplines in the fields of design, construction and urban infrastructure. Ethiopia needs to rethink current tendencies of just copying misleading architectural images from abroad, which increase the country's dependence on imported materials and know-how. There is a need to enhance indigenous construction capabilities and the use of local materials and knowledge to cope with the dramatic need for urban dwelling. This knowledge must be based on an integrative thinking of design, construction, building physics, sociology, energy, ecology and also take into account microeconomic considerations. New methods of low-cost housing and sustainable neighborhood infrastructure and management must be explored. In this context, Ethiopia could even draw from its past interaction with Italy. Streets radiating from grand central buildings are conducive to social exchange and community-building and maybe well in line with existing social habits in Ethiopia. A mixity of ideas and building technologies may offer a chance to better manage community services and tackle traffic problems [4]. There are also many possibilities to combine low-cost housing with existing know-how and resources in the region and build sustainable operating double-story building techniques as they can be found in many African cities. These would allow to double the urban density of the current territory without wasting valuable territories for agricultural land use.

6. The SUDU Project

In the summer months of 2010, the Ethiopian Institute of Architecture, Building Technology and City Development (EiABC), together with the Swiss Federal Institute of Technology in Switzerland (ETH Zurich) started to build on its campus a double-story Sustainable Urban Dwelling Unit (SUDU), based on the current urban conditions and needs. It is used as a show case for integrative thinking and an experimental laboratory to convince decision makers, economists, environmentalists, urban planners and also architects to rethink traditional building methods and social space requirements in order to find new ways to build a city.

For less than 1000 Ethiopian Birs (60 EUR) per square meter, the EiABC constructed a SUDU prototype to illustrate how an integrative design and construction process could work that involves local and foreign experts as well as students from the ETH in Zürich and the EiABC under the umbrella of Addis Ababa University. Students from different backgrounds, cultures and disciplines worked closely together to plan, design and build the project in full scale and experienced first hand the need to listen to

and learn from each other in order to accomplish a joint project successfully. It enabled transdisciplinary and cross -cultural thinking and acting. In addition, it was also a test-run for building-up innovative organizational structures in the field of sustainability at the University of Addis Ababa as well as within ETH Zurich. Under the guidance of ETH Sustainability and the ETH North-South Center several departments at ETH Zurich managed to develop institutional relationships that allow to handle such projects in the future and use the connections to EiABC and Ethiopia for further research activities.

7. Sustainable Urban Dwelling Unit (SUDU)

The need to reduce global emissions, energy consumption, and material waste requires the systematic development of sustainable buildings in large, as well as small scales. Materiality, social space, water management, waste management, energy production and consumption, operation, and maintenance have to be designed and coordinated so that the economic, social and environmental objectives are achieved in the most effective way. In this context, the project served as a first experiment that helped identify the opportunities and challenges associated with the translation of theory into action. Based on the concrete experience with the prototype, performance standards will be established emphasizing innovation and integrated design.

Ethiopia, once called the corn chamber of Africa, has a rich soil, which contains high levels of clay particles. Almost every excavation material in the city of Addis Ababa is a possible source for the material needed to build new structures. The SUDU project used a “rammed earth” technology to construct the first level of the building with a 60cm wide wall structure. With a formwork, which was designed for multiple use, the loam soil is brought in form and densified with small metal rammers. Each layer is 120 cm high and when the first layer of the formwork is filled, the form is lifted up so that filling and ramming can start again. Openings for doors and windows are just speared out. A small ring beam was constructed on top of the last layer, to ensure the structural strength needed to accept the ceiling, done in a specialized technique.

The first ceiling of the SUDU project was done in a tiled vault technique, designed and introduced for the first time in Ethiopia by Prof. Dr. Philippe Block from the ETH Zürich, who gathered some practical experience already in the 2008/09 project for the Mapungubwe Museum in South Africa together with architects Peter Rich and Henry Fagan and John Ochsendorf and Michael Ramage as structural engineers (see article in this ATDF issue). The technique, also known as Guastavino or Catalan vaulting, was introduced already in the end of the 19th century in many public buildings in New York, such as the Central station or City Hall Subway Station. The system was patented in 1885 by the architect Rafael Guastavino. It supports robust, self-supporting arches and vaults using interlocking tiles and layers of mortar to form a thin skin. The tiles are usually set in a herringbone layout with a sandwich of thin layers of Portland cement. Unlike much heavier stone construction, these tile domes or barrel constructions could be built in space without additional support. Each tile cantilevers out over the open space during construction, relying only on a quick drying cement, known as “Plaster of Paris”, produced in Ethiopia. With this technique, no scaffold is needed to construct the ceiling or dome, just a string guide system is used to make sure the form is kept in an ideal structural line.

The second floor of the SUDU project was constructed with loam stone produced in a hand-operated loam stone press, with an output of several hundred stones per day, operated with local know how and work force. The first layer of stone is put in a loam mortar bed enriched by 5% cement, all other layers are just placed on top. This technique also allows for additional structural support if needed by spearing out an internal formwork for small columns, securing the building against lateral forces, since the area around Addis Ababa is seismic active. The argument here is once again, that no additional formwork is needed and a combined technique of interlocking loam stones and a possible pillar structure allows for a heterogeneous construction method, according to location and regional requirements regarding seismic activities.

The roof construction followed again the “Catalan Vaulting” technique, this time covered on top with a special 10cm thick waterproof mortar, produced out of prickly pear cactus juice, salt, lime and loam soil. Since 2008, this method is introduced again by an Ethiopian born artist, Meskerem Assegued in a project in the village of Aslam, near by the city of Dire Dawa, in the very east of Ethiopia. She investigated the technique in Mexico and brought it back to Ethiopia, where she found proof, that it was used for centuries and forgotten over the years. Out of this loss, the inhabitants of the village could not repair their roofs anymore and replaced them over the last decades with corrugated metal sheets, producing unbearable conditions in the overheated homes. Through her project, more and more of the villagers are replacing their roofs again, coming back to the old techniques and traditions. Micro enterprises and know how developed fast in Aslam and it was brought through the SUDU project to Addis Ababa. The technique uses prickly pear cactus, cut in small pieces and let set for 5 days with water in a dark barrel. After this period, the slimy juice is then filtered and mixed with salt, loam and lime, and thus ready for use. The villagers use the juice already to paint all of the exteriors of their homes to seal them against rain and also started a loam stone production, with astonishing results in strength and durability. The plastering of the SUDU project was done in the same technique, easy to handle and to produce, without any imported materials.

In total, SUDU uses only 5% of the cement, which would have been needed compared to a hollow cement block construction as it is the most common construction method right now in Addis Ababa. Local materials such as loam, local know-how and local workers led to a first case study building, which will be used to gather more information and will hopefully lead to its first implementation phase very soon on a larger scale. The project may encourage the

local industries and small-scale enterprises to think more and more about alternative construction methods than concrete. Less than 100 years ago, Ethiopia had the tradition of constructing seven story loam buildings, but almost forgot about it. New technical infrastructures in connection with those traditional methods will help to develop a sustainable construction for future generations, in urban as well as rural conditions. EiABC was already granted another research project to investigate the possibilities to build a rural counterpart commencing in 2011.

The SUDU project represents a catalogue of possibilities, it is a combination of different possible techniques, available and appropriate in Ethiopia. Those appropriate technologies can and will change in Ethiopia over the next decades, when its population will shift from rural to urban. Appropriateness is a moving target and it can only be understood in a certain moment in time. Different regions in Ethiopia have different material resources, which have to be exploited and combined with other, even maybe foreign techniques and technologies. Those heterogeneous technologies could be an answer to one of the most urgent questions in Ethiopia: how to house an additional 45 million people in the next 15 years to come.

A city is maybe one of the most complex systems, human mankind ever came up with. The SUDU project can just be a particle of such a system, but it can enhance the understanding of how urban infrastructure and the quality of materials as well as spaces can lead to a project which is adopted by the people living in it and becomes their own, rooted in their own history and culture.

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