Impacts of Urbanisation in Low-Income Countries

Dick Urban Vestbro

Prof. Emer., School of Architecture and the Built Environment, the Royal Institute of Technology (KTH), SE-10044 Stockholm, Sweden Corresponding author email: dick-urban.vestbro@abe.kth.se

ABSTRACT

The rate of urbanisation is considerably higher in low-income countries than in the industrialised world. The driving forces behind this process include reduced livelihood possibilities in rural areas, man-made and natural disasters, new economic opportunities in urban areas and the fact that children's survival prospects are higher in cities than in rural areas. The paper analyses differences between urbanisation trends in high and low-income countries. In the former countries the special spatial patterns of urbanisation are shown not to be sustainable, while it is found that urbanisation in low-income regions seem to promote economic growth and still fall below the level of acceptable ecological footprint. The paper shows how urbanisation has contributed to high levels of homelessness, the spread of informal settlements and urban sprawl especially in Sub-Saharan Africa. To address these problems it is necessary to understand these phenomena, and the need to shift to the enabling strategy in housing and planning, it is argued. The paper is based on a literature review and the research of the author's master and PhD students. The author concludes that Sub-Saharan cities can be densified considerably through a participatory process of upgrading under professional guidance towards more appropriate house and neighbourhood types, while securing basic spatial qualities such as usability of outdoor spaces, air circulation, daylight in rooms and land for urban cultivation.

Keywords: enabling strategy, homelessness, informal settlements, urbanisation, urban sprawl.

1.0 DEFINITIONS AND RELIABILITY OF STATISTICS

The concept 'urbanisation' usually refers to *the increase in a country's population living in settlements classified as urban.* 'Level of urbanisation' is defined as the proportion of the total population that live in urban areas, while 'rate of urbanisation' refers to the growth (usually measured in per cent) of the urban population from one year to the next. Since there is a certain movement of people from urban to rural areas it should be noted that 'urbanisation' refers to the net movement.

Cities can grow in population (measured as a percentage) from one year to the next without increasing the level of urbanisation in the country. This is the case when the rural population grows at the same or a lower rate compared to the urban population. The birth rate is often higher in rural than in urban areas, but it seems that access to health facilities contributes to lower death rates in urban areas – despite the fact that large proportions of the urban population live in slums without clean water or proper sanitation. Lower child death rate in urban areas is often a more important factor for urban growth than rural-to-urban migration (UN Habitat, 1996).

An important factor for the level and rate of urbanisation is the classification of settlements into urban and rural. In the Nordic countries there is no classification of 'urban'. Instead there is a definition of 'dense settlement' ('tätort' in Swedish). Any settlement of more than 200 buildings closer than 200 m from each other is classified as dense. All the rest of the country is defined as 'rural area'. Small settlements in the Nordic countries usually consist of one-family houses with an average of two to three persons in each unit. This means that a settlement may be classified as dense (= urban) even if it has only 400-600 inhabitants. This may be compared to the situation in India where settlements must have more than 5,000 inhabitants to be classified as urban. If a country such as China changes its definition of

'urban' from 5,000 to 10,000 inhabitants, it would lower the global level of urbanisation from one day to the next in global statistics without any process of ruralisation taking place (Sattherthwaite, 2005).

Sociologists may define urban and rural with respect to lifestyles, while economists base their definitions on the type of economic activity in the settlement. It is obvious that a settlement classified as rural may have urban lifestyles and the other way round, and that economic activities defined as urban do not exist in all areas classified as urban. Statistics on urbanisation rely to a large extent upon the classification and the methods of compilation of data in the respective country. Thus the question 'Who belongs to this household?' can be misleading, since many people in urban areas include relatives in rural areas when answering the question. Likewise, inmates not belonging to the family may be missed in the population census inquiry, since they may be considered not to part of the household. To avoid bias the following question is normally asked: 'Who slept in this house last night?', assuming that residents who happen to be absent are evened out by those who happen to be present at the day of the census inquiry.

Since figures about levels and rates of urbanisation are based on uncertain approximations, they should be given as ranges instead of very exact numbers (for instance 45-52 instead of 47.7 per cent).

The fact that statistics on urbanisation depend on different types of classifications in different countries, and are based on estimations with various degrees of uncertainty, is pointed out in a report from the International Institute of Environment and Development (IIED). This report, called *The Scale of Urban Change Worldwide 1950-2000 and its underpinnings*, is based on the analysis of scientific studies and not only on government reports. The author shows, among other things, that the figures given about global urbanisation have been exaggerated. Many former colonies had a very high rural-to-urban migration directly after independence due to the lifting of the so called 'influx control' imposed during the colonial period. The high rates were documented in censuses carried out in the 1960s and 1970s. For various reasons planned censuses were not carried out in the 1980s and 1990s in a number of countries with limited resources. In the absence of reliable and up-to-date figures earlier trends were extrapolated without considering the fact that rural-to-urban migration actually slowed down. On the basis of his analysis the author has adjusted UN figures. He showed for instance that the date when half the world was urbanised should be shifted forwards a couple of years compared to earlier UN estimations (Satterthwaite, 2005).

2.0 DRIVING FORCES BEHIND URBANISATION

The IIED report also analyses the driving forces behind urbanisation. An important factor is the fact that new economic opportunities are created in urban areas. This factor is valid also in low-income cities with large slum areas. Another factor is access to education, health facilities and other urban services. Besides these pull factors the report refers to a number of push factors. Among them one may note diminishing prospects to make a living in rural areas due to dispossession of peasant land and developments by large transnational corporations cultivating products for the international market without any concern for the local population. These types of transformations may be seen as a continuation of earlier colonial policies such as imposed cash crop production, forced recruitment of labour and policies of taxation. The report also refers to deforestation, soil erosion, flooding and other natural and man-made disasters as driving forces behind rural-to-urban migration, especially in low-income countries (Satterthwaite, 2005).

The rate of urbanisation is considerably higher in Asia, Africa and Latin America than in North America and Europe. In the former regions the annual urban growth rate is 3.2 per cent as compared to 0.70 per cent in the developed countries. The urban population in middle and

low income countries is estimated to increase five times in 50 years (Burgess, 2000). Table 1 shows that there are large differences between continents both in level and rate of urbanisation. Africa and Asia have the fastest urban growth rates, while North America has the highest level of urbanisation.

% urban	1950	1970	1990	2000	2010
World	29.1	36.0	43.2	47.1	51.3
Africa	14.9	23.2	31.9	37.1	42.4
Asia	16.6	22.7	31.9	37.1	42.7
Europe	51.2	62.9	71.5	72.7	74.2
S. America + Caribbean	41.9	57.4	71.1	75.5	79.4
N. America	41.9	73.8	75.4	79.1	82.3
Oceania	60.6	70.6	70.1	72.7	73.7

Table 1. Urban population in various continents from 1950 to 2010 (Source: Satthertwaite,
2005).

In a later paper from IIED (Tacoli, 2010) rural-to-urban migration is analysed on the basis of recent research. The paper shows that climate change and other environmental factors contribute strongly to rural-to-urban migration. With reference to a UN report on world population policies (UN, 2008) the author notes that the number of governments that try to restrict rural-to-urban migration has risen from 47 per cent in 1976 to 65 per cent in 2007. Many civil servants and city governments blame migrants for deficits due to the growing number of people living in informal settlements in need of infrastructure investments. Tacioli remarks that "such policies... reflect deeply held assumptions that are often unsupported by reality" and concludes that "there is enough evidence to show that this [migration control] does not lower the number of migrants, while it certainly contributes to making them more vulnerable" (Tacioli, 2010:2).

Tacoli shows that urbanisation often stimulates economic growth. With reference to reports from the World Bank (2009) and UNDP (2009) it is assessed that migration and development go hand in hand, and that a free flow of skilled and unskilled labour probably does more to reduce poverty than any other single policy or aid initiatives. The author concludes:

All nations with successful economies have experienced rapid rural-to-urban migration in response to the concentration of new investments and opportunities. Yet city and national governments often have negative views of migrants, even blaming them for a range of city problems that are far more linked to their own inadequacies and incapacities. (Tacoli, 2010:1)

3.0 RURAL-URBAN SPATIAL PATTERNS

In Sweden – which urbanised later than many other European countries – people in rural areas typically first moved to a small town, while the next generation moved from smaller to larger cities. This contributed to a fairly balanced settlement structure with respect to the proportion of villages, small and middle-sized towns, and larger cities. In Africa under colonialism the pattern was different. The establishment of extractive industries, the location of colonial administration along the coast and the special type of oppressive measures mentioned above, contributed to a more polarized situation with respect to settlement structure. Rural people

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more often moved directly to large cities, which contributed to a smaller proportion of small and middle-sized towns (Hance, 1970).

The discussion above is based on the assumption that people live **either** in rural **or** urban areas. This is not how people often conceive of themselves, however, especially in low-income countries with a high rate of urbanisation. When asking urban inhabitants where their home is, the answer is often that home is the rural place of origin, even when someone has been living all her/his life in a city. Urban residents usually consider their rural roots to be important parts of their identity. They pay frequent visits to relatives in their rural home, they may own land in their place of origin and they want to be buried in this place.

In many countries villages are provided with more of educational and commercial facilities, a phenomenon that may be called 'urbanisation of the rural'. Similarly, in many cities in low-income-countries urban agriculture and animal-rearing is expanding, which can be seen as 'ruralisation of the urban'. The fact that many cities have peri-urban fringes or expand by building suburbs with villas and apartment blocks in lush green areas, may also be seen as combinations of the rural with the urban.

As pointed out by Tim Greenhow, a senior officer in the consultancy company SIPU International, spatial patterns of rural-urban dynamics are far from one-dimensional. As shown in figure 1 many people move to peri-urban satellite settlements, both from rural areas and from dense urban locations. Should this be seen as urbanisation of the same kind as migrants moving from rural areas to the centres of big cities? (Greenhow, 2010).



Figure 1. Patterns of rural-urban dynamics showing different types of migration. Legend: a) migration from village via a small town to a big city, b) migration directly from village to central parts of big cities, c) migration from village to peri-urban satellites of big cities, and d) movements from central to peripheral parts of big cities (source: Greenhow, 2010).

In industrialised countries mobility is increasing rapidly. As illustrated in figure 2 people commute not only between cities from home to their jobs, but rapid means of transport also allow people to live in rural areas while travelling daily up to 100 kms or more (one way) between homes and work places. Furthermore, in countries such as Sweden a majority of the population have summer houses in rural locations, to which they travel frequently. These leisure time residences are increasingly provided with urban services and modern facilities at the same time as they allow direct access to forests, lakes and wild nature. One may ask whether these patterns of movement should be called urbanisation, suburbanisation or ruralisetion. Considering the fact that multiple habitation and long distance car transports contribute negatively to climate change, it may be concluded that these patterns are anything but sustainable



Figure 2. Patterns of travel between home and workplaces in advanced economies, showing how multiple residences and increased long-distance commuting blur the distinction between rural and urban (source: Greenhow, 2010).

4.0 IMPACTS OF URBANISATION

4.1 Homelessness

Rapid urbanisation makes it more difficult to provide the urban population with appropriate infrastructure and housing. The fact that most low-income countries lack economic resources, adequate institutions and professional skills to deal with urbanisation, means that migrants are forced to sleep on streets or occupy any type of land to satisfy their shelter needs. In collaboration with national governments UN Habitat tries regularly to assess the need for housing in urban areas. When assessing such needs the following indicators of homelessness are often used:

- 'Sleeping rough'. This is when people sleep in streets or other places without any house at all. It is possible to assess the number belonging to this category by counting people seen in the urban landscape.
- Sleeping in shelters. This refers to persons accommodated in shelters provided by charity or other organisations on a night-to-night basis. Shelter organisations usually report the number of people being accommodated, which means that figures are fairly reliable.
- Concealed houselessness. This term refers to people living with relatives and friends against their own will. Reliable assessments about this indicator rely on social surveys, from which it is difficult to interpret responses into housing demand, since there is a discrepancy between stated preferences and capacity to pay for a house of one's own.
- Inadequate, substandard housing. This factor is usually defined as lack of security of tenure, lack of infrastructure, substandard housing quality and overcrowding. What is adequate standard depends on subjective criteria, which in turn affects the estimation of homelessness considerably (UN Habitat, 1996).

From this analysis it is evident that calculations of homelessness are based on very uncertain estimations. Nevertheless the UN Habitat regularly makes assessments of housing needs based on the mentioned indicators. Thus it is estimated that there was a need for one billion new houses in the year 2000. One of the Millennium Development Goals is to build 100 million houses until 2015 (goal 7, target 11). Strangely enough this target covers only a small part of the real need. The UN estimates that there will be two billion slum dwellers in 2030 even if 100 million new units will be built by 2015. In 2005 UNDP found that not even this low target is likely to be reached (Sachs, 2005).

4.2 Informal settlements

Another impact of rapid urbanisation is the development of slums and informal settlements. Such settlements are estimated to accommodate 72 per cent of the urban population in Sub-

Saharan Africa; 42 percent in Asia, and 32 per cent in Latin America. The driving force behind the development of informal settlements is not only rapid urbanisation, but also lack of economic resources, political will, appropriate legislation and institutions to meet the demands for housing and associated infrastructure (Hamdi, 1991; Vestbro, 2008).

Historically the most dominant policy to address the problem of informal settlements was the modernist provider model, characterised by public sector initiatives to build standardised housing units. This model has failed in all low-income and many middle-income countries, as shown elaborately by Nabeel Hamdi (1991). In his book Hamdi refers to the works of John Turner, who was one of the first to show the weaknesses of the provider model. In opposition to the general thinking about informal settlement Turner worked out an alternative model, which later became known as *the Enabling strategy* (Turner, 1976).



Figure 3. Diagram showing the difference between the housing system of the invaders in Lima and the conventional provider model (source: Turner, 1976).

In figure 3 the difference between Turner's and the provider model is shown. Turner recognises that squatters often plan their housing areas. In the model of 'autonomous housing' the public sector plays an insignificant role. Sometimes the private commercial sector gets involved, but only in construction. This model stands in stark contrast to the modernist provider model (called 'heteronomous' by Turner), in which the public sector is supposed to plan as well as construct and manage housing. In practice the provider model has been successful only in a handful of European countries (Vestbro, 2008).

Turner's observations in Peru made him conclude that for urban dweller without an income the most important thing is to get a job. This means that the urban poor have to be available where jobs may be offered or where customers are found for small-scale business. Since the poor person cannot afford transport costs he/she must live within walking distance from job opportunities. Thus he/she pays less attention to acquiring a plot or a house. When the poor gets a regular income priorities change. Then it becomes meaningful to find another place to stay and incomes may allow certain travel costs. This means that the low-income earner can look for a plot further away from the city. Security of tenure is still more important than the house, however. Only when incomes increase further the house itself starts to become a priority. The low-income earner can usually not afford standards such as several rooms, durable building materials, drainage, paved roads or clean water. The élite in most countries (to which the architects and planners belong) usually do not want to recognize the truth of this theory (Vestbro, 2008).

Before the 1980s aid agencies and international organisations often described informal settlements as unsafe, unhealthy and centres for unproductive activities. Since then the perspective has changed. An example of this is the assessment of the UN Habitat that urban areas, with their higher densities, provide for lower costs per household and enterprise when it comes to piped, treated water, waste handling, electricity, roads and transport (UN Habitat 1996). The report concludes that

"Cities have the potential to combine safe and healthy living conditions and culturally rich and enjoyable lifestyles with remarkably low levels of energy consumptions, resource use and wastes. The fact that cities concentrate production and population gives them some obvious advantages over rural settlements and dispersed populations". (UN Habitat 1996:418)

As a positive factor it is also mentioned that cities allow a "social economy" to develop, i.e. non-profit activities of citizen groups, resident associations, street committees, parent associations etc. Such initiatives may promote local business and stimulate neighbours to work together, and thus make cities safer and more fun (UN Habitat 1996).

4.3 Urban sprawl

A third consequence of rapid urbanisation is urban sprawl, here defined as *expansion of urban areas without efficient land use*. In cities of the South urban sprawl is becoming one of the most problematic issues. To a large extent the debate about urban sprawl is based on the experience in USA and other industrialised countries. In his book *The Limitless City: A Primer on the Urban Sprawl Debate* Gillham identifies the following elements as part of urban sprawl:

- Leapfrog development
- Commercial strip development
- Low density of the built environment
- Large expanses of single-use development
- Automobile dependency

By leapfrog development Gillham means the fact that cities often jump over forests and farmlands when expanding. The commercial strip phenomenon is defined as the development of huge arterial roads lined with shopping centres, gas stations, fast-food restaurants, parking lots etc (Gillham, 2002). In her PhD thesis Nnaggenda-Musana uses the definition of Gillham to assess the relevance of sprawl factors to low-income cities such as Kampala. She finds that leapfrog and commercial strip development are factors without relevance to the Ugandan situation, mainly because informal settlements expand without control by authorities. She also finds that the functional separation typical of modernist planning is a factor of little importance, although some elements of this type of planning remain from Uganda's colonial past. One part of the modernist doctrine is planning for the private car. The author finds that car dependency contributes to urban sprawl, but the influence of this factor is limited by the fact that the vast majority of the population do not own cars (Nnaggenda-Musana, 2008). The most important factor contributing to urban sprawl is the low density of the built environment. This is mainly due to the fact that the major part of the population lives in informal settlements dominated by detached one-storey, one-household units. Also formally planned areas have low densities, as shown in the licenciate thesis of the same author (Nnaggenda-Musana, 2004).

For the purpose of understanding urban sprawl it is important to use an appropriate definition of *physical density*. Such density is expressed in number of houses/apartments per hectare, or Floor Area Ratio (FAR). FAR is defined as the space covered by buildings multiplied by the number of floors of each building, divided by land area. It is easy to calculate the floor area of a group of buildings, but there is much confusion when it comes to the land by which the floor area is to be divided. Often land is defined as the plot. This is far from adequate since cities consist of many other types of land uses. Streets, parking spaces, playgrounds, sports fields, gardens, impediments and other types of spaces outside the plots are to be included in the calculation, if urban sprawl is to be properly understood. In order to assess what land to include one must have an idea of what 'belongs to' the respective urban types. The garden city idea implies, for instance, the existence of common green spaces adjacent to houses,

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while long distances between tall buildings are part of the modernist walk-up housing model (Rådberg, 1996).

Often population density (expressed in number of people per hectare) is assumed to be related to physical density. There is no such direct relationship, however. Population density depends to a large extent on overcrowding (number of persons per habitable room) and this type of density depends mainly on the income and cultural habits of households. It is possible to have high population density with fairly low building density and the other way round. The problem of overcrowding cannot be addressed by building more houses per land unit – unless densification leads to access to jobs that provide higher incomes.

What is the problem of urban sprawl in low-income cities? To some extent the consequences are the same as in industrial countries, for instance appropriation of valuable agricultural land and high infrastructural costs per unit (when such investments are made). In other respects there are considerable differences. While sprawl generally leads to longer distances to work, this factor is more severe in low-income cities, because poor people cannot afford costs for transport to job opportunities. For survival the urban poor need to be present where small-scale business may meet customers, or where temporary jobs are offered (often on a day-to-day basis).

With reference to the situation in South Africa – where urban densities are lower than in other African countries – Professor Dave Dewar from the School of Architecture and Planning at the University of Cape Town concludes that urban compaction is needed for the following reasons:

- Compaction promotes diversification and specialisation, the motors of urban economic growth.
- Movement on foot is the only mode of travel affordable by a growing majority of urban dwellers.
- When trying to solve the problems of public transport compaction is necessary along continuous transportation routes (Dewar 2000:212-213; text shortened by Vestbro).

Dewar's analysis is available in one of the few books that deal with sprawl in low and middle income cities, namely the anthology *Compact Cities: Sustainable Urban Forms for Developing Countries* edited by Mike Jenks and Rod Burgess (2000). The book provides a useful account of the situation in non-OECD countries. In his chapter about the compact city debate Rod Burgess points out that compaction by reclaiming oversized spaces for cars or abandoned industrial sites is not feasible in low-income cities. He notes that low-income settlements have low residential densities, and points out that these areas (whether formal or informal) are usually subject to continuous densification through squatting and self-help extensions *"finely tuned to changes in household income and space requirements. Densification efforts should therefore be aimed at assisting this process and should focus on the upgrading and guided rationalisation of urban space within these settlements"* (Burgess, 2000:18).

A study of Dar es Salaam by John Lupala shows that FAR is as low as 0.4-0.6 in consolidated informal settlements, where the densification process has been going on for many decades. In younger informal settlements FAR often range from 0.2 to 0.3. It is only in the central district of Kariakoo that one finds FAR as high as 1.5 to 2.2 (Lupala, 2002). The observations of Lupala are confirmed in studies by his colleague Huba Nguluma. Her study focuses on the development of house types in the consolidated informal settlement Hana Nasif (see figure 4). The densification process has been stimulated by the fact that this area lies within walking distance from the city centre. At the time of the fieldwork (2002) densities ranged from 0.2 to 0.7. The author shows that densification leads to a reduction of open spaces, which are frequently used for household activities and for socializing. She concludes that there is a need

to promote multi-storey constructions in order to allow further densification while safeguarding spatial qualities such as daylight in rooms and air circulation both indoors and outdoors (Nguluma, 2003).



4. Figure Aerial photo of Hana Nasif with floor а area ratio of 0.2-0.7. Only a handful of buildings in this area are more than one storey high.

Taking Nguluma's study as a starting point two Swedish civil engineering students at the Royal Institute

of Technology in 2008-2009 carried out a study of the possibility to introduce two-storey constructions in low-income informal settlements in Dar es Salaam while keeping costs down through the use of self-educated craftsmen and local building materials. On the basis of a comprehensive survey of the construction sector in Tanzania and a fieldwork in Hana Nasif, the students worked out a proposal for a two-storey version of the urban Swahili type house. Walls are to be made of interlocking bricks made of soil cement, a building material available at low cost in Dar es Salaam. This construction is easy to execute and demands less technical knowledge of workers. For the intermediate floor, composite slabs with reinforcement sheets were proposed. Since such sheets are imported the researchers found that a shift to local production would be required in order to promote community development. According to the authors the FAR would increase to 0.55 if one third of the houses in Hana Nasif would be two-storey instead of one-storey. Some two-storey houses may replace buildings that now encroach upon streets and common areas (Kruse and Torstensson, 2010).

5.0 CONCLUSIONS

The analysis above shows that urbanisation is an irreversible process and that measures to control it often prove futile. Globally the rate of urbanisation is highest in Sub-Saharan Africa and very high in other low and middle-income countries. Current research shows that the rural push factors to a large extent explain the high rate of urbanisation, and that the impacts of this process are not only negative. Evidence indicates that increased mobility is linked to economic growth and that denser settlements are more in line with modern concepts of sustainable development (lower costs for infrastructure, local building materials, less travel).

Together with a lack of economic and institutional resources for house construction the high rate of urbanisation contributes to homelessness and the spread of informal settlements. It is assessed that the modernist provider model has failed to address these two ills. The paper concludes that it is necessary to shift to enabling strategies based on decentralisation, deregulation, self-help efforts, acceptance of Home-Based Entreprises and urban agriculture, and the creation of small-scale construction companies. Informal settlements need to be provided with basic infrastructure such as clean water and rainwater drainage. For this to take

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place, professional guidance is required, as well as interventions by local authorities (Nawangwe & Vestbro, 2003). In Sub-Saharan cities 60-85 per cent of the population live in informal settlements. Almost all buildings in these areas are detached one-storey houses. The analysis above shows that land coverage usually range from 10 to 30 per cent, which equals Floor Area Ratios of 0.1-0.3. The informal settlements are continuously being densified. If professionals would better understand the need for incremental upgrading and the possibility to promote compact house and neighbourhood types, then densification can take place while maintaining basic spatial qualities such as functional outdoor spaces, air circulation inside and outside buildings, and daylight in rooms.



densification of a housing cluster in Mbuya, Kampala through the construction of new houses, the extension of certain houses from one to two storeys, and by modifying plot dimensions while securing cross-ventilation and daylight.

Nnaggenda-Musana's model for incremental upgrading shows that it is possible to increase densities three to five times and still maintain ample space between buildings for household chores, agriculture and animal-rearing. If her model would be applied in all of Kampala's informal settlements the capital could double or treble in population without encroaching upon agricultural land around the city. Alternatively households may extend houses to reduce overcrowding (when incomes increase). In the 3-million city of Dar es Salaam densities in informal settlements are slightly higher, but even here densification is possible without further jeopardising basic spatial qualities, especially if simple construction techniques are introduced for two-storey buildings. Even if guided incremental densification measures are implemented according to the enabling model as described, floor area rations would be less than 1/3 or 1/4 of typical inner city densities in Europe (where FAR is often 1.5 to 2.5).

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CHAPTER 2: ARCHITECTURE, URBAN PLANNING AND BUILT ENVIRONMENT

Design of Weather Station and Measurement Equipment for Assessment of Buildings Energy Use in Mozambique

Gabriel Auziane¹, Anne Landin, Daniel Baloi

¹PhD Student, Faculty of Engineering, Eduardo Mondlane University, P.O.Box 257, Maputo, Mozambique Corresponding author email: Gabriel.Auziane@construction.lth.se

²Professor, Division of Construction Management, Lund University, P.O.Box 22263-Lund,

Sweden

³Professor, Department of Civil Engineer, Eduardo Mondlane University, P.O.Box 257, Maputo Mozambique

ABSTRACT

The use of modeling and simulation tools for assessment of the buildings energy in Mozambique is under investigation. Thus, measurement equipment was installed in "3 de Fevereiro Building" in Maputo City, Mozambique. The measurement equipment comprises Data Logger System, Weather Station, temperature and humidity sensors. These aim to measure the climate factors around the building and indoor parameters which influence the internal environment of the buildings. This paper describes the plan design and the layout of the measurement equipment. It also presents and discusses the results of the climate parameters and the building factors for the winter season such as global and diffuse solar radiation, outdoor temperature and humidity, indoor temperature and humidity, wind speed, wind direction and rainfall. The measured results relate to a period of four months from June to September, 2009. With this field measured results it was possible to analyze a greater part of the winter climate factors. Maputo City has a subtropical climate with two seasons, a wet season from October to March (summer) and a dry season from April to September (winter). The measured results show that the equipment provides fair data which can be used for evaluating the energy of the building and for testing and validating the simulation tools of building energy.

Keywords: Design experiment, Energy efficiency, Outdoor and indoor thermal environment, Field measurements, Subtropical climate.

1.0 INTRODUCTION

Maputo City, the capital of Mozambique, is situated at 25°57′S and 32°35′E with a subtropical climate which means that it is submitted to vast solar energy with potential to increase the thermal heat inside the buildings especially in summer. On the other hand, the solar energy can be used to reduce the electrical energy used in buildings if active systems using solar energy are implemented in the buildings.

The main aim for installing the measurement equipment in "3 de Fevereiro Building" is to collect data and create database from field measurements for testing and validation modeling and simulation tools of the energy use in buildings for Mozambican climatic conditions. DEROB-LTH Program, an acronym for Dynamic Energy Response of Buildings, was selected by the author in the work related to Energy assessment Methodologies and Energy use in Buildings. This Program was tested in other tropical and subtropical countries. Espriella (1993), verified the conditions of comfort in offices in Bocota, Colombia, Fernandes (2004), analyzed the indoor