# Density in Urban Development

## 20 January 1996

This is a complete draft text prepared for Building Issues. A summarized version is published as Building Issues, 3/96. Vol 8, No 3 (http://www.hdm.lth.se/bi/report/frame.htm).

Claudio Acioly Jr.

Forbes Davidson

IHS-Institute for Housing and Urban Development Studies

## *The authors*

The authors have been involved both through teaching and working with urban development issues in a wide range of countries. They have worked at project level and have first hand experience both of the power of local traditions and of bureaucratic inertia when any changes to the existing norms are proposed. Any change from the status quo is difficult. To support this it is hoped that the report provides a stimulus for critical thinking, arguments for change and access to useful material.

*Claudio Acioly Jr*

Claudio Acioly Jr . is an architect & urban planner with experience in planning, design, management, implementation and evaluation of housing and urban development projects. He has long-term experience in Brazil, The Netherlands and Guinea-Bissau and short-term missions in diverse countries. He is the author of two books on self-help housing and neighbourhood upgrading and several papers in international journals. In 1992, he earned his master degree in Design, Planning and Management of Buildings and the Built Environment at the Delft University of Technology, The Netherlands. Apart from consultancy works, he presently teaches in the IHS in the areas of planning and management of urban development programmes, urban renewal and human settlement upgrading, housing and community-based action planning.

*Forbes Davidson*

Forbes Davidson specialises in urban planning and its linkages with urban management. By profession he is an urban planner, and has worked for extended periods in United Kingdom, Egypt, Indonesia, and India . The experience contributing particularly to the present study was from an extended involvement with the Ismailia Demonstration Project in Egypt, and the development from that experience of a practical guide to urban development called the "Urban Projects Manual". That experience also emphasised the importance of the issues which could not be controlled by designers, and the need for more creative links between professionals and better understanding of markets and politics. Recent work in South Africa and in Bombay, India on resettlement further emphasises the importance of density issues.

Currently Forbes Davidson teaches in the Institute for Housing and Urban Development Studies in Rotterdam, Netherlands, and undertakes consultancy.

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# Density in Urban Development

*"What are the proper densities for city dwellings? The answer to this is something like the answer Lincoln gave to the question, 'How long should a man's legs be?' Long enough to reach the ground, Lincoln said. Just so, proper city dwelling densities are a matter of performance. They cannot be based on abstractions about the quantities of land that ideally should be allotted for so-and-so many people (living in some docile, imaginary society). Densities are too low, or too high, when they frustrate city diversity instead of abetting it. We ought to look at densities in much the same way as we look at calories and vitamins. Right amounts are right amounts because of how they perform. And what is right differs in specific instances".*

Quoted from Jane Jacobs, "The Death and Life of Great American Cities", Penguin Books, London, page 221.

## *Introduction*

The density of urban development is a controversial and sometimes confusing subject. Decisions made in this area can have significant impact on health, on urban environment, on the productivity of cities, and on human development as a whole.

Unfortunately, there are no magic formulae which can be applied universally to give optimum results. There is, however, a wealth of experience and many relevant figures that when compared to one another can provide useful references for decision making in planning, design and management of human settlements.

The objectives of the report are:

- to clarify the issues connected with density;
- to review experiences and cases where density assumes particular importance in urban development;
- to identify the most important variables linking density and performance;
- to disseminate the information gained during the study and to provide reference points, tools and guidelines to help in decision making concerning urban density, particularly as it concerns low income settlements.

The report is aimed at professionals involved in urban development who have to advise or make decisions regarding density. In particular it focuses on those who design and make decisions concerning human settlements and shelter for low income groups. The report is primarily addressed to developing countries, but is designed to have a wider relevance.

We recognise the dangers inherent in attempting to be relevant in every country in the world, and in turn running the real risk of being universally irrelevant. We attempt to achieve this by recognising from the start that perceptions of density vary widely between and within countries and cities. In other words, they are very much influenced by their cultural context. In addition, comparisons are complicated by use of differing measures -population density, housing density and building density are all used and have inherent differences. There is no universal best answer, but there are common issues and themes.

There are lessons to be learnt, but the figures and formulas have to be adapted locally before being adopted. It is more important to stimulate good thinking on the subject than to provide easy but potentially dangerous standard answers.

The approach adopted is to clarify the meaning and significance of density and then to focus on actions which are likely to be effective given the often limited power of local governments to enforce regulations. For this reason there is a discussion of the legal and management implications to back up the design aspects. Case studies provide illustrations for the information and recommendations. The examples selected include cases from Brazil, Egypt, Guinea Bissau, Hong Kong, India, and the Netherlands. The selection focuses on the developing and transitional countries, but refers also to Western experience as this is often taken as a reference point.

### *Organization of the report*

The report is organized in three main sections, as illustrated in Figure 1. The first part deals with the conceptualisation of density, how it is understood and the major implications.

The second part focuses on the planning and design processes in relation to density. The major elements that affect density are reviewed and a series of general guidelines are suggested as potential to improve performance of human settlements leading to sustainable development.

The third section deals with the management and legal aspects of density, and highlights how regulations and enforcement have a potentially important role. The ability and willingness of the major urban actors from public and private sectors to enforce density related regulations is analysed.

The case studies of experiences with density are presented in boxes. These are used to reflect particular approaches or issues dealt with in the major sections of the report. For example, when dealing with the design and planning aspects, one of the issues is the optimisation of infrastructure networks. The case of Curitiba is used to illustrate this.

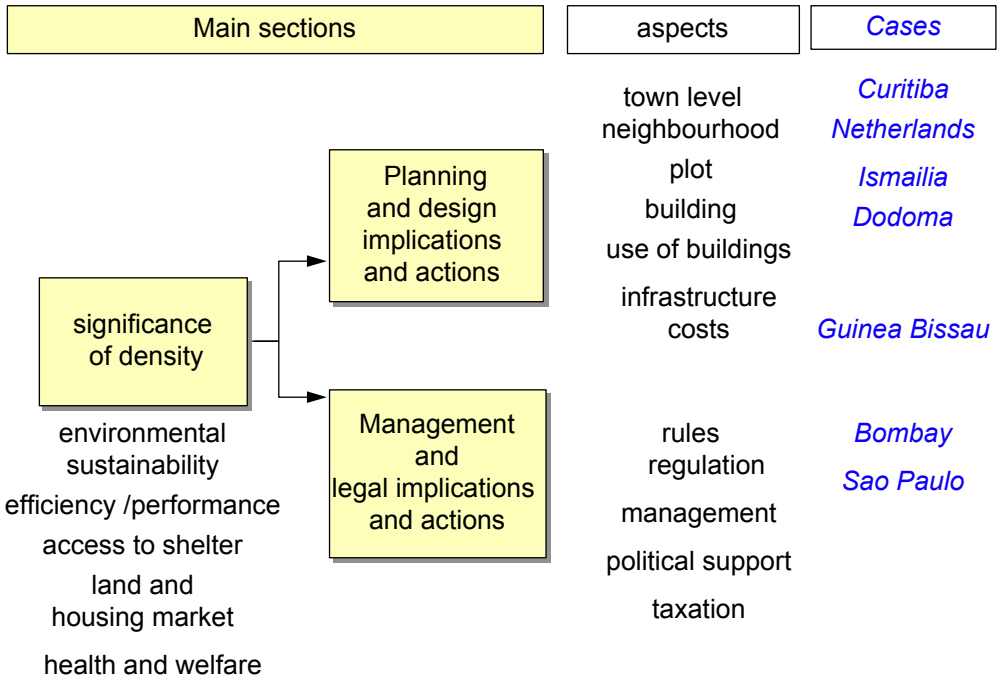



**Figure 1 Structure of report**

## Significance of density

### *Density is in the mind of the perceiver*

Density is a difficult subject to discuss in a publication addressed to an international audience. Ask an Indian planner what he thinks about a 100 square metre plot for low income groups and he will say that it is far too large and will be unaffordable. His colleague from East or Southern Africa, however will argue that this is far too small, and that it will never be accepted. The response may be "We didn't fight for independence to reduce our standards." An Egyptian or a Bolivian might think that 100 $m^2$ is fine. Given this situation, is it possible to have a sensible discussion of the subject? We argue that it is, provided that readers accept the initial position that we are talking about relative situations. Every reader must read the situation from his or her own starting point. Figure 2 provides an overview of residential density figures of the largest cities by continent[1]. Even within one country different social groups will perceive density differently. What people see and feel depends on their own background, and also to some extent on the layout, building form and building use and spatial use in an area.

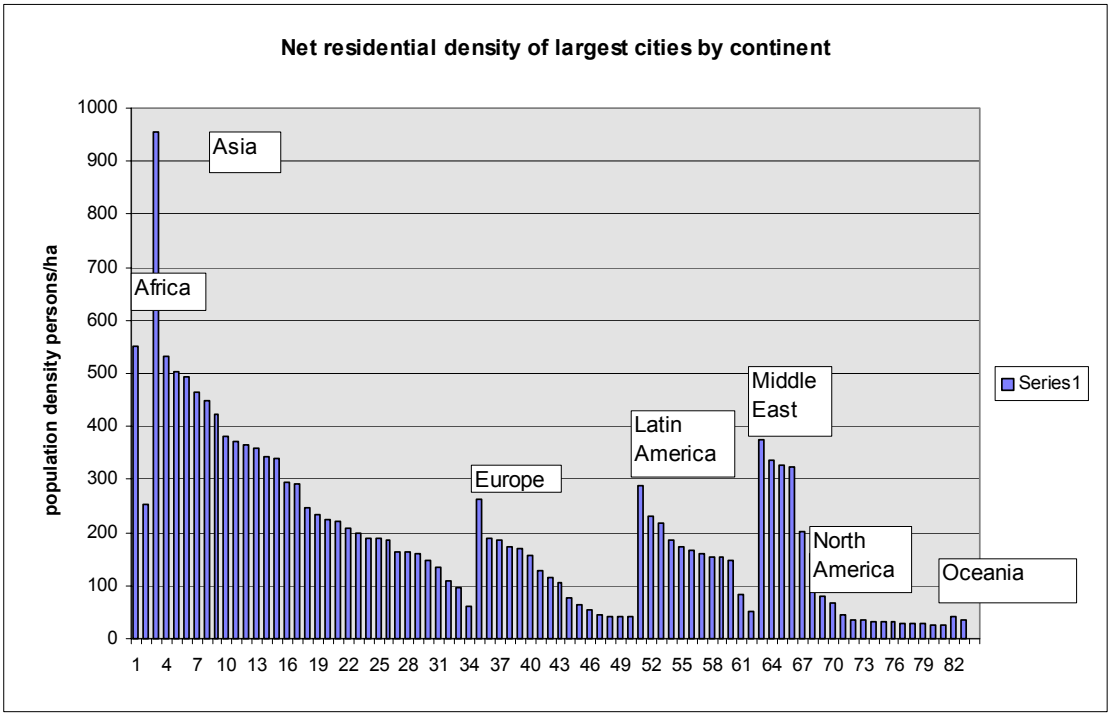



**Figure 2 Net residential densities in large cities by continent**

**(source of figures: Source: figures from Bureau of the Census, U.S. Dept. of Commerce quoted in The World Almanac® and Book of Facts 1994 Funk and Wagnalls Corporation. Figures are based on residential area of largest cities defined by urban area rather than administrative boundaries)**

What is common is that urban planners and designers, policy makers and decision makers are confronted with an increasing demand for efficiency of the urban environment. This means better use of land and natural resources, infrastructure, and human and financial resources. In this, the density of urban areas plays an important role.

A number of the key issues related to density are reviewed briefly below. Where the subjects can be influenced through design interventions they are detailed in the following section on planning and design implications.

[1] see also appendix II for comparative density figures for examples from different countries

***Density as a technical issue***

Density is one of the most important indicators and design parameters in the field of housing and human settlement planning and design. It is generally expressed as population per unit of land or number of dwellings per unit of land. It serves as an instrument for urban planners, urban designers, architects and engineers to design and assess the performance and efficiency of human settlement configurations. Inhabitants per hectare and dwellings per hectare are used to express specific qualities and development potentials of a site in relation to residential densities. It is common to find indicators translated as net and gross densities. The former includes only the area allocated for residential use and the latter refers to the whole settlement area including roads, public spaces and other uses (see glossary for definitions). The density of areas becomes a very important issue for the technical and financial assessment of the distribution and consumption of land, infrastructure and public services in human settlements. In principle, housing practitioners have assumed that the higher the density the better is the utilization of infrastructure and land.

The assumption is that high density assures the maximisation of public investments including infrastructure, services and transportation and allows efficient utilization of land. It may guarantee high rates of return and efficient revenue generation assuming that there are benefits derived from strong concentration of people and activities. However, one must look at this with caution since high density settlement schemes can also cause an overload on infrastructure and services and put an extra pressure on land and residential spaces, producing crowded and unsuitable environments for human development (see Figure 3).

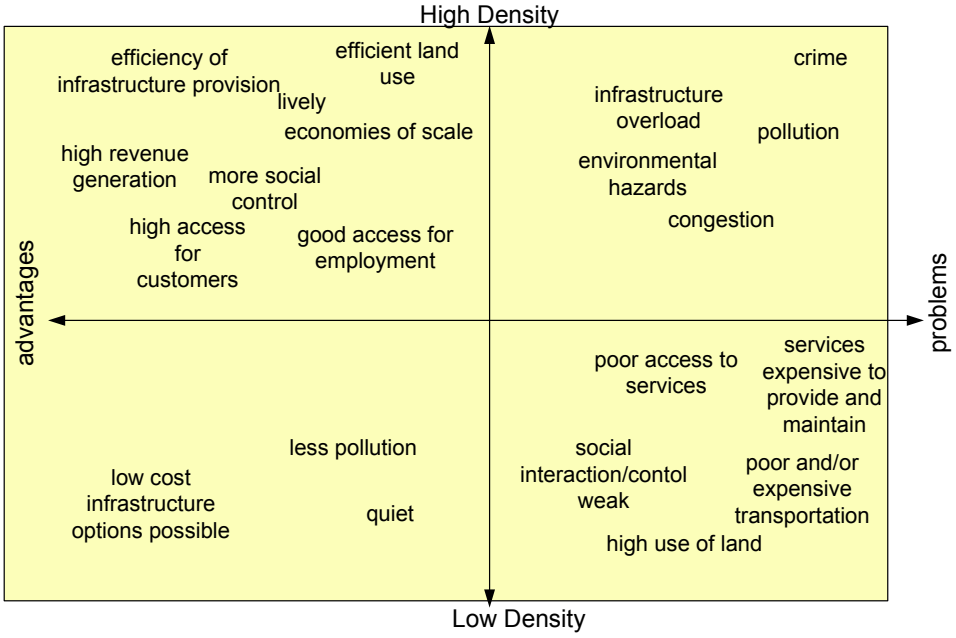



**Figure 3 advantages and disadvantages of high vs low density**

At the other extreme, low densities may produce an increase of per capita costs of land, infrastructure and services, affecting the sustainability of human settlements and producing urban environments that constraint social interactions. These advantages and disadvantages are summarised in Figure 3.

Closely linked to density is the concept of *crowding* . This implies that density is too high - that too many people live or work in a given neighbourhood house or room. There is evidence that perception of crowding is related to whether the "other people" are family or strangers. Crowding, however, goes beyond perceptions to levels where there is measurable impact on health. Recent studies in Guinea Bissau for example reveal a strong correlation between high population densities -resulting in in-house crowding, crowding of beds and ill health. The neighbourhoods of Bissau show extreme levels of density which seem to have parallels in many African countries. Overcrowding and densification of neighbourhoods have been one of the major negative effects of constrained land and housing markets, rather than being the result of direct planning decisions (see Box 1)..

As elsewhere in Sub-Saharan Africa, densities are increasing rapidly in Bissau, the capital of Guinea-Bissau. The primate cities have very common urban growth patterns. The colonial core is usually surrounded by informal settlements that are characterised by poor housing conditions, inadequate infrastructure, poverty, informal market activities, renting and subletting of rooms and high densities and overcrowding. Densification - in terms of population increase and spatial occupation - has been principally caused by an inefficient performance of the housing sector. Surveys in four neighbourhoods of Bissau revealed that population density varies in a range from 204 to 400 inhab/ha and housing density from 14 dwellings/ha to 18 dwellings/ha. Apparently these figures are not exceptionally high but one must bear in mind that the houses are particularly large - reaching 180 $m^2$ or more - and are mostly overcrowded, number of occupants varying from 10 to 22 persons per house. A large number of households live in one or two rooms of 16 $m^2$. In the African context, densities are reaching alarming figures. The 52 country survey carried out by the UNCHS/World Bank-sponsored Housing Indicator Program reveals that Sub-Saharan Africa next to South Asia detains the lowest mean floor area per person - the median useable living space per persons - which is 7.55 $m^2$/person. For South Asia this figure is 7.10 $m^2$/person (Angel, et al, 1993). A recent survey in Bissau announces 3.2 $m^2$ per person as the floor area indicator for the city (UNCHS & COWIconsult, 1995) which is apparently a paradox when placed next to the size of the houses. This highlights external factors that create an acute form of density symbolised in the phenomenon of in-house crowding and expressed as in-bed crowding. Recent surveys in three neighbourhoods of the city indicates that 67% of the houses had 3 to 4 persons per bed. This extreme form of density has serious social and health impacts for the population, specially vulnerable groups like children, pregnant women, elderly. The longitudinal study confirmed that continuous and long-term exposure to crowded living environment is directly linked with increases in morbidity and mortality rates, transmission of communicable diseases, airborne and respiratory infections and specific chronic and infectious diseases.

Source: Acioly, 1992;1993;1994;1995; UNCHS and COWIconsult, 1995;1995a.

**Box 1 Crowding in Guinea Bissau**

### *Influences on density*

There are many factors influencing density, some of which can be influenced directly, some indirectly and others over which there is very little possible action. In this report we focus on areas where effective action is possible -but it is important to understand the forces that influence dynamic changes in density.

Figure 4 summarises some of the most important influences.

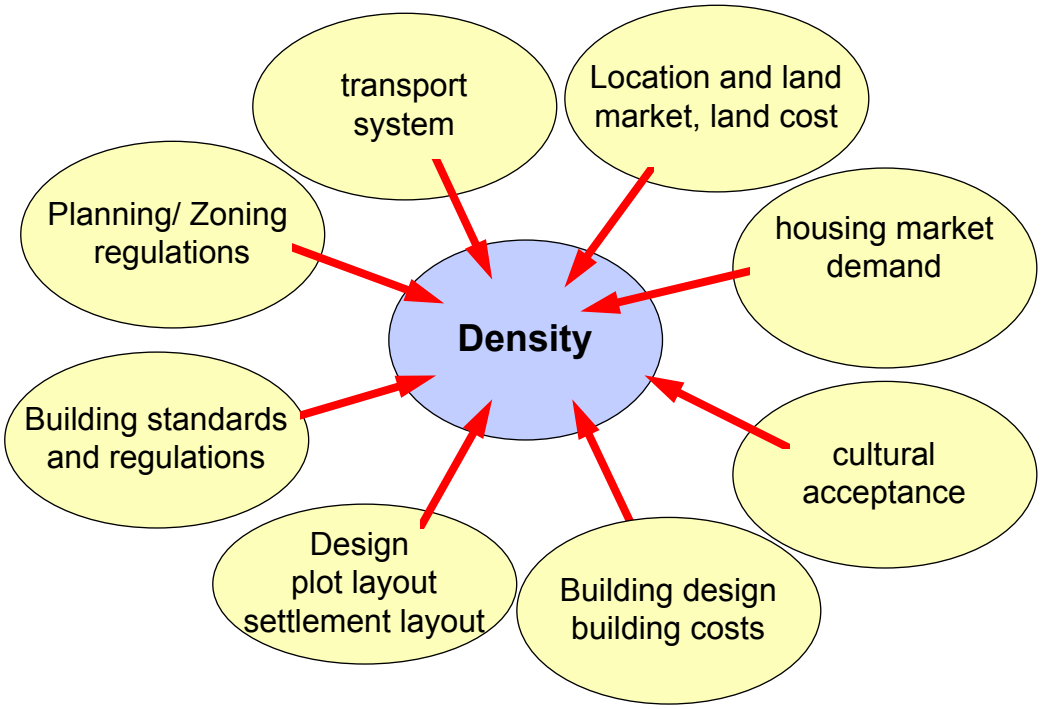



**Figure 4 Influences on density**

***New development***

The most common situation in which density is being considered is when new formal (legal)development is being planned. The decision may be direct in the case that government directly implements a programme, or indirect, when the development is promoted by the private sector. In this situation government influence will be a combination of regulations and negotiation.

The issue of the density of new development is seen as critical in a wide range of environments. Discussion of the affordability of low density with expensive services, high maintenance and expensive transportation is a major issue of debate in countries as wide apart and as different economically as South Africa, New Zealand (Dekel 95) and California. ( Box 1 ). Low density suburbs or informal development have led to very extensive and expensive use of land -urban sprawl.

A recent report entitled “Beyond Sprawl: New Patterns of Growth to Fit the New California” has been sponsored by a coalition-the California Resources Agency, a government conservation agency; Bank of America, California's largest bank; Greenbelt Alliance, the Bay Area's citizen conservation and planning organization; and the Low Income Housing Fund, a non-profit organization dedicated to low-income housing. The introduction states

“The fact that such a diverse group has reached consensus on the ideas in this report reflects how important the issue of growth is to all Californians. We hope this report will make a meaningful contribution to the public dialogue about the quality and direction of California's growth in the 21st century.”

What is interesting is that the report concludes that the pattern of low density sprawl that had served California well in the past is no longer sustainable.

“One of the most fundamental questions we face is whether California can afford to support the pattern of urban and suburban development, often referred to as *sprawl* that has characterised its growth since World War II.
There is no question that this pattern of growth has helped fuel California’s unparalleled economic and population boom, and that it has enabled millions of Californians to realise the enduring dream of home ownership. But as we approach the 21st century, it is clear that sprawl has created enormous costs that California can no longer afford. Ironically, unchecked sprawl has shifted from an engine of California’s growth to a force that now threatens to inhibit growth and degrade the quality of our life.”
The report goes on to show that infrastructure costs, maintenance, transportation, access to work, loss of agricultural land and air pollution all contribute to an unsustainable pattern of development. A call is made to build up a political consensus which can produce a co-ordinated strategy to move towards greater control and promotion of denser forms of development.

Source: Bankamerica Corporation December 1995 World Wide Web file:///c|/cserve/mosaic/denc_env.htm

**Box 2 Beyond Sprawl: New Patterns of Growth to Fit the New California**

### *Change of density in existing settlements*

Density in urban areas commonly varies over time. This may be a result of market forces or of a city level policy. Densification may be promoted to increase efficiency of infrastructure or to improve social conditions. Lowering of density may be promoted through urban renewal programmes when there is congestion or overcrowding.

### *Upgrading of informal areas*

In the case of informal settlements, densities may be very high, with narrow streets and very limited open space and probably no areas for common amenities. In this situation reblocking or restructuring of the existing layout. will probably result in less land available for development, unless one opts for resettlement of part of the population to another site. Resettlement has serious social and economic implications for the population, and is in itself a difficult process to manage[i]. For this reason it is best to try to minimise the resettlement necessary. This in turn tends to increase pressure on existing land and buildings -resulting in higher densities. Depending on the location of the settlement, land prices may stimulate increases of floor area ration abd amendment of density regulations, which may themselves result in the displacement of low income groups. The case of Bombay illustrates this issue (see Box 13)

### *Fluctuating densities*

Inner city and CBD areas may experience extremely high population densities while satellite/dormitory towns have extremely low densities during working hours. These

variations affect drastically the consumption and management of public services and infrastructure. The cases of Sao Paulo and Brasilia illustrate this disparity. While the former opted to increase densities the latter remains limited by static and strict zoning regulations reinforced by the decision to make the Plan Piloto of Brasilia a World Heritage site.

***Density of plots or houses***

The size of plots of land, the amount of plot which can be built up (plot coverage) and the height of the building (Floor Space Index) give the dimensions of the most visible aspect of density - the amount of space which is built. This is what designers can decide in the design phase, and which officials can reinforce and control in planning and building permissions and in development control. The measure is expressed in dwellings per ha (dw/ha) -and this is commonly used in developed countries where crowding of housing units is relatively less of a problem. To take account of the number of people involved -which is critical for all forms of infrastructure, then other definitions of density have to be used. These include persons per ha (pph). A wide range of definitions is used, which can make comparisons of experience difficult. The terms are explained in the glossary. Examples of density related figures from a range of experiences is provided in Appendix II.

***Density of use of dwellings***

The use of individual dwelling units is described in terms of persons per dwelling and square metres per person. Here we are dealing with issues of crowding within buildings - with implications of stress on social relations, and mental and physical health. Bissau and Hong Kong illustrate extreme figures of crowding which motivated a number of studies of assess the health impacts of such levels of use. We should emphasise that there is an important difference between housing density and crowding. It is possible to have high density of housing without crowding within buildings.

***Density and economic activity***

Density is significant for the economic performance of a city. High population density means a high level of access for business both to employees and to markets. This is generally seen as positive. High access to workers means more competition and less energy spent in travel. Curitiba (Box 5) illustrates benefits of this approach. High access to market is important for transportation costs and also in the potential of being accessible and of knowing the market. However, in the very common situation where increase in density is unplanned, or badly managed, it can also mean an overstressing or overload of infrastructure with resulting poor functioning and inefficiencies. For example, irregular water supply in Hyderabad, India, means that businesses and homes have to invest in water storage and pumps. Unreliable electricity means that businesses have to invest in generators -resulting also in increased pollution.

***Density and land and housing market***

In the absence of governmental control, density will tend to increase in locations which have a high level of accessibility -particularly to employment and services. In the absence of alternatives for land and housing there will be a natural tendency to increase population density by means of informal increases of either built density - increases in plot density and plot coverage through new building expansions -or increases in the occupancy rates of existing buildings. Market distortions, legal frameworks and private sector mobilization will dictate the degree to which this phenomenon will occur.

Government can stimulate and reinforce this mechanism while providing high levels of profit to private developers through allowing high occupancy rates of plots and buildings, as is the case in Hong Kong (Lai, 1993). See Box 4.

***Density and the efficient provision of services***

One of the main arguments for encouraging higher densities is the efficient provision and maintenance of infrastructure. The arguments are simple - low density means long infrastructure runs and thus higher cost per consumer both for installation and for operation as the cases of Ismailia and Sao Paulo show.( Box 8 and Box 14). Journey to work becomes longer and more expensive. Schools and health clinics are difficult to reach for many people. In Africa, the extensive informal settlements surrounding many towns mean that many people are living without support of any municipal services. This is partly because the municipalities are not functioning well and partly because these areas are very expensive to service because of the use of large plots and often unplanned forms of land occupation that result in inefficient urban configurations.

At the other end of the density spectrum, higher than planned density creates problems for overloaded infrastructure including water and sanitation systems. In particular on-site sanitation systems become overloaded and “grey water” cannot be evacuated though drainage systems. Some of the trade-offs are illustrated in Figure 5.

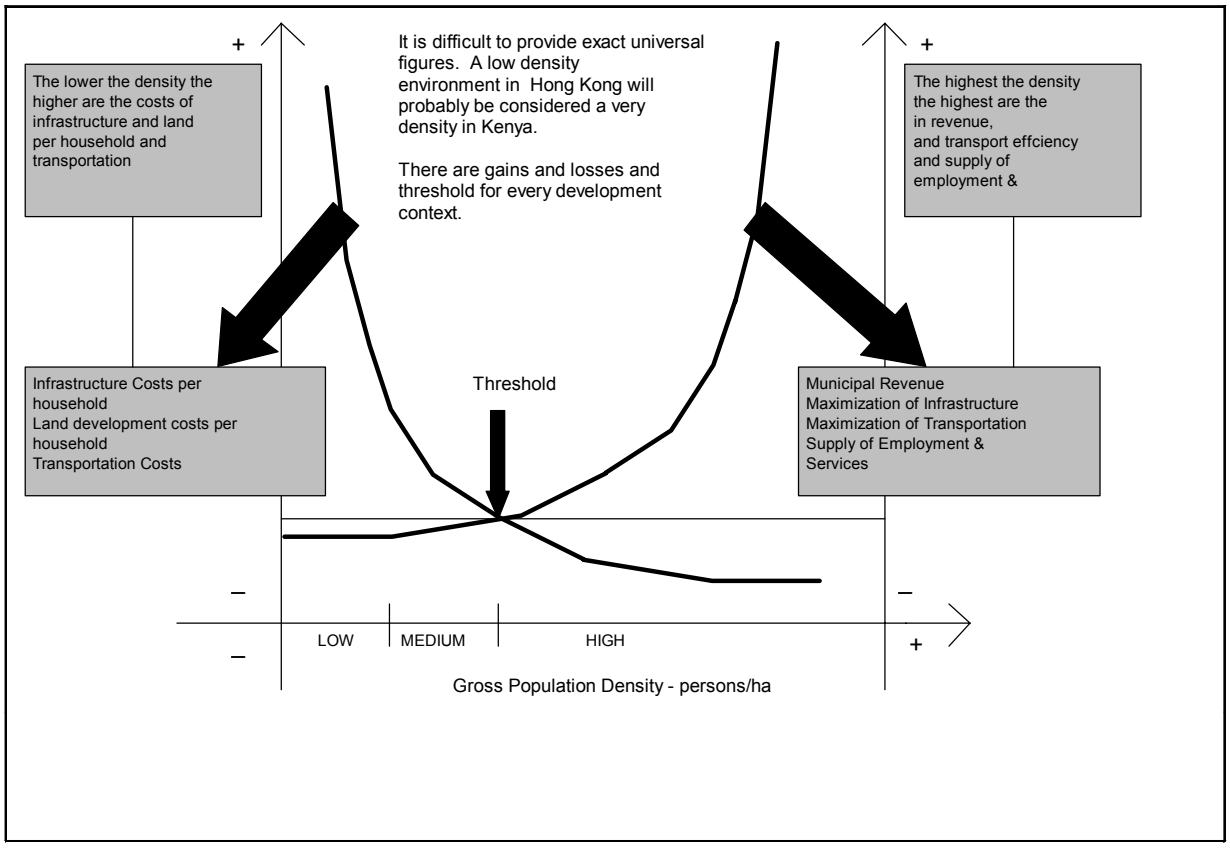



**Figure 5 Trade-off between infrastructure level and municipal revenue generation**

### *Health, water supply and sanitation*

High density generally allows for more efficient provision of infrastructure as the network lengths per unit served decreases. The case of low income settlements in Natal, Brazil, show that an efficient network layout combined with certain sanitation technologies and high population density accomplish substantial gains in lowering the overall cost of the system per household[2].

At the other extreme, low density can allow the use of on plot water supply and sanitation which can provide a flexible and cost effective means of upgrading over time. In health terms, low densities allow the use of low cost on-plot sanitation systems -however, they also mean that distance to travel for medical support can be considerable.

There is little doubt that extremely high densities result in poor health conditions - though it is difficult to isolate what is caused by density and what caused by the poverty which is associated. ( see Box 1, Guinea-Bissau and Box 3 ,Brazil).

The paper on density in Hong Kong brings some interesting discussion on the relationship between high density and stress. It argues in favour of new approaches to high density that emphasises the ability of human beings to adjust and to cope with the environment. It denounces as a priori the assumption that high density is invariably pathological (Lai, 1993). Some argue that the Chinese show a successful tolerance for high density and crowding but arguments are questionable due to inaccurate research methods.

**Box 3 Density and Sewerage Costs in Natal, Brazil**

Experiences with shallow sewerage in Northeast Brazil show relationships between population density and optimal costs in the sewerage network costs. In two squatter settlements (Rocas and Santos Reis) in the city of Natal density averaged 350 persons/ha. Since conventional sewerage was unaffordable, the population agreed to have an alternative sewerage network - called locally as condominial sewage - passing through the backyard of the plots. Total capital costs reached US$350 per household and efficiency of the system motivated replicability in other site and service and settlement upgrading sites in the city and elsewhere in Brazil. The efficiency of the system was not only as a result of technological innovation but also thanks to a different layout design of the system - passing through the backyard of plots and optimising network length with system coverage. Evaluations of the system showed noticeable reduction in costs per household as density increases. It also showed that at a given density it can become more economical than on-site sanitation systems. At densities above 160 persons/ha annual cost per household falls bellow US$48.

**Source: Sinnatamby, 1990).**

### *Fire protection*

High density informal development, especially in Asia has had a bad history of fire. Temporary materials, unsafe power connections, alcohol abuse and sometimes pressure tactics by local land owners or Mafiosi have led to widespread loss of

[2] for further discussion of this see Caminos and Goethert (1978) Davidson and Paine (1983) and Bazant (1978), Cotton (1991)

property and sometimes life. Narrow streets mean both that fire spreads easily and that fire services have difficulty in reaching sites. The rationale for upgrading and sometimes decreasing the building density of low income squatter areas is often linked to improving access for emergency services such as ambulances and fire brigade, and ensuring that there are fire breaks in dense settlements. The fault is not density alone, but is a combination of building density and material with the dimensions of streets and other open space.

***Roads and transportation***

Efficient public transport requires medium to high densities to be able to provide frequent and efficient services. Low densities with reliance on private cars or long periods of walking for the poor, cannot support good public transport. For this reason, density of urban development, including residential development, has become an important issue relating to sustainable urban development. High densities without excessive road space requires an efficient public transport system. Residential densities influence the number and types of trips and modes of travel used. Overall number of trips per person by private car decreases as cities or neighbourhoods become more dense.

The discussion of Curitiba (Box 5) emphasises this aspect .

***Land use planning***

There are many different views amongst planners as to whether high density is better-with ideas such as the “compact city”- or lower density “garden city” types of development. Fashions change and there are arguments on both sides. These issues are explored in the section on planning and design options.

The efficient use of land as a limited resource, and whether the state or the market should control this is an element which has a wide range of perceptions in different countries. In particular there are major differences between approaches in market and planned economies. In market economies there are normally some controls, but the tendency is to let the market influence density. This has the disadvantage that the broader social costs, for example of poor access to schools, shopping or health facilities and loss of agricultural land are not taken into account. (Box 2). Mixed economies such as The Netherlands do make strong use of density as an instrument of planning. Planned economies had a strong tradition of planning with the use of densities as a key element. This had the disadvantage of being inflexible and often of producing undesirable urban forms (Box 5 )

In the former Soviet Union (FSU) as in most Eastern European Countries, most of planning regulations have been based on minimum sanitary norm of residential space per inhabitant which have guided State sponsored housing production, urban expansions and master plans. In the FSU, this minimum norm was defined as 5-7 sqm/person and later raised to 9 sqm/person. In 1992, one third of the Soviet families and single persons were still living with less than 9 sqm/person and the housing shortage was estimated in 10 million families who were still waiting in the official list for government housing. Rather than specifically determining urban densities, soviet planners did strive to define the size of an ideal city. There was a strong preoccupation with the city since it was considered to become the agent for social and economic change. The town should be national in character and socialist in content. In the post-revolution period, there was a boiling debate and polarity about the role of cities in the new society. On one hand, the urbanists, lead by the economist and statistician Leonid Sabsovich, argued that cities should be strictly limited in size - 50,000 to 60,000 people - a size assumed to be the ideal necessary to make the production and consumption of goods and services economic. There should be a strict land-use zoning, a minimal commuting by placing housing and employment close to one another, the city centre should not be commercial, ample green space and recreational facilities should be made available and more emphasis on pedestrian movements. Sabsovich idealised a compact city inscribed within clear bounds, formed by high-rise housing blocks of 15 to 29 storeys, supposedly with high densities. On the other hand, the "desurbanism" movement, headed by the economist and philosopher Mikhail Okhitovich, advocated an entirely new urban structure and townless socialist society, population dispersion, and a communal lifestyle, with very low densities. Spatial mobility should rely on the use of automobile. This ideals gave birth to the linear city model based on spatial decentralisation - not concentration - of items of collective consumption. The 1929 national five-year plan of economic development advocated the construction of 17 new cities and subsequently, the Soviet Union undertook one of the most comprehensive guided process of urbanisation which led to the establishment of a national settlement systems and the creation of 3,000 new settlements scattered around the country. The changing conception about the nature of urban economies in the 60s raised the size of the optimum city to 200,000-300,000 people. The planning of residential areas in the FSU has been guided by a strong normative approach and based on the concept of "mikrorayon" - a type of neighbourhood unit that houses more than half of the population of the FSU. The residential complex is formed by 4-5 "mikrorayon" and houses 8,000 to 12,000 people within a radius of 300-400 mts, and in high-rise buildings of 5 to 22 storeys. It is a self-contained neighbourhood unit that should provide the sense of communal ethos and collectivism. Day-to-day requirements should be within reach by pedestrian journeys. Alike Brasilia, this housing typology has been influenced by the Charter of Athens (1933 CIAM) and reflects a strong segregation of functions in the city. Net population densities are usually very high nonetheless there is a disparity between the percentages of land allocated for residential and non-residential uses. Green areas, roads and circulation account to even more than half of the total areas. The master plans for the reconstruction of Moscow and Leningrad, the new peripheral neighbourhoods of Chisinău, Riga and many other cities throughout the FSU follow these principles. The inner cities were also subject to interventions. They should become readily identifiable centre in centrality and size and reflect an overwhelming weight of the State in contrast to the CBDs in the West. The large monumental spaces and excessively broad roads and green areas raised problems related to the size, utility and appearance of these spaces - apparently being continuously empty. Maintenance costs became very high. After the collapse of the FSU, market oriented policies were revealing the inefficiency of such models. Housing, infrastructure and services were provided as social benefits and had very little concern with resource optimisation and cost recovery. Many of these cities show clearly how planners and planning guidelines were not conformed with the principles of human settlement efficiency in the use of major inputs - land and infrastructure. The usual high rise high density neighbourhoods developed in the peripheral rings of the former Soviet cities are now confronted with a serious problem of economic feasibility in a market-oriented environment. Some studies reveal that the population density of Moscow at 17 Km from the centre equals the density of the innercity of Paris. Bertaud and Renaud write about a perverse population density gradient that rises as one moves outwards. This highlights internal inneficiencies of these cities today, poses a negative asset value to the housing stock in these locations and a risk for abandonment when energy and trasnport prices are levelled to world prices.

Source: Grava, 1993; Bater, undated; Acioly, 1995; Kosareva, 1993. Bertaud and Renaud , 1994.

**Figure 6 Density issues in the form Soviet Union**

A very important indicator of efficiency of land use is the ratio between public and private space. Public open space is an attractive idea and norms for this are often

included in planning legislation. However, high proportions of public space increase infrastructure and maintenance costs. Often open spaces are often badly maintained and become a nuisance. This issue is discussed further in the next section.

### *Social implications*

Hong Kong claims the highest urban density in the world. Of the 5.6 million inhabitants, about 80 % live in the urban built-up areas which amount only 10% of the total territory. Population density in some housing estates like Ngau Tau Kok, Chai Wan, Hong Wah and Hing Wah I reaches 5858, 5059, 4420 and 5470 persons/ha respectively. Hong Kong is also known by its peculiar choice for high-rise urban housing, most of which ranges from 20 to 30 storeys. The high density and high-rise solution has been determined by government policy since 1954 and by a restrictive land market. Public housing and private developers have adopted this solution but the buildings constructed by the private sector are taller and have greater density than public housing. While implementing a slum clearance policy, the government established a department of Resettlement and the Housing authority in 1954. The first eight experimental resettlement buildings were 6 storey high - a sort of tenement housing solution where families were required to share communal water and sanitation facilities - (7272 persons/ha), the first Housing Authority project was 11 storey high to accommodate families of 5 to 10 persons on the legal minimum of 35 $ft^2$ (1777 persons/ha) while the legal maximum for private residential structures was 4 storeys. The 1954 policy decision was in fact a revision of the predominant British town planning tradition that advocated low density and low-rise developments. Most of the arguments behind the advocacy for high-rise and high-density housing was based on the principle of economising on land take. Guidelines and planning standards were even amended so that public housing in new towns could reach densities up to 3000 persons/ha. In 1988, the central government launches a strategic plan that attempts to bring down population density in urban Hong Kong which has led to local controversies. By the year 2011, gross urban density is expected to be as low as 460 persons/ha and high density housing less than 1900 persons/ha. The private sector is very concerned since lowering densities implies lowering the maximum permissible plot ratio which will affect their profit margins by diminishing the number of saleable unites or saleable floor area. The shift in density policies also implies more emphasis on horizontal growth since only 10 % of Hong Kong is built-up. Two arguments are presented against spatial decentralisation, one economic and one environmental. The development of Honk Kong's country side will not only destroy important recreational outlets but also reduce Honk Kong's already minimal capacity to produce its own food.

Source: Lai, 1993.

**Box 4 Density in Hong Kong**

Socially, low densities are connected with high incomes and a low degree of casual social contact. High densities are associated often with low income, with liveliness and social contact but also with conflict. The impacts of density are also influenced by the quality of design of layout -how buildings and spaces are designed and linked.

Low densities are associated with clean air, space for recreation. Much low density development was a reaction against the overcrowding of dense inner city areas. However they have also been related to different problems -the New Towns with low to medium densities and plenty of recreation space were also the home of "New Town Blues". This was a common description of the dissatisfaction of social life of families who moved from large cities such as London and Glasgow in UK to newly created relatively low density towns.

Security anxieties are tending to promote higher densities. Large gardens of middle class families in low density neighbourhoods may be seen as a danger rather than an advantage. New middle class development in cities such as Nairobi and Johannesburg promote compact "Town houses" crouching behind barbed wire topped walls.

### *Environment and sustainability of urban development*

The relation between density and environment is complex. On the one side, dense development with little open space can increase run-off, but also reduces the amount

Curitiba, a city of 1.6 million in Brazil, highlights how the concept of density was applied as the backbone of the urban transformation that the city experienced in the last 30 years since the approval of the master plan in 1966.

The plan had two major concerns: to decongest the inner city and revitalize the urban and architectural heritage situated in this area and to shift the radial concentric growth of the city to a linear growth pattern by introducing an important north-south axis of traffic and transportation, tangent to the inner city, called the “structural axis”.

The zoning was based on the type of use - commercial, residential, industrial and mixed use - and the desired population density. The strategy was to encourage new commercial developments to move out of the inner city, matching high density residential areas with commercial activities and linking them with the availability of public transport. The principle is that the sites must be well served by public transport and the density coefficient would decrease as its distance to the public transport network increases. Development permits could only be issued by the local government provided that it is accompanied by a careful analysis and information about traffic generation and the requirements for infrastructure and parking.

The structural axis is formed by a three part system. The central road reserves the central lane exclusively for the bus system, a solution that accomplishes performances equal to those of metro systems, while two parallel roads provide room for local traffic within the same road profile (see Error! Reference source not found.**)** The system is completed by two other roads, usually situated one block further from the central road, which accommodate the continuous one way traffic towards and from the inner city. The area situated in-between these two one way traffic roads is denominated structural sector and is zoned as a high density area, accommodating commercial and residential uses, and reaching densities up to 600 inhab/ha. In the structural sector, buildings can reach a total floor area equal to 6 times the plot size.

In terms of policy pursued by the municipality, land acquisition took place during and prior the implementation of the transport network so that the local government could guarantee the maximisation of the infrastructure and services and the materialization of the desired densification along side the structural axis. Towards the buildings considered of historic value, situated in the inner city, the municipality applied a creative “white” appropriation mechanism that allowed the transfer of development rights or building potentials (principle of “solo criado”) from the sites where they were situated to elsewhere in the city if the existing infrastructure and services could cope with the increase of the built up area and higher density. The owners would pass the title of these buildings to the municipality in exchange of more floor area in another plot of their property. One hand, the municipality safeguards the building heritage and allocates special uses and functions to these buildings such as museums, foundations, training centres, etc. On the other hand, it increases densities elsewhere in the city and provides a good trade-off for the private sector. An automated cadastre and a land information system established at the beginning of the eighties allows the Municipality to provide to any resident information about building coefficient, densities and development potentials of every single plot in the city.

The concept of density, translated in Curitiba as an increase in plot occupancy and coefficients in relation to plot areas, and resulting in figures measured in inhabitants per hectare, was applied in a very balanced way. It defined a clear profile and skyline of the city. The areas situated between the structural axis have middle and low population and building densities. Middle densities are the areas where multi-family housing is predominant, reaching a density up to 180 inhab/ha. The low density areas are characterised by low rise unifamily housing with densities up to 70 inhab/ha.

The urban planning solutions applied in Curitiba endeavours the recovery and consolidation of the urbanity of the traditional city that allows the inhabitants to identify themselves with their urban environment and socially interact with their fellow inhabitant. It advocates the mixture of functions, incomes and densities, brings the green areas into the urban environment, maximizes the existing roads and infrastructure and links all that through simple but extremely efficient public transport. The reinforcement of high densities throughout the public transport axis provides not only the maximization of public investments but helps Curitiba to save 25% in fuel consumption and to achieve a significant reduction of dioxide emissions. This gives the plan, and the use of density a significant impact on the sustainability of development.

**Box 5 Density issues in Curitiba, Brazil**

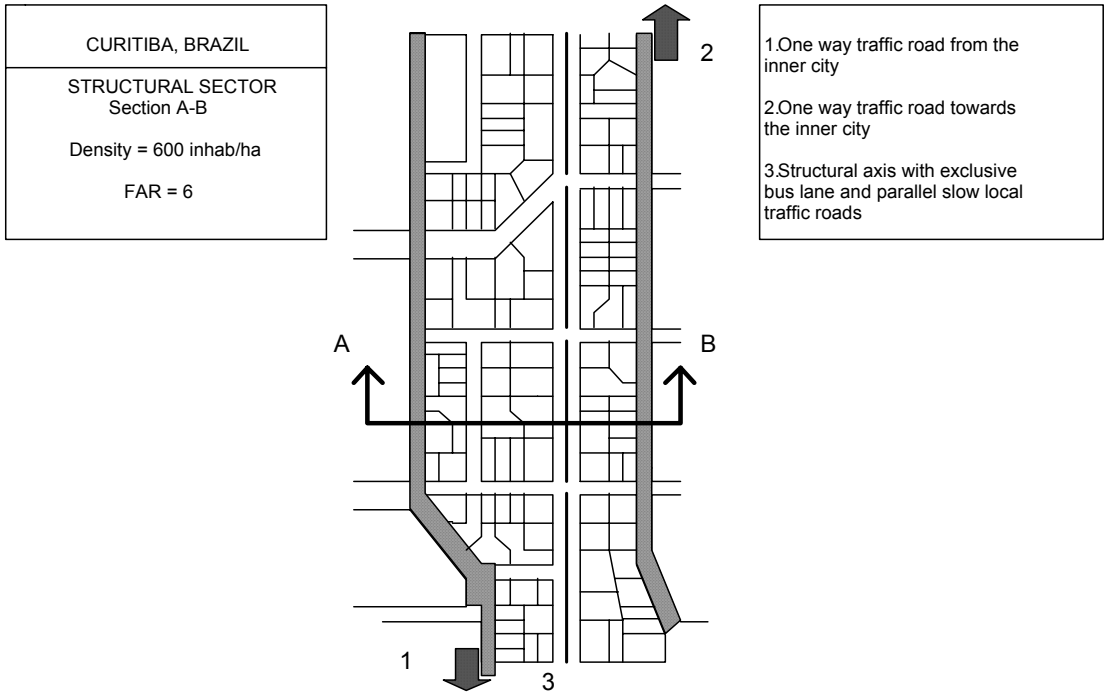



**Figure 7 Curitiba structural axis**

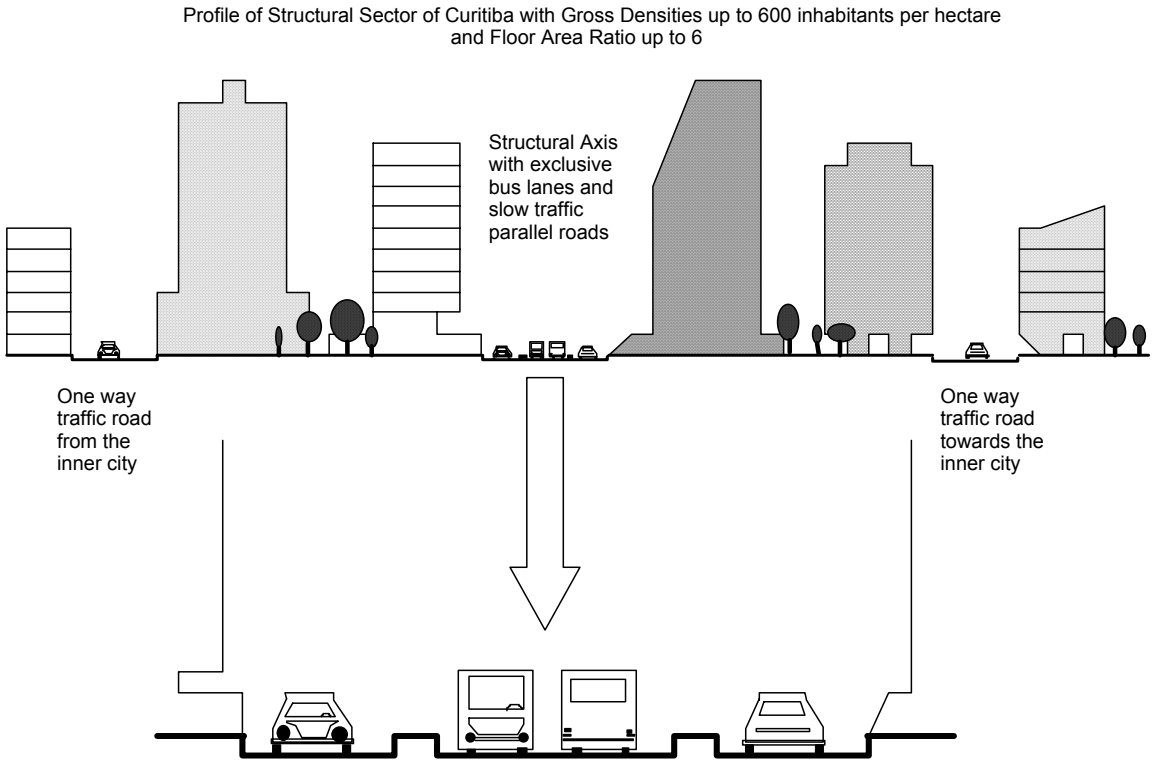



**Figure 9 Curitiba structural axis -section**

of land take for urban development. Low density green urban development takes enormous areas of land. In Hong Kong there is a controversy concerning Government's intention to decrease densities, because it implies a shift from the typical high rise high density approach towards low rise lower density schemes that consequently will promote horizontal growth of the city over its limited countryside. Not only are private developers concerned with the decrease in saleable floor area and profit, but also environmentalists are concerned with the environmental impact. Environmental impact is raised in the cases of California (Box 2) and also in the case of Hong Kong (Box 4)

## Planning and Design implications

Sustainable human settlement development calls for special attention to the improvement of physical planning outcomes in which densities occupy a pertinent position. Particularly, during the process of paradigm changing in the 90s in which cities are recognized to be the engines of development and their performance and productivity a question to be approached through effective management. Not only the management of the urban environment assumes importance but also the actual spatial planning, the design of the urban environment and the way cities are built gain relevance in the present agenda of discussion. The sustainable city as a concept emerges linked to better designs of the urban environment. Efficiency in the design and spatial planning of human settlements is a key area of concern which certainly must deal with the problem of density within a broader perspective. This implies a rediscovery of the economics of space and the value of the end product of planning and design processes.

However, as discussed earlier, density holds a strong cultural dimension which makes it difficult for anyone to express universal and ideal density figures without placing it exactly within the context and the conditions where it is applied. Density outcomes must be economically efficient and reinforce sustainable human development but must be culturally acceptable as well.

When arguing that cities do work as they manage to grow and keep urbanity and vitality, Jacobs, in her classic book (Jacobs 1961) presents not only an attack to conventional city planning but brings a series of evidences about unsuitability of the ideal cities adovocated by the garden city movements of Howard and Le Corbusier.

Cities and particular their districts and neighbourhoods must envisage city diversity and generate interesting and vigorous city life, but four conditions are indispensable:

1. Multipurpose district - not monofunctional
2. Blocks and clusters must be short, producing opportunities for corners and social encounters
3. Different types of buildings - scale, age and forms - mingling urban spaces and architecture
4. Sufficiently dense concentration of people and dwellings

She deserves a whole chapter to point four. There is a need for concentration and not for segregation since there is a close relationship between diversity - different uses like work, entertainment, linving - and the intensive use of city. The housing density (dw/ha) is a factor of vitality and important prerequisite for the future development of a neighbourhood. Base on studies in American cities, Jacobs argues that as housing densities drop-off, vitality and popularity drop off too. One of these

examples is Greenwich Village, New York, a very dynamic and vital residential area with net housing densities ranging from 125 to more than 200 dwellings per acre. There is no standardization of buildings, there is a mixture of everything in terms of land use, there are different housing typologies - from low rise one house per plot to high-rise multifamily buildings - and a high proportion of land allocated for residential use with an average plot coverage ranging from 60 to 80%.

Density should be the result of a process of human settlement layout design through which the settlement designer must deal dynamically with standards, plot and dwelling sizes, housing typology and spatial planning. It should not be the unilateral result of a cost analysis and financial exercise aiming at the optimisation of infrastructure, services and land.

Due to the fact that the form and nature of dwelling occupancy is very dynamic and subject to several external factors e.g. housing delivery system, land price, rent price, etc. it becomes very hard to stipulate or control population density.

For the purpose of human settlement design, it is much more pertinent to work with housing and building densities. These are more controllable figures and give more possibilities to assess the trade-offs in relation to land occupation and the costs of infrastructure and services. The number of dwellings in relation to the provision of services and infrastructure may remain as originally planned, but increase of building occupancy, sub-division and overcrowding may occur if land and housing delivery is constrained.

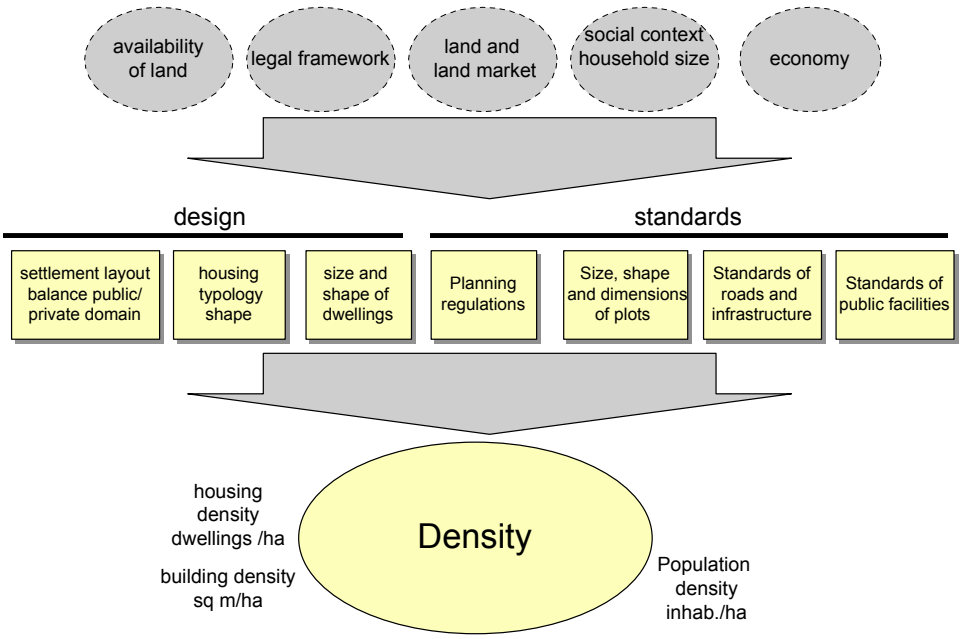



**Figure 11 Context and design issues affecting density**

***Models of Development***

*City level*

The discussion about the size and scope of an urban settlement, measured through its population size and density is not new in the debate. The assumed benefits gained from economy of scale and concentration of population which have influenced the densification and verticalization of human settlements and promoted the compact

city model are now once more on the order of the day. This movement is also stimulated by the fact that local governments lack resources and means to cope with increasing public expenditures including the demand for investments necessary to foster sustainable urban development. Resources need to be utilised efficiently. The use and occupation of available space and vacant land should be rationalised. Public utilities must be efficiently managed. Municipal services must be financially sustainable and housing projects must fit into available land and be economically and environmentally sound.

A whole generation of professionals in the developed and developing world were influenced by paradigms elaborated during the emergence of the garden city movement in the European continent. This was a reaction to the “explosive” growth of cities and overcrowding of residential areas developed during the industrial revolution. The debate provided urban planners and designers with a city model based on low densities, social and spatial stratification and satellite developments. Such a model of an ideal city was widespread through the -International Congress of Modern Architecture (CIAMs) and exported to all developing countries. The garden city movement expressed strong sanitary justifications and concerns towards the quality of urban life. The British new towns, the post war new neighbourhoods and satellite cities in the Netherlands, new towns in developing countries like Brasilia, Chandigarh, Gaborone, Dodoma and Abuja, just to mention a few, are clear examples of this model.

The advocates of the compact city model argue that peripheral developments and unbalanced weights between green and unoccupied spaces and the built up area created other levels of economic problems related to population mobility, transportation and commuting, energy consumption and disruption of the daily urban systems. A compact city with higher densities and mixed land uses would recover urbanity and sustain the economic recovery of the inner city.

The assumption that high density is hazardous to the quality of life is misleading. There are other factors that when combined with high density will cause a negative impact in the quality of life of a settlement. Availability of infrastructure and public services, scarcity of space for leisure, poor environmental conditions and poverty all play vital roles

High density areas are often linked with low income while low density areas are linked with high income. It is assumed that the inhabitants of high density urban areas tend to live in smaller plots or dwellings, will have limited resources and will tend to have difficulties to access education, health, housing and basic public services. A social and economic profile that would differ radically from the inhabitants of low density areas where plots and houses are usually much bigger. This highlights the direct linkage between density and housing typology, urban standards and social economic development.

The amount of space allocated for private and public domains will not only influence density indicators but will also define certain morphological characteristics and specific qualities of human settlements. While certain settlements have a major part of their areas allocated to public use - green areas, vehicular traffic and pedestrian circulation and complementary public services - providing a certain feeling of space and confined social contacts, others have most of the space allocated to private use e.g. residential, mixed residential-commercial or solely commercial-industrial uses.

Density influences social interaction, but Hillier (1988) showed that in the case of high density inner city high rise housing in London the configuration -or the layout and design of buildings and spaces-can have more impact than the density itself. Hillier argues that regardless of the density of the housing estate, if the spatial layout



of the settlement constrains natural movement then there will be never sufficient people to generate the sense that the space is well used.

Density indicators usually refer to city wide or neighbourhood levels and only then it is possible to make comparisons, trade-offs and pay-offs between human settlements based on different housing typologies, land subdivision and land use.

### *Guidelines for urban designer's decision making in relation to density at the settlement level*

A quick assessment of a large number of urban settlement layouts in different countries will reveal a waste of land and costly infrastructure outcomes, characterised by wide roads and excessive land destined for public spaces. Rather than be a sole consequence of inappropriate standards and regulations, it is mostly the result of design decisions. There is a merit to look at settlement layout efficiency in relation to densities considering that sustainable human settlement developme partly depends on the degree the layout solution accomplishes an optimal land utilisation and infrastructure distribution.

Since design decisions are mostly taken at a very early stage of the development process, it is important to provide some quick references and call the attention for specific outcomes when certain choices and decisions are made at the design phase. Table 1 illustrates population and housing densities for a new neighbourhood for 5,000 people and the needed land to provide housing to them according to predefined percentage for residential use for both low rise and high rise housing typologies.

Examples from Karachi show that different types of urban layouts in residential developments produce totally different density outcomes. A katchi abadi - squatter settlement - with an irregular configuration, densely occupied and only 25% of the land used for open spaces and circulation, presents a density of 650 persons/ha for plots of 75 $m^2$. An inner-city residential area, with a gridiron layout based on narrow and small plots of 90 $m^2$ and only 25% of land used for circulation and open space presents a high density equal to 625 persons/ha. In north-east Karachi, a gridiron planned residential site based on plots of 150 $m^2$ and 40% of the land used for circulation and open space presents a medium density of 260 persons/ha. In North Karachi, a planned residential area based on plots of 350 $m^2$ and a having substantial part of the land utilised for open space and circulation (45 %) presents a low density equal to 102 persons/ha.

Source: Dowall, 1991.

**Box 6 Density variations in Karachi, Pakistan**

After all, the costs of infrastructure and public utilities will depend on the optimisation of the layout solution and the percentage of land utilised for residential, public - circulation, streets, pedestrian pathways, parking areas - and semi-public spaces - schools, playgrounds, public facilities, recreational spaces - and the level and standard of services. If the solution implies substantial land allocated for public use then it is logic that there will be less land for other purposes, higher burden on public and community sectors in terms of maintenance costs, taxation, etc.; longer distances to be covered by walking and infrastructure networks and higher costs to serve it with public utilities. The layout must enhance an efficient and balanced

**Table 1 Relation between housing type and density**

| Population | | | | | Land | | *High rise housing* | | | | | Low rise housing | | | | Settlement |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Total Population | Persons per Household | Total Households | Gross Density (persons/ha) | Net Density (persons/ha) | % Residential Land | Individual Plot Size (sqm) | *Flat size (sqm)* | *Number of floors* | *Flats per floor* | *Number of blocks* | *Block size (sqm)* | Housing Density | Net Housing Density | Total Residential Land (ha) | Total Land Needed (ha) | Settlement Type |
| 5,000 | 5 | 1,000 | 140 | 400 | 35% | 125 | | | | | | 28 | 80 | 12.5 | 35.7 | Low rise - 1dwelling p/plot |
| 5,000 | 5 | 1,000 | 200 | 400 | 50% | 125 | | | | | | 40 | 80 | 12.5 | 25.0 | Low rise - 1dwelling p/plot |
| 5,000 | 5 | 1,000 | 260 | 400 | 65% | 125 | | | | | | 52 | 80 | 12.5 | 19.2 | Low rise - 1dwelling p/plot |
| 5,000 | 5 | 1,000 | 120 | 200 | 60% | 250 | | | | | | 24 | 40 | 25.0 | 41.7 | Low rise - 1dwelling p/plot |
| 5,000 | 5 | 1,000 | 250 | 417 | 60% | 120 | | | | | | 50 | 83 | 12.0 | 20.0 | Low rise - 1 dwelling/plot |
| 5,000 | 5 | 1,000 | 333 | 556 | 60% | 90 | | | | | | 67 | 111 | 9.0 | 15.0 | Low rise - 1 dwelling/plot |
| 5,000 | 5 | 1,000 | 1,167 | 3,333 | 35% | | *50* | *4* | *20* | *12.5* | *1,200* | 233 | 667 | 1.5 | 4.3 | High rise - 80 flats/block |
| 5,000 | 5 | 1,000 | 1,667 | 3,333 | 50% | | *50* | *4* | *20* | *12.5* | *1,200* | 333 | 667 | 1.5 | 3.0 | High rise - 80 flats/block |
| 5,000 | 5 | 1,000 | 2,167 | 3,333 | 65% | | *50* | *4* | *20* | *12.5* | *1,200* | 433 | 667 | 1.5 | 2.3 | High rise - 80 flats/block |
| 5,000 | 5 | 1,000 | 2,000 | 3,333 | 60% | | *50* | *4* | *20* | *12.5* | *1,200* | 400 | 667 | 1.5 | 2.5 | High rise - 80 flats/block |
| 5,000 | 5 | 1,000 | 2,500 | 4,167 | 60% | | *50* | *5* | *20* | *10.0* | *1,200* | 500 | 833 | 1.2 | 2.0 | High rise - 100 flats/blocks |
| 5,000 | 5 | 1,000 | 3,250 | 5,000 | 65% | | *50* | *6* | *20* | *8.3* | *1,200* | 650 | 1,000 | 1.0 | 1.5 | High rise - 120 flats/block |

trade-off between the private and public domains. These issues are discussed under “Efficiency of layout”

Can density become a parameter for decisions taken at this level? As a routine, urban designers commonly use population density as a measurement reference, referring most of the time to gross population density. Apparently, Table 1 provides some indications of implications of design decisions.

While keeping the same plot size of 125 $m^2$ and net population density of 400 inhabitants/ha, and varying the percentage of land allocated to residential use, one verifies that the net housing density (80 dwellings/ha) and the total land for residential use (12.5 ha) remain unchanged as the result of keeping the same plot size. As the percentage of land allocated for residential use increases (up to 65%), the total land needed to accommodate this population decreases drastically and the gross population density increases up to 260 inhabitants/ha. Thus increasing density should lead to an optimal use of essential development inputs - land and infrastructure. The decision on the trade-off between public and private domains has been made - it is acceptable that 60 to 65% of land allocated for residential use in a human settlement should lead to efficiency - however the urban standards will be also relevant, whether there will be wide roads or not, if local green areas and recreational spaces are concentrated or spread. Final costs will also depend on whether services are incrementally executed or ready-made.

If we decide to predefine 60% of land allocated for residential use as the criteria to accomplish settlement layout efficiency but varying the plot size to accommodate the same population, both housing and population densities increase and there is a substantial decrease in the total residential land and the total land needed. Decreasing the plot size at a ratio of 2.7 all densities will be increased at the same ratio. Thus the plot size determines most of outcomes. The smaller the plot the highest the density and less land is required to accommodate the same population. The question now is whether the plot size is culturally acceptable and financially marketable and again whether the urban standards respond to efficiency requirements.

If high rise housing alternatives are applied then the situation changes completely. Using a four storey high building with 20 flats of 50 $m^2$ per floor and increasing the

percentage of land allocated for residential use, net population and housing densities remain unchanged but gross densities increase dramatically. In comparison to the low-rise solution, this alternative consumes far much less land but all infrastructure and services will be extremely concentrated. The case of Hong Kong shows this very well. The urbanised area occupies only 10% of the territory as a result of government policy towards high-rise high density developments that reach up to more than 5,000 persons per hectare. The settlement layout will be decisive in the definition of the trade-offs public-private domains, the amount of green areas, distance between buildings, parking places and the availability of infrastructure.

Higher densities in this case imply an extensive use of the available land on one hand and on the other hand, it places a heavy occasional load on existing infrastructure like electricity supply, drainage, sewage and pavement for parking.

In principle high densities are beneficial for water supply and sewerage networks. High density is not advantageous in relation to the electricity network since the increase and concentration of consumers will demand more strength for the system and eventually more power stations. High-rise multi-family buildings will place a demand for more public and open space.

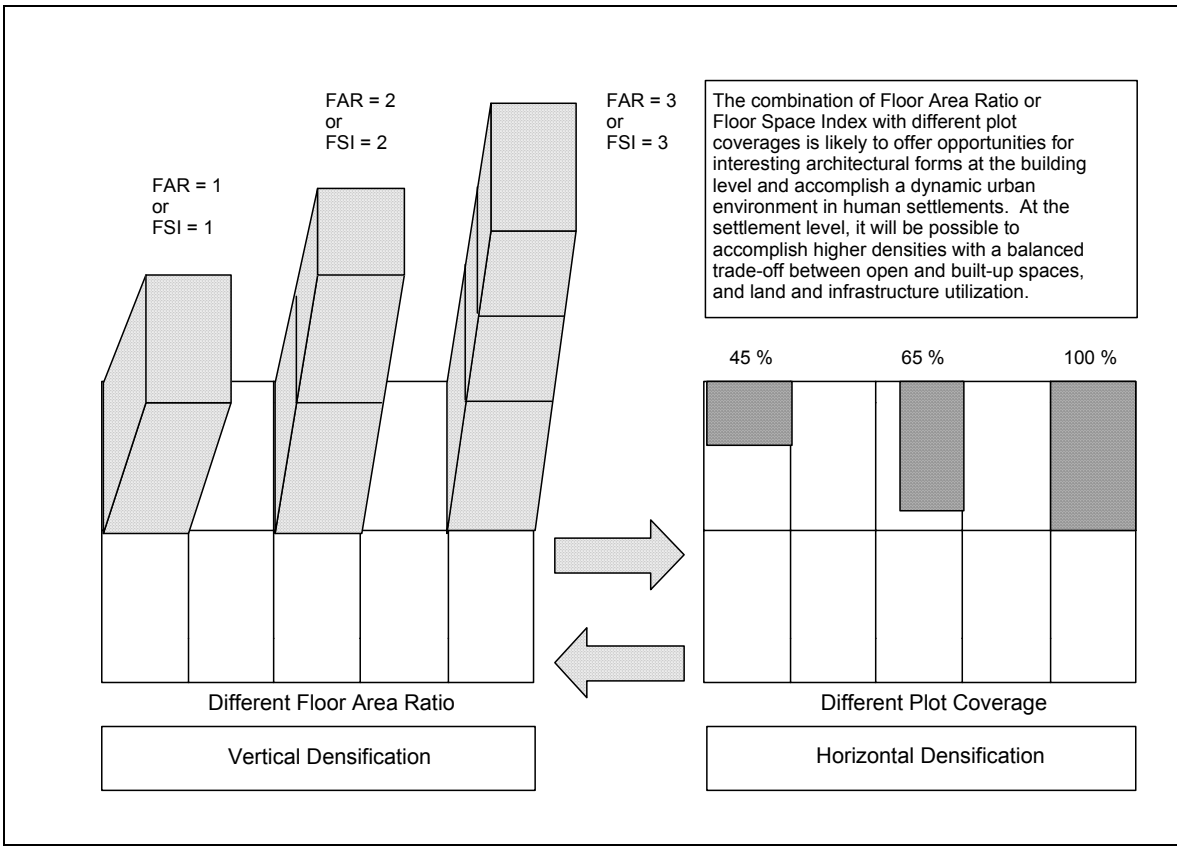



**Figure 12 Relation between floor area ratio and plot coverage**

During project design phase, densities are controllable variables but one should never forget that the real figures are subject to influences from external factors such as housing shortage, location, accessibility to public transport and services. For example, if there is an acute housing shortage and the plot size allows housing extensions, experience shows that there is a natural densification of settlements -

thus an increase of plot occupancy and decrease of floor area ratio per person - usually related to informal rented housing, specially if the area is well situated in relation to employment opportunities and services. The cases of Bissau and Brasilia illustrate this. This means that external conditions may transform density values that might even oppose existing land use legislation. One may speak of a fluctuating density that is sensitive to changes in the composition of the population living in a given area. Changes in the zoning regulations that allow increases in plot coverage or floor area ratio may affect density outcomes as well through vertical or horizontal building expansion.

The relationship between density and infrastructure costs seems to be even more complex. While studying the design and implementation of low income settlements in Brasilia, Brandão argues that per capita costs of infrastructure decreases spectacularly when the population density is increased from 50 to 200 inhabitants/ha (Brandão, 1975). From 200 to 300 inhabitants/ha, per capita costs increase but not significantly and tend to remain at the lowest values from 300 to 600 inhabitants/ha.

This is also confirmed by Mascaró who studied the cost of urban infrastructure networks in relation to densities (Mascaró, 1987). When assessing the share of each network in the total network cost, Mascaró shows that as population density increases, the share of pavement, drainage, sewage and public lighting is increased while the share of water, gas and electricity supplies is decreased. This means that for some networks higher densities lead to optimal or maximisation of use. The pavement of roads seems to be the most costly component followed by sewage and drainage. The overall cost of the networks per dwelling decreases drastically from US$2,500 per dwelling for a density of 75 inhabitants/ha to US$750 per dwelling for a density of 300 inhabitants/ha. What Mascaró does not clarify is in which context the real dollar figures are applied. Evidence from Northeast Brazil (**Box 3**) also confirms these statements.

Brasilia has been an experimental field for urban design. Apart fmrom the peculiar world famous and UNESCO protected Plan Pilot, several types of urban configuration settings have been implemented in the newly created satellite cities, housing estates and site and services projects since the construction of the city started in 1957. The Plano Piloto is known by its residential units designed according to CIAM's guidelines, specially the 1933 Charter of Athens, which advocates the strict separation between residential, working, commercial and recreational spaces. The neighbourhood units are formed by 4 superblocks. Each superblock measures an average of 300 x 300 meters or 7-8 ha and contains 8 to 15 apartment buildings with height varying from 3 to 6 storeys above the pilotis. Each building may have from 36 to more than 70 apartments occupied by 160 or even more than 300 persons. The height and number of apartments vary according to location. One superblock may have up to 3,000 inhabitants and gross densities varying from 150 to 250 persons/ha which is a contrast with other residential areas in the satellite towns where densities reach up to 400 persons/ha although they are developed on the basis of low-rise housing and individual plots. The amount of open space and green areas in the Plano Piloto is noticeable. It provides a pleasant urban environment but social contacts are minimised due to the distances and segregation of functions and automobile oriented town planning. Furthermore, the costs of development and maintenance of public spaces are excessively high. The density of the central areas and the sectors of government building vary drastically between day time when hundreds of thousand of people commute to work, and night time when everyone but security guards return back to their home. During the weekends, density figures goes down to zero when one may only find the guards and eventual cleaners of governmental buildings. In the 1980s, the government decreased housing production and increased control over land occupation - 60% of land is public property - meaning that any illegal occupation or existing squatter settlements and labour camps were under strict "police control". Land and house prices increased dramatically. Next to that, the urban standards of the Plano Piloto impliies that the building costs in the area are prohibitive for low income groups. Consequently, population mobility increased and there was a process of densification through house crowding of the existing settlements and through plot crowding of the satellite cities where subletting of backyard rooms became a common practice. The situation became explosive - every satellite city had tenants associations defending the rights of those who occupied rooms and houses of backyards of residential plots - and in the Plano Piloto subletting of houses and apartments started to take place and commercial areas were transformed in housing accomodations despite the strict land-use regulations. The pressure on the existing housing stock was noticeable in the densely occupied sites & services projects where the inhabitants started to increase building densities through rental units. Studies carried out in some of these settlements like Itamaraca and Candangolandia, provided evidences of this phenomenon but highlighted interesting outcomes from project costs, urban layouts and displacement of target groups. The displacement of target residents of these two projects was not only caused by restrictive government policies -that placed extra pressures on their property - but also the impact of high monthly housing expenditures brought by inappropriate urban layouts that squandered land and infrastructure.

Source: Acioly, 1987.

**Box 7 Density in Brasilia**

***Settlement Layout***

- The layout of a planned residential area is the result of a design action that subdivides available land for development and defines the public and private domains in a human settlement. That is why the gross density in a human settlement is greatly affected by its urban configuration. When deciding about the layout options for a human settlement is important to look at efficiency from the point of view of the amount of land used for residential, public and semi-public functions and the related costs to serve it with basic infrastructure, and the potential revenues it can generate. The density equation embraces some important practical conditions beyond the urban configuration. These include:
- the total number of occupants per dwelling,
- the total area of the dwellings,
- the legislation regulating the plot coverage - the proportion of the plot that is allowed to be covered by the building -,
- the floor space index (FSI) or floor area ratio - the ratio between the plot area and the total built up area allowed to be constructed,

- the total space allocated for vehicles - the standards defining the width of roads and pedestrian pathways.

The degree to which the above regulations and standards are respected. Independently from being the result of a deliberate action or of vernacular or spontaneous/collective processes, every human settlement carries a spatial configuration that has some inherent qualities and constraints. In principle, it should be suitable and even conducive for social interactions, be culturally accepted by its inhabitants and be economically and environmentally sustainable in relation to the consumption of infrastructure and land that it generates.

# Case of Ismailia

## *Background*

The Ismailia Demonstration Projects commenced in Egypt in 1978 aimed to develop a model for urban development which would be accessible to low income groups and which would echo the pattern of development in Egyptian cities

Housing in Egypt is normally developed incrementally, depending on income and demand. This poses a particular challenge in how to plan for layouts and infrastructure that can accommodate these changes. In broad terms the challenge was to design a system affordable to middle and low income families starting with one storey development, but assuming that average development would extend to two storeys within a 10-20 year period. In other words, density would at least double and over time could reach 4 or more times the original level.

Practical approaches for design for densification included:

*Aspect* *Response*

*Plot size* Plot sizes were kept at a size of average 100 sq m which allowed more options for economic vertical expansion, rather than keeping them very small which would have maximised initial affordability.

*Plot shape* Plot width was designed to be sufficient to allow stairs. Wider plots can be more efficient as two plats can be constructed on each floor sharing stair access

*Water supply* Design was related to the first threshold of density, with the possibility of doubling up later

*Drainage* This was initially designed for on-plot sanitation, with upgrading to water borne possible later

*Schools* School sites and buildings were designed with potential of vertical expansion. Multi shift use was also common in Egypt

Flexibility also extended to use of small contracts and strong local decision making which allowed implementation to be responsive.

## *More can be less*

The process of development of the design involved a lot of discussion with trade off between smaller plots giving greater affordability, or larger plots with greater flexibility over time. This debate was mainly between design professionals. Later, in the implementation phase, the response of local people to the plots that were being developed was that they were too narrow -the frontage was 6 metres -designed to be economical for infrastructure provision. People complained, rightly, that if the plots were wider - 7.5m or 9m, they could develop with two flats on each floor sharing the same stair -and thus be more efficient. In this case the paradoxical result was that the approach which initially aimed at greater densities, in the end would have resulted in lower density.

*Lessons*

Lessons from the experience in Ismailia are:

- it is possible to plan for densification

Whatever you plan to start with, something else is likely to occur!

**Box 8 Plot development in Ismailia, Egypt**

***Design for efficiency***

Land is a basic asset. How it is subdivided and occupied is of ultimate importance and that is why densities become an important parameter. Whether land is squandered or efficiently occupied will basically depend on the standards used for roads and plots. The size, the width, length or depth and shapes of plots , plot coverage regulation and dimensions of roads will significantly affect ultimate density.

For example, square meter of roads per house in a typical Malaysian land subdivision is up to four times greater than in comparable North American or Western European projects. When compared with commonly accepted international practices, about 25 % of the land set aside in the typical subdivision could be assessed as being wasted. The streets are too wide, the set-backs too great, and land is set aside for redundant community facilities (WB, 1989; Dowall, 1991).

As mentioned earlier, plot size is culturally bound and varies from country to country. In Delhi, the Rohini sites & services project offers plots from 26 to 90 $m^2$ in which two storey buildings can be constructed, permitting plot coverage up to 75 % and allowing 2 dwelling units for plots of 48, 60 and 90 $m^2$. In Brasilia, the Candangolândia and Itamaracá projects were based on the 120 $m^2$ plot but the national legislation for low income projects establishes a minimum plot of 126 $m^2$. In Guinea-Bissau, urban plots are conventionally defined as 20 by 25 m, covering an area of 500 $m^2$. These differences in plot size make it very difficult to compare densities and reinforce the observation that density figures are strongly related to the cultures of the cities concerned. However, whatever the cultural acceptance, low density implies either low standard of infrastructure or high costs which are very difficult to afford and which also have high environmental costs (see also **Box 2**, California sprawl).

The discussion of efficiency developed by Caminos and Goethert (1976) defines three classes of land:

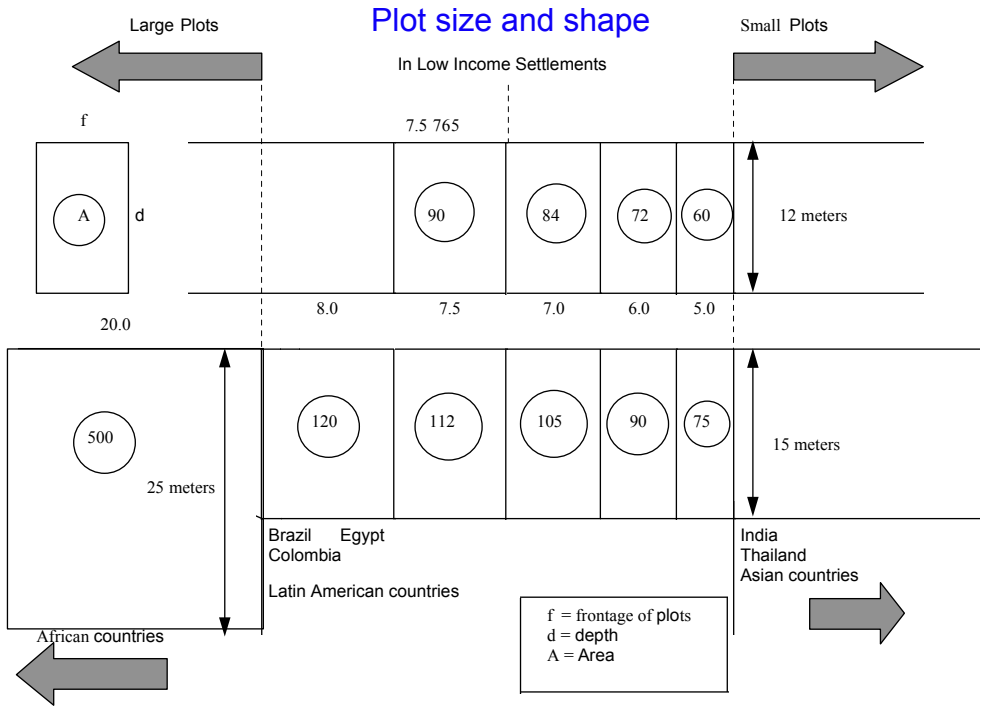
- *Public land* This includes the area occupied by roads and public open spaces, the cost of which has to be born by residents.
- *Semi-public land* This includes al schools and other specialized institutions, the cost of which is normally born by the institution concerned, and
- *Private land* This includes all individual plots for housing, commerce and other uses, the cost of which is normally born by the occupants.

Caminos and Goethert recommend from analysis of cases that efficient percentages in each category are:

| | |
|---|---|
| Public land | 20-25% |
| Semi-public land | 15-18% |
| Private land | 55-62% |

These figures will be affected by large public institutions and by local cultural context -but are useful as a reference point.

Box 10 provides some examples from Mexico of the range of densities in one city and the differences in layout efficiency




### *The Issue Of Plot Frontage*

The narrower the plots the more plots will fit in a particular cluster pattern which is often pre-defined by urban design regulations. However, narrow plots impose limitations to housing design and usually imply very narrow houses, narrow rooms with a housing expansion pattern towards the backyard, specially if minimal setbacks allow circulation, ventilation, light and rainwater catchment are respected. It also encourages the implementation of row houses in order to optimise the use of land. (see Ismailia Box 8)

The trade-off in terms of infrastructure costs offered by narrow plots is high because it means a greater number of dwellings and thus more families can be served per length of networks. There is indeed an optimisation of the infrastructure network.

However, in terms of land market, narrow plots may become unattractive for potential buyers due to restrictions or difficulties in developing the land. Although narrow plots do tend to maximise the profit per plot for the settlement developer whether this is government or a private developer.

A survey in 12 settlements in Mexico city provides a comprehensive and detailed information about the performance of the sites in relation to densities and utilisation of land and infrastructure. Nine of them are low income settlements. The lowest density was found to be 166 persons/ha in Netzahualcóyotl, a settlement based on low-rise and one house (80-100 $m^2$) per plot, situated 9 Km from the city centre and built in 1963; the site is characterised by a regular gridiron layout presenting excessive land allocated for public use and large roads, covering an area of 4,000 ha for 137,000 plots of 150 $m^2$. The clusters are 200 by 50 meters with 45 plots per cluster, with a gross density of 110 persons/ha (1970). The highest density of 1,442 persons/ha was found in Tepito (La Florida), a settlement based on medium-rise housing with a high percentage of land used for residential-private domain, with extensive plot coverage - most of the private area is covered - and low percentage for roads and footpaths. Growth density in the study area reached 900 persons/ha. Tepito is a centrally located and consolidated neighbourhood resulted from a series of land subdivision where more than 40,000 people live. The building stock is formed by flats and houses (26 $m^2$) of one or two storey high, the majority being tenements (vecindades and tugurios). Most plots are regular in form and size. The study assumes that acceptable and desirable densities for residential areas should range between 300 and 600 persons/ha, also assuming that the housing typology would vary between 1 and 3 storey high with an average residential floor area per person between 10 and 20 $m^2$ and a plot coverage varying between 30 and 35%. The study also presumed an optimal trade-off in land allocation: 20 to 30% for pubic areas, 3 to 13% for semi-public and 39 to 77% for private use. Only few settlements fell under the mentioned density range and those satisfying the density condition did not satisfy the land utilisation criteria. A great deal of the settlements were squandering land and others creating congestion due to excessive land allocated for residential use. In terms of layout efficiency, 6 settlements were graded inefficient from which half accomplished the density condition and the other half low population density. The layout efficiency of the other 6 settlements was not measured. It is worth to mention the outcomes of a high-rise and high density (711 persons/ha) and public sponsored settlement (115 ha) implemented in 1966. Half of the buildings are 4 and 5 storey high and the rest 7, 8, 14 and 22 storeys with flats measuring 74 $m^2$. Only 15 % of the land is for residential use, 27% for roads, footpaths and parking and 49% - almost half - for green and recreational spaces. Since high-rise buildings demand special care for norms related to setbacks, distance between buildings, spaces for parking and recreation, and community services, all in a compact - concentrated - site, this alternative does not always achieve a balanced trade-off even when population densities reflect a potential increase of beneficiaries. The survey could show how densities can vary so much within an urban fabric formed by different urban configurations and housing typologies that result in a myriad of urban environments in a single urban agglomeration as Mexico city. Considering that urban sprawl is questioning the sustainability of the city, this study was already calling the attention for inefficiencies in land and infrastructure utilisation as a consequence of inappropriate settlement configurations.

Source: Bazant, 1978.

**Box 10 Density and efficiency of layouts in Mexico**

### *The Issue Of Road Width*

Wider roads tend to increase the costs of plots when the trade-offs are made between the available land that was subdivided for private use and the total area for services and infrastructure. The circulation system - streets and main roads - is the most costly component in a project, especially if they are going to receive any kind of surface or pavement treatment

Wider roads have a direct impact in the cost of plots since the cost of infrastructure is naturally increased as a consequence of wider roads,. The standard of road dimensions also makes a major impact on the costs of land development.

Wider roads increase the percentage of land allocated for public use and diminishes opportunities for land subdivision for private use. However, on the positive side they may offer more long term flexibility as road space can have multiple uses such as transportation, parking, play area, work area and social meeting space. In this Brasilia provides a negative example, and India a positive case.

### *Density and Land Market*

Some studies and examples drawn from Seoul have pointed out that restrictions in the land delivery system and by-laws and planning control on densities of residential development greatly affect land costs (Dowall and Clarke, 1991). Specific regulations related to zoning, urban standards, plot layouts and building setbacks can severely reduce available space for residential development but the ultimate impacts will greatly depend on controls and constraints related to high density developments. The process of deregulation of the building codes and regulations in Bogotá resulted in increasing building densities. Bangkok experiences remarkable and rising densities as housing typology has shifted from small town houses to 4 to 5 storey multifamily buildings. Due to rising prices of residential plots, housing supply is shifted to peripheral locations, project sites areas have decreased by more than half and consequently are more dense, reaching 56 dwellings/ha in comparison to 35 dwellings/ha (Dowall and Clarke, 1991). These cases highlight that there is a strong relationship between the land market and residential densities emerging in particular cities. Hong Kong (**Box 4** ) provides a useful case.

### *Density and Plot layout*

We have seen that the plot dimensions - width and depth - , infrastructure standards - road width, infrastructure networks regulations - and settlement layout are important variables to define density outcomes and to accomplish efficient utilization of land and infrastructure. Dowall and Clarke argue that plot frontages of 4-4.25 meters and plot areas of 35 $m^2$ are the most profitable figures for human settlement development in the context of Asia (Dowall and Clarke, 1991). This may be true from the economic point of view but will certainly fail to be culturally acceptable in many other contexts. The same applies to urban densities. These plot areas will bring residential densities to very high levels which may not suit all countries.

The size of a residential plots in many African countries reaches above 250 $m^2$ , a factor that differs very much from other parts of the world and that greatly influences density outcomes. Certain traditions affect these outcomes such as the need for private open spaces in the vicinity of the houses, large houses and plot sizes and the traditional use of these spaces. Assumptions that these standards are unchangeable are questioned by an examination of what is happening in many African cities. In Zimbabwe, informal occupation of gardens of formal subdivisions is common (ref. ichpb paper). In Nairobi a sites and service project designed for single storey development is now developed in multi storey buildings (xx ref. name? photo?)

### *Density and Optimisation of use of Land*

Studies carried out in different urban centres in India indicate that present urban growth rates are putting an explosive pressure on available land. There is a decrease of per capita land available and therefore a need for a more intensive utilization of land. One of the prime concerns expressed by HUDCO's study is to achieve higher levels of density. It is argued that there is a multiplying effect from this - an optimal use of land, a reduction of shelter costs per unit and stabilisation of land costs. There is a need to assess possible shifts from low rise plot one storey housing development - one family housing - to high rise apartment - multi-storey multifamily housing. (See **Box 13**, Bombay)

In the new town of Dodoma, the Capital Development Authority recommends desirable residential densities between 12.5 and 35 dwellings/ha. The CDA advocates compact communities where most effective use of roads, infrastructure and land can be accomplished provided that next to efficiency and economy, the housing schemes should offer privacy, pleasant living environment and recreation facilities (CDA, 1980). The CDA set the conditions and criteria for urban development standards in the city which is based on plot sizes, minimum plot widths, setbacks, maximum densities and plot ratio coverage. It is interesting to notice the contrast with density recommended by HUDCO for India. The settled part of Dodoma had a gross density of 4.2 housing units per ha in 1974, a net density of 9.2 and population density of 88 persons/ha. In its attempt to control housing developments, the CDA establishes a density of 26 units/ha in row housing developments with a minimum plot of 225 $m^2$. Densities can vary from 7.5 units/ha for detached houses built in 1,000 $m^2$ plots to 16.5 units/ha for semi-detached houses built in 425 $m^2$ plots.

**Box 11 Density in Dodoma, Tanzania**

Experimental designs using cluster layouts (ssref)provided density outcomes of 280 dwellings/ha with two storey dwellings up to 600 dwellings/ha with 5 storey walk-up multifamily buildings both based on a minimum dwelling unit up to 30 $m^2$ per dwelling (HUDCO, undated). It is difficult to assess whether these are realistic and accepted housing typologies and density outcomes for the Indian context but the fact remains that the scarcity of developed land in the cities and increasing demand for residential space is urging for an urgent and sustainable approach to human settlement planning and design.

***Density In A Developed Country: The Netherlands***

In the Netherlands, during the second half of the 70s, the advantages of high density residential were promoted through the *compact city* model. This approach was partly a reaction against the departure of families with children towards suburban areas. The cities and particularly the inner cities were decreasing in population or were confronted with a stratified urban environment since those who left usually were wealthier.

This model allowed the occupation of available open space in the urban fabric through the *densification projects*. These projects were defined as housing projects - middle and high rise buildings - with residential densities above 80 dwellings/ha, situated in a consolidated urban area and in land which was not originally zoned for residential purpose in cities with more than 100,000 inhabitants. It was argued that the use of existing infrastructure and service/facilities would be optimized. Land costs would be minimal since it usually belonged to the local government, thus there was no need for expropriation. The ground was ready for building and there were possibilities to create new architectural styles, breaking or contrasting with the existing neighbourhoods. The target groups of these projects were those who were motivated to live in the inner city, the highly educated young people and older people with higher income. The first projects were implemented in the beginning of the 80s and up to 1989, more than 100 projects had been carried out in Dutch cities with more than 100,000 inhabitants.

A major part of these projects were implemented through middle rise building up to 5-6 storeys high. Densities could vary from 80 dwellings/ha in Amsterdam to 260 dwellings/ha in The Hague. In Rotterdam, projects reached up to 300 dwellings/ha. However, population density in these areas was not extraordinarily high due to the typical low occupancy rate of the dwellings. This highlights a cultural and social factor behind density measurements which planners and urban designers must consider when assessing an urban environment from the perspective of ideal densities. In the Netherlands, residential plots, houses and households are usually small in comparison with many developing countries. The average household size for the whole Netherlands is 2.35 persons/household and occupancy rate reaches an average of 2.5 persons per dwelling. The new dwellings have an area of 81 $m^2$ and in average have 4.1 rooms - including the living room. The minimum Dutch dwelling has an area of 43.6 $m^2$.

Density becomes an important indicator in physical planning activities in the Netherlands being it a small country but having one of the highest overall population densities in the world - 452 inhab/$km^2$. Figures are usually presented as dwelling per hectare, demonstrating an excessive concern for the physical planning and the process of land occupation of the restricted amount of territorial space available for human settlement -in the west of the country land often has had to be reclaimed from the sea.

What do the residents think about a densified residential environment? A research carried out in five densification projects situated in Rotterdam, Amsterdam, Breda, Enschede and The Hague, demonstrated that in general the inhabitants did not appreciate to live in such a densified urban environment. Except in Amsterdam and Rotterdam, the inhabitants of the other projects found the housing environment boring and the dwellings encroached on one another. The researchers explain that the former housing situation of the respondents - living in a traditional one-family house - played an important role during their assessment of their new residential area (Roosen and Kropman, 1989).

Related to public transport in the Netherlands, Central Government funding requires that within 300 metres of public transport stops there is a defined minimum population.

**Box 12 Density issues in Netherlands**

## Management and legal implications

### *Overview*

the previous sections focused on decisions taken during the planning and design stages. The effectiveness of development guidelines and regulations is limited by the degree to which governments can enforce or influence the enforcement of decisions.

There are four main stages in development, each of which has a different degree to which government has a control.

- *Subdivision*. Here government normally has control unless development is informal. However, many cities may have in the order of 50% of their fabric comprising informal development.
- *On plot development*. Here again, control depends on the degree to which all city development is controlled. Forms of control include on-site inspections, penalties, licences and taxation. Experiences show that even when these enforcement mechanisms and regulations do exist, some individuals and private developers find a way to over-rule them.
- *Building use*. The most problematic area to control is the actual use of houses. In most situations this cannot be controlled, as urban development needs and priorities are subject to rapid change. Many slums, particularly in Europe, United States and Latin America were a result of internal subdivision of individual, often large, houses and the emergence of multifamily occupancy.
- *Change of existing buildings and use* Government may wish to influence existing density patterns. This may be stimulated by what is considered over or under use of certain areas. Where controls are enforced, then regulations relating to, for

**Capitalising on Density: the case of the Slum Redevelopment Programme in Bombay**

Greater Bombay has a population of in the order of 12 million. Land values in downtown are reputed to be the highest in the world. Densities are high and any land that is unused tends to be occupied by informal development. Pressures are increased as the centre of Bombay is an island. This means that there is both high pressure for development and very limited options in terms of space. One major innovation has been to promote a very large scale development at New Bombay. However, New Bombay is far from existing sources of employment, and the opportunities developing there are formal sector and of limited use to the poor who are crammed in high density shacks along railway lines, on sites reserved for government projects or sleeping in the streets. An approach with considerable potential, but not without risks of its own is now attracting a lot of interest.

The programme aims to re-house squatters in or close to their present location in accommodation built by the private sector. The motor of the scheme is the offer of increase in the allowable Floor Space Index (FSI) from the normal 1 to 2.5. This can be used on another site within limits set by government. The additional value of the permission is sufficient to make it worth building the new units -though the units are small ( sq m) and there are doubts about their suitability to all families affected.

The high land market and potential profit from the programme seem to be attracting considerable interest - though detailed figures were not available. Developers express satisfaction and the intention to carry out further projects. The advantage of private developers or “builders” is that they bring in capital and are able to arrange permissions quickly. On the other hand there does need to be an effective mechanism to ensure quality in design, layout and construction -as is likely that there will be considerable pressure to minimise on these.

Reference:

Box 13 Bombay, slum rehabilitation programme

example, increase in allowable building through increased Floor Space Index, can be very powerful.(Boxes Box 13and Box 14concerning Bombay and Sao Paulo give examples of this situation)

For the above reasons it is very difficult to control population densities. Building densities are easier to control and manage that population densities, but either would have to be supported by political will if they are to be enforced. In cases where the housing market is restricted it will normally not be possible to enforce.

Guidance of density may be more effective than control. The closer to market forces a development plan is, the better the chance of implementation. For example, encouraging high density near high volume public transport is likely to work as the interests of all main actors tend to coincide. A similar pattern can work in Brazil, in Holland and in Egypt. Partnerships between government and private sector provide opportunity for government to influence density through negotiation.

### *Checklist for legal and management tools to influence density*

The following represents a listing of tools that be used to influence density, with a note on their advantages and disadvantages

| Tool | Advantages | Disadvantages |
|---|---|---|
| Building regulations | Regulations can stimulate optimal use of private space and public infrastructure. Existing systems of building regulation are normally in place -changes can make significant difference | Conservatism in system<br>may constrain development if not adequately reflecting the dynamics of urban development.<br>May be open to abuse. |
| Floor Space Index or Floor Area Ratio –increase | Relatively easy to manage. Has major influence. Can be used as a trade- off against other development objectives | Its high value in the context of high land values make it attractive for corrupt practices.<br>Does not work where land values are low. |
| Good governance , accountability- efficiency and effectiveness of local government | Any of the measures outlined above require efficient and effective local government to work. This includes transparency, ability to generate revenues, rapid decision making and responsiveness to local needs | Takes considerable effort to have an effect.<br>Interested groups may feel marginalised in decisions and political preferences of local government. |
| Guided land development | gives potential of some degree of control without high entry costs. Development standards can be easier adapted to the needs and resources of inhabitants. | Difficult to implement where land market is active as it goes against land developer interests. There may also be resistance from conventional planners |
| Increase the proportion of land developed formally by legalization of existing informal areas | allows problems of excessive density to be ameliorated. The degree of overcrowding of properties can be reduced | requires some resettlement. High costs are involved through acquisition of appropriate alternative land, provision of infrastructure and ensuring access to employment. |
| Land sharing -or partnership in land development | can encourage good balance between residential use and other uses.<br>It can be used as an instrument of urban equity and redistribution of wealth in cities. | If not implemented under supervision of government it might cause undesirable land occupation/ use. |
| Land taxation | If realistic related to value of location land taxation tends to encourage high density in high access locations if limited by zoning and land use regulations.<br>Taxing vacant land can also encourage use | Requires political will. In a context without clear accountability and transparency this can be a source of corruption |
| Land Use regulations | Define development parameters and provide guidelines for development. Provide clarity in | Tend to be inflexible and restrain development. May stratify the city and constrain access of low income |

| Tool | Advantages | Disadvantages |
|---|---|---|
| | the market | groups to housing. |
| Partnerships in urban development projects | Density objectives can be balanced with private sector objectives | partnerships may exclude community interests. |
| Property taxation | If up to date and implemented, taxation can be used to stimulate more intensive uses including use of vacant land.<br>Research (Dekel 95) suggests that high income but low density areas often do not cover the real costs of services and should thus be taxed higher or restricted. | Difficult instrument to use flexibly. Seldom popular politically |
| Public transport management and planning | Investment in public transport both allows densification and requires it to be able to operate efficiently. | May require subsidy in interim stages |
| Upgrading of infrastructure via improved management/ improved financing | Upgrading of infrastructure can allow densification<br>Better health conditions.<br>Environmental improvement | Can lead to increased prices of property which can go against affordability objectives. |
| Zoning | clear. Normally there is an existing system for control | tends to be inflexible -difficult to change<br>Depends on degree to respect for regulations |

***Density In São Paulo - Brazil***

With a population of about 9.4 million (1991) living in an area of 149,300 ha and a density of 63 inhabitants/ha, São Paulo is one of the largest cities in the world. Great Sao Paulo, with 38 municipalities, is expected to reach 25 million inhabitants in the beginning of the next century. In the period 1989-92, the city experienced an innovative planning process related to density. The increase of building densities in residential and non-residential areas was one of the backbones of an strategic urban development plan based on the argument that there are strong relationships between the production of built-up space, densification and demand for infrastructure. A careful analysis and inventory of the different zones of the city was carried out in order to detect where the infrastructure and services installed could cope with increased density of land use. This is despite the situation that the city is apparently "saturated" -it is expected to grow to over 23 million in the next decade. A series of indicators were developed in order to establish the relationship between the accepted capacity of the available infrastructure and services, and the built-up area. The existing spare capacity must be able to be translated into potential square meters of built-up space. This densification potential was called "stock of space".

Transport, road, water, drainage, electricity and sewage networks were systematically assessed. Transport deserved a special attention since the location of origins and destinations of journeys are simultaneously affected by any change in land use. The circulation system of the city centre presented traffic congestion and is almost saturated with traffic towards the inner city already reaching 2000 vehicles during the peak hour of the morning. it was also found high numbers of passengers commuting: 30,000 passengers only in the peak hour of the morning. The bridges and viaducts were overloaded and the buses were registering very low speed though transporting 19,000 passengers/hour/one way. The drainage system presented an indirect relationship with density. Increasing building densities made the urban surface impermeable, representing risks of flood. The water, sewage and electricity systems were assessed through their three subsystems: production (capture, treatment, generation), arterial distribution (primary network, collectors, substations) and local networks.

The plan utilised the same concept of floor are ration used in Curitiba, Rio de Janeiro and Bombay, called locally coefficient of use/maximisation - CA (Coeficiente de Aproveitamento Unico). The plan adopted CAU=1 for the whole urban area of the city as a unique floor are ration. This means that the building might reach a built up area equal to the area of the plot. The CAU is an index that relates the built-up area with the plot area and determines the area for which the building right is free of charge. The CAU was used as a starting point to define the zones possible to have increases in density (CAU>1) and those which do not fulfil the criteria. The guiding principle for densification was the availability of infrastructure and their capacity to absorb consumption increases. In general, the urban areas with poor water supply, lacking sewage, and with insufficient structural roads and precarious public transport were defined as areas not possible to increase densities. Wherever there was a high utilization of space, high energy power concentration, traffic congestion and high concentration of public transport, the area was called critical - MA1. An area where the limit of the infrastructure is almost accomplished, the plan would stimulate diversification of land use and guide the land occupation-densification. The zone presenting low density of power, structural roads, availability of public transport and a high stock of development space was defined as an area for potential densification. In this region, government intervention should constrain, guide and stimulate the intensification of land use that will lead to higher densities

The plan revealed measurements of infrastructure consumption per square meter of built-up space. For example, non-residential uses consumed between 6.76-15.60 kwh/month/$m^2$ while residential uses between 1.74-3.33 kwh/month/m Average residential consumption was defined as 2.5 kwh/month/$m^2$ and was used as reference to assess future increases in use and density. Further studies finally defined 15 different zones of the city where increases of density could occur - ZA - resulting in a total of 51,400,000 $m^2$ of potential stock of space. Computer models helped the planning team to simulate traffic and transport scenarios and assess the general circulation in the city during a period of 5 years.

The crucial point and innovation of the plan was exactly the management of this stock. An information system was established in order to monitor the registration, processing and periodic dissemination of the changes in use, density and occupation throughout the 15 ZA zones. The municipality would act as a bank. The stock of space would correspond to credit in infrastructure and the consumption of space in the form of built-up area would represent the debts of the client of individuals and private developers. The local government innovated by linking this potential for increasing building densities with mechanisms to foster housing production. Density - the concept of densification - was used in a very creative way, extrapolating its pure physical planning character to become an instrument to stimulate social housing production. In the past, the municipality has paid development rights for the costs of land expropriation when it enlarged the most important road of the city - Avenida Paulista. More recently, it ammended legislation in order to stimulate social housing production through partnership-based urban operations called interlinked and social interest operations. Very similar with the floor area ration (solo criado) used in Curitiba. A municipal housing fund - FUNAPS - was linked with these operations and became an urban management tool to revise and consolidate the most desirable physical and functional organization of the city. Basically, the operations are used when private land or public land has been occupied by unauthorized human settlements. For both cases, the owner makes a request to change the CAU in the plot where the settlement is situated or in another plot he owns elsewhere in the city. The land is carefully valuated before and after interventions are carried out. Infrastructure and building costs are implemented by the owner who in exchange pays with housing units to the local government and receives in exchange densification possibilities or development rights in the plot where the project takes place or in another plot he owns elsewhere in the city.

54 proposals generated 4,088 social housing units. In 37 of them, for each 2.44 $m^2$ of residential space given by the municipality as development right, 1 $m^2$ of social housing was paid in exchange by the land owner. In 16 operations involving commerce/service uses, for each 2.29 $m^2$ of space provided by the local government, the land owner paid 1 $m^2$ of social housing. Up to 1992, roughly 7,000 operations have been realised. During four years (1988-92), the city received an additional built-up area of 580,000 $m^2$ through densification mechanisms, with an annual increase of 129,000 $m^2$. For those who criticised the municipality's densification policy, the result of this policy only represents 1.5% of the annual increase in the city's built-up area but in terms of development potentials - social housing, optimisation of infrastructure and services, redistribution of resources - this policy accomplish a significant result, not mentioning the generation of US$67 million through urban operations.

**Box 14 Density management in Sao Paulo, Brazil**

## Conclusions

This report has attempted to highlight some of the key issues concerning density and to review the tools which can be used to intervene in this crucial but still unclear area of urban development.

The overall context of urban development, especially in developing countries is one where issues of employment, efficiency of infrastructure provision, access of the urban poor to adequate shelter and environmental sustainability are all key issues which are tending to increase in importance. This is especially the case in those urban areas where there is considerable and increasing pressure of population on urban areas.

The density of urban development, and especially residential density is a subject that is difficult to generalise about especially in an international context. Concepts of what is high and low density and what is acceptable are very specific to different continents, countries, cities and even neighbourhoods. Even in these contexts, however there are increasing calls for change - and these changes are generally in the direction of more compact cities, though there is also considerable resistance. The costs of low density solutions are becoming increasingly recognised even in the "mother of all sprawls" in California. Cases of cities including Curitiba, Hong Kong, Singapore, Stockholm and London show that government policies plans and controls can shape cities and densities, even though there may never be agreement on what is ideal.

The recommendations and guidelines in terms of settlement layout design presented in this study should not be seen as universal and unquestionable parameters. They are intended to provide urban designers and planners with means to anticipate and evaluate the functionality and efficiency of the layout in the use of resources - land and infrastructure.

Density will always be a crucial parameter in the planning and designing of cities, particularly because of its social impact and its effect on the costs of infrastructure provision. However, perfect final design of cities is not possible :

a) because it is not possible to define "perfect",

b) because the development pressures are continually changing and

c) because instruments to influence density are relatively crude. This means that it is very important to build in robustness and flexibility in design parameters and in regulations. These should allow for variation over time without systems breaking down. Perhaps we need the concept of designing for and managing "elasti-city"

## Appendices

### *Glossary*

| Word/ concept | Definition |
|---|---|
| **1 acre =.405 ha** | |
| **1 sq ft = .092903 sq m** | |
| **Crowding** | degree to which the number of people in an area exceeds an accepted level of occupancy. "Accepted" is, of course, a relative concept depending on cultural background and socio-economic status |
| **Density, population** | number of persons living in an area |
| **Density, residential** | Number of persons per unit area in residential areas. |
| **gross** | number of persons living in an area divided by the total area. This includes schools, public open space, roads, green areas and other facilities |
| **net** | number of persons living in an area divided by the net residential area. This is the area developed with dwellings and gardens. In places with UK influence on regulation this includes local circulation including half width of surrounding roads and small public spaces. |
| **Density, perceived** | The level of density which people feel an area has. This is dependent on the individual and his/ her background culture and also on the nature of the built up area. |
| **Dwellings/ha** | Number of dwelling units per hectare |
| **Floor area ratio** | The ratio between the total floor area, including thickness of walls, and the total area of a plot (same as FSI) |
| **Floor space index (FSI)** | The ratio between the total floor area, including thickness of walls, and the total area of a plot (same as FAR) |
| **Gross area** | Total area including all land uses without any deduction |
| **Formal development** | Development which is according to zoning and building regulations. |
| **Habitable rooms / area** | A room normally used for prolonged everyday activities e.g. living, sleeping, working |
| **Habitable space** | Floor area in a dwelling excluding service/ utility spaces (kitchen, WC, bathroom, storage, hallways) |
| **Inhabitants/ha (gross or net)** | Number of persons per hectare -(either gross or net) |
| **Informal development** | Development which is not according to zoning and building regulations. Normally refers to spontaneous housing and related commercial development. May account for up to 50% of development in some major cities. |
| **Net area** | Area of land or building after deduction of certain uses- |

| Word/ concept | Definition |
| --- | --- |
| | for example non residential areas. |
| **Occupancy rate** | Ratio of occupants to the number of habitable rooms |
| **Plot coverage** | Proportion of total plot area occupied by buildings |
| **Space per person** | Habitable space available per person in a dwelling. |
| **Sprawl** | Situation where land uses make an extensive use of land which is more than is required |

## Table 2 Reference figures relating to density

| Location / Project | Country | Continent | Housing Typology | Gross Population Density (inhab/ha) | Net Population Density (inhab/ha) | Gross Housing Density dwellings/ ha | Plot/Dwelling Size | Dwelling size | Floor Space index | sq m /person | Total Housing Units | Total area (ha) | Total Population |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ismaila Hai el Salaam | Egypt | Africa | walk up flats | | | | 100 | | | | | | |
| Guinea Bisau minimum offic | Guinea Bisau | Africa | single storey detached | | | | 500 | | | | | | |
| Nairobi | Kenya | Africa | | | | 476 | | | | | 40 | | |
| Nairobi | Kenya | Africa | | | | 937 | | | | | 62 | | |
| Nairobi, Uhuru Phase4 | Kenya | Africa | Row house/2 floors | 312 | 78 | | 71 | | | | | | |
| Nairobi, Kenya, Mathare Val | Kenya | Africa | Tenements | 1600 | 3333 | | 3 | | | | | | |
| Monrovia, Liberia | Liberia | Africa | Sites&services | 174 | 305 | 25.2 | 163 | | | | 593 | 23 | |
| Dodoma 1974 | Tanzania | Africa | | | 88 | 9.20 | | | | | | | |
| Dodoma recommendation | Tanzania | Africa | row | | | 26.00 | 225 | | | | | | |
| Dodoma recommendation | Tanzania | Africa | single | | | 16.50 | 425 | | | | | | |
| Lome, Togo | Togo | Africa | Sites&services | 124 | 230 | 27 | 217 | | | | 540 | 20 | |
| Hong Kong | Hong Kong | Asia | emergcy high rise | | | | | | | 4.00 | | | |
| Experimental-HUDCO | India | Asia | 5 storey | | | 600.00 | | 30 | | | | | |
| Rohini, Delhi | India | Asia | 2 storey | | | | 26 | 20 | | | | | |
| Rohini, Delhi | India | Asia | 5 storey | | | | 26 | 20 | | | | | |
| Amsterdam, Osdorp | Netherlands | Europe | Flats/4 floors | | | 80 | | | | | 347 | | |
| Den Haag, Turfmarkt | Netherlands | Europe | Flats, 5-6 floors | | | 260 | | | | | 336 | | |
| Enschede, Transburg | Netherlands | Europe | Flats, 5 floors | | | 90 | | | | | 370 | | |
| Rotterdam, Spaanse Kade | Netherlands | Europe | Flats/5-11 floors | | | 200 | | | | | 268 | | |
| minimum standard | | Europe | minimum | | | | | | | 15.80 | | | |
| Nairobi Mathare | Kenya | General | detatched | | | 270 | | | | | | | |
| Efficient plots(Dowal) | | General | | | | | 35/ | | | | | | |
| residential density high | | General | | 400 | | 666 | | | | | | | |
| residential density low | | General | | 100 | | 166 | | | | | | | |
| residential density medium | | General | | 200 | | 333 | | | | | | | |
| residential density very high | | General | | 600 | | 1000 | | | | | | | |
| Brasilia-Itamaraca | Brazil | Latin America | detached core hous | 215 | 441 | 40 | 120 | 36 | | | 452 | 11.1 | 2,400 |
| Brasilia-Candangolandia | Brazil | Latin America | semi-detached core | | | 36.00 | 120 to 250 | 42 | | | 2,236 | 62.2 | 11,200 |
| Curitiba | Brazil | Latin America | | 37 | | | | | | | | | |
| Sao Paulo | Brazil | Latin America | | 63 | 160 | | | | | | | | |
| Brasil official minimum | Brazil | Latin America | | | | | 126 | | | | | | |
| Medellin, Colombia, Villa So | Colombia | Latin America | Grouped house | 279 | 574 | | 96/43 | | | | | | |
| Montego Bay, Jamaica | Jamaica | Latin America | Sites&services | 229 | 468 | 44.2 | 100/- | | | | 828 | 18.7 | |
| Iztacalco | Mexico | Latin America | high-rise, flats | 405 | 433 | 77 | | 80 | | | 5,690 | 74 | 30,000 |
| San Juan Aragon | Mexico | Latin Americ | Detached house | 338 | 178 | | 190/32.5 | 64 | | | 9,900 | 193 | 65,340 |
| Lima/Peru, El Agostino | Peru | Latin America | Flat/row house | 525 | 664 | | 36/36 | | | | | | |
| Piura, Peru | Peru | Latin America | Flats | 408 | 1949 | 137 | 76 | | | | 170 | 1.24 | |
| Ciudad Guayana, Venez, El | Venezuela | Latin America | Detached house | 124 | 186 | | 300/65 | | | | | | |
| Boston | United States | North America | flat, high rise | | | 1449 | | | | | | | |
| Boston | United States | North America | flat, row | | | 480 | | | | | | | |
| Boston, Cambridge Post | United States | North America | Walk-up flats, deta | 112 | 148 | | 319/114 | | | | | | |
| Boston, Columbia Point | United States | North America | Flats, 7 floors | 747 | 1449 | | 78 | | | | | | |
| minimum standard | | North America | minimum | | | | | | | 31.60 | | | |

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