Chapter 1:

Background and Concepts

Introduction

Density measures are an integral part of the design professional's vocabulary and "kit of tools". These measures include density indexes such as the number of people per hectare and the number of dwelling units per acre of land, and related measures of land use intensity, like coverage and floor area ratios. They are part of the conceptual vocabulary of architects, municipal engineers, land use planners, and urban designers, and affect applications ranging from the design of housing clusters to the zoning standards for entire cities.

The application of density measures is aimed at creating, changing, or otherwise affecting the form of the built environment. When they are invoked, it is because of their assumed relationship to urban form. The architect and her developer client, mulling over the optimal housing mix for their residential project, the urban planner submitting zoning modifications to his planning commission for approval, the engineer calibrating a land use model to project sewer capacities for the year 2000, or the urban designer sketching the layout of a neighborhood center, are all using density measures as a surrogate for something they want to acheive in the actual real-world environment of the city, suburb, or countryside.

In architectural design, urban and regional planning, municipal engineering infrastructure design and land use planning, and urban design, density measures are a constantly used tool. Yet few of the many users of these measures have a sound understanding of their true meaning. Though there is a fair body of research on densities, building intensity, and density measures (which is reviewed below) there is little convergence among these studies and even less diffusion of their results.

The application of density measures is suffused with a kind of "folklore" that relates densities within quite narrow ranges to specific dwelling types. Nearly twenty years ago some regulators realized that: "Because there is wide variation in the size of living units and the number of occupants...density is a rather crude measure of the degree of land use." (FHA, 1971:6).

Yet, in an obvious attempt to estimate ultimate population densities and use intensities of proposed developments, the zoning ordinances of many cities still associate specific dwelling types with a sliding scale of "density points" depending on the number of bedrooms (League of Oregon Cities, 1977). Planning and design standards also frequently relate given housing types to specific densities (e.g. Lever, 1971).

Also open to considerable doubt is the precision of many density measures themselves. Ambiguity abounds regarding what is included under the "acres" or "hectares" in these measures' denominator. As a result, the association between the apparently regular increments of density expressed in these indexes and what may be experienced or perceived in the actual built environments that density measures are expected to express is much weaker than most users of these measures suspect.

The aim of this project is to promote peoples' understanding of the relation between density measures and the built environments of cities. A better appreciation of the complexities of this relationship will make more intelligent users of density measures out of the professionals who apply these measures in their daily tasks, and may assist those members of the public who encounter these measures in their interaction with the designers, planners, and regulators of the built urban environment.

The study consists of three parts:

* 1). A review and consolidation of previous research, focusing on the different definitions and measures of density that have been developed in the past, many of which are still in use. This analysis explores the differences between various density measures and exposes all the ambiguities that exist. In its conclusion a set of measures and definitions are presented that form the basis for the following sections.
* 2). A deductive exploration of the relationship between density measures and urban form. Four dwelling types: single family residence, row housing, low-rise "garden" apartments and high rise apartments are systematically analysed through a series of housing unit variations, lot sizes and block layouts, to see how these changes affect measured densities, and some of the physical characteristics of the perceived built environment.
* 3). An inductive empirical review of actual built environments, linked to the abstract exploration described above. Here

real-world examples of urban neighborhoods and housing developments are juxtaposed with their parallel diagrammatic variations. These examples illustrate better than the diagrams can the range of variation that is found, and the ambiguities of superficially similar numbers. Evaluation of the quality of these environments and their perceived characteristics suggests the uses and limits of density measures in designing and regulating the built environment.

A separate handbook is planned to summarize and illustrate the relationships between various measured densities and built environments presents the results of this study in a form that should be readily usable by practitioners and laypersons. This handbook is being designed to serve as a guide for the intelligent use of density measures and an accessory to design and planning guides and standards in the kinds of situations where these are consulted.

Concepts: Perceived, Physical and Measured Densities

In considering densities, it is important to distinguish between three different types of density which represent different phenomena and appear in different contexts though, as we shall see, they are intimately linked. They are: 1) Perceived Density; 2) Physical Density; and 3) Measured Density. As Rapoport (1975: 134-135) has said, "density itself is a perceived experience", made up of a physical system which is transformed into a perceived system and, when matched against personal and cultural norms, generates an "affective density" that communicates evaluative judgements like a sense of isolation, a feeling of comfort, or a perception of crowding.

This realization also enables us to distinguish between density and crowding. While closely linked to density, crowding is an appraisal relating perceived density to desired standards and norms, which may vary widely from one social group to another, and between different cultures (Rapoport, 1975: 134-141). Through crowding, density is related to environmental stress (Crothers, 1976; Krupat, 1985: 95-99).

We deal with density, then, in our roles as professional shapers of the built environment, or confront density as actual or potential users of an environment which is being moulded by some intervention. In any of these roles, we actually want to create environments that will have positive "affective" densities, stimulating positive evaluations on the part of their users. If we take social and cultural norms of desired levels of intensity of landuse, occupancy etc. as given, then what we are really trying to manipulate in each specific intervention is perceived density.

Perceived Density
Rapoport (1975: 138-140) identifies some of the factors contributing to perceived density. They include perceptual, associational-symbolic and physical aspects of the environment, temporal aspects of activities, and sociocultural aspects of actors and settings. In an attempt to systematize the way in which factors act together to generate perceived density, we suggest an interaction as shown in Figure 1-1.

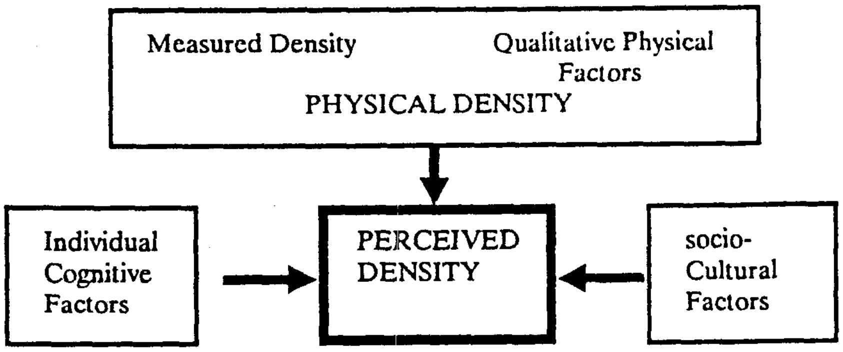

Figure 1-1: Perceived Density - Contributing Factors

Perceived density is the interaction between three major vectors, or combinations of factors: physical density, which itself contains both measured density and "qualitative density" made up of other relevant physical factors; individual cognitive factors; and social and cultural factors. The last two may contribute both to perceived density, and, in the sense that they incorporate norms and standards, to the "affective density" as well.

Physical density is discussed below. Individual cognitive factors can include feelings of control or lack of it (these may also be affected by physical stimuli, such as enclosure or openess), privacy, etc. Social and cultural factors include homogeneity or heterogenity of users of the environment, presence or absence of socioculturally regulated norms of interaction, levels of social interaction and the character of activites in relevant settings: their spatial and temporal dimensions (Rapoport, 1975), and their intensity (Lerup, 1971), etc.

We will not deal with individual-cognitive and socio-cultural factors any more in the course of this study, which, in focusing on density measures, approaches the outcome that is of interest: perceived density, through the physical density vector. But it is important to remember, even when considering density measures, that the ultimate perceived density is not the result of physical density alone.

Physical Density

Physical density is made up of those objective and physical characteristics of the built environment and its users that contribute to the density that is perceived by people in an actual setting. Some of these characteristics are attributes of the built environment that are not included in density measures. These more qualitative factors are included in what we are calling:"qualitative density"in the component of physical density which we are calling "measured density".

This "qualitative" part of physical density expresses attributes of structures and buildings such as height and relative spacing (though these can be expressed in light, sun or shadow angles, e.g De Chiara and Koppelman, 1982:, conventional density measures fail to include them), massing, juxtaposition (e.g. openess or closure of a site layout) and diversity. Some other qualitative factors related to physical density are the character of buildings (e.g the intricacies of their elevations and materials, and diversity or homogeneity of color), lighting levels, and landscaping.

The "bounding" of an area -- i.e whether adjacent alternative locations are available for nonresidential uses (shops, streets, pubs, etc) or not, and the presence or absence of nonresidential landuses, and their mixture (Rapoport, 1975: 139), may also be an important factor. Another aspect of "bounding" that may contribute to physical density is scale: the sheer extent of an area of homogenous development, and the scale of the construction within an area. This aspect of density is often neglected (Boudon, 1981), but planners and designers ignore it at their peril.

Other characteristics can be expressed in the component of physical density which we are calling "measured density". These more quantitative attributes of the built environment include the number of potential occupants or users in an area, the number of dwellings in an area, the proportion of a site that is built upon, etc. These are the principal focus of this study.

The effects of different physical layouts within similar measured densities will be explored below. Previous such explorations (e.g Martin and March, 1966; Keeble, 1969; Holloway, 1971; Diamond, 1976) show clearly that measured density and other physical factors are quite independent of each other.

This study does not address the qualitative aspects of physical density, focusing as it does on measured density. But that does not mean that qualitative density can be ignored. The qualitative aspects of physical density may be just as important as the ones that can be quantified in measured densities, and warrant equal attention in research, planning and design.

Measured Density

Measured density is the focus of this study, though, as suggested above, other aspects of physical density combine with sociocultural and individual- cognitive factors to produce the perceived density which is the actual object of planning and design manipulations. A bewildering variety of measures exist to express density.

One way density measures have been grouped is by distinguishing between "molecular" and "molar" measures. Molecular measures reflect density within the dwelling unit: people per room, sq.ft. floor area per person,etc. Molar density refers to the space outside the dwelling: the site, neighborhood or community. These two may not be directly related; indeed, sometimes their relationship is inverse. In a wealthy urban area such as Manhattan, for example, luxury apartments may have low molecular densities (i.e low numbers of occupants per room), while the molar density (say, DUs/acre) is very high. Conversely, in a rural slum dwellings are crowded, while neighborhood densities are very low (Krupat, 1985: 100-102).

Many density measures are ratios of some "occupier" or user as the numerator (persons, rooms, households, dwelling units) and a unit of area as the denominator (acres of residential land, neighborhood area, city area in hectares etc.). As we shall see, definitions of the area used in the denominator are critical, but frequently absent. These density measures will be reviewed in detail below.

Another class of measures express the "bulk" components of physical density, i.e expression of the physical form and volume of buildings. These include the following:

* Floor Area Ratio (FAR) which is the ratio of built floor area (on all floors) to the area of the site; FAR is usually expressed as a % or a decimal fraction.
* Coverage: the ratio of the area covered by buildings (i.e the area of the ground floor "footprint") to the area of the site; Coverage is also expressed as a % or a decimal fraction.

* Angles such as light angles and shadow angles are additional measures that may be used to define a building envelope in relation to its site, street, or adjoining structures.
* Height and Setbacks: the combination of these measures determines the site- specific maximum permitted massing or building "envelope".

Given some assumptions about building capacity and usage (e.g how many dwelling units of a specific size "fit" into a particular volume, and how many persons make up the "average" household occupying a dwelling) all the other density measures can be derived from these basic units on a given site. However, at higher levels of aggregation, these units are usually unknown or indeterminate, hence the need for other measures of density like the ones discussed above.

In zoning and building regulations, these measures are frequently used in combination with other density ratio measures to approach an expression of the permitted maximum intensity of land use.

Finally, some more complex indexes of land use intensity have been developed, often from a sense of the limitations of the conventional density measures presented above. Probably the best known and most used of these is the Land Use Intensity Rating (LIR) of the Federal Housing Authority (FHA, 1971).

The FHA developed the LIR as a substitute for conventional measures of density because it is "more reliable because less variable" (p.6). The LIR takes FARs as its point of departure, and maps them onto an arbitrary interval scale, so that a LIR of 0= FAR of .0125, and a LIR of 8.0= FAR of 3.2. Given some assumptions of average sizes of dwelling units, equivalent densities (in DUs per "gross acre") can be deduced, so that if the housing unit is 1089 sq.ft. the LIR of 1.0 = 1.0 DUs/acre, and the LIR of 8.0= 128 DUs/acre, while if the dwelling is 871.2 sq.ft., then the LIR of 3.0= 5.0 DUs/acre, and the LIR of 6.0 = 40 DUs/acre, and so on. Adoption of the LIR outside the FHA itself was limited, probably because of its lack of intuitive transparency and its complexity. The FHA's claims for its index, as being a more "reliable" reflection of the actual physical density and the use intensity of a development, are also not really supported in practice.

Other complex density or land use intensity measures have been developed and received limited application, but their use never became widespread, probably for the same reasons as the LIR's lack of acceptance. With the LIR, the FHA developed a more complex measure, the Land Use Intensity Ratio (LUI) which combines FAR with five other indexes: 1) an "Open Space Ratio" (OSR) expressing standards for minimum open space required per built floor area; 2) Living space ratio (LSR), expressing requirements for non-vehicular open space per sq.foot of living area; 3) Recreation Space Ratio (RSR): open recraetion space per sq.foot of floor area; 4) Total Car Ratio (TCR): minimum number of parking spaces per DU; 5) Occupant-Car Ratio (OCR): number of required unlimited time parking spaces per DU.(FHA, 1971; Hanke, 1966). This was also incorporated in the FHA's "densitometer" (Hanke, 1972). Besides their complexity, these measures are flawed because they build in a set of rigid and determinate standards upon which all the relationships are based.

Some cities developed their own measures, such as the system used in Eugene Oregon, where a scale of "density points" is related to dwelling type and number of bedrooms (League of Oregon Cities, 1977: 2). However, in spite of the prevailing disatifaction with conventional density measures, reflected in the development of these more complex indexes, none of the latter has gained general acceptance and all have fallen into disuse. In planning, design, and regulation of the built environment today, use of the conventional density ratios with all their oversimplification and their ambiguities is the norm, though they are usually combined with one or more of the other measures characterising building-land relationships that are described above (So and Getzels, 1988, p274).