HOW THE OTHER HALF BUILDS

Volume 2: Plots

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This report is the second volume of a continuing series, part of a long-term research project--**How the Other Half Builds**--undertaken by McGill University's Centre for Minimum Cost Housing. The first volume, entitled Space, was an investigation of the activities that take place in the public spaces adjacent to and around the house plot in unplanned settlements, and how spaces are arranged to accomodate these activities. The **Whole Earth Review** called Volume 1 "an experienced version of A Pattern Language that's been seasoned with a dash of Architecture Without Architects"--and who would argue with such praise?--but there is another inspiration for this work: the writing of the architect John Habraken. In **Transformations of the Site** (1983) Habraken dared to suggest that:

> "The built environment is always more than the sum of professional interventions. It is, by itself, not a professional product. It cannot be invented nor designed...we should not confuse the study of the built environment with the study of architecture, planning or engineering."

Urban slum settlements in developing countries are perhaps the most extreme example in the modern world of built environments that have been realized without any professional intervention. If only for that reason, they bear study. But this is no academic exercise; at least, it is more than that. Given the large-scale housing programs of most developing countries, a better understanding of the present housing stock is at least desirable, probably essential, investigative tools are required. Our previous survey of public space relied on that most traditional of techniques: the measured drawing. The present study, which tries to understand how and why plots acquire certain physical characteristics, has adopted a quantitative approach, borrowing the statistical tools of the social scientists. The analysis was done in the School of Architecture's Computers in Architecture Laboratory on Osborne 1s and IBM ATs using Supercalc and Lotus 123; the graphics were generated using Autocad.

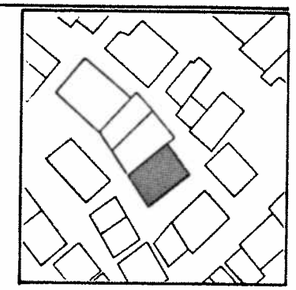
Thanks to Prof David Covo, Dan Corsillo and I-Jen Chen for their assistance; and to Prof Bruce Anderson, Director of the School of Architecture, for his continuing support.

This work has been carried out as part of the minimum cost housing graduate program of the McGill School of Architecture, and is a component of a project called "Low-Income Urban Shelter, India," which is supported by the Special Programs Branch of the Institutional Cooperation and Development Services Division of the Canadian International Development Agency, the Vastu-Shilpa Foundation of Ahmedabad, and McGill University. We would like to acknowledge the cooperation of Prof B.V.Doshi of VSF, who released one of his staff, Visiting Scholar Rajinder Puri, for a three-month period to assist in this work. Carl Calantone of the Faculty of Management, and Dr Richard Salisbury, Director of the Anthropology of Development Unit, offered useful advice. My friend and colleague Prof Vikram Bhatt played a vital role in assembling the raw data, and in offering his suggestions at various stages of the project. Graduate students Benjamin Danjuma and Vin Dhami assisted in the early stages of the work. The Indore Development Authority, which carried out the actual slum surveys on which we based our analysis was extremely helpful.

Witold Rybczynski, Director
Centre for Minimum Cost Housing

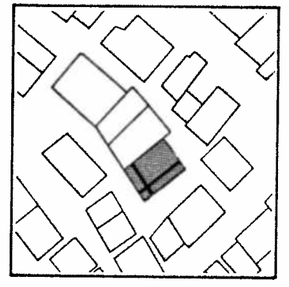
1. Survey

BUILT PLOT AREA IS DETERMINED BY MULTIPLYING PLOT FRONTAGE BY PLOT DEPTH.

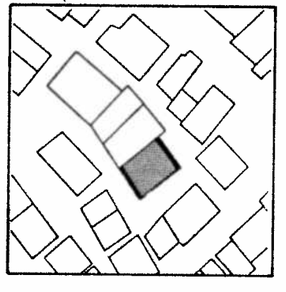


PLOT SPACE AVAILABILTY IS DETERMINED BY DIVIDING BUILT PLOT AREA BY THE NUMBER OF PLOT INHABITANTS.

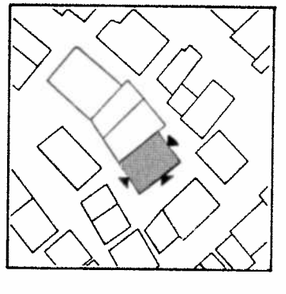
BUILT PLOT RATIO IS DETERMINED BY DIVIDING BUILT PLOT DEPTH BY BUILT PLOT FRONTAGE.



PLOT FRONTAGE IS DETERMINED BY MEASURING THAT SIDE OF THE PLOT THAT FRONTS ON THE MAIN ACCESS STREET.



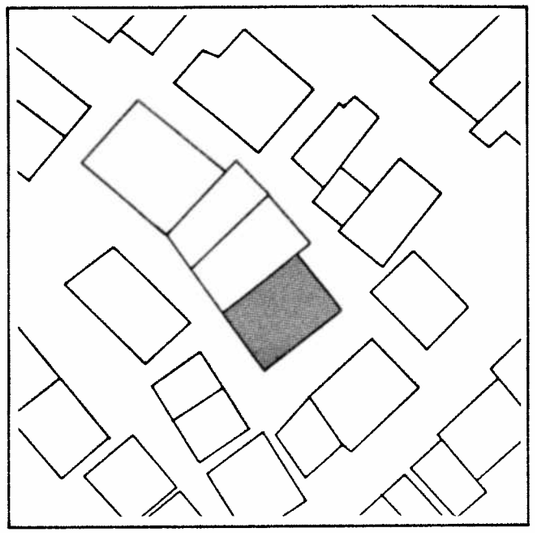
PLOT EXPOSURE IS DETERMINED BY COUNTING THE NUMBER OF SIDES OF THE BUILT PLOT THAT ARE CONTIGUOUS TO PUBLIC OPEN SPACE.



The single most important planning decision in designing sites and services projects is probably the determination of the area of the plot. Plot areas vary widely from region to region, from as small as 18 M2 in south Asia, to over 100 M2 in Africa and South America. But even in particular countries there is little agreement as to what constitutes an "optimal" or even a "minimal" area. On the one hand, the public authorities, responding to the high cost of land and infrastructure, have tended to reduce plot areas, on the other hand, critics of small plots have pointed out that the larger the plot, the greater the economic benefit to the owner who, over time, can improve and invest in his home. Moreover, they argue, once fixed, the small plot cannot be changed in the future. It has also been suggested that plots in slums and squatter settlements are frequently larger than those found in formally planned sites and services projects, reflecting the high priority that the users themselves put on plot size.

A number of questions bear examination. What is the relationship between plot areas in slums, and official area standards? Are slums characterized by uniformity or variety when it comes to plot areas? Is the correlation between family income and plot area as direct as it is usually assumed to be?

A difficulty was encountered in establishing the exact area of individual plots since the slum upgrading survey documents were vague about the exact extent of unbuilt private open space. House extensions (stoops, platforms, porches) were usually indicated--though not differentiated--on the plans, as were fences and walls, but ownership of such open areas was not specified. Therefore, based on the information indicated on the site plans, and on observations made during visits to the individual slums, only an estimation of private open space was possible, and then only as an aggregate for each settlement. This has been presented as an



"average private open area per plot," although, as the plans indicate, such open areas were not necessarily adjacent to all built plots. Since individual houses were clearly identified, the plot area study was based on built plots. Plot area was determined on the basis of built plot dimensions, taken from the survey plans.

Information on plot areas, for each of the six settlements, as well as for the study as a whole, is presented in four categories:

Plots smaller than 20 M2
Plots 20-30 M2
Plots 30-40 M2
Plots larger than 40 M2

In addition, maximum, minimum and average built plot areas have been calculated, together with land use data according to: built plot area, private open area, and public open area.

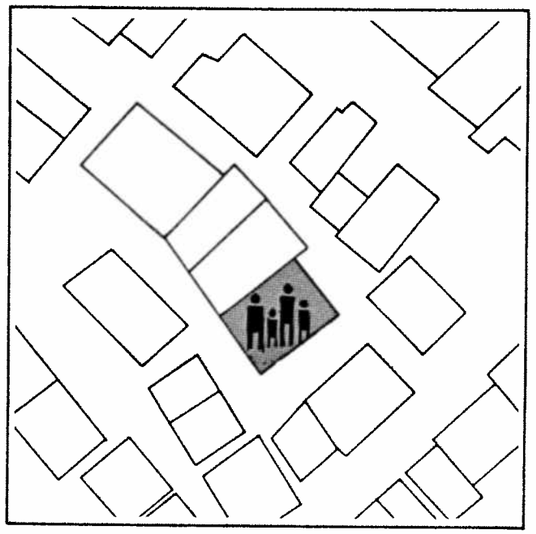
BUILT PLOT AREA IS DETERMINED BY MULTIPLYING PLOT FRONTAGE BY PLOT DEPTH.

The amount of available living space in conventional single-family housing is directly proportional to the house size, since the number of occupants is more or less constant; the larger the house, the more the amount of space per inhabitant. For a number of reasons, the concept of "average family size" is of limited use in the conditions of developing-country low-income urban housing. For one thing, the presence of the extended family means that, in addition to parents and children, there are usually grandparents, uncles, aunts and other relatives, and friends. Moreover, if space is "left over" it is frequently rented, to augment the small family income.

Since the single-family plot frequently houses many people--more than one family--the area of the plot gives no indication of the degree of crowding within the home. A large plot with many inhabitants is no better, and no worse, than a small plot with fewer. The critical measure is not how big the plot is, but how much space is available in the house to each dweller.

If space availability, rather than simply plot area, is an indication of actual living conditions, this raises a number of pertinent questions. Conventional wisdom has it that larger plots, because they cost more, represent a solution for higher income groups. In most site and services projects, it is assumed that there is a direct link between plot area and family income, and access to the smallest plots is restricted to the poorest families. Is there a strong correlation between space and family income in unplanned settlements? And is more space/person actually available on larger plots, or do they simply contain more people? Is the amount of space per inhabitant on the plot a function of plot size, family income, or of market demand?

Since the Indore social survey documents indicated both numbers of families per plot, as well as family size, it has



been possible to calculate the space available on the plot in terms of square meters per person (built plot area divided by the number of inhabitants). Since virtually all the houses were single story (the exceptions were noted in the survey plans), built plot area is identical to house area.

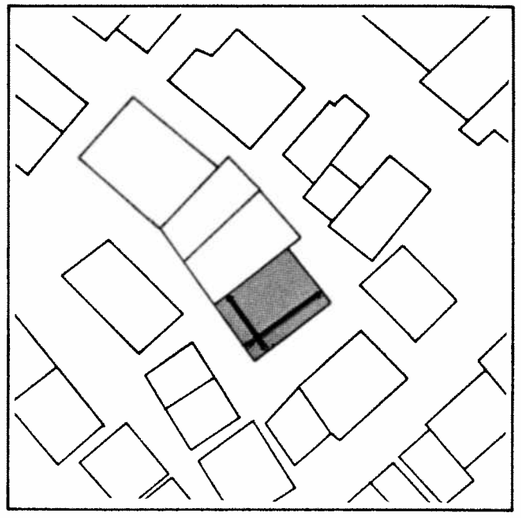
Information on plot space, for each of the six settlements, as well as for the study as a whole, is presented in four categories:

Less than 3 M2/person
3-4 M2/person
4-5 M2/person
More than 5 M2/person

In addition, maximum, minimum and average space availability has been calculated.

PLOT SPACE AVAILABILTY IS DETERMINED BY DIVIDING BUILT PLOT AREA BY THE NUMBER OF PLOT INHABITANTS.

The shape of a plot can be expressed as a numerical ratio, that is, depth divided by frontage. The greater is the plot ratio (long and narrow plots) the more efficient is the layout in terms of streets and infrastructure. Conversely, as the plot ratio approaches, or even drops below 1 (squarish or even shallow and wide plots), the quantity of streets and infrastructure increases. High density urban housing plots typically demonstrate a high plot ratio, 6-8 is not unusual and may even be higher in exceptional cases such as Amsterdam. Low density Canadian suburban plots typically have a ratio of 1.7. While there are examples of square plots, plots with ratios of less than 1 are more rare, although they do sometimes occur in rural situations.



Plot ratios in slums and squatter settlements are determined by a push-and-pull. The external pressure from neighbors and the community at large is to increase the plot ratio so as to permit as many plots as possible. At the same time, the generally small plot areas set an absolute limit on the narrowness of the plot. Under such circumstances, what does the user--or the landlord, if plots are rented--decide? Is the unplanned settlement characterized by extremely low plot ratios, or by unimaginably high ones? What is the relationship between plot ratio and plot area? Is there a "natural" plot ratio, irrespective of plot area?

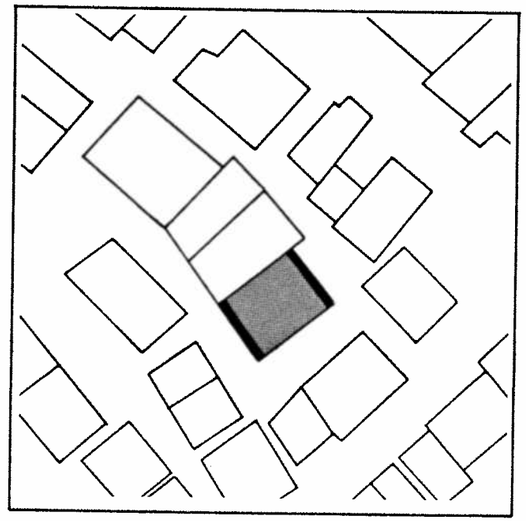
Information on plot ratios, for each of the six settlements, as well as for the study as a whole, is presented in four categories:

Plot ratios less than 1
Plot ratios 1-2
Plot ratios 2-3
Plot ratios greater than 3

In addition, maximum, minimum and average plot ratios have been calculated.

BUILT PLOT RATIO IS DETERMINED BY DIVIDING BUILT PLOT DEPTH BY BUILT PLOT FRONTAGE.

Plot frontage and plot ratio are not the same. Plot ratio describes the shape of the plot, frontage is a measure of the width of the plot, that is, of the side that faces the street. Larger frontage permits more fenestration, and easier access to the street. It is usually socially desirable as well, especially in the case of row-houses, since a house with wider frontage looks larger and more imposing. The importance of frontage is reflected by the fact that in many situations it is the amount of frontage, not simply land area, that determines the monetary value of a plot.



As with plot ratio, frontage is the product of two opposing forces: the desire of the householder to maximize the amount of street facade, and the need of the community as a whole to limit individual frontages so as to increase the number of plots that can be placed along any particular given length of street.

Unlike plot ratio, plot frontage usually encounters a lower limit that is established by custom, regulation, and ultimately by market demand. Frontages of individual house plots in Canadian suburbs are usually not less than 18 meters; urban rowhouses may be as narrow as 8 meters, and in exceptional projects such as Siedlung Halen (Bern) plots may reduced to 5 meters. The narrowest frontages, found in Indian sites and services projects built in the 1970s, are 3 meters, which barely allows for a corridor alongside a small room.

Under normal conditions, one would expect a direct correlation between plot frontage and plot area--as area increases so does frontage--and between larger frontages and higher family incomes. Does an unplanned settlement follow the same rules? Do frontages exhibit the result of market demand, or are they set by other forces?

For the purpose of this study, "frontage" refers to the dimension of only that side of the plot that fronts the street, irrespective of how many other secondary exposures there may be. Information on plot frontages, for each of the six settlements, as well as for the study as a whole, is presented in four categories:

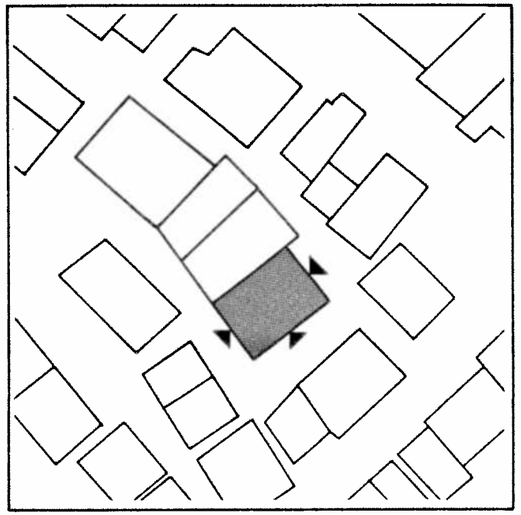
Frontages less than 3 M
Frontages 3-4 M
Frontages 4-5 M
Frontages more than 5 M

In addition, maximum, minimum and average plot frontages were calculated.

PLOT FRONTAGE IS DETERMINED BY MEASURING THAT SIDE OF THE PLOT THAT FRONTS ON THE MAIN ACCESS STREET.

The concept of plot "exposure" requires explanation. In this study "exposure" is used to refer to the number of sides of the plot that are contiguous to public open space. Why is this important? It can be stated as a generalized truth that until plot area exceeds the required house area, plot coverage will be near, or at, 100 percent. Or, to put it another way, the requirement for built space will override the requirement for open space on small plots. As a result, when plots are very small ("smallness" will depend on market demand and user expectations and living habits) the plot is entirely built over. This phenomenon occurs in many countries where owner-builders, despite the best intentions of sites and services planners, inevitably build over space that was intended for patios and courtyards. This is certainly the case in both formal and informal low-income urban settlements in India. In a house that entirely covers the plot, the only possibility for doors and windows will be on those sides of the plot that are adjacent to unbuilt public open space. Hence the importance of "exposure" as a measure of plot amenity.

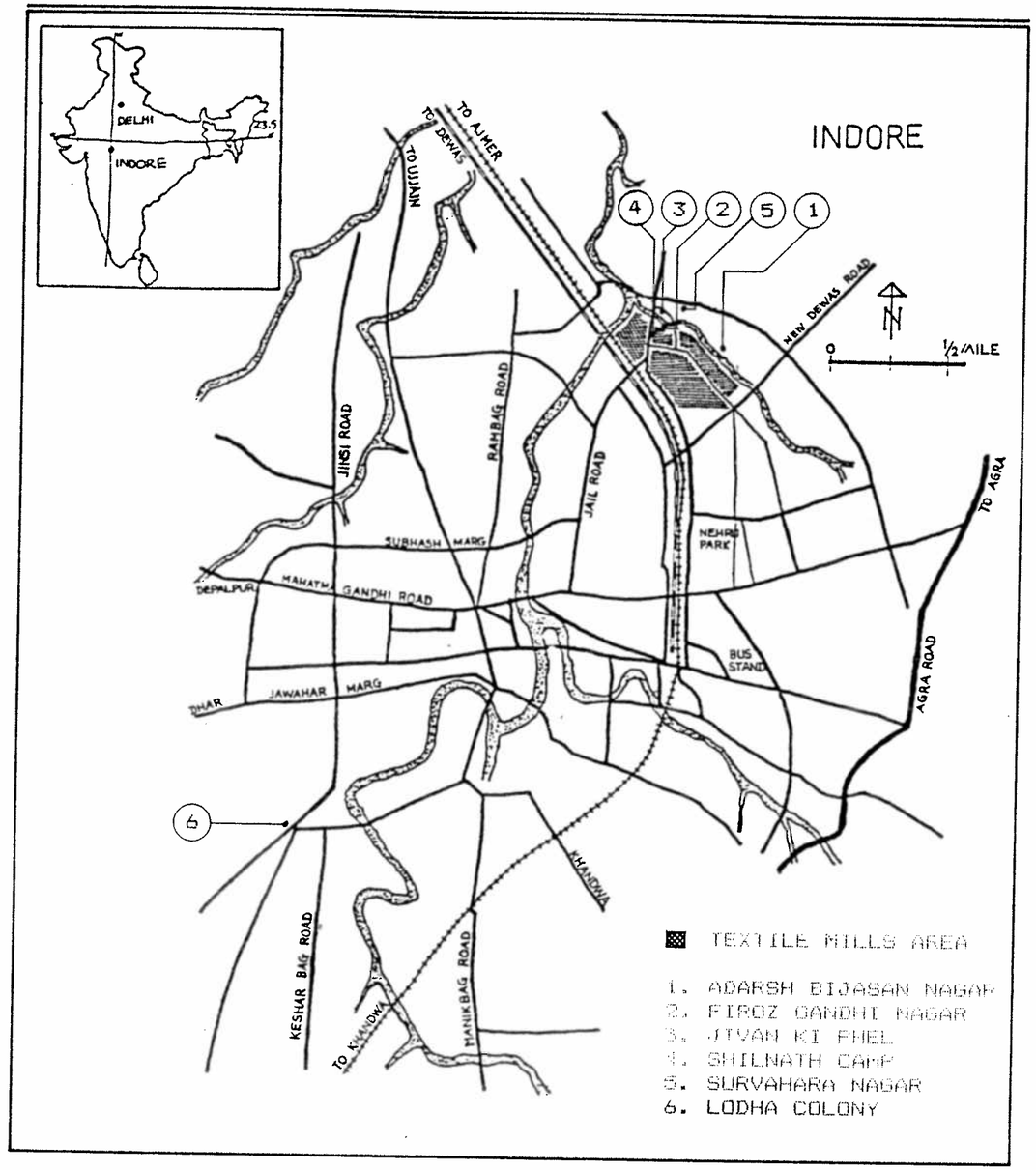
Since the plot must be accessible, at least one exposure is required. Single exposure plots that are fully built upon will be characterized by poorly lit and badly ventilated interiors. Two or more exposures, even if only to an alley, increase the possibility of cross-ventilation, and assure access to natural light for more of the rooms. Two or more exposures may also allow multiple entry to different parts of the house from the street. (This is not a precondition for exposure in this study -- exposure simply requires adjacency to public open space which may, or may not, be used for circulation.) Multiple plot access becomes important when many people share a single house or when part of the house is rented to another family, or is dedicated to commercial use. Single exposure plots with only one entry reduce privacy and increase the amount of interior space devoted to circulation.

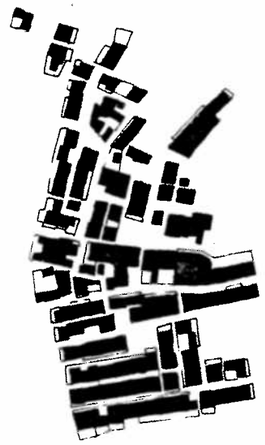


Since the majority of formally planned low-income urban settlements consist of back-to-back, single exposure plots, it would be interesting to know what has been the approach of slum-dwellers to this amenity. Information on plot exposure, for each of the six settlements, as well as for the study as a whole, is presented in four categories:

Plots with one exposure
Plots with two exposures
Plots with three exposures
Plots with four exposures

PLOT EXPOSURE IS DETERMINED BY COUNTING THE NUMBER OF SIDES OF THE BUILT PLOT THAT ARE CONTIGUOUS TO PUBLIC OPEN SPACE.



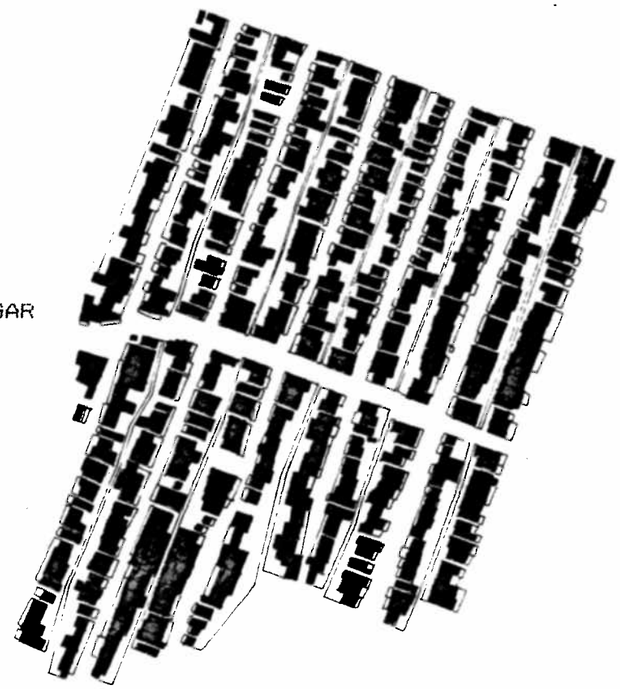


ADARSH BIJASAN NAGAR

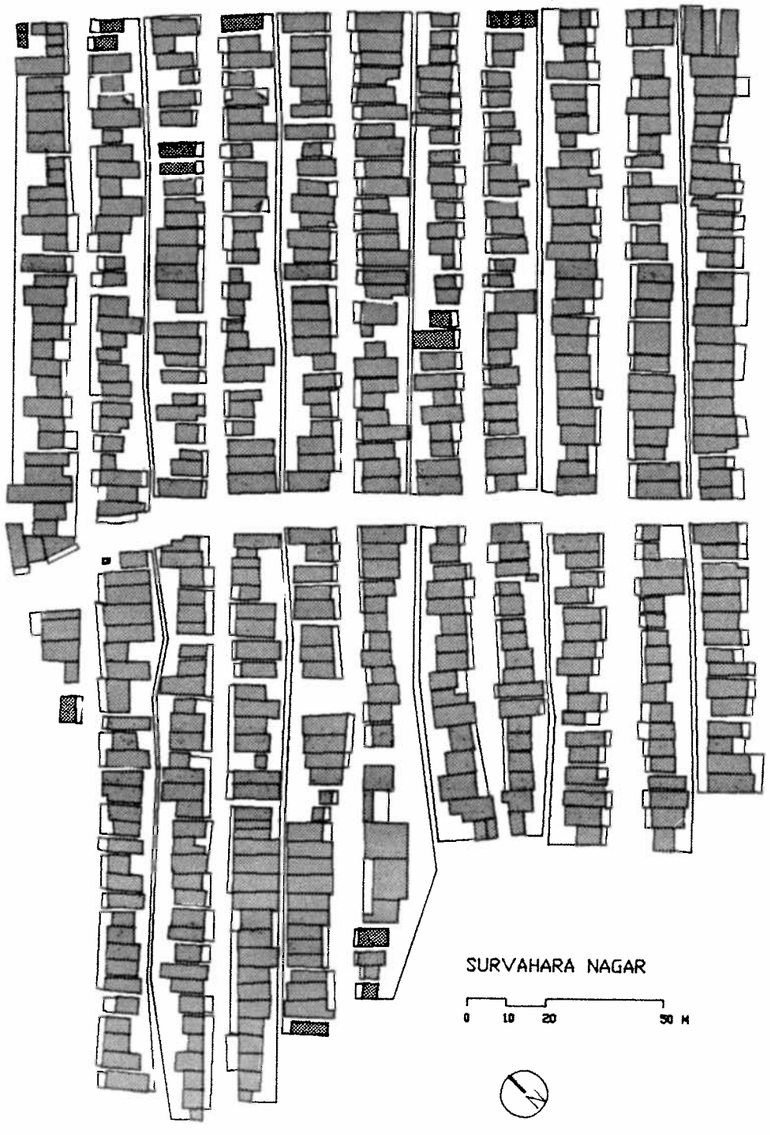
SHILNATH CAMP

FIROZ GANDHI NAGAR

SURVAHARA NAGAR



JIVEN KI PHEL

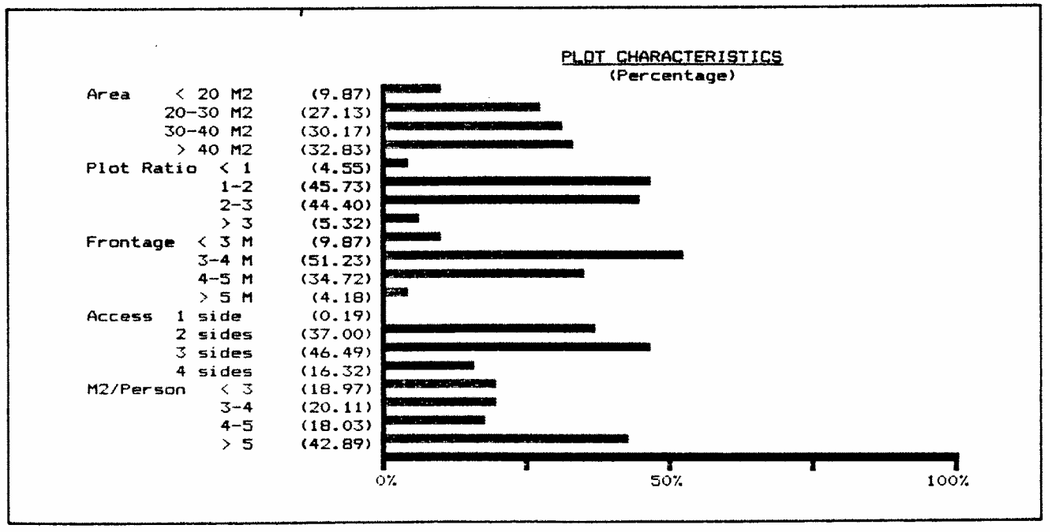


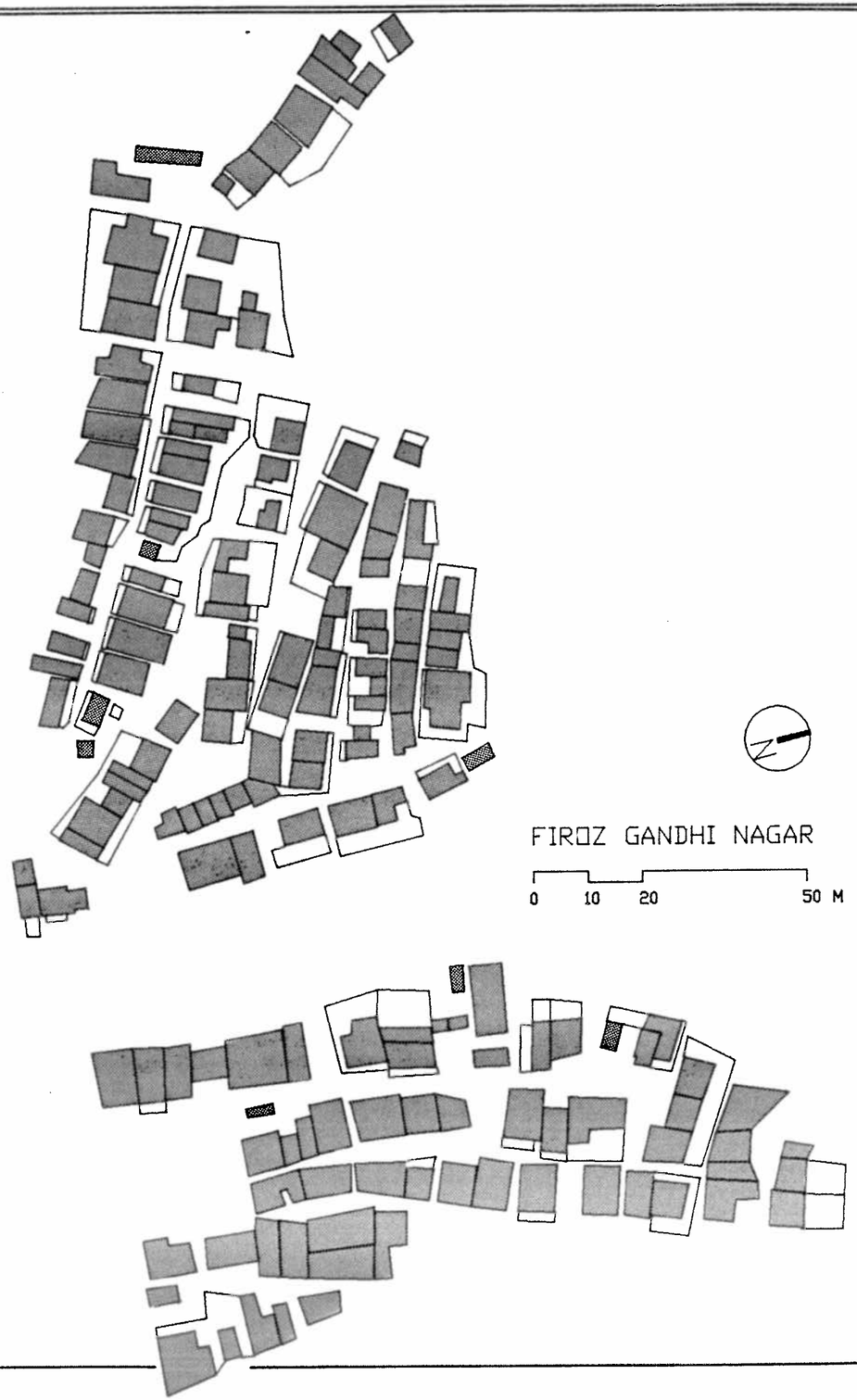
Site Area = 4.65 ha. | Number of Plots = 527 | Built Plots Area = 39 %
Population = 3,829 persons | | Private Open Area= 20 %
Density = 823 pph | Persons/plot = 7.3 | Public Open Area = 41 %
| Income/family = 503 rs/month |

A R E A		R A T I O		S P A C E	
Built Plot Area	No. of plots	Built Plot Ratio	No. of plots	Space on Built Plot	No. of plots
<20 M2	52	<1	24	<3 M2/person	100
20-30 M2	143	1-2	241	3-4 M2/person	106
30-40 M2	159	2-3	234	4-5 M2/person	95
>40 M2	173	>3	28	>5 M2/person	226
Max. area =	144.00 M2	Max. ratio =	4.25	Max. space =	60.00 M2/person
Min. area =	7.50 M2	Min. ratio =	0.33	Min. space =	0.95 M2/person

F R O N T A G E		E X P O S U R E		A V E R A G E S
Plot Frontage	No. of plots	No. of exposures	No. of plots	
<3 M	52	1	1	Built plot area = 34.68 M2
3-4 M	270	2	195	Private open area= 18.04 M2/plot
4-5 M	183	3	245	Plot ratio = 2.05
>5 M	22	4	86	Space = 4.77 M2/person
				Plot frontage = 4.17 M
				Exposure = 2.8

Max. frontage = 12.00 M
Min. frontage = 2.00 M





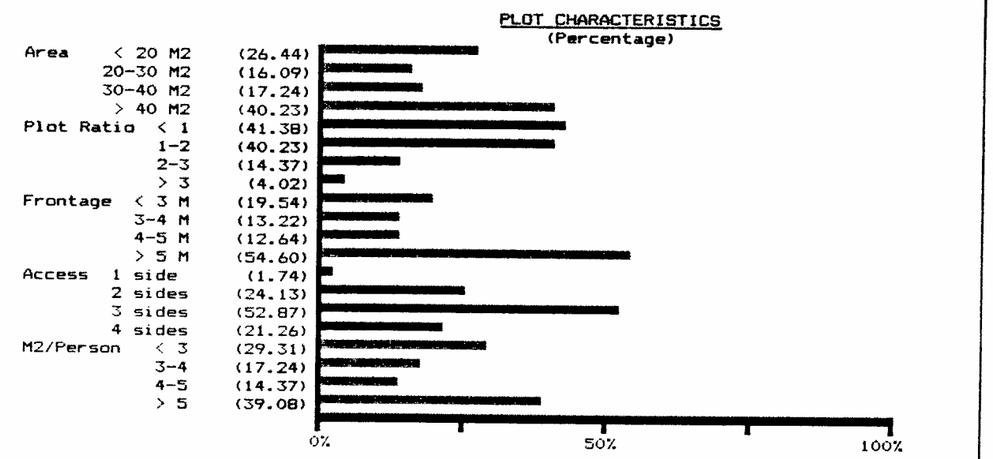
Site Area = 1.33 ha.
Population = 1,500 persons
Density = 1,128 pph

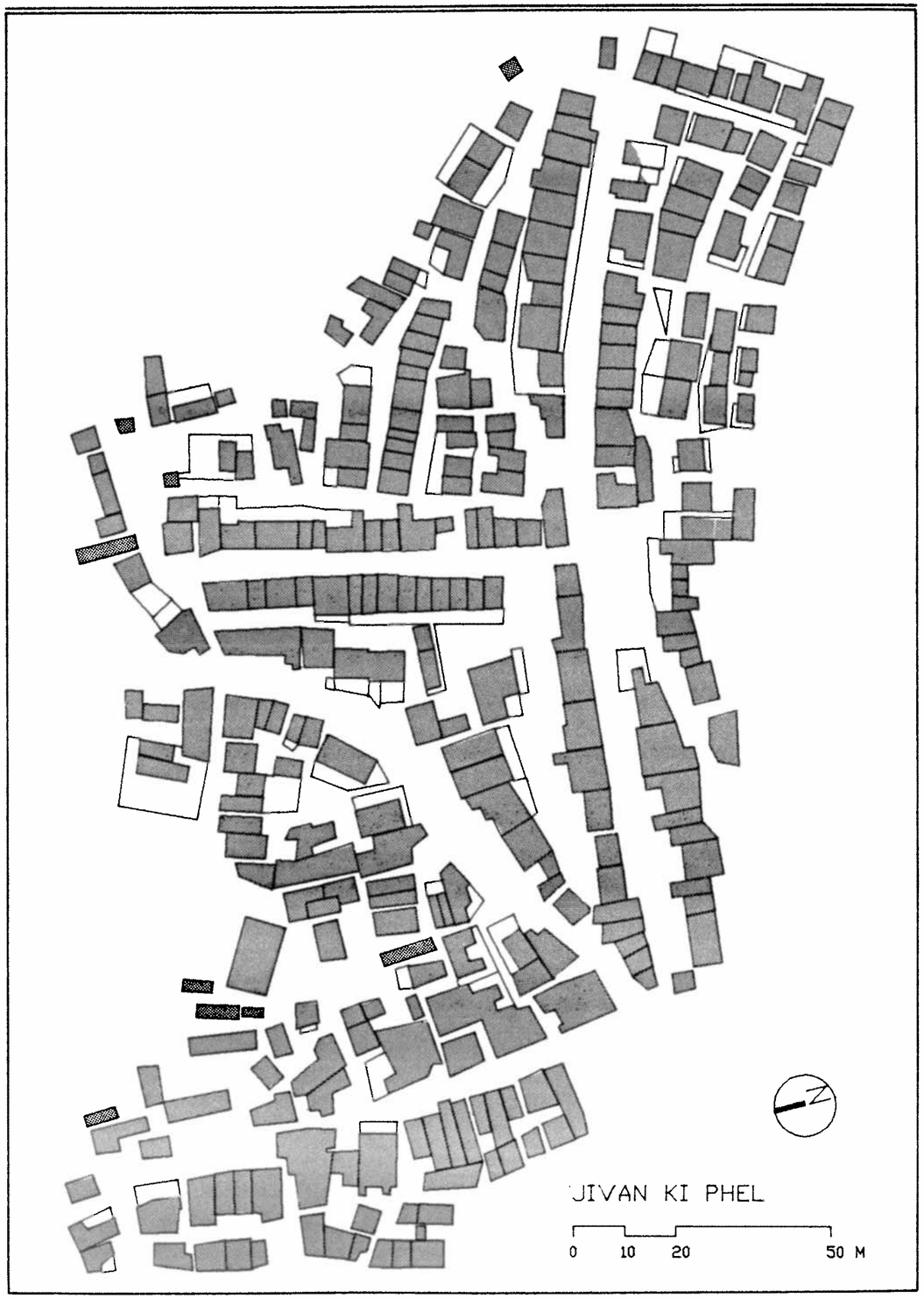
Number of Plots = 174
Persons/plot = 8.6
Income/family = 451 rs/month

Built Plots Area = 49 %
Private Open Area= 17 %
Public Open Area = 34 %

A R E A		R A T I O		S P A C E	
Built Plot Area	No. of plots	Built Plot Ratio	No. of plots	Space on Built Plot	No. of plots
<20 M2	46	<1	72	<3 M2/person	51
20-30 M2	28	1-2	70	3-4 M2/person	30
30-40 M2	30	2-3	25	4-5 M2/person	25
>40 M2	70	>3	7	>5 M2/person	68
Max. area =	131.25 M2	Max. ratio =	4.60	Max. space =	16.41 M2/person
Min. area =	7.50 M2	Min. ratio =	0.26	Min. space =	1.07 M2/person

F R O N T A G E		E X P O S U R E		A V E R A G E S
Plot Frontage	No. of plots	No. of exposures	No. of plots	
<3 M	34	1	3	Built plot area = 37.49 M2
3-4 M	23	2	42	Private open area= 13.13 M2/plot
4-5 M	22	3	92	Plot ratio = 1.36
>5 M	95	4	37	Space = 4.35 M2/person
Max. frontage =	12.50 M			Plot frontage = 5.61 M
Min. frontage =	2.50 M			Exposure = 2.9

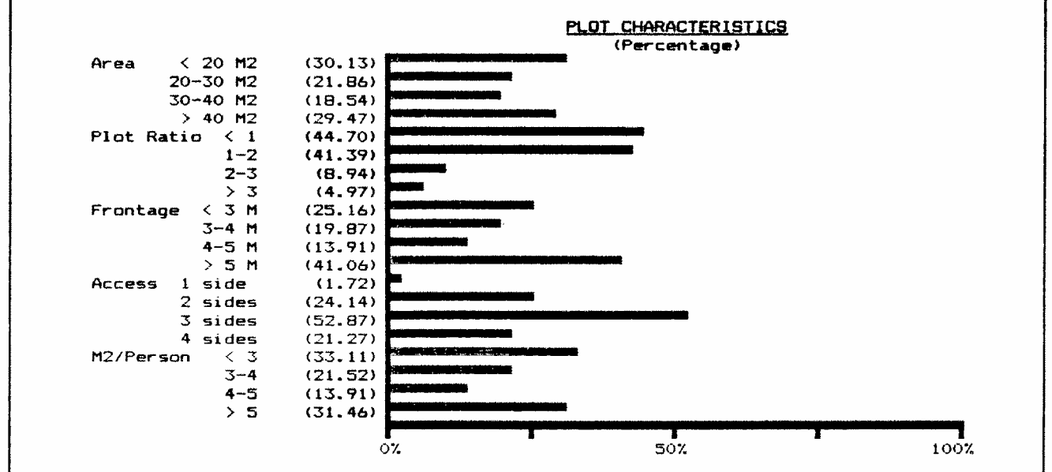


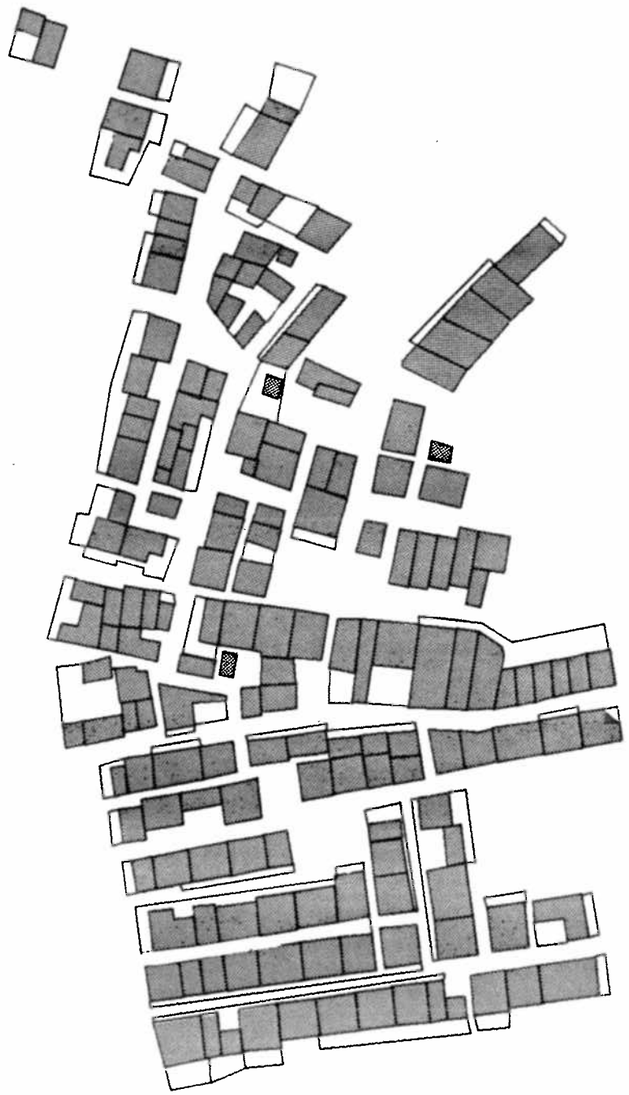


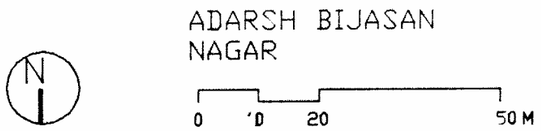
Site Area = 2.26 ha. | Number of Plots = 302 | Built Plots Area = 43 %
Population = 2,603 persons | | Private Open Area= 8 %
Density = 1,152 pph | Persons/plot = 8.6 | Public Open Area = 49 %
| Income/family = 390 rs/month |

AREA		RATIO		SPACE	
Built Plot Area	No. of plots	Built Plot Ratio	No. of plots	Space on Built Plot	No. of plots
<20 M2	91	<1	135	<3 M2/person	100
20-30 M2	66	1-2	125	3-4 M2/person	65
30-40 M2	56	2-3	27	4-5 M2/person	42
>40 M2	89	>3	15	>5 M2/person	95
Max. area =	144.00 M2	Max. ratio =	5.20	Max. space =	40.00 M2/person
Min. area =	5.25 M2	Min. ratio =	0.23	Min. space =	0.56 M2/person

FRONTAGE		EXPOSURE		AVERAGES
Plot Frontage	No. of plots	No. of exposures	No. of plots	
<3 M	76	1	4	Built plot area = 32.49 M2
3-4 M	60	2	107	Private open area= 5.82 M2/plot
4-5 M	42	3	118	Plot ratio = 1.36
>5 M	124	4	73	Space = 3.77 M2/person
Max. frontage =	16.00 M			Plot frontage = 5.50 M
Min. frontage =	1.50 M			Exposure = 2.9







Site Area = 0.96 ha.
Population = 1,274 persons
Density = 1,327 pph

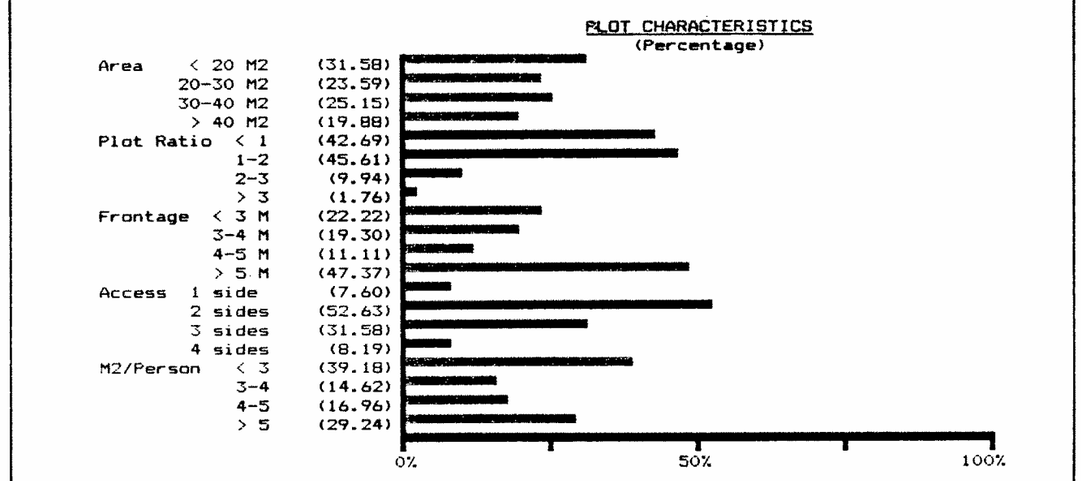
Number of Plots = 171
Persons/plot = 7.5
Income/family = 423 rs/month

Built Plots Area = 50 %
Private Open Area= 17 %
Public Open Area = 33 %

AREA		RATIO		SPACE	
Built Plot Area	No. of plots	Built Plot Ratio	No. of plots	Space on Built Plot	No. of plots
<20 M2	54	<1	73	<3 M2/person	67
20-30 M2	40	1-2	78	3-4 M2/person	25
30-40 M2	43	2-3	17	4-5 M2/person	29
>40 M2	34	>3	3	>5 M2/person	50
Max. area =	81.00 M2	Max. ratio =	5.60	Max. space =	24.00 M2/person
Min. area =	5.00 M2	Min. ratio =	0.33	Min. space =	0.33 M2/person

FRONTAGE		EXPOSURE		AVERAGES
Plot Frontage	No. of plots	No. of exposures	No. of plots	
<3 M	38	1	13	Built plot area = 28.06 M2
3-4 M	33	2	90	Private open area= 9.32 M2/plot
4-5 M	18	3	54	Plot ratio = 1.07
>5 M	81	4	14	Space = 3.77 M2/person
				Plot frontage = 4.92 M
				Exposure = 2.4

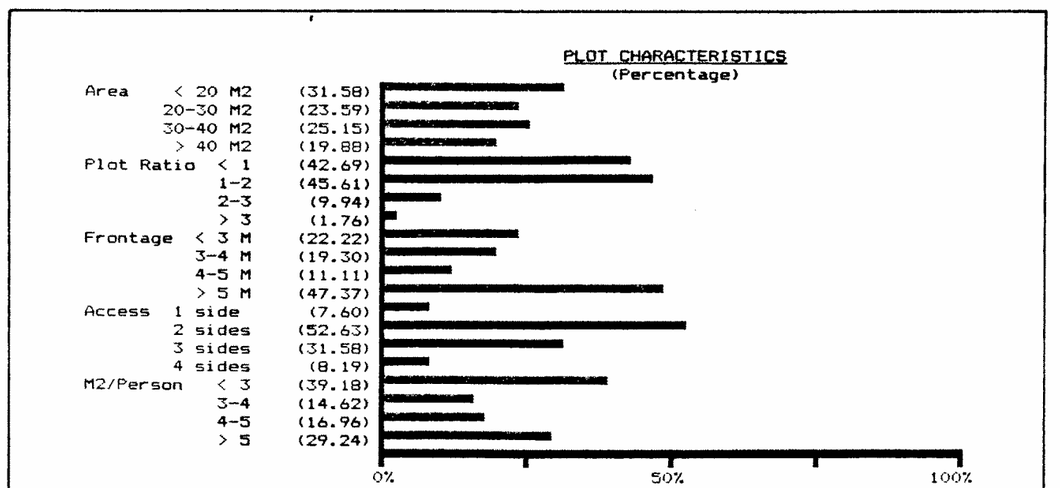
Max. frontage = 12.50 M
Min. frontage = 10.00 M

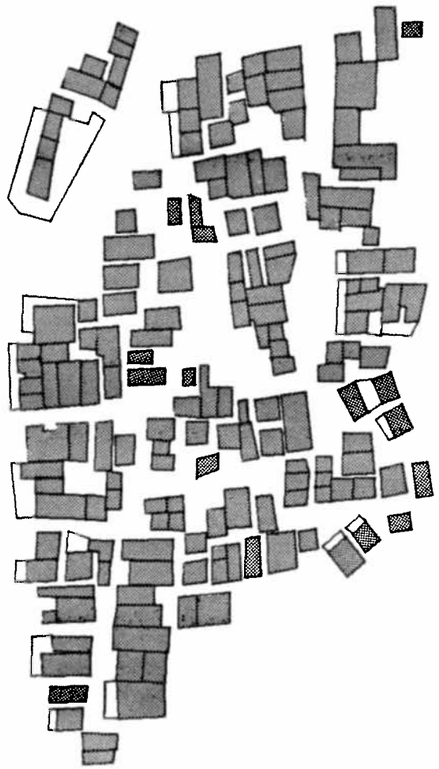


Site Area = 1.43 ha. | Number of Plots = 150 | Built Plots Area = 46 %
Population = 1,714 persons | | Private Open Area= 7 %
Density = 1,199 pph | Persons/plot = 11.4 | Public Open Area = 47 %
Income/family = 543.7 rs/month

A R E A		R A T I O		S P A C E	
Built Plot Area	No. of plots	Built Plot Ratio	No. of plots	Space on Built Plot	No. of plots
<20 M2	13	<1	48	<3 M2/person	37
20-30 M2	20	1-2	79	3-4 M2/person	27
30-40 M2	31	2-3	15	4-5 M2/person	20
>40 M2	86	>3	8	>5 M2/person	66
Max. area =	201.25 M2	Max. ratio =	4.40	Max. space =	56.00 M2/person
Min. area =	6.00 M2	Min. ratio =	0.33	Min. space =	0.86 M2/person

F R O N T A G E		E X P O S U R E		A V E R A G E S	
Plot Frontage	No. of plots	No. of exposures	No. of plots		
<3 M	28	1	0	Built plot area	= 50.59 M2
3-4 M	20	2	54	Private open area	= 6.48 M2/plot
4-5 M	23	3	66	Plot ratio	= 1.50
>5 M	89	4	30	Space	= 6.18 M2/person
				Plot frontage	= 6.23 M
Max. frontage =	12.50 M			Exposure	= 2.8
Min. frontage =	20.00 M				





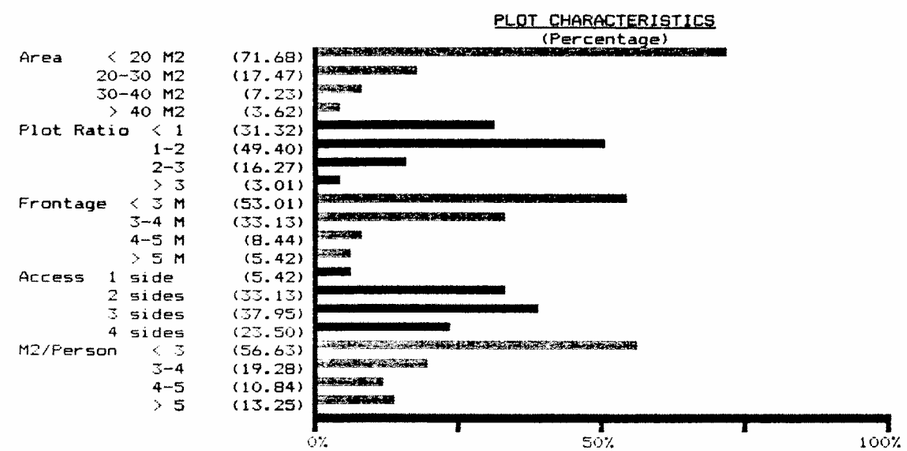
LODHA COLONY

0 10 20 50 M

Site Area = 0.67 ha. | Number of Plots = 166 | Built Plots Area = 43 %
Population = 1,030 persons | | Private Open Area= 6 %
Density = 1,521 pph | Persons/plot = 6.2 | Public Open Area = 51 %
| Income/family = 293 rs/month |

AREA		RATIO		SPACE	
Built Plot Area	No. of plots	Built Plot Ratio	No. of plots	Space on Built Plot	No. of plots
<20 M2	119	<1	52	<3 M2/person	94
20-30 M2	29	1-2	82	3-4 M2/person	32
30-40 M2	12	2-3	27	4-5 M2/person	18
>40 M2	6	>3	5	>5 M2/person	22
Max. area =	56.00 M2	Max. ratio =	4.75	Max. space =	20.00 M2/person
Min. area =	5.00 M2	Min. ratio =	0.39	Min. space =	0.63 M2/person

FRONTAGE		EXPOSURE		AVERAGES
Plot Frontage	No. of plots	No. of exposures	No. of plots	
<3 M	88	1	9	Built plot area = 15.24 M2
3-4 M	55	2	55	Private open area= 2.48 M2/plot
4-5 M	14	3	63	Plot ratio = 1.57
>5 M	9	4	39	Space = 2.44 M2/person
				Plot frontage = 3.05 M
Max. frontage =	8.50 M			Exposure = 2.8
Min. frontage =	1.50 M			

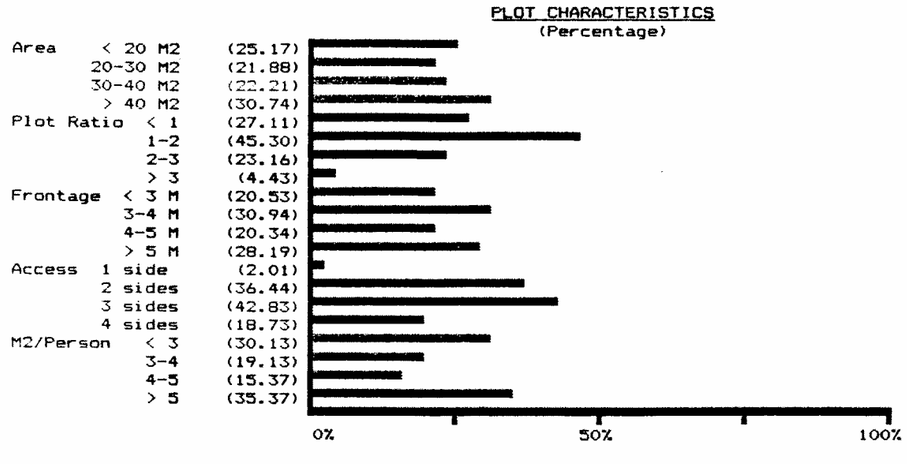


Survey Area = 11.30 ha. | Number of Plots = 1,490 | Built Plots Area = 43 %
Population = 11,955 persons | | Private Open Area= 15 %
Density = 1,057 pph | Persons/plot = 8.0 | Public Open Area = 42 %
| Income/family = 391 rs/month

A R E A		R A T I O		S P A C E	
Built Plot Area	No. of plots	Built Plot Ratio	No. of plots	Space on Built Plot	No. of plots
<20 M2	375	<1	404	<3 M2/person	449
20-30 M2	326	1-2	675	3-4 M2/person	285
30-40 M2	331	2-3	345	4-5 M2/person	229
>40 M2	458	>3	66	>5 M2/person	527
Max. area =	201.25 M2	Max. ratio =	5.60	Max. space =	60.00 M2/person
Min. area =	5.00 M2	Min. ratio =	0.23	Min. space =	0.33 M2/person

F R O N T A G E		E X P O S U R E		A V E R A G E S
Plot Frontage	No. of plots	No. of exposures	No. of plots	
<3 M	306	1	30	Built plot area = 32.57 M2
3-4 M	461	2	543	Private open area= 11.09 M2/plot
4-5 M	303	3	638	Plot ratio = 1.61
>5 M	420	4	279	Space = 4.06 M2/person
				Plot frontage = 4.78 M
				Exposure = 2.8

Max. frontage = 20.00 M
Min. frontage = 1.50 M



2. Analysis

This study is based on documents provided by the Indore Development Authority which has been undertaking social and physical surveys of urban slums in preparation for a World Bank-funded upgrading oper ation. The survey documents (prepared 1983-84) consist of scaled plot layouts, and cross-referenced social data (e.g. family size and income). This study examines the first six slum settlements for which complete data is available: Firoz Gandhi Nagar, Jivan Ki Phel, Adarsh Bijasan Nagar, Survahara Nagar, and Lodha Colony. The first five form a contiguous neighborhood in northwest Indore, the fifth, Lodha Colony, is about one mile away. Prof Vikram Bhatt and Bhushan Pathare of CMCH visited all six of the settlements during the summer of 1984. Data on two of these settlements--Firoz Gandhi Nagar and Adarsh Bijasan Nagar--appears in "How the Other Half Builds, Volume 1: Space."

The procedure of this study is as follows: (1) Data for the individual settlements is presented according to five plot characteristics:

AREA
SPACE
RATIO
FRONTAGE
EXPOSURE

indicating distribution, average and range. The characteristics are defined in the following pages.

(2) The same information is presented for the entire study population (11,955 persons).

(3) The rest of the analysis is based on a random sample of 200 plots, drawn from the total number of 1,490 plots. The random sample is drawn proportionately to the number of plots in each slum.

(4) A large number of the plots in this study contain more than one family, hence plot size, number of inhabitants and their aggregate incomes vary accordingly. Consequently, the results of the analysis of the random sample are presented in two categories: single family plots and multi-family plots.

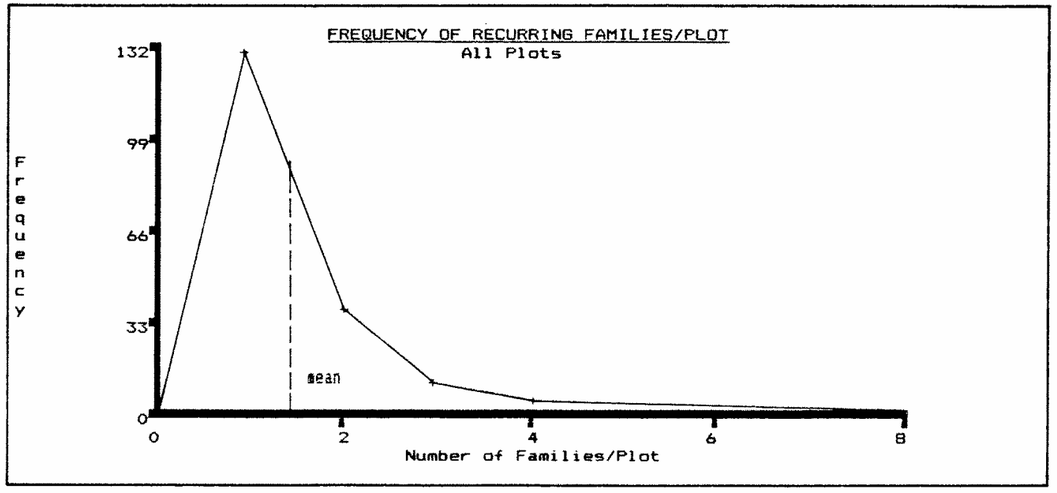
(5) Frequency distribution graphs of the random sample have been drawn for each of the five plot characteristics studied. This produces average and mode data for each characteristic.

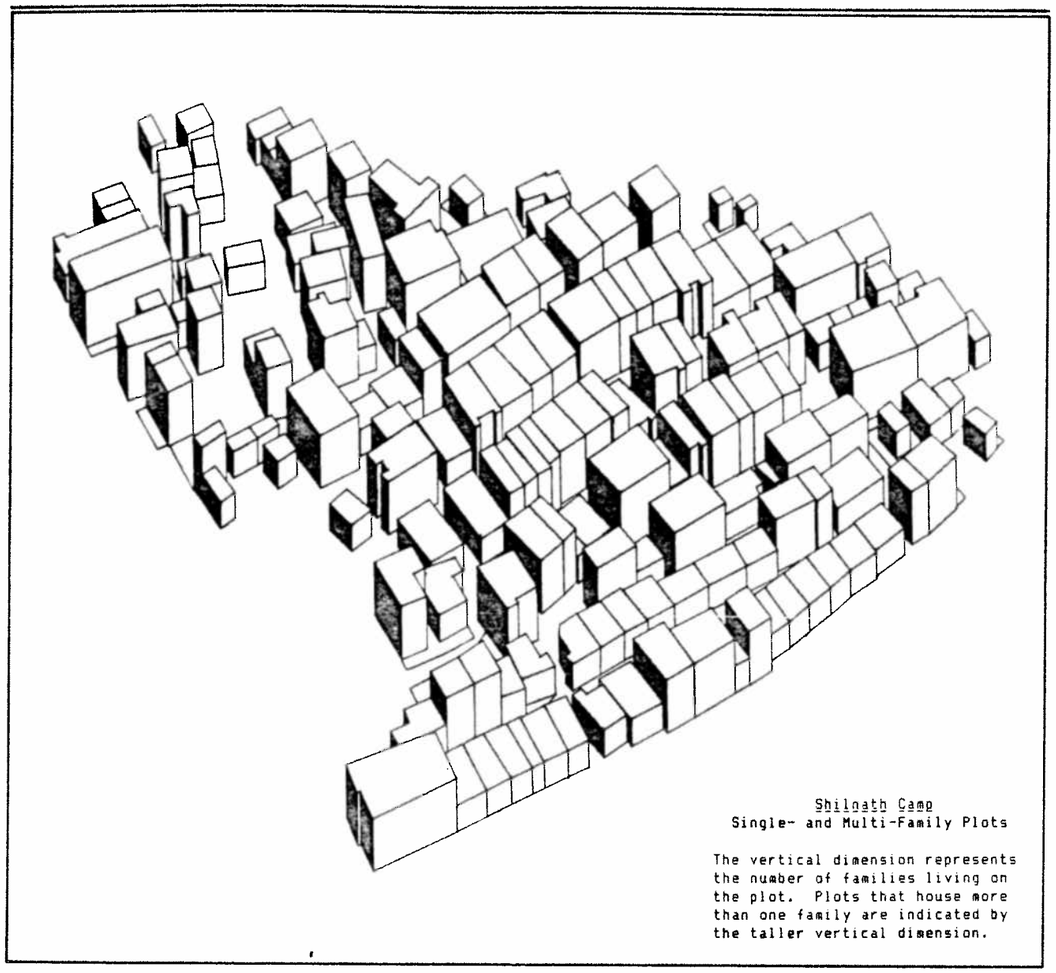
(6) Values for the five plot characteristics have been converted into standard scores. Any plots that had a score over two standard deviations from the mean were excluded from the sample. These standard scores were used to estimate the strength of the linear relationship between each pair of variables by calculating Pearson's "r" correlation coefficient.

(7) The main aim of this study has been to examine the physical characteristics of slum plots; inevitably this raises issues related to family income. Thus, in addition to the five plot characteristics, family income has also been taken into account when analyzing the random sample and when looking for correlations. The results of this part of the study are presented at the end of this section.

The averages for built plot areas for the six settlements vary widely, between 15.24 M2 and 37.49 M2, with an average of 32.57 M2 for the total population. This last figure is close to the standard for Economically Weaker Sector (EWS) plots that is used in Indian sites and services projects. This average figure can be deceptive, however, for what emerges from a closer look at the survey is the extremely large variety of plot sizes present in all the settlements, from as small as 5 M2 to 200 M2. Nor does any one size predominate; plots less than 20 M2 account for 25% of the total, plots 20-30 M2 and 30-40 M2 for 22% each, and plots over 40 M2 for 31%. This is a significant range considering the extremely high density of these settlements (the majority contain over 1,000 persons/hectare) and the value and utility of every additional square meter of space.

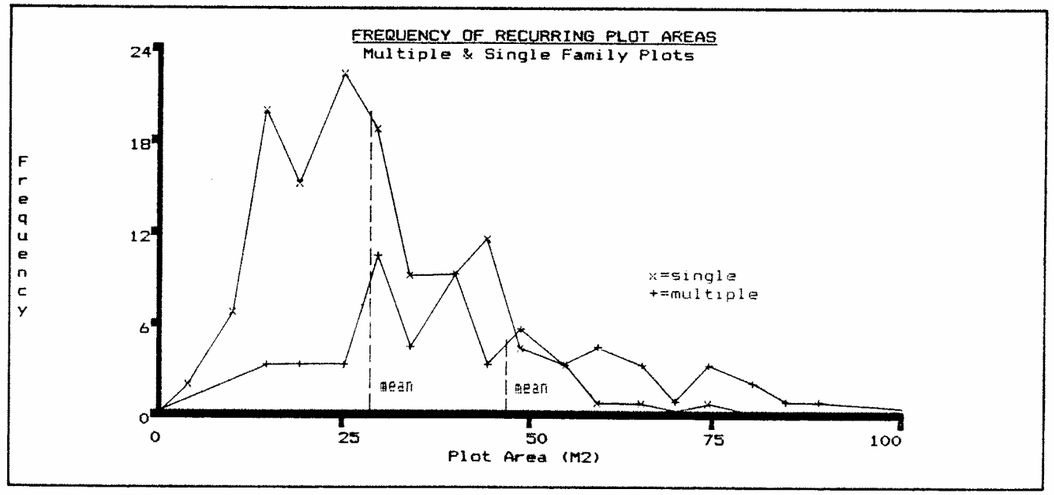
One explanation for the variety of plot sizes might be the fact that one third of the plots contain more than one family, in fact, slightly more than half of the population (51%) lives on multi-family plots. One would expect the multi-family plots to be larger, as indeed they are: the average area being 47.57 M2 vs 27.20 M2 for single-family plots. The difference between the most frequently recurring (mode) plot areas is less dramatic, however: 30 M2 for multi- vs 25 M2 for single-family plots. Thus, the number of families on a plot influences plot area, but not to the extent that one might expect. Nor is plot area a function of family size; there is a weak correlation between family size and plot area for multi-family plots, and none at all for single-family plots. The effect of variations in family income on plot areas are discussed later.





Shilgath Camp
Single- and Multi-Family Plots

The vertical dimension represents the number of families living on the plot. Plots that house more than one family are indicated by the taller vertical dimension.

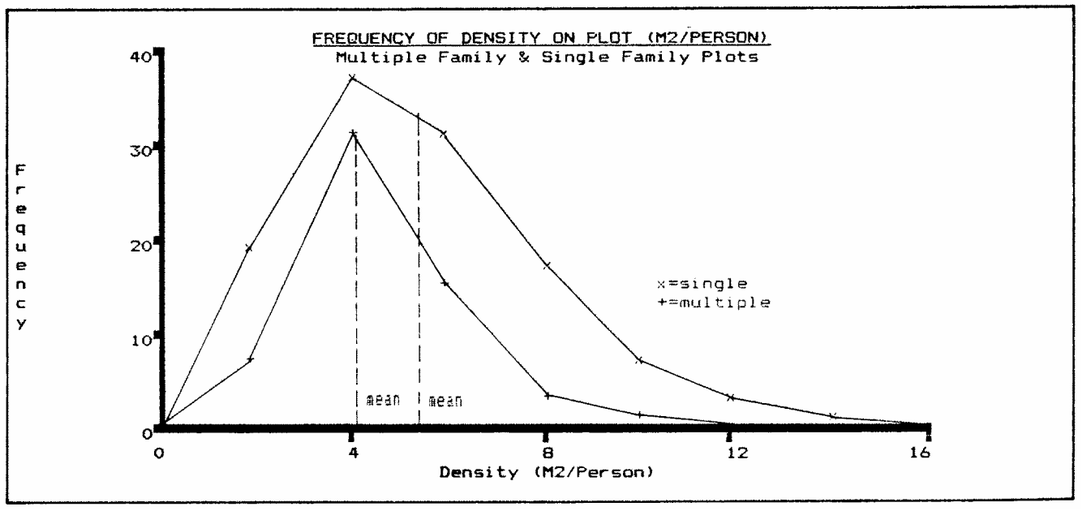


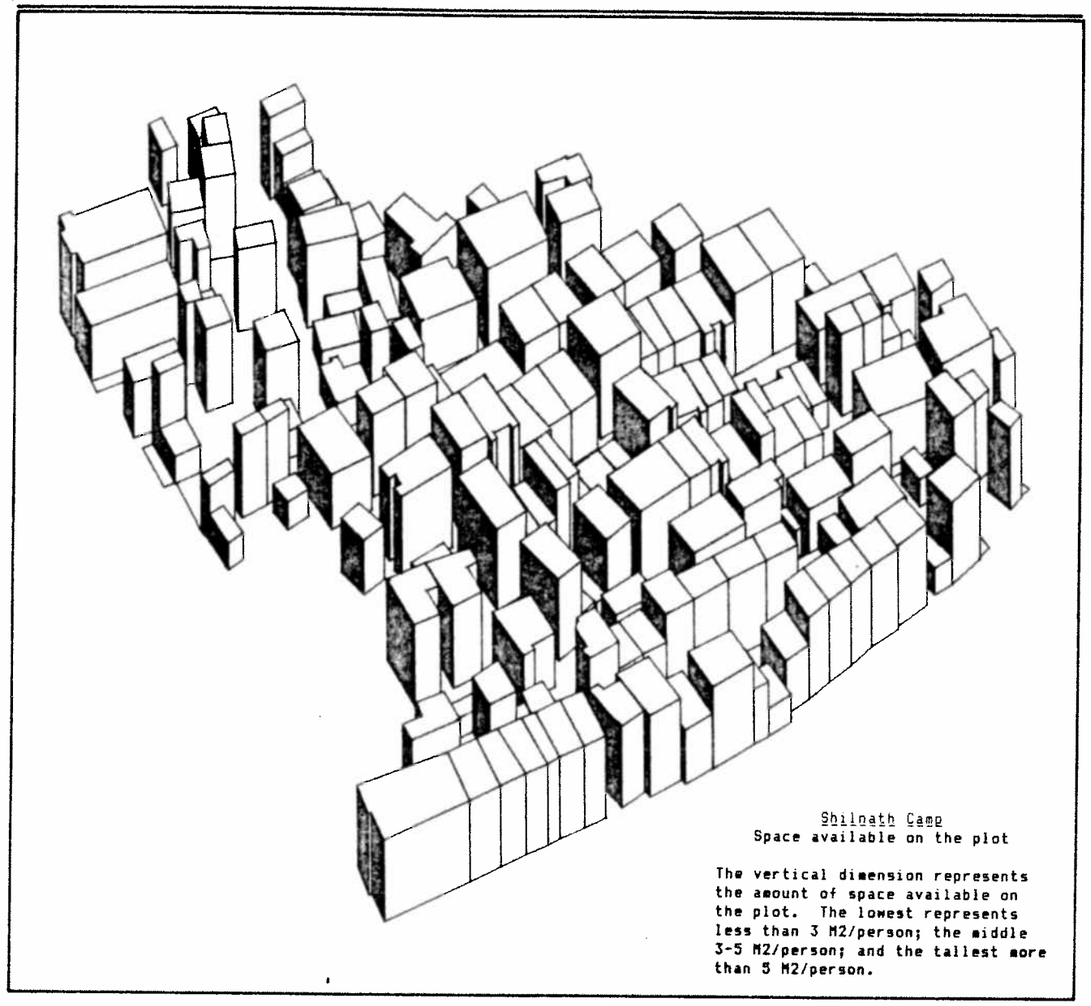
The environmental quality of the built plot is less a function of its area than of the amount of space that is available to its inhabitants (M2/person).

Space availability does not vary greatly in the six settlements; from averages of 3.05 M2/person to 4.77 M2/person. The average for the total population is 4.06 M2/person. However, as with plot areas, a closer look reveals a variety of space availability. The range is remarkably equally distributed: less than 3 M2/person (30%), 3-5 M2/person (34%) and more than 5 M2/person (36%). As the frequency distribution graph shows, the majority (75%) falls between 2-6 M2/person.

There is a difference between single- and multi-family plots, with the single-family plots being slightly more spacious (5.44 M2/person) than the multi-family plots (4.15 M2/person). The small difference in space availability between single- and multi-family plots, despite the fact that they are close in area, can be explained by the fact that the average family size on multi-family plots is considerably smaller than on single-family plots, 4.7 persons as opposed to 6.4 persons. As a result, the mode space for both is identical, 4.00 M2/person.

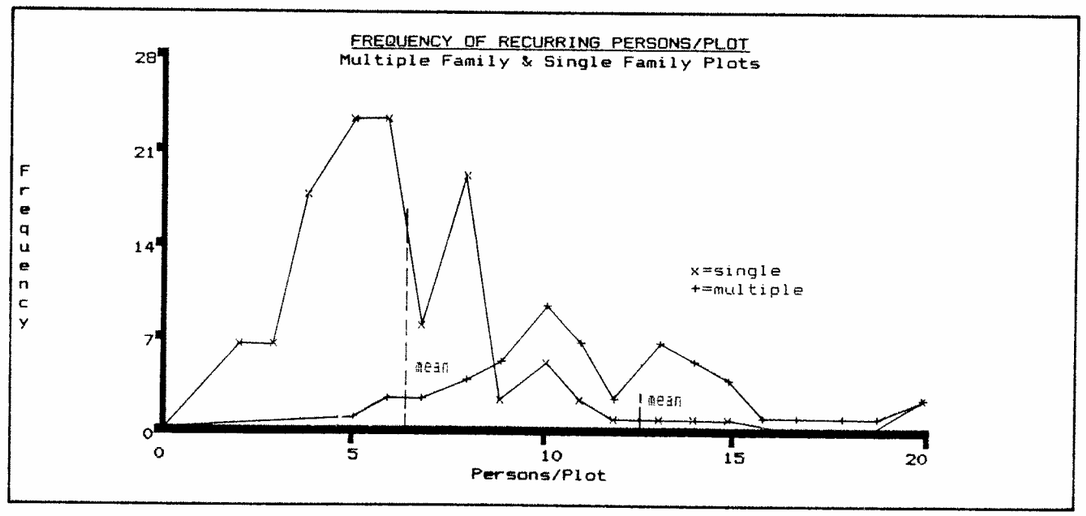
There is a strong positive correlation between space and area for both single- and multi-family plots (stronger for the latter), indicating a direct linear relationship between the two, that is, larger plots are generally less crowded than small ones. The correlation between space and family size follows the same pattern: it is weak and negative for multi-family plots, and strong and negative for single family plots.





Shilpath Camp
Space available on the plot

The vertical dimension represents the amount of space available on the plot. The lowest represents less than 3 M2/person; the middle 3-5 M2/person; and the tallest more than 5 M2/person.

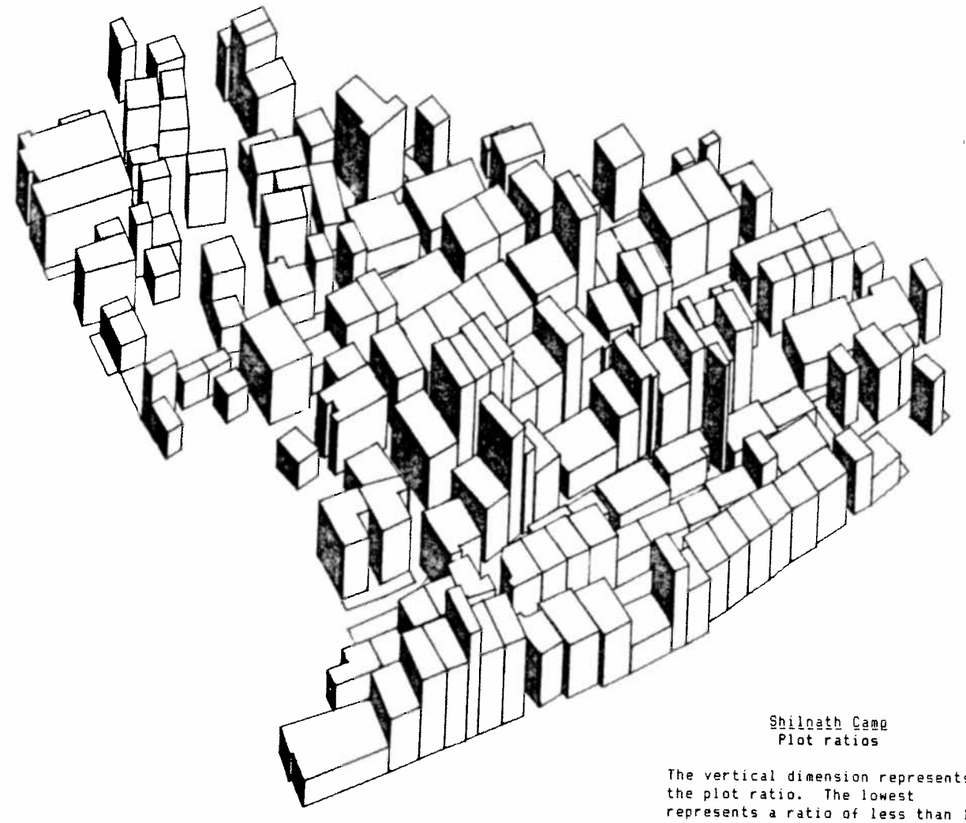


Unlike built plot area and plot space, plot ratios in the six settlements not only remain within a narrow range--the averages of plot ratios vary between 1.07 and 2.05 (the average ratio for the total survey is 1.61)--but also exhibit very little variety. 45% of the plots have a plot ratio of between 1 and 2, while only a small 4% exceed 3.

The frequency distribution graph indicates a small difference between single- and multi-family plots; the average ratio for multi-family plots is slightly lower (1.4) than that for single-family plots (1.7). The difference between mode ratios is greater, 1.5 vs 2.0 for single-family plots.

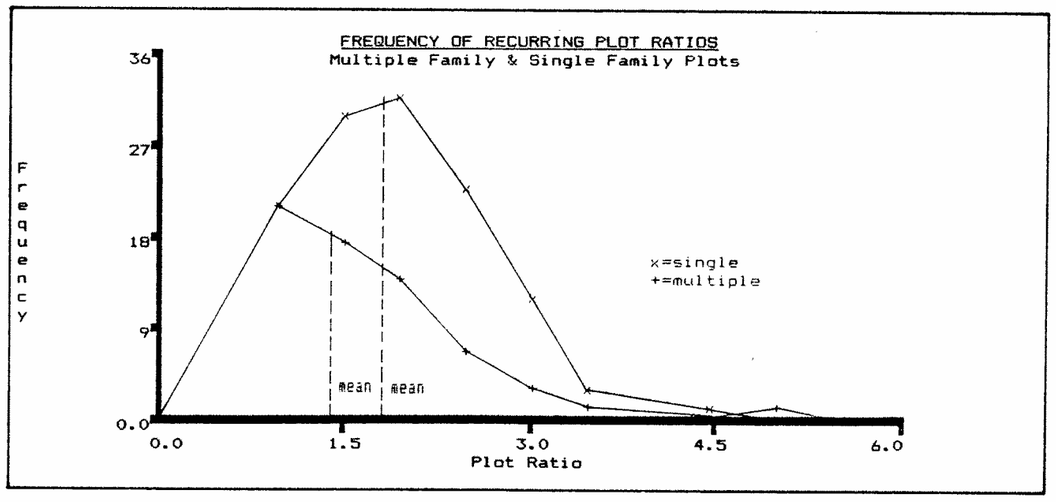
There is no correlation between plot ratio and built plot area for multi-family plots, that is, smaller and larger plots tend to have the same general proportions, about 2.0. The correlation between ratio and area for single-family plots is, contrarywise, strong and direct. It appears that single-family plots grow towards the front or rear and larger plots acquire narrower proportions (hence the correlation), while multi-family plots grow sideways, keeping a more constant ratio. Larger small plots tend to have narrower proportions. There is no correlation between plot ratio and plot space for either plots, or between plot ratio and family size.

In conclusion, there is a consistent plot ratio--between 1.5 and 2.0--in unplanned settlements. One might have expected a higher ratio, given the high population density, but this is not the case.



Shilnath Camp
Plot ratios

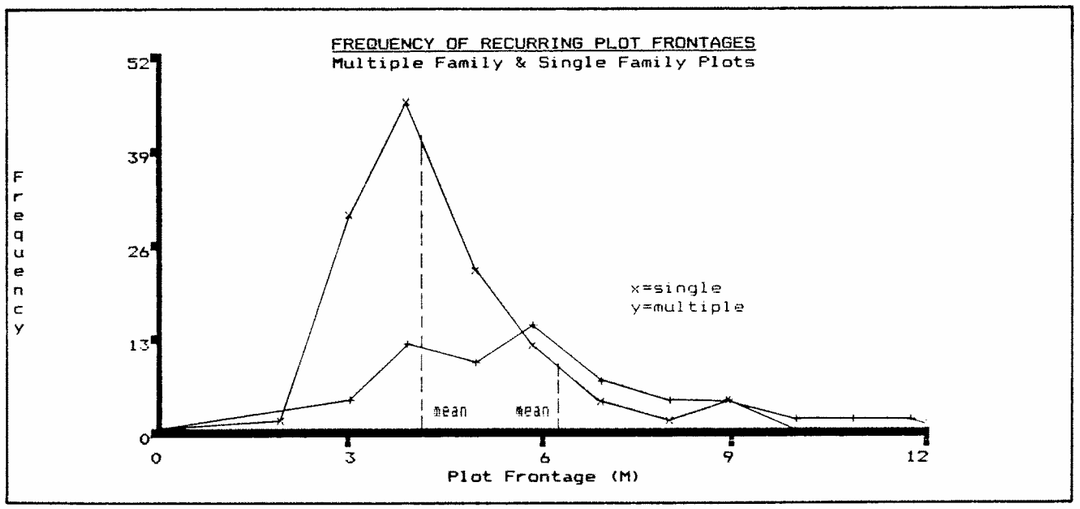
The vertical dimension represents the plot ratio. The lowest represents a ratio of less than 1; the next taller 1-2; the next 2-3; and the tallest a ratio greater than 3.



The average plot frontage in the six settlements falls between 3.05 M and 5.61 M (total average is 4.78 M). As with space, the distribution of different ratios shows no particular preponderance. Given the consistency of plot ratios, this would suggest that larger plots simply have larger frontages, and indeed this is the case; there is a very strong, positive correlation between area and frontage for both single- and multi-family plots.

The average frontage for single-family plots is 4.14 M (mode=4.00 M) and the average frontage for multi-family plots is 6.25 M (mode=6.00 M). This difference is the result of the slightly larger multi-family plot area, and of its greater plot ratio.

There is no correlation between family size and frontage for single-family plots, and a weak correlation for multi-family plots. There is a weak correlation between frontage and space for single-family plots, and a very strong one for multi-family plots. Since greater frontage is associated with larger plots, this supports the previous assertion of a strong positive correlation between area and space, likewise stronger for multi-family plots.



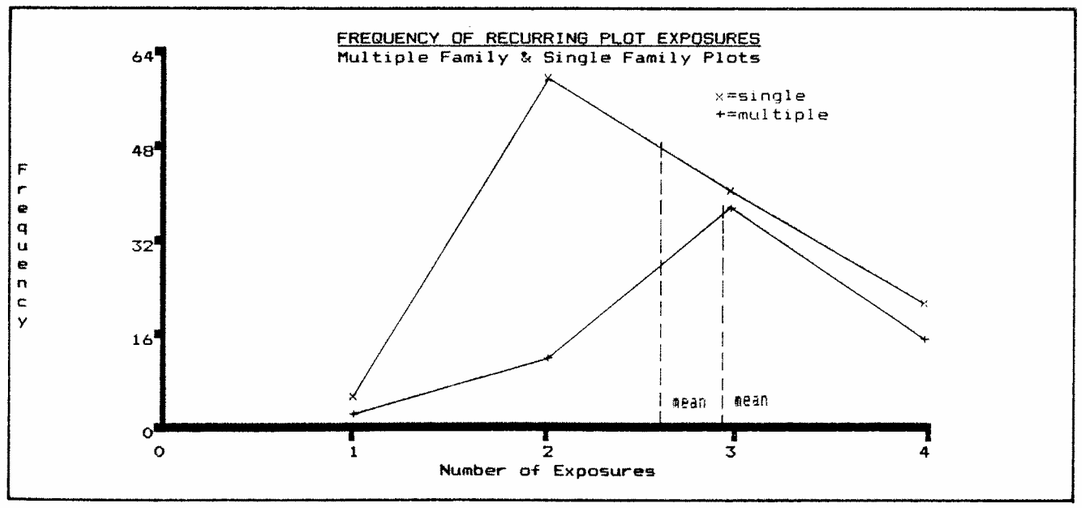
The survey indicates a clear pattern in the number of sides of the plot that are adjacent to public open space. The averages of the number of exposures fall between 2.4 and 2.9 in the six settlements. A negligible number of plots have only a single exposure (2% in the whole survey). The majority (79%) have 2 (36%) or 3 (43%) exposures.

There is a difference between single- and multi-family plots. The average for single-family plots is 2.63 exposures (mode=3.00), and the average for multi-family plots is 2.97 exposures (mode=3.00).

There is no correlation between exposure and plot area. Nor is there a correlation between exposure and either ratio or frontage. If small plots, or narrow plots, or narrowly proportioned plots are just as likely to have 2-3 exposures as large, or wide, or squarish ones, this suggests that multiple exposure is an important plot characteristic which is provided to all plots.

There is a very strong positive correlation between exposure and space for multi-family plots, but no correlation for single-family plots. This is difficult to explain. Does it have something to do with the differences between occupations on single- and multi-family plots? Do multi-family plots, for example, incorporate work areas or shops, which would tend to increase the M2/person?

The fact that most plots in unplanned settlements have 2 or 3 sides adjacent to public open space demands more open space than in a planned settlement where almost all the plots are back-to-back houses with single (and generally minimal) frontages. The gross built plots area in the six settlements varies between 39% and 50% (average=43%) of the site, and if one deducts the private open spaces, the area dedicated to public open space is between 33% and 51% (average=42%) of the site. This is a great deal, considering that the average population density is 1,057 persons/hectare. It indicates the premium that is placed on multiple exposures, as well as the importance that is attached to the provision of open space adjacent to the home, and available for many domestic activities.



At the time that this survey was conducted, the Indian government identified three income categories in popular housing: the Economically Weaker Sector (EWS), the Low Income Group (LIG), the Middle Income Group (MIG), and the High Income Group (HIG), according to the following incomes:

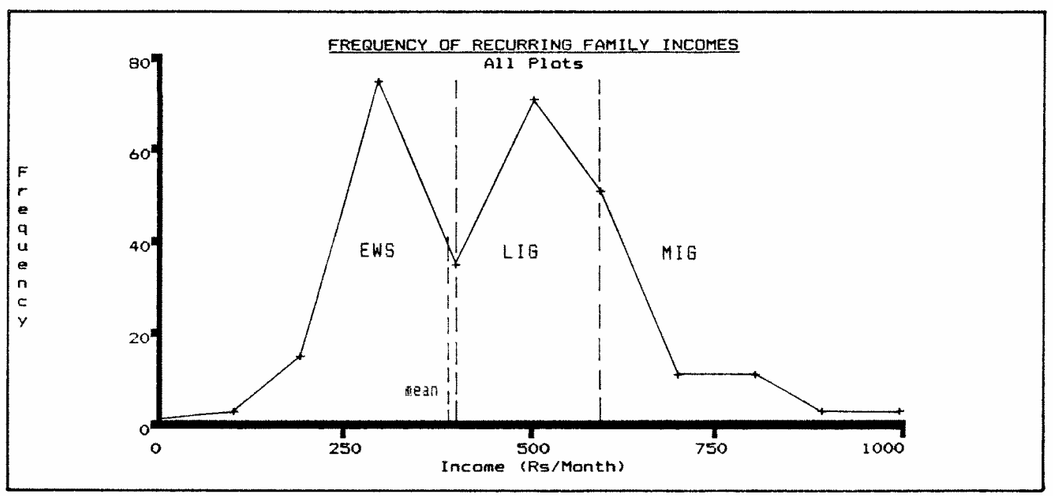
EWS -- below 400 Rs./month
LIG -- 400-600 Rs./month
MIG -- 600-1,800 Rs./month
HIG -- over 1,800 Rs./month

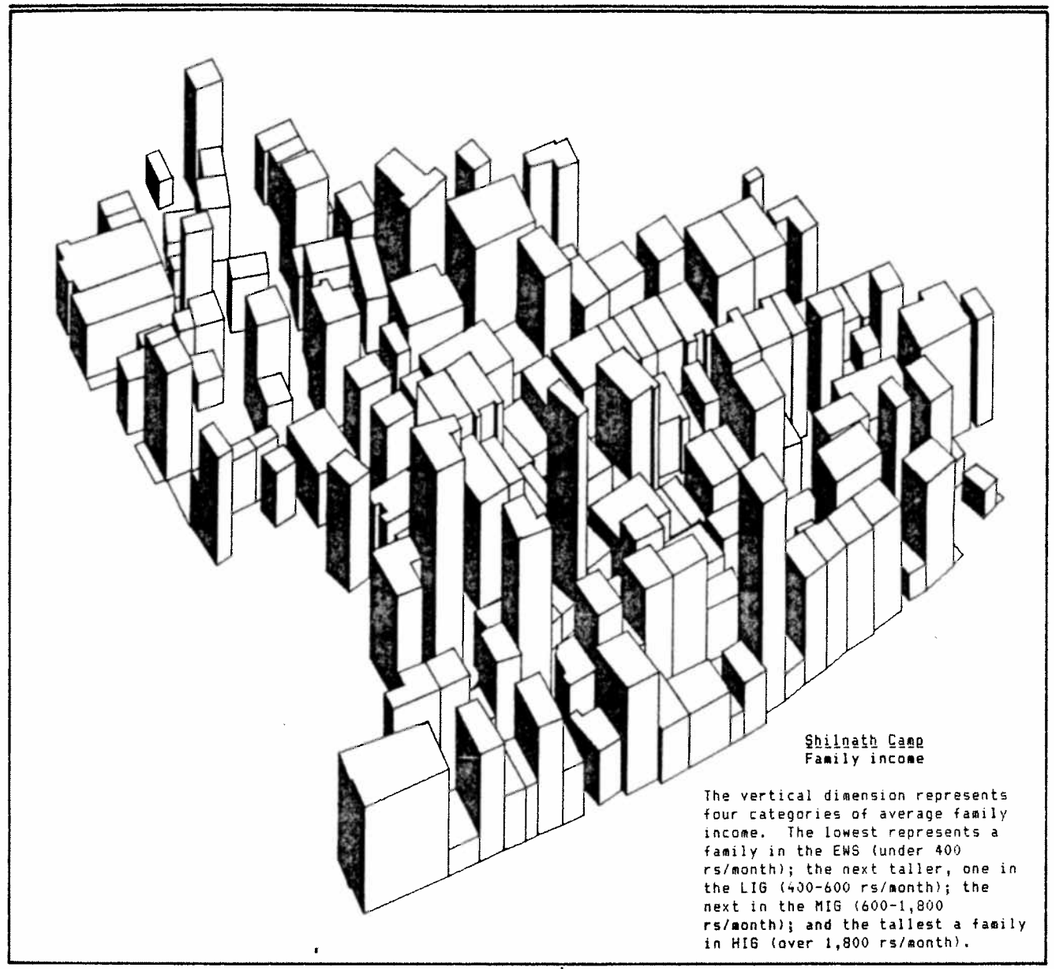
The averages of family income in the six settlements vary between 293-503 Rs/month, the average for the total population being 391 Rs./month (mode=300 Rs./month). As the frequency distribution graph for incomes of families living on both single- and multi-family plots indicates, all income groups were represented: EWS (47%), LIG (42%) and MIG (11%). Unplanned settlements house a broad cross-section of urban society, not simply the poorest.

Both single- and multi-family plot families demonstrate two modes, at 300 Rs./month, and at 500 Rs./month. The average income of families living on single family plots is 468 Rs./month; for families living on multi-family plots it is slightly lower, 439Rs./month. This is not a significant difference. If the reason for sharing a plot with other families is not economic it may be due to family ties, caste, work groups, and so on.

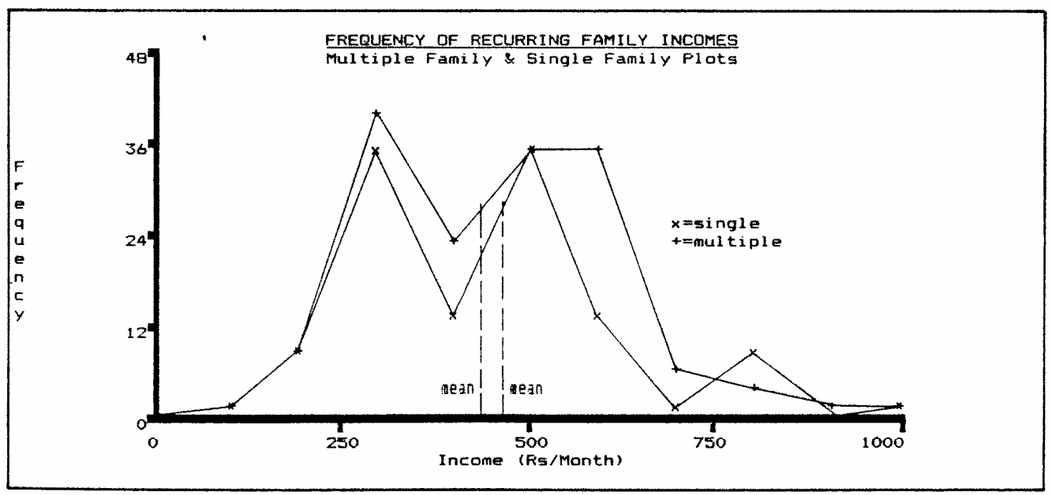
There is a strong correlation between family income and area for single-family plots, and a none between multi-family plot areas and family incomes. This suggests either that as families become better off they tend to move to larger, individual plots, or that wealthier families acquire larger plots of their own; why this should be more so for single-family plots is unclear. In any case, it appears that when families share a plot, its size is determined by things other than family income. The correlation between family income and the number of persons in the family is strong for both single- and multi-family plots--obviously larger families have more wage-earners.

There is no correlation between family income and any other of the physical plot characteristics--space, ratio, frontage or exposure--for either type of plot. The variety of plot shapes, sizes and exposures appears to be unrelated to differences in family income, despite the fact that the latter are considerable.





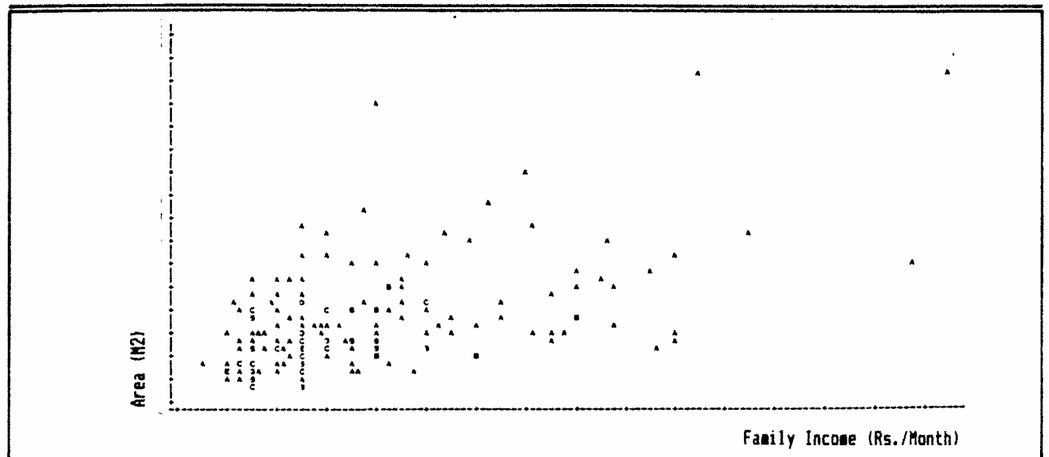
The vertical dimension represents four categories of average family income. The lowest represents a family in the EWS (under 400 rs/month); the next taller, one in the LIG (400-600 rs/month); the next in the MIG (600-1,800 rs/month); and the tallest a family in HIG (over 1,800 rs/month).

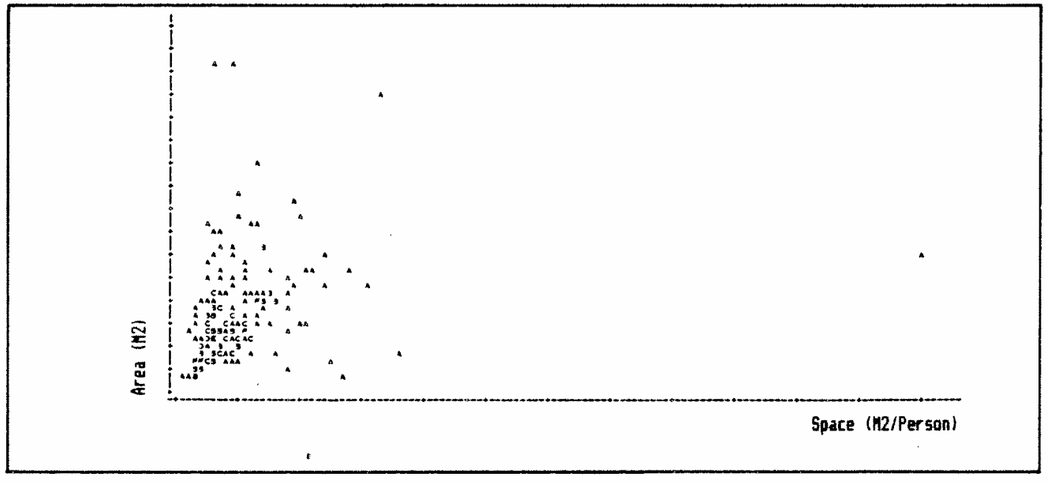


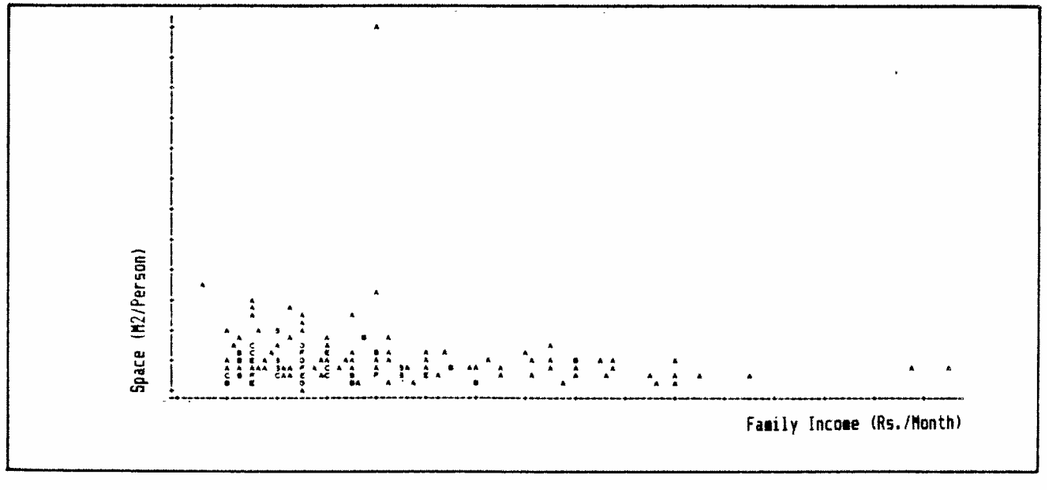
Plot Characteristic		Average	Mode	Maximum	Minimum	Std. Dev'n.	Variation
AREA (M2)	Single	27.20	25.00	72.00	5.00	13.26	175.70
	Multi	47.27	30.00	144.00	15.00	27.61	762.20
SPACE (M2/person)	Single	5.44	4.00	60.00	0.33	5.79	33.52
	Multi	4.15	4.00	16.41	1.47	2.61	6.79
RATIO	Single	1.77	2.00	4.40	0.39	0.72	0.52
	Multi	1.44	1.50	4.80	0.36	0.79	0.62
FRONTAGE (M)	Single	4.14	4.00	9.00	2.00	1.33	1.76
	Multi	6.25	6.00	16.00	2.50	2.85	8.11
EXPOSURE (sides)	Single	2.63	3.00	4.00	1.00	0.79	0.63
	Multi	2.97	3.00	4.00	1.00	0.73	0.53
FAMILY SIZE (persons)	Single	6.41	n/a	21.00	1.00	3.15	9.91
	Multi	4.70	n/a	16.00	1.00	2.50	6.25
FAMILY INCOME (Rs./Month)	Single	467.58	300.00	2000.00	100.00	245.85	6044.37
	Multi	439.43	300.00	1100.00	100.00	169.13	28606.57

Pearson's "r" Correlation Coefficient

AREA and SPACE	Single	+0.20	strong	FAMILY SIZE and SPACE	Single	-0.22	strong
	Multi	+0.38	very strong		Multi	-0.14	weak
AREA and RATIO	Single	+0.35	very strong	FAMILY SIZE and RATIO	Single	+0.03	none
	Multi	-0.04	none		Multi	+0.01	none
AREA and FRONTAGE	Single	+0.37	very strong	FAMILY SIZE and FRONTAGE	Single	0.00	none
	Multi	+0.40	very strong		Multi	+0.12	weak
AREA and EXPOSURE	Single	-0.10	none	FAMILY SIZE and EXPOSURE	Single	-0.13	weak
	Multi	+0.09	none		Multi	+0.17	weak
SPACE and RATIO	Single	+0.04	none	FAMILY INCOME and AREA	Single	+0.23	strong
	Multi	+0.02	none		Multi	+0.10	none
SPACE and FRONTAGE	Single	+0.16	weak	FAMILY INCOME and SPACE	Single	-0.02	none
	Multi	+0.31	very strong		Multi	-0.03	none
SPACE and EXPOSURE	Single	-0.02	none	FAMILY INCOME and RATIO	Single	+0.08	none
	Multi	+0.38	very strong		Multi	+0.01	none
RATIO and FRONTAGE	Single	-0.32	very strong	FAMILY INCOME and FRONTAGE	Single	+0.10	none
	Multi	-0.39	very strong		Multi	+0.06	none
RATIO and EXPOSURE	Single	+0.05	none	FAMILY INCOME and EXPOSURE	Single	+0.03	none
	Multi	+0.07	none		Multi	+0.10	none
FRONTAGE and EXPOSURE	Single	-0.07	none	FAMILY INCOME and SIZE	Single	+0.30	strong
	Multi	+0.03	none		Multi	+0.20	strong
FAMILY SIZE and AREA	Single	+0.09	none				
	Multi	+0.17	weak				







Empirical analysis--the study of observed behavior--has an important role to play in developing a socially and culturally responsive design process. The decisions made by a people in response to their shelter needs occur within a set of locally specific, socio-economic constraints. Statistical profiles of the six unplanned settlements in Indore revealed reoccuring patterns that have important design and planning implications.

Income groups in these settlements covered an evenly distributed range from the so-called Economically Weaker Sector (EWS) to Middle Income Group households. The mean income for the total survey was between the upper range of the EWS and the lower range of the Low Income Group. Statistically significant differences between single- and multi-family plots, in the physical aspects of the built environment, were noted for all six settlements. Differences among the six, reflecting differences in community level constraints, were then studied in order to test their influence on the linear relationships noted between variables for the aggregate random sample.

Dummy variables were used to identify data from the random sample by settlement and group (single- or multi-family). Scatter graphs revealed linear relationships between area/income, family size/income, and area/space per person for all settlements, for and both groups (see following page).

The relationship noted between area/income and family size/income were very similar. The slope of the relationship for both was very low, indicating that plot size increased slowly in relation to increases in income, and that, likewise, income increased slowly in relation to family size. The similarities in these two relationships suggested that there could be a significant relationship among these variables. That is, that income and family size were significant determinants of plot size.

Space per person was a constant variable among all settlements and both groups. The variance in the data was not significantly different for either settlement or group. The relationship between area and space revealed that larger plots had more space per person, but the slope of this relationship was very steep, indicating that this increase was only marginal. The linear relationship between space and income was not significant in any settlement or either group. While this may seem to contradict the relationship between area and income, it should be noted that the differences in the slopes of these relationships suggests that marginal increases in income do not affect the amount of space per person-- that larger families (with more people generating income) simply live on larger plots. The variation in plot sizes was large for all settlements and both groups, while the variation in space was relatively constant. More space per person on larger plots could suggest differences in income-generating activity, and the need to provide space for this activity.

These relationships indicate that arbitrary income categorization does not accurately reflect the underlying social patterns that determine household income levels within these settlements . The relationship between area/income and area/family size suggested the possibility of developing a predictive model for plot size based on information on income and family size. Such a model could be used by planners to predict design parameters for density and plot size for specific target populations based on local constraints.

A regression analysis was run on the total population of the random sample to test the above hypothesis. Regression analysis tests the variance of a dependent variable against two or more independent variables. The significance of the relationship explains the accuracy of a prediction of the dependent variable based on data of the independent variables. The variance between the predicted result of the dependent variable and the actual observed data is measured, and the degree to which this variance can be explained by the independent variables is calculated as a percentage.

A regression analysis that used area as the dependent variable and income and family size as the independent variables was highly significant, indicating that a 0.0001 chance that this relationship was a random event. The model, based on income and family size, can account for 44 percent of the variance between the predicted area and the actual recorded observation. Since there was such a large variation in plot sizes in the population to begin with, this represents a very accurate predictive model. The strength of the model could probably be improved by including space per person as another independent variable.

The design implications of this study depend on the accuracy of the data collected, and are specific to these communities. More study will show how many of our conclusions have broader application. However, the aim of this study is also to demonstrate that an empirical methodology can assist designers to understand the underlying social patterns that influence the physical characteristics of the built environment. This methodology can be applied both in small-scale designs and in large-scale planning, to facilitate the decision-making process, and to develop appropriate standards.

3. Planning Studies

This section of the report describes a planning study that was carried out in order to evaluate the implications of alternative standards based on our analysis of plot characteristics in unplanned settlements.

THE CONTROL MODEL

The context chosen for this study is a large, World Bank financed, sites and services project for the city of Indore that has been planned by our collaborator, the Vastu-Shilpa Foundation, and which is now under construction. The 89-hectare site provides plots for about 7,000 families Our planning study examined alternative plans for a single neighborhood (2.4 hectares) within the Indore master plan.

The following pages show the plan developed by VSF, as well as an anlysis of Circulation Space, Semi-Public Open Space, and Built-Form. The VSF plan served as a control, against which the planning study, using alternative standards, could be evaluated.

THE PLANNING STUDY

The planning study was intended to test the following hypotheses:

1. Sites and services projects should provide a variety of plot areas based not on income, but on varying family size, and on a density of about 4 M2/person.
2. Plot areas should range from less than 20 M2 to as much as 60 M2.
3. There should be a variety of plot shapes, and in no case should plot ratio exceed 2.
4. No plot should have access on less than 2 exposed sides.
5. As much as possible, open space should be semi-public in character.
6. Instead of underground sewers, pour-flush, double-vault composting (DVC) privies should be used.

PROJECT I

This alternative was designed by Rajinder Puri. It assumes that all plots are planned and laid out beforehand. There are three different plot areas (18, 36 and 54 M2) and two shapes (square and rectangular), hence 6 different plots. These plots are organized in small groups of about fifty families. Most plots have access from at least 2 sides. There is a clear separation between public streets and semi-public cul-de-sacs. This planning pattern, which gives identity to different social groups, can be observed in the old areas of cities such Ahmedabad.

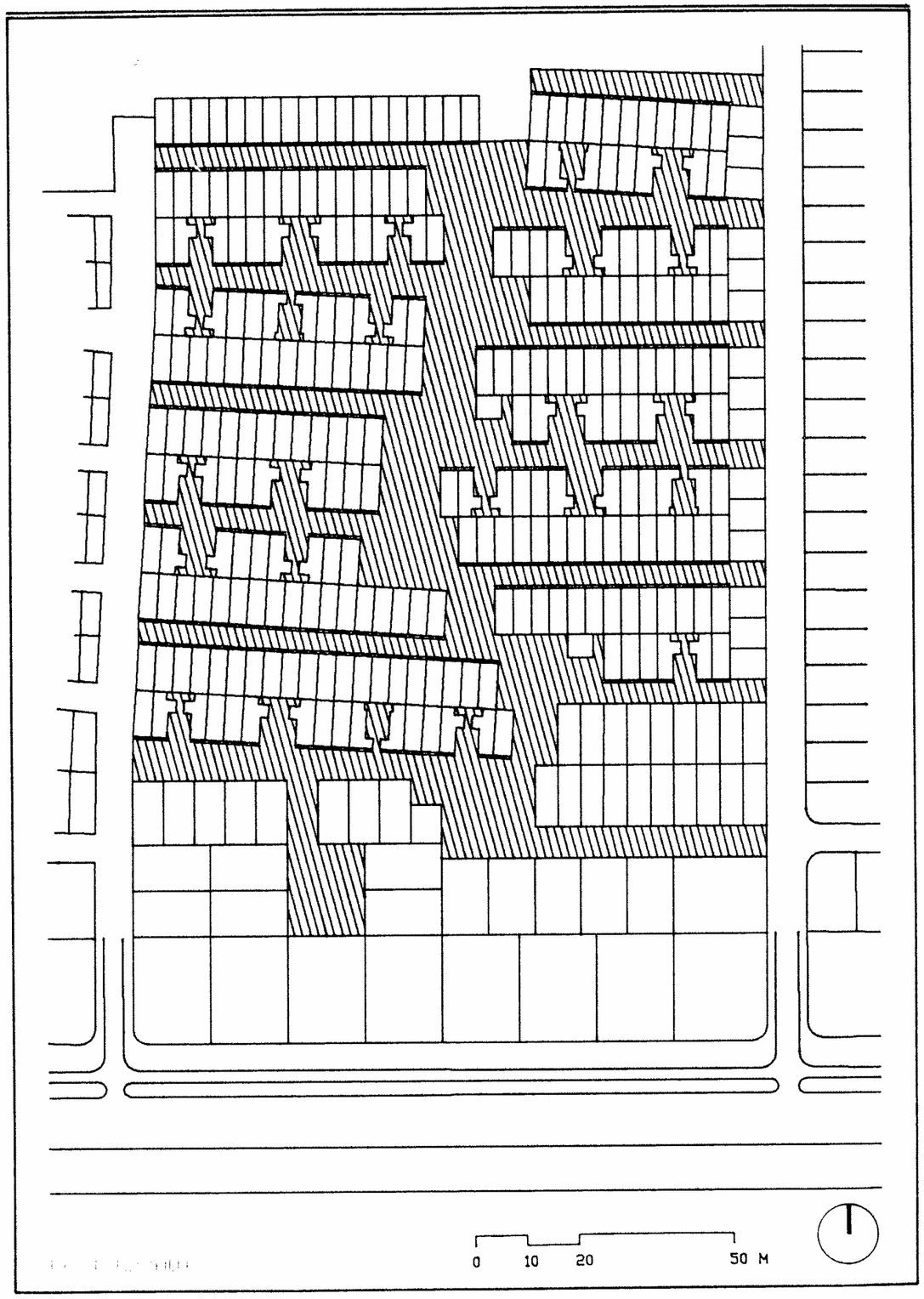
PROJECT II

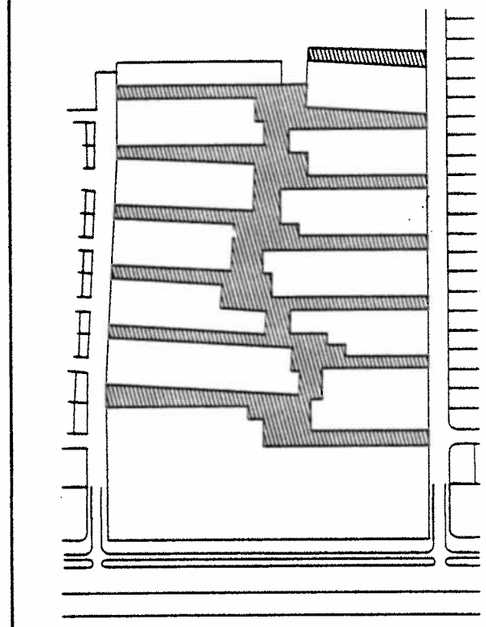
This alternative was designed by Carlos Barquin. It accomodates a variety of plot areas without predetermining in advance their exact location or size. The L-shaped planning module consists of 18, 24 and 36 M2 space units, which can be used together or separately to give a wide range of plot areas (10 combinations, 18-78 M2). Each module includes one shared DVC toilets, to which individual connections are made once the plots are occupied. As the plan shows, the use of a planning module does not necessarily impose a rigid pattern.

PROJECT III

This alternative was designed by Richard Brook. It provides a "support structure" consisting of shared DVC toilets, around which a group of plots can be laid out. Each cluster of plots follows a pattern rather than a predetermined plan. The constraint on each grouping is the size of the 12 M3 DVC tank (which can serve 65-100 persons). The size, number and exact shape of the plots is not predetermined, and can be varied according to the size of families, and the number of plots shared by more than one family.

Vastu-Shilpa Foundation

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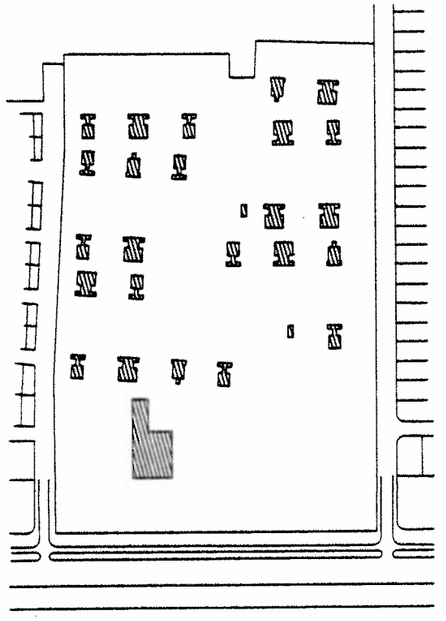
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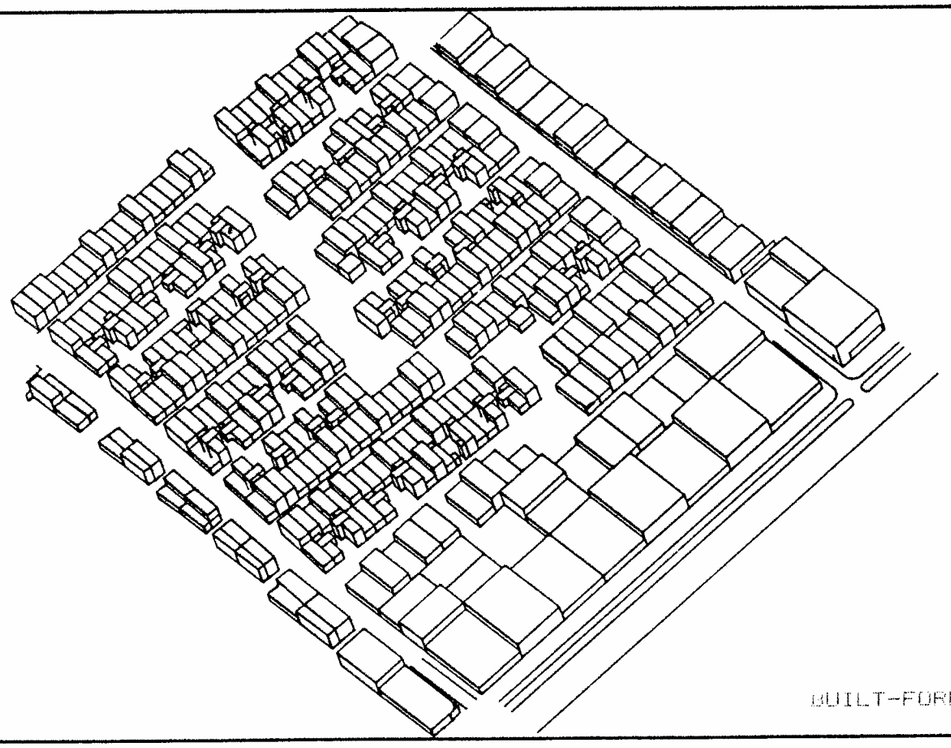
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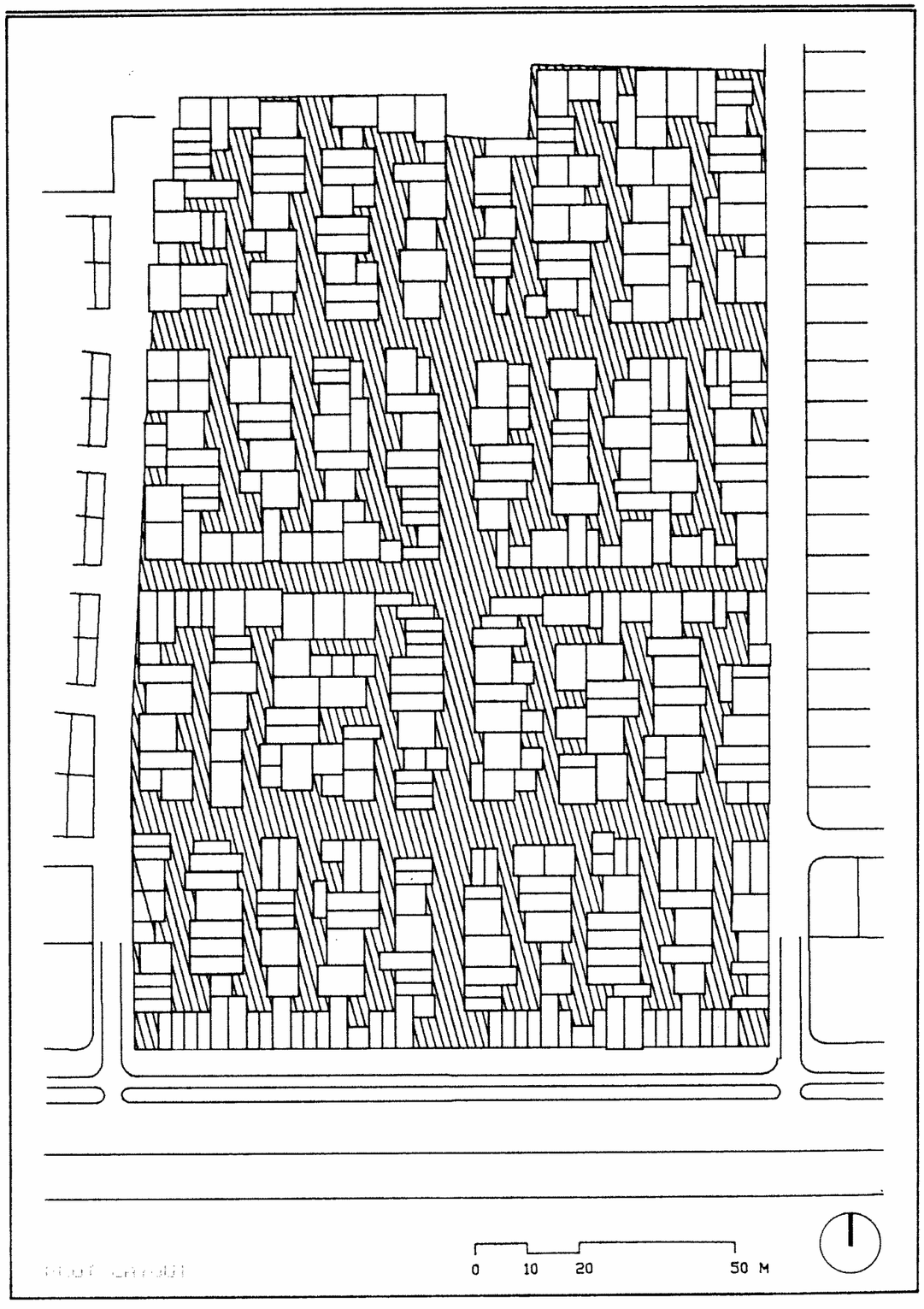

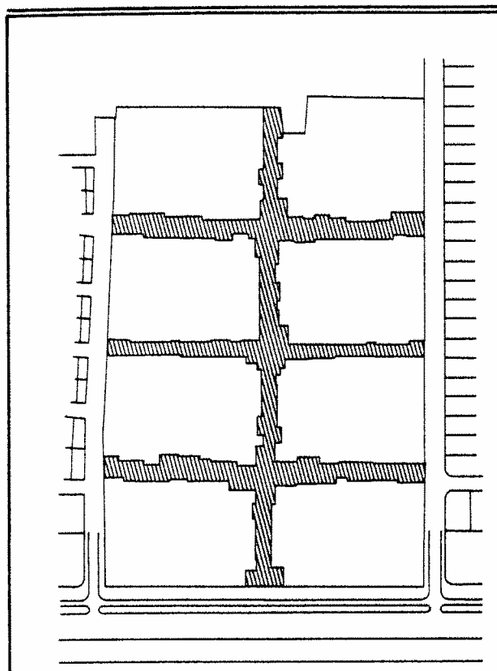

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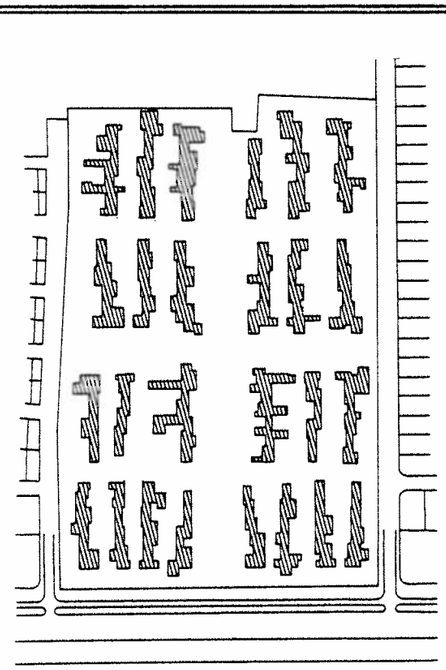

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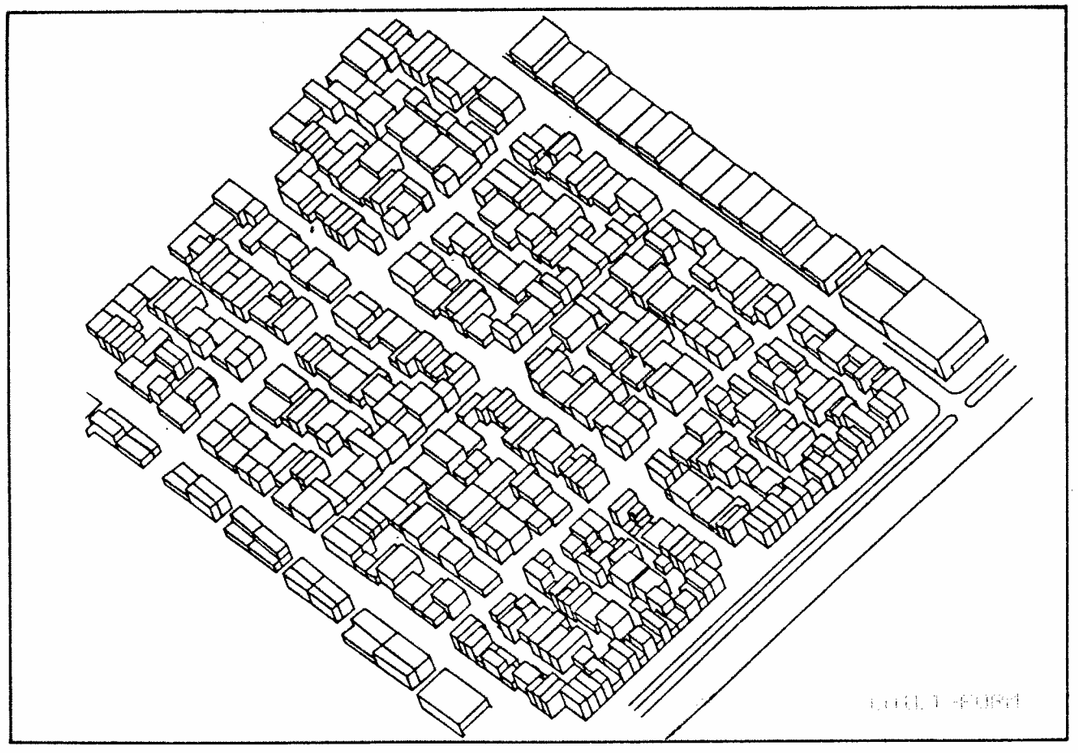

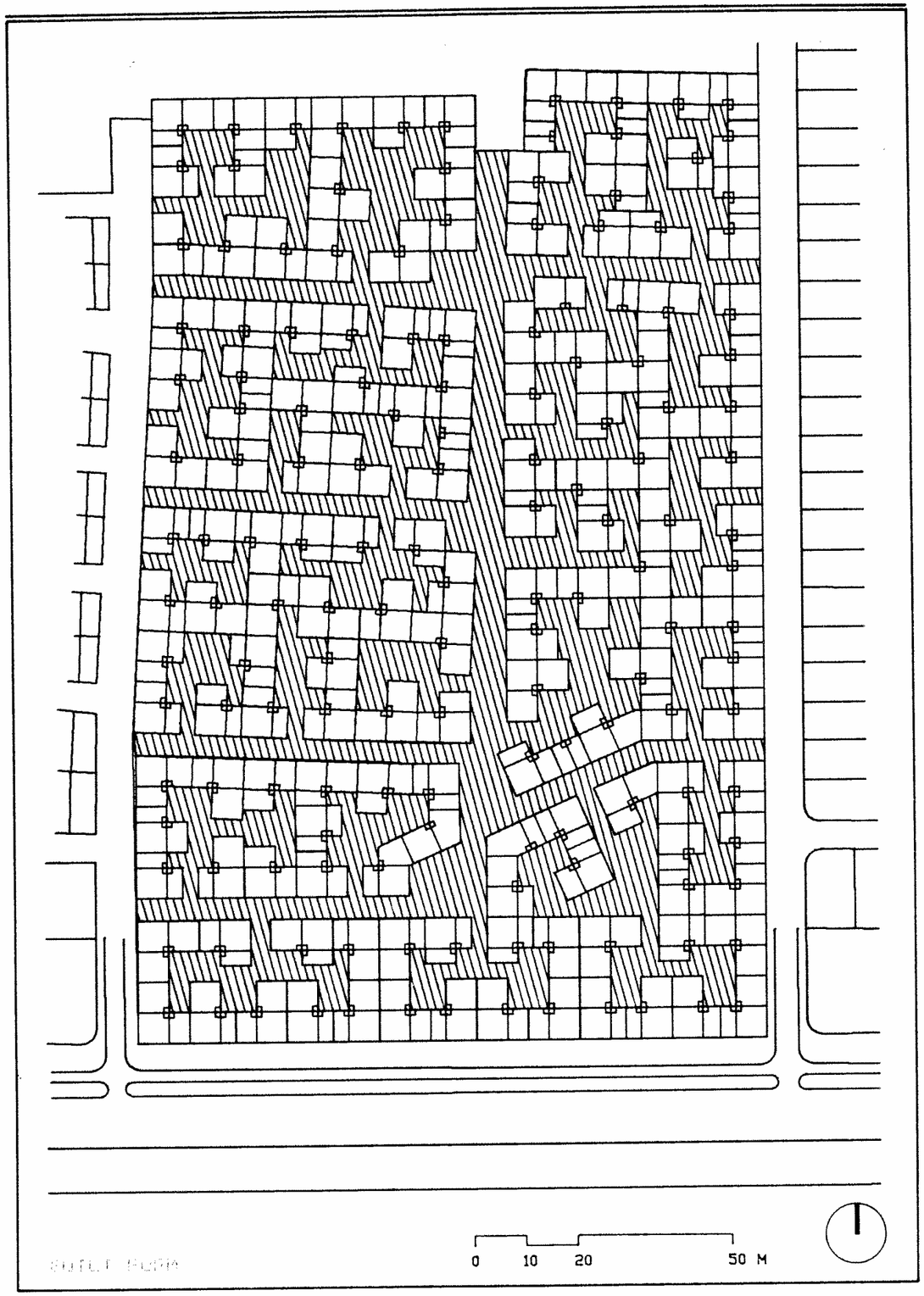

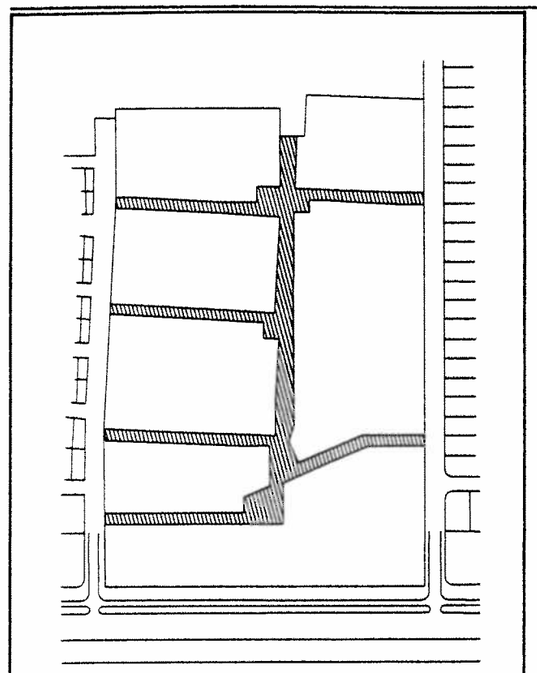
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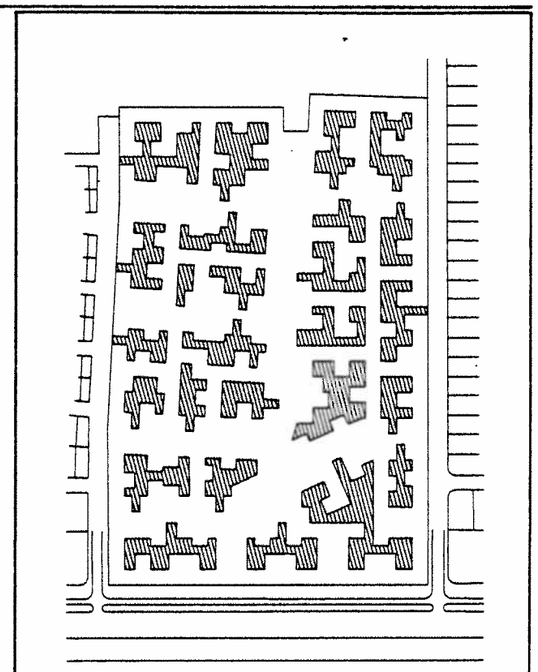
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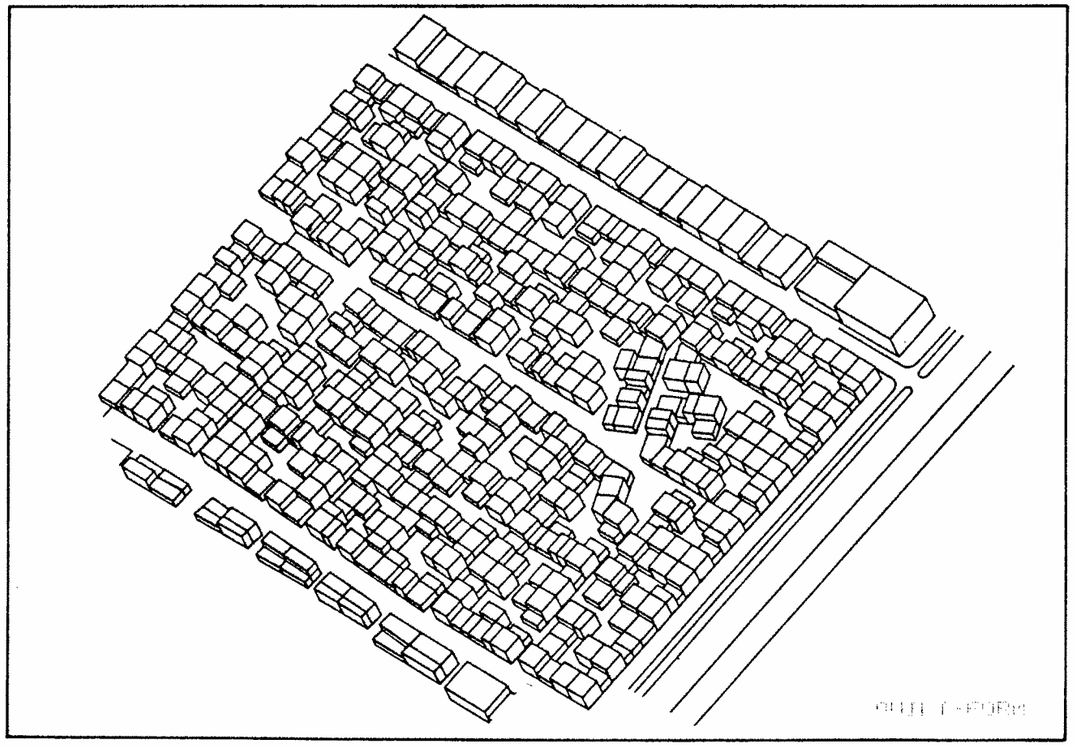

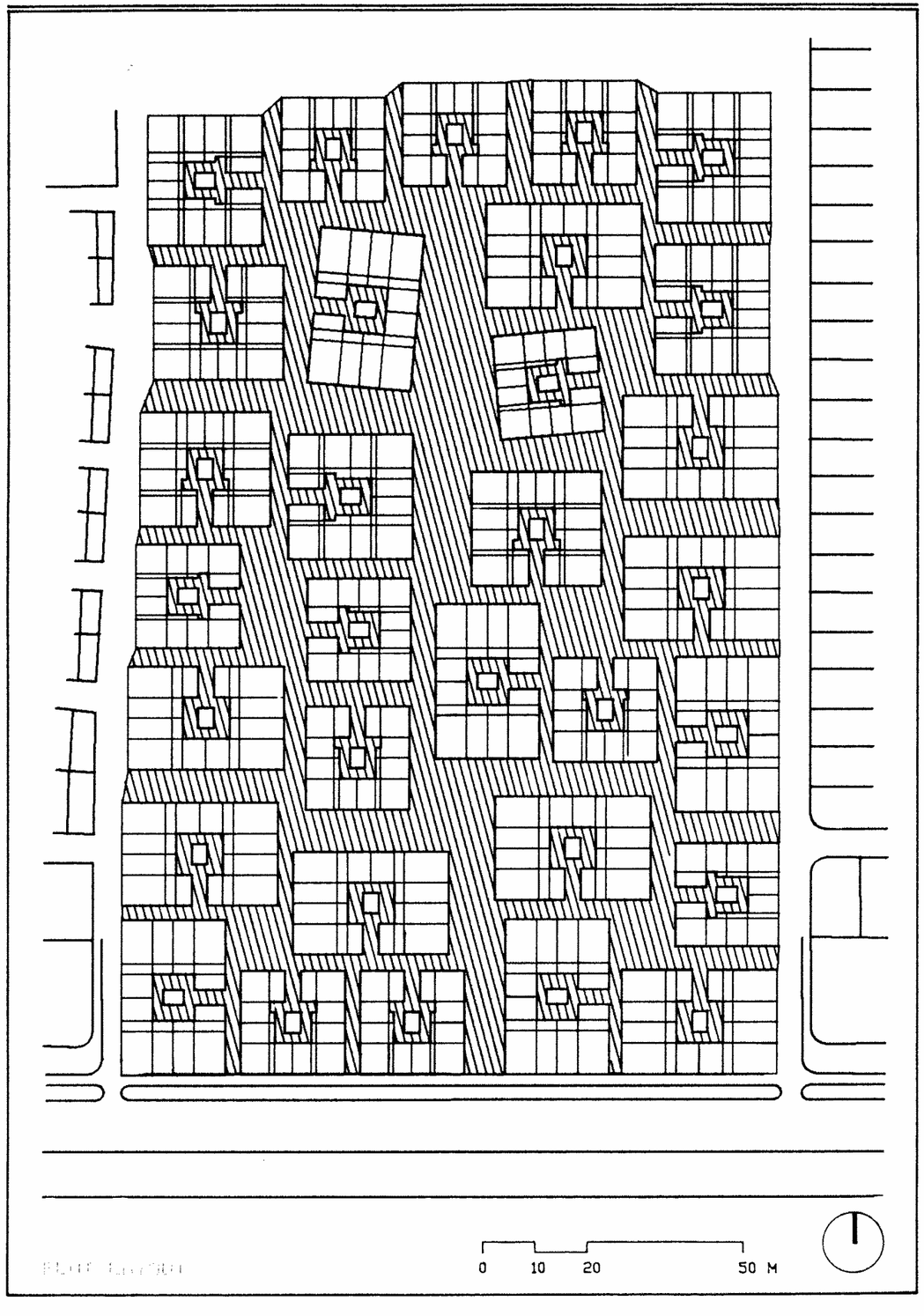

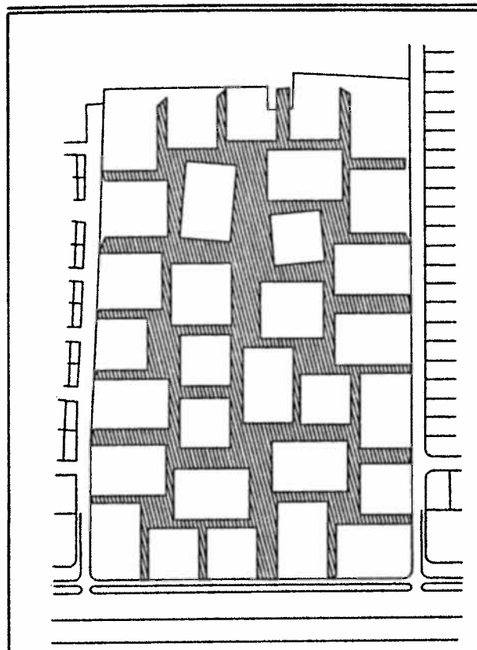

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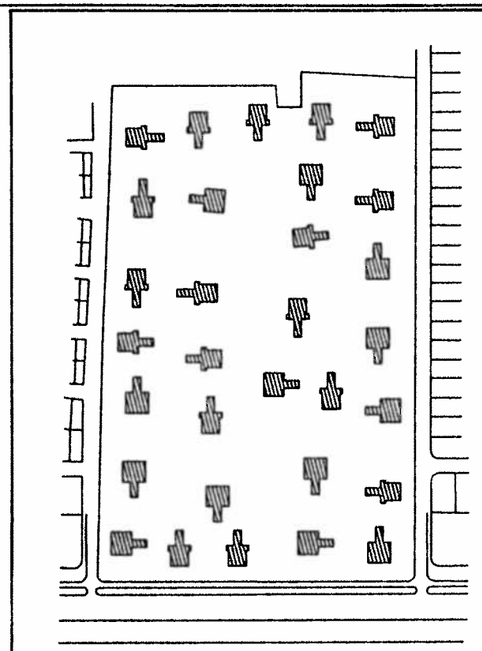

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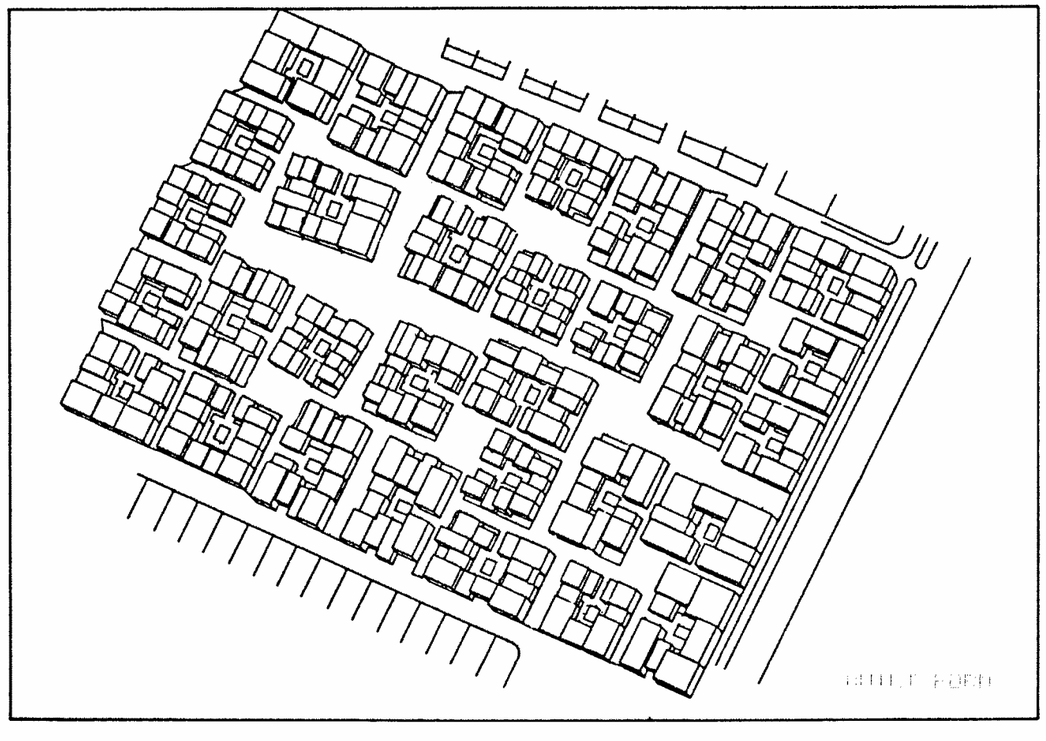
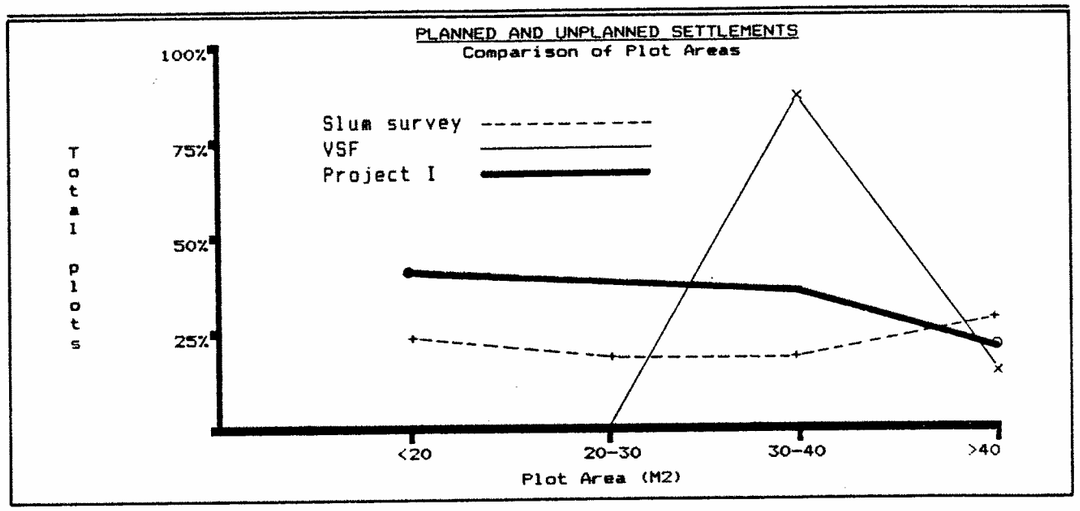
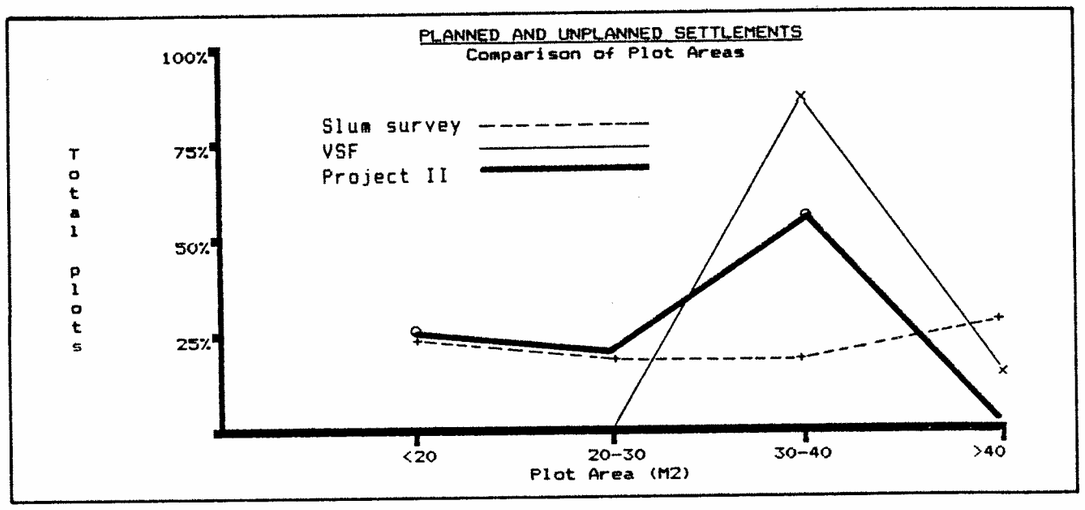



PLANNED AND UNPLANNED SETTLEMENTS
Comparison of Plot Areas
Slum survey
VSF
Project I
Total plots
100%
75%
50%
25%
<20
20-30
30-40
>40
Plot Area (M2)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Comparison of Plot Areas
Slum survey
VSF
Project II
Total plots
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50%
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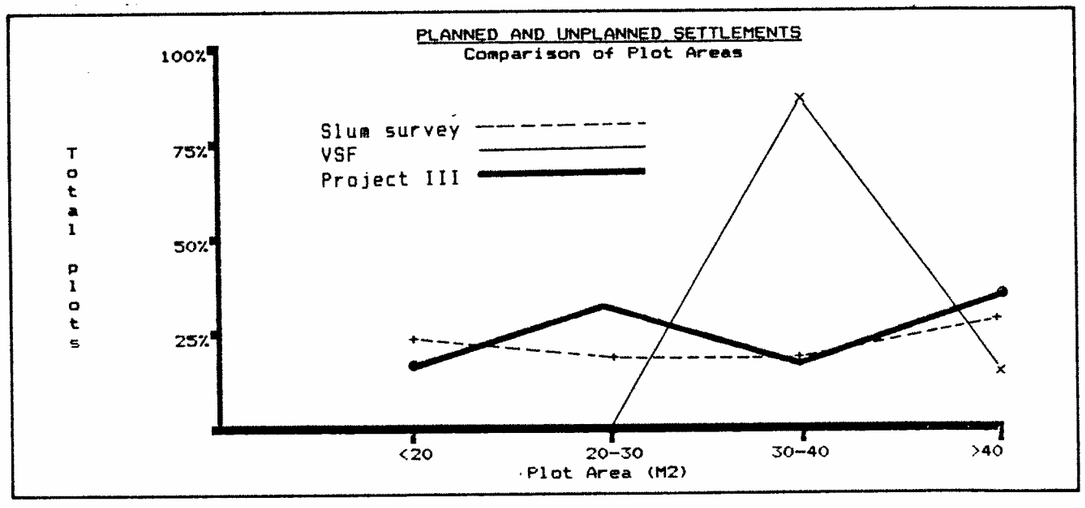
20-30
30-40
>40
Plot Area (M2)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Comparison of Plot Areas
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Project III
Total plots
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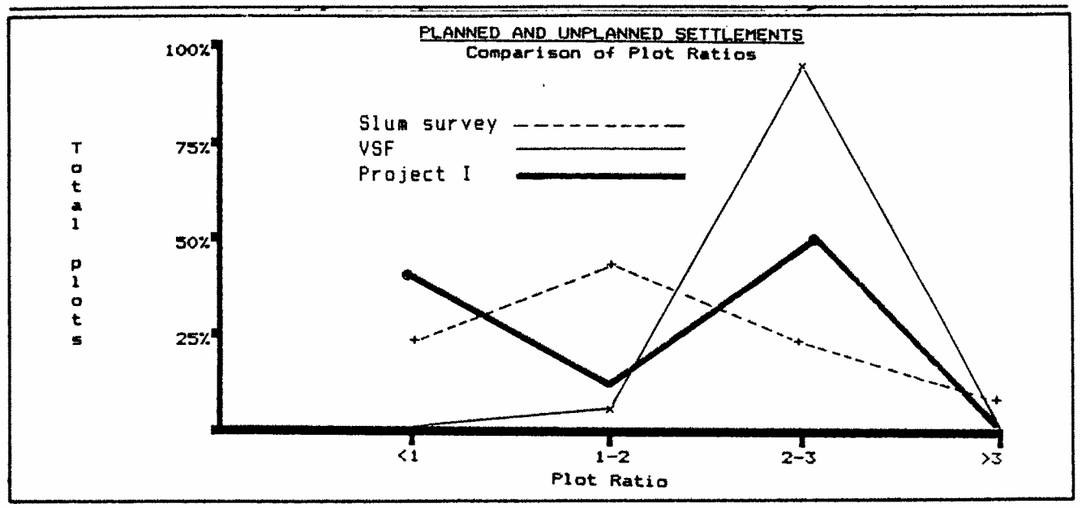
20-30
30-40
>40
Plot Area (M2)


PLANNED AND UNPLANNED SETTLEMENTS
Comparison of Plot Ratios
Slum survey
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Project I
Total plots
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50%
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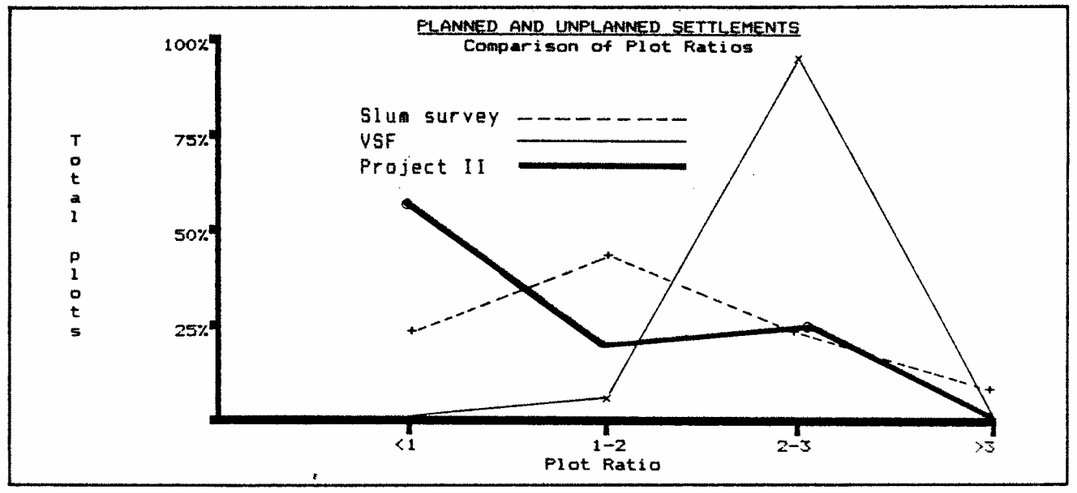
<1
1-2
2-3
>3
Plot Ratio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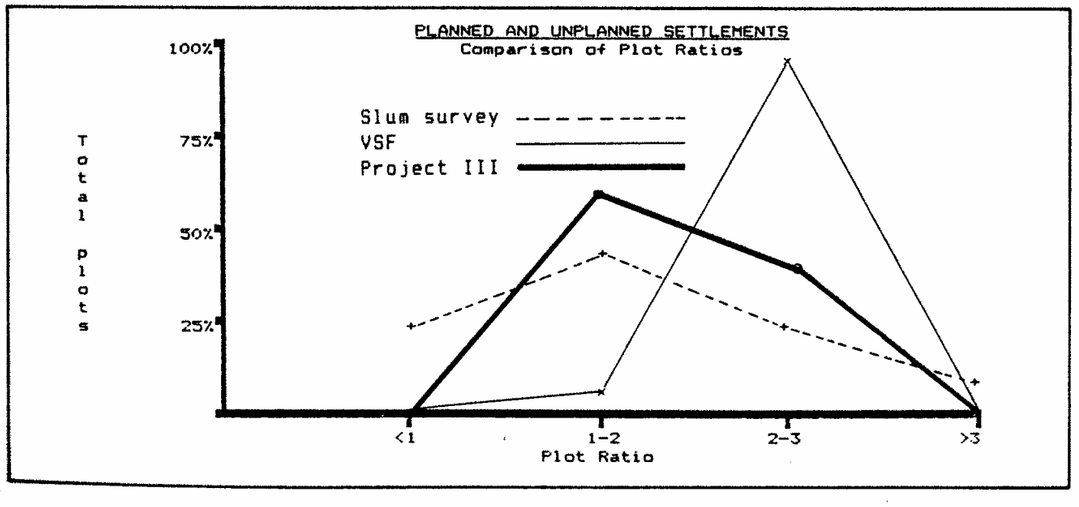
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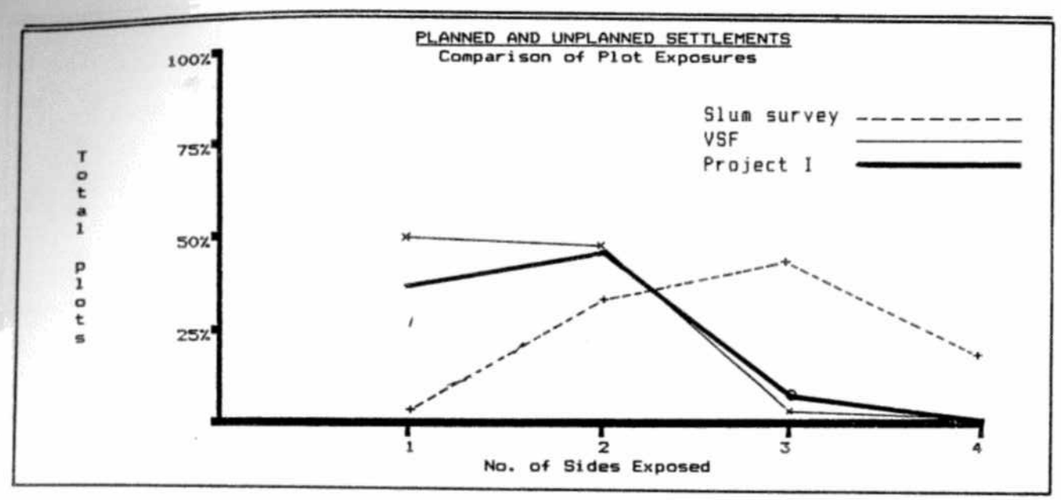

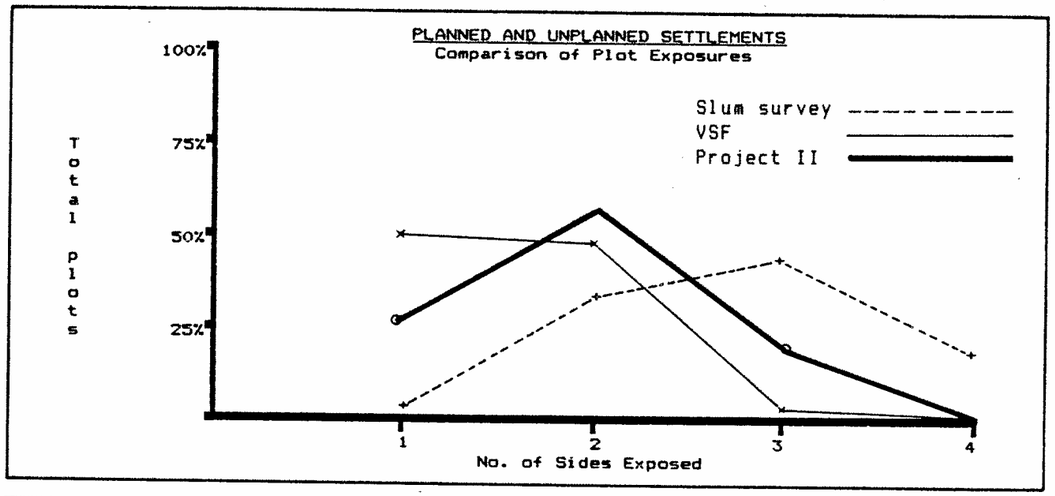

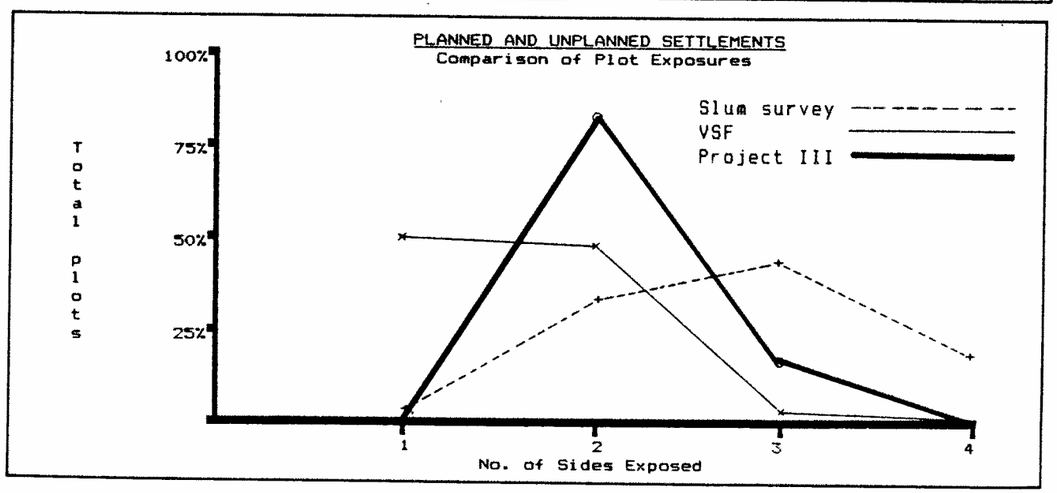

RESULTS

The intention of the planning study was to investigate the impact that altering standards would have on the overall efficiency and land-use characteristics of the site and services project.

The results of the study are presented in two tables: "Plot Characteristics" and "Land-Use Characteristics," and in a series of frequency distribution graphs. The graphs indicate the distribution of average plot areas, exposures, and ratios for each of the three planning study projects, for the total survey of unplanned settlements, and for the VSF control project. This permits comparisons between the planning studies and the VSF control, as well as the unplanned settlements, and also comparisons between the three planning studies themselves.

COMPARISON WITH VSF CONTROL PLAN

The average plot area is not significantly different in the planning studies (see "Plot Characteristics"), but, as the graphs indicate, the **distribution** of the plot areas is much wider in the three studies, and is closer to that of the unplanned settlements. The graphs of the plot ratios are also smoother, and approximate those of the unplanned settlements.

The frequency distribution graphs of plot exposure are inconclusive, and indicate that the profiles of the planning studies resemble the VSF project more closely than they do the unplanned settlements. It is perhaps to be expected that although all three projects have managed to reduce the number of single exposures, they have not provided many, if any, plots with 3 or 4 exposures.

PLOT CHARACTERISTICS

	Total Survey	VSF Project	Project I	Project II	Project III
Average Area (M2)	32.57	38.10	36.25	29.21	37.63
Average Ratio	1.61	2.54	1.98	1.35	1.90
Average No. of Exposure	2.80	1.52	1.97	2.09	2.30
Average Frontage (M)	4.78	3.90	4.35	4.86	4.72

LAND-USE CHARACTERISTICS

	Total Survey	VSF Project	Project I	Project II	Project III
No of Plots	-----	330	411	461	384
Population *	-----	1,750	3,355	3,366	3,363
Density (persons/ha)	1,057	722	1,384	1,388	1,387
Plots area (% of site)	43.00	61.97	55.37	55.56	55.50
Roads (%)	42.00	32.27	23.29	19.00	33.70
Semi-public open (%)	15.00	5.76	21.34	25.44	10.80

* Assuming 1-storey development

COMPARISON BETWEEN PROJECTS I, II & III

Although the three different planning projects all begin by making the same six hypotheses, they have adopted different degrees of planning flexibility. Project I, provides a variety of plot shapes and sizes, but does so according to a conventional planning process: the plots are laid out before people begin moving onto the site. Project II provides a greater degree of flexibility, and is based on a layout that permits modules to be occupied as separate plots, or grouped together to make larger plots, as required. Consequently, it is not necessary to predetermine the mix of plot sizes before occupation. Project III goes farthest in providing a support structure which can be occupied with plots of virtually any shape and size, according to need. Consequently, its distribution of plot areas, and of plot ratios, most closely approximates those of the unplanned settlements.

Interestingly, the different assumptions do not appear to have had any impact on overall efficiency of layout since the plots areas, as percentages of the site, are almost identical. There is a difference, however, in the amount of land devoted to semi-public space. In Project III this is less than half of the other two projects, indicating the price that must be paid for free-standing cluster planning.

GENERAL CONCLUSION

What is the price paid for the adoption of standards that more closely approximate those found in unplanned settlements? In terms of overall land-use, the planning studies achieve considerably greater efficiency than the unplanned settlements, both in plots area and in roads. The "Land-Use Characteristics" chart indicates that there is a very slight decrease (5%) in the amount of land devoted to plots use in all of the three planning studies, compared to the VSF project. This is a direct result of (a) the decision to increase the number of exposures, from less than 2 to more than 2, (b) the reduction of plot ratio to less than 2, and (c) an increase in the average frontage from 3.90m to as much as 4.86m.

On the other hand, there is a decrease in the roads area, and a marked increase in the amount of land devoted to semi-public use. This latter is significant as semi-public spaces tend to be more useful for many domestic, social, work and commercial activities.

Finally, the 5% decrease in plots area must be weighed against the increase in efficiency of use that results from the provision of plots of different areas that more closely approximate family needs.