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Report INU 42

THE USE OF SATELLITE IMAGES FOR URBAN PLANNING

A Case Study from Karachi, Pakistan

by Marie-Agnes Bertaud

May 1989

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TECHNICAL NOTE

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The World Bank

The Use of Satellite Images for Urban Planning

A Case Study from Karachi, Pakistan

TECHNICAL NOTE

PREFACE

This report is one element of ongoing research in the application of new technologies for urban planning and management, the analysis of urban land use and reconnaissance of physical infrastructure.

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THE USE OF SATELLITE IMAGES FOR URBAN PLANNING

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INTRODUCTION

THE USE OF SATELLITE IMAGES FOR URBAN PLANNING

0.01 Effective urban planning requires access to accurate and continually updated information concerning the changing conditions of urban areas. Originally, remote sensing using satellite media was not very suitable for urban applications because of the relatively poor resolution provided 80m x 80m. The new generation of remote sensing systems with resolution equal to 10m x 10m in panchromatic mode and 20m x 20m in multispectral mode has now made urban applications possible. In addition, advancements in micro-computers, related hardware and software have made this technology more affordable and accessible to urban managers, planners, and engineers.

0.02 In most Third World cities, accurate up-to-date data on current land use are non-existent. This makes planning urban infrastructure and shelter programs difficult, if not impossible, since there is no knowledge of the existing urban area. Further, the high costs and time required for traditional data collection efforts have made systematic updating of urban databases beyond the reach of many planning authorities.

0.03 Land use changes induced by rapid urban growth amplify the need for up-to-date land use inventories. Many cities in the developing world have urban population growth rates in excess of 6 percent, doubling their population about every ten years. They need to monitor more closely the pattern of urban growth to improve planning and activities to accommodate this growth.

0.04 The lack of adequate spatial data has been a serious constraint on many recent Bank-financed projects. For example, recently the Bank participated in the financing of a drainage master plan for Karachi. Work on the project was seriously delayed due to the lack of adequate maps showing the extent of the built-up area and existing drainage systems. The only data were aerial photos which could not be made easily available to the project. Similar delays in obtaining accurate spatial data confront practically every other Bank-financed (and other donor agencies, for that matter) urban projects.

0.05 New technological advances now provide a relatively inexpensive solution to some of these problems. Satellite images, such as LANDSAT, have been generating land resource data over the past 16 years for such purposes as agriculture, forestry, mining, etc.; but the resolution was not sharp enough for most urban planning purposes. PADCO first applied LANDSAT data for urban planning in Egypt (the Egyptian National Urban Policy Study in 1980-1982), but data were limited to gross land uses and built-up urban areas. Nevertheless, this information was a valuable tool in developing structure plans for small towns where map data were inaccurate. Unfortunately, this application was limited because the processing costs were still relatively expensive.

0.06 Since 1986, SPOT I, a satellite financed by France, Belgium and Sweden, has been sending images with eight times the spatial resolution of LANDSAT and other civilian satellites. It produces data with a ground resolution equal to 10 meters in panchromatic mode (black and white image) and 20 meters in multispectral mode (false color image). Ten-meter resolution is generally adequate for urban spatial planning and macro land management as it roughly corresponds to most urban physical features of concern: street widths and lengths, building and plot size, etc.

0.07 SPOT I, in a continuous regular orbit, provides up-to-date images of urban centers throughout the world. Change detection in the urban environment can be conducted by purchasing satellite images at regular intervals to monitor the changes of urban land use, estimate population growth and evaluate the need on new infrastructure.

0 08 Images media can be accessed commercially without the lengthy security clearances usually required for aerial photography. Furthermore, much of the required mapping data extraction can be undertaken both in and outside the country concerned.

0 09 The time required to acquire satellite images for any part of the world is about 15 days to one month. It should be noted that for tropical countries the time to acquire an image may be several months, especially if the order is placed during the monsoon, or rainy, season where cloud coverage is very dense.

0 10 One SPOT satellite image or scene covers an area of 60 km by 60 km, an area large enough to encompass most metropolitan settlements in the world. In some cases, SPOT satellite can also be programmed to get a special image focused on a particular zone of interest (for example, to capture on one image a metropolitan area split between two or three scenes, or to monitor areas devastated by flood, earthquake, fire, etc.) SPOT system can also be programmed to produce 3-dimensional stereoscopic images useful for topography and for infrastructure planning purposes such as roads and drainage design systems.

0 11 For most urban development and management purposes, the satellite images provide an excellent source of detailed land use data for highway planning and construction, urban mass transit, urban renewal, neighborhood facilities and infrastructure planning, open space land programs, land assessments, housing stock assessment, environmental impact statements, and growth management systems.

0 12 The processing of satellite images is the most effective way to perform such tasks at an affordable cost. Satellite images provide less expensive views of human settlements than aerial photography and these materials can be much more readily obtained.

0 13 Film or transparency of an image can be enlarged through photographic processes to scales of 1:100,000 down to 1:20,000. One satellite panchromatic image (on black and white film) and a photographic print at scale 1:100,000 cost only US\$1,600, far less expensive than a set of aerial photographs needed to cover the same area. (Cost refers to early 1989.) Photographic prints derived from satellite images made from transparencies or films can be used to make base maps and to do preliminary urban land use analysis without sophisticated equipment (micro-computer, digitizing tablet, and CAD software).

0 14 The purpose of this publication is to provide the necessary information concerning the use of remote sensing satellite images in urban planning and to assess their usefulness. PART 1 of this publication gives basic information regarding remote sensing, listing different civilian satellite systems, and their particularities. PART 2 provides information concerning the different satellite image media and ways of processing satellite image data. PART 3 is a case study that illustrates the use of satellite image for urban planning purposes. The case study demonstrates how satellite images, complemented by aerial photography, can be used to conduct a housing typology study, evaluating population densities among different types of residential developments.

PART 1**REMOTE SENSING AND SATELLITE IMAGERY**

1.01 Remote sensing is the measurement of the reflection of objects or terrain on Earth by recording devices or remote sensors fixed on airplanes or satellites. Over the years, a number of sensing devices have been used such as photographic cameras, multispectral scanners, thermal scanners and microwave instruments. Remote sensing has generated a great deal of information about the Earth -- its surface, environment and resources.

A. From Aerial Photography to Satellite Images

1.02 Remote sensing in urban areas dates back to 1858 when Tournachon (later known as "Nadar") used a camera carried aloft in a balloon to study parts of the city of Paris. In his photographs of the village of Petit Bicetre, the houses could be seen clearly. Since then, the morphology or form of urban space has been used directly or as a surrogate for functional identification and classification of urban areas. Until World War II, remote sensing techniques remained basically the same as the first aerial photographs. Either a single photograph or a stereo pair was used for each area of interest. Photography was essentially black and white and of medium-to-large scale because of altitude limitations.

1.03 The second world war brought about a dramatic increase in the awareness of the potential of remote sensing in urban areas. In the sixties and early seventies, the conventional approach to remote sensing was dramatically changed by the introduction of color, color infrared, multiband, high altitude, and space photography. This was due to the increasing availability of products and data brought about by new technologies often developed for non-civilian purposes that were later declassified for general use. Declassification of technology and data provided a major stimulus to the development of non-military applications.

1.04 The United States National Aeronautics and Space Administration (NASA) accepted a major responsibility for developing civilian applications of remote sensing. The Earth Resources Observation System Program (EROS), initiated in 1965, involved the development of aircraft and spacecraft for remote sensing systems.

1.05 In 1967, NASA encouraged by the US Department of the Interior, initiated the Earth Resource Technology Satellite (ERTS) program. This program resulted in the deployment of five satellites carrying a variety of remote sensing systems designed primarily to acquire earth resource information. The chronological launch and subsequent retirement history of some of the satellites are shown in Fig. 1.1. The ERTS-1 satellite launched on July 23, 1972, was the first experimental system designed to test the feasibility of collecting earth resource data by unmanned satellites. Prior to the launch of ERTS-B on January 22, 1975, NASA renamed the ERTS program **Landsat**, distinguishing it from the Seasat oceanographic satellite launched June 26, 1978. At this time ERTS-1 was retroactively named Landsat 1 and ERTS-B became Landsat 2 at launch. Landsat 3 was launched March 5, 1978; Landsat 4 on July 16, 1982, and Landsat 5 on March 1, 1984. A variety of mechanical failures prompted the retirement of some of the Landsat satellites.¹

¹ Remote Sensing Data Acquisition Alternatives. John R. JENSEN - Introductory Digital Image Processing - A Remote Sensing Perspective. Published by Prentice-Hall, Englewood Cliffs, New Jersey 07632.

B. Different Remote Sensing Satellite Systems

1.06 Three satellite sensor systems providing commercially available digital data are operational. These include the LANDSAT 4, the LANDSAT 5, and SPOT I. Depending on available resources, the application, and the level of information needed, users have these systems from which to choose. Below is a brief description of the three satellite systems and their possible applications for urban analysis.

1. LANDSAT 4

1.07 The satellite LANDSAT 4 was launched in July 1982. This system originally had two sensors on board, Multi-Spectral Scanner (MSS) and Thematic Mapper (TM), but only the MSS sensor is still in service. (See definition of Multi-Spectral Scanner and Thematic Mapper in Glossary.) Images from the LANDSAT 4 MSS sensor have a ground projected instantaneous-field-of-view (IFOV) or ground resolution equal to 56m x 79m. A satellite image or scene covers an area of 185km x 185km with 10 percent overlap between west and east scenes at the equator. As latitude increases, so does the amount of overlap because of the curvature of the earth. The LANDSAT sensor systems have the capability of covering the entire globe every 16 days.

1.08 Because of the large geographic area of a LANDSAT 4 scene, this product is convenient for country planning and for global analysis of regional and country resources, to monitor climate, agriculture and other changes due to drought, deforestation, etc. However, the low resolution of LANDSAT MSS images does not make this product particularly valuable for urban planning.

2. LANDSAT 5

1.09 LANDSAT 5 was launched in March 1984. This system has both Multi-Spectral (MSS) and Thematic Mapper(TM) sensors operating on board. The MSS images have a ground projected instantaneous-field-of-view (IFOV) or ground resolution equal to 56m x 79m and the TM images have a 30m x 30m ground resolution. Both satellite images or scenes cover an area of 185km x 185km. The period between repetitive coverage is 16 days.

1.10 LANDSAT 5 data has been generated for more than four years. Its resolution has proved adequate for natural resource management, agriculture and forestry land use classification. LANDSAT 5 has also been used for urban applications, but with limited success due to its relatively poor resolution. The advantage, however, of the LANDSAT 4 and 5 images are that they can be used together with earlier scenes to provide longer term time series on land use changes.

3. SPOT I

1.11 The SPOT I sensor system, developed by the French Centre National d'Etudes Spatiales (CNES), was launched in early 1986. It has a ground projected instantaneous-field-of-view (IFOV), or ground resolution equal to 10m x 10m in panchromatic mode (black-and-white) and 20m x 20m in multispectral mode (false color). The period between repetitive coverage is 26 days in "nadir" viewing (vertical viewing). Since the SPOT satellite has a pointable High Resolution Visible Sensor (HRV), it can be programmed to view an area that is not directly below the spacecraft (i.e., off-nadir). For example, this capability would allow a location on the equator to be observed during seven different passes if on the equator and on eleven passes if at a latitude of 45° (Figures 1.2 and 1.3). A given region can be revisited several times each week as opposed to twice a month

as with other satellites. This capability is useful for monitoring rapidly changing processes and events on Earth and for increasing the possibility of image acquisition over areas with frequent cloud cover.

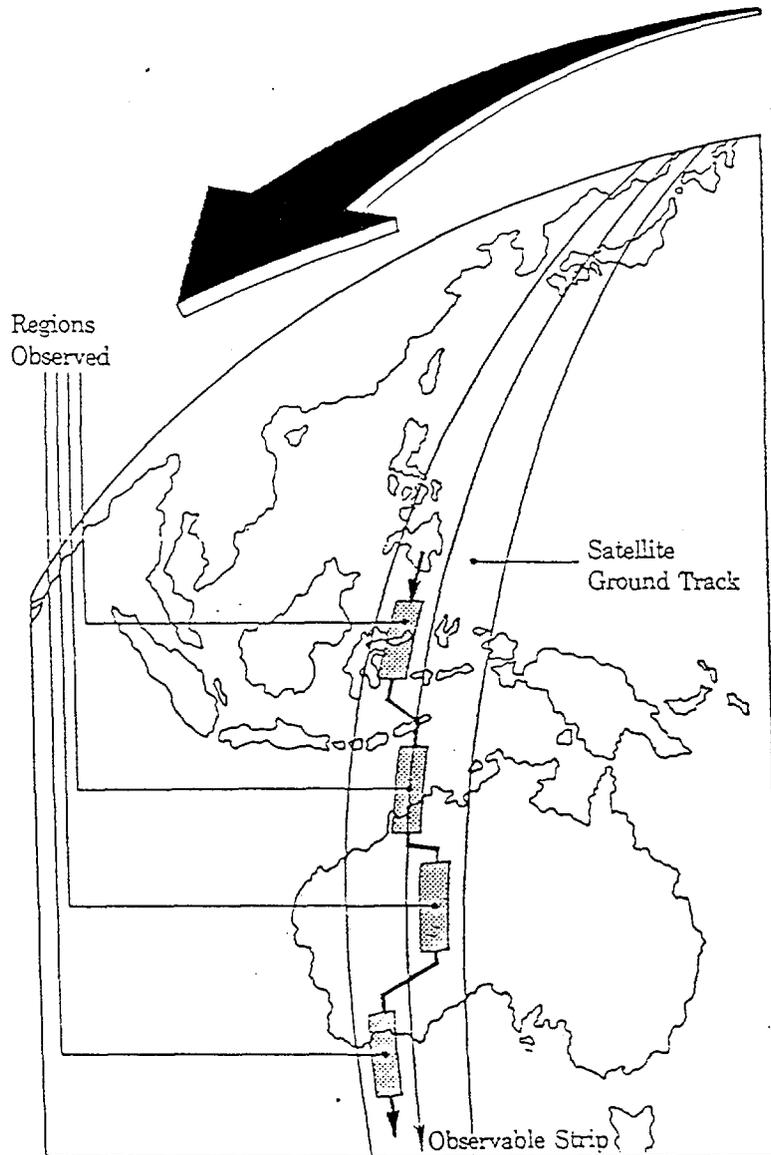
1.12 The SPOT sensors may also acquire stereoscopic pairs of images for a given area (Figure 1.4). Two observations may be made on successive days in that the two images are acquired at angles on either side of the vertical. The three-dimensional stereoscopic imagery may be used to produce topographic maps with contour intervals as low as 10 and 20 meters. It is also used in digital terrain modeling and the production of three-dimensional perspective views for terrain simulation, strategic planning and impact assessments.

1.13 SPOT's ten-meter resolution provides information that was previously available only with aerial photographs. SPOT data are useful for urban and suburban land use mapping, monitoring of urban growth and change detection, impact of development and policies on the natural environment and cultivated lands, and map updating.

1.14 As with all satellite images publicly available, SPOT resolution is not to be compared with low or medium altitude aerial photography. SPOT images cannot be used for cartography as a unique source of information. No cadastral map can be made with such products until remote sensing systems reach 1 or 2 meters resolution. Satellite systems are also vulnerable to technical problems developing on the spacecraft which may not be solved immediately. As for SPOT 1, only one of the two recorders is now operational, this restricts the number of scenes that can be registered before downloading data to receiving stations on Earth. Figure 1.5 is a diagram illustrating the spatial resolution of the LANDSAT MSS, the LANDSAT TM and SPOT panchromatic mode.

1.15 The Soviet Union sells commercial satellite images with a resolution equal to five meters. Their photographic products are recorded on film and reproduced on digital tapes. So far, few of these photos have been made public, and it is unclear how many scenes from around the globe will ultimately be available.

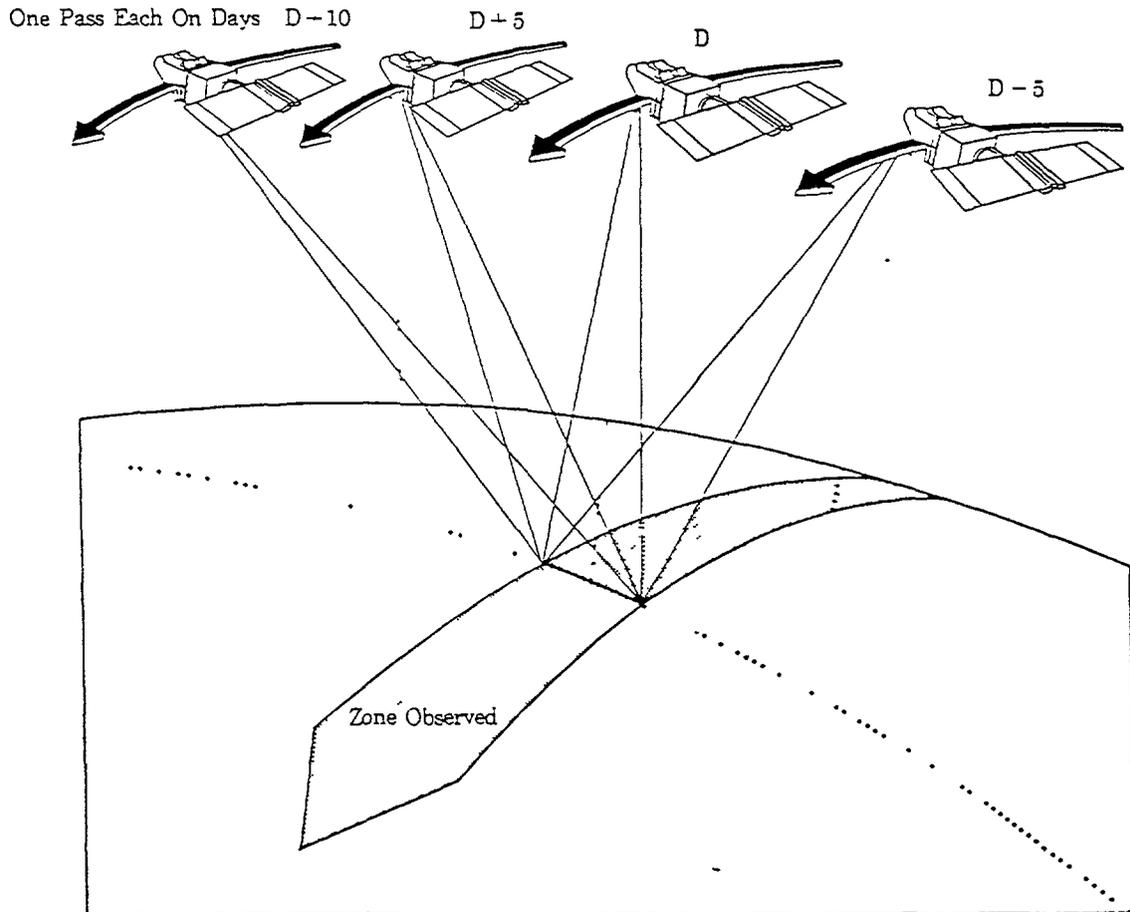
FIGURE 1.2
OFF-NADIR VIEWING



(Courtesy of SPOT Image Corporation)

If the HRV instruments were only capable of viewing the terrain directly below the spacecraft (i.e., at nadir), the revisit frequency for any given region of the world would be 26 days. However, SPOT is pointable. This means that it can be used to view areas that are not directly below the spacecraft (i.e., off nadir). This is very useful for collecting information in the event of a natural or human-made disaster when the satellite track is not optimum, or for collecting stereoscopic imagery.

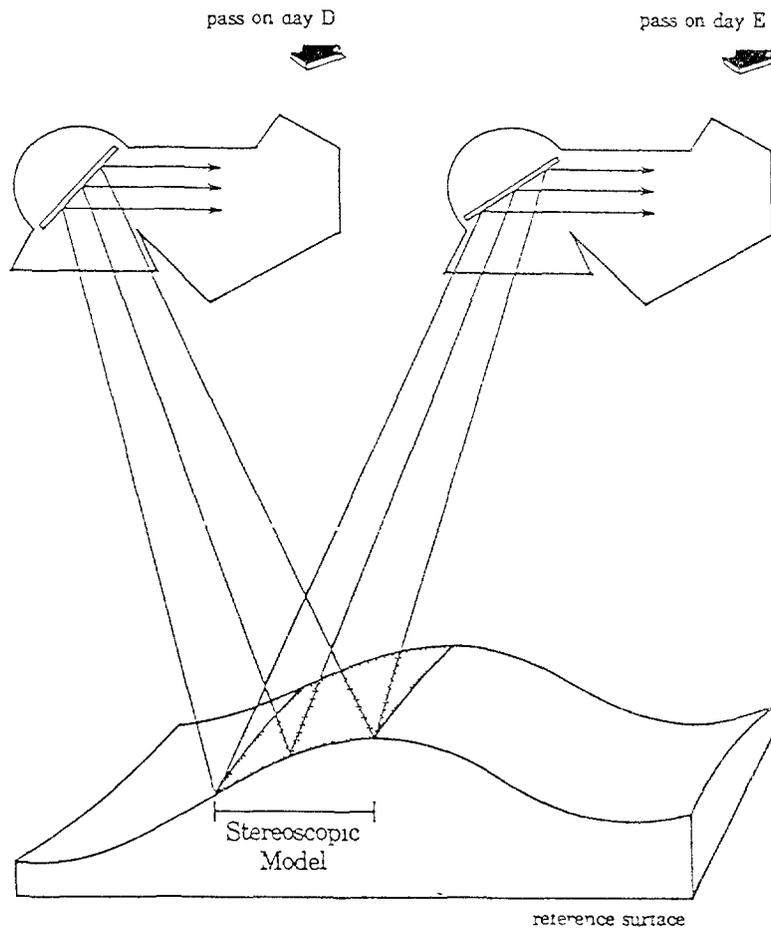
FIGURE 1 3
SPOT OFF-NADIR REVISIT CAPABILITIES



(Courtesy of SPOT Image Corporation)

During the 26-day period separating two successive SPOT satellite overpasses, a point on the earth could be observed on seven different passes if it is at the equator and or 11 occasions if at a altitude of 45 degree. A given region can be revisited on dates separated alternatively by 1,4 and occasionally 5 days.

FIGURE 1 4
STEREOSCOPIC VIEWING CAPABILITIES

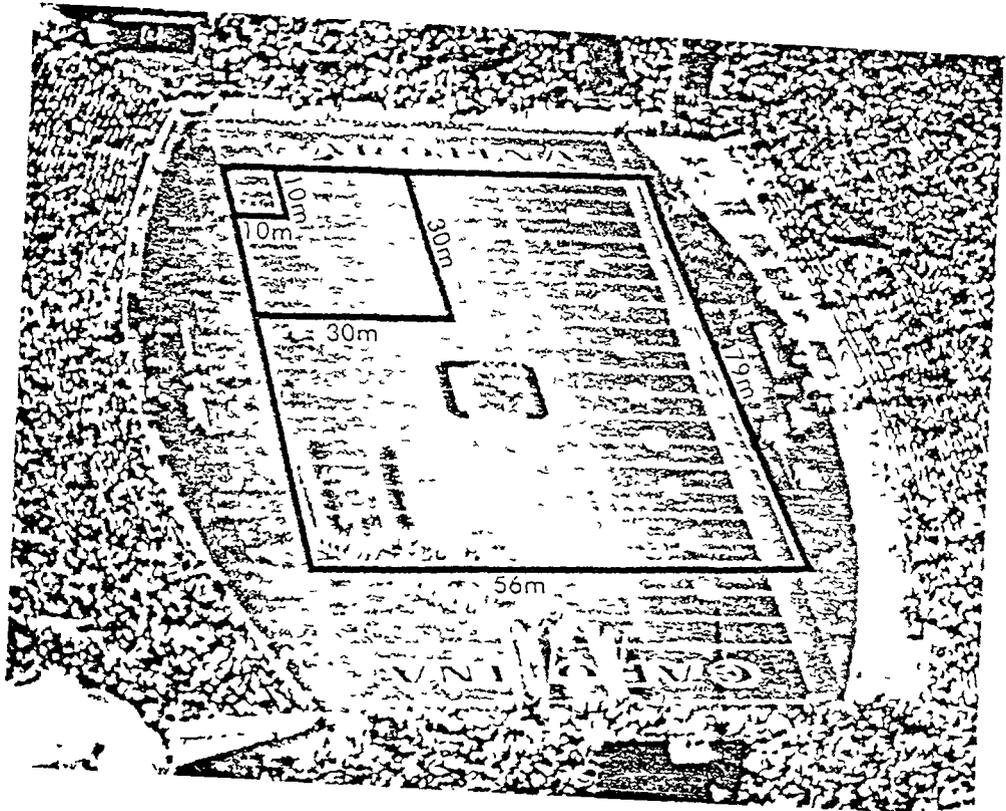


(Courtesy of SPOT Image Corporation)

The observations can be made on successive days such that the two images are acquired at angles on either side of the vertical, resulting in stereoscopic imagery. Such imagery can be used to produce topographic and planimetric maps.

FIGURE 1 5

DIAGRAM ILLUSTRATING THE SPATIAL RESOLUTION OF THREE DIFFERENT SATELLITE IMAGES



Source Jensen, 1986

- LANDSAT MSS Ground Resolution = 56 x 79 m
- LANDSAT TM Ground Resolution = 30 x 30 m
- SPOT Panchromatic Band Ground Resolution = 10 x 10 m

PART 2**VARIOUS TYPES OF MEDIA AND WAYS OF PROCESSING
AND INTERPRETING SATELLITE IMAGES**

2.01 Sensors fixed on satellites register spectral reflectance of objects from Earth on digital tape and send the scanned image to receiving stations. Receiving stations on Earth collect images as digital data. Radiometric and/or geometric corrections of the remotely sensed data are needed to improve their interpretability. Subsequently, data may be enhanced also for visual analysis using computer applications such as digital image processing. Information extracted from satellite images at different processing levels are made available to governments, public agencies and private enterprises in need of such information.

2.02 The techniques to process satellite images vary according to the type of media used (film negative or transparency, and digital tape). The processing of a negative film is similar to the processing of ordinary photos. When using digital tapes, image processing is done on a computer to enhance an image or to obtain more contrast and increased definition for improved data interpretation. Below, ways of processing SPOT satellite images from panchromatic and multispectral films and digital tapes are discussed, together with some rules of how to visually interpret satellite images. LANDSAT images (MSS or TM) can be processed in the same ways though the resolution is much lower.

**A. Processing SPOT Satellite Images from Panchromatic
Photographic Prints**

2.03 SPOT panchromatic images have only one data band in the visible part of the spectrum providing the equivalent of a black and white image when reproduced as a photographic print. A panchromatic film (black and white) at a scale of 1:400,000 can be printed at a scale of 1:100,000 down to 1:25,000 without losing too much detail. (Enlargement of an image results in loss of clarity.) See panchromatic prints at various scale, Figures 2.1 to 2.3. A trial was conducted in which a digital panchromatic image was edge enhanced using high-pass filtering techniques to increase contrast. Different urban patterns were used to determine scale limits in which images can be reproduced. Figure 2.4 is one of these urban patterns where the image was clear enough down to scale of 1:6,000. At this level, panchromatic images start to lose some context but can be used to evaluate urban population densities in different types of development.

2.04 In such prints (made from panchromatic negative film), urban features can be identified by different intensities of grey. For example, healthy vegetation produces a dark shade of grey and concrete structures are shown in light tones. Asphalted roads will have a dark tone while low-density urban areas will be composed of a mixed pattern of light and dark grey where houses are surrounded by trees or some other kind of vegetation. Water (i.e. rivers) will usually be in medium dark grey tones. However, the relative turbidity of the water, its depth, the composition and color of the bottom will affect the eventual tone of such areas. The tone of water in reflecting ponds is often unpredictable due to these variables.

2.05 In general, the fundamental materials found in urban environments may be distinguished from one another. Different roofing materials, plaster, concrete, vegetation, asphalt, earth, etc., will produce different tones of grey. In Figure 2.2, the differences between a squatter settlement area, an industrial area, a low density and a high density area are readily identifiable.

FIGURE 2 1
"SPOT" SATELLITE IMAGE PANCHROMATIC FILM, SCALE 1 400,000
KARACHI, PAKISTAN

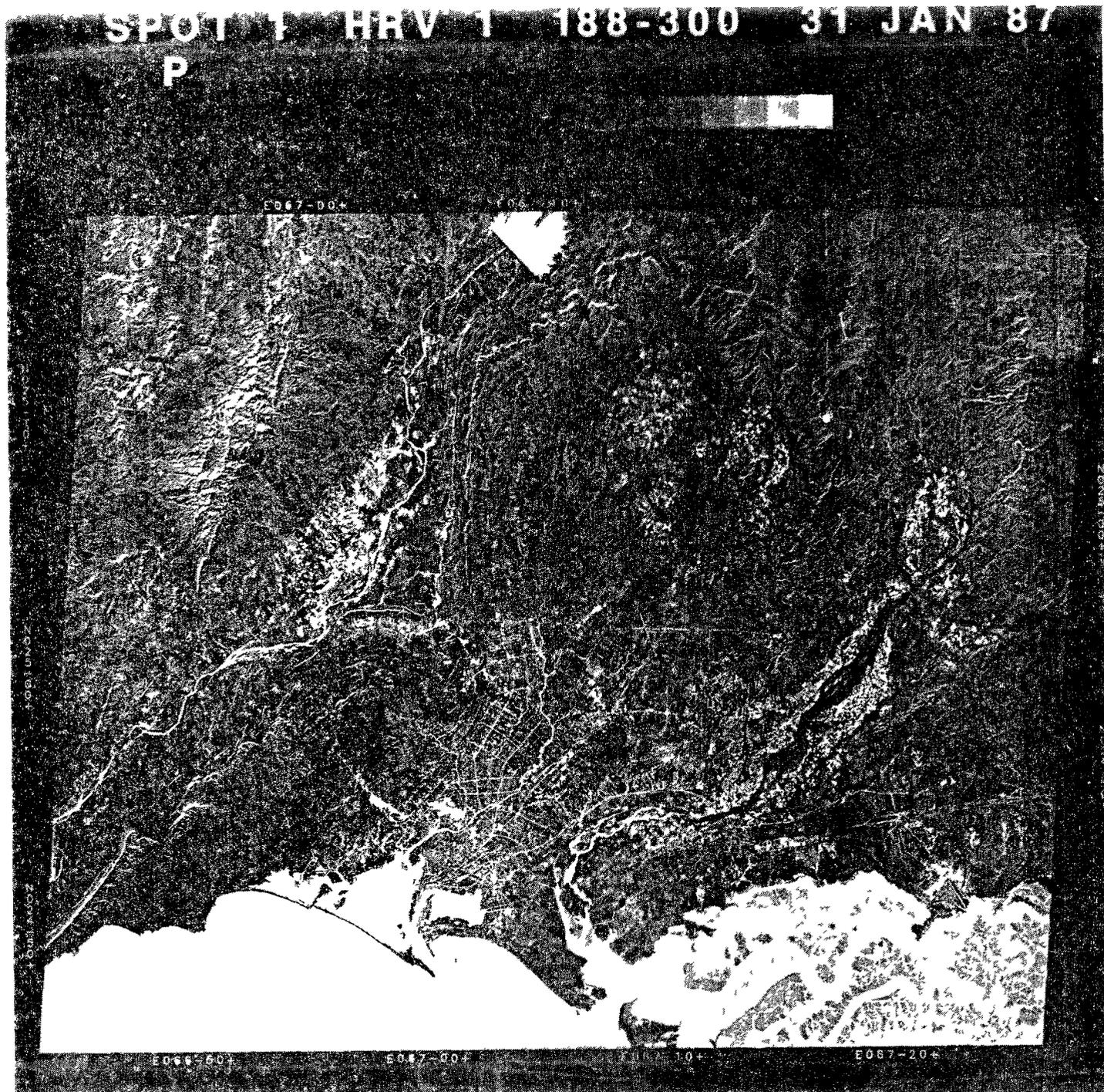


FIGURE 2.2
 IDENTIFICATION OF DIFFERENT PATTERNS OF DEVELOPMENT
 FROM "SPOT" PANCHROMATIC PHOTOGRAPHIC PRINT
 AT SCALE 1:100,000
 KARACHI, PAKISTAN

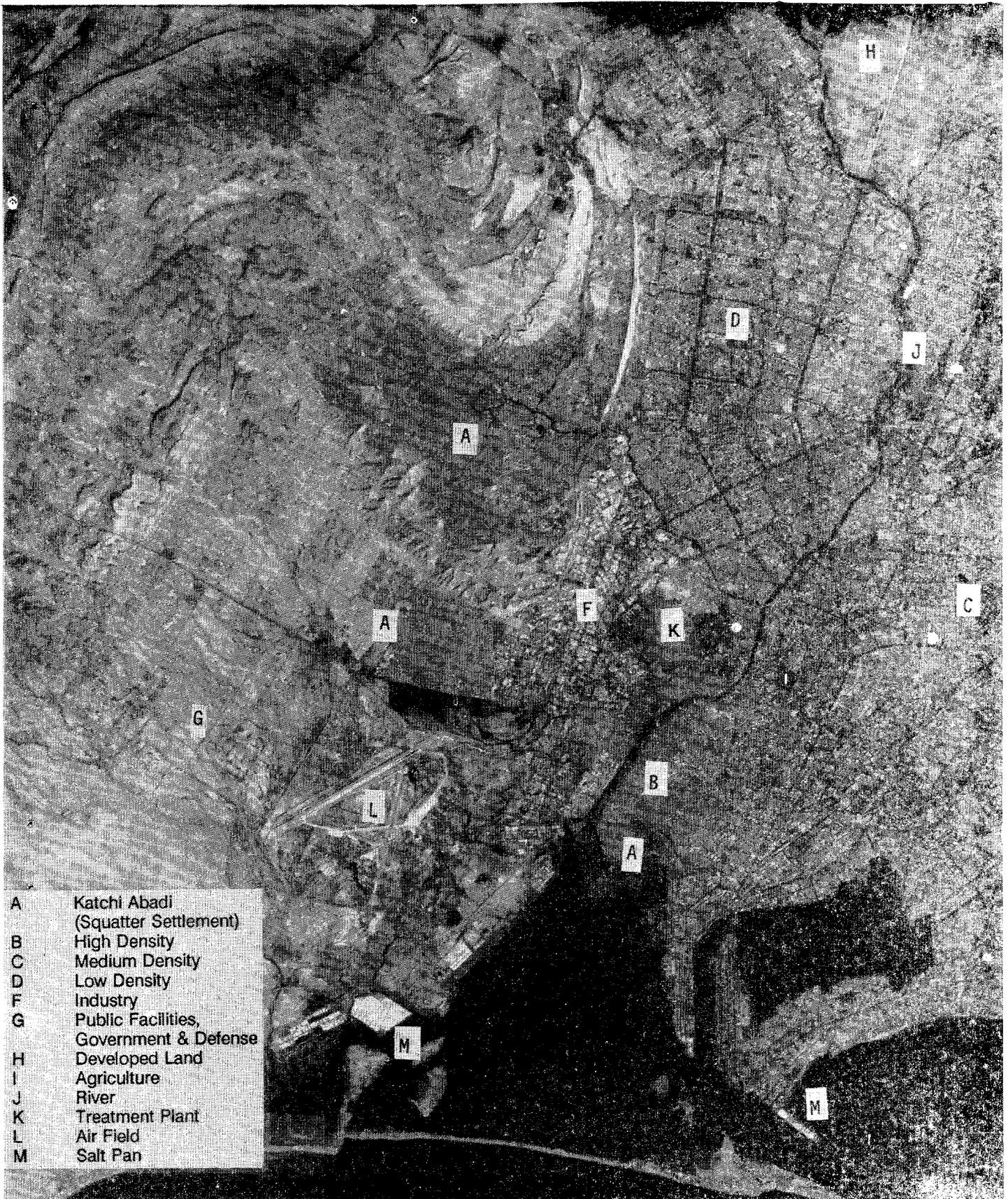


FIGURE 2.3
"SPOT" PANCHROMATIC PHOTOGRAPHIC PRINT
AT SCALE 1:24,000
KARACHI, PAKISTAN



FIGURE 2.4
"SPOT" PANCHROMATIC PHOTOGRAPHIC PRINT
AT SCALE 1:6,000
KARACHI, PAKISTAN



B. Processing of SPOT Satellite Images from Multispectral Photographic Prints

2.06 SPOT multispectral images have three data bands (green, red and near infrared) which provide a unique record of spectral reflectance. The interpretation of a multispectral image reproduced as a photographic print is quite different from aerial photographs. The "false color" of these images are generally interpreted as indicated below.¹

2.07 Healthy vegetation is recorded in bright tones and dark red in the multispectral color print. Concrete or asphalt roofs in downtown urban areas will often appear bluish grey. Squatter settlements are more easy to distinguish in multispectral image than in panchromatic mode where they may appear in the same grey shade as vegetation. Squatter areas in the multispectral mode have a bluish tone. In dense urban areas, such as slums, the rooftops of the small houses are close to one another giving a more uniform reflection than in other residential areas where plots are larger and roofs are sometimes overshadowed by trees. In multispectral mode, bare soil appears as yellowish and grey and non-forested mountainous sites are easily identified by their wrinkled pattern of grey and brown tones. Where forests or vegetation exist, these appear in red (Figure 2.5).

2.08 It should be noted that for tropical countries, low density type of urban development may not be as easy to identify as in dry or semi-dry countries such as Pakistan. The vegetation may cover roads and roofs, and cloud cover may be a problem at times. When using films and photographic prints, images from tropical countries should be enhanced to better define built-up areas for visual interpretation. Two multispectral photographic prints at a scale of 1:50,000 made from the same image of south Djakarta, Indonesia, are shown in Figures 2.6 and 2.7. Figure 2.6 is a print made from a non-enhanced image while in Figure 2.7 the image on digital tape was enhanced prior to the reproduction of the film.

¹ False colors on hard copy images depend on the operator's discretion regarding the assignment of colors to individual bands.

FIGURE 2 5
IDENTIFICATION OF DIFFERENT URBAN FEATURES FROM
MULTISPECTRAL PRINT AT SCALE 1 24,000
KARACHI, PAKISTAN

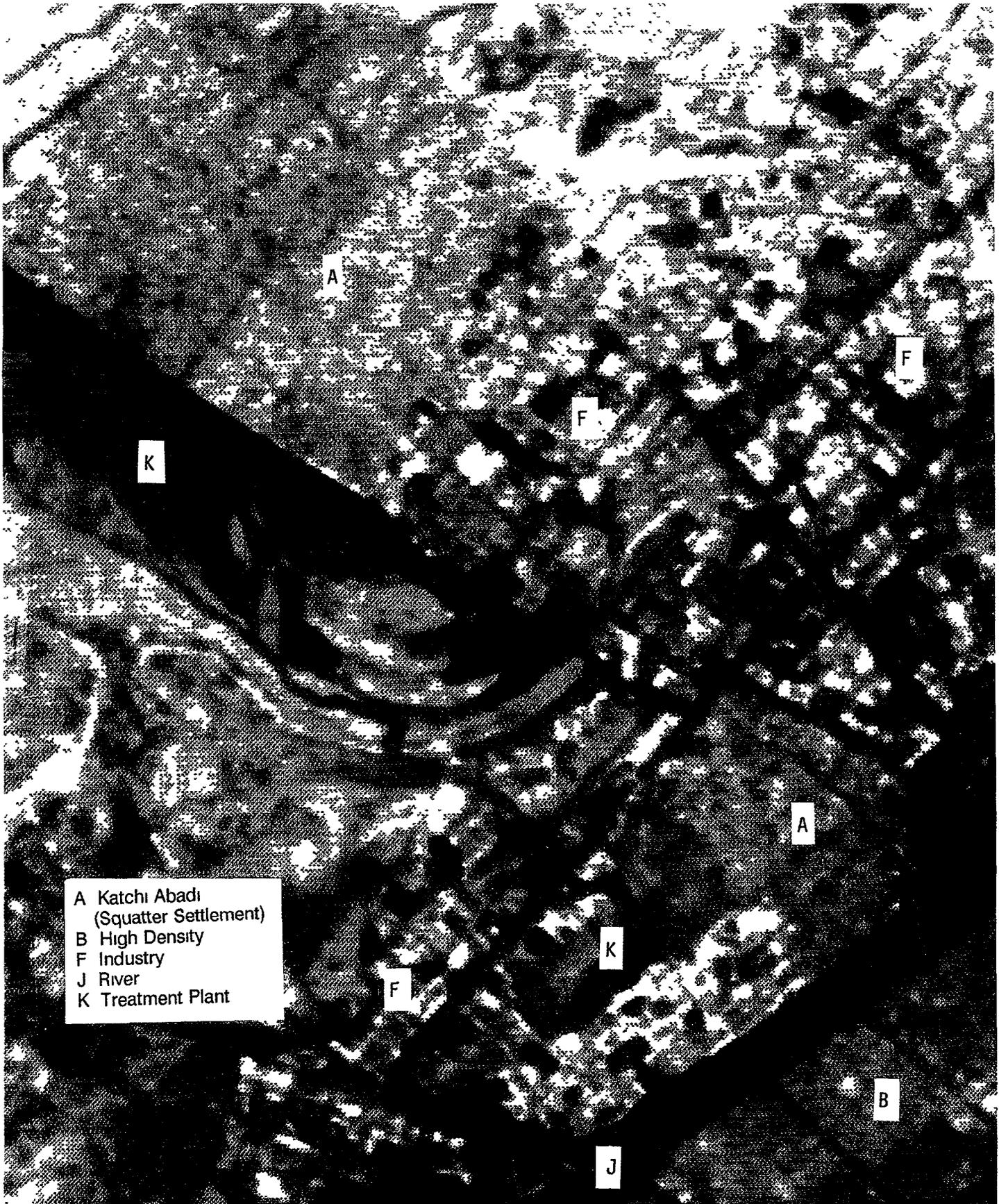


FIGURE 2 6
PHOTOGRAPHIC PRINT MADE FROM "SPOT" MULTISPECTRAL FILM
IMAGE BEFORE ENHANCEMENT - SCALE 1 50,000
SOUTH JAKARTA, INDONESIA

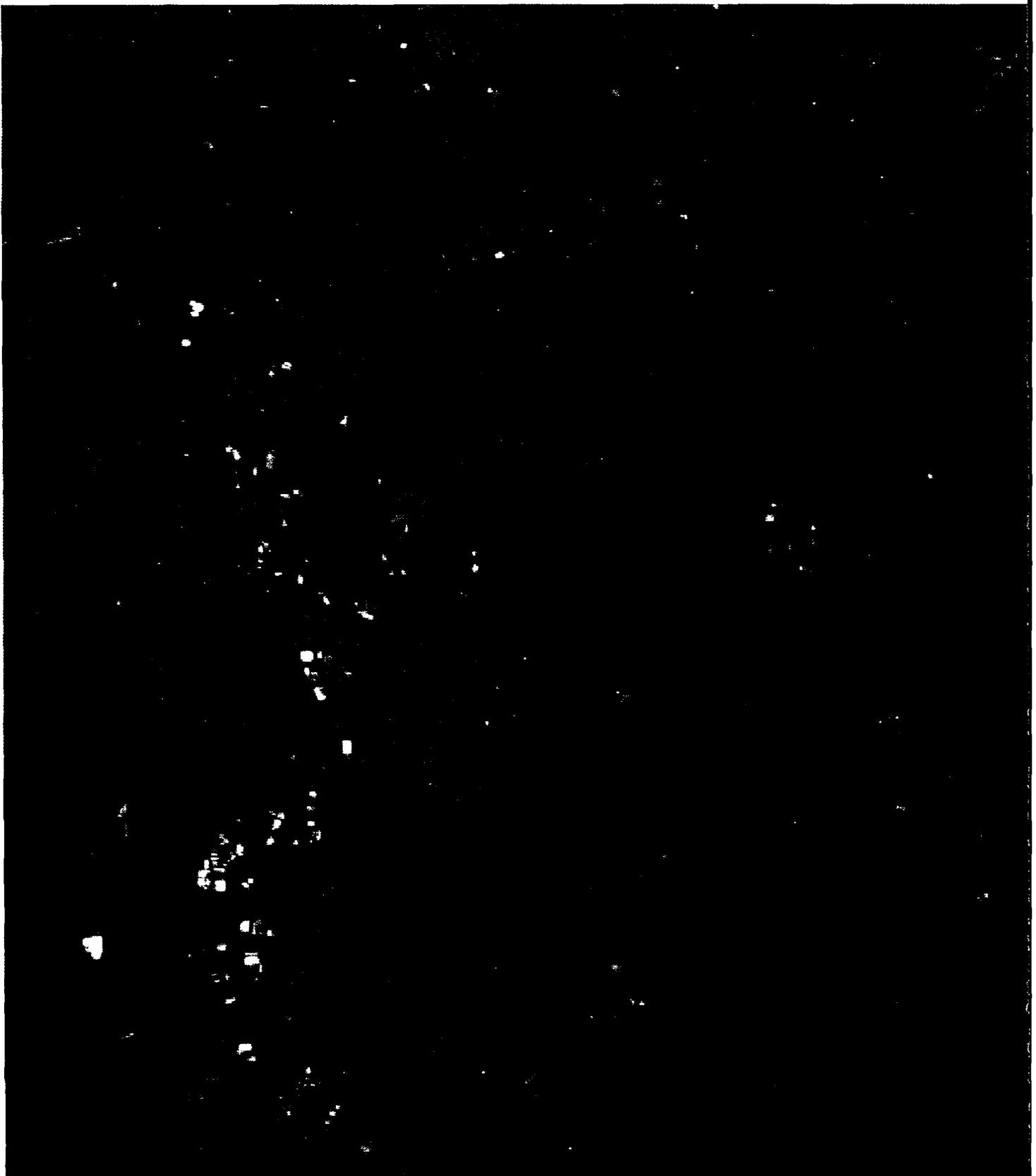
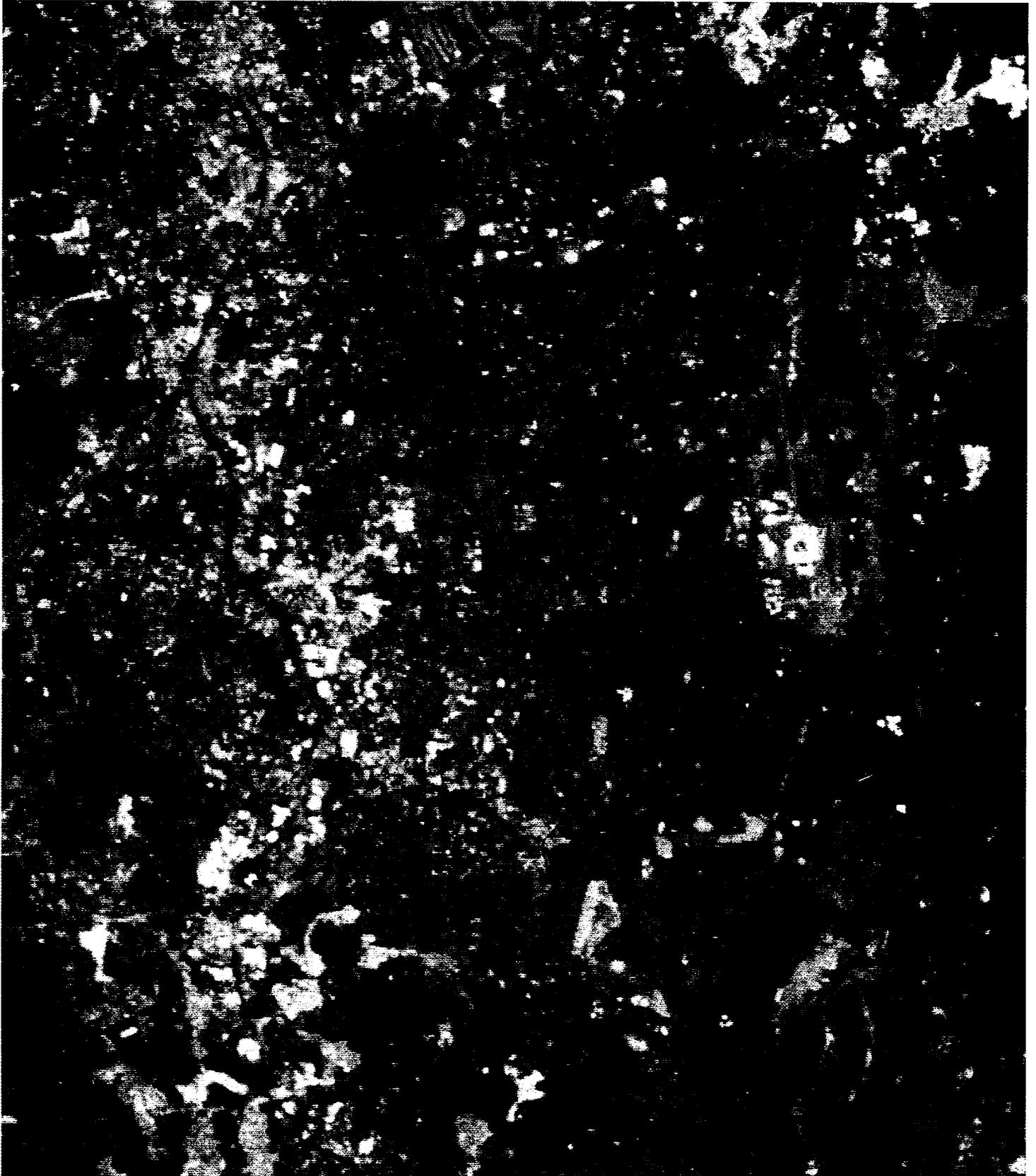


FIGURE 2.7
PHOTOGRAPHIC PRINT MADE FROM "SPOT" MULTISPECTRAL FILM
ENHANCED IMAGE - SCALE 1:50,000
SOUTH JAKARTA, INDONESIA



C. Processing Satellite Images from Digital Tapes

2.09 When panchromatic and multispectral SPOT digital images are merged using an image processing system, the image can be enhanced to obtain a picture much like aerial photographs at scale 1:25,000. The color of the multispectral image permits one to distinguish urban from non-urban areas, residential areas of varying density as well as other land use types. From these images, maps can be produced with still limited accuracy. The accuracy is a function of the quality and the number of ground control points (minimum 9 to 12 points) that have been used to correct the image. Ground control points can be road crossings or buildings (monuments) which are easy to identify in the image. Using distances between these points, geometric image corrections are made.

2.10 Processing satellite images from digital tapes has proven effective for change detection in rapidly growing urban areas. Using two sets of images taken of the same scene at different times, the interpreter can locate areas that have been "disturbed" by urban growth or other phenomena: flood, earthquake, fire, etc.

2.11 Remote sensing digital data may also be analyzed in correlation with existing digital maps and related to a geographical information system (GIS) to improve its usefulness. A GIS can be used to relate the remote sensing data with other types of spatially distributed data such as soils, topography, existing maps, etc., to facilitate more complex analysis.

2.12 Use of image processing software to classify land cover such as forests, and to differentiate agricultural and soil types has proven to be a reliable technique. However, for classifying urban features the capacity of digital image processing is limited. The major problem is that digital image processing uses the spectral signature or reflective value of a feature in order to classify it. Unfortunately, numerous man-made materials have roughly the same spectral reflectance properties. Thus, the spectral signature of urban phenomena obtained by remote sensors is often not unique, presenting a high degree of heterogeneity, and accurate identification or classification require using visual image interpretation in addition to the spectral response.

2.13 Various techniques have been used to measure and incorporate additional elements of image interpretation into the image analysis process. For example, numerous studies have synthesized "texture" information from the "spectral" data in the imagery. Several attempts at "contextual" classification make use of neighboring pixel values enabling the classification of different urban features.

2.14 While a computer cannot differentiate between a type of urban development such as a squatter settlement and the surrounding rocky area, a planner with experience in aerial photographic interpretation can. The reflectance from housing roofs and rocks surrounding this area may be the same but the patterns of urban form are different. This was the case for the Karachi image, where the land use classification could not be made by computer alone. For most of the urban area, the reflectance from roofs, rocks, and dry land was the same, thus the land classification was done visually based upon a photographic print of the image.

D. Cost Comparison Between Different Satellite Image Processing Techniques

2.1 Essentially, there are three general levels of processing remote sensing data. These are summarized in Figures 2.8 and 2.9, and described below:

1. High Level of Data Processing

2.16 A high level of data processing involves the use of digital tapes and image processing software. This computer assisted method for enhancing satellite images allows one to better interpret urban features such as land use classifications. Most image processing systems offer the possibility to draw vectors and polygons over the image display on screen. This feature can be used to trace road networks and to produce thematic maps such as land use maps. Another useful application in image processing is merging existing computerized digital maps with an image. This technique is used in cartography to create or update maps and for change detection when using time series data.

2.17 Processing images at this level requires a good knowledge of image processing techniques and requires investment in computer hardware and software and training. The average cost of an image processing system running on microcomputer is in the range of US\$40,000 to US\$60,000. Companies specialized in the processing of remote sensing data do offer image enhancement and mapping services. Depending on the application, the cost per image or scene may vary between US\$10,000 to US\$24,000.

2.18 High level data processing techniques can be incorporated with medium level techniques as well, particularly for adding additional data for analysis.

2. Medium Level of Data Processing

2.19 A medium level of data processing involves the use of negative films or transparencies that are reproduced as photographic prints at various scales. Satellite image data are visually interpreted from the panchromatic or color prints. Land use and road maps are digitized directly from these prints at their scale. Using secondary sources other infrastructure networks (water supply, sewerage, drainage, etc.) can be superimposed on the road base map. This can form the basis for an urban information system.

2.20 Medium level data processing requires some knowledge of CAD (Computer Aided Design) and GIS (Geographic Information System) to digitize maps and to develop database programs for exporting data from maps into information systems for use in urban infrastructure and management models. This level of processing requires a microcomputer and peripherals (digitizer, plotter and printer) costing approximately US\$10,000 to US\$25,000 and the use of software such as CAD or GIS costing between US\$3,000 and US\$12,000.

3. Low Level of Data Processing

2.21 A low level of data processing involves using photographic prints made from films or transparencies. Satellite image data are visually interpreted and maps are manually traced from these prints.

2.22 This level of processing does not require specialized computer equipment nor skills since all spatial information would be produced manually, including the measurement of areas by planimeter. However, inexpensive micro-computers (costing between US\$2,000 and US\$3,000) can be used to process the data derived from the interpretation of the photographic print.

FIGURE 2.8
 REMOTE SENSING SATELLITE IMAGE DATA PROCESSING
 AND THEIR APPLICATIONS
 IN REGIONAL AND URBAN PLANNING

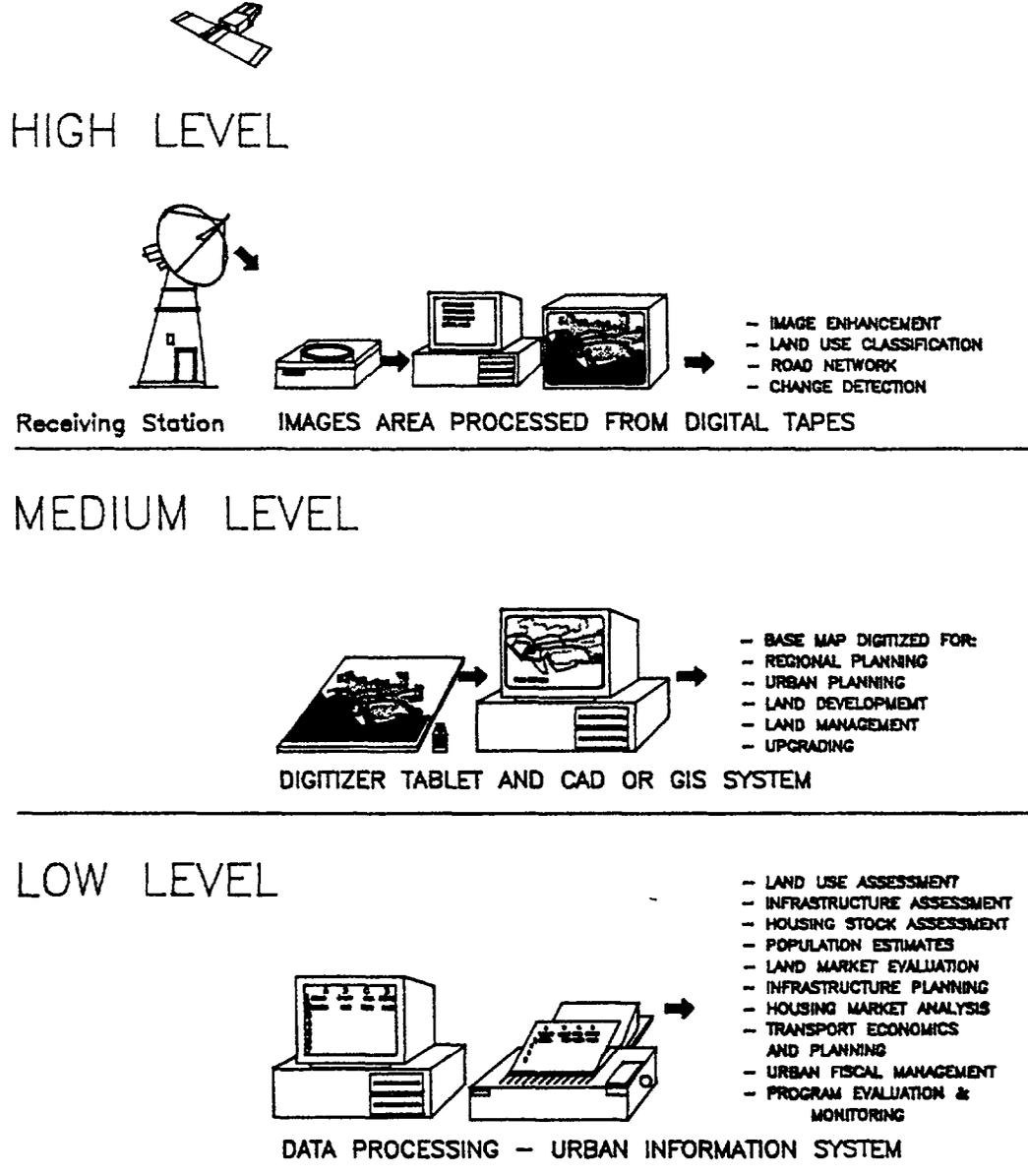


FIGURE 2.9
"SPOT" SATELLITE IMAGE PRODUCTS - PROCESSING COST
AND RESULTING OUTPUT

"SPOT" SATELLITE IMAGE PRODUCTS AND PROCESSING COST (1989 Cost in US Dollars)					
PROCESSING LEVELS	SATELLITE PRODUCTS	PRODUCT COST/UNIT	TYPE OF PROCESSING	PROCESSING COST	RESULTING OUTPUT
HIGH LEVEL -----> Using digital tapes, satellite images are processed and enhanced with Image Processing software Computer system & Image processing software cost: \$60,000	MULTI-SPECTRAL DIGITAL TAPE (Color image) 20m. resolution	\$1,700	Digital tapes, multi-spectral and panchromatic are merged to improve resolution. Images are enhanced in order to enlight urban feature.	This type of processing cost approximately \$12,000	HIGH LEVEL: - Enhanced image - Land use classification - Road network map - Change detection - Three dimensional image for terrain modeling
	PANCHROMATIC DIGITAL TAPE (B&W image) 10m. resolution	\$2,200	Photographic printout of the enhanced images are comparable to high altitude aerial photos.		
MEDIUM LEVEL -----> Using prints made from panchromatic and multi-spectral films, maps are digitized with GIS or CAD software Computer system & software cost: \$10,000	PANCHROMATIC FILM (B&W) Negative transparency made from digital tape 10m. resolution scale= 1:400,000	\$1,500	Photographic enlargement: scale: 1:100,000 scale: 1:50,000 scale: 1:24,000	Print (B&W) \$65 \$100 \$350 Print (Color) \$160 \$275	MEDIUM LEVEL: - Land use and road computerized maps - Computerized overlay maps for water, sewerage drainage & electricity. - Urban Management System using GIS System.
	MULTI-SPECTRAL FILM (Color) Negative transparency made from digital tape 20m. resolution scale= 1:400,000	\$1,300	Photographic enlargement: scale: 1:100,000 scale: 1:50,000		
LOW LEVEL -----> Using B&W and/or color prints, maps are manually drawn Computer system & software cost: \$3,500	PANCHROMATIC FILM (B&W) Negative transparency made from digital tape 10m. resolution scale= 1:400,000	\$1,500	Photographic enlargement: scale: 1:100,000 scale: 1:50,000 scale: 1:24,000	Print (B&W) \$65 \$100 \$350	LOW LEVEL: - Land use, road and utility maps drawn manually. - Urban Management System using LOTUS 1-2-3 and database management system.

E. Cost Difference Between SPOT Satellite Images and Aerial Photos

2.23 Using SPOT satellite images for mapping at a scale of 1:50,000 is less expensive than conventional mapping with aerial photos. Although it is too early to have precise figures from large surveys, IGN France (Institut Geographique National) reported a ratio of 3:1 in favor of SPOT data. The cost comparison presented in Figure 2.10 suggests this ratio is generally correct.

FIGURE 2.10

COST COMPARISON FOR MAPPING WITH AERIAL PHOTOS AND SPOT SATELLITE IMAGES

	Photos or Images Acquisition Price per Km ²	Staff	Total Cost * US Dollars
Conventional mapping using aerial photos	170 US\$	Surveying & Mapping 24 Person/Months	142,500
Mapping with SPOT satellite images	45 US\$	Surveying & Mapping 3 Person/Months	80,000

*Cost for mapping a coastal zone of 500 km² in Polynesia, Loyalty Islands at a scale of 1:50,000.

Study conducted by the French Hydrographic and Oceanographic Survey (Service Hydrographique et Oceanographique de la Marine), FOURGASSIE and LE GOUIC, 1987.

NOTE: Cost differences between aerial photos and satellite images are due not only to product cost but diverse processing techniques and significantly different timetables.

2.24 From this finding it can be concluded that SPOT satellite images, particularly panchromatic images with ten-meter resolution, offer an alternative to medium-scale aerial photos for urban planning purposes. It should be noted again that for tropical countries, image interpretability may be limited when vegetation obscures housing development. Another area where photo interpretation may not be possible is in desertic regions where houses are made of mud blocks and villages are dispersed without any visible roads to link settlements. Scale limits are also a constraint and Konecky in a 1987 UN publication "World Cartography" pointed out that "interpretability" is a factor which limits satellite images scale to 1:50,000 for cartographic uses. Such scale limits do not permit the use of satellite remote sensing products for cadastral purposes in urban areas.

PART 3

USING SATELLITE IMAGES FOR URBAN PLANNING

KARACHI CASE STUDY

To illustrate the usefulness of remote sensing in urban planning and urban management, a case study is presented in this section starting with a brief overview of the City of Karachi, Pakistan.

A. Karachi Urban Development from 1943 to 1988

3.01 Karachi has a long recorded history of settlement, but its rapid growth has taken place in the past several decades.

3.02 By 1843, Karachi was still a walled township of 14,000 people on a site of 35 acres that had been developed as a port by the British for exporting the products of the Punjab. See Figure 3.1, an old map of Karachi dated 1885. As recently as 1941, the population of Karachi District was less than half a million. A metropolis burst into being with the birth of the new nation.

3.03 Between 1947 and 1951, approximately 600,000 displaced persons who migrated into Karachi from India, as a result of the creation of Pakistan in 1947, found shelter in the city, swelling the population to 1,130,000.

3.04 Karachi's population increased at a rate of 4.8 percent per year between 1971 and 1981. If this trend continues, metropolitan Karachi could have close to 13 million inhabitants by the end of the century, or more than twice the estimated population of six million in 1987.

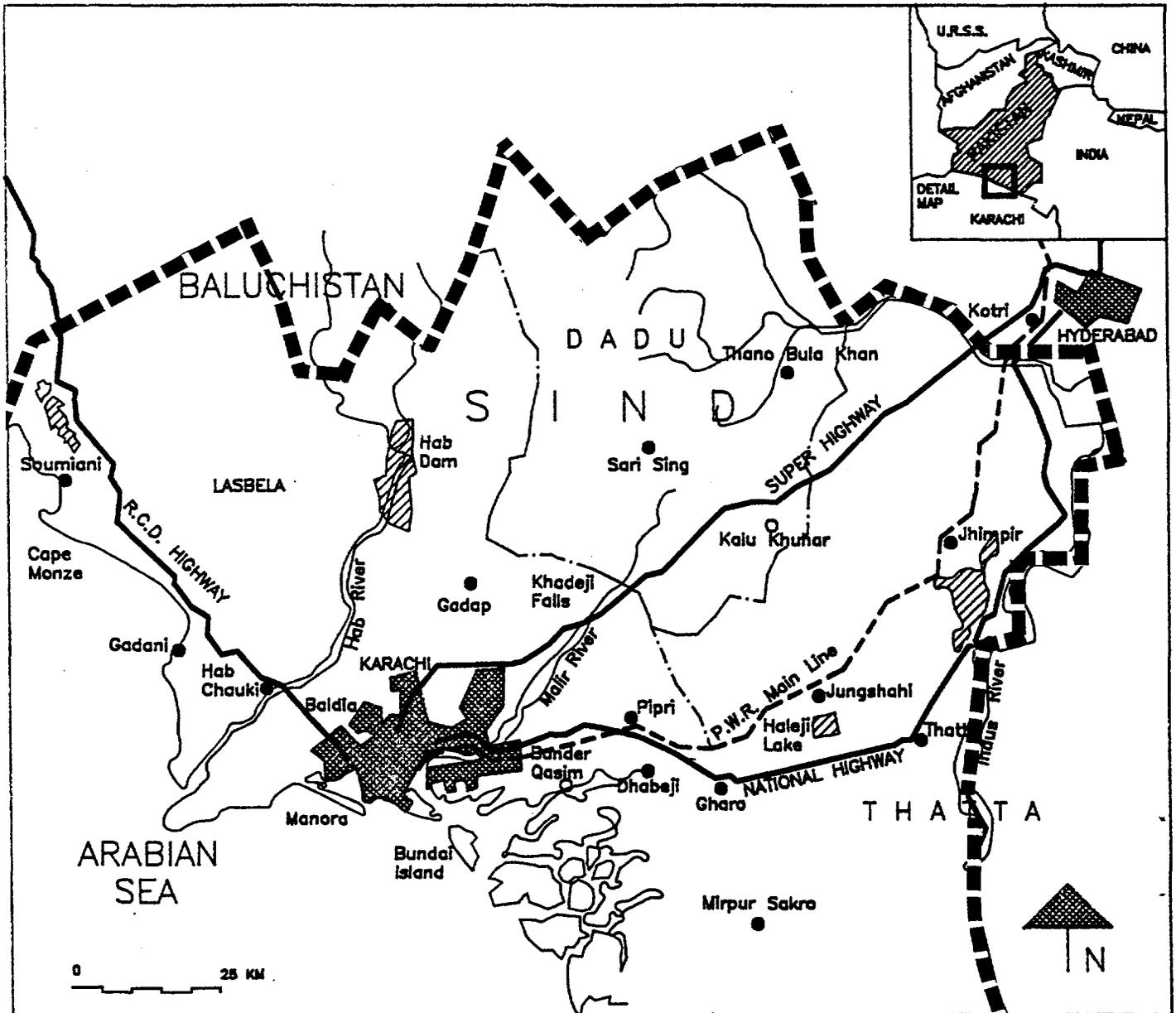
3.05 The Development Plan Report of 1974 defined metropolitan Karachi as an area covering some 349 square kilometers. Today, it is ten times larger (3520 km²) and stretches from the Dhabeji Water Works in the east to Baldia and the Bander Qasim port in the west when the urban area calculated from satellite image dated from January 1987 is 1,012 km² (Figure 3.2).

3.06 Despite official attempts to contain Karachi's growth and disperse development to secondary cities, economic activities in the metropolis have been expanding steadily. Incentives and tax relief designed to stimulate growth, in fact, prompted industries to set up operations at the edge of the Karachi administrative district in areas such as Hub Chowki in Baluchistan, just 24 kilometers from Karachi's center, and Dader in Sind, 80 kilometers along the Karachi-Hyderabad Highway.

3.07 Close to 30 percent of the population of Sind province lives in Karachi metropolitan area and 33,000 households are added to the area annually.

3.08 Although close to 45 percent of all employment is concentrated in four areas -- the Sind and Landhi industrial trading estates, the port, and the city center -- the adjoining areas are not highly populated. In fact, more than one quarter of the built-up area has been pre-empted for defense purposes and developed under cantonment boards at very low densities. About five square kilometers of fully or partly serviced land lie unused in the heart of the city, and infrastructure has been extended into outlying areas at great expense in response to private speculation. Labor outflows to the Middle East and remittances from the 1.25 million emigrant workers there (said to average Rs30,000 a year per worker) have been largely responsible for the speculation on land and housing. Although approximately 80 percent of the land in the metropolitan area is publicly owned, and a planning study was undertaken between 1968 and 1973 to deal with land use, Karachi has been unable to control the development of its urban land.

FIGURE 3.2
KARACHI REGION



3.09 A large part of Karachi's housing is now situated on the periphery of the city, in sprawling informal settlements that exhibit little planning and nominal infrastructure. To add to its problems, Karachi has by far the largest squatter settlements in the province. Referred to as Katchi Abadis, these house about one third of Karachi's population in generally unsanitary conditions (Figure 3.3).

3.10 Recently, national policy has become cognizant of the needs of low- income groups. For example, land leases have been granted to squatters, and in situ amelioration of squatter settlements (Kachi Abadis) is a current priority. Upgrading of services in squatter settlements has resulted in visible self- improvement in the quality of shelter.

3.11 In the past ten years, Karachi has endeavored to reorganize its institutions in order to improve urban management. In some fields, such as water supply and sewerage, sectoral objectives have been accepted and the institutional mechanisms needed to achieve them have been established.

3.12 The Government of Pakistan asked UNCHS (Habitat, Nairobi) to assist KDA (Karachi Development Authority) on "Strengthening of the Karachi Master Planning Process (1986-2000)."

3.13 The project's development objective is to contribute to the Government's efforts to improve the overall conditions of human settlements in Karachi and further more in the country by:

- Improving the efficiency of the delivery of urban services and shelter to inhabitants of Karachi;
- Developing new approaches and methodologies that could be replicated in other parts of the country;
- Developing and implementing within KDA a new urban growth management tool;
- Creating and establishing mechanisms for the continuous updating of Development Plans prepared by KDA, and
- Training the operative staff and senior officials of KDA in the use of these methodologies and approaches.

3.14 The UNCHS recommended the use of satellite images to evaluate the actual extension of Karachi urban area and its land use. SPOT satellite image products (films and digital tapes, both panchromatic and multispectral) were acquired to conduct this study. Films were reproduced at different scales from 1:400,000, 1:100,000, and 1:24,000 and digitized for the making of land use and road network maps. Images on digital tapes were enhanced to analyze urban development patterns such as population density.

3.15 The following case study illustrates how data derived from remote sensing and other sources were utilized to develop computerized maps and the beginning of an urban or geographical information system.

FIGURE 3.3
KATCHI ABADI OR SQUATTER SETTLEMENT - KARACHI



B. Computerized Mapping and GIS System

3.16 Thematic land use mapping from photographic prints of a satellite image can be done manually using mylar or tracing paper. A base map is made over the original print including all visible road networks. A second land use map may also be derived from the same print after visual interpretation and field checks if possible. Using available secondary data, various overlay maps for water supply, sewerage, electricity networks and density maps, etc., may also be prepared.

3.17 In a traditional mapping process, modifications usually require the preparation of new maps. Changes or additions are not made without redrawing the entire maps.

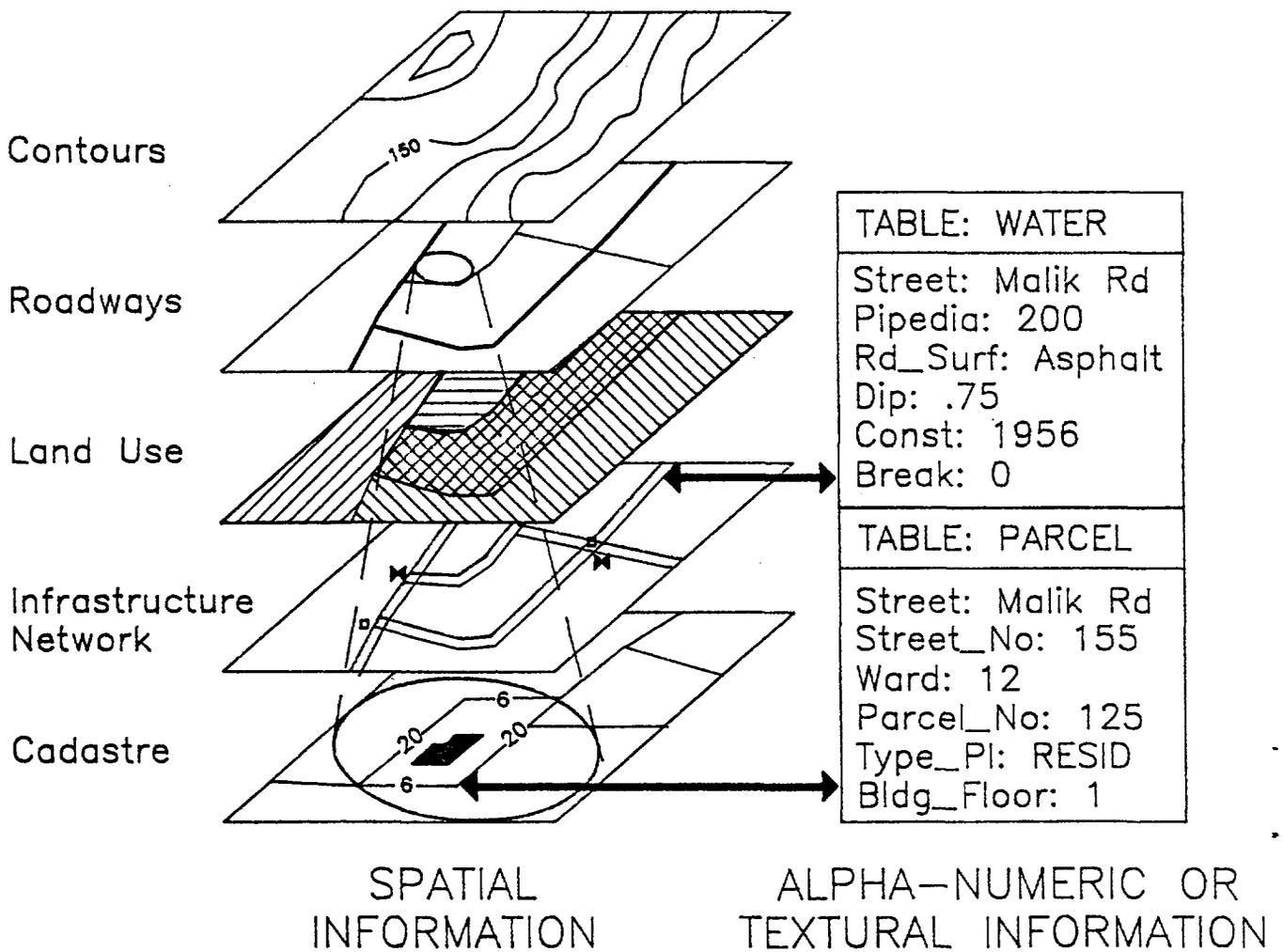
3.18 Using micro-computer applications such as a Geographic Information System (GIS) computerized base maps can be created, modified and completed by overlays of information. Facilities management can be introduced by transforming all geographical data into digital or numerical data. In other words, a map or a chart can be altered, expanded, sorted and output printed according to the particular specifications of a project.

3.19 Geographic Information Systems (GIS) is a term which first appeared in general use in the late 1960s. It is normally used to describe computer facilities, which are used to handle data referenced to the spatial domain, with the capability to inter-relate datasets to assist in their analysis and the presentation of the results. This system allows the user (a planner, an engineer, a site assessor, a data processor, etc.) to efficiently manage and manipulate data about geographic locations. An important concept to understand is that geographic data include both spatial and descriptive data. Spatial (or geographic) data are simple data that have a geographic location such as a zone, an institution, a building, etc. Descriptive data, or attribute data, are information associated with a particular physical object. These data describe an entity that has a unique geographic location, for example an industrial estate covering 12 hectares with 40 percent of land area allocated to circulation and open space. These items are descriptive elements or attributes of this zone.

3.20 A GIS offers substantially more features and flexibility than traditional mapping and data management techniques. A key feature is the capability to store and manage graphical and alpha-numerical data simultaneously within the same system, allowing cross-referencing, merging and sorting of all relevant information stored in the database of the GIS system (Figure 3.4).

3.21 For this case study all maps presented below were computerized. The land use map and road network were digitized from the photographic print at a scale of 1:100,000 using AutoCAD, a Computer Aided Design (CAD) software package running on micro-computer system. Auxiliary data such as water supply, sewerage, and drainage networks were also prepared as base map overlays. Computerized maps and associated data may form the basis for an embryonic urban information system or GIS system.

FIGURE 3.4
GEOGRAPHIC INFORMATION SYSTEM



C. Mapping Land Use and Road Networks from Satellite Images: Starting an Urban Database

3.22 The steps followed in preparing the Karachi case study are described below and graphically represented in Figure 3.5.

Use of Satellite Images for Mapping Purposes

3.23 At the present time, SPOT satellite panchromatic and multispectral images are most appropriate for urban applications. Transparencies or film negatives can be enlarged on photographic paper at a desirable scale and used to trace roads and land use base maps. Use of digital tapes requires access to an image processing system. Images on tapes can be enhanced for better interpretation and/or classification of areas of interest such as squatter and dense settlements and other critical areas of concern. Digital images can also be reproduced on films or printed using an inkjet or thermal printer.

Convenient Scales of Photographic Prints made from Satellite Images

3.24 Images from SPOT satellite negatives may be printed at different scales. For a large metropolitan area, broad analysis using a panchromatic photo at a scale of 1:100,000 may be sufficient. For general planning purposes panchromatic photos at a scale of 1:25,000 are suitable to identify most urban features.

3.25 NOTE: Multispectral films at a scale of 1:50,000 - 1:100,000 are also very useful for metropolitan analysis.

Visual Interpretation of Urban Features (roads and land use)

3.26 "SPOT" photographic prints at a scale of 1:100,000 scale permit major road networks and various land uses to be identified and a thematic land use map to be prepared.

3.27 The major road network on panchromatic prints appears in dark grey and are continuous lines. Industrial areas can be recognized by their large roofs which have a higher reflectance than any other type of construction. These appear on black and white print as large white squares with a more important road network than in residential areas (Fig. 3.6).

3.28 Through visual photo interpretation, dense and loose grid patterns were identified. These were used to determine urban density and to classify residential areas. Other urban areas where no street patterns could be identified were classified as squatter settlements locally known as "Katchi Abadies." Various residential urban fabrics, or housing types, are schematically presented in Figure 3.7.

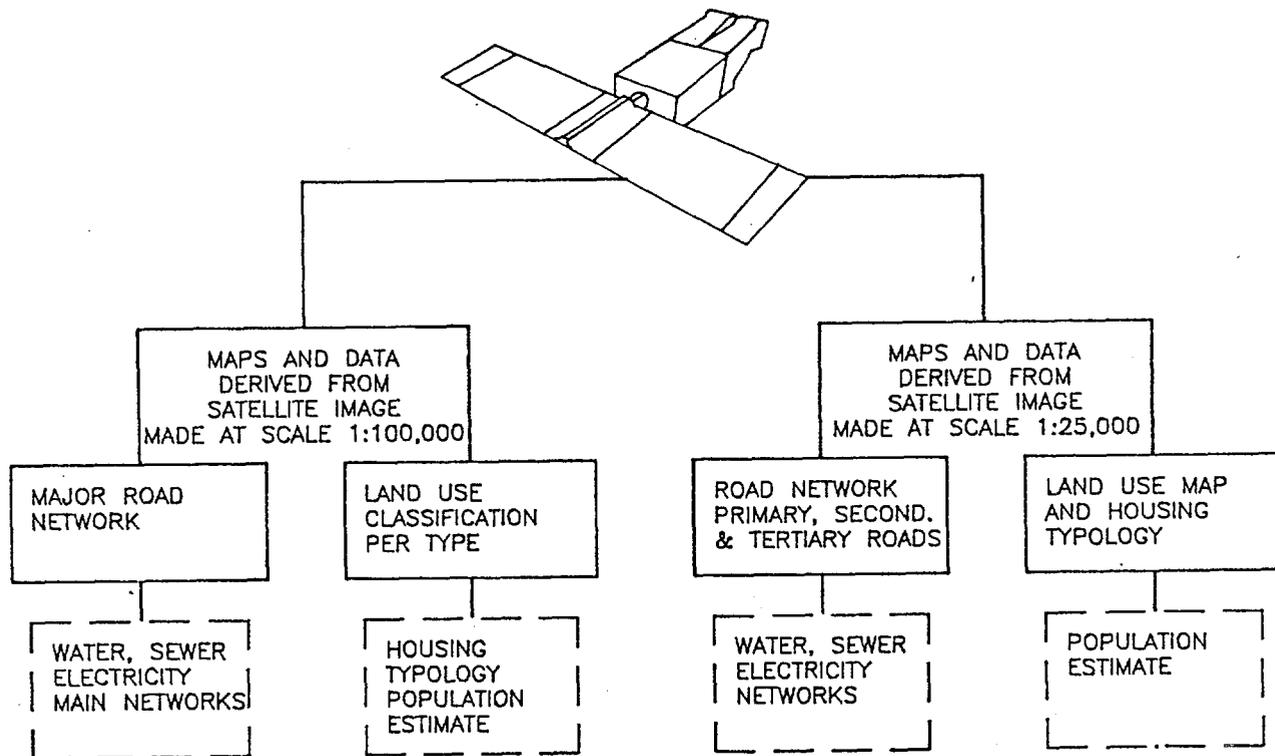
3.29 High density housing types (A and B) include squatter settlements located next to the industrial area (S.I.T.E.) on the east side of Karachi, along the Malir River and in the center of the old city where the road network is more visible than in slum areas. The old center of Karachi appears in a homogenous dark grey tone (Figure 2.2 and 2.6).

3.30 Medium density types of development (type C) were partly identified by the road network, which was more visible than in high density areas. A mixture of light and dark grey shades indicates that the land is occupied by small buildings with open space and vegetation in between.

3.31 Low density types of development (type D) are located in northern and southern parts of Karachi and in its peripheral areas. Roofs in this type are noted as a small white dot surrounded by a mixed tone of dark and light grey background (see Figure 3.6).

3.32 From a multispectral photographic print (false color photo) at scale 1:100,000, the urban areas can be clearly defined. They appear in a grey-bluish shade while non-developed land appears in the grey-yellowish tones. Squatter settlements are definitely more easy to locate than in the panchromatic image where their grey shade may be interpreted as vegetation. In the multispectral mode, slums appear in a bluish shade while vegetation stands out in red or brown-red in the color print. For visual interpretation and general land use classification (residential, industrial, transport network, agriculture), multispectral prints are certainly of greater use than a panchromatic image printed at the same scale; however, both serve useful purposes.

FIGURE 3.5
USE OF SATELLITE IMAGES IN URBAN PLANNING
AND URBAN MANAGEMENT



NOTE: Items enclosed in broken line are not directly obtained from satellite images. these data are derived from existing engineering maps and field surveys.

FIGURE 3.6
 IDENTIFICATION OF DIFFERENT URBAN FEATURES FROM
 "SPOT" PANCHROMATIC PHOTOGRAPHIC PRINT - SCALE 1:100,000
 KARACHI PAKISTAN

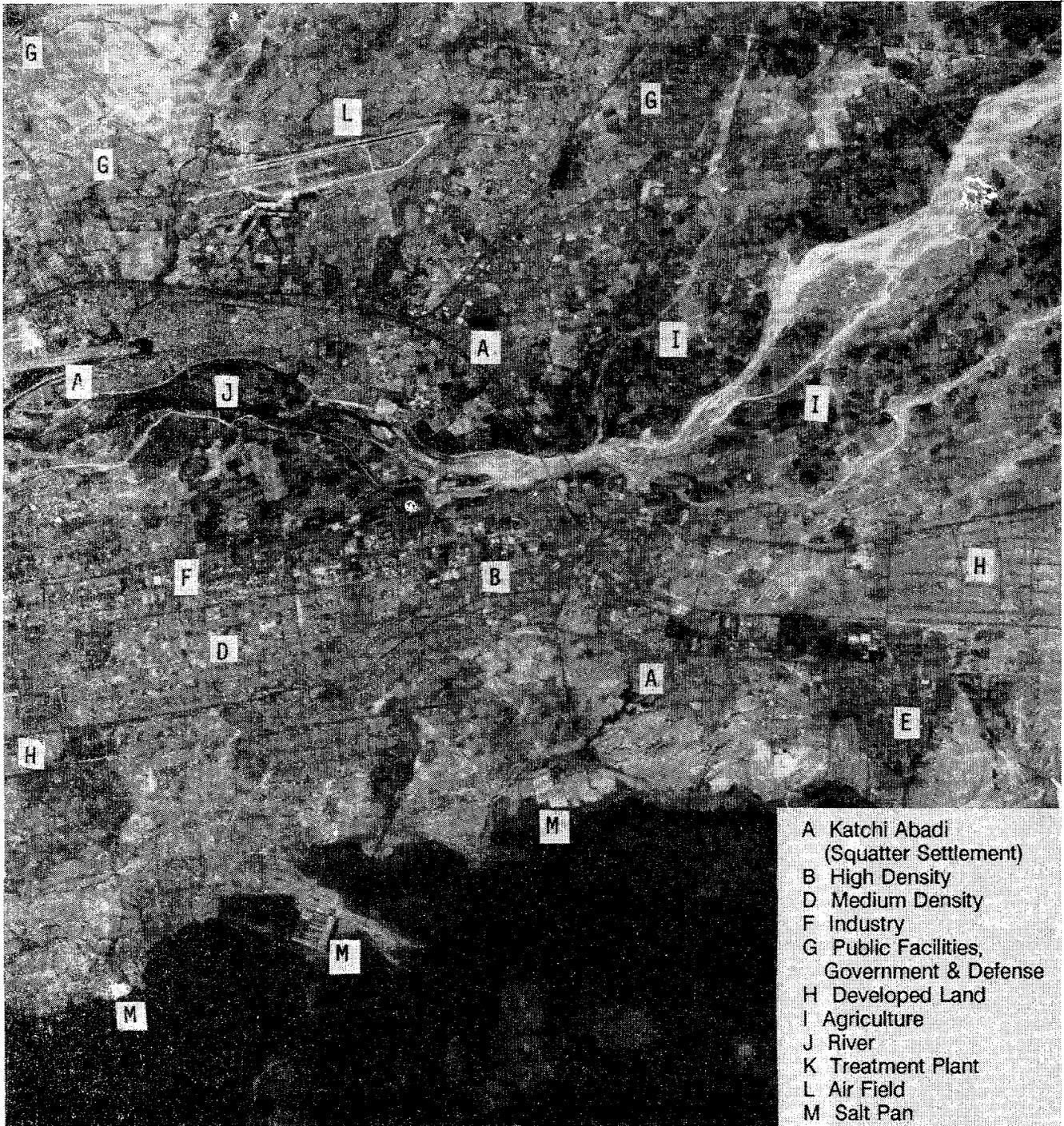
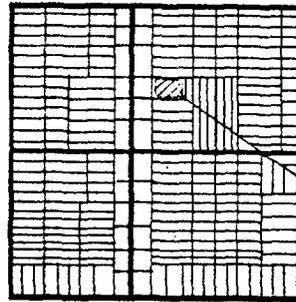


FIGURE 3.7
DIFFERENT TYPES OF RESIDENTIAL DEVELOPMENT
KARACHI, PAKISTAN



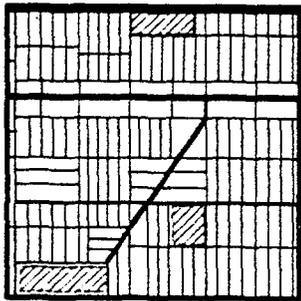
TYPE A (Katchi Abadi)
SQUATTER SETTLEMENT

Average plot size (m ²)	75
No. of persons/plot	6.5
% circul. & open space	25
Density persons/ha	650



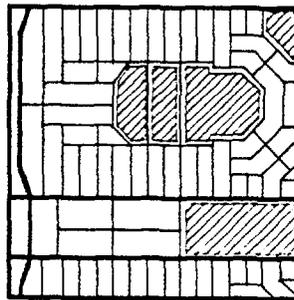
TYPE B (City Center)
HIGH DENSITY

Average plot size (m ²)	90
No. of persons/plot	8.5
% circul. & open space	25
Density persons/ha	625



TYPE C (North-East Karachi)
MEDIUM DENSITY

Average plot size (m ²)	150
No. of persons/plot	6.5
% circul. & open space	40
Density persons/ha	260



TYPE D (North Karachi)
LOW DENSITY

Average plot size (m ²)	350
No. of persons/plot	6.5
% circul. & open space	45
Density persons/ha	102

Maps Derived from Satellite Images

3.33 The land use and road network maps for Karachi were derived directly from satellite images. The thematic land use map and road network presented in Figure 3.8 was digitized from a panchromatic photographic print at a scale of 1:100,000. The road network map, shown in Figure 3.9 was digitized from a panchromatic photographic prints made at a scale of 1:24,000.

3.34 At a scale of 1:24,000, depending on the quality of the image, different residential types of development from high density to medium and low density settlements can be identified. Their areas can be measured and after field surveys their densities can be evaluated for population estimation by sector or for the entire city. To conduct a housing typology used to evaluate the population of Karachi for the year 1988, both panchromatic and multispectral images at a scale of 1:24,000 were used to identify different urban fabrics before selection of the housing types. The Karachi housing typology is to be presented in Section D.

Other Map Overlays

3.35 The road network map derived from the "SPOT" photo can be used as computer base map to overlay other network systems (water supply, sewerage, drainage, etc.) by digitizing existing network maps and matching these to the base map created from satellite images. (See Fig. 3.10, 3.11, 3.12.)

3.36 The land use map, developed at a scale of 1:25,000, can also be used as a computerized base map for other land information such as zoning map, land value, etc.

Urban Mapping and Urban Data Integration

3.37 Data directly derived from satellite images: land types and their corresponding areas, road types and lengths, plus the auxiliary data concerning water supply, sewerage, electricity and other networks can be listed on maps as shown in Figure 3.13. These data can be extracted from the computerized map done in AutoCAD and imported to database and/or to spreadsheet for further analysis (Figure 3.14). This is the principle of a (GIS) or Geographical Information System.

3.38 Data extraction from map to database is possible only if the data listed on the map has been written as attributes and linked to a point, a line, or a specific area. As shown in Figure 3.13, the notation or attribute "INF - 2375.22" corresponds to informal or squatter settlement development of 2375.22 hectares and is registered in the drawing file with the same "tag" name as in the database field name.

3.39 GIS Systems which were first developed for mini and mainframe computers are now being used for urban mapping and data management purposes. ARC- Info is an example of such software. Micro-computer GIS software such as MunMAP may be used to extract and/or insert attributes to a computerized map drawn in AutoCAD to database management systems such as RBASE 5000. MunMAP can be used as a GIS system for data queries within a map with enough flexibility for the user to develop a proprietary system adapted to countries and cities that have different needs. The other GIS software for micro-computer systems is pcARC/INFO, which is described in Annex I, Section D "Software needed for Mapping and Data Management Systems."

FIGURE 3.8
THEMATIC LAND USE MAP WITH MAJOR ROAD NETWORK
KARACHI, PAKISTAN

KARACHI
LAND USE

	AREA (HA)	%		AREA (HA)	%		AREA (HA)	%		
	KATCHI ABADI	5722	5.65		INDUSTRIES	5370	5.30	AGRICULTURE	4619	4.56
	HIGH DENSITY	2740	2.71		DEVELOPED LAND	9965	9.84	OTHER	50515	49.89
	MEDIUM DENSITY	8607	8.50		SERVICE/UTIL. GOVERNMT/INST.	1009	1.00			
	LOW DENSITY	3584	3.54		DEFENSE	9125	9.01	TOTAL URBAN AREA	101256	100.00

Map derived from "SPOT" satellite image of Jan. 1987

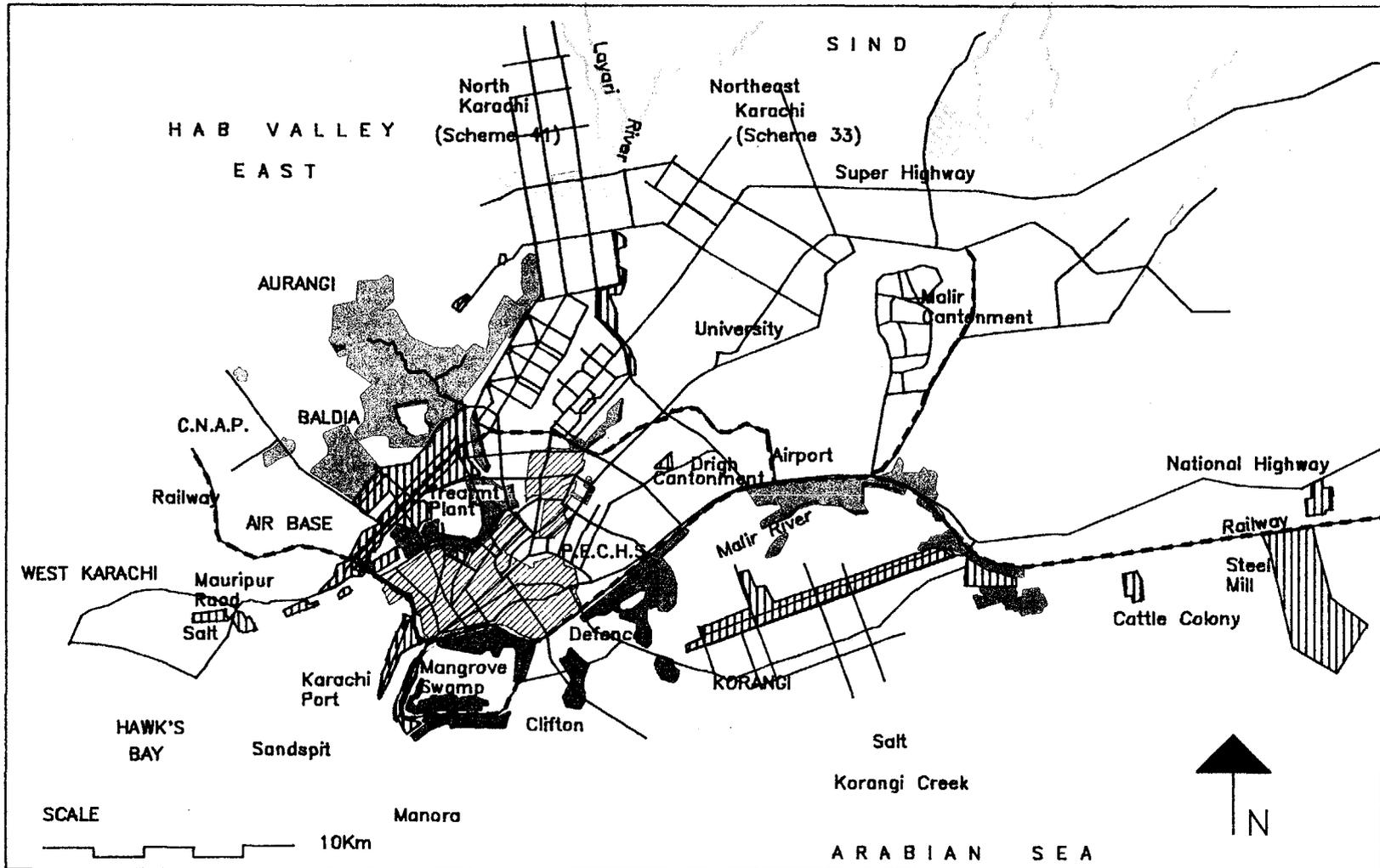
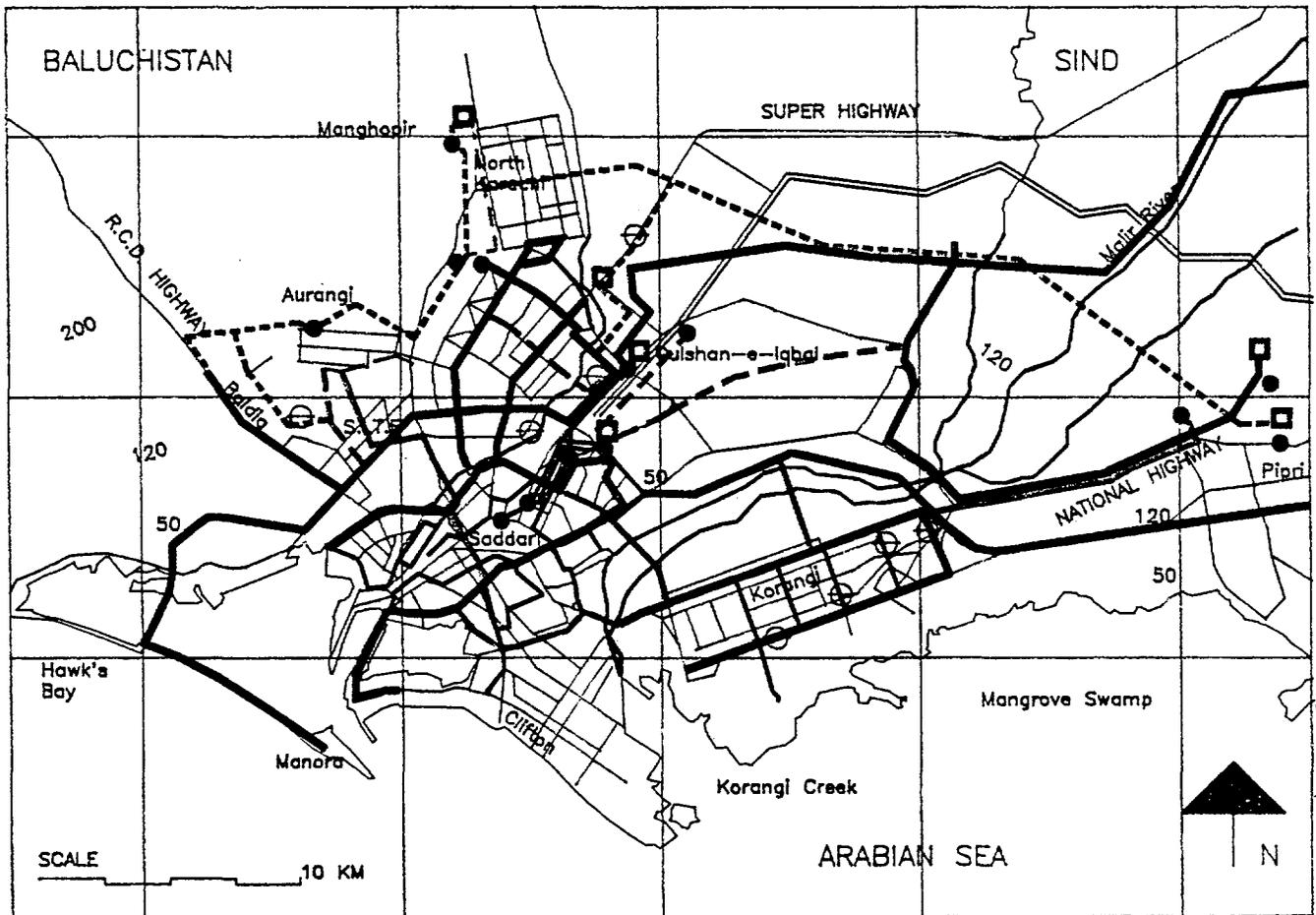


FIGURE 3.10
KARACHI WATER SUPPLY NETWORK

KARACHI
WATER SUPPLY NETWORK

- | | | |
|---------------------|--------------------------|-------------------|
| Existing Water Main | Proposed Water Main/Zone | ▣ Filter Plant |
| — All Zones | — Zone 0' – 50' | ● Reservoir |
| — Conduit | - - - Zone 50' – 120' | ▲ Pumping Station |
| | - - - Zone 120' – 200' | ⊖ Pressure Valves |

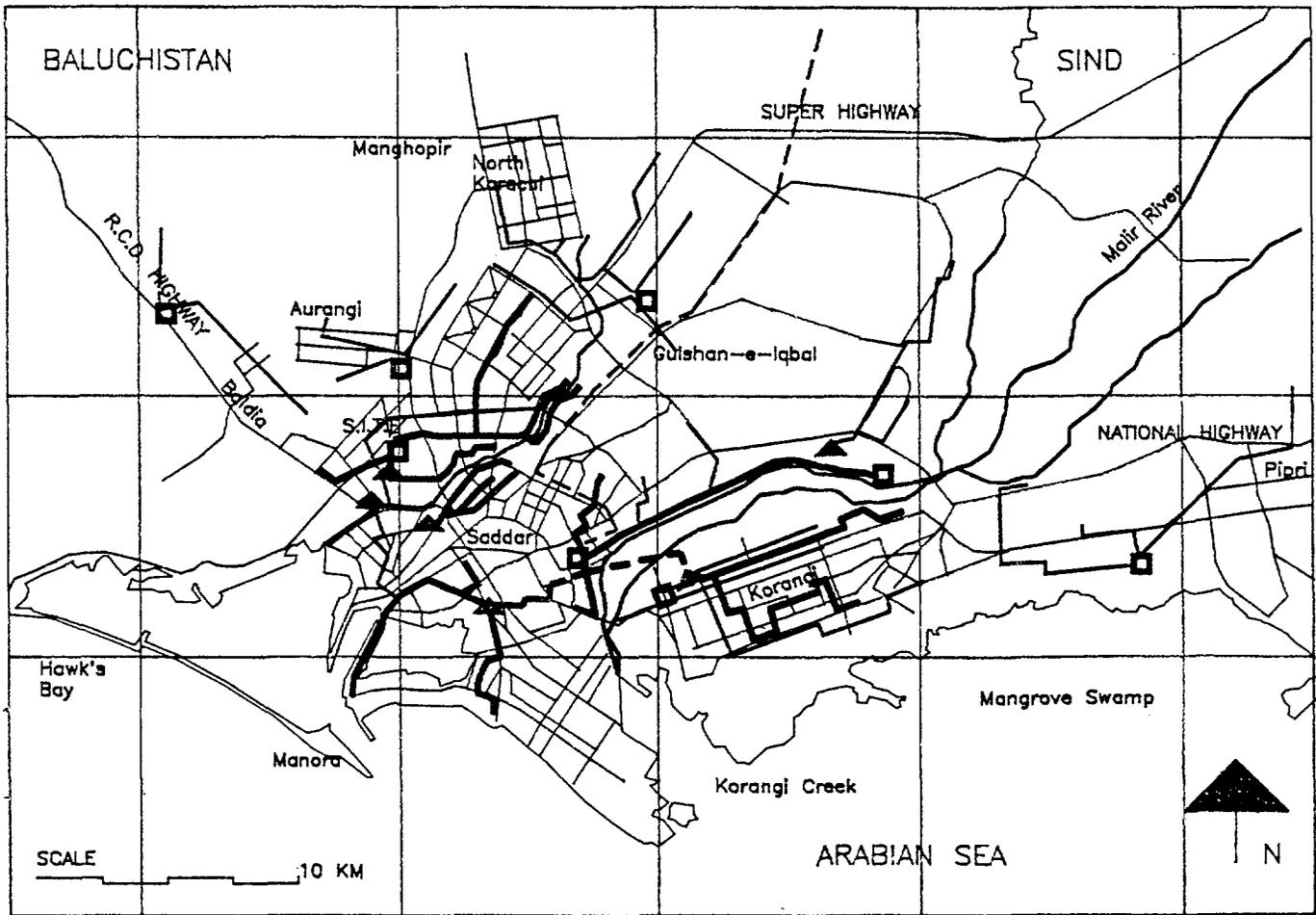


Source: Karachi Development Plan 1976 - 1985
Karachi Development Authority - Karachi, Pakistan

FIGURE 3.11
KARACHI SEWERAGE NETWORK

KARACHI
SEWERAGE NETWORK

- Existing Trunk Sewer
- Proposed Trunk Sewer
- - - Existing Rising Main
- - - Proposed Rising Main
- Treatment Plant
- ▲ Pumping Chambers

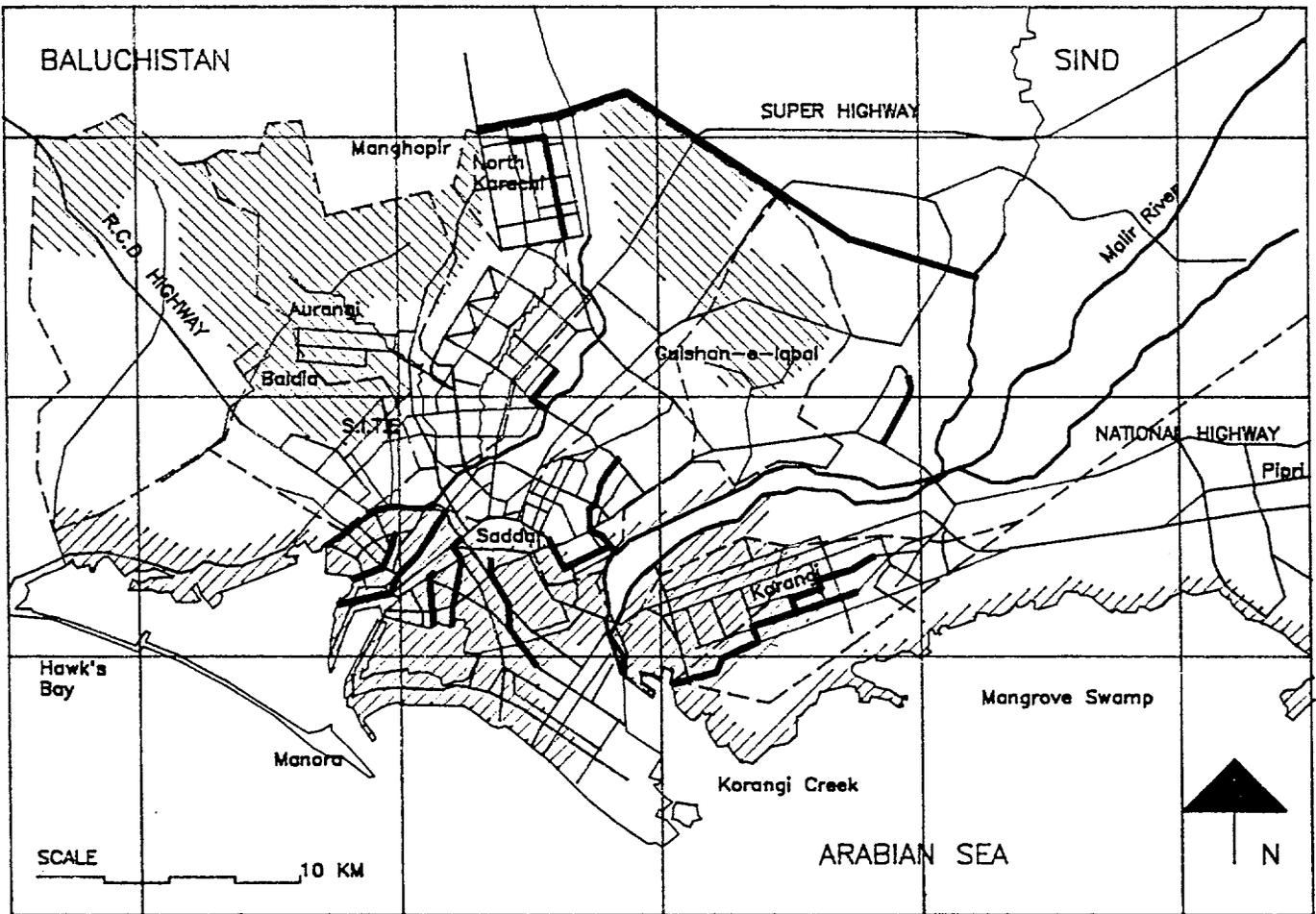


Source: Karachi Development Plan 1976 - 1985
Karachi Development Authority - Karachi, Pakistan

FIGURE 3.12
KARACHI DRAINAGE NETWORK

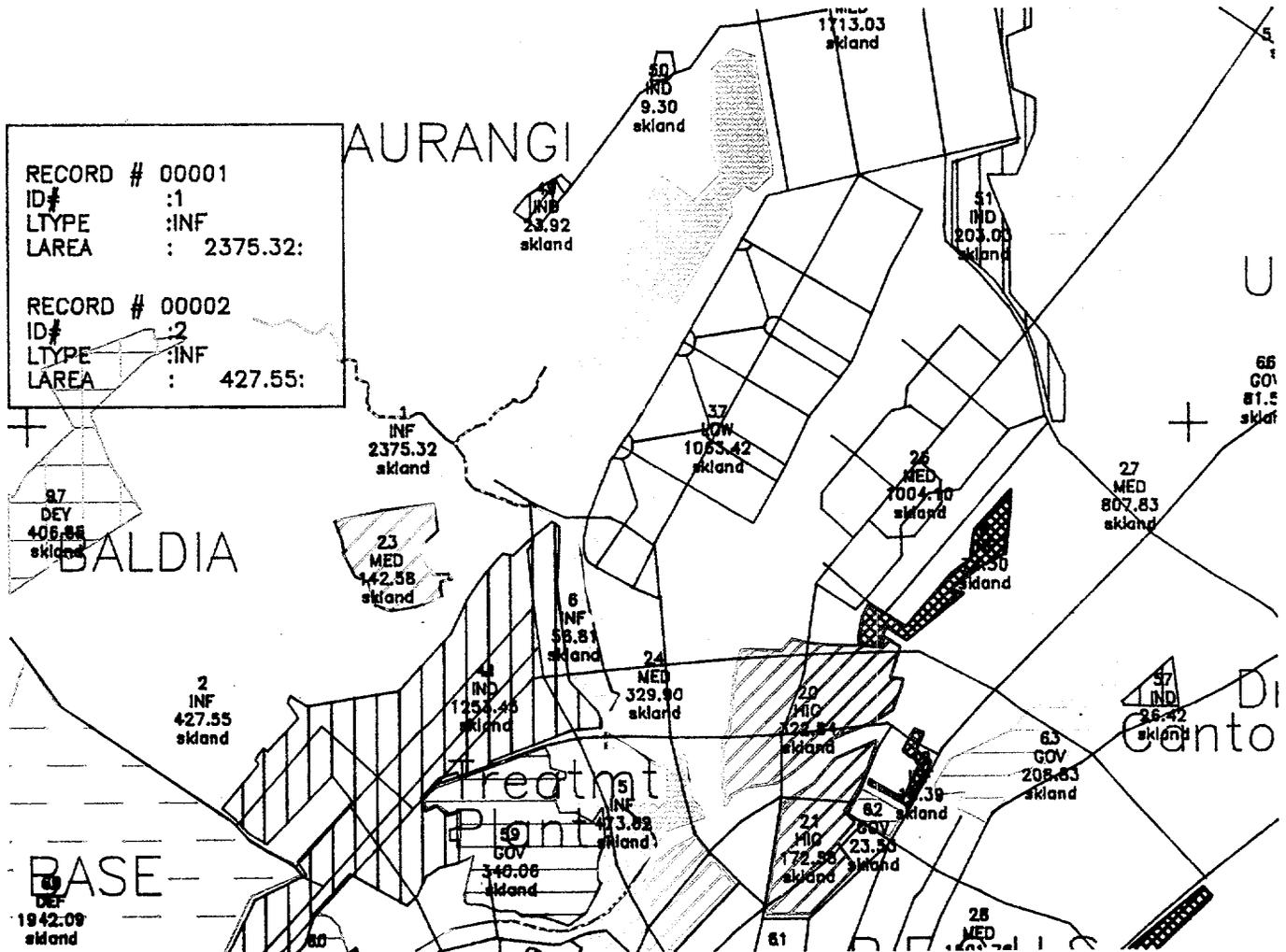
KARACHI
SURFACE DRAINAGE

-  Trunk Drain
-  Nalas—Natural Drain
-  Foot Hill Zone
-  Sea Zone
-  Catchment Area Boundaries



Source: Karachi Development Plan 1976 - 1985
Karachi Development Authority - Karachi, Pakistan

FIGURE 3.13
LAND USE TYPE AND AREA ATTRIBUTES ARE LISTED ON MAP



All data attributes listed on maps are directly imported to database management systems such as dBASEIII, R:BASE and LOTUS 1-2-3 spreadsheet.

Map derived from "SPOT" satellite image dated January 1987.

FIGURE 3.14(A)

ATTRIBUTES OR DATA LISTED ON "AUTOCAD" MAP ARE DIRECTLY
IMPORTED TO DATABASE AND LOTUS SPREADSHEET

AUTOCAD DATA

1	INF	2375.32	33	LOW	53.04	65	GOV	21.72
2	INF	427.55	34	LOW	295.37	66	GOV	51.53
3	INF	44.49	35	LOW	273.62	68	DEF	5576.68
4	INF	11.43	36	LOW	203.04	69	DEF	1942.09
5	INF	477.62	37	LOW	1057.42	70	GOV	77.72
6	INF	52.81	38	LOW	560.72	71	DEF	1103.94
7	INF	12.77	39	LOW	1104.33	72	DEF	43.76
8	INF	74.30	40	MED	35.37	73	DEF	33.45
9	INF	256.03	41	IND	1253.47	74	DEF	411.57
10	INF	147.75	42	IND	21.69	76	AGR	566.88
11	INF	130.14	43	IND	172.38	77	AGR	621.46
12	INF	144.28	44	IND	98.70	78	AGR	78.12
13	INF	509.57	45	IND	38.77	79	AGR	1161.75
14	INF	57.21	46	IND	54.53	80	AGR	229.37
15	INF	632.64	47	IND	40.76	81	AGR	27.81
16	INF	27.57	48	IND	14.13	82	AGR	171.71
17	INF	176.35	49	IND	27.92	83	AGR	130.23
18	INF	185.09	50	IND	9.30	84	AGR	72.33
19	INF	16.39	51	IND	207.07	85	AGR	372.02
20	HIG	322.84	52	IND	879.30	86	AGR	37.56
21	HIG	172.56	53	IND	136.75	87	AGR	39.46
22	HIG	2244.61	54	IND	78.64	88	AGR	14.89
23	MED	142.58	55	IND	1134.42	89	AGR	375.67
24	MED	329.90	56	IND	1164.42	90	AGR	52.34
25	MED	1717.07	57	IND	26.42	91	GOV	40.28
26	MED	1004.10	58	GOV	65.90	92	GOV	1165.55
27	MED	307.83	59	GOV	140.06	93	DEF	5347.44
28	MED	1501.76	60	GOV	44.30	94	DEF	796.15
29	MED	1215.76	61	GOV	23.15	95	DEF	467.71
30	MED	81.39	62	GOV	27.57	96	GOV	1501.18
31	MED	152.56	63	GOV	208.87	97	DEF	406.65
32	MED	1603.20	64	GOV	56.99			

Polygon
ID Number

Area of
different
land use
type

Abbreviation
for different
land use type

The above data filed in AUTOCAD, (polygon ID number, land use types and areas), are imported to dBASEIII, RBASE and LOTUS spreadsheets and can be used together with physical and socioeconomic data gathered from field surveys as seen Figure 3 14(C)

FIGURE 3.14(B)

ATTRIBUTES OR DATA ON "AUTOCAD" MAP ARE DIRECTLY
IMPORTED TO DATABASE AND LOTUS SPREADSHEET

DATA EXTRACTED FROM AUTOCAD ARE IMPORTED TO dBASEIII

	AREA (Ha)	%
KATCHI ABADI (Squatter)	5722	5.65
HIGH DENSITY	2740	2.71
MEDIUM DENSITY	8607	8.50
LOW DENSITY	3584	3.54
INDUSTRY	5370	5.30
DEVELOPED LAND	9965	9.84
SERVICE/UTIL/GOVMT/INST.	1009	1.00
DEFENSE	9125	9.01
AGRICULTURE	4619	4.56
OTHER	50515	49.89
TOTAL	101256	100.00

Data extracted from AutoCAD are imported to database management system. A dBASEIII program classified the land use types and computed the areas by categories as shown Figure 3.14(B).

FIGURE 3.14(C)

ATTRIBUTES OR DATA ON "AUTOCAD" MAP ARE DIRECTLY
IMPORTED TO DATABASE AND LOTUS SPREADSHEET

DATA EXTRACTED FROM AUTOCAD ARE IMPORTED TO LOTUS 1-2-3

	A	B	C
1	ID#	LTYPE	LAREA
2	1	INF	2375.32
3	2	INF	427.55
4	3	INF	44.49
5	4	INF	11.43
6	5	INF	473.62
7	6	INF	56.81
8	7	INF	12.77
9	8	INF	74.3
10	9	INF	256.05
11	10	INF	147.75
12	11	INF	130.14
13	12	INF	144.28
14	13	INF	509.57
15	14	INF	59.81
16	15	INF	632.64
17	16	INF	27.57
18	17	INF	136.86
19	18	INF	185.09
20	19	INF	16.39
21	20	HIG	322.84
22	21	HIG	172.58
23	22	HIG	2244.61
24	23	MED	142.58
25	24	MED	329.9
26	25	MED	1713.03
27	26	MED	1004.1

A	B	C	D	E	F	G	H	I
TYPE	AREA_HA	AREA_%	CIR_OPEN	PLOTSIZE	PERSONPL	POPULAT	DENSITY	POP_%
TINF	5722	5.65	25	75	6.5	3719300	650	45.61
THIG	2740	2.71	25	90	7.5	1712500	625	21.00
TMED	8607	8.50	40	150	6.5	2237820	260	27.44
TLOW	3584	3.54	45	350	6.5	366080	102	4.49
TIND	5370	5.30	100	1	6.5	0	0	0.00
TDEV	9965	9.84	45	1	0	0	0	0.00
TGOV	1009	1.00	100	1	0	0	0	0.00
TDEF	9125	9.01	90	500	6.5	118625	13	1.45
TAGR	4619	4.56	100	1	0	0	0	0.00
TOTH	50515	49.89	100	1	0	0	0	0.00
TOTAL	101256	100.00				8154325	81	100.00

Data extracted from AutoCAD, (land type and their corresponding areas), can also be read in LOTUS 1-2-3 spreadsheets using the LOTUS Commands: / File Import Number. There they can be sorted by categories and other data such as percentage of circulation and open space, average plot size, persons per plots can be added to the table to evaluate population density.

D. Establishing a Housing Typology
Using "SPOT" Satellite Images and a Set of Aerial Photographs

3.40 A housing typology is a classification of different residential patterns of development or urban fabrics that have the same physical and socioeconomic characteristics. A housing typology may structure or complement socioeconomic data gathered through census and sample surveys. Such study helps disaggregate data spatially after different patterns of development have been identified from a satellite image. (See Figure 3.6 for the Identification of Different Urban Features from "SPOT" Panchromatic Print.)

3.41 The methodology for developing the typology, selecting housing types, gathering data and performing the appropriate analyses is described in this section.

Selecting the Housing Types

3.42 Housing types are selected from satellite images or aerial photographs according to distinctive development patterns consisting of plot and dwelling unit sizes, construction types, and density. Areas to be studied are selected from aerial photos enlarged at scales 1:5,000 to 1:10,000. If aerial photos are not available, a typology may be developed from SPOT satellite images. Ideally, both aerial photos and SPOT satellite images should be used because each has relative advantages. A satellite image covers an area of 60km x 60km, eliminating the need for photo mosaics when analyzing a large urban area such as Karachi. On the other hand, aerial photos provide excellent resolution for more detailed analysis.

3.43 Using a panchromatic photographic print at the scale of 1:24,000, four different patterns of development were identified by the study. Some of the selected urban patterns were blown up to a scale of 1:6,000 after computer enhancement of the image. While these prints (Figures 3.15 to 3.18) do not offer the same detail as aerial photos at the same scale, they can be used to evaluate densities based on block dimensions, street widths, and the number of plots per block. This was possible on two of the prints (Figures 3.17 to 3.18) where streets and blocks were well defined.

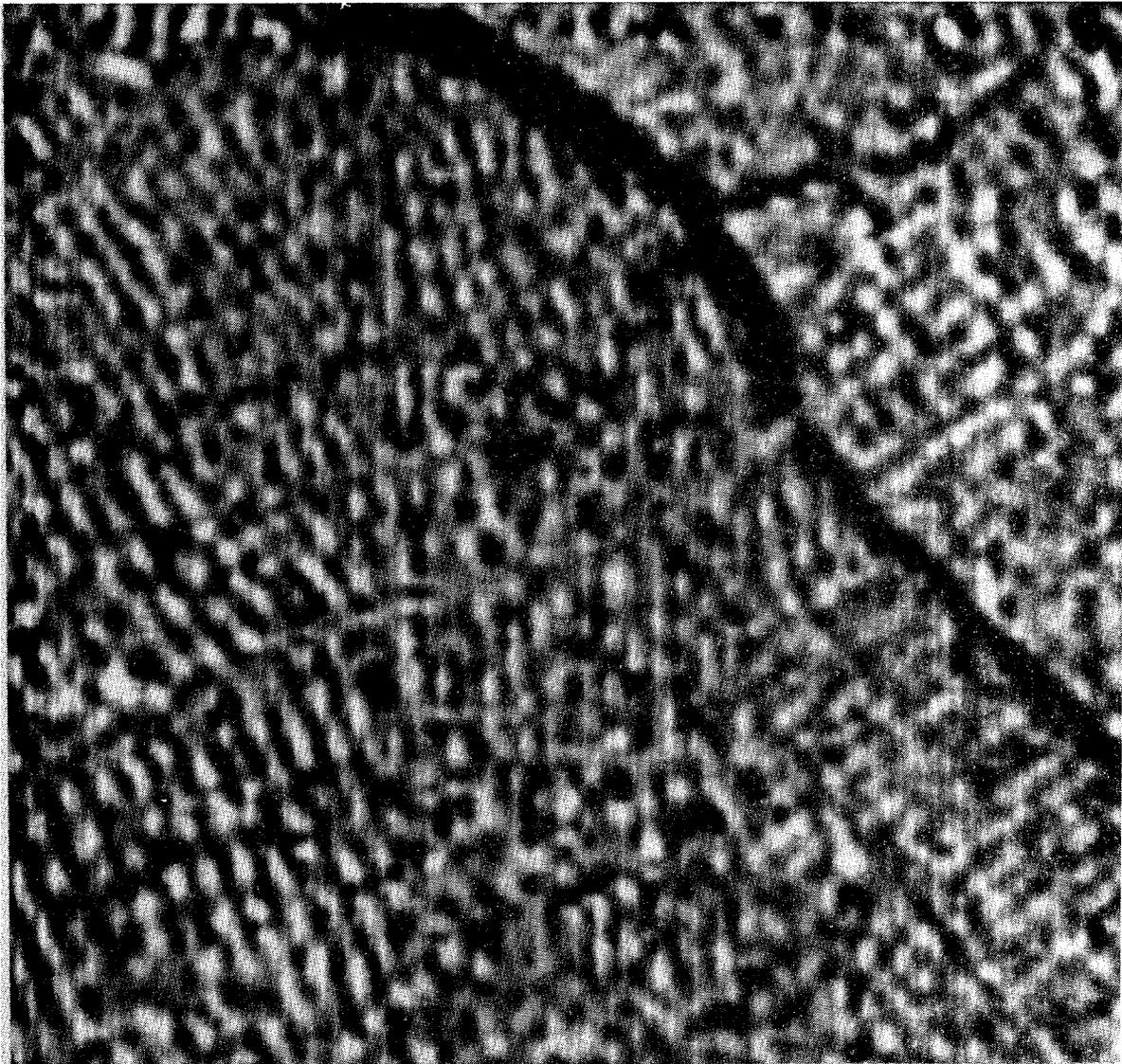
3.44 The resolution of a SPOT image is not precise enough to evaluate densities in compact urban areas, such as squatter settlements and the congested city center. Aerial photos coupled with field surveys are recommended to calculate with accuracy urban density. However, recent SPOT images in combination with older aerial photos can produce the same level of accuracy.

3.45 In the case of Karachi, both SPOT images and aerial photographs were used but it was not possible to obtain full aerial coverage for the entire city. The available set of photos, dated from October 1988, covered three areas: a strip along the Layari River, Baldia, and Korangi. These photos were used to more accurately evaluate the four types of development previously selected from satellite images. From the aerial photo (shown in Figure 3.19) it was possible to differentiate a fifth residential type, an apartment complex, which was misclassified in the first interpretation of the satellite images. Most apartment complexes are located along the Hyderabad Super Highway and in the center of Karachi.

FIGURE 3.15

Type A - Squatter Settlement
"SPOT" Panchromatic Satellite Image
Photographic Print at Scale 1:6,000
Karachi, Pakistan

DENSITY: 650 PERSONS/HA



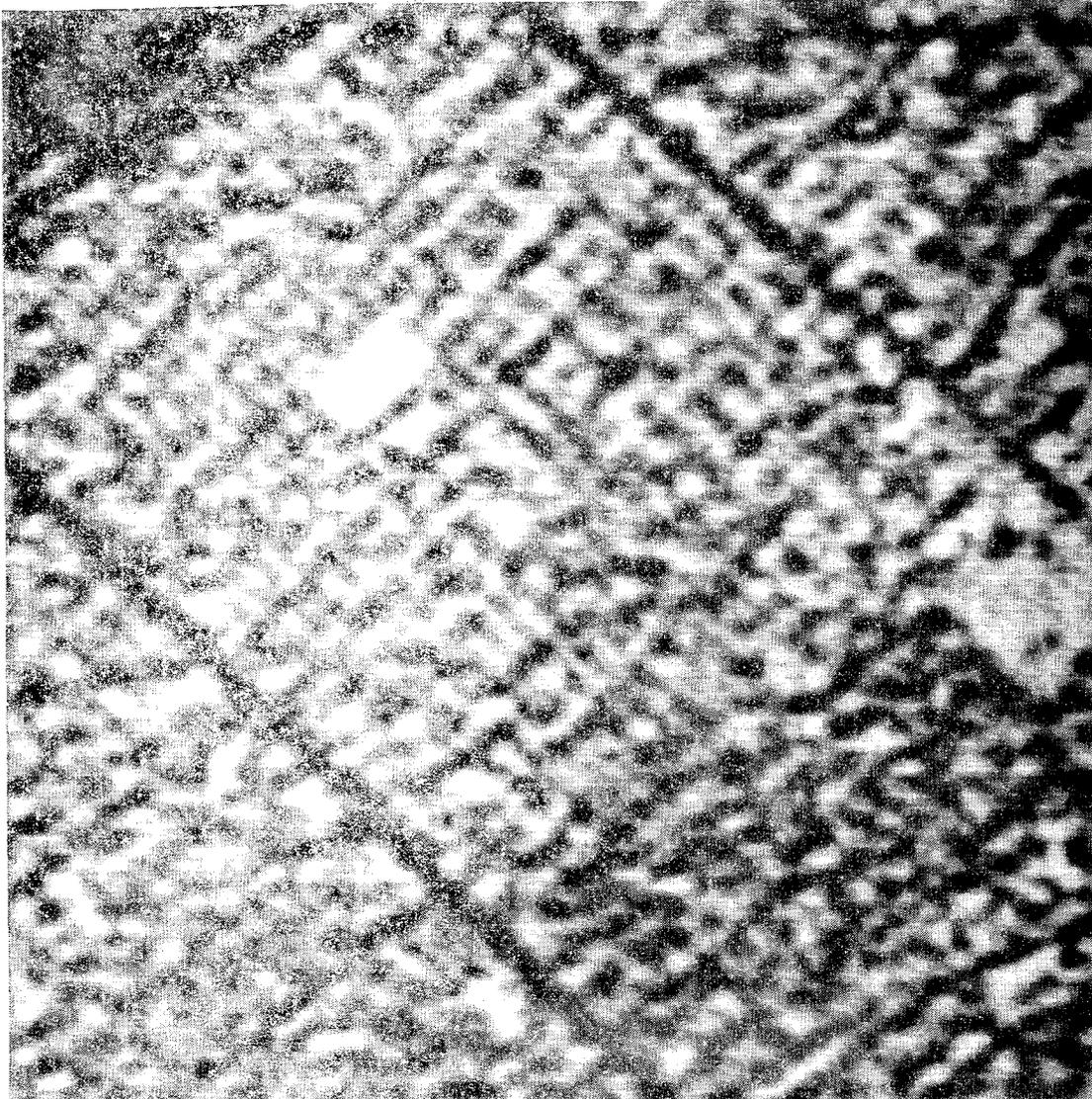
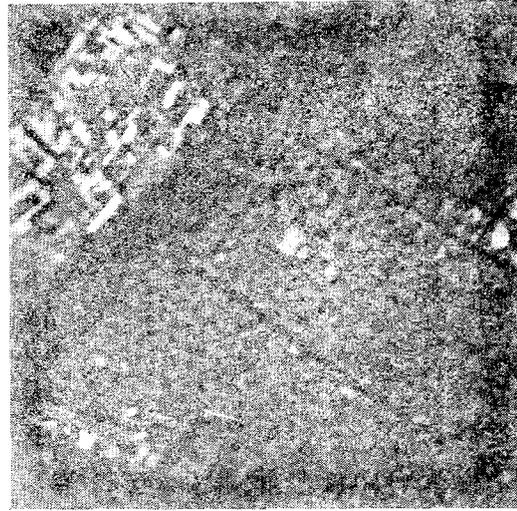
Copyright 1986 CNES. SPOT Image Corporation, Reston Virginia

This photographic print is the result of 3x3 high pass filter Kernel applied to enhance urban detail.

FIGURE 3.16

Type B - High density
"SPOT" Panchromatic Satellite Image
Photographic Print at Scale 1:6,000
Karachi, Pakistan

DENSITY: 625 PERSONS/HA



Copyright 1986 CNES. SPOT Image Corporation, Reston Virginia

This photographic print is the result of 3x3 high-pass filter Kernel applied to enhance urban detail.

FIGURE 3.17

Type C - Medium density
"SPOT" Panchromatic Satellite Image
Photographic Print at Scale 1:6,000
Karachi, Pakistan

DENSITY: 260 PERSONS/HA



Copyright 1986 CNES. SPOT Image Corporation, Reston Virginia

This photographic print is the result of 3x3 high-pass filter Kernel applied to enhance urban detail.

FIGURE 3.18

Type D - Low Density
"SPOT" Panchromatic Satellite Image
Photographic Print at Scale 1:6,000
Karachi, Pakistan

DENSITY: 102 PERSONS/HA



Copyright 1986 CNES. SPOT Image Corporation, Reston Virginia

This photographic print is the result of 3x3 high pass filter Kernel applied to enhance urban detail.

3.46 After the different urban patterns were identified from satellite images, identical patterns of development were extracted from the aerial photos and average densities were calculated. From aerial photos, block dimensions, street widths, percentages of circulation and open space, plot sizes, and number of plots per block could be evaluated and used to calculate average densities (as shown in Figures 3.20 to 3.22). Types A and C were reclassified into sub-types since plot size variations between these types may change these averages.

3.47 Density was calculated on the basis of block dimensions (from road center line), percentage of open space for each type of development (percentage estimated from satellite photographic print at a scale of 1:24,000), the number of plots per block and the number of persons per plot. Household size was drawn from secondary data and was verified by selected field surveys. Density (persons per hectare) was calculated according to the following formula:

$$D = (n \times p) / ((b1 \times b2) + (b1 \times b2)/100 \times s) \times 10000$$

where D = Density persons/ha

n = Number of plots in block

p = Number of persons per plot

b1 = Block length

b2 = Block width

s = Percentage of open space

3.48 Various densities calculated from the seven different types are listed in Table 3.1. The densities estimated from satellite images were updated to reflect the data calculated from aerial photographic analysis. On the basis of this analysis it was possible to estimate Karachi's population. A map of Karachi's population distribution by housing type was derived from this study and is presented in Figure 4.13.

TABLE 3.1
AVERAGE DENSITIES AMONG DIFFERENT TYPES
OF RESIDENTIAL DEVELOPMENT

Type	Description	Density Persons/Hectare
A1	Katchi Abadi - Next to waterways & railways	655
A2	Katchi Abadi - Illegal subdivision	496
B	Semi Pucca Houses - Old city center	630
C1	Semi Pucca & Pucca Houses - Small plot size	424
C2	Pucca Houses - Medium plot size	213
D	Bungalow - Houses on large plot size	110
E	Apartment Complex	1125

FIGURE 3.19
 IDENTIFICATION OF DIFFERENT HOUSING TYPES
 ON AERIAL PHOTOGRAPH AT SCALE 1:4,000

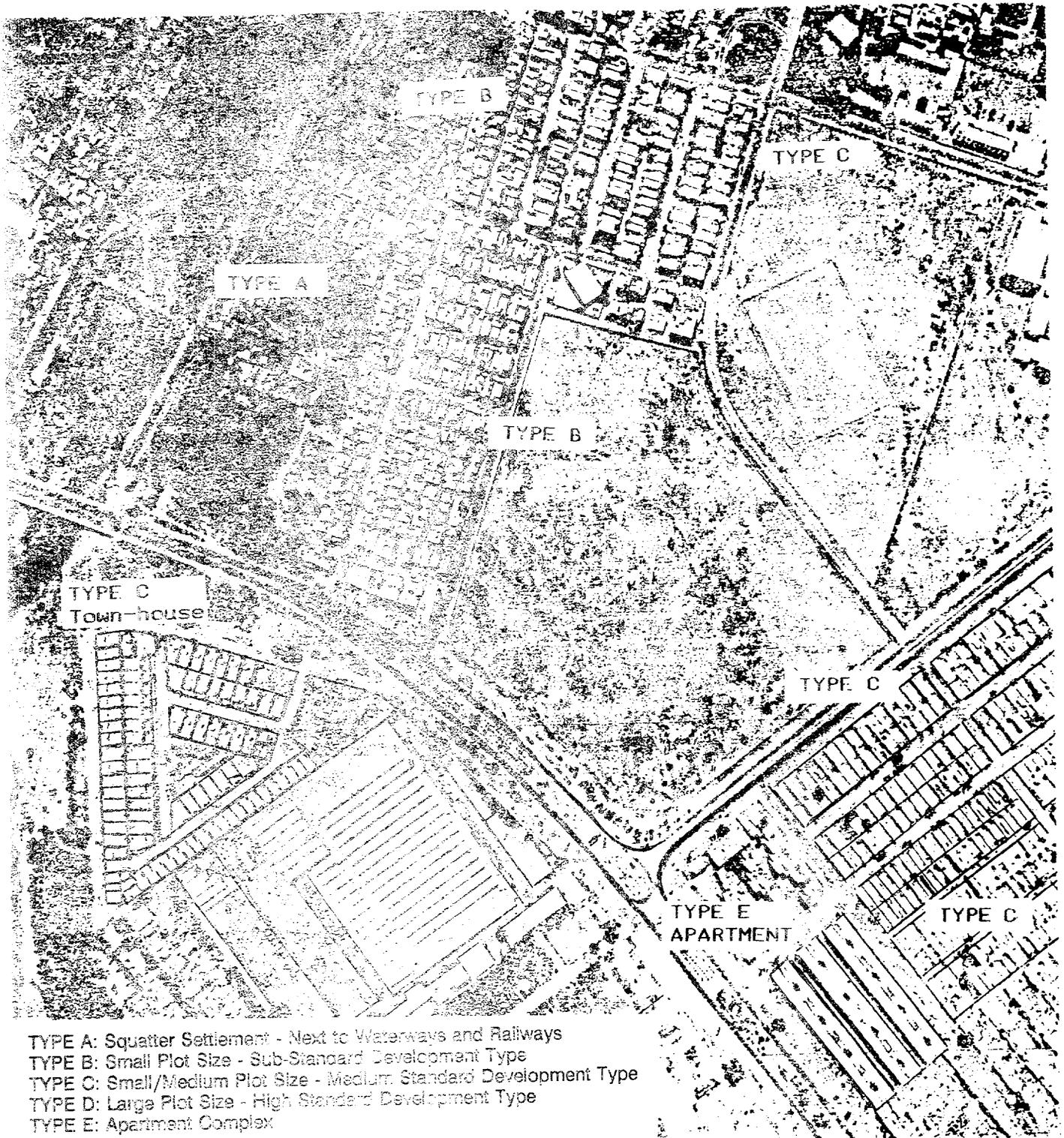


FIGURE 3.20
DIFFERENT TYPES OF RESIDENTIAL DEVELOPMENT

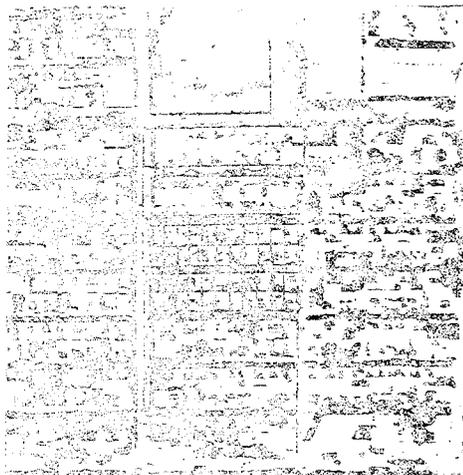
TYPE A1 - KATCHI ABADI
Squatter Settlement

Block Length (m)	:	55
Block Width (m)	:	26
Collateral Road (m)	:	4.5
Access Road (m)	:	2
% of Circulation	:	10
% Open Space & Comm.Fac.:		25
No. of Plots in Block	:	18
Average Plot Size (m ²)	:	60
No. Persons/Plot	:	6.5
Density Persons/Hectare	:	655



TYPE A2 - KATCHI ABADI
Illegal Subdivision

Block Length (m)	:	90
Block Width (m)	:	30
Collateral Road (m)	:	10
Access Road (m)	:	4.5
% of Circulation	:	18
% Open Space & Comm.Fac.:		12
No. of Plots in Block	:	20
Average Plot Size (m ²)	:	90
No. Persons/Plot	:	7.5
Density Persons/Hectare	:	496



TYPE B - OLD CITY

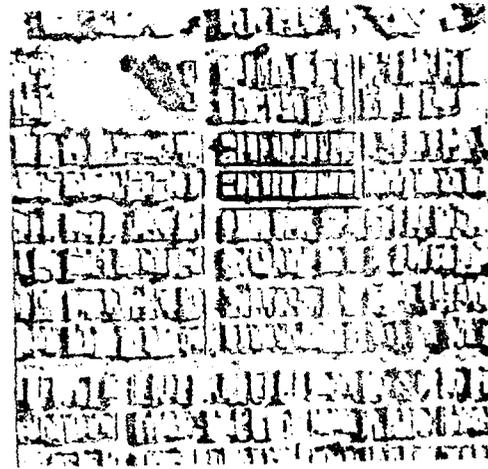
Block Length (m)	:	84
Block Width (m)	:	52
Collateral Road (m)	:	6
Access Road (m)	:	2.5
% of Circulation	:	14
% Open Space & Comm.Fac.:		5
No. of Plots in Block	:	34
Average Plot Size (m ²)	:	115
No. Persons/Plot	:	8.5
Density Persons/Hectare	:	630



FIGURE 3.21
DIFFERENT TYPES OF RESIDENTIAL DEVELOPMENT

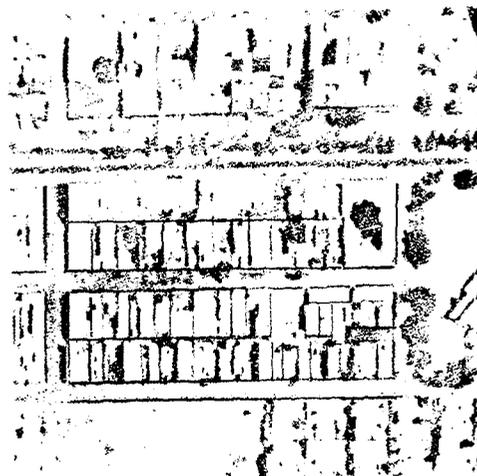
TYPE C1 - SMALL PLOT SIZE

Block Length (m)	:	80
Block Width (m)	:	40
Collateral Road (m)	:	10
Access Road (m)	:	6
% of Circulation	:	18
% Open Space & Comm.Fac.:	:	15
No. of Plots in Block	:	24
Average Plot Size (m ²)	:	90
No. Persons/Plot	:	6.5
Density Persons/Hectare	:	424



TYPE C2 - MEDIUM PLOT SIZE

Block Length (m)	:	185
Block Width (m)	:	58
Collateral Road (m)	:	15
Access Road (m)	:	10
% of Circulation	:	20
% Open Space & Comm.Fac.:	:	25
No. of Plots in Block	:	44
Average Plot Size (m ²)	:	180
No. Persons/Plot	:	6.5
Density Persons/Hectare	:	213



TYPE D - BUNGALOW

Block Length (m)	:	190
Block Width (m)	:	56 to 84
Collateral Road (m)	:	12
Access Road (m)	:	8
% of Circulation	:	35
% Open Space & Comm.Fac.:	:	18
No. of Plots in Block	:	18 to 26
Average Plot Size (m ²)	:	350 & +
No. Persons/Plot	:	6.5
Density Persons/Hectare	:	110

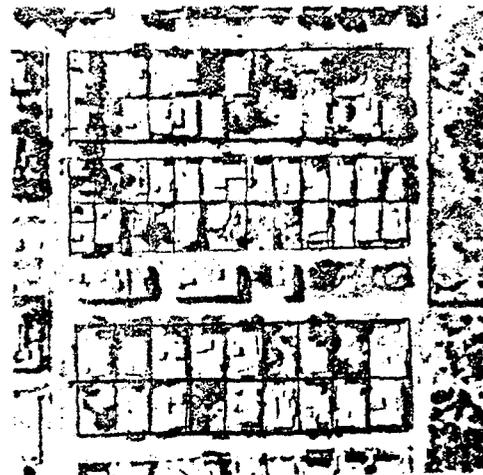


FIGURE 3.22
DIFFERENT TYPES OF RESIDENTIAL DEVELOPMENT

TYPE E**Apartment Complex**

Total area (m ²)	: 9600
Collateral Road (m)	: 22
Access Road (m)	: 20
% of Circulation	: 32
% Open Space & Comm.Fac.:	28
Built-up Area (m ²)	: 4032
Number of Floors	: 4
Floor Area (m ²)	:16128 (FAR=1.7)
Number of Apartments	: 216
Average Unit Size (m ²)	:60 to 80
No. of Persons/Unit	: 6.5
Density Persons/Hectare	: 1125



3.49 Within the five different types of residential development (A, B, C, D and E) as listed above, fourteen different dwelling units were selected for field survey. Housing categories such as katchi abadi, semi-pucca, pucca and bungalow, are terms used by the Karachi Development Authority to classify different dwelling units found in the Karachi urban area. These categories are briefly described below:

- **Katchi Abadi** - Squatter settlements, along waterways, adjacent to railways and other hazardous areas. This term is also applied to illegal subdivisions. The dwelling units are generally made of stone, brick and cement block with corrugated roofs.
- **Semi-Pucca House** - Low standard type of development; houses made of stone, brick, concrete block and corrugated roofs.
- **Pucca House** - Medium to high standard type of development; concrete structures and concrete slab roofs.
- **Bungalow** - High standard type of development; houses built on large plots, consisting of concrete structures and concrete slab roofs.
- **Apartment Complex**

3.50 Other characteristics attributed to each dwelling unit type, such as average number of rooms, average plot sizes and household incomes are listed in Table 3.2

TABLE 3.2
HOUSING TYPE CLASSIFICATION

HOUSING TYPOLOGY - HOUSING TYPES					
Category	Type	Description	Plot Size (m ²)	House or Apartment Size (m ²)	Income Range (Rs.)
KATCHI-	A1	1 Room - Sharing WC, no water, no electricity	30 to 40	12 to 15	501 - 1000
ABADI	A2	1 Room - No water no electricity	30 to 40	12 to 15	501 - 1000
	A3	2 Rooms - Squatter Settlement next to waterways	50 to 70	25 to 50	1001 - 1800
	A4	2-3 Rooms - Illegal Subdivision	70 to 90	50 to 70	1500 - 2000
SEMI-PUCCA	B	2-4 Rooms, 1,2 Levels - Old City Center	70 to 90	55 to 120	2001 - 6500
PUCCA	C1	2-3 Rooms - New Development, Small plot size	70 to 100	30 to 60	2001 - 2500
	C2	2-4 Rooms, 1-2 Levels - Small plot size	70 to 100	60 to 85	2501 - 5000
	C3	2-4 Rooms, 1-2 Levels - Metroville, medium plot	100 to 250	60 to 85	5001 - 8000
	C4	4-5 Rooms, 1-2 Levels - Medium plot size	120 to 250	70 to 95	10001 and more
	C5	5-8 Rooms, 2 Levels - Townhouse	120 to 180	90 to 120	20001 and more
BUNGALOW	D	5-10 Rooms, 1-2 Levels - Large plot size	300 and +	150 to 400+	25001 and more
APARTMENT	E1	1-2 Rooms, Building of 4 to 5 levels	FAR: 2.2	25 to 45	4001 - 6000
	E2	3,5 Rooms, Building of 4 to 5 levels	FAR: 1.7	50 to 140	15000 and more
	E3	3-5 Rooms, Building of 4 to 18 levels	FAR: 1.3	70 to 180	25001 and more

Data To Be Gathered During Field Surveys

3.51 Once urban fabrics or housing types have been identified, selected field surveys are needed to check plot sizes, road widths, number of floors, number of units in multi-family dwelling units and walk-up apartment buildings. During the field surveys, other physical and socioeconomic data are collected such as building condition, household sizes, rents, monthly expenses and consumption of water, electricity, gas or fuel, use of transport, estimated property value, etc. In the case of Karachi, a qualitative questionnaire was designed to provide basic data used in this study. Plans and photos of some of the fourteen housing units visited are presented together with the data collected during field survey in Annex 3.

3.52 Data of fourteen housing units with graphics that show space utilization (or living area) per person and plot size variation by housing type are presented in Table 3.3 and Figures 3.23 and 3.24.

TABLE 3.3

HOUSING TYPES AND CHARACTERISTICS

HOUSING TYPES:	A1	A2	A3	A4	B	C1	C2	C3	C4	C5	D	E1	E2	E3
Description:	Katchi- Abadi Semi- Pucca 1 Room Sharing Toilet	Katchi- Abadi Semi- Pucca 1 Room	Katchi- Abadi Semi- Pucca House Next to River	Katchi- Abadi Semi- Pucca House Illegal Developmt	Semi- Pucca House Old Construc- tion	Pucca House New Cons- truct- tion	Pucca House Small Plot Size	Pucca House Medium Plot Size Metro- ville	Pucca House Medium Plot Size 2 to 3 Levels	Pucca Town- House Medium Plot Size 2 levels	Bungalow Single House Large Plot Size	Apartmt Small Size Unit	Apartmt Medium Size Unit	Apartmt Large Size Unit
Plot size (m2)	163.87	31.53	50.63	90	90	70	86.13	114.7	161.88	162	416	1500	7316	3600
No. Units/Plot	8	1	1	2	1	1	1	1	2	1	1	40	128	24
Built-up Area (m2)	75.00	16.95	27.50	64.00	75.00	33.66	60.17	81.50	76.41	92.40	254.50	2190	6604	1125
Covered Area (m2)	75.00	16.95	27.50	64.00	90.00	33.66	60.17	81.50	145.31	216.48	254.50	45.00	140.00	269.00
Living Space (m2)	12.25	10.56	21.88	26.53	80.42	26.88	40.57	47.60	54.04	164.40	133.71	40.00	92.54	165.88
No. Rooms/Unit	1	1	2	2	4	2	5	4	4	7	6	2	5	5
Kitchen	0	0	1	1	1	1	1	1	1	1	1	1	1	1
Bathroom	0	0	0	1	1	1	2	1	1	3	4	1	3	4
Toilet WC	1/8	1	1	1	2	1	2	1	1	3	4	1	3	4
No. Persons/Unit	5	5	5	5	16	5	6	7	6	7	5	5	8	5
No. Persons/Room	5.0	5.0	2.5	2.5	4.0	2.5	1.2	1.8	1.5	1.0	0.8	2.5	1.6	1.0
Living m2/person	2.45	2.11	4.38	5.31	5.03	5.38	6.76	6.80	9.01	23.49	26.74	8.00	11.57	33.18
Dweller Status	Illegal	Illegal	Renter	Owner	Illegal	Owner	Owner	Owner	Owner	Owner	Owner	Owner	Owner	Owner
Propert. Value Rs.	30,000	3,750	25,000	60,000	200,000	46,900	200,000	200,000	800,000	900,000	1,500,000	100,000	500,000	1,000,000
Value/m2	400	221	909	938	2222	1393	3324	2454	5505	4157	5894	2222	3571	3717
Monthly Rent Rs.	200	200	300	400	2,000	350	1,000	800	3,500	6,500	15,000	1,000	3,000	12,000
Water+Gas+Elec.	50	54	104	121	262	129	243	187	747	1,008	1,708	227	625	1,833
Transport Expenses	0	0	300	300	270	600	600	1,800	1,500	1,500	2,000	1,200	1,500	2,000
Month. Income Rs.	800	800	1,800	2,500	6,500	2,750	5,000	8,000	15,000	25,000	50,000	6,000	15,000	50,000
Employed Persons	2	2	1	1	3	2	1	3	2	2	1	3	1	1
% of Monthly Income for Rent	25.00	25.00	16.67	16.00	30.77	12.73	20.00	10.00	23.33	26.00	30.00	16.67	20.00	24.00
% of Month. Income for Rent+Elect+ Water+Gas+Transp.	31.25	31.75	39.11	32.84	38.95	39.24	36.86	34.84	38.31	36.03	37.42	40.45	34.17	31.67

FIGURE 3.23

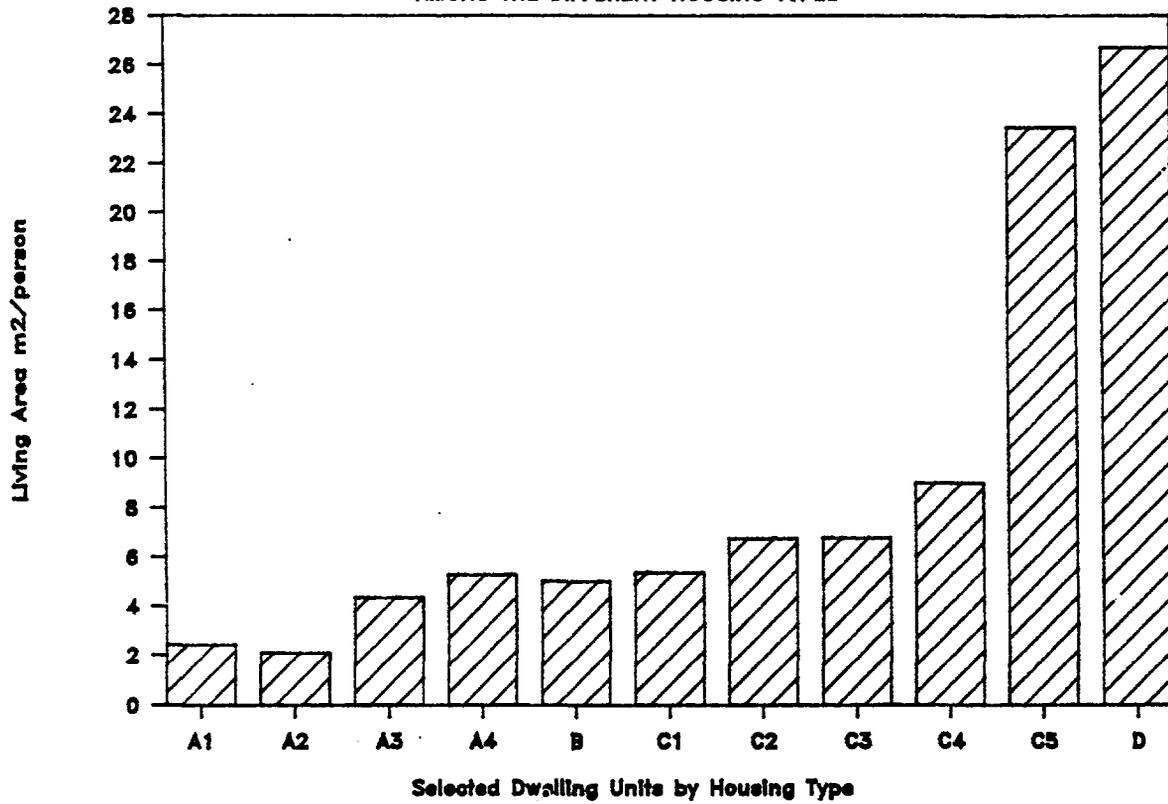
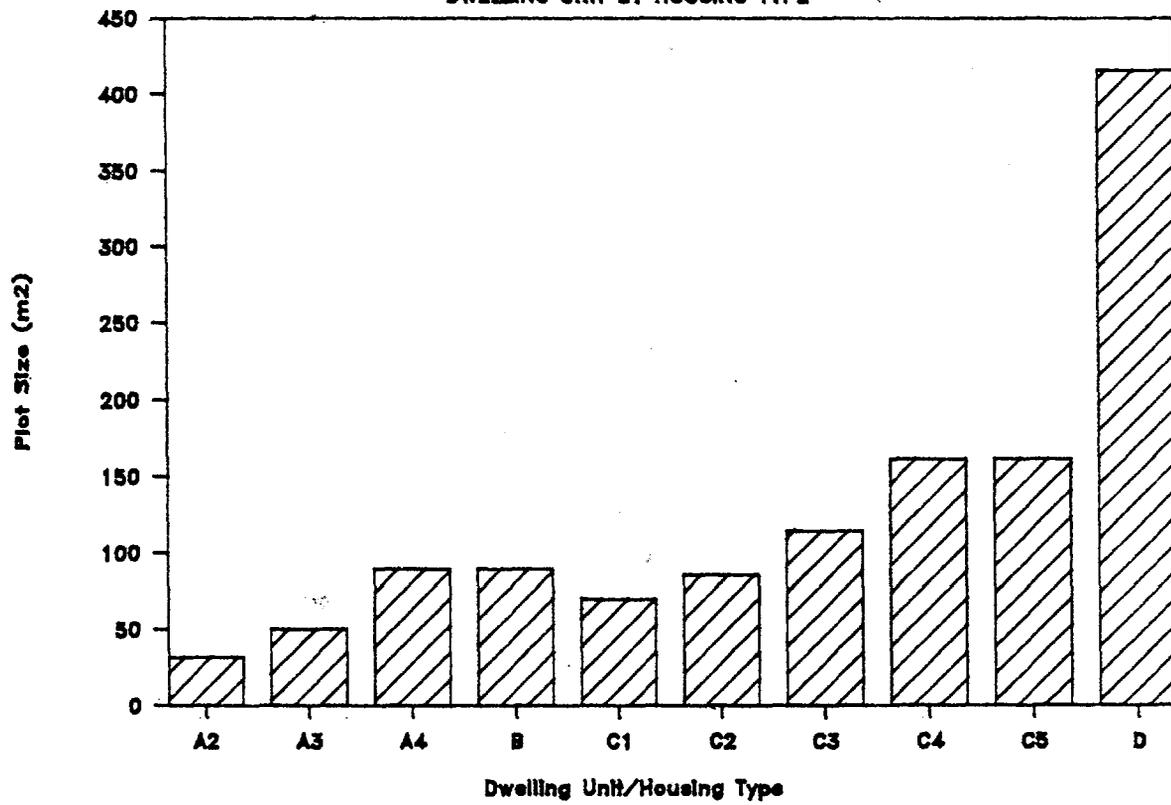
**SPACE ACCOMMODATION PER PERSON
AMONG THE DIFFERENT HOUSING TYPES**

FIGURE 3.24

**PLOT SIZES COMPARISON BETWEEN SELECTED
DWELLING UNIT BY HOUSING TYPE**



Potential Use of Housing Typology Data

3.53 A housing typology may be used in urban planning to project land requirements by type. The typology also permits an evaluation of urban dwellers' housing investment. In the case of Karachi, squatter settlements represent sizable housing investments by low and medium income group families. Unfortunately, the environmental conditions and services in many of these settlements are poor and it is clear that households in these settlements have no alternative to squatting on undesirable areas as seen in Figure 3.25. A map derived from a SPOT satellite image dated January 1987 shows the Katchi Abadies locations and their projected expansion by the year 2000 (Figure 3.26). The expansion area has been calculated in relation to data collected from a previous study, "The Low-Income Housing Markets in Karachi: 1988 Conspectus". In this technical note Mr. J. Van der Linden estimated the expansion of Baldia and Aurangi, two large katchi abadi settlements, close to 3 percent per year. If the population of katchi abadies is growing at an annual rate of 6 percent, as indicated in this document, and if the density remains the same, at 496 persons/hectare, the area of the katchi abadies in the Year 2000 will be 7900 hectares. This area will accommodate a population close to 4 million inhabitants.

3.54 A housing typology may also be used to assess trends in the housing market, evaluating the supply and demand of each type of housing. For example, it is clear from this brief study that the demand of housing for medium income groups is not entirely satisfied by the formal development process. As a result, medium income group households are also looking for purchasing plots in illegal subdivisions while hectares and hectares of land have been developed but remain inaccessible to this group. This explains why construction standards in some katchi abadies are quite high.

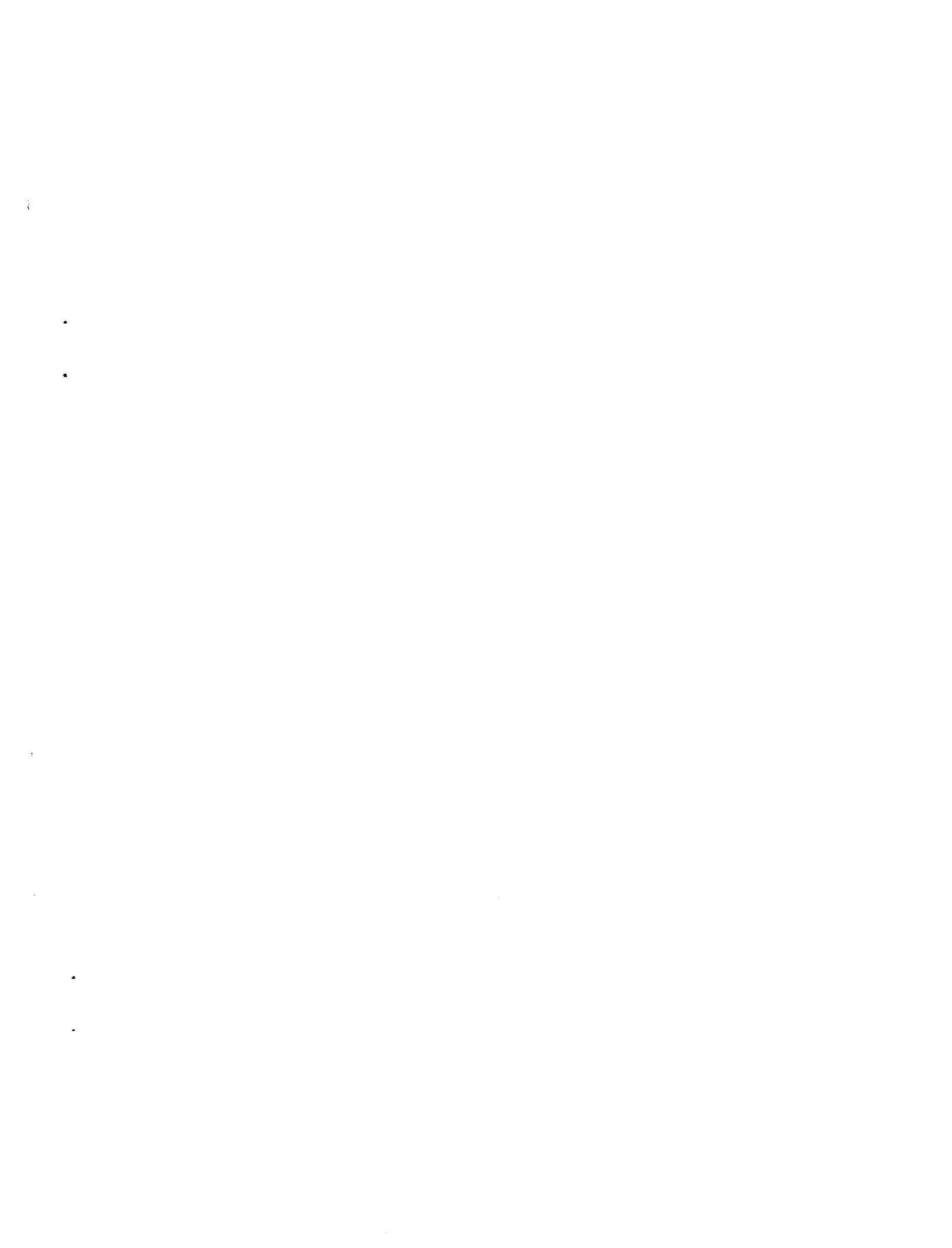
3.55 A major complaint voiced during the field survey was poor water supply. This was a problem not only in illegal subdivisions but in other housing types as well. In apartment complexes, for example, there was insufficient pressure for water to reach the third and fourth floors. Demands on water can be evaluated according to the different consumption patterns. For low standard types of construction (types A and B) with limited kitchen and toilet facilities such as a turkish toilet and a washing basin in kitchen and bathroom, the average daily consumption is about 30 to 40 liters per person. Where houses with modern kitchen and bathroom facilities the average is about 120 liters per person per day. The demand on water supply can be evaluated by sector or the entire city using these consumption rates and population data that can be estimated from satellite image as discussed below.

3.56 As indicated earlier, the housing typology was used to assess densities by residential development types. Areas corresponding to the different housing types were identified on panchromatic and multispectral satellite image photographic prints at a scale of 1:24,000. The areas were measured on the housing typology and land use map digitized from the panchromatic satellite image (Figure 3.27).

FIGURE 3.25

SQUATTER SETTLEMENTS ALONG RAILWAYS AND ON SWAMP LAND



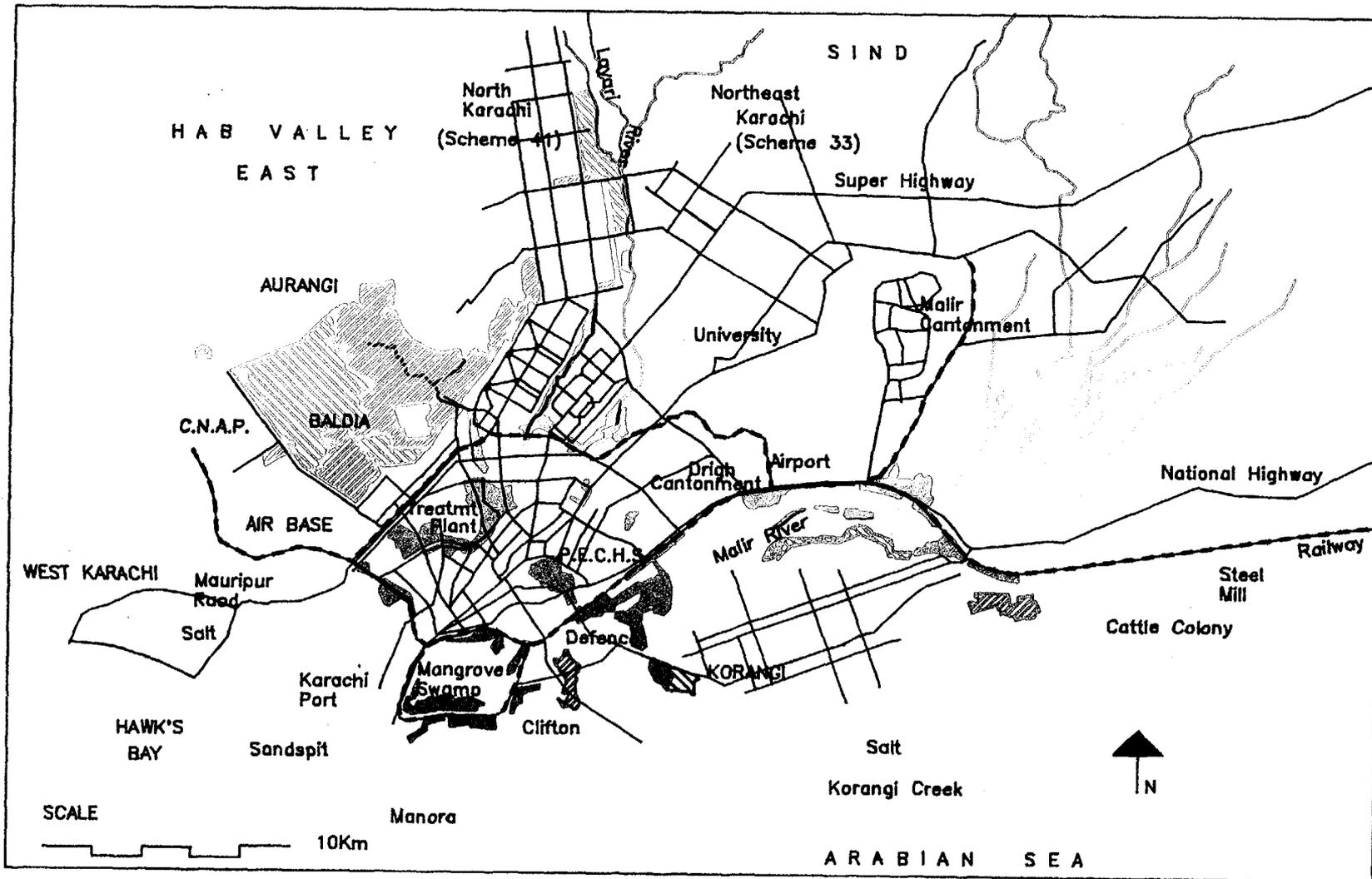


**FIGURE 3.26
KATCHI ABADIES LOCATIONS
AND PROJECTED EXPANSION BY THE YEAR 2000**

**KARACHI — KATCHI ABADIES LOCATIONS YEAR 1988
AND PROJECTED EXPANSION YEAR 2000**

Map derived from a "SPOT" satellite image of Jan. 1987

	AREA (HA)	AVERAGE DENSITY PERSONS/HA	AREA Ha
A1 Katchi Abadi Next to Waterway & Railway	2331	655	Katchi Abadi Expansion Year 2000 2500
A2 Katchi Abadi Illegal Subdivision	3077	486	



1. 1

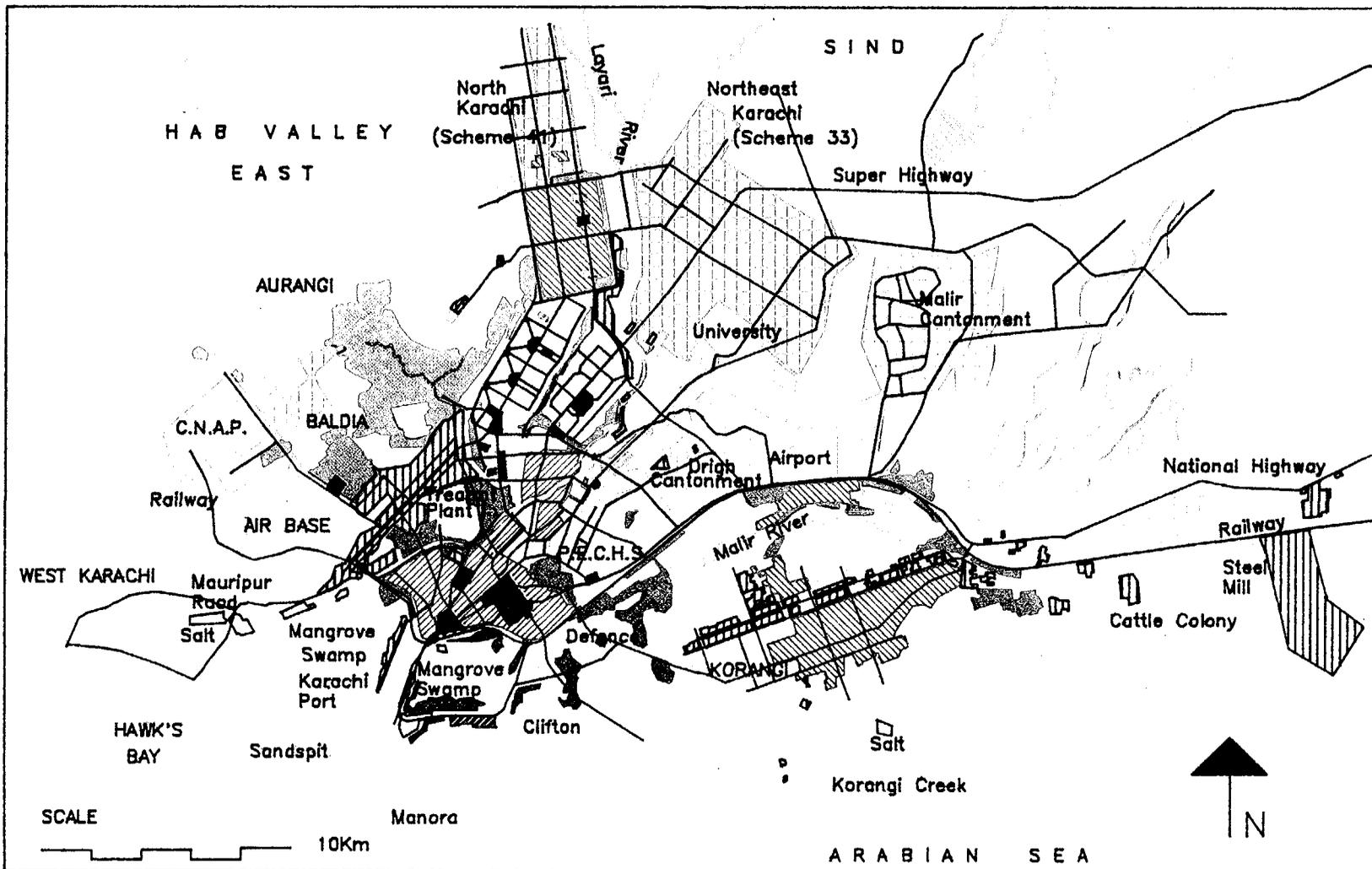
1. 1

FIGURE 3.27
KARACHI - HOUSING TYPOLOGY AND LAND USE MAP

KARACHI — HOUSING TYPOLOGY AND LAND USE

Map derived from "SPOT" satellite image of Jan. 1987 and aerial photographs from Oct. 1988

- | | | | |
|--|---|--|--|
|  A (Katchi Abadi) Squatter Settlement |  C2+ (Pucca) Medium Plot Size |  Commerces |  Services/Util. Govemnt/Inst. |
|  B (Semi Pucca) High Density |  D (Bungalow) Large Plot Size |  Industries |  Defense |
|  C1 (Pucca & Semi-Pucca) Small Plot |  E (Apartment) |  Developed land |  Agriculture |



3.57 Population calculation was made according to the different residential areas and their corresponding densities as listed in Table 3.1. The average density of 564 persons per hectare for type A, corresponds to type A1 - squatter settlements - (2331 hectares, density 655 persons/hectare) and type A2 - illegal subdivisions - (3077 hectares, density 496 person/hectare). Karachi's population estimation for the year 1988 according to these data is close to 8,200,000 inhabitants. Figure 3.28, Karachi population distribution by housing type, indicates that a large proportion of the urban population, about 37 percent, is living in either katchi abadies or in sub-standard type of houses. Low and medium income group families represent about 81 percent of the population of Karachi, 37 percent living in squatter settlements, 34 percent in the old city center (type B), 9 percent living in semi-pucca and small pucca houses (type C1) and about 1 percent or more in small apartment units.

3.58 NOTE: The field work and analysis for this Section was carried out over a ten day period. The data and analysis presented in this study is meant to be indicative of how satellite images, aerial photographs, and limited field surveys can be used as tools in a planning process.

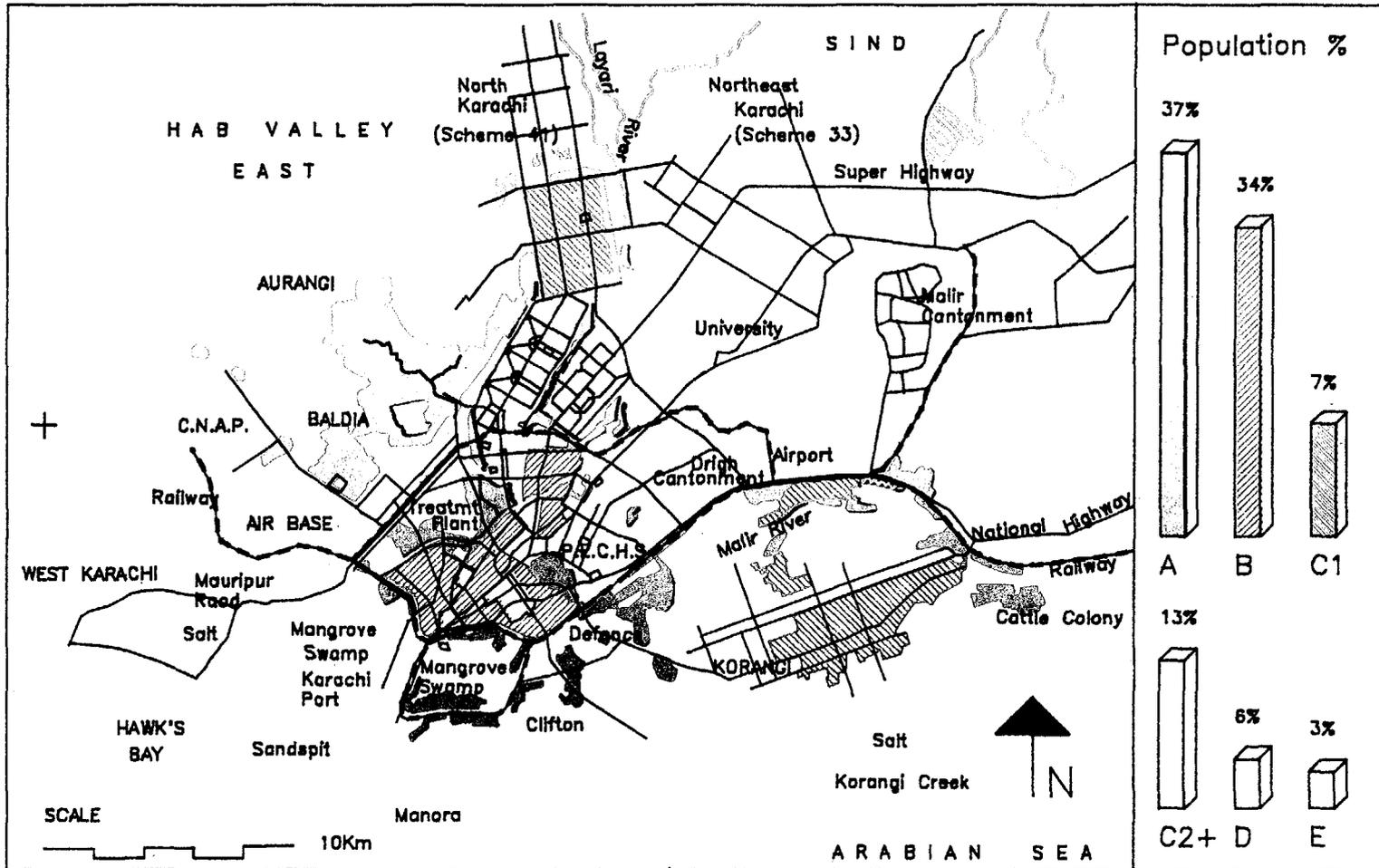


FIGURE 3.28
KARACHI POPULATION DISTRIBUTION BY HOUSING TYPE

KARACHI – POPULATION DISTRIBUTION BY HOUSING TYPE

Map derived from a SPOT satellite image of Jan. 1987
and aerial photographs from Oct. 1988)

TYPE	AREA (HA)	AVERAGE DENSITY PERSONS/HA	TYPE	AREA (HA)	AVERAGE DENSITY PERSONS/HA
A (Katchi Abadi) Squatter Settlement	5408	584	C2+ (Pucca) Medium Plot	5068	213
B (Semi Pucca) High Density	4403	630	D (Bungalow) Large Plot	4119	110
C1 (Pucca & Semi-Pucca) Small Plot	1284	424	E (Apartment)	238	1125
					TOTAL POPULATION 1988
					8,172,982





CONCLUSION

4.01 Satellite images provide a useful planning tool to monitor the growth of large and small cities. No country on Earth can afford to update its maps at the same pace development and land use changes occur. The largest cities of the industrial world share this same problem with the mega cities of the developing world. Maps often are out of date before they are distributed. Land use maps do not correspond to zoning and more often, recently constructed roads and new developments have not been reported and located on maps. When planning new developments or monitoring urban images, satellite images can provide the information necessary to focus on the environmental problems and the need for new infrastructure. The best alternatives can be selected by determining the location of available land that can be most efficiently developed.

4.02 Previous studies using Landsat MSS and Landsat TM have shown that satellite images are valuable tools for urban planning purposes. The improved resolution of the latest generation of remote sensing satellite-based systems, "SPOT", offers even more promise. Many government agencies and universities in developing countries have remote sensing laboratories equipped with mini and microcomputers and image processing systems. They have been mainly used for strategic purposes and to monitor agriculture and the environment. SPOT data are an interesting material for these agencies and some of these countries have begun to use this new technology to monitor urban growth and as a tool for urban planning. More needs to be done in order to make this technology available to other countries where these methods can be used to monitor and manage urban areas more efficiently.

4.03 Satellite images can be used in the preparation of base maps and thematic land use maps at a scale of 1:25,000. Road maps can also be traced from satellite images (major road to secondary and tertiary roads can be clearly identified from "SPOT" panchromatic images). The road base map can be integrated with other urban networks such as water supply, sewerage, drainage, etc. The information listed on the maps, such as road length and width, pipe length and diameter, can be transferred to database management systems or Geographic Information System (GIS). These data management systems can be used for the evaluation of the various networks and for supporting maintenance activities.

4.04 Microcomputers are evolving rapidly and software running on minicomputers are now available for personal computers making GIS systems more affordable to LCD countries. Specific GIS systems for urban management have been developed for industrial countries and need to be adapted to the specific needs of developing countries. Impressive gains in microcomputer knowledge have been made in these places and government agencies in many countries are looking for tools to more efficiently manage their cities. Computerized urban information systems can be easily updated and can be shared with other planning agencies. Having access to the same information will permit a better coordination among public and private groups that provide urban services to urban dwellers.



A N N E X I

**COMPUTER EQUIPMENT NEEDED FOR PROCESSING SATELLITE IMAGES
FOR MAPPING AND FOR URBAN MANAGEMENT SYSTEM**



A N N E X I

COMPUTER EQUIPMENT NEEDED FOR PROCESSING SATELLITE IMAGES FOR MAPPING AND FOR URBAN MANAGEMENT SYSTEM

5.01 Satellite images in digital format can be analyzed using image processing software that runs on mainframe, mini- and micro-computer such as an IBM/AT, PS/2 and compatible systems. To efficiently run an image processing application on a microcomputer, processor speed and large hard disk size are an advantage. The volume of data to be processed is such that speed and storage capacity are needed. Microcomputers should be configured with a processor running at a speed equal to 16 to 25 mega-hertz, with a minimum hard drive storage capacity of 80MB. A 300MB hard disk, with two monitors, one for menu display and the other for image display would be best. (The second monitor should be controlled by a graphic board providing a resolution equal to 512x512 or 1024x1024 for best results.)

A. Hardware Needed to Process Satellite Images

5.02 The basic microcomputer system and peripherals needed to perform image processing analyses include the following:

- (i) IBM/AT, PS/2-386 or compatible microcomputer system with:
 - 1 high density (1.2MB) floppy drive
 - minimum 80MB to 300MB hard disk
 - 1 monochrome monitor
 - math-coprocessor
 - 2 serial ports and 1 parallel port
- (ii) 1 color monitor with high resolution graphic board (512x512 or 1024x1024 resolution)
- (iii) 1 digital tape drive to read the images from digital tapes
- (iv) 1 printer (dot matrix, color ink-jet printer or color wax-thermal printer)
- (v) 1 digitizer table size 24" x 36" or larger to be used with image processing GIS module and eventually CAD system

5.03 An IBM-PS/2 or 386 microcomputer with 80MB hard disk as described above and with peripheral equipment will cost approximately \$35,000.¹

B. Software Needed to Process Satellite Images

5.04 Several microcomputer-based image-processing software packages are now available for under \$20,000. (See list below Table I.1.) These software packages provide many of the image processing functions required; however, the processing is not performed as rapidly as in a mainframe or minicomputer.

¹ This and other approximate prices in this section are in US Dollars and refer to late 1989 data.

TABLE I.1
LIST OF SOME IMAGE PROCESSING SOFTWARE
FOR MICROCOMPUTER SYSTEMS

Software	System	Screen Resolution (pixels in rows x columns)	Compiler
ERDAS-PC	IBM/AT (and compatible systems)	512 x 512 or 1024 x 1024	FORTRAN
DECISION-IMAGE	IBM/AT	512 x 512 or 1024 x 1024	PASCAL
TERRA-MAR	IBM/AT	512 x 512 or 1024 x 1024	FORTRAN
GRASS-ELAS	ITT-UNIX	512 x 512 or 1024 x 1024	FORTRAN
GRASS	MACINTOSH IIX	512 x 512 or 1024 x 1024	FORTRAN
EASI-PACE	IBM/AT	512 x 512	FORTRAN

5.05 Digital data can be processed by companies that sell satellite images usually through a subcontracting arrangement with other groups. Processing fees for an image vary between \$10,000 to \$24,000 according to the degree of processing required. The end products will be photographic prints of the image with correction made according to existing maps, land use thematic classification, high resolution photographic prints done by merging two images (e.g. SPOT panchromatic merged with multispectral images or Landsat TM image), change detection analysis using two images of exactly the same area taken two to three years apart. Some cartography companies use satellite images and offer different services such as designing and/or updating maps at various scale, from 1:100,000 to 1:25,000.

C. Hardware Needed for Mapping and Data Management Systems

5.06 Alternatively, satellite images can be processed by digitizing a photographic print. Images can be reproduced from a film by a good photographer at a scale of 1:100,000 to 1:25,000, and using a computer-aided design (CAD) software, maps can be traced over the original print. This processing system is more affordable to developing countries. The cost of photographic print of a satellite scene (multispectral or panchromatic) made at scale 1:100,000 is less than \$2,000. From a photographic print a base map can be digitized using a CAD or GIS software.

5.07 CAD or GIS run best on IBM-PS/2 or 286 and 386 systems. The basic microcomputer hardware needed for a mapping and data management system includes the following:

- (i) IBM/AT or PS/2-386 microcomputer system with:
 - 1 high density (1.2MB) floppy drive
 - 40MB hard disk
 - 1 color monitor and graphic board
 - math-coprocessor
 - 2 serial ports and 1 parallel port
- (ii) 1 printer (dot matrix, or ink-jet printer)
- (iii) 1 digitizer tablet size 12" x 12" or larger
- (iv) 1 plotter with 2 to 6 pens (optional) to draw maps at correct scale

5.08 An IBM-PS/2 or 386 microcomputer with 40MB hard disk as described above with peripheral equipment listed above will cost approximately US \$9,000 to \$12,000 depending on the size and make of peripheral devices (printer, digitizer and plotter).

D. Software Needed for Mapping and Data Management Systems

5.09 Low-cost software packages are now available for mapping purposes. According to budget constraints one can purchase CAD (Computer Aided Design) software such as EasyCAD or AutoSketch for less than \$200. These two software packages work on an IBM/PC system with or without math-coprocessor and have the advantage to have compatible drawing files that can be immediately imported to more sophisticated CAD systems such as AutoCAD.

5.10 AutoCAD is among the most commonly used CAD software running on IBM/AT and other compatible microcomputer systems. The cost of AutoCAD (version 10) is \$3,000.

5.11 AutoCAD data written on a map can be directly imported to most popular data base management systems. dBASEIII, RBASE, and LOTUS-123 are the software that can be used to interact with an AutoCAD datafile. Third party software does permit a direct link between data generated in AutoCAD to database packages in order to extract information from maps according to specified criteria.

5.12 More advanced GIS systems have been developed for mainframe and minicomputer with software compatibility for microcomputers. The most widely used GIS system in the US and also in developing countries is ARC/INFO for mainframe and minicomputer systems, and pcARC/INFO for the microcomputer. The cost of pcARC-INFO is \$12,000.

5.13 The pcARC-INFO for microcomputers is to be used in relationship with mainframe or minicomputer ARC/INFO system. A planning agency can start with a low application such as pcARC/INFO or AutoCAD and later have their drawing files and data transferred to mini or mainframe computers. AutoCAD files are compatible with pcARC/INFO and ARC/INFO.

5.14 It should be noted that no GIS system can be immediately implemented if data have not been previously collected and formatted for computer applications. The integration of data with maps and the query possibility within a GIS system is possible only if the data share the same name. For example a data or "attribute" such as "LTYPE" should be spelled the same in a drawing file and the database field in order to extract this information from drawing to database or reverse.

5.15 The most recommended data management systems for micro-computer are dBASEIII, dBASEIV and R-BASE 5000. The cost of such software is in the range of \$400 to \$500.

E. Registered Trademarks

AutoCAD is a registered trademark of Autodesk, Inc.

ARC/INFO and pcARC/INFO are registered trademarks of ESRI, Environmental System Research Institute.

Easy CAD is a registered trademark of Evolution Computing.

ERDAS, Inc. is a registered trademark of Advanced Technology Development Center.

dBASEIII Plus and dBASEIV are registered trademarks of Ashton-Tate.

IBM, AT and PS/2 are registered trademarks of International Business Machines Corporation.

LOTUS 1-2-3 is a registered trademark of Lotus Development Corporation.

MunMAP is a registered trademark of Generation 5 Technology.

RBASE 5000 is a registered trademark of Microrim, Inc.

A N N E X II
HOW TO ACQUIRE SPOT SATELLITE IMAGES



A N N E X II

HOW TO ACQUIRE SPOT SATELLITE IMAGES

6.01 Satellite images for any city on Earth can be directly purchased through the agencies that process the images.

6.02 The information needed to order image(s) for a particular city are:

- City and country names
- 4 point coordinates - latitude and longitude - of this area
- Distances between the 4 point coordinates
- Brief description of the area or city location
- Maximum acceptable cloud cover (10 percent or less)
- Type of product needed.

(See SPOT Satellite Image Products & Processing Costs, Fig. 2.9.)

6.03 **Note: It is possible that a metropolitan area will be split between two images, in which case extra costs would be involved. If time is not a constraint, SPOT can be programmed to obtain the entire city in one scene, or two scenes can be shifted to produce a single scene. Processing costs (to merge two scenes) are less expensive than purchasing two scenes; this is possible only if the metropolitan area does not exceed SPOT scene limits (60km x 60km).**

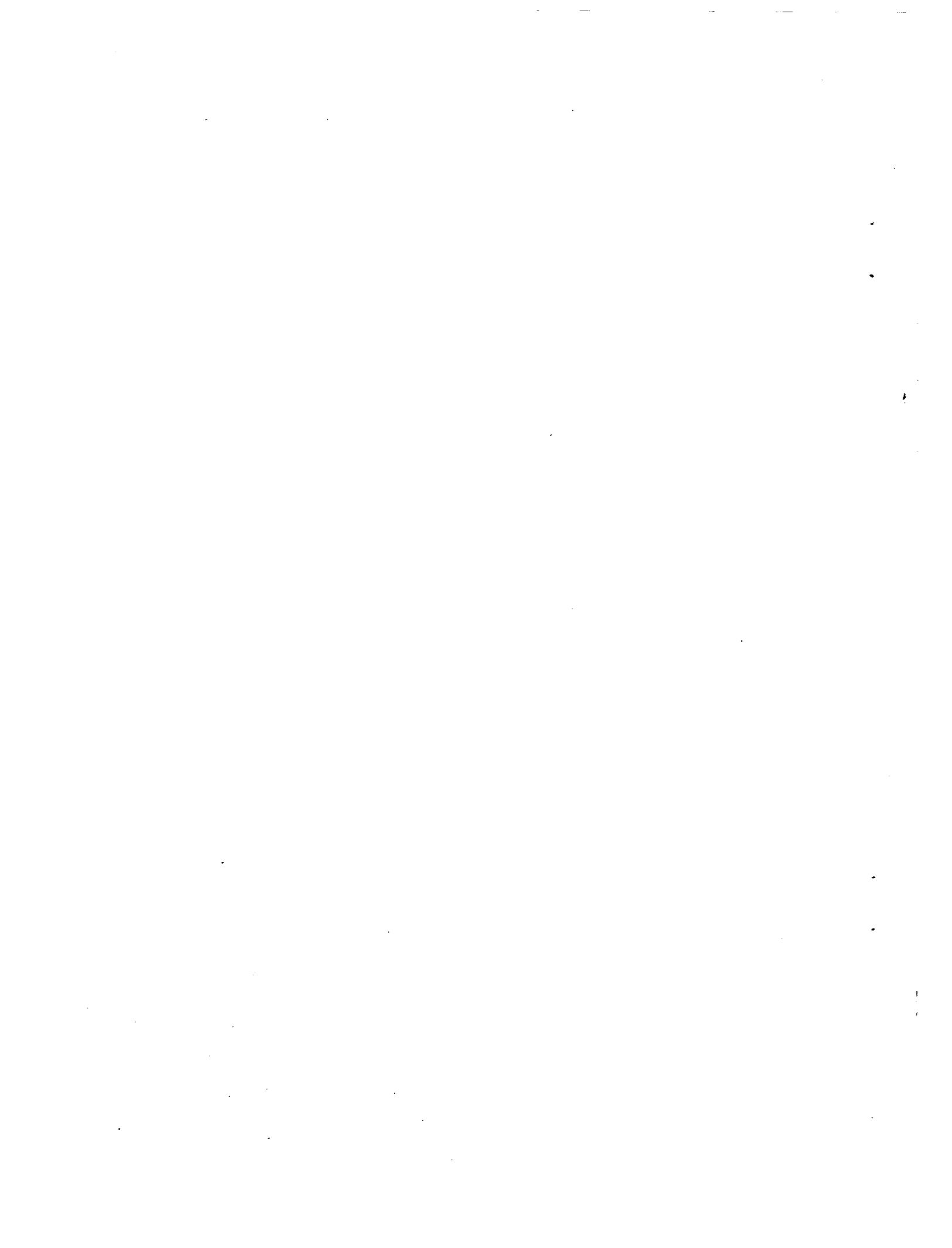
6.04 The cost for processing the satellite image will vary depending on the media (films, digital tapes, etc.). Table II.1 lists different media costs and their corresponding processing costs for different photographic prints (black & white or false color) and at different scales.

TABLE II.1
 "SPOT" SATELLITE IMAGE PRODUCTS
 AND PROCESSING COSTS

"SPOT" SATELLITE IMAGE PRODUCTS AND PROCESSING COST (1989 Cost in US Dollars)			
SATELLITE PRODUCTS	PRODUCT COST/UNIT	TYPE OF PROCESSING	PROCESSING COST
MULTISPECTRAL DIGITAL TAPE (Color image) 20m. resolution	\$1,700	Merging Multi-spectral & Panchromatic Images and Image Enhancement	\$12,000
PANCHROMATIC DIGITAL TAPE (B&w Image) 10m. resolution	\$2,200		
MULTISPECTRAL FILM (Color) Positive transparency made from digital tape 20m. resolution Scale: 1:400,000	\$1,300	Photographic Enlargement Scale: 1:100,000 Scale: 1:50,000 Scale: 1:25,000	Print (Color) \$160 \$275 \$350
PANCHROMATIC FILM (B&W) Negative transparency made from digital tape 10m. resolution Scale: 1:400,000	\$1,500	Photographic Enlargement Scale: 1:100,000 Scale: 1:50,000 Scale: 1:25,000	Print (B&W) \$65 \$100 \$350

A N N E X III

**KARACHI HOUSING TYPOLOGY
PLANS DATA AND PHOTOGRAPHS OF DIFFERENT DWELLING UNITS**



TYPE A1 - SEMI PUCCA HOUSE, Katchi Abadi

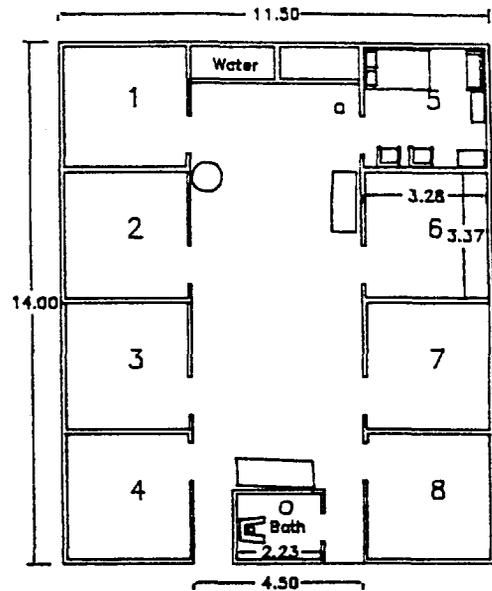
Location : MACHAR Colony - Mauripur Road
Development Type : Room accomodation around a courtyard.
Description : Informal type of development. Near dumping ground, stagnant polluted water.
Structure Condition : Fair - Building age: 8 years

Plot size : 163.87 m2 or 195.99 sq.yd.
Number of units : 8 rooms (1 room for 1 family)
Built-up Area : 75 m2 = 43.94% of plot area
Covered Area : 102.46 m2 or 122.54 sq.yd.
Unit size (room size) : 12.25 m2 or 14.65 sq.yd.
Construction Type : Structure concrete block and brick
Floor C.C. - Roof G.I.S

Equipment & Connections : No kitchen, fuel wood and kerosene
1 Turkish toilet and bath for 8 units
Not connected to water supply and sewerage, No electricity

Persons per Unit : 3 Adults, 2 Children
Area/Person : 2.45 m2 or 2.93 sq.yd.

Tenure : Illegal occupation of site
Housing Present Value : Rs. 30,000 (for plot with 8 rooms)
Monthly Rent : Rs. 200
Monthly Expenditure (Rs.): Electricity: 0 - Fuel: 50
Water: public standpipe
Transport: 0
Yearly Maintenance Cost : Rs. 38 per room unit
Employment : Fishermen
Monthly Income : 800 (2 persons' incomes)



TYPE A2 - KATCHI ABADI

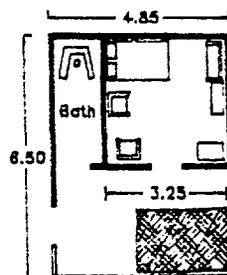
Location : MACHAR Colony - Mauripur Road
Development Type : Single house with one room
Description : Informal type of development. Near
dumping ground, stagnant polluted water.
Structure Condition : Fair - Building age: 1 year

Plot size : 31.53 m² or 47.71 sq.yd.
Built-up Area : 16.95 m² = 53.76 % of plot area
Covered Area : 19.95 m² = 20.27 sq.yd.
Unit size (room size) : 10.56 m² or 12.63 sq.yd.
Construction Type : Structure concrete block and brick
Floor C.C. - Roof G.I.S

Equipment & Connections : No kitchen, fuel wood and kerosene
1 Turkish toilet
Not connected to water supply
and sewerage, No electricity

Persons per Unit : 3 Adults, 2 Children
Area/Person : 2.11 m² or 2.52 sq.yd.

Tenure : Illegal occupation of site
Housing Present Value : Rs. 3,750
Monthly Rent : Rs. 200
Monthly Expenditure (Rs.): Electricity: 0 - Fuel: 50
Water: public standpipe
Transport: 0
Yearly Maintenance Cost : Rs. 50
Employment : Truck repairman
Monthly Income : Rs. 1,200 (2 persons' incomes)



TYPE A3 - KATCHI ABADI

Location : MEHMOODABAD - Near Malir River
Development Type : Semi Detached House
Site Description : Access by paved road (4.50m)
1 Level
Structure Condition : Fair - Building age: 5 years

Lot size : 50.63 m2 or 60.55 sq.yd.
Built-up Area : 27.50 m2 = 54.32% of plot area
Covered Area : 27.50 m2 or 32.89 sq.yd.
House size : 21.88 m2 or 26.17 sq.yd.
Construction Type : Structure concrete block
Floor C.C. - Roof G.I.S

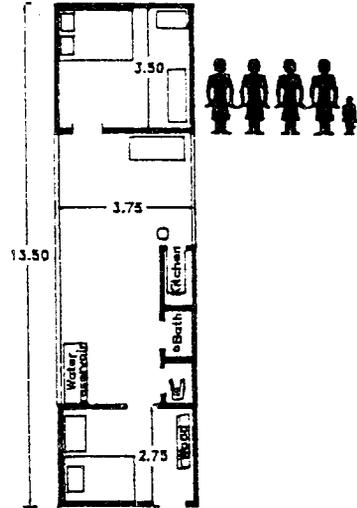
Equipment & Connections : Kitchen in courtyard, fuel wood
1 Turkish toilet, 1 bath
Connected to water supply, sewerage,
and electricity

Persons per Unit : 4 Adults, 1 Child
Area/Person : 4.38 m2 or 5.24 sq.yd.

Tenure : Renter
Housing Present Value : Rs. 40,000
Monthly Rent : Rs. 400

Monthly Expenditure (Rs.): Electricity: 50, Fuel: 50, Water: 50/Year
Transport by bus: Rs.450/Month

Employment : Carpenter
Monthly Income : Rs. 1,800



TYPE A4 - KATCHI ABADI

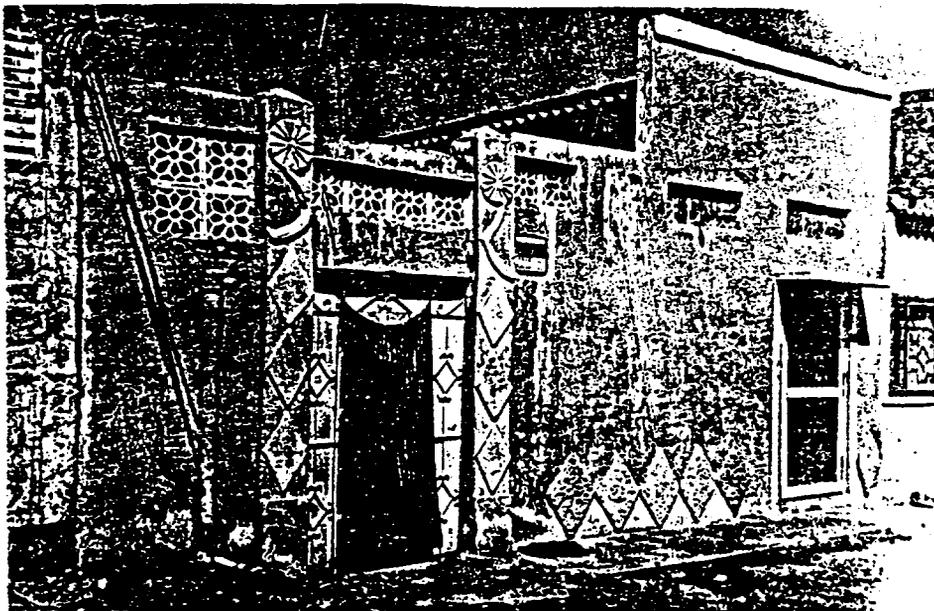
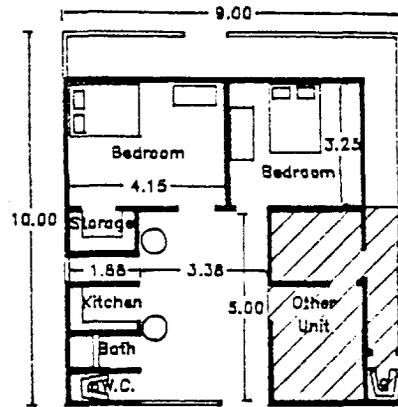
Location : KORANGI COLONY
Development Type : Semi Detached House
Site Description : Access by unpaved road (6m)
1 Level
Structure Condition : Fair - Building age: 2 years

Plot size : 90.00 m2 or 107.64 sq.yd.
Number of Unit per Plot : 2
Built-up Area : 64.00 m2 = 71.11% of plot area
Covered Area : 64.00 m2 or 76.54 sq.yd.
Living Area : 26.53 m2 or 31.73 sq.yd.
Construction Type : Structure concrete block
Floor C.C. - Roof G.I.S

Equipment & Connections : Kitchen
1 Turkish toilet, 1 bath
Connected to water supply & electricity
Open drain sewerage

Persons per Unit : 2 Adults, 3 Children
Area/Person : 5.31 m2 or 6.35 sq.yd.

Tenure : Owner
Housing Present Value : Rs. 45,000
Monthly Rent : Rs. 400
Monthly Expenditure (Rs.): Electricity: 50, Fuel: 50, Water: 50/Year
Transport by bus: Rs.300/Month
Yearly Maintenance Cost : Rs. 200
Employment : Self Employe
Monthly Income : Rs. 2,000



TYPE B - SEMI PUCCA HOUSE, Old Construction

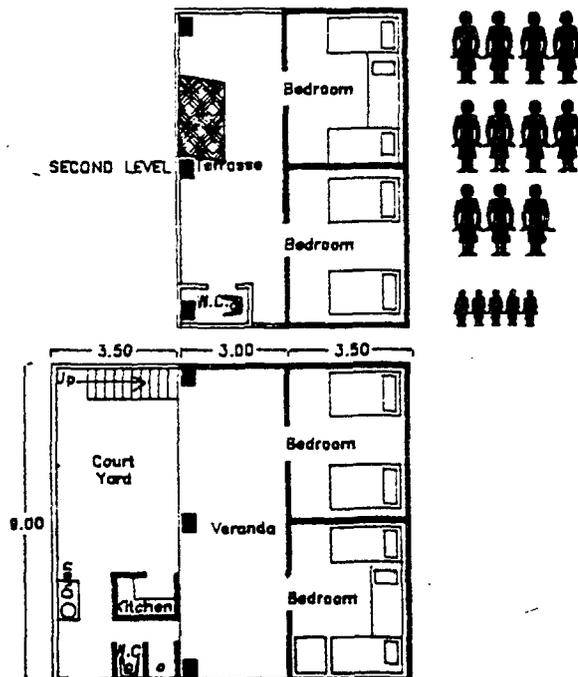
Location : BHUTTA Village - Panjari Para
 Development Type : Single House
 Description : Access by 2 meters passage
 2 Levels
 Structure Condition : Fair - Building age: more than 50 years

Plot size : 90 m² or 107.64 sq.yd.
 Built Area : 75 m² = 83.37% of plot area
 Covered Area : 90 m² or 107.64 sq.yd.
 House size (floor area) : 80.42 m² or 96.18 sq.yd.
 Construction Type : Structure concrete block and brick
 Floor C.C. - Roof G.I.S

Equipment & Connections : Traditional bread oven built in courtyard,
 Gas range
 2 Turkish toilets, 1 bath
 Connected to water supply & electricity
 Open drain sewerage

Persons per Unit : 11 Adults, 5 Children (4 families)
 Area/Person : 5.03 m² or 5.21 sq.yd.

Tenure : Illegal occupation since 1947
 Housing Present Value : Rs. 200,000
 Monthly Rent : Rs. 2000 (if rented)
 Monthly Expenditure (Rs.): Electricity: 150; Fuel: 60; Water: 120/yr
 Transport by bus: Rs. 270/month
 Yearly Maintenance Cost : Rs. 500
 Employment : Driver, Laborer, Private service
 Monthly Income : Rs. 6,500 (3 persons' incomes)



TYPE C1 - PUCCA HOUSE, New Development

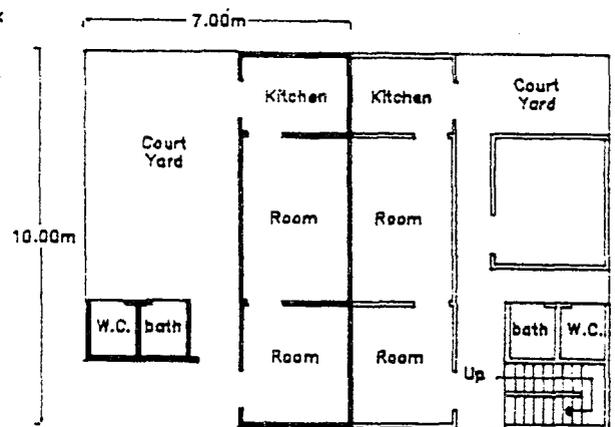
Location : KDA Scheme No. 41 - Surjani Town
 Development Type : Semi Detached House
 Description : Access by unpaved road
 Structure Condition : Good - Construction started in 1986

Plot size : 70 m² or 83.72 sq.yd.
 Built Area : 33.66 = 48.09% of plot area
 Covered Area : 33.66 m² or 40.26 sq.yd.
 House size (floor area) : 26.88 m² or 32.15 sq.yd.
 Construction Type : R.C.C. Structure - Wall: concrete block
 Floor C.C. - Concrete Roof

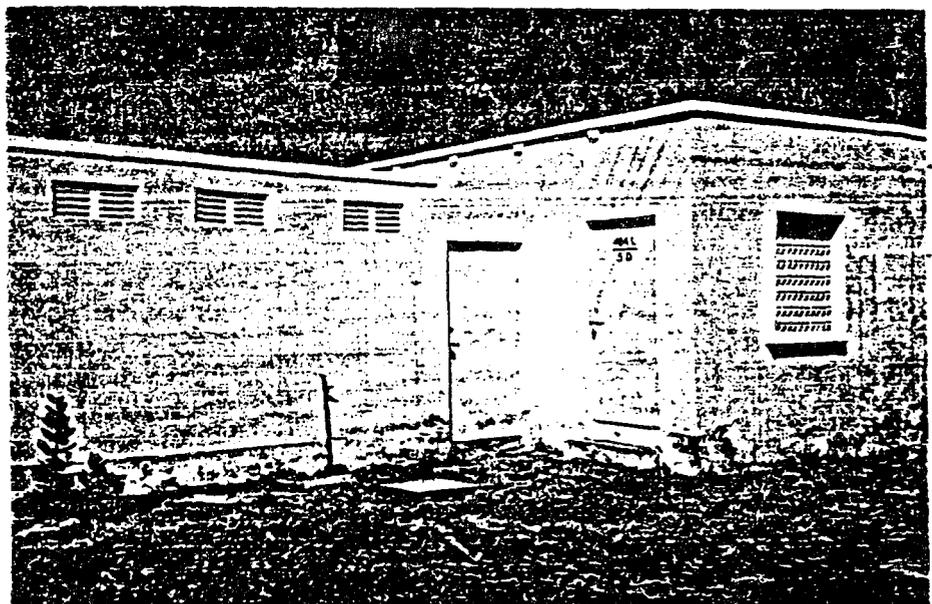
Equipment & Connections : Kitchen, 1 WC, 1 Bath
 Connected to water supply, sewerage
 and electricity

Persons per Unit : 3 Adults, 2 Children
 Area/Person : 5.38 m² or 6.43 sq.yd.

Temure : Owner
 Source of Financing : Family savings and bank loan
 Unit Present Value : Rs. 46,900
 Monthly Rent : Rs. 350 (if rented)
 Monthly Expenditure (Rs.): Electricity: 50; Gas: 50; Water: 50/yr
 Transport by bus: Rs. 300/month
 Yearly Maintenance Cost : Rs. 300
 Employment : Government Employee
 Monthly Income : Rs. 2,200



Basic unit Expansion of the basic unit



TYPE C2 - PUCCA HOUSE, Small Plot Size

Location : NAZIZABAD - F.B. Area
Development Type : Semi Detached House
Site Description : Access by paved road of 12 m.
1 Level
Structure Condition : Good - Building age: 18 years

Plot size : 86.13 m2 or 103 sq.yd.
Built-up Area : 60.17 m2 = 69.86% of plot area
Covered Area : 60.17 m2 or 71.96 sq.yd.
House size : 40.57 m2 or 48.52 sq.yd.
Construction Type : R.C.C. Structure - Wall concrete block
Floor C.C.

Equipment & Connections : Modest kitchen, gas, refrigerator
1 Bathroom with turkish toilet, 1 bath,
1 turkish toilet
Connected to water supply, sewerage,
and electricity

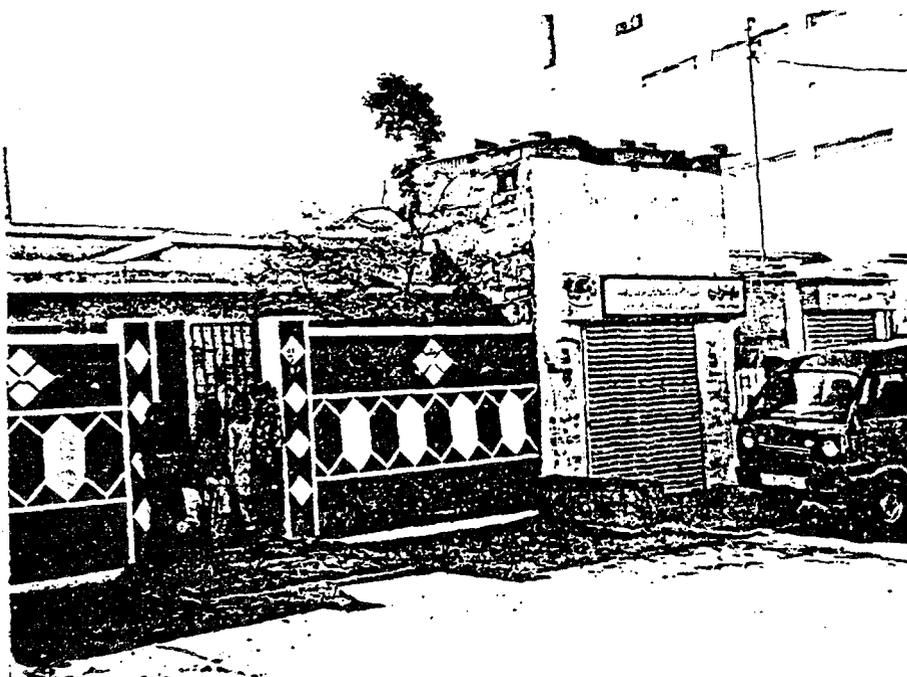
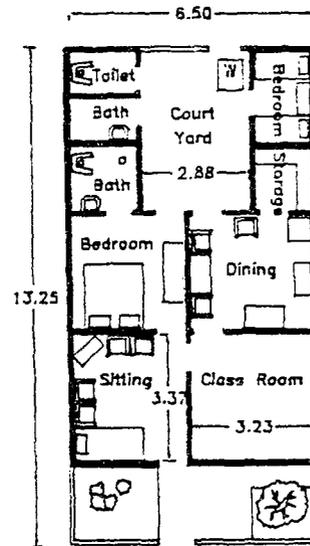
Persons per Unit : 5 Adults, 1 Child
Area/Person : 6.76 m2 or 8.08 sq.yd.

Tenure : Owner
Source of Financing : Family savings

Unit Present Value : Rs. 200,000 to 250,000

Monthly Rent : Rs. 1,000 to 1,200 (if rented)
Monthly Expenditure (Rs.): Electricity: 100 - Gas: 50 - Water: 120/Yr
Transport by bus: 600
Yearly Maintenance Cost : Rs. 1,000

Employment : Private Business
Monthly Income : Rs. 5,000 (1 person's income)



TYPE C3 - PUCCA HOUSE, New Development

Location : METROVILLE - Near S.I.T.E
 Development Type : Single House
 Site Description : Access by unpaved road, near major road
 1 Level (2nd level in construction)
 Structure Condition : Good - Building age: 2 years

Plot size : 114.70 m² or 126.86 sq.yd.
 Built-up Area : 81.50 m² = 71.05% of plot area
 Covered Area : 81.50 m² or 97.47 sq.yd.
 House size : 47.60 m² or 56.93 sq.yd.
 Construction Type : R.C.C. Structure - Wall concrete block
 Floor C.C.

Equipment & Connections : Kitchen, gas cylinder, refrigerator
 1 Turkish toilet, 1 bath
 Connected to water supply, sewerage, electricity

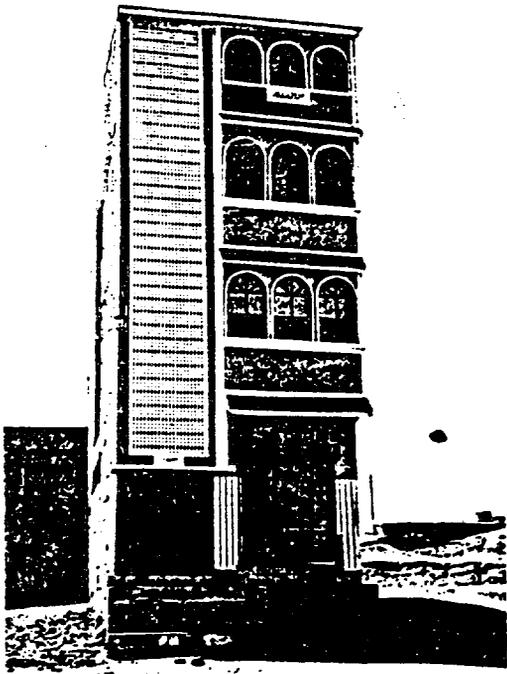
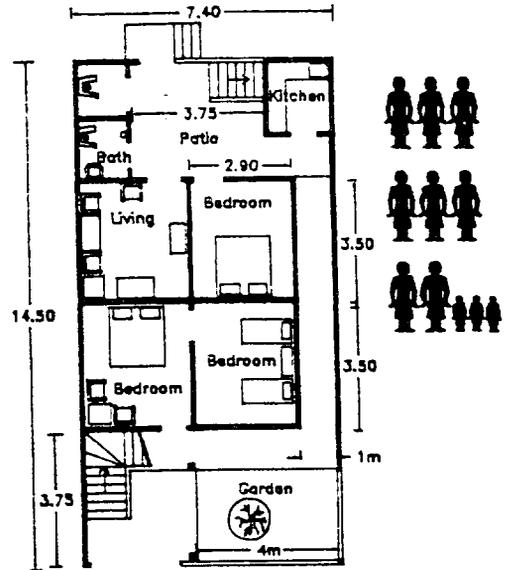
Persons per Unit : 5 Adults, 2 Children
 Area/Person : 4.33 m² or 5.18 sq.yd.

Tenure : Owner
 Source of Financing : Family savings

Unit Present Value : Rs. 200,000

Monthly Rent : Rs. 800 (if rented)
 Monthly Expenditure (Rs.): Electricity: 100 - Gas: 35 - Water: 120/Yr
 Transport by car and bus: 1500
 Yearly Maintenance Cost : Rs. 500

Employment : Private Business
 Monthly Income : Rs. 8,000 (3 persons' incomes)



TYPE C4 - PUCCA HOUSE, Medium Plot Size

Location : NORTH NAZIMABAD - Block H.M.
 Development Type : Semi Detached House
 Site Description : Access by 12 m. paved road
 3 Levels (2 family units)
 Parking on plot for resident on ground floor
 Structure Condition : Good - Building age: 15 years

Plot size : 161.88 m2 or 193.61 sq.yd.
 Number of Units on Plot: 2 Units
 Built-up Area : 76.41 m2 = 56.61% of plot area
 Covered Area : 145.32 m2 = 173.80 sq.yd.
 Unit size(ground floor): 54.04 m2 or 64.63 sq.yd.
 Construction Type : R.C.C. Structure - Wall concrete block
 Floor mosaic - Concrete roof

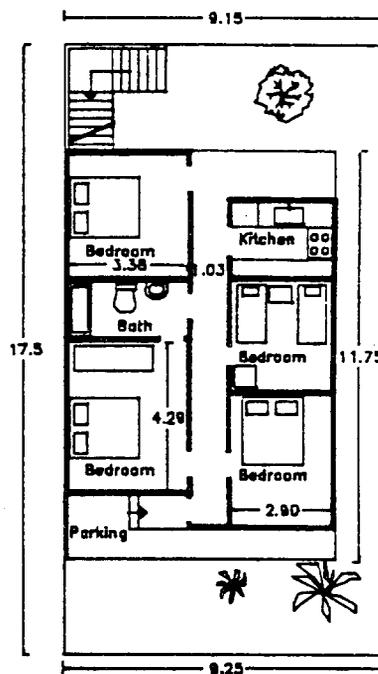
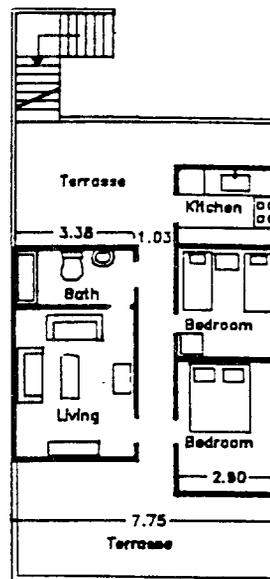
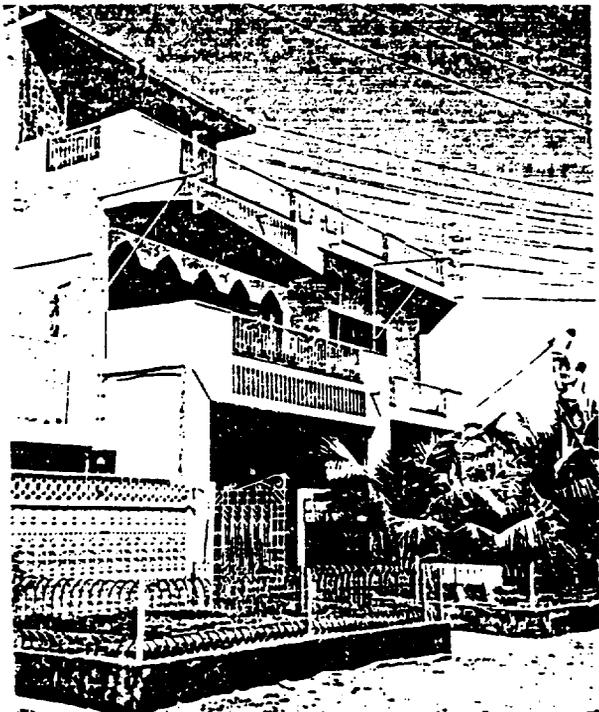
Equipment & Connections: Modern Kitchen, gas and refrigerator
 1 Modern Bathroom
 Connected to water supply, sewerage,
 and electricity.

Persons per Unit : 5 Adults, 1 Child
 Area/Person : 9.01 m2 or 10.77 sq.yd.

Tenure : Owner
 Source of Financing : Family savings

Unit Present Value : Rs. 900,000
 Monthly Rent : Rs. 3,500 (for ground floor if rented)
 Monthly Expenditure : Electricity: 250; Gas: 80; Water: 120/Yr
 Transport by car: Rs.1,500/Month
 Yearly Maintenance Cost: Rs. 5000

Employment : Police, Bank employee
 Monthly Income : Rs. 15,000 (2 Persons' incomes)



TYPE C5 - PUCCA TOWNHOUSE, Medium Plot Size

Location : Next to Shafique Textile Factory
 Development Type : Townhouse
 Site Description : Access by 8 m. paved road
 2 Levels - Parking on plot
 Structure Condition : Good - Building age: 2 years

Plot size : 162 m² or 193.75 sq.yd.
 Built-up Area : 92.40 m² = 57.04% of plot area
 Unit size(ground floor): 164.48 m² or 196.72 sq.yd.
 Construction Type : R.C.C. Structure - Wall concrete block
 Floor mosaic - Concrete roof

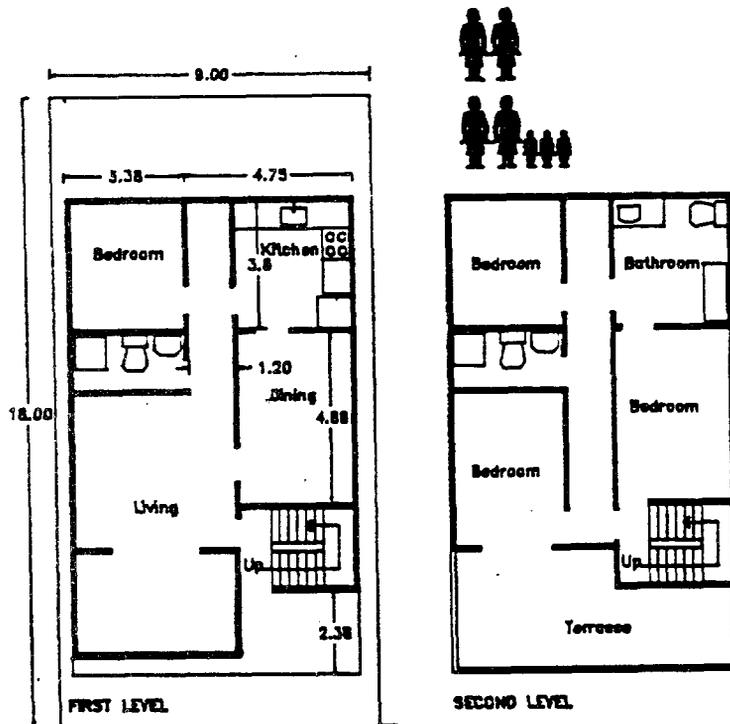
Equipment & Connections: Modern Kitchen, gas and refrigerator
 3 Modern Bathrooms
 Connected to water supply, sewerage,
 and electricity.

Persons per Unit : 4 Adults, 3 Children
 Area/Person : 23.50 m² or 28.10 sq.yd.

Tenure : Owner
 Source of Financing : Family savings and bank loan

Unit Present Value : Rs. 850,000
 Monthly Rent : Rs. 6,500 (for ground floor if rented)
 Monthly Expenditure : Electricity: 350; Gas: 200; Water: 120/Yr
 Transport by car: Rs.1,500/Month
 Yearly Maintenance Cost: Rs. 5000

Employment : Private Business
 Monthly Income : Rs. 25,000



TYPE D - BUNGALOW

Location : STEEL MILL TOWNSHIP
 Development Type : Bungalow, Single Family House
 Site Description : New Town developed by Steel Mill Corp. for their employees.
 Access by paved road of 12m.
 Structure Condition : Good - New Building

Plot size : 416 m2 or 497.54 sq.yd.
 Built Area : 254.50 m2 = 61.18% of plot area
 Covered Area : 254.50 m2 or 304.38 sq.yd.
 House size : 133.71 m2 or 159.92 sq.yd.
 Construction Type : R.C.C. Structure - Wall concrete block
 Floor mosaic - Concrete roof

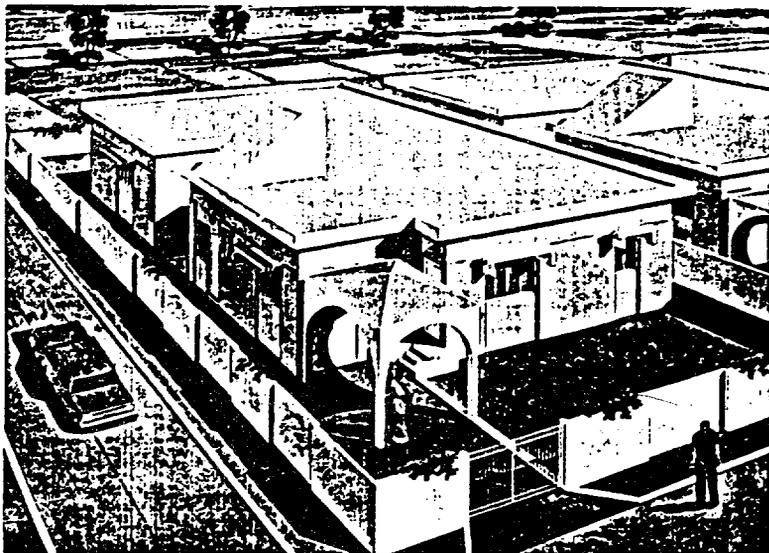
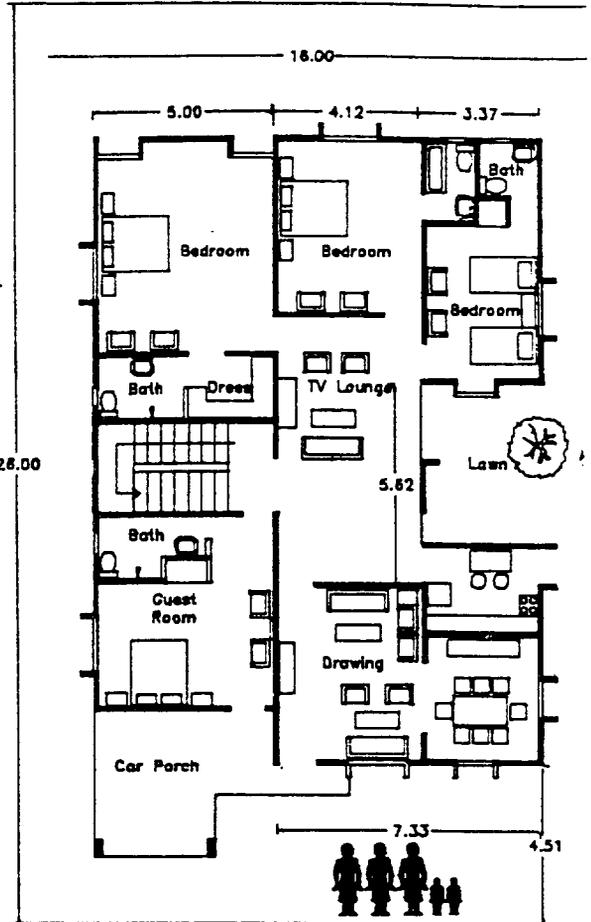
Equipment & Connections : Modern Kitchen, with gas range, refrigerator
 4 Modern Bathrooms
 Connected to water supply, gas, sewerage, and electricity - Air conditioning
 Telephone

Persons per Unit : 3 Adults, 2 Children
 Area/Person : 26.74 m2 or 31.98 sq.yd.

Dweller Status : Owner
 Source of Financing : Family savings and bank loan

Unit Present Value : Rs. 600,000 to Rs. 1,500,000 for bungalow next to city center
 Monthly Rent : Rs. 1500 (if rented) or Rs. 15,000 for same housing unit in city
 Monthly Expenditure (Rs.): Electricity:1,000 - Gas:500 - Water:500/Yr
 Transport by car: 1500
 Yearly Maintenance Cost : Rs. 2000

Income Source : Steel Mill Employee
 Monthly Income : Rs. 25,000 to Rs. 50,000



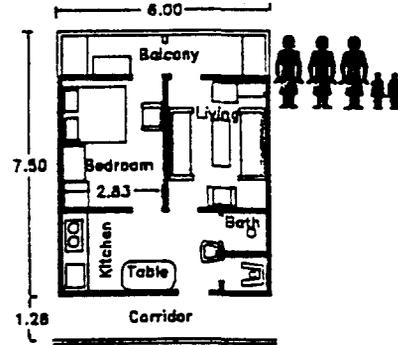
TYPE E1 - SMALL APARTMENT SIZE

Location : KARIMABAD - F.B. Area
Development Type : Apartment Complex

Site Description : Access by paved road to complex and unpaved passage to units
5 Level apartment building

Structure Condition : Fair - Building age: 17 years

Plot size : 1500 m2 or 1795 sq.yd.
Built-up Area : 2190 m2 (FAR: 1.46)
Number of Units on Plot : 40 Apartments/building
Apartment size : 45 m2 or 53.82 sq.yd.
Living Space : 40.00 m2 or 53.82 sq.yd.
Construction Type : R.C.C. Structure - Wall concrete block
Floor C.C. - Concrete roof



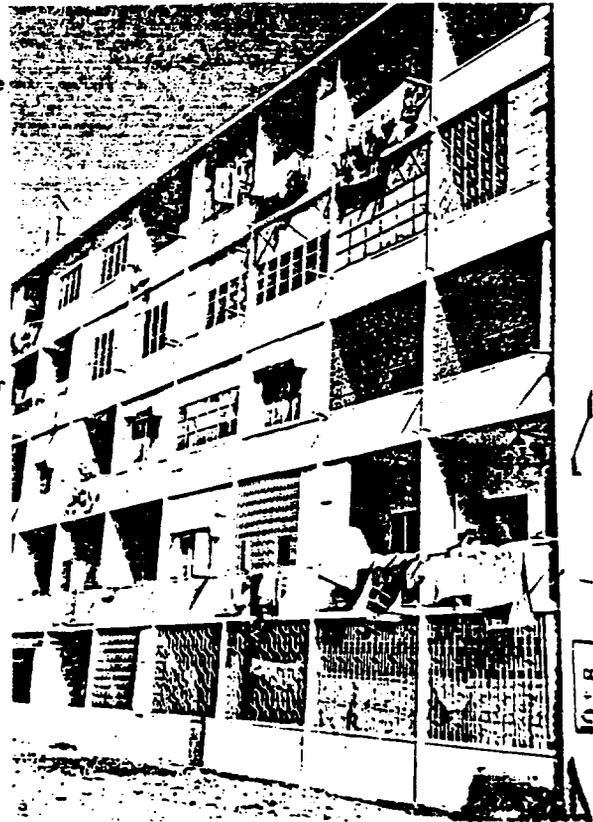
Equipment & Connections : Kitchen, refrigerator
1 Turkish toilet, 1 bath
Connected to water supply, gas, sewerage and electricity

Persons per Unit : 3 Adults, 2 Children
Area/Person : 8.75 m2 or 10.46 sq.yd.

Tenure : Owner

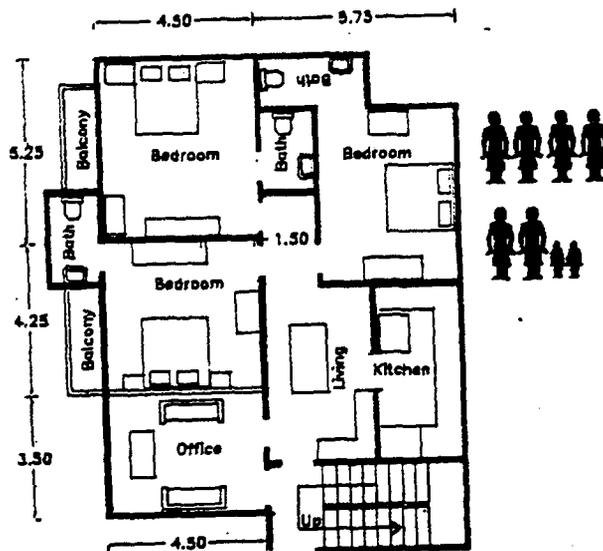
Unit Present Value : Rs. 100,000
Monthly Rent : Rs. 1,000 (if rented)
Monthly Expenditure (Rs.): Electricity: 150; Gas: 50; Water: 120/Yr
Transport by bus: Rs. 1,500/Month
Yearly Maintenance Cost : Rs. 200

Employment : Private (Owns Business)
Monthly Income : Rs. 6,000 (3 persons' incomes)



TYPE E2 - MEDIUM APARTMENT SIZE

Location : P.E.C.H.S. - BAHADRABAD
 Development Type : Apartment Complex
 Site Description : Access by paved road, 5 floors with shops on ground floor and parking for resident inside block
 Structure Condition : Good - Building age: 5 years
 Plot size : 7316 m2 or 8750 sq.yd
 Built-up Area : 6604 m2 (FAR=4.51)
 Number of Units on Plot : 128 apartments, 40 shops
 Apartment Size : 140 m2 or 167.44 sq.yd.
 Living area : 92.54 m2 or 110.51 sq.yd.
 Construction Type : R.C.C. Structure - Wall concrete block
 Floor mosaic - Concrete roof
 Equipment & Connections : Modern kitchen, 3 bathrooms well equipped
 Connected to water supply, gas, sewerage, and electricity - Telephone
 Persons per Unit : 6 Adults, 2 Children
 Area/Person : 11.57 m2 or 13.83 sq.yd.
 Tenure : Owner
 Source of Financing : Family savings and bank loan
 Unit Present Value : Rs. 500,000 to 800,000 for apartment facing the street and in lower level
 Monthly Rent : Rs. 3,000 to 5,000 (if rented)
 Monthly Expenditure (Rs.): Electricity: 300; Gas: 200; Water: 500/Yr
 Transport by car: Rs. 1,500/Month
 Income Source : Private Business
 Monthly Income : Rs. 15,000 (1 person's income)



TYPE E3 - LUXURIOUS APARTMENT TYPE

Location : CLIFTON - Marine Blessing
 Development Type : Luxurious Apartment Complex

Site Description : Access by 12 m. paved road
 Apartment bldg (ground+3 floors)
 Parking, Garden patio, Swimming pool
 Servants' Quarters on ground floor

Structure Condition : Good - Building age: 5 years

Plot Size : 3600 m2 or 4305 sq.yd.
 Built-up Area : 1125 m2 (FAR: 1.25)
 Apartment Size : 269 m2 or 321.72 sq.yd.
 Living Space : 165.88 m2 or 198.39 sq.yd.
 Construction Type : R.C.C. Structure - Wall concrete block
 Floor mosaic - Concrete roof

Equipment & Connections : Modern Kitchen, gas and refrigerator
 3 Bathrooms and Bath well equipped
 Connected to water supply, sewerage,
 electricity, air-conditioning
 telephone

Persons per Unit : 3 Adults, 2 Children
 Area/Person : 33.18 m2 or 39.68 sq.yd.

Tenure : Owner
 Source of Financing : Family savings

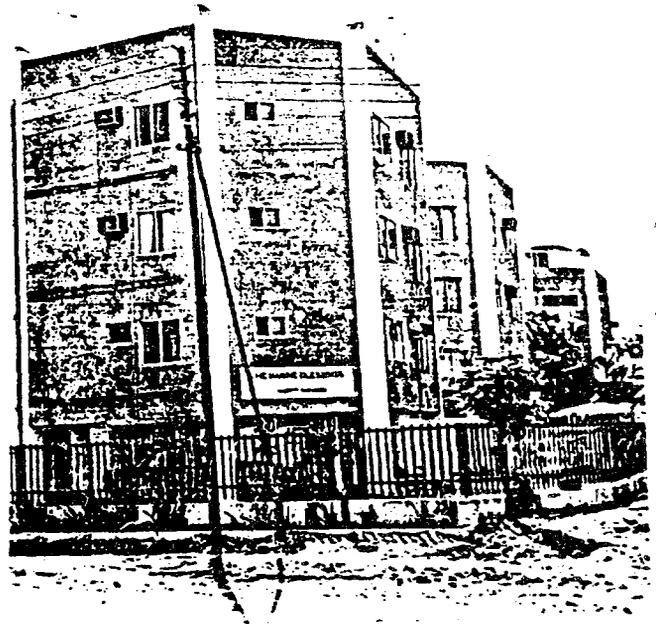
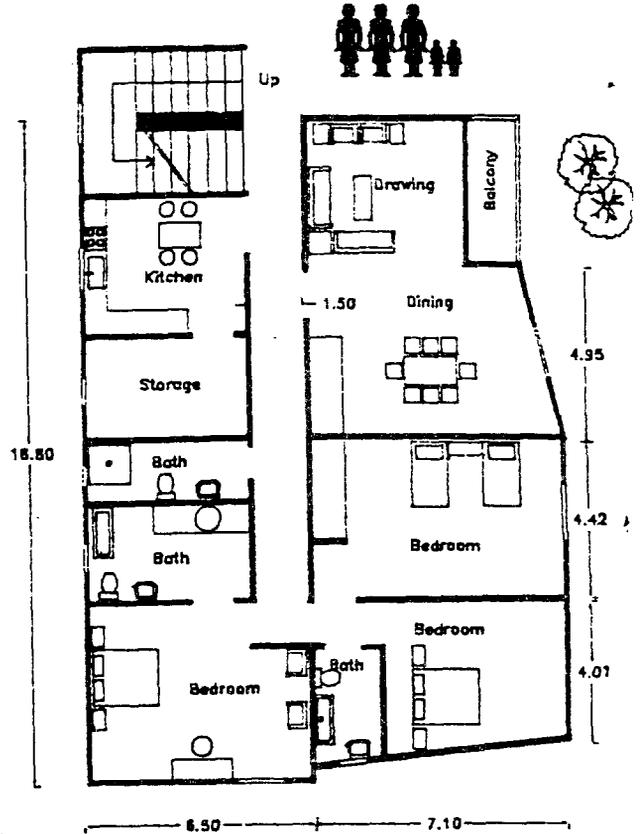
Unit Present Value : Rs. 1,000,000 (Apt. inside block)
 Rs. 1,200,000 (Apt. facing main street)

Monthly Rent : Rs. 12,000 to 15,000 (depending on
 apartment location and floor level)

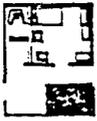
Monthly Expenditure (Rs.): Electricity:1000; Gas:500; Water:500/Yr.
 Transport by private car: Rs. 2,000/Month

Yearly Maintenance Cost : Rs. 3,500

Employment : Private Business
 Monthly Income : Rs. 50,000



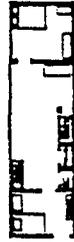
HOUSING TYPES AND VALUES
ALLOCATED BY INCOME



UNIT 1
KATCHI ABADI
VALUE Rs.3,750



UNIT 2
NEW - SCHEME 41
VALUE Rs.46,900

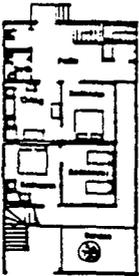


UNIT 3
KATCHI ABADI
VALUE Rs.60,000

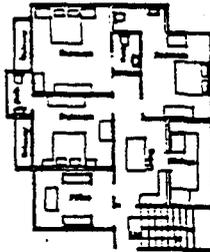


UNIT 4
APARTMENT
VALUE Rs.100,000

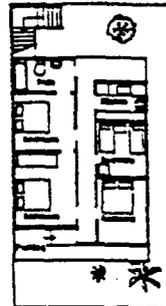
LOW INCOME



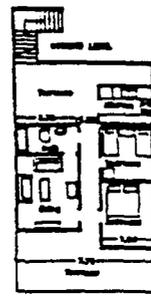
UNIT 5
METROVILLE
VALUE Rs.200,000



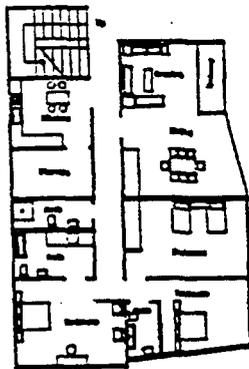
UNIT 6
APARTMENT
VALUE Rs.500,000



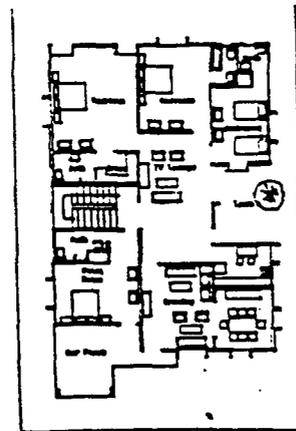
UNIT 7
NEAR CENTER
VALUE Rs 900,000



MEDIUM INCOME



UNIT 8
APARTMENT
VALUE Rs.1,000,000



UNIT 9
BUNGALOW
VALUE Rs.1,500,000

HIGH INCOME



GLOSSARY



GLOSSARY

Attribute

Non-graphic information associated with a point, line, or area element in a GIS.

Cadastre

A cadastre is an official public record usually recording property rights, the value and quantity of land in a jurisdiction, state or country, recorded in fiscal or real property parcel units. It is best thought of today in terms of fiscal and legal cadastre.

Cadastral Map

A cadastral map shows the real property framework of an area. A cadastral map usually shows property boundaries, administrative boundaries, legal road corridors, parcel identifiers, and some times the area of each parcel, road names and administrative area names.

Computer-Aided Design (CAD)

Computer software for design. Such applications are used in engineering, architectural and planning agencies for technical design of plan and other drawings produced by such agencies.

Coordinate (geographic)

A system of spherical coordinates for describing the positions of points on the Earth. The declinations and polar bearings in the Earth system are the latitudes and longitudes respectively.

Digitizer

A device for entering the spatial coordinates of mapped features from a map or document to the computer.

Edge Enhancement

The result of the application of a high-pass filter designed to enhance high frequency variations between a pixel and its neighboring pixels.

Electro-magnetic Radiation (EMR)

Energy propagated through space or through material media in the form of an advancing interaction between electric and magnetic fields.

Flux

The rate of flow of some quantity, often used in reference to the flow of sor. of energy. Generally, the number of radioactive particles per unit volume time. mean velocity.

FORTTRAN (FORmula TRANslation)

A high-level programming language, much used in computer graphics and CAD/CAM. Recent improvements, embodied in FORTRAN 77, have made structured programming and interactive data input much easier.

Geometric Correction

The removal of sensor, platform, or scene induced geometric errors such that the data conform to a desired projection. This involves the creation of a new digital image by resampling the original image data.

Glossary, continued

GIS

A Geographic Information System or GIS is a system for collecting, inputting, checking, processing, integrating, analyzing, modelling and reporting on information relating to the earth. They may be established and used for many functions, some of which are forecasting potential commercial areas, analyzing factors contributing to seismic hazard levels, determining high risk erosion areas, or used to assist in the determination of optimum use of land.

Gray Scale

A monochrome strip of shades ranging from white to black with intermediate shades of gray.

Ground Control Points

Control points obtained by ground surveys to control and correct distortion of remote sensing images.

Ground Resolution

The smallest object size which can be seen, or detected, by the sensors on a remote sensing satellite.

Ground Survey

A survey made by ground methods, as distinguished from an aerial survey.

High-pass Filtering

A spatial enhancement technique operating on digital image data which detects and enhances high frequency variation within a specified image kernel. The high-pass filter evaluates the central pixel of a kernel and its neighboring pixels and alternates the central value to increase the contrast with the neighboring pixels of the kernel.

Hue

That attribute of a color by virtue of which it differs from gray of the same brilliance, and which allows it to be classed as red, yellow, green, blue, or intermediate shades of these colors.

Image

The counterpart of an object produced by the reflexion or refraction of light when focused by a lens or mirror. The recorded representation of an object produced by optical, electro-optical, optical mechanical, or electronic means. It is generally used when the electro-magnetic radiation emitted or reflected from a scene is not directly recorded on film.

Image Enhancement

The manipulation of image density or image digital data to more easily see certain features of an image.

Infrared

Pertaining to or designating the portion of the electro-magnetic spectrum with wavelengths just beyond the red end of the visible spectrum, such as radiation emitted by a hot body.

Instantaneous Field-of-View (IFOV)

A term specifically denoting the narrow field of view designed into scanning radiometer systems.

Glossary, continued

Kernel

The minimum subset of image pixels which is used in a digital spatial filter to define the "input" set of pixels. The input kernel is evaluated to define an output pixel, according to analytical functions defined by the type of filter applied to the kernel.

LIS

The term Land Information System (LIS) is being applied to systems which are focused on land parcels as their unit of information or are land administration based. A land information system is a series of operations used for strategic and operational management, information provision for day-to-day operations, which involves the collection, storage, maintenance, processing, analysis, and dissemination of land related data including maps and records for land registration, land assessment and evaluation.

Monitor

Usually a TV screen used to display data, graphic and images.

Mosaic

An assemblage of overlapping aerial or space photographs or images whose edges have been matched to form a continuous pictorial representation of a portion of the Earth's surface.

Multiband System

A system for simultaneously observing the same target with several filtered bands, through which data can be recorded; usually applied to camera and sensors on satellites.

Multispectral

Generally used for acquisition of remote sensing data in two or more spectral bands.

Multi-Spectral Scanning (MSS)

A remote sensing device which operates on the same principle as the infrared scanner except that it is capable of recording data in the ultraviolet and visible portions of the spectrum as well as the infrared.

Nadir (ground)

The point on the ground vertically beneath the perspective center of the camera lens or sensor.

Near Infrared

The preferred term for the shorter wave lengths in the infrared region extending from about 0.7 micrometers (visible red), to around 2 or 3 micrometers (varying with the author). The term really emphasizes the radiation reflected from plant materials, which peaks around 0.85 micrometers.

Negative

A photographic image on film, plate, or paper, in which the tones are reversed.

Noise

Any undesired sound. By extension, noise is any unwanted disturbance within a useful frequency band, such as undesired electric waves in a transmission channel device.

Glossary, continued

Panchromatic

Used for films that are sensitive to broad bands. Satellite image with only one band that scans images in black and white.

Pixel

A contraction of a picture element. In satellite images, an integrated radiance mapping unit.

Preprocessing

Commonly used to describe corrections and processing done to image data before information extraction. Includes geometric and radiometric correction, mosaicking, resampling, and formatting.

Processing

The operation necessary to produce negatives, slides, or prints from exposed film, plate, or papers. The manipulation of digital data by means of a computer.

Radiance

The accepted term for radiant flux in power units (e.g. watts).

Radiometer

An instrument for quantitatively measuring the intensity of electro-magnetic radiation in some band of wave lengths in any part of the electro-magnetic spectrum.

Radiometric Correction

Processing of sensor data to calibrate and correct the radiation data provided by the sensor detectors.

Raster

The scanned (illuminated) area of the CRT.

Reflectance

The ratio of the radiant energy reflected by a body to that incident upon it.

Remote Sensing

In the broadest sense, the measurement or acquisition of information of some property of an object or phenomenon, by a recording device that is not in physical or intimate contact with the object or phenomenon under study.

Resolution

The ability of an entire remote sensor system to render a sharply defined image. It may be expressed as line pairs per millimeter or meters, or in many other manners. If expressed in size of objects, or distances on the ground, the distance is termed ground resolution.

Scanner

A device that scans and, by this means, produces an image.

Scene

The area on the ground that is covered by an image or photograph.

Glossary, continued

Sensor

Any device which gathers electro-magnetic radiation or other energy and presents it in a form suitable for obtaining information about the environment.

Signature

Any characteristic or series of characteristics by which a material may be recognized. Used in the sense of spectral signature.

Spectral Band

An interval in the electromagnetic spectrum defined by two wave lengths, frequencies, or wave numbers.

Stereopair

A pair of photos which overlap in area and are suitable for stereoscopic examination.

Stereoscopic Image

The mental impression of a 3-dimensional object which results from stereoscopic vision.

Texture

In a photo image, the frequency of change and arrangement of tones.

Thematic Map

A thematic map is one with a theme (e.g., soil map, land use map, a cadastral map.)

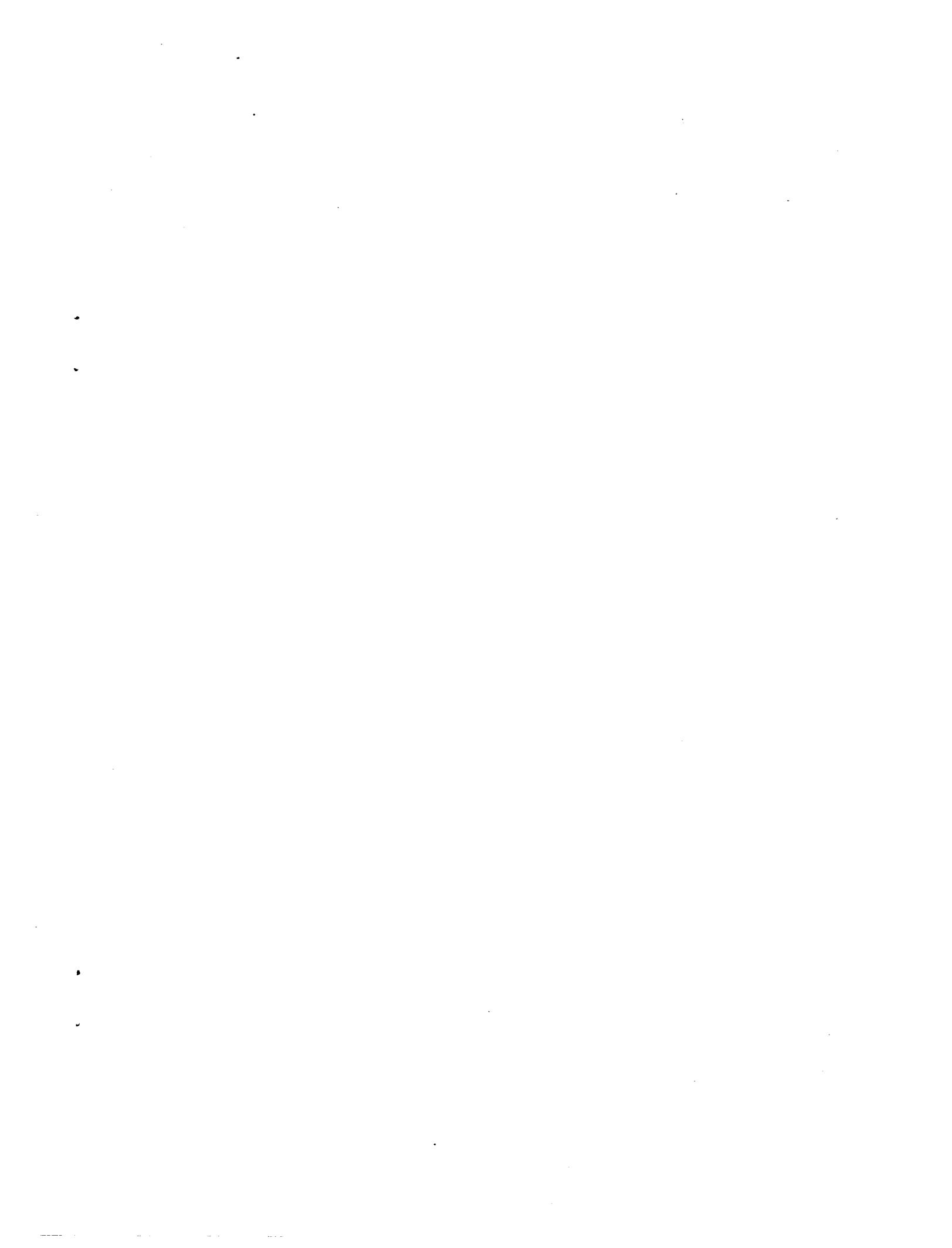
Thematic Mapper

Sensor system on satellite Landsat series four and five with six multispectral bands and one thermal band that permits land use classification for the making of thematic maps.

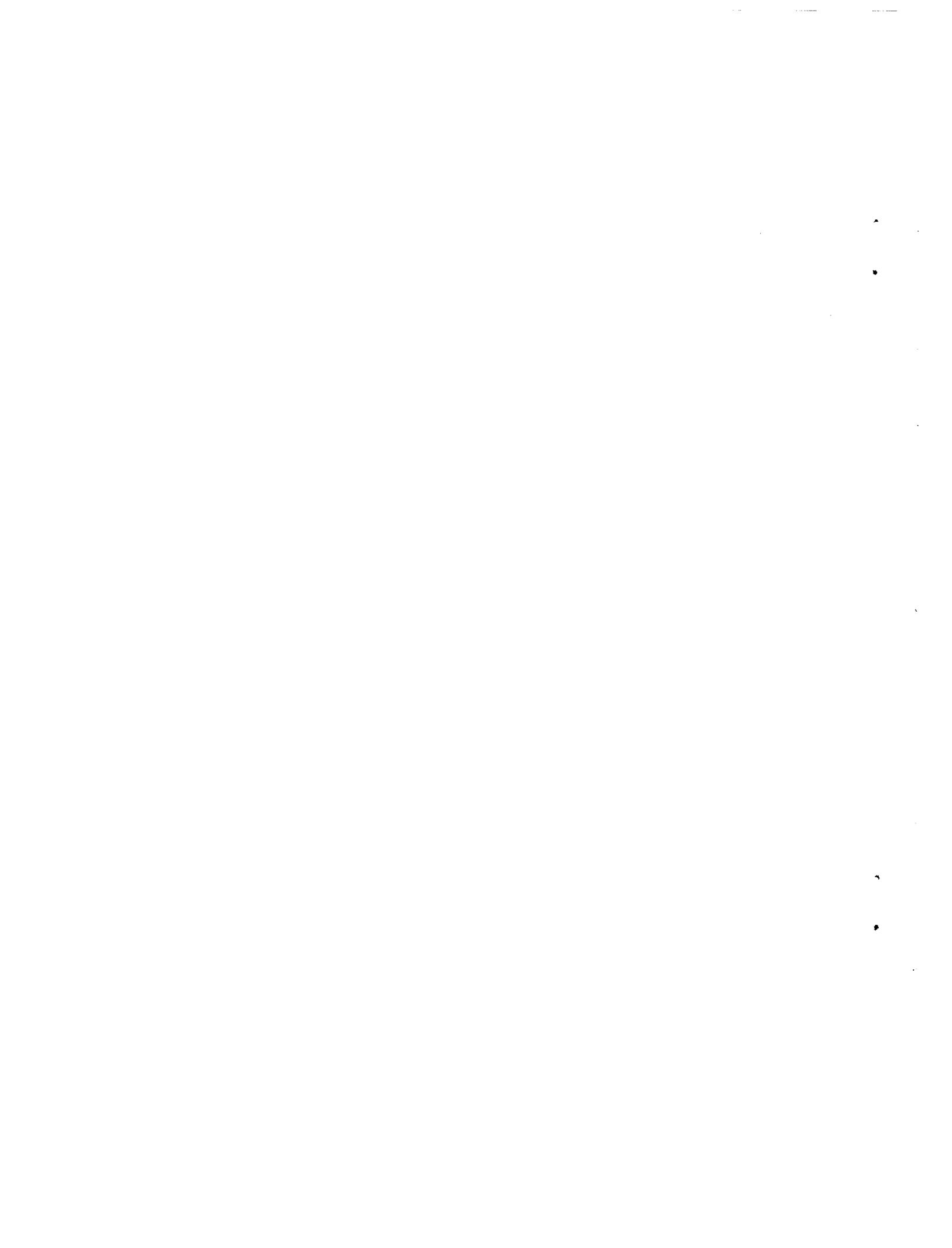
Source:

Multilingual Dictionary of Remote Sensing and Photogrammetry, George A. Rabshevsky, Editor. The American Society of Photogrammetry. 1983.

LIS Definition for the World Bank Land Information System Seminar - Lynn Holstein - March 1987.



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