

Aerial Photo-Interpretation Techniques for Classifying Urban Land Use

A land-use classification scheme is designed for and tested on Bikaner City, India.

INTRODUCTION

STUDY OF LAND-USE for comprehensive planning needs a multi-disciplinary approach, wherein specialists in various fields need to analyze a bulk of data in order to arrive at an integrated plan. The nature of data requirement, its source and method of collection may differ from discipline to discipline. However, a major effort is almost always directed towards preparation of a

generalize information and fall back on less accurate methods of data collection. The traditional technique of mapping existing land-use through ground methods has been found deficient in meeting the requirements of planners. Its incapability to yield research data accurately and quickly has led planners and administrators to search for more modern tools for data acquisition. In most of the developing countries, ground

ABSTRACT: An effort to map the urban land-use of Bikaner City by using aerial photo-interpretation techniques is presented. Although the aerial photographs reveal a large amount of information connected with the land-use, only the important and selected ones have been considered. An attempt is also made toward evolving a suitable land-use classification for an Indian urban situation as well as to test the existing land-use classification scheme designed by various urban geographers in India. The approach is basically functional and tries to show how the physical character of land-use classes can be recognized on aerial photographs for the purpose of land-use mapping. The scope of the classification scheme will, of course, differ from one study to another depending on the scales of photography and the nature of settlement. On small-scale aerial photography, urban areas can be placed in broad categories whereas on large-scale photography the areas can be classified into small units.

base map and survey of present land-use.

Urban land-use mapping has always been a time-consuming and expensive step in the process of land-use planning. Often, when the study has a time limitation, the planners and specialists in various disciplines are forced to use the existing data on land-use which is invariably out-dated because of the dynamic trends in urbanization. To save time, planners also are compelled to

data are already being supplemented by information derived from aerial photo-interpretation. The requirements of mapping land-use, its classification systems, and the accuracy standards, differ from one environment to another. Because of their flexibility in revealing a variety of information, photo-interpretation techniques are being used as a tool for data acquisition.

The aerial photographs used in this paper

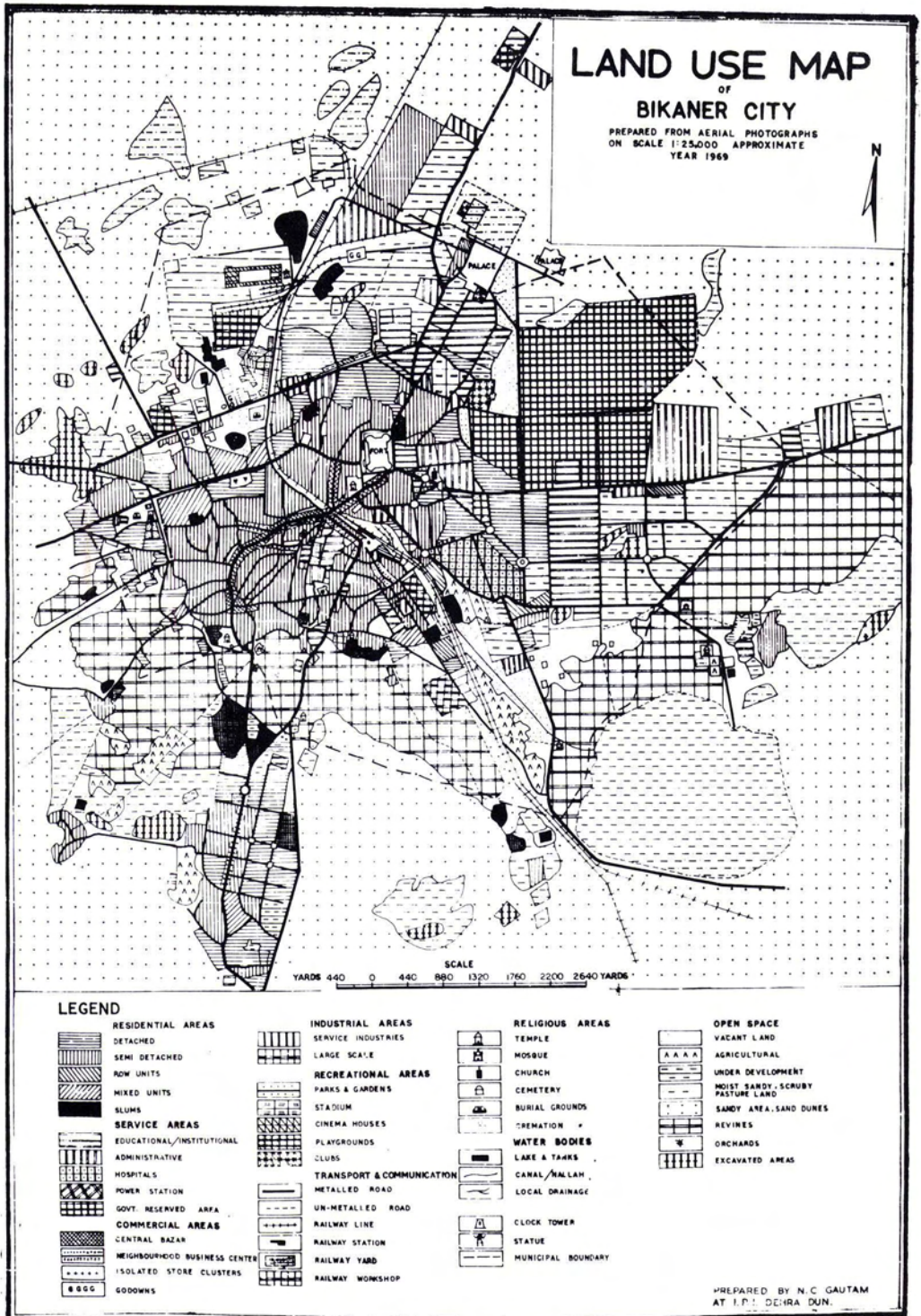


FIG. 1. Land-use map of Bikaner City.

were taken during the year 1969 using an Eagle IX camera. The scale of photography was approximately 1:25,000. Figure 1 shows the land-use map of Bikaner City which has been prepared through aerial photographs.

METHODOLOGY FOR INTERPRETATION OF URBAN LAND-USE

Both qualitative and quantitative techniques have been used for developing the urban land-use classification. The map prepared was based on aerial photographs with limited field check.

PRE-FIELD STUDY

The aerial photographs covering Bikaner City were first arranged in the form of a mosaic to demarcate areas of interest. The stereo-pairs were then selected for examination. The area was studied under a mirror-stereoscope in order to obtain a general idea of the topography and land-use.

A list of all right-hand side photographs on which delineation of classification was to be made was prepared. For land-use mapping purposes, a transparent overlay (Astrafol sheet) of suitable size was used. That could cover the area of work on photoscale.

FIELD STUDY

A rigorous field verification of two sample areas was made parcel-by-parcel by going through each area systematically to find the percentage of change if any. Each parcel of 5mm-x-5mm on photo scale, i.e., 125m-x-125m on the ground was checked and any changes were noted in the field record. Also, corrections in the field map were made.

POST-FIELD STUDY

After field verification and necessary corrections in the base map, the land-use map was prepared. Errors under each land-use classification unit were tabulated separately and were calculated for the analysis of errors. Table 1 and Figure 2 show the change of land-use per unit area.

CRITERIA FOR THE EVALUATION OF LAND-USE CLASSIFICATION

In order to provide a framework for the evaluation of a land-use classification scheme for the urban area of Bikaner City, it was essential to consider the functional land-uses peculiar to an Indian settlement. Within the scope of this study, the factors of significance to photo identification only were taken into consideration. However, it is recognized that some relevant quantities such as socio-economic and cultural factors affecting land-use should be analyzed from other sources to make a comprehensive study.

Factors and limitations considered were—

- Although up-to-date photography on a large scale would have proved more useful in the classification of land-use due to the limitations in time, funds etc., it could not be obtained. Therefore, the system for land-use classification had to be evolved around the data obtainable from the existing photography.
- Due to high density of mixed-type uses and lack of open space around dwellings in the city center, it was found difficult to specify micro uses of the buildings. The space use in such cases, both in horizontal and vertical directions, had little bearing on their signa-

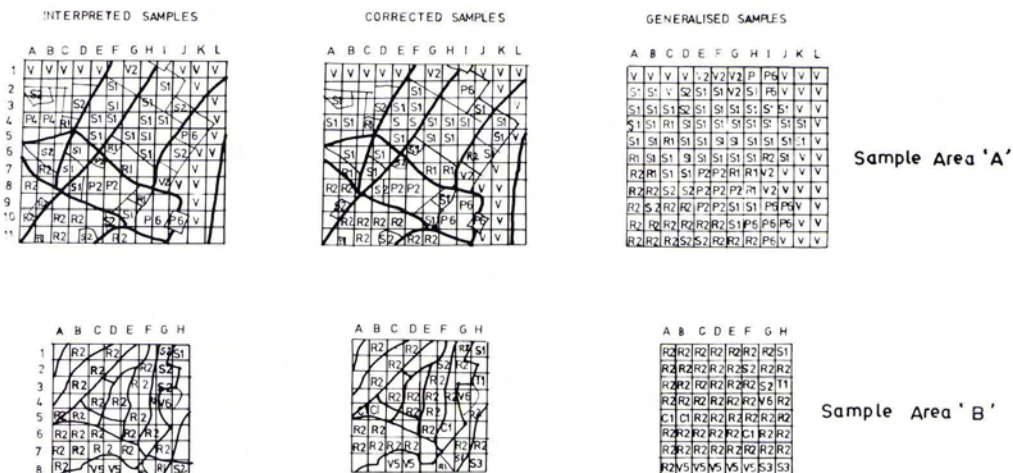


FIG. 2. Sample area analysis, Bikaner City land use, 1974.

TABLE I. THE PERCENTAGE OF ERROR IN CLASSIFICATION UNDER EACH LAND-USE CATEGORY

Classification unit	Total area verified in hectare	Change due to		Percentage Change due to	
		Fresh Development	Wrong Identification	Fresh Development	Wrong Identification
1	2	3	4	5	6
SAMPLE AREA 'A'					
R1	9.37	0.62	—	6.65	—
R2	14.05	0.62	0.78	4.27	5.57
S1	53.10	7.72	9.52	14.52	18.00
S2	11.71	2.95	—	22.22	—
P1	6.24	—	—	—	—
P2	7.81	—	—	—	—
P4	4.68	—	—	—	—
P6	9.37	—	—	—	—
V	40.00	—	1.17	—	11.11
SAMPLE AREA 'B'					
R1	2.58	—	1.56	—	66.3
R2	71.85	1.56	0.93	2.11	1.30
S1	2.78	1.56	—	55.55	—
S3	2.78	1.56	—	55.55	—
C1	4.87	—	2.1	—	30.7
T1	0.78	—	—	—	—
V5	4.68	—	—	—	—
V6	1.87	—	—	—	—

tures on a 1:25,000 scale of photography. Detailed classification of such areas was, therefore, not attempted. These areas were classified under semi-detached residential categories on the basis of parcels. However, large commercial, industrial and service establishments were separated within such heterogeneous parcels.

- Classification by unit could not be attempted in every case because of the small scale of photography. The classification of categories such as residential and commercial was made on parcel basis, parcels generally conforming to the layout of the streets.
- Small commercial establishments such as retail trade, wholesale trade, warehouses, restaurants, etc. could not be identified separately because of poor photographic resolution and the absence of indicators. Such land-uses were grouped under a single category—Central Bazaar.
- The public utility/public use buildings such as offices, banks, etc., were grouped under the Service category because of the nature of their functions.
- Due to the small scale of photography and inadequate photo resolution, certain land-uses were generalized and grouped together. Land-use such as agriculture, areas under construction or under development, sandy area, orchards, rivers, and excavated areas were classified under a main heading

of Open Space. Land having no specified use has been classified under the category of Vacant Land. Vacant land is defined as the area left as open space between residential parcels, etc. that is land still undeveloped.

- The scope of development of a land-use and classification was limited to examination and evaluation of land-uses existent in Bikaner City. Therefore, the non-existent land-use categories have been omitted from the list.
- Large services such as educational, administrative, power houses water tanks, etc., and the industrial categories of land-uses were recognized individually and delineated on a unit basis.
- Since the identification of linear objects, was possible, boundaries formed by regular walls or vegetation hedges were discernible.
- For the purpose of generalization, the smallest unit area for study was limited to 0.5×0.5 cms on photo scale, i.e., $125\text{m} \times 125\text{m}$ on ground. However, individual units of importance or landmarks were picked up and shown on the maps.
- The ground resolution was limited to 0.75 meter assuming a photo-resolution of 15 lines/mm ($0.03 \times 25,000$). Therefore image indicators measuring less than 0.75 meter were not available to aid in the identification of some objects.

LAND-USE CLASSIFICATION

Based on the above criteria, the following land-use classification was used:

S.N. Categories & Sub-Categories	Description
1. RESIDENTIAL	
A. Detached Dwellings	Dwellings having usually separate campus and identity. None of the outer walls being common to any other structure. Parcels having more than 75 per cent of such dwellings are classified under this category.
B. Semi-detached Dwellings	Dwellings constructed independently but having common outer walls with other structures on one side or more than one side. Two adjoining buildings of this nature may or may not have their roofs at the same level but invariably should have a boundary wall separating them. Parcels having more than 75 per cent of such dwellings are classified under this category.
C. Row Units	Dwellings of the same type and design constructed as a single structure in rows. Such structures generally have the same roof levels and may or may not have independent courtyards. Apartments, houses, hostels, etc., have also been included under this category. Parcels having more than 75 per cent of such dwellings are classified under this category. Parcels where dominance of any of the above categories cannot be established are classified as mixed areas signifying a mixed nature of dwelling types. Parcels having mixed use but predominantly residential are also categorized here.
D. Slums	Dwellings having semi-permanent or temporary structures and insufficient infra-structural facilities, located on undeveloped or under developed ground, are called slums. Parcels having more than 75 per cent of such dwellings are classified under this category.
2. COMMERCIAL USE	
A. Central Bazaar	The Central Bazaar or intensively commercialized areas with predominant inter-mixed retailing, and wholesaling activities including service, industries are categorized under this sub-head. Here one finds the greatest concentration of retail stores and a high density of construction, signifying high land values. It includes large godowns, stores, etc. All parcels having more than 75 per cent of such land-use are classified under this category.
B. Neighborhood Business Centers	The neighborhood business centers are the larger retail nuclei, developed near residential areas. All local market and commercial areas serving a locality or neighborhood are classified under this category. Residential commercial buildings such as restaurants etc are included in this category. All parcels having more than 75 per cent of this land-use are classified as neighborhood business centers.
C. Isolated Store Clusters	The isolated store clusters are minor retail business units having limited service areas and located mostly along the road to serve the needs of passersby, etc., are classified under this heading.
D. Godowns	Large storage sheds and godowns, having areas to facilitate loading and unloading are classified on a unit-identification basis.
3. INDUSTRIAL USE	
A. Service Industries	Service industries such as flour mills, shoe making, oil extraction, industries etc., with or without independent land and lo-

- cated within a mixed commercial area are classified here. They provide more-or-less auxiliary services which assist essential city functions. They are classified on a unit-identification basis. Industries having independent areas and engaged in large-scale manufacturing activity are classified under this category on a unit-identification basis.
- B. Large-Scale Industries
4. SERVICES
- A. Educational Educational buildings having an independent identity and campus with open spaces, playgrounds, etc., are classified under this group on a unit-identification basis.
- B. Administrative and Service Use Government administrative buildings, semi-public and public institutions including large dispensaries, post offices, pump-houses, etc., and excluding large hospitals and power stations etc., are identified under this category on a unit-identification basis.
- C. Hospitals Large hospitals with independent campus and lawns, parking facilities, etc., are classified under this category on a unit-identification basis.
- D. Power Stations Large power stations with recognizable boundaries and transmission equipment are identified on a unit-classification basis.
- E. Government Reserve Area Land under occupation of security forces and areas not open to the public and having large areas with open space, rifle ranges, and number of barracks are classified under this category.
4. RECREATIONAL AREAS
- A. Parks and Gardens Open areas organized for recreational purposes come under this category.
- B. Stadiums and Community Halls Large stadiums or community halls having their own campus are classified under this category.
- C. Cinema Houses Large theaters and cinema halls, having their own parking areas, grounds, and housed in large buildings having double pitched roofs are identified under this category.
- D. Playgrounds Organized playgrounds open for institutions or public use come under this category, however, where they form a part of educational institutions, they are marked as educational land-use.
- E. Clubs Large clubs and meeting halls with tennis courts, etc., and parking areas with their own premises are categorized under this heading.
5. RELIGIOUS AREAS
- A. Temples Large temples having independent areas with open spaces for their activities are classified under this heading.
- B. Mosques These include large mosques with independent grounds.
- C. Churches Large churches having some open space are classified under this heading.
- D. Cremation Grounds Cremation or burial grounds having sheds and organized pyres are classified under this category.
6. TRANSPORT AND COMMUNICATION
- A. Roads Primary and feeder roads have been included in this category.
- B. Railway Lines Main lines and branch railway lines have been included in this category.
- C. Railway Stations Large and long platforms with sheds and having the capacity to accommodate a number of trains and also having parking places.
- D. Railway Workshops Factories for manufacturing railway equipment and having new repair facilities.
- E. Railway Yards Enclosed yards.

7. WATER BODIES

- A. Lakes and Tanks Artificial as well as natural lakes and tanks having specific boundaries on four sides are put under this category.
- B. Drains Reinforced drainage, symmetrical and regular man-made drainage are classified under this sub-head.
- C. Open Space Land not grouped under the categories of residential, service, or commercial is classified under this group. Open space is further classified:
- C-1. Under Development Under this category areas under development or construction and in the process of allotment of land-use have been included.
- C-2. Moist Sandy Areas and Pasture Land Land under permanent pasture and sandy areas with some moisture have been classified under this category.

LAND-USE CLASSIFICATIONS

GENERAL LAND-USE PATTERN

General pattern of land-use indicates that a predominant part of the city is utilized for residential purposes, i.e., 2247 acres of land which is 26.3 percent of total urban area. An area of 3184 acres, which forms 37.1 percent of the total urban area, is under open space, of which 1016 acres (33 percent) is under development (12 percent of the total urban area). Almost 19.8 percent of the area comes under services and about 11.6 percent is used for transportation and communication. The industrial area of the city is substantially low (130.5 acres), while the commercial areas occupy slightly more (147 acres). These figures are summarized in Table 2.

CONCLUSION

This paper highlights the advantages of aerial photointerpretation for the study of

land-use and settlement. Advantages in terms of time, effort, and accuracy are considerable.

Aerial photo-interpretation techniques, cannot be considered a complete system for data acquisition. Additional research and development of these techniques are needed to develop a more functional classification system for urban land-use study.

The land-use classification system developed in this paper is broad and generalized. However, a more thorough system can be developed to meet the specific requirements of any development purposes.

The usefulness and the scope of aerial photo-interpretation techniques as tools for the study of multi-faceted problems of urban areas is well established. The problems arising due to the fast rate of urbanization cannot be faced by any administrator or planner without a quick system of data acquisition and appraisal. In spite of the limited usefulness of aerial photographs in providing data on socio-economic and cultural aspects of urban areas they have become the most reliable base material for planning purposes to date.

TABLE 2. LAND-USE AREAS AS CALCULATED WITH AERIAL PHOTOGRAPHS.

S.N.	Category	Area in acres	Percentage of total urban area
1.	Residential Areas	2247.0	26.3
2.	Commercial Areas	147.0	1.7
3.	Service Areas	1694.5	19.8
4.	Industrial Areas	136.5	1.6
5.	Recreational Areas	85.0	1.0
6.	Religious Areas	50.0	0.7
7.	Transport & Communication	995.0	11.6
8.	Water bodies	16.0	0.2
9.	Open space	3184	37.1
TOTAL		8561.0	100.00

Note: Area under Transport and Communication shown in the table is calculated by taking an average figure of 20 per cent of the total built-up area on the photography.

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3. Each article should include an abstract, which is a *digest* of the article. An abstract should be 100 to 150 words in length.
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