Kathmandu Valley GIS Database

Bridging the Data Gap

Basanta Shrestha

Sushil Pradhan

ICIMOD

UNEP

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International Centre for Integrated Mountain Development
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FOREWORD

Because of rapidly growing populations and a dwindling resource base in mountain areas, sustainable development involves greater and conflicting demands on available resources. Decision-makers need to monitor and analyse the changing resource bases of specific ecosystems in order to make informed choices. Modern Information Technologies, such as GIS, RS, and GPS, can facilitate this. These technologies allow planners to process large volumes of data from multiple sources. These data can be integrated to produce maps, monitor changes, and model the impact of management decisions. GIS and related technologies improve data handling capabilities and encourage different stakeholders to re-examine their roles with respect to the supply and availability of data both in terms of bio-physical and socioeconomic aspects. The demand for accurate and homogeneous spatial data has clearly been established by research and development communities. There is hardly anywhere in the HKH area that is as much in need of a reliable and dynamic database as the Kathmandu Valley in Nepal. Rapid urban expansion is taking over fertile agricultural land and scenic spots. The increasing population needs basic services such as water, electricity, telephones, and other essential infrastructure.

With support from the United Nations Environment Programme (UNEP/EAP-AP), ICIMOD facilitated the establishment of an Environment, Information, and Assessment (EIA) Unit at the Ministry of Population and Environment, HMG, Nepal. One of the components of the EIA project was to carry out a Kathmandu Valley GIS study with the aim of preparing a core GIS Database. This study was taken up as a pilot study to raise awareness about the potential of the technology and its usefulness in planning and decision-making.

The study established a core Kathmandu Valley GIS database based on available maps and remote-sensing images. It is hoped that the database will be used as a starting point for research and development activities in planning and management of the Valley. This document serves to raise awareness about the existence of digital data, and it will hopefully serve to avoid duplication of efforts in future. To encourage and improve information exchange the database and the complete publication are available on an interactive CD-ROM.

This study was undertaken by Mr. Basanta Shrestha, Systems' Specialist, and Mr. Sushil Pradhan, GIS Analyst. Digitisation of the topographic database was undertaken by Mr. Anirudra Man Shrestha, senior cartographer at MENRIS. Other MENRIS staff who assisted in the study are 'Mr. Pradeep Mool, Mr. Birendra Bajracharya, Mr. Sushil Pandey, Mr. Govinda Joshi, Mr. Saisab Pradhan, Ms. Mona Thapa, and Ms. Monica Moktan. EIA project staff at MoPE, Mr. Bhusan Pradhan, Mr. Manohar Bhattarai, Ms. Sunjita Pradhan, and Mr. Madhav Adhikari, have assisted in the compilation of data sets. On behalf of ICIMOD, we would like to thank them all for their contributions. We would also like to thank Mr. Surendra Shrestha, Regional Coordinator of the United Nations Environment Programme, Environment Assessment Programme – Asia Pacific (UNEP- EAP/AP) for his inputs and for facilitating th financial support of UNEP. Lastly, we would like to express our sincere thanks and appreciation to the Ministry for all the support provided for this study.

Pramod Pradhan Head - MENRIS ICIMOD	Egbert Pelinck Director General ICIMOD

ABSTRACT

Recently, there has been a continuing growth in the use of GIS and related technologies by many organizations engaged in planning and management of the Kathmandu Valley. As a result, the demand for accurate standardised spatial data of the Valley for government use as well as for use by research and development organizations has grown.

This study is about attempts to build a comprehensive GIS Database of the Kathmandu Valley as a means of bridging important data gaps. The study employs a fresh approach using the maps available and integrating with satellite images. The maps presented in this publication visualise the environment and raise awareness about digital databases. It is hoped that the application presented in this publication will increase awareness about the usefulness of digital databases and demonstrate what can be achieved with GIS and related technologies. It is also hoped that this database will improve information on the Kathmandu Valley and assist different stakeholders engaged in planning and management of services.

Furthermore, the study advocates a building block approach to development, management, and revision of databases in a complementary way to avoid duplication of efforts in costly production of digital data. The study aims to sensitise senior executives and decision-makers about the need for a sound policy on database sharing, development, and standards. Such a policy, at the national level, known as a National Spatial Database Infrastructure (NSDI), should evolve in order for everyone to benefit from the prevailing GIS technology. In using GIS and related technologies, the study facilitated the establishment of a Spatial Data Infrastructure of the Kathmandu Valley.

ACRONYMS

ADEOS	Advanced Earth Observation Satellite
AML	Arc Macro Language
AVNIR	Advanced Visible and Near – Infrared Radiometer
CBS	Central Bureau of Statistics
CD-ROM	Compact Disc – Read Only Memory
DBMS	Database Management System
DEM	Digital Elevation Model
DHUD	Department of Housing and Urban Development
DOS	Department of Survey
DTM	Digital Terrain Model
DWSS	Department of Water Supply and Sanitation
EAP-AP	Environment Assessment Programme – Asia Pacific
EIA	Environment Information and Assessment
ESRI	Environmental Systems Research Institute
ERDAS	*Trade mark of ERDAS Inc., developer of ERDAS Imagine software*
FINNMAP	Finnish Map
FCC	False Colour Composite
GIS	Geographic Information Systems
GPS	Global Positioning System
GCP	Ground Control Points
HKH	Hindu-Kush Himalayas
HMG/N	His Majesty's Government of Nepal
HRV	High Resolution Visibility
IBM	International Business Machine
IRS	Indian Remote Sensing Satellite
KMC	Kathmandu Metropolitan Office
KUDP	Kathmandu Urban Development Project
ICIMOD	International Centre for Integrated Mountain Development
IUCN	International Union for Conservation of Nature
LANDSAT	Land Observation Satellite
LRMP	Land Resource Mapping Project
MENRIS	Mountain Environment and Natural Resources' Information Service
MoPE	Ministry of Population and Environment
MSS	Multi-spectral Scanning
NEPAP	Nepal Environmental Policy and Action Plan
NSDI	National Spatial Data Infrastructure
NTC	Nepal Telecommunications Corporation
PAN	Panchromatic

RS	Remote Sensing
RDBMS	Relational Database Management Systems
SPIN	Space Information
SPOT	Satellite Probatoire d'Observation de la Terre
TM	Thematic Mapper
TCC	True Colour Composite
VDC	Village Development Committee
UNEP	United Nations Environment Program
UTM	Universal Transverse Mercator System
XS	Multi-spectral

LIST OF MAPS

LIST OF FIGURES

LIST OF TABLES

TABLE OF CONTENTS

1. BACKGROUND

The Environment Information and Assessment Project (EIAP) was the result of collaboration between the United Nations Environment Programme, Environment Assessment Programme–Asia Pacific (UNEP/EAP-AP), Ministry of Population and Environment (MOPE) and International Centre for Integrated Mountain Development (ICIMOD). The primary objective was to facilitate institutionalisation of the newly-established Ministry on the use of modern information-based technologies for environmental data and information management in Nepal. The Mountain Environment and Natural Resources' Information Service (MENRIS) of ICIMOD facilitated the implementation of an Environmental Impact Assessment (EIA) project at the Ministry.

As a result of this project, the Ministry is now equipped with an Internet communication system based on UNEP's system, UnepNET. It has a Mercure satellite earth station (MENRIS/ICIMOD 1998), and the EIA Unit is also furnished with hardware and software to carry out work with Geographical Information Systems (GIS). One of the components of the EIA project involved a study of the Kathmandu Valley to prepare a core GIS Database of the Valley. This study was carried out as a pilot study to demonstrate the potential of GIS and related technologies and their usefulness for planning and for management of infrastructure and services in the Kathmandu Valley.

The Mountain Environment and Natural Resources' Information Service (MENRIS) of the International Centre for Integrated Mountain Development (ICIMOD) serves as a resource centre for the HKH Region for the study and application of geo-information technologies. Close collaboration with research institutions, space agencies, and vendors has led to the establishment of nodal agencies in ICIMOD's participating Regional Member Countries (RMCs) as part of a GIS network to serve a vast region of immense diversity. The network encourages dialogue between professionals working in the HKH Region on a mutually compatible, integrated GIS platform. Sharing public domain data and information on analytical problems is encouraged as a means of bridging the data gap. A regional mechanism for pooling resources, expertise, and facilities for and work on common problems in the HKH region for the mutual benefit of regional member countries is encouraged through a network of collaborative institutions.

2. THE CONTEXT AND RATIONALE

Urbanisation of the Kathmandu Valley is occurring rapidly and the present, growing population has limited access to basic utilities such as drinking water, drainage, sewerage systems, electricity, and sanitation. The valley has been subjected to haphazard and increasing industrialisation and commercialisation over the years. Carpet and garment manufacturing units have mushroomed over the past two decades. The establishment of large numbers of industries and manufacturing units in the valley is causing water and air pollution. These industries have attracted many migrant labourers who account for approximately 30 to 35 per cent of the valley's estimated total urban population.

The natural resources of the valley, particularly the forests, have decreased substantially over the last two decades. Quarrying, on both a large and small scale, has increased in the surrounding hills, causing an increase in soil erosion and frequent landslides and floods. This has also led to a decrease in the quality of sites for tourists and for public recreation. Prime agricultural land has been taken over by urban development and industry. Cultural heritage sites and historical monuments are in bad shape and the open spaces around monuments are subject to severe encroachment (IUCN and NPC/HMG Nepal 1995).

The growing problems of the Kathmandu Valley environment are among the important issues addressed by the Nepal Environmental Policy and Action Plan (NEPAP) endorsed in September 1993 by the Environmental Protection Council of His Majesty's Government of Nepal. The development and implementation of an 'Environmental Action Plan' for the Kathmandu Valley was identified as a priority.

3. THE NEED FOR A GIS DATABASE

Sustainable and equitable development has to be based on reliable and accurate information, hence application of geo-information technologies is becoming more and more significant. Decisions are influenced by geographic locations. Complex analyses require digital spatial data that define the characteristics of geographic space. Solving the complex problems of an urban environment, such as that of the Kathmandu Valley, requires accurate, up-to-date information with an integrated spatial component, information that is accessible and comparable with basic predictions. For this, a GIS database can provide a useful source of information.

Many organizations have used different methods for acquiring, storing, processing, analysing, and viewing spatial data. Today, exchanging, sharing, and integrating spatial data from various sources have become increasingly important. This is a result of the growing environmental concerns and of pressures on governments and different sectors to perform more efficiently because of limited budgets. Due to the pressure for efficient use of limited resources, cooperation among different sectors is essential for the design and development of spatial databases. Such a need is now constantly expressed in various forums. It is therefore important to introduce a systematic approach to developing a spatial dataset of the Kathmandu Valley that will serve different planning purposes.There is a general consensus among various sectors that better datasets of the Kathmandu Valley are of prime importance for improving assessment, monitoring change, and implementing effective programmes and policies.

3.1 Critical Issues in GIS Database Development

As a technology, use of GIS is gradually replacing the conventional approach to spatial information handling. However, current handling of spatial information among line agencies is neither efficient nor effective. Spatial data are generally not available or are poorly maintained, out of date, and often inaccurate. Maps are on varying scales and have different coordinate systems, making it difficult to make overlays and integrate them. Also, maps on higher scales, which are needed for the type of urban management applications required, are not available. Spatial information is not defined in a consistent manner and naturally is of a low standard. Data (metadata) are not documented, rendering them unavailable for future use.

There are no clear mandates and policies for the institution responsible for defining, maintaining, and revising such data. There is little or no interaction between the institutions or projects and often their mandates, authorities, responsibilities and functions overlap (IUCN and NPC/Nepal 1995) . Our experience shows that to bring different sources of spatial data on the Kathmandu valley together and to integrate them are very difficult, if not impossible.

3.2 Existing Scenario

The Survey Department has the primary responsibility for spatial data for the whole country. Some achievements in the context of establishing digital data have been accomplished. However, a systematic and integrated approach is clearly what is needed now. The Survey Department has a clear mandate to produce maps and related products, but it needs clear-cut plans and policies concerning methodology and development of its work. Introduction to new techniques applicable in the country and in tune with modern trends and developments is essential (Department of Survey 1998)

The Department has a more liberal policy than departments in other parts of the HKH region. Maps and aerial photographs are readily available at reasonable prices. Research and Development projects have used these as per their needs. Lack of standards and limited knowhow on digital databases mean that each study employs its own methods. From certain perspectives, without long-term implications, the resources are wasted and efforts are duplicated. Consequently, results derived from the studies are limited and can not be used for any other purpose.

The Physical Development Plan for the Kathmandu Valley, produced in 1969, is one of the most comprehensive studies for the overall development of the valley and is an excellent example of manual GIS. It was financed by the United Nations and took seven to eight years (It started in 1962 and the work was published in 1969) to prepare the Master Plan. Many studies have been carried out since then, but they lack the balanced coverage of subject areas and comprehensive spatial components are not included. The number of publications that promote the use of a spatial framework for basic planning purposes indicates how important such a framework is for the development of the valley. Significant amounts of resources have already been poured into these studies. A comprehensive list of studies on the Kathmandu Valley is given in 'Regulating Growth – Kathmandu Valley Main Report'. For example - there have been initiatives to map the Kathmandu Valley on a larger scale by the Nepal Telecommunication Corporation (NTC), Department of Water Supply and Sanitation (DWSS), and municipal mapping projects under the Department of Survey (DOS). But, the data derived from these studies are difficult to use because of the isolated nature of each project and the fact that data are not shared. More recently, the Kathmandu Metropolitan Office introduced a project to map the Kathmandu Valley as an aid to planning and development activities. This project received support from the European Union.

It is a general problem that most studies have no comprehensive spatial component, and hence there is little or no relationship between one study or the other in terms of spatial data and information. Projects need to be complementary with appropriate policy focus and guidance. The increasing importance of data and the rapid progression of the technology have provided new ways to manage geographic information and comprehend the existing scenarios. It is against this background that GIS database development took place.

4. GEO-INFORMATION TECHNOLOGY - AN INTEGRATING TOOL

The advent of information technology has altered the scope of information processing. Computers are now able to process maps (spatial data) and tabular data (non-spatial data) and merge them together to give added value. Geo-information technology has given added dimensions to the visualisation of information. A geographic information system (GIS) is a computer-based tool for mapping and analysing whatever exists and events that happen on earth. GIS technology facilitates the merging of map and tabular data quickly, thus processing spatial information. These abilities distinguish GIS from other information systems and make it useful for multi-sectoral analysis and planning strategies.

Remote sensing systems are used to observe the Earth's surface from satellites and make it possible to collect and analyse information. Remote sensing is a complementary technology for capturing data about the earth's surface. The data obtained from remote sensing are in a digital raster format and can be integrated into a GIS environment. Recent advancements in space technology have provided a lot of new information that is less expensive and easier to use than previous data.

Remote Sensing (RS) observations from satellites provide data about the earth in a spatial format. Remote-sensing techniques are more cost effective than ground-based techniques over large areas. The RS data have benefits in terms of synoptic views and large area coverage; the proverbial 'bird's eye-view' of features. The speed with which RS data can be made available (from 3-20 days' interval) make it useful for processing and monitoring features on earth over a given period of time. High-resolution satellite data are another feature emerging in recent years. These make it possible to examine more spatial and temporal variations than ever before. Global Positioning System (GPS) technology computes and captures a position anywhere on the earth's surface within a 24-hour period. This has brought about rapid advancements in surveying and mapping. At the same time, there has been a sharp decline in the price of hardware, an increase in computing power, and improvements in software – making it easier for the user to handle. As a result, GIS and related technologies can be handled by desktop computers.

Developments in geo-information (GIS/RS/GPS) technologies in recent years and rapidly growing convergence among them have facilitated the integration of bio-physical and socioeconomic information and their analysis on a common platform. Hence, planners and decision-makers can visualise alternative strategies.

These factors have helped to create a suitable context for the management of geographic information, i.e., systematic collection, updating, processing, analysing, and distribution of spatial data. As a result, design and development of spatial databases have emerged as priorities and are appreciated by many different sectors. Today, many organizations have shown a keen interest in adopting the technology and putting it into effective use. This study makes an attempt to integrate geo-information technologies and encourage information exchange among stakeholders. The study attempts to provide the opportunity and benefits of improved availability of information and application of such technologies for the overall planning and development of the Kathmandu Valley.

4.1 Application of GIS in a Mountain Environment

The diversity, marginality, and strategic importance of mountains, together with vastly different rates of change in their physical, biological, and societal systems, present challenges for GIS and related technologies. In contrast to the widespread use of GIS in other areas, the use of the technology for mountain environments is limited. Compared to the plains and lowlands, the physical characteristics of the mountains are complex and need to be analysed using a three-dimensional approach or methodology to arrive at an approximate representation of the topography, slope, and aspects (Heywood *et al.* 1994).

The application of geo-information technologies to the mountain environment involves special considerations because of its topographic variations. Much depends on the knowledge of particular characteristics and our understanding of how mountain systems work. Geo-information technologies are gradually being modified to address the conditions of mountain areas. In this context, MENRIS is engaged in disseminating technology in the HKH region and developing some of the potential applications mentioned below.

- Land use/cover analysis
- Snow and glacial lake inventory
- Mountain hazard mapping

- Mountain natural resource management
- Infrastructure planning and accessibility analysis

All these applications require a sound information base in terms of both spatial and temporal dimensions. (See Annex 1 for a glossary of technical terms used in the text.)

5. THE STUDY AREA: KATHMANDU VALLEY

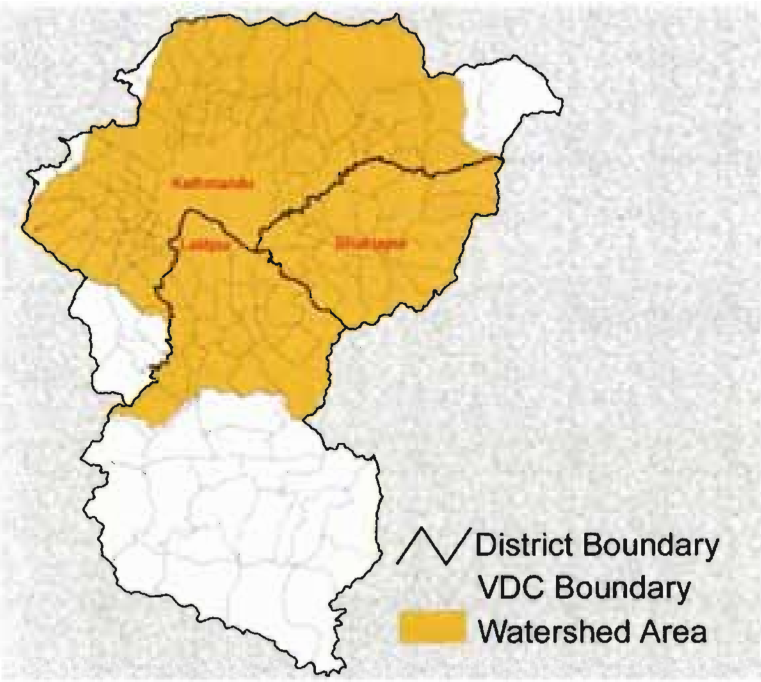


Figure 1: **Kathmandu Valley Based on the Watershed Boundaries**

The area of Kathmandu Valley is based on a watershed boundary covering 81 per cent of Kathmandu district, 32 per cent of Lalitpur district, and the whole of Bhaktapur district (Figure 1). The Kathmandu Valley has three large cities, viz., Kathmandu, Lalitpur, and Bhaktapur, and many small market towns. Several studies have been carried out on the Valley, but the areas and boundaries provided by them do not coincide (IUCN and HMG/Nepal 1995). The reported area ranges from 596 to 760 sq. km. In this study, the area of the Kathmandu Valley is calculated from a topographic map on a scale of 1:25,000; the area is 583 sq. km.

For the present study, the study area is considered to be the entire administrative district boundaries of Kathmandu, Lalitpur, and Bhaktapur (Figure 2) so that aggregation of data at the district and sub-district levels can be carried out easily. Another reason for choosing the district boundaries is that district databases can be used by different stakeholders working in the districts. There are altogether 131 village development committees (VDCs) in the Kathmandu, Lalitpur, and Bhaktapur districts: 67 in Kathmandu, 41 in Lalitpur, and 22 in Bhaktapur.

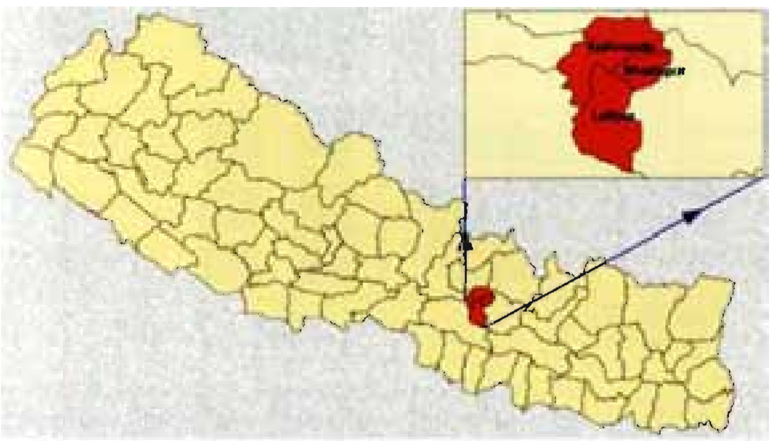


Figure 2: **Location of Kathmandu, Lalitpur, and Bhaktapur Districts**

6. OBJECTIVES OF THE STUDY

The overall objective of this study was to gather comprehensive spatial information on the Kathmandu Valley. It was also used as a pilot study for establishing appropriate policy and programme guidelines for use by different stakeholders.

The particular focus of this study was to design and develop a spatially referenced digital database that will provide a basis for research and development focussed on planning and management for development of the Valley in an environmentally sound manner.

The study also aimed to do the following.

- To bridge the important gaps in data on the Kathmandu Valley
- To identify and present key bio-physical and socioeconomic factors of the Kathmandu Valley on maps
- To use application cases based on the spatially referenced database as examples of the potentials of geo-information technologies
- To encourage information exchange among line agencies on a mutually compatible GIS platform
- To eliminate duplication in the costly and time-consuming work of establishing spatial datasets

7. GIS DATABASE DESIGN AND DEVELOPMENT

Kathmandu Valley GIS Database integrated map data, satellite data, and secondary sources of data. The study attempted to integrate these divergent sources of data. To do so, it was essential to collect and compile spatial and non-spatial information from disparate sources and merge this information by using GIS. The study made extensive use of satellite imagery and specifically explored the use of high-resolution satellite imagery for urban environmental management. Thus, the study was able demonstrate the applicability of GIS and RS technologies to planning and management of the Valley. The advancement of space technology made it possible to look at the possibilities for using different satellite imagery to complement spatial data. Efforts were made to integrate attribute information from the Population Census 1991, e.g., aspects of demography and socioeconomic data.

Data for the topographic map (vector format) were organized into the database by digitising topographical maps; remote sensing data (raster format), i.e., satellite images and aerial photos, were organized into the database by means of image processing; and the non-spatial data (attribute information) were organized into a Relational Database Management System (RDBMS). The overall methodology employed is given in Figure 3.

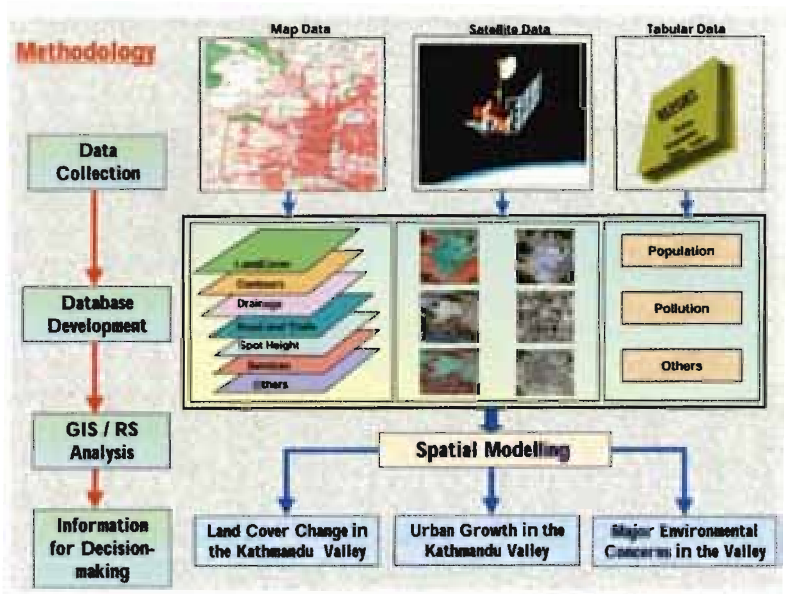


Figure 3: **Overall Methodology of GIS Database Development**

7.1 Topographic Database

For development of a GIS database of Kathmandu Valley, the following secondary sources of information were used.

- Topographic maps published by the Topographical Survey Branch, Department of Survey of Nepal on a scale of 1:25,000, 1992

- Maps published by the Land Resource Mapping Project (LRMP) on a scale of 1:50,000, 1978/79
- Socioeconomic data published by the Central Bureau of Statistics of Nepal, 1991

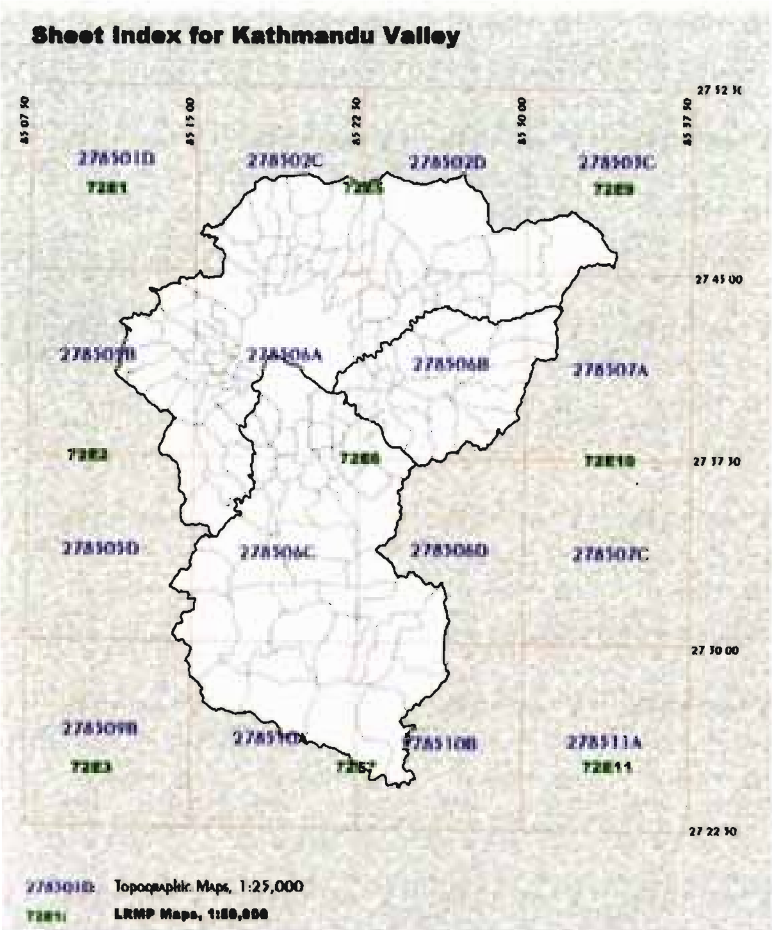


Figure 4: **Reference System for Topographic and LRMP Map Sheets**

Information from existing maps was extracted by manual digitisation using PC Arc/Info software Version 3.5. These maps were digitised sheet by sheet and joined on an IBM Workstation Computer using Arc/Info version 7.0.3 software. The reference system for the 1:25,000 scale maps produced by FINNMAP is shown in Figure 4 and, on the basis of this reference, all other thematic layers were extracted.

Information on land use, road and trails, drainage network, contours, settlements, spot heights, services, and administrative boundary was extracted from 1:25,000 scale topographic maps (1991); land use, land systems, and land capability were based on a 1:50,000 scale map published by LRMP (1978/79). Although the maps produced by LRMP were published in 1986, the aerial photographs used for the project were from 1978 and the field verification was carried out in 1982. Table 1 indicates the various themes of the topographic database of the Kathmandu Valley.

The methodology used for preparation of the topographic database of Kathmandu Valley is depicted in Figure 5.

Table 1: **List of the Topographic Database of the Kathmandu Valley**

Layers	Source	Scale	Date
Road Network	Topographic Map	1:25,000	1995
Drainage Network	Topographic Map	1:25,000	1995
Contours	Topographic Map	1:25,000	1995
Land Use/Cover	Topographic Map	1:25,000	1995
Services	Topographic Map	1:25,000	1995
Spot Heights	Topographic Map	1:25,000	1995
Land Use/Cover	Topographic Map	1:25,000	1995
Land Use/Cover	LRMP Map	1:50,000	1978/79
Land Capability	LRMP Map	1:50,000	1978/79
Land Systems	LRMP Map	1:50,000	1978/79

The details of these data layers, i.e., the data dictionary, are presented in Annex 2. The database thus developed was then applied to attain more knowledge by creating secondary layers, e.g., Elevation Zone, DEM (Digital Elevation Model), Slope, and Aspect, were derived from contours. The main topographic features and the derived data layers are briefly discussed below.

7.1.1 Contour/Spot Height

The digitised index contours at 20-metre intervals and supplementary contours at 10-metre intervals were interpolated using the TIN (Triangulated Irregular Network) module of Arc/Info 7.0.3 version software to derive a DEM of the Kathmandu Valley on a resolution of 10 metres. The derived DEM was, again, used to generate DTMs (Digital Terrain Models), e.g., Slope, Aspect, and Hillshade. The database included spot heights representing elevation (in metres) of particular locations, and these can be used as an alternative approach to interpolating surface to derive a DEM.

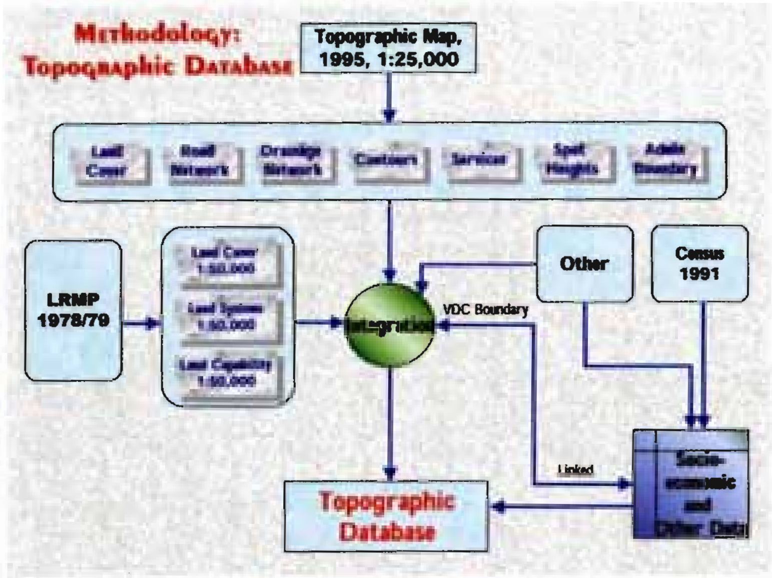


Figure 5: **Methodology Applied for the Preparation of a Topographic Database**

7.1.2 Road Network

The road network database contains the different types of roads in the Kathmandu Valley, and these have been entered in five categories.

Highway	Roads used mainly for travelling long distances.
Major Roads	Motorable paved roads mainly within urban areas.
Feeder Roads	Motorable unpaved roads
Foot Trails	Foot trails along which only light vehicles such as motor-cycles, cycles, etc. can pass.
Minor Foot Trails	Trails that are only for walking.

7.1.3 Drainage Network

The drainage database includes different types of rivers, such as river embankments, main rivers, seasonal rivers, sandy areas, and so on. Sample pictures of sources showing types of rivers in terms of water pollution were also integrated into the database. This was to show the potential integration of multimedia into the GIS database, giving the pictorial situation of each location.

7.1.4 Land Use and Land Cover (1:25K)

The database on land use and land cover was generated from a topographic map (1:25K) with the same categories of classification and some of the classes were generalised into standard classes for the purpose of analysis. So, the database includes both detailed and generalised classifications.

7.1.5 Location of Services

The database includes the location of 11 different types of service taken from a 1:25K topographic map, for example, hospitals, bus terminals, schools, and so on. This information can be used for planning infrastructure for basic services and network analysis.

7.1.6 Land Use, Land Capability, and Land Systems (1:50K)

The database also includes information on land use/cover, land capability, and land systems. Maps published by the Land Resource Mapping Project (LRMP) on a scale of 1:50K were digitised for this purpose. For details, users may refer to the LRMP report published in 1986.

It is our observation that a database on this scale might suffice for natural resources and many environmental management applications, but such a database may not provide the right answers for application to specific urban or municipal environments. Maps on higher scales of 1:5,000 or above are not available for the entire valley. This is one of the reasons why we used high-resolution satellite imagery. However, efforts have been made to produce maps of the urban area of the Kathmandu Valley on higher scales of 1:2,000 through collaborative projects, e.g., Nepal Telecommunications (NTC) and Department of Water Supply and Sanitation (DWSS) and metropolitan area mapping by the Department of Survey (DoS). A list of other maps available (with potential new projects in the near future) of the valley from different sources is provided in Annex 3. We have no specific information about digital versions of these.

The following maps (Maps 1 - 14) were prepared from the spatially referenced database for spatial visualisation purposes.

List of Maps Prepared from Spatially Referenced Topographic Database

Kathmandu Valley

Map 1
Index Countours at 20 Metres Intervals

Legend

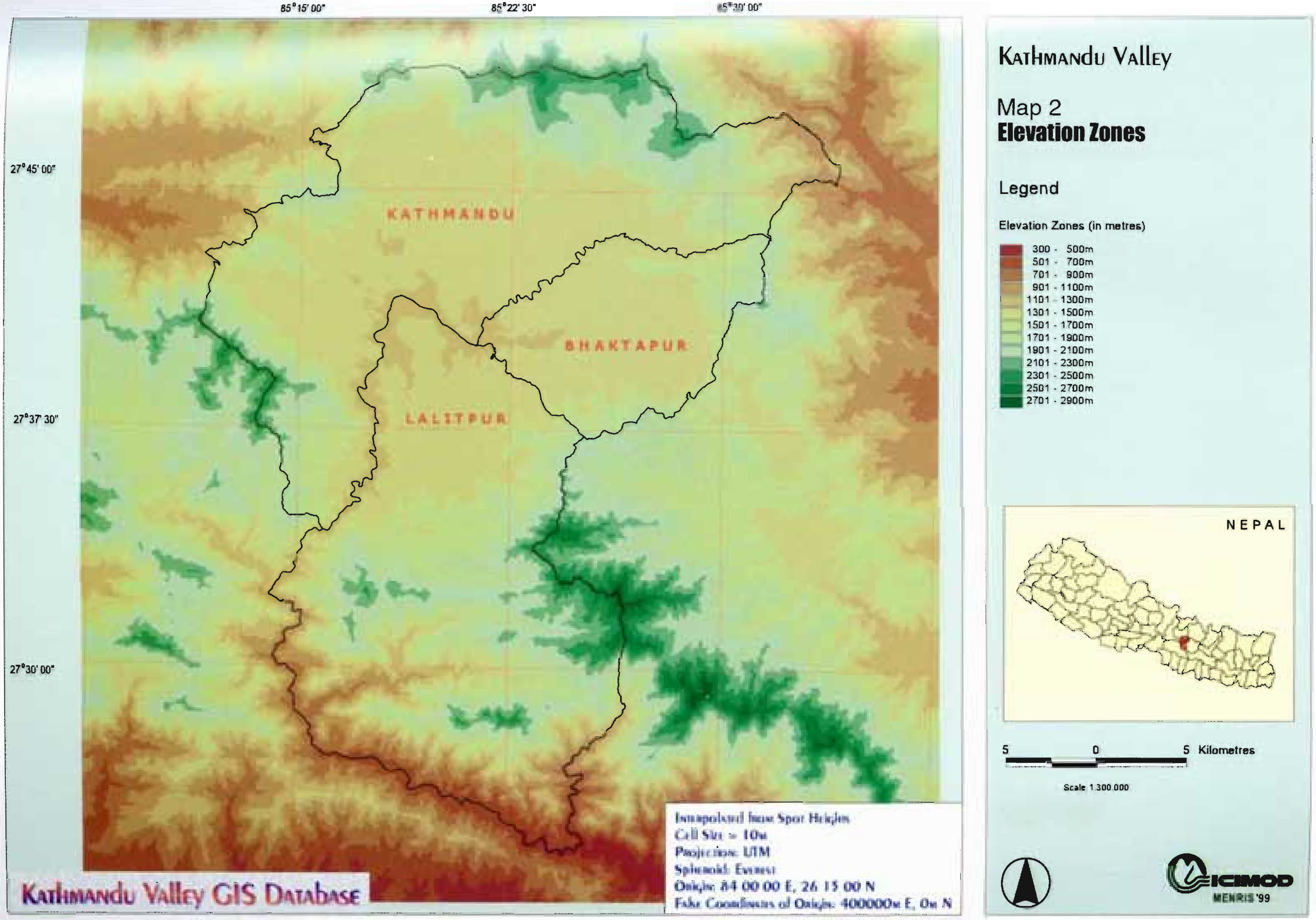
Contours (in metres)

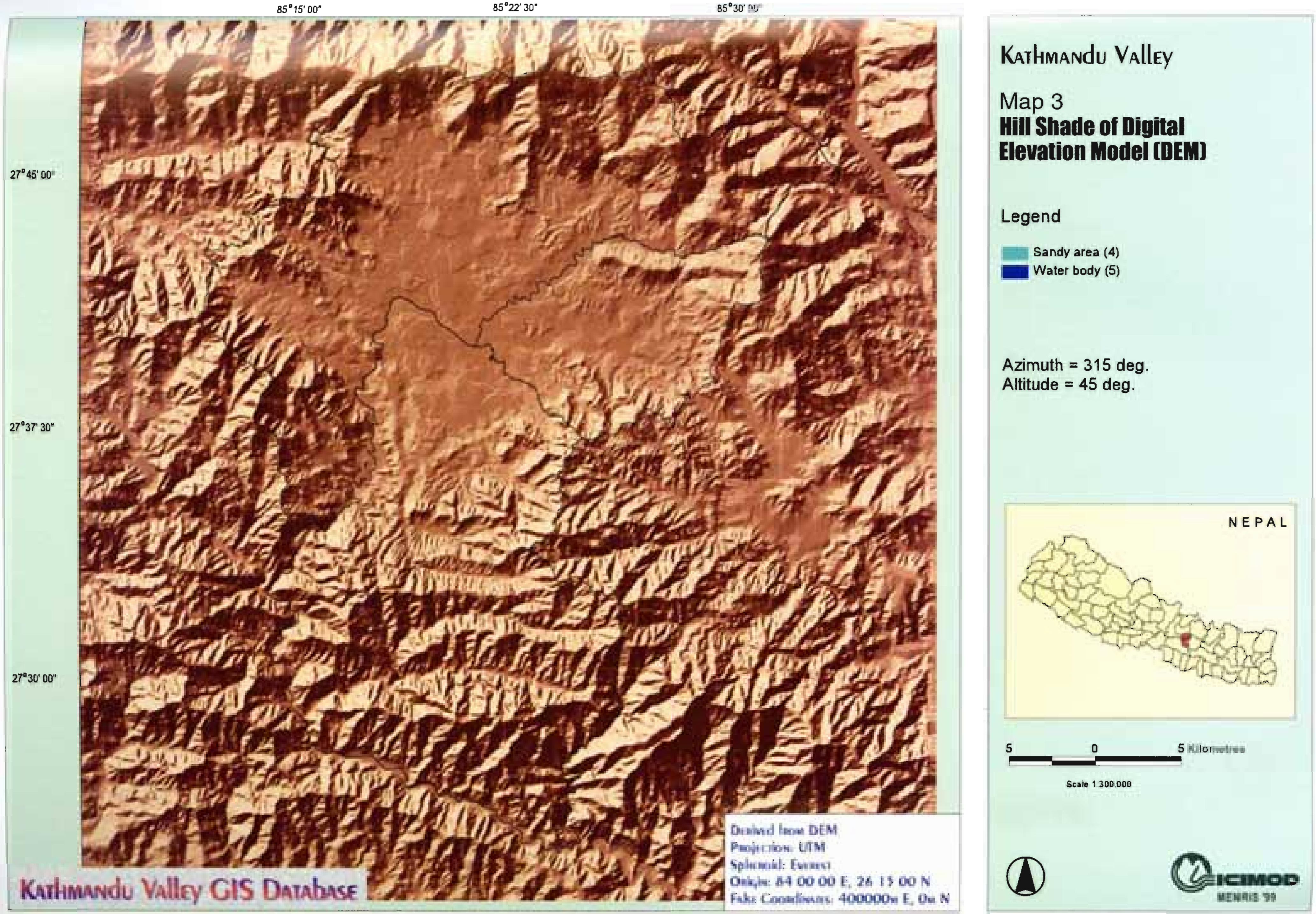
- Below 500
- 501 - 1000
- 1001 - 1500
- 1501 - 2000
- 2001 - 2500
- 2500 - 2900

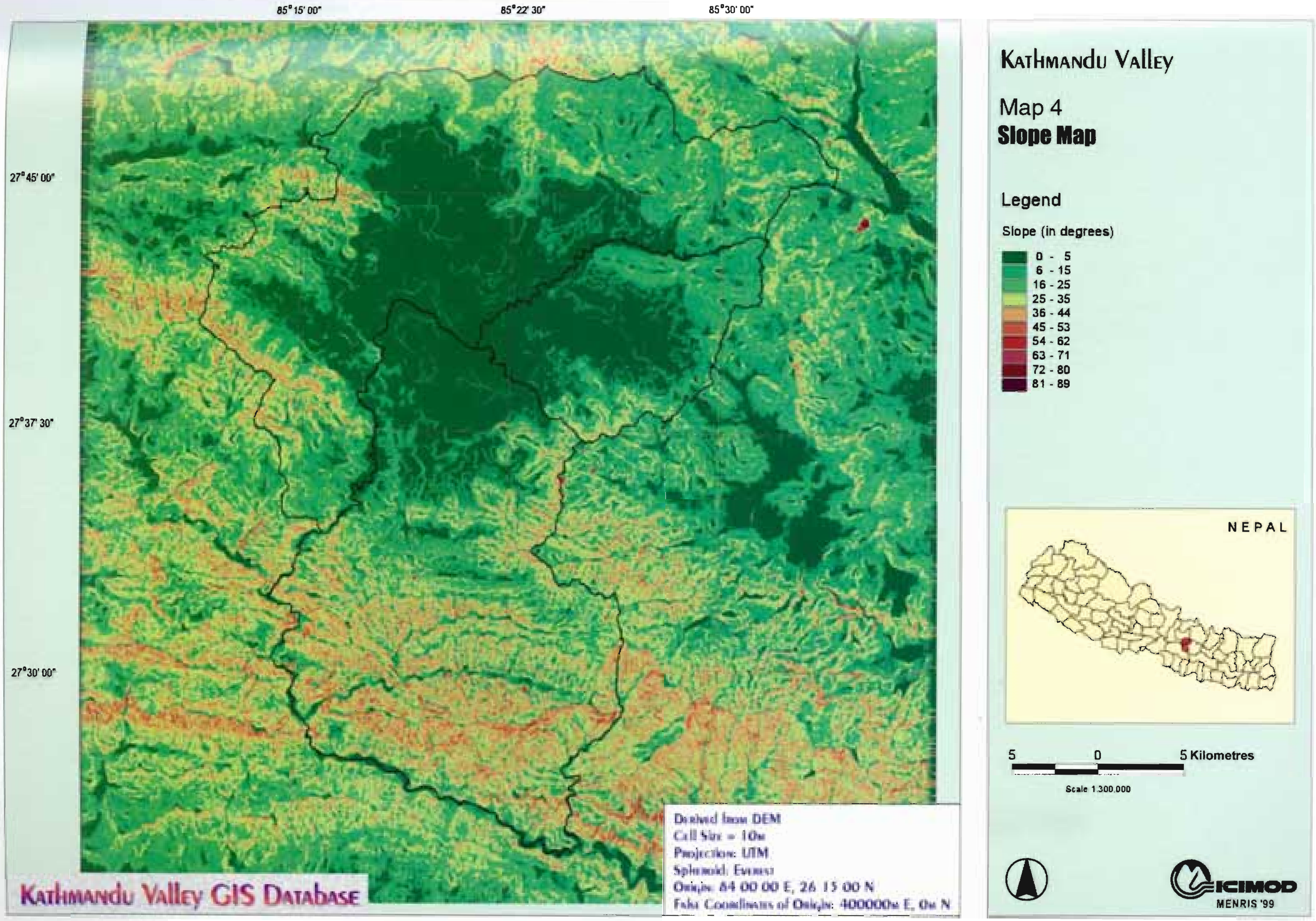
5 0 5 Kilometres

Scale 1:300,000

ICIMOD
MENRIS '99


Kathmandu Valley
Map 2
Elevation Zones
Legend
Elevation Zones (in metres)
300 - 500m
501 - 700m
701 - 900m
901 - 1100m
1101 - 1300m
1301 - 1500m
1501 - 1700m
1701 - 1900m
1901 - 2100m
2101 - 2300m
2301 - 2500m
2501 - 2700m
2701 - 2900m
NEPAL
5 0 5 Kilometres
Scale 1:300,000
ICIMOD
MENRIS '99
85°15' 00"
85°22' 30"
85°30' 00"
27°45' 00"
27°37' 30"
27°30' 00"
KATHMANDU
BHAKTAPUR
LALITPUR
Interpolated from Spot Heights
Cell Size = 10m
Projection: UTM
Spheroid: Everest
Origin: 84 00 00 E, 26 15 00 N
False Coordinates of Origin: 400000m E, 0m N
Kathmandu Valley GIS Database

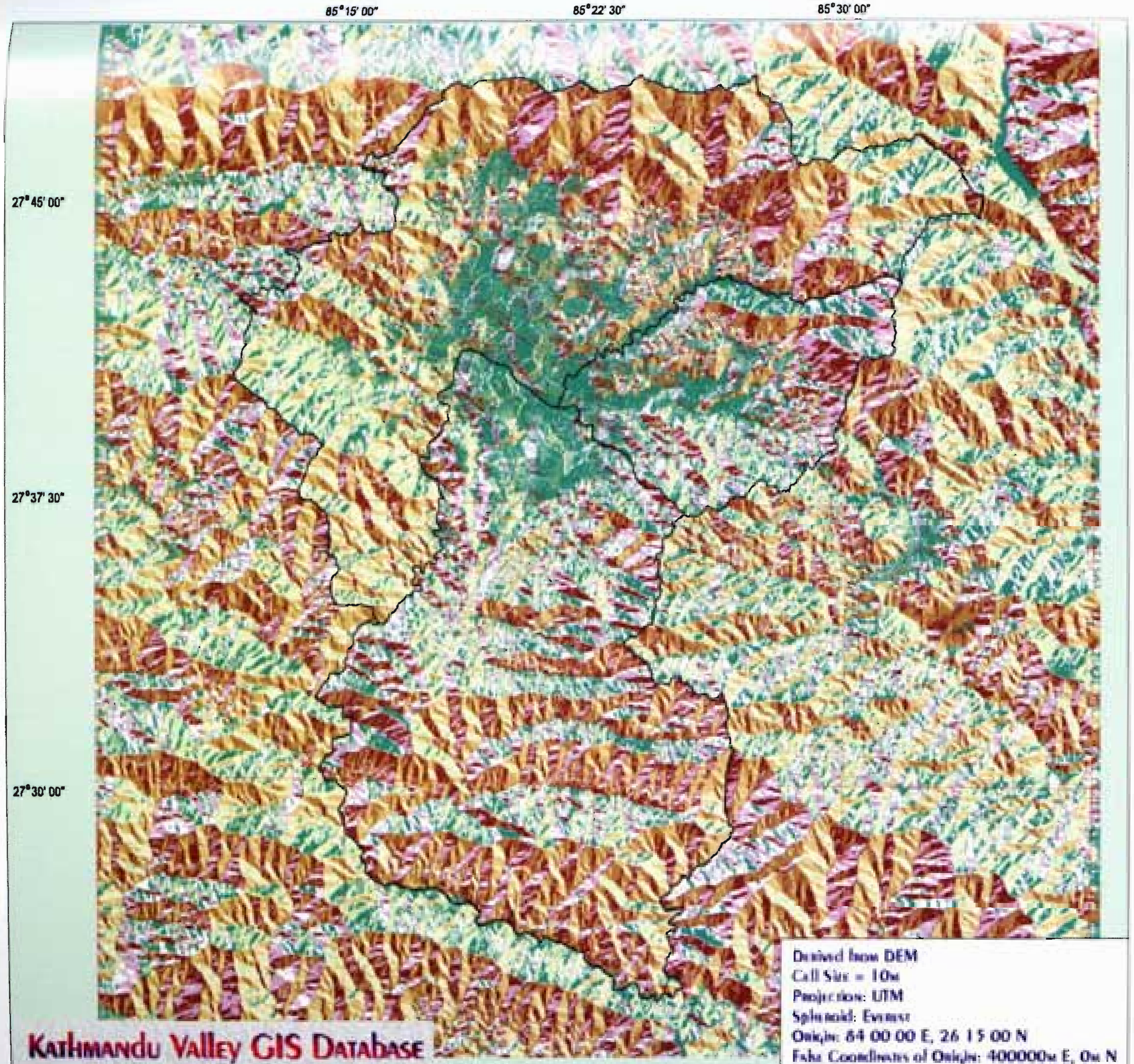

85°15' 00"
85°22' 30"
85°30' 00"
27°45' 00"
27°37' 30"
27°30' 00"
Kathmandu Valley
Map 3
Hill Shade of Digital Elevation Model (DEM)
Legend
Sandy area (4)
Water body (5)
Azimuth = 315 deg.
Altitude = 45 deg.
NEPAL
5 0 5 Kilometres
Scale 1:300,000
Derived from DEM
Projection: UTM
Spheroid: Everest
Origin: 84 00 00 E, 26 15 00 N
False Coordinates: 400000m E, 0m N
Kathmandu Valley GIS Database
ICIMOD
MENRIS '99


85° 15' 00"
85° 22' 30"
85° 30' 00"
27° 45' 00"
27° 37' 30"
27° 30' 00"
Kathmandu Valley GIS Database
Derived from DEM
Cell Size = 10m
Projection: UTM
Spheroid: Everest
Origin: 84 00 00 E, 26 15 00 N
False Coordinates of Origin: 400000m E, 0m N
Kathmandu Valley
Map 4
Slope Map
Legend
Slope (in degrees)
0 - 5
6 - 15
16 - 25
25 - 35
36 - 44
45 - 53
54 - 62
63 - 71
72 - 80
81 - 89
NEPAL
5 0 5 Kilometres
Scale 1:300,000
ICIMOD
MENRIS '99

Kathmandu Valley

Map 5

Aspect Map



Legend

Aspects (in degrees)

- North 0 - 22.5, 337.5 - 361
- Northeast 22.5 - 67.5
- East 67.5 - 112.5
- Southeast 112.5 - 157.5
- South 157.5 - 202.5
- Southwest 202.5 - 247.5
- West 247.5 - 292.5
- Nortwest 292.5 - 337.5

5 0 5 Kilometres

Scale 1:300,000

ICIMOD

MENRIS '99

Source: Topographic Map, 1995
Scale: 1:25,000
Projection: UTM
Spheroid: Everest
Origin: 84 00 00 E, 26 15 00 N
False Coordinates of Origin: 400000m E, 0m N

Kathmandu Valley GIS Database

Kathmandu Valley

Map 6
Road Network

Legend

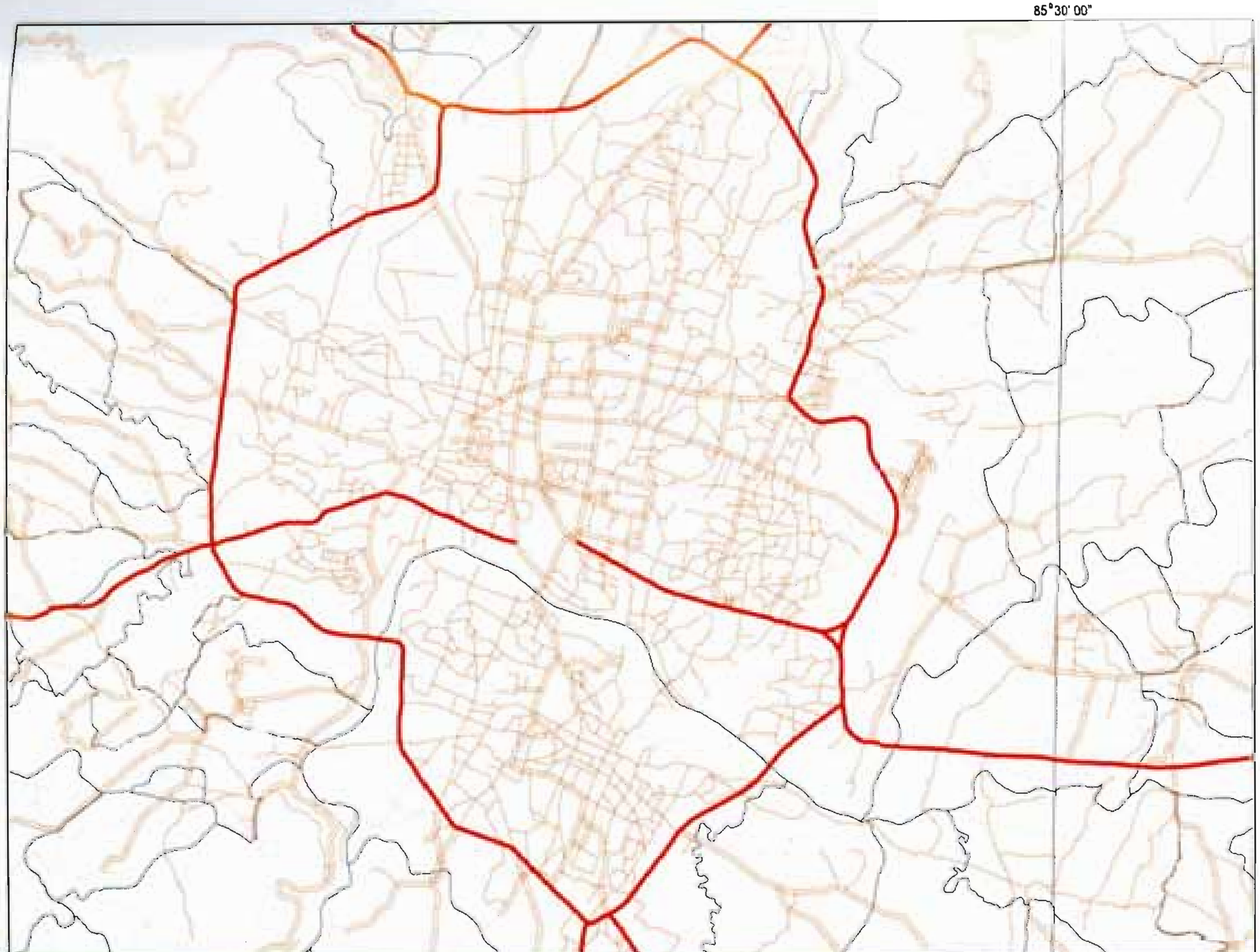
Road Types
- Highway
- Major Road
- Feeder Road
- Foot Trails
- Minor Foot Trails
- VDC Boundary

Road Type	Length (Km)
Highway	98.7
Major Road	435.7
Feeder Road	640.7
Foot Trails	304.3
Minor Foot Trails	2273.2

5 0 5 Kilometres

Scale 1:300,000

ICIMOD
MENRIS '99



Kathmandu Valley

Map 7
Road Network: Core Urban Area

Legend

Road Types
- Highway
- Major Road
- Feeder Road
- Foot Trails
- Minor Foot Trails
- VDC Boundary

Road Type	Length (Km)
Highway	98.7
Major Road	435.7
Feeder Road	640.7
Foot Trails	304.3
Minor Foot Trails	2273.

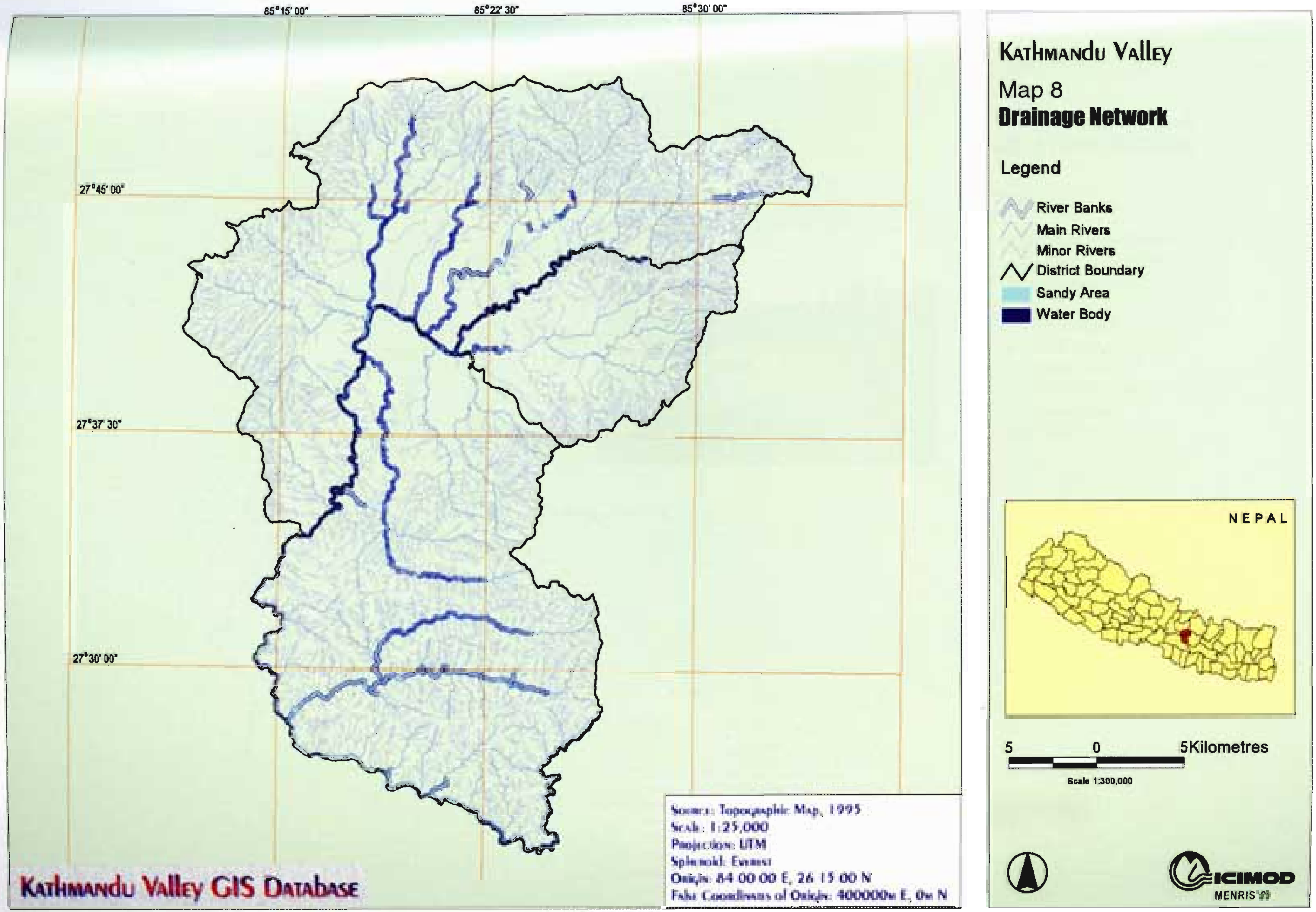
5 0 5Kilometres

Scale 1:300,000

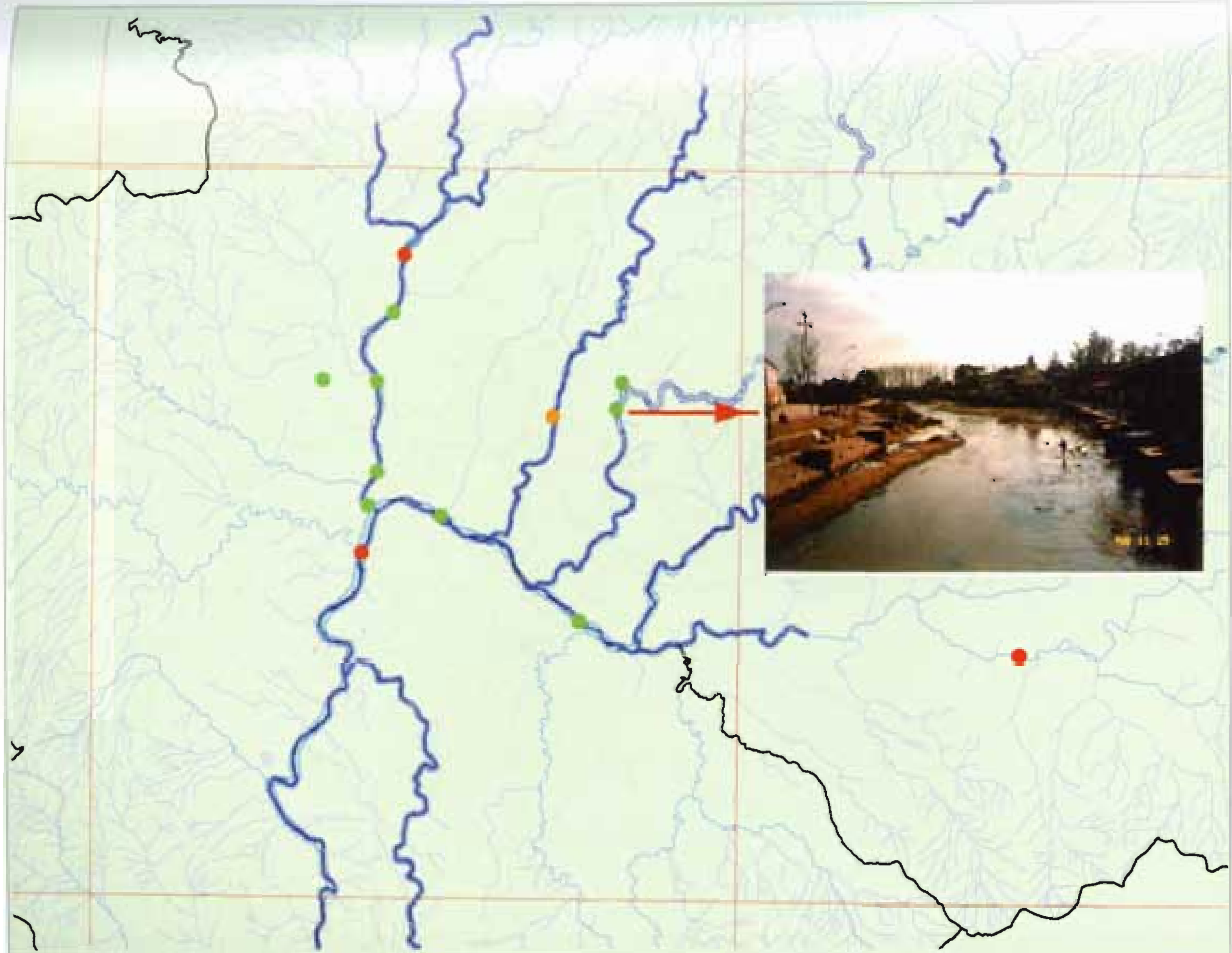
Source: Topographic Map, 1995
Scale: 1:25,000
Projection: UTM
Spheroid: Everest
Origin: 84 00 00 E, 26 15 00 N
False Coordinates of Origin: 400000m E, 0m N

ICIMOD
MENRIS '99

Kathmandu Valley GIS Database



Kathmandu Valley
Map 8
Drainage Network
Legend
River Banks
Main Rivers
Minor Rivers
District Boundary
Sandy Area
Water Body
NEPAL
5 0 5Kilometres
Scale 1:300,000
85°15' 00"
85°22' 30"
85°30' 00"
27°45' 00"
27°37' 30"
27°30' 00"
Source: Topographic Map, 1995
Scale: 1:25,000
Projection: UTM
Spheroid: Everest
Origin: 84 00 00 E, 26 15 00 N
False Coordinates of Origin: 400000m E, 0m N
Kathmandu Valley GIS Database
ICIMOD
MENRIS '99



Kathmandu Valley

Map 9
Sources and Types of River Water Pollution

Legend

- Industrial Water Pollution
- Sanitary Sewer Outfill
- Storm Sewer Outfill
- River Banks
- Main Rivers
- Minor Rivers
- District Boundary
- Sandy Area
- Water Body

2 0 2 Kilometres
1:100,000 scale

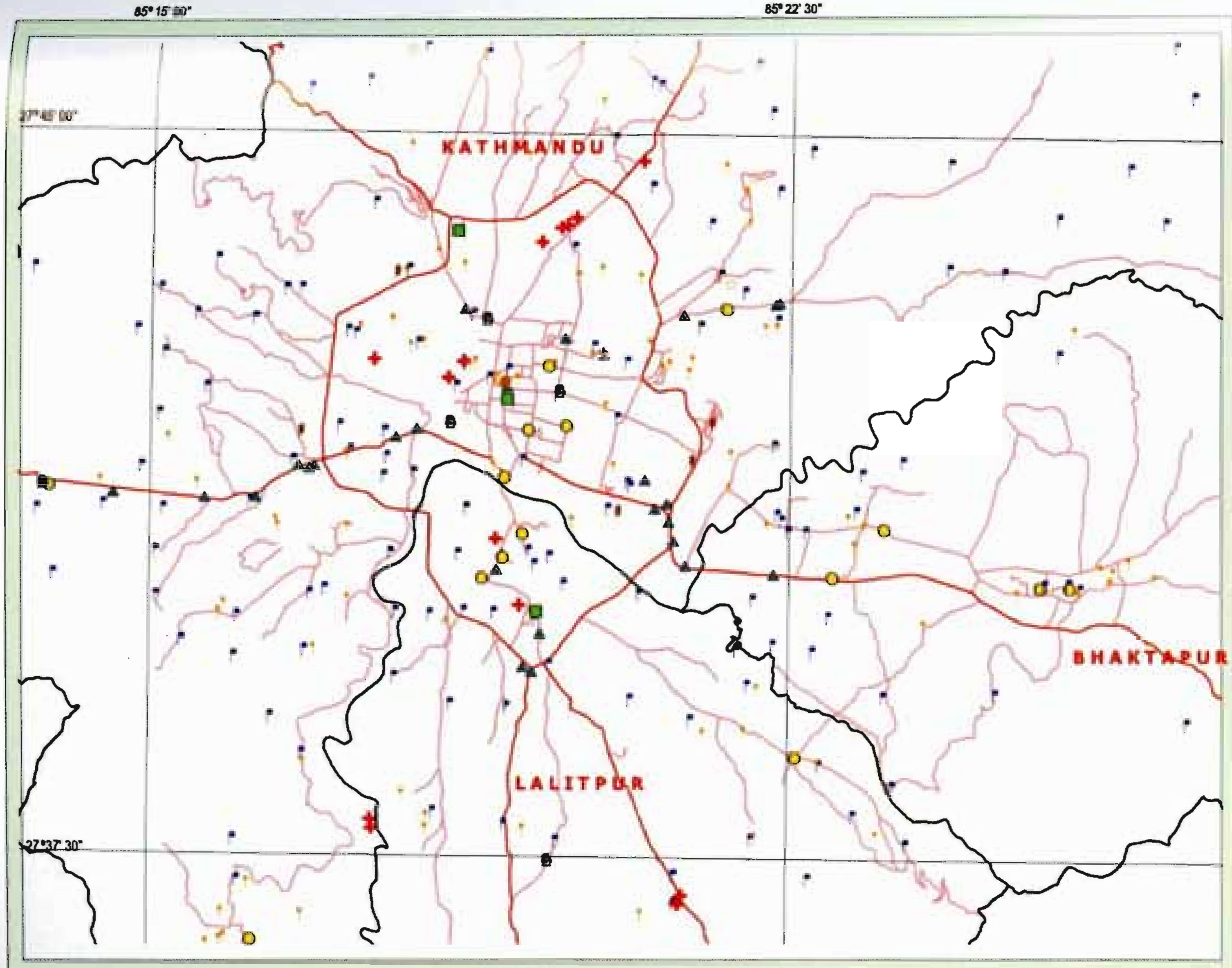
ICIMOD
MENRIS '99

Source: Field Verification and Topographic Map, 1995
Scale: 1:25,000
Projection: UTM
Spheroid: Everest
Origin: 84 00 00 E, 26 15 00 N
False Coordinates of Origin: 400000m E, 0m N
Field visit done by - Mr. T. M. Tamrakar, NPC
Photograph by - Mr. Anirudha M. Shrestha, ICIMOD

Kathmandu Valley GIS Database

Kathmandu Valley

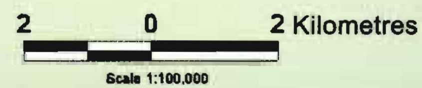
Map 10
Location of Services



Legend

Services
- Bus Terminal
- Church
- Hospital
- Mani
- Mosque
- Others
- Petrol Pump
- Post Office
- School
- Temple/Stupa
- Transformer Station

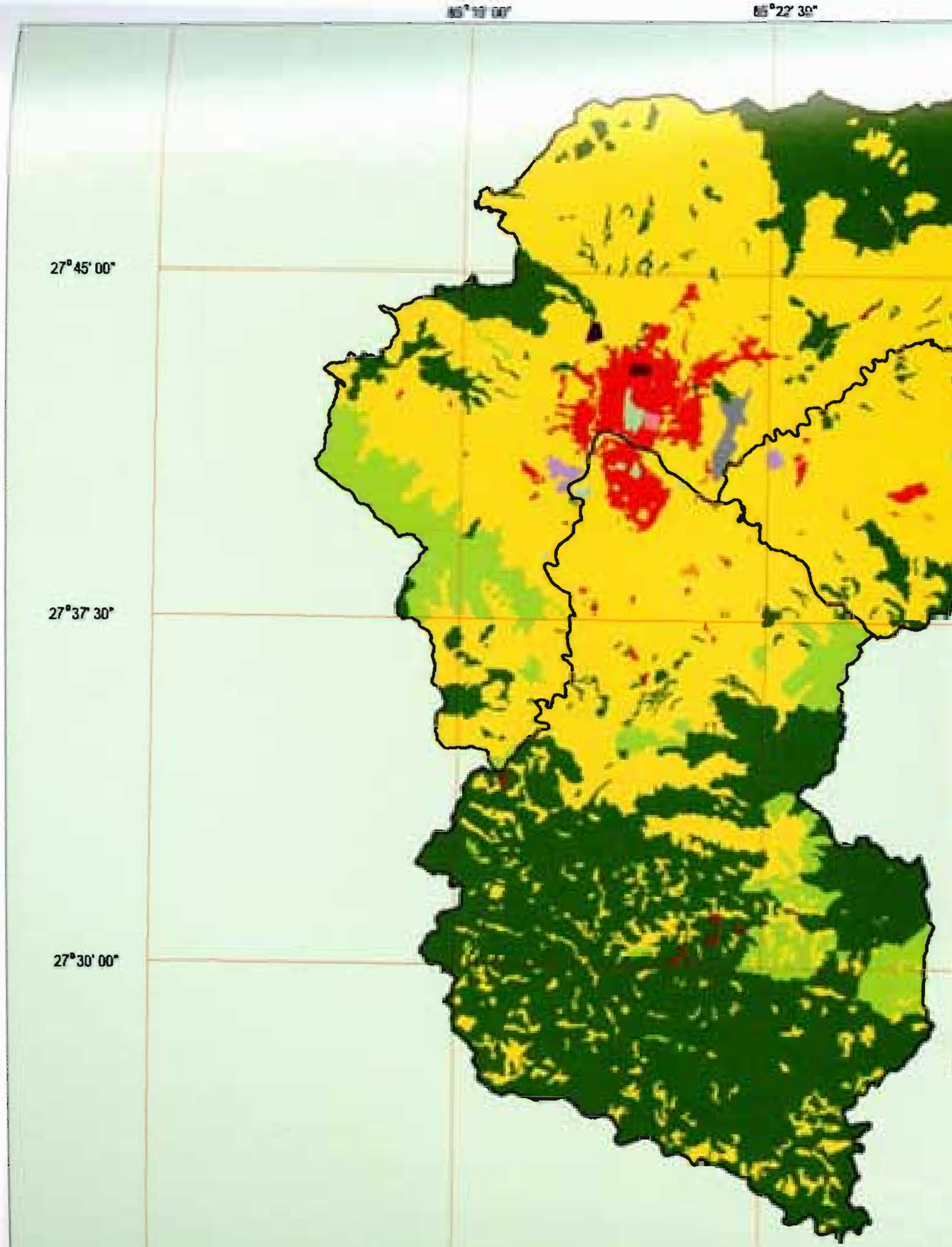
Roads
- Highway
- Major Roads
- District Boundary



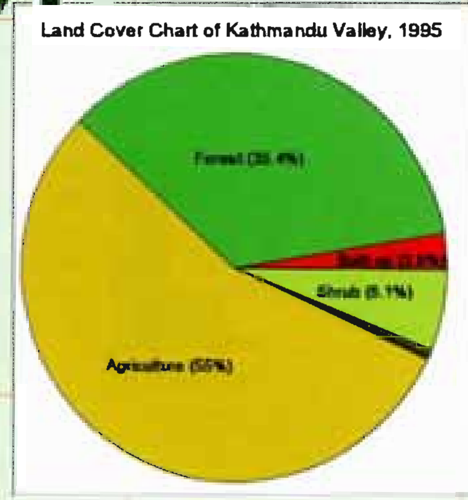
Source: Topographic Map, 1995
Scale: 1:25,000
Projection: UTM
Spheroid: Everest
Origin: 84 00 00 E, 26 15 00 N
False Coordinates of Origin: 400000m E, 0m N

ICIMOD
MENRIS '99

Kathmandu Valley GIS Database



Kathmandu Valley GIS Database



Source: Topographic Map, 1995
Scale: 1:25,000
Projection: UTM
Spheroid: Everest
Origin: 84 00 00 E, 26 15 00 N
False Coordinates of Origin: 400000m E, 0m N

Kathmandu Valley

Map 11
Land Cover Map, 1995

Legend

Land cover classes

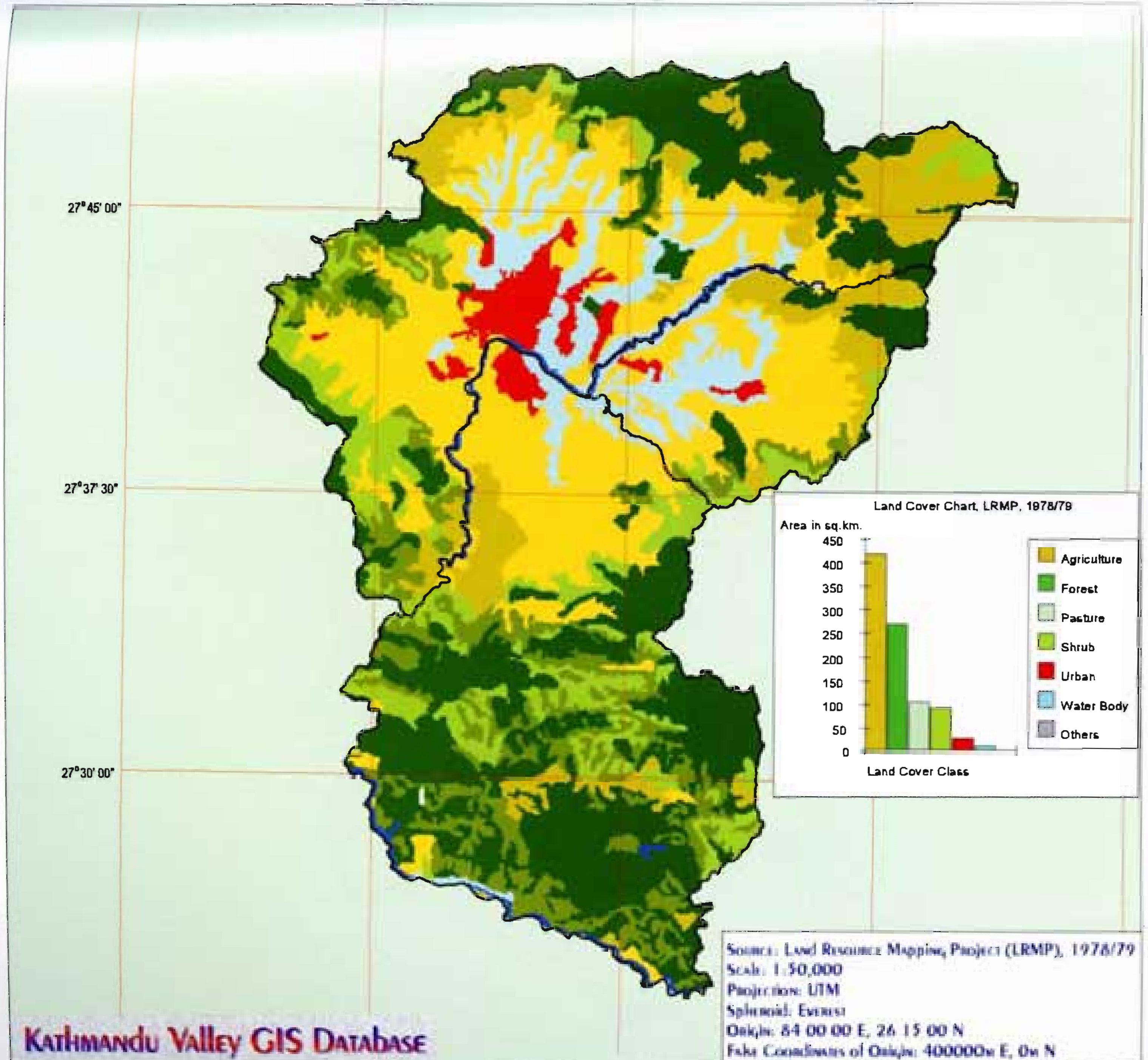
- Agriculture
- Airport
- Brick Factory
- Built-up
- Forest
- HMG Secretariat
- Industrial Area
- Institutional Area
- Open field
- Royal Palace
- Shrub Land
- Soil Cliff
- Water Body

Class	Area_SqKm	Percent
Built-up	24.4	[illegible].6
Forest	[illegible].7	35.4
Agriculture	[illegible]	55.[illegible]
Open Field	[illegible].4	[illegible]
HMG Secretariat	0.[illegible]	[illegible]
Royal Palace	0.4	0.[illegible]
Water body	0.[illegible]	[illegible]
Institutional Area	1.[illegible]	[illegible]
Airport	[illegible].3	[illegible]
Brick Factory	[illegible].3	[illegible]
Industrial Area	0.4	[illegible]
Shrub Land	56.[illegible]	6.1
Soil Cliff	1.1	[illegible].1

5 0 5 Kilometres

Scale 1:300,000

ICIMOD
MENRIS '99



Kathmandu Valley

Map 12
Land Cover, 1978/79

Legend

Land Use/Cover Class

- Forest
- Hillslope Level
- Pasture
- Water Body
- Shrub
- Tars, Alluvial Fans
- Urban
- Valley Floors

Class	Land Cover Class
Agriculture	417.6708
Forest	268.5029
Pasture	105.1981
Shrub	93.6138
Urban	24.1439
Water Body	12.2368
Others	0.6652

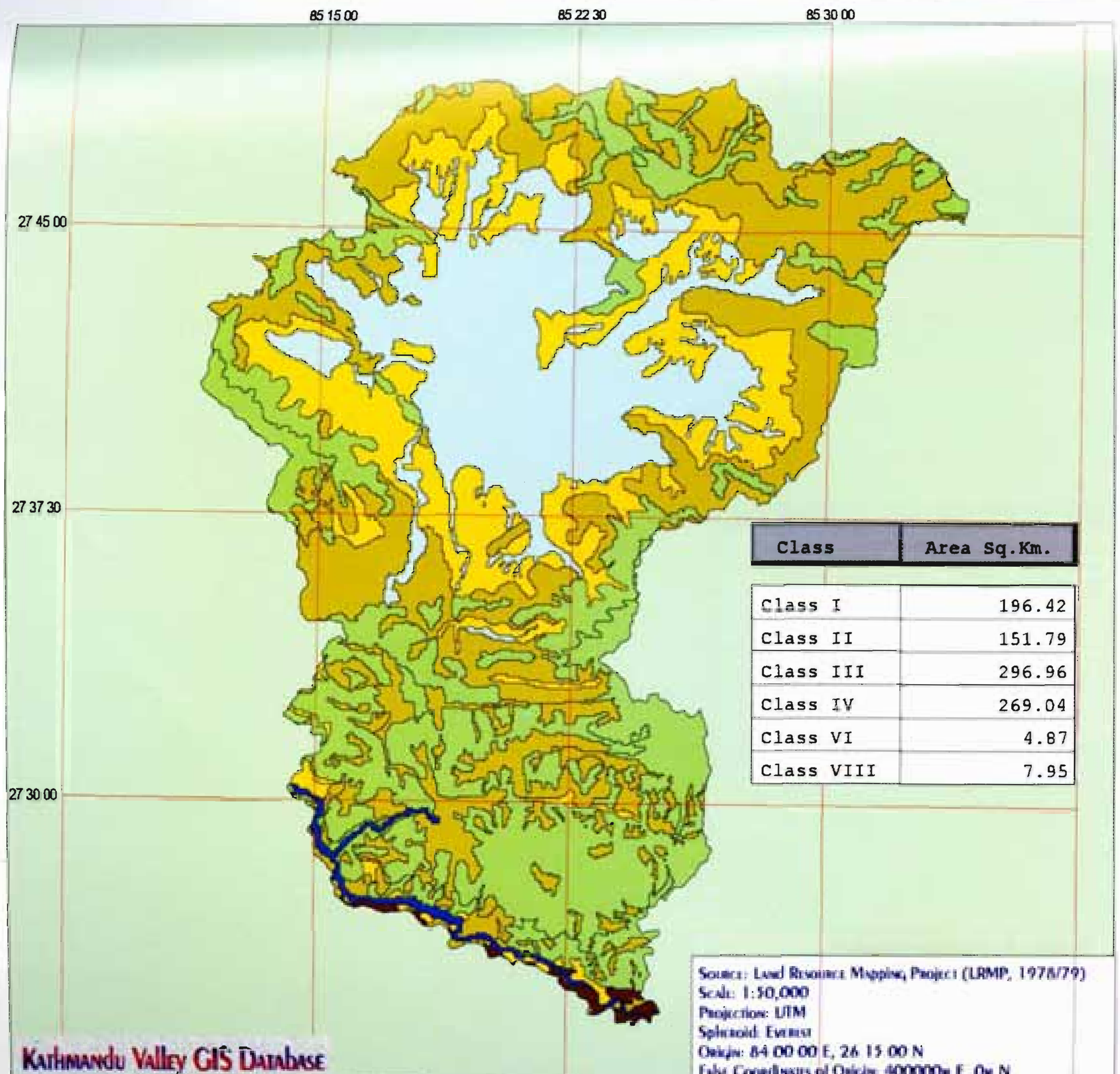
5 0 5Kilometres

Scale 1:300,000

ICIMOD
MENRIS '99

Kathmandu Valley

Map 13
Land Capability



Class	Area Sq.Km.
Class I	196.42
Class II	151.79
Class III	296.96
Class IV	269.04
Class VI	4.87
Class VIII	7.95

Source: Land Resource Mapping Project (LRMP, 1978/79)
Scale: 1:50,000
Projection: UTM
Spheroid: Everest
Origin: 84 00 00 E, 26 15 00 N
False Coordinates of Origin: 400000m E, 0m N

Legend

- Class I: Slope nearly level (<1 deg.)
- Class II: Slope gentle (1-5 deg.) Soils: deep and well drained
- Class III: Slope: moderate to steep (5-30 deg.) Soils: 50-100cm deep, well drained
- Class IV: Slope: too steep for terracing (> 30 deg.) Soils: more tham 20cm deep, well to iperfectly drained
- Class VI: Slope: very steep (40-50 deg.) or varied slope (< 40 deg.) Soils: varried depth and drainage or < 20cm deep
- Class VIII: Riverbeds

5 0 5 Kilometres

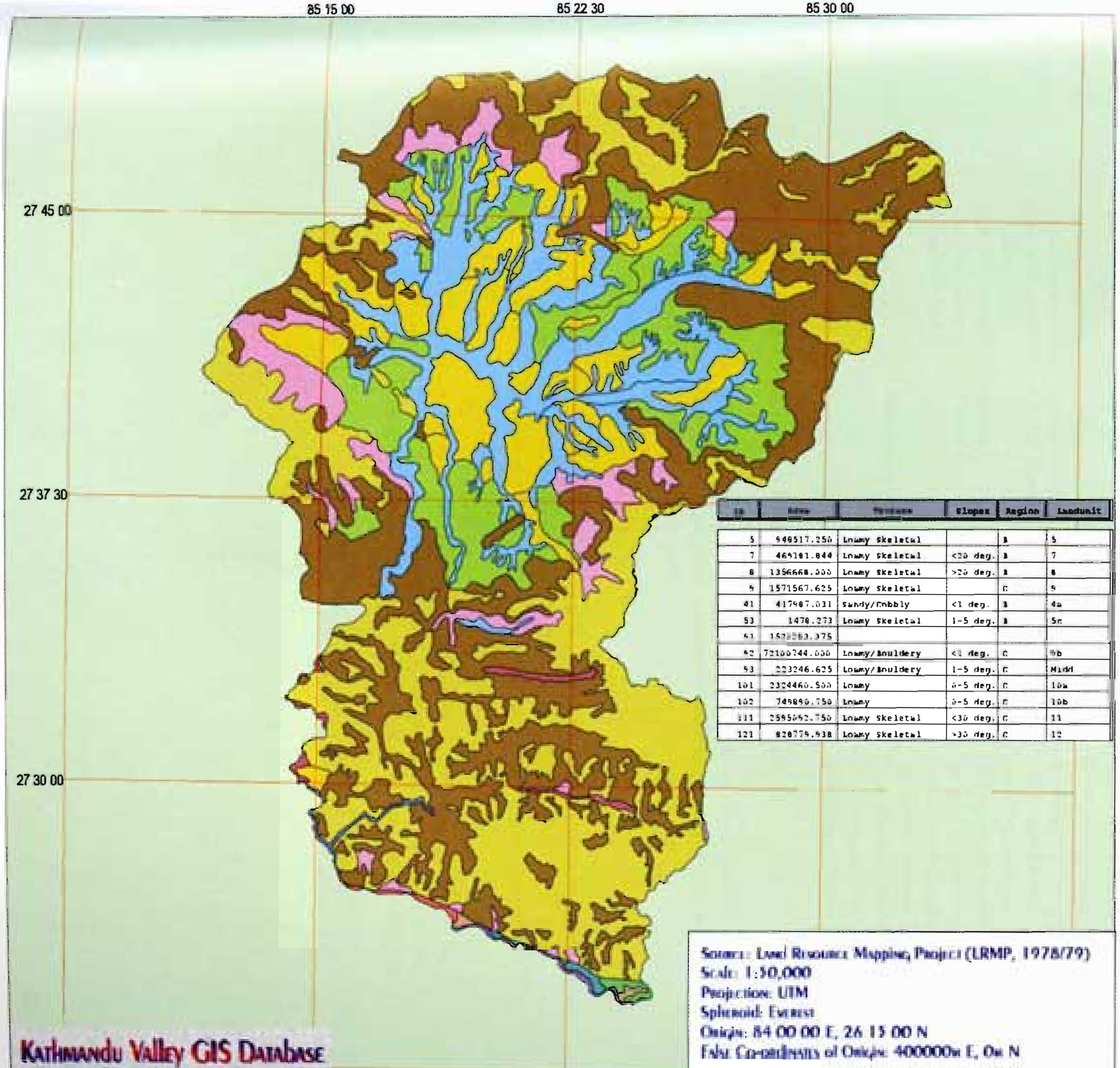
Scale 1:300,000

ICIMOD

MENRIS '99

Kathmandu Valley

Map 14
Land Systems



[illegible]	[illegible]	[illegible]	Slopes	Region	Landunit
5	948517.250	Loamy Skeletal		B	5
7	469181.844	Loamy Skeletal	<20 deg.	B	7
8	1356668.000	Loamy Skeletal	>20 deg.	B	8
9	1571567.625	Loamy Skeletal		C	9
41	417987.031	Sandy/Cobbly	<1 deg.	B	4a
53	1478.233	Loamy Skeletal	1-5 deg.	B	5c
61	[illegible].375				
62	72100744.000	Loamy/Bouldery	<1 deg.	C	9b
93	223246.625	Loamy/Bouldery	1-5 deg.	C	Midd
101	2324460.500	Loamy	0-5 deg.	C	10a
102	749890.750	Loamy	0-5 deg.	C	10b
111	2595052.750	Loamy Skeletal	<30 deg.	C	11
121	828779.938	Loamy Skeletal	>30 deg.	C	12

Source: Land Resource Mapping Project (LRMP, 1978/79)
Scale: 1:50,000
Projection: UTM
Spheroid: Everest
Origin: 84 00 00 E, 26 15 00 N
False Co-ordinates of Origin: 400000m E, 0m N

Legend

- Loamy Skeletal
- Loamy Skeletal, Slope < 20 deg.
- Loamy Skeletal, Slope > 20 deg.
- Loamy Skeletal
- Sandy/cobby, Slope < 1 deg.
- Loamy Skeletal, Slope 1-5 deg.
- Fragmented Sandy, Slope < 1 deg.
- Loamy/Bouldery, Slope < 1 deg.
- Loamy/ Bouldery, Slope 1-5 deg.
- Loamy, Slope 0-5 deg.
- Loamy, Slope 0-5 deg.
- Loamy Skeletal, Slope < 30 deg.
- Loamy Skeletal, Slope > 30 deg.

4 0 4 Kilometres

Scale 1:300,000

ICIMOD
MENRIS '99

Kathmandu Valley GIS Database

7.2 Integration of Socioeconomic Information

As depicted in Figure 5, the topographic database also includes socioeconomic or non-spatial information. The socioeconomic information, e.g., information on population, household distribution, and so on at Village Development Committee (VDC) level is available from the Census 1991 statistical report published by the Central Bureau of Statistics (CBS). This information has been linked to the spatial information about the administrative unit, i.e., the VDC, by digitising the VDC boundaries. The information was organized in a GIS relational database management system that can be used to portray various socioeconomic indicators in the form of maps (Table 2). The details of attribute data can be found in the Data Dictionary (Annex 2).

Table 2: Integration of Socioeconomic Information at the VDC Level

Themes	Layers	Source	Scale	Date
Administration	District boundary	Topographic map	1:25,000	1995
	VDC boundary	Topographic map	1:25,000	1995
	Metropolitan and sub-metropolitan boundaries	Topographic map	1:25,000	1995
Social Information	Total population at VDC level	Census report		1995
	Male population	Census report		1995
	Female population	Census report		1995
	No. of households at VDC level	Census report		
	Population density	Derived		
	Ratio of males to females at VDC level	Derived		
Others	Sources of environmental concern	Various sources		

7.2.1 Administrative Boundary (District / VDC boundary)

The Administrative Unit layer is at district-level with Village Development Committee (VDC) boundaries and metropolitan and sub-metropolitan boundaries. These were compiled from 1:25K topographic maps.

7.2.2 Census 1991 Data

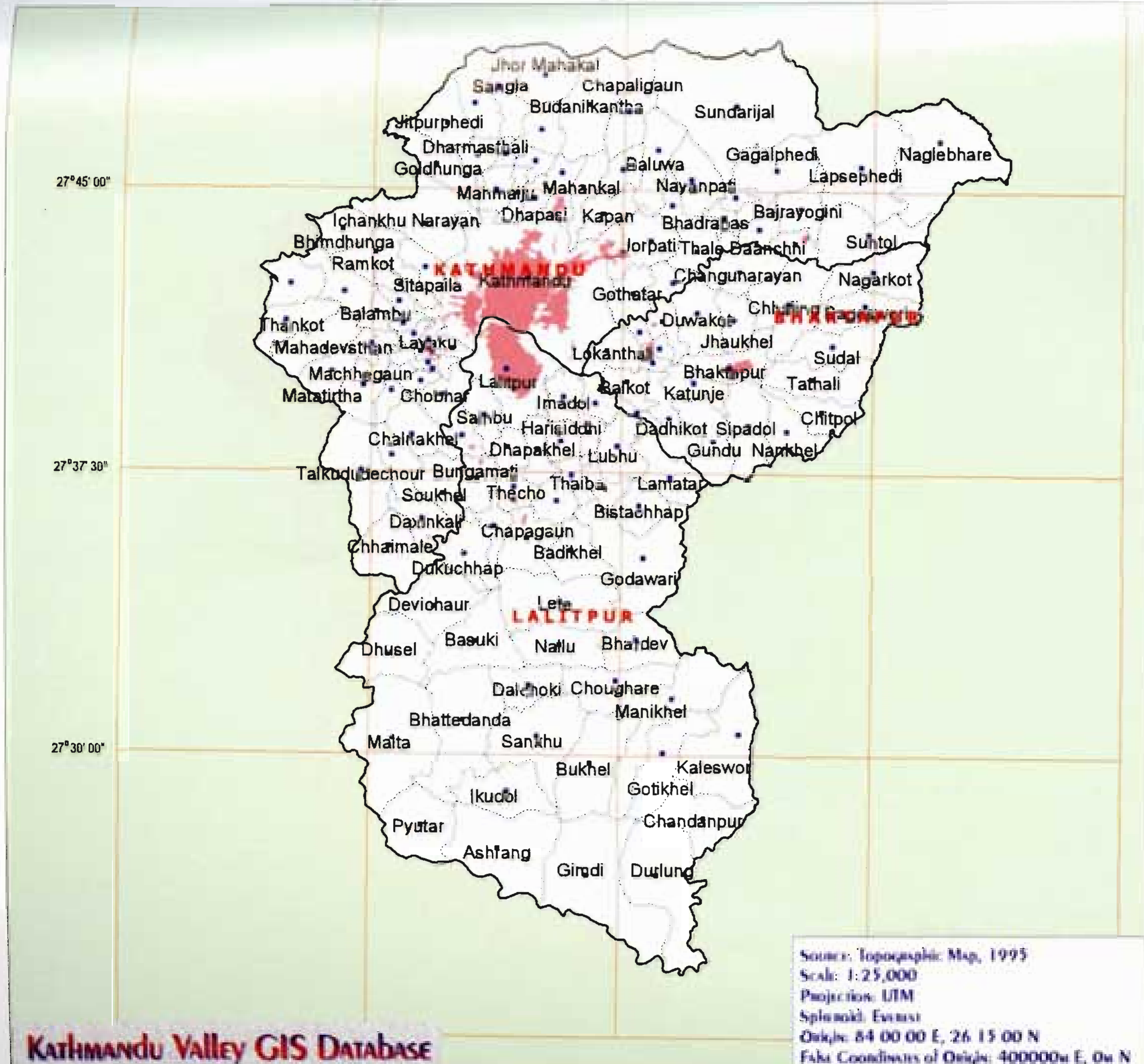
Using the Census report of 1991, population and household data at the VDC level were integrated with the administrative layer and different layers were generated through GIS. This was done to illustrate the integration of non-spatial data with a GIS Database.

The database thus developed was used to produce the following maps (Maps 15-22). These maps are merely for the demonstration of integration of socioeconomic data into a GIS. Many such maps can be produced once integration of the census database has taken place.

List of Maps Prepared from Integrated Socioeconomic Information

Kathmandu Valley

Map 15
Administrative Map



Legend

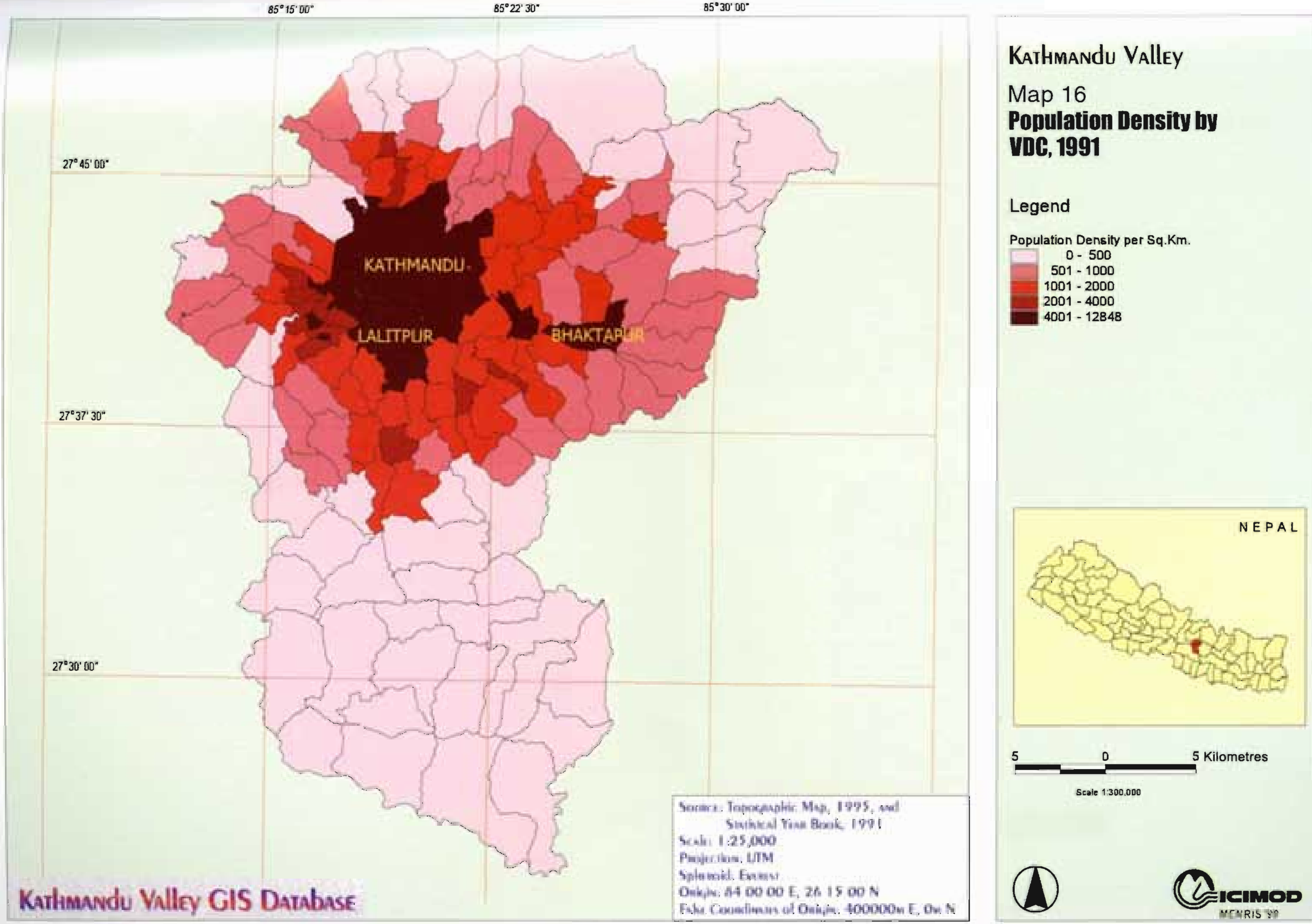
- District Boundary
- VDC Boundary
- Built-up Area

5 0 5Kilometres

Scale 1:300,000

ICIMOD

MENRIS '99


Kathmandu Valley
Map 16
Population Density by VDC, 1991
Legend
Population Density per Sq.Km.
0 - 500
501 - 1000
1001 - 2000
2001 - 4000
4001 - 12848
NEPAL
5
0
5 Kilometres
Scale 1:300,000
ICIMOD
MENRIS '99
85°15' 00"
85°22' 30"
85°30' 00"
27°45' 00"
27°37' 30"
27°30' 00"
KATHMANDU
LALITPUR
BHAKTAPUR
Source: Topographic Map, 1995, and Statistical Year Book, 1991
Scale: 1:25,000
Projection: UTM
Spheroid: Everest
Origin: 84 00 00 E, 26 15 00 N
False Coordinates of Origin: 400000m E, 0m N
Kathmandu Valley GIS Database

Kathmandu Valley

Map 17
Household Distribution by VDC, 1991

Legend

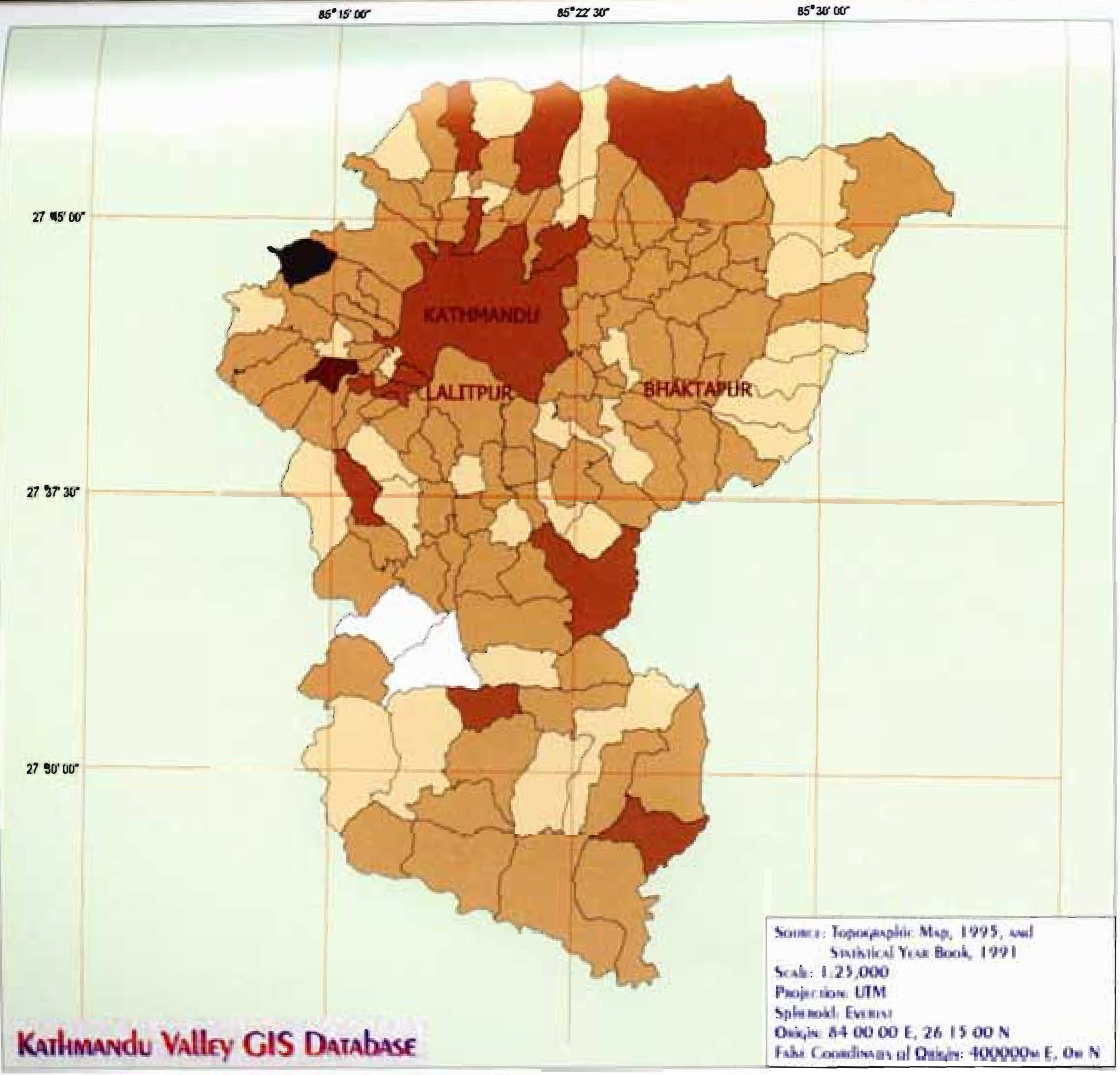
Household Distribution (In Numbers)

- Below 600
- 601 - 2000
- 2001 - 10000
- 1001 - 20000
- Above 20000

5 0 5 Kilometres

Scale 1:300,000

ICIMOD
MENRIS '99



Kathmandu Valley

Map 18
Percentage of Males by VDC, 1991

Legend

Male Population (in percentage)

- 47 - 49
- 50 - 51
- 52 - 56
- 57 - 61
- 62 - 80
- No Data

5 0 5 Kilometres

Scale 1:300,000

ICIMOD
MENRIS '99

Kathmandu Valley

Map 19
Percentage of Females by VDC, 1991

Legend

Female Population (in percentage)

- Below 20
- 21 - 39
- 40 - 48
- 49 - 50
- 51 - 53
- No Data

5 0 5 Kilometres

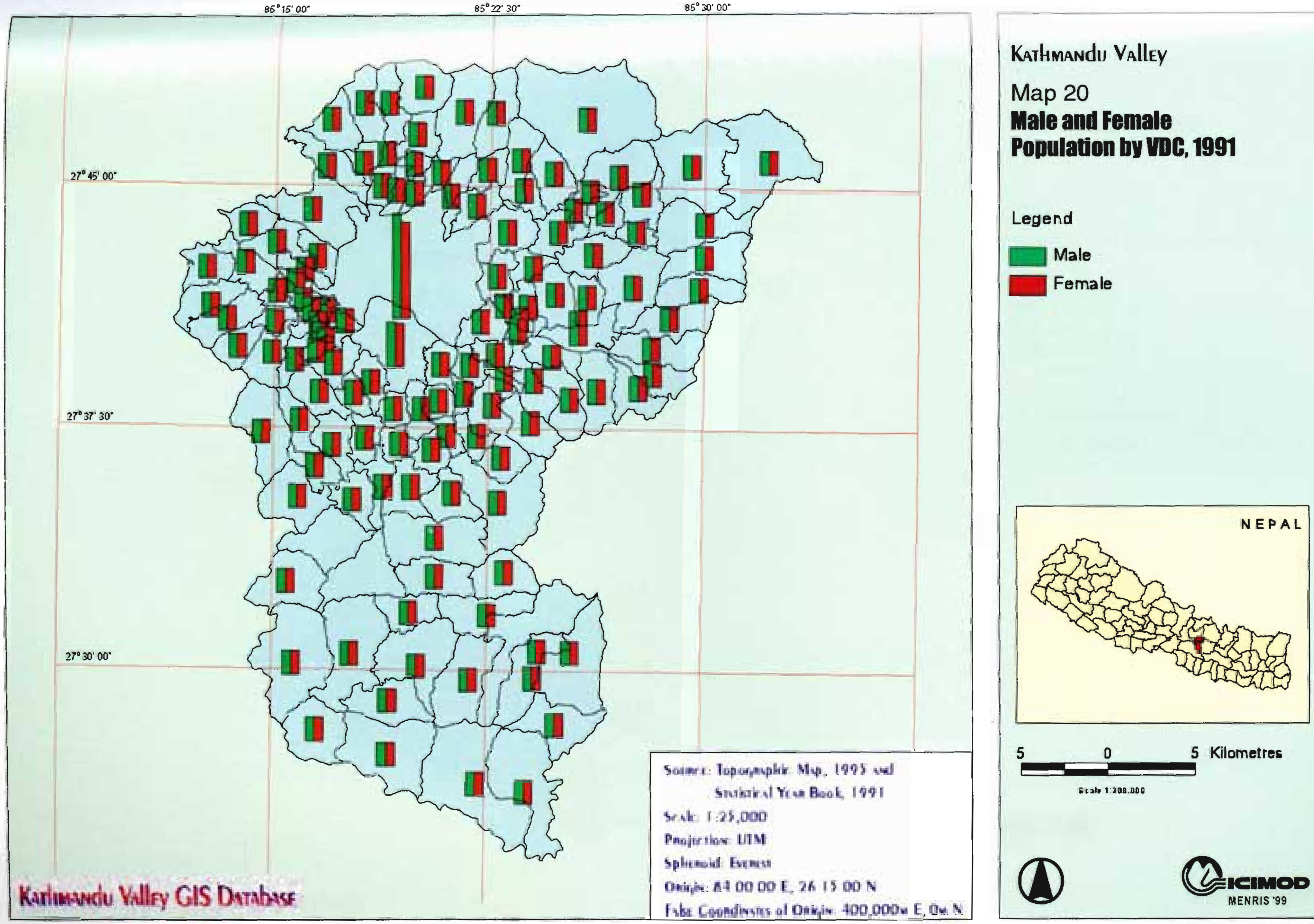
Scale 1:300,000

ICIMOD

MENRIS '99

Kathmandu Valley

Map 20
Male and Female Population by VDC, 1991

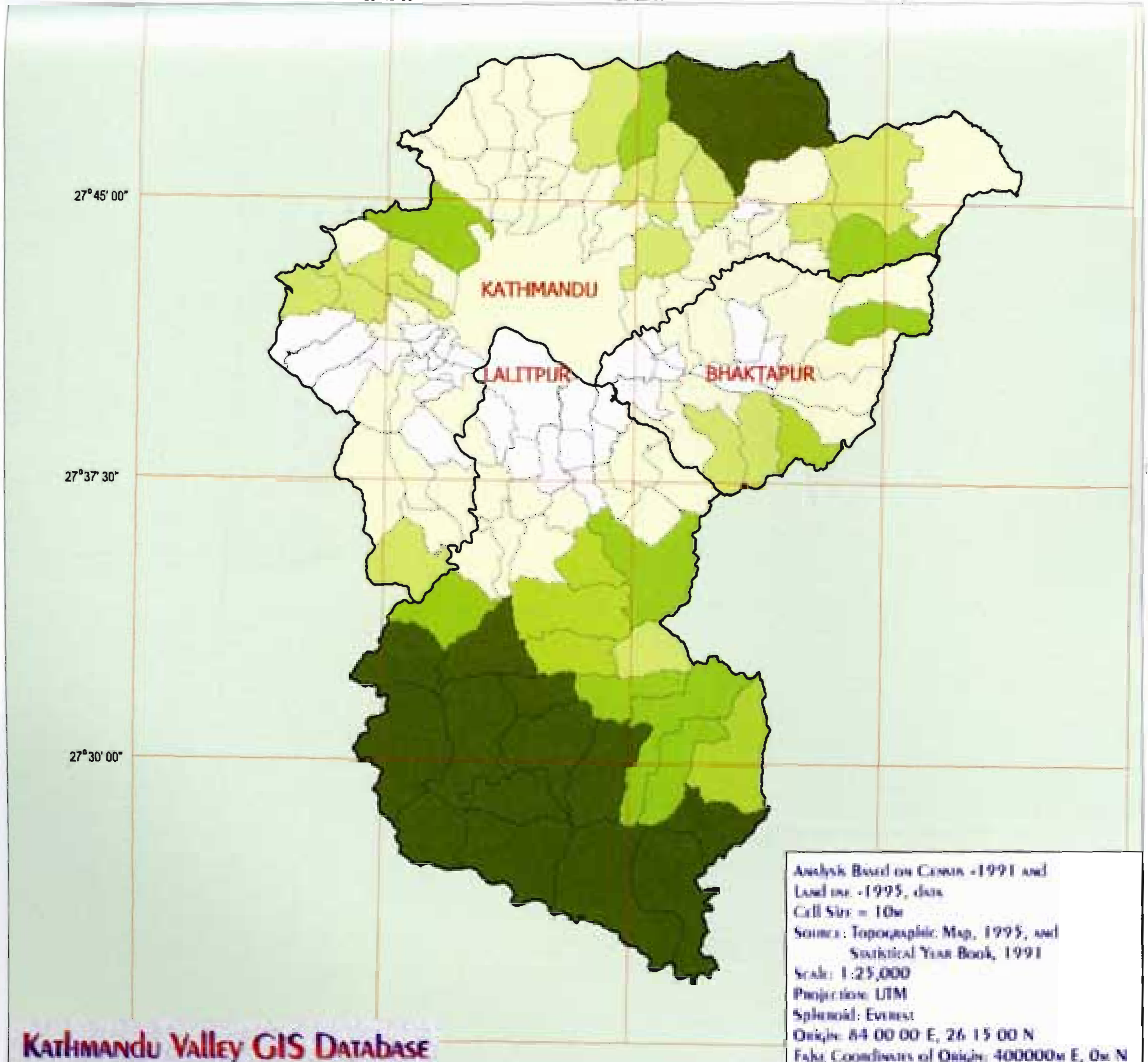


Source: Topographic Map, 1995 and Statistical Year Book, 1991
Scale: 1:25,000
Projection: UTM
Spheroid: Everest
Origin: 84 00 00 E, 26 15 00 N
False Coordinates of Origin: 400,000m E, 0m N

Kathmandu Valley GIS Database

Kathmandu Valley

Map 21
Forest Land per VDC, 1995



Legend

Forest Land Per VDC (In percentage)

- 0 - 18.28
- 18.28 - 36.56
- 36.56 - 54.84
- 54.84 - 73.12
- 73.12 - 91.4
- No Data

District Boundary

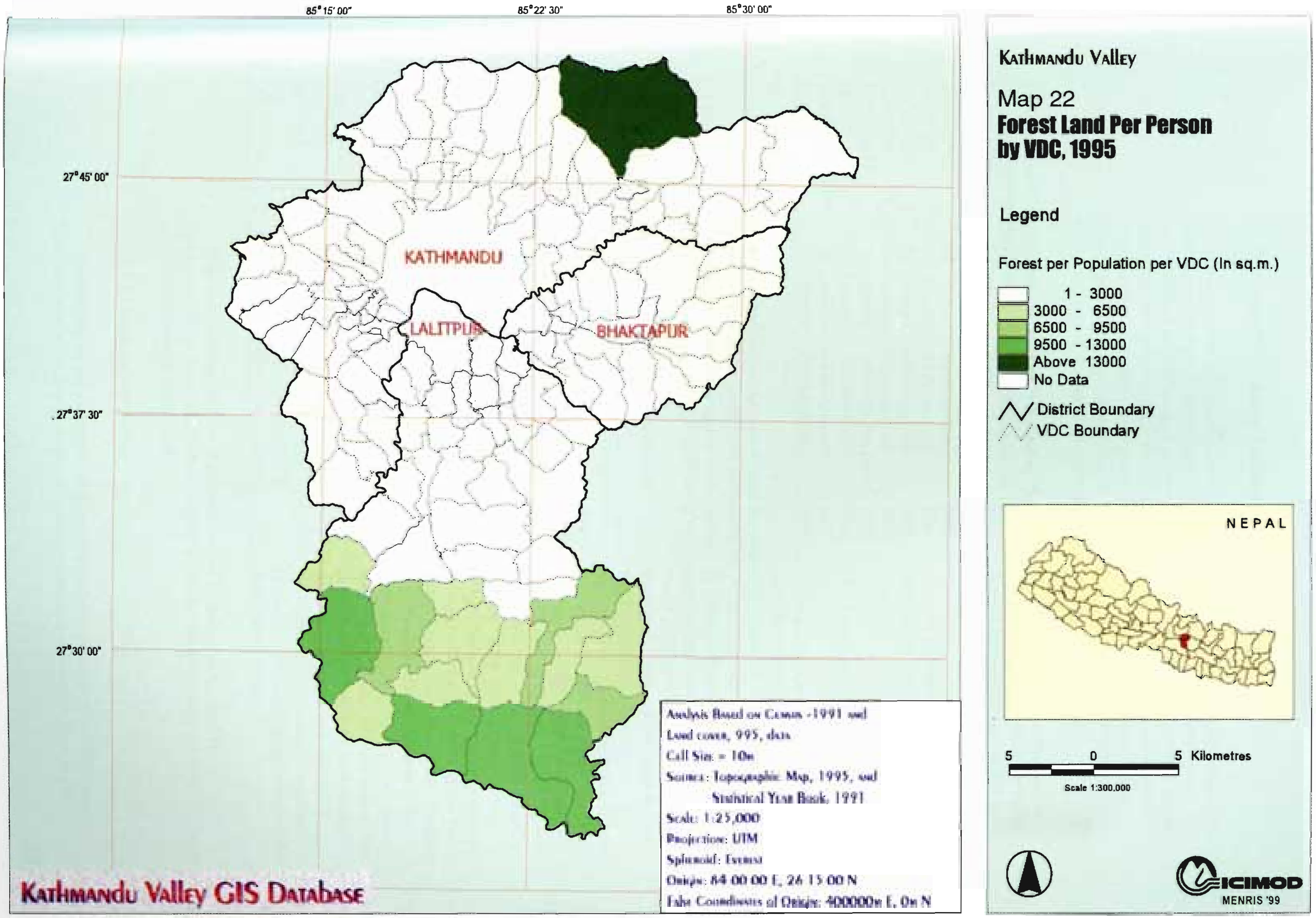
VDC Boundary

5 0 5 Kilometres

Scale 1:300,000

ICIMOD

MENRIS '99


85°15' 00"
85°22' 30"
85°30' 00"
27°45' 00"
27°37' 30"
27°30' 00"
KATHMANDU
LALITPUR
BHAKTAPUR
Analysis Based on Census -1991 and
Land cover, 995, data
Cell Size = 10m
Source: Topographic Map, 1995, and
Statistical Year Book, 1991
Scale: 1:25,000
Projection: UTM
Spheroid: Everest
Origin: 84 00 00 E, 26 15 00 N
False Coordinates of Origin: 400000m E, 0m N
Kathmandu Valley GIS Database
Kathmandu Valley
Map 22
Forest Land Per Person by VDC, 1995
Legend
Forest per Population per VDC (In sq.m.)
1 - 3000
3000 - 6500
6500 - 9500
9500 - 13000
Above 13000
No Data
District Boundary
VDC Boundary
NEPAL
5 0 5 Kilometres
Scale 1:300,000
ICIMOD
MENRIS '99

7.3 Satellite Image Database

The emergence of high-resolution satellite imagery (1 to 3 metres) has brought about revolutionary changes in comprehending our real world situations. The applications of high-resolution satellite imagery are proving to be useful in urban applications. This study aims to use satellite imagery for the Kathmandu Valley and especially high-resolution satellite imagery for urban applications in particular, hence this study has used high-resolution satellite data (two metres) for the first time in Nepal to validate data for urban and environmental management applications.

Table 3: **List of the Satellite Imageries Included in the Kathmandu Valley GIS Datbase**

Name of the Satellite	Spatial Resolution	Type	Date
Landsat TM	30 metres	Multi-spectral	1988
SPOT-XS	20 metres	Multi-spectral	1994
SPOT-XS	20 metres	Multi-spectral	1992
SPOT-XS	20 metres	Multi-spectral	1986
SPOT-PAN	10 metres	DEM (Stereo Pair)	1992
IRS-1C	5.6 metres	Panchromatic	1996
ADEOS-AVNIR	16 metres	Multi-spectral	1997
SPIN-2	2 metres	Panchromatic	1991

The database includes various satellite images of Kathmandu Valley acquired from different satellite sensors on different dates (Table 3).

The important characteristics of each of these satellites can be found in Annex 4.

7.3.1 Processing of Satellite Data

Raw satellite images received directly from the distributors have their own format and can not be used directly for analysis. To make use of these raw satellite images, pre-processing needs to be carried out, i.e., rectification and geometric correction to the standard coordinate system of the country. To establish the satellite image database, all the satellite images were rectified and geometrically corrected using the Ground Control Points (GCPs) of the Geodetic Survey Branch of the Ministry of Land Reform and Management - Department of Survey. All the GCPs were verified in the field (Table 4) with the aerial photographs, topographic maps, and SPIN-2 satellite images. The GCPs were then registered on the SPIN-2 image by identifying the same location on the images, features of the topographic map, i.e., digitised road and drainage networks, and geo-corrected using ERDAS Imagine 8.3.1 image processing software. The geo-corrected SPIN-2 image was then used to rectify other satellite images. The training samples were selected through visual interpretation and supervised classification of all satellite images was carried out for mapping land cover of the Kathmandu Valley.

Table 4: **List of GCPs Used for the Geo-correction of Satellite Images**

Grid Sheet No.Align-ment No.	ID No.	UTM Coordinates Easting	UTM Coordinates Northing	Height above mean sea level
102	7	628633.79	3069584.06	1317.29
102	6	632479.08	3069423.39	1353.84
102	8	629248.02	3068335.66	1329.11
102	9	627440.20	3066912.23	1407.11
102	10	626572.01	3064882.02	1328.06
102	11	627507.35	3064088.09	1297.88
102	13	628436.17	3061733.76	1304.19
102	12	627969.86	3062701.79	1278.74
102	14	627915.80	3061023.77	1355.72
102	15	626291.25	3062667.17	1414.83
102	3	635081.60	3066372.31	1339.08
102	4	636492.53	3067786.07	1319.31
102	5	636916.20	3069600.81	1338.03
102	2	633310.55	3062518.81	1247.31
102	1	629600.05	3065364.84	N/A

The methodology used for the preparation of a satellite image database of Kathmandu Valley is depicted below (Figure 6) and the following maps (Maps 23-47) were prepared using the image database.

7.3.2 Visualisation of Satellite Images

Colour plays an important role in effective visual interpretation of satellite images. There are two colour display methods: colour composite and pseudo-colour display.

Colour composite is used to generate images with multi-band data and pseudo colour is used to assign different colours to grey scales on a single band image. Three selected single-band images are composed using three primary colours; for instance, RGB (Red, Green, Blue). Different colours can be generated depending upon selection of three band images and the assignment of the three primary colours. The assignment of image bands to primary colours can be in any combination, however, there are two standard methods, namely, True Colour Composite (TCC), and False Colour Composite (FCC).

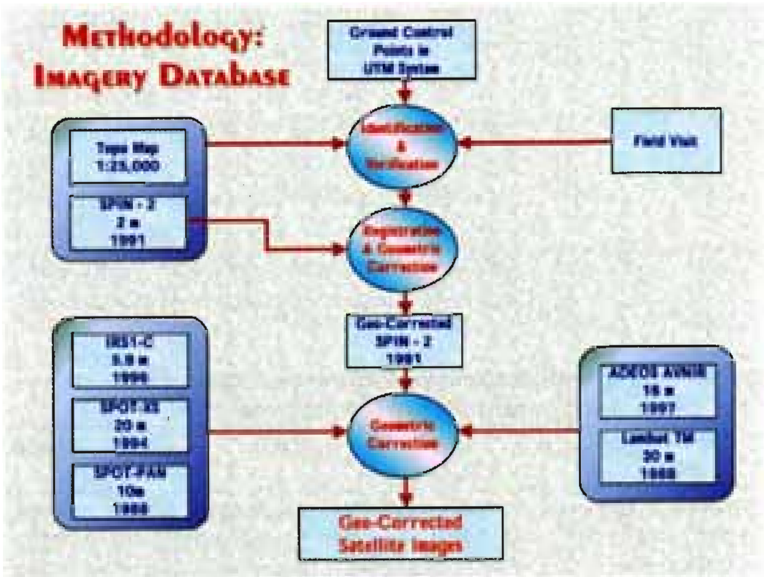


Figure 6: **Applied Methodology for Preparation of the Image Database**

True Colour Composite (TCC)

True Colour Composite was used to generate an image of natural composites that make it possible to see features as they would be seen by the human eye. It can be prepared by using Landsat TM bands 3 (red), 2 (green), and 1 (blue) for the primary colours. The advantage of this composition is that it is easier for a lay person to interpret the features.

False Colour Composite (FCC)

Multi-band images through remote sensing sensors are not always divided into the same spectral region as the three primary colours. In addition, invisible regions, such as infrared, are used to enhance spectral resolution. Within an infrared band, a colour composite is no longer a natural colour, hence false colour composite. In this composition, blue to green band, green to red band, and red to infrared band are assigned. The main advantage of this is that one can study different types of vegetation cover. In this composition, the vegetation is red.

Examples of these compositions are given in the maps (e.g. refer to Maps 23 and 27).

7.3.3 Data Fusion

Different types of satellites use different numbers of bands with varying resolutions. The characteristics of some of the most common satellite imagery are presented in Annex 4. Satellite images from different sensors can thus be used for different purposes. Different techniques in digital image processing help identify the features of the earth's surface as accurately as possible by using different types of satellite image. One popular technique is data fusion or resolution merge, combining information from different satellite images. Usually it entails enhancement of lower resolution, multi-band images by merging them with higher resolution, panchromatic (grey-single band) images. This technique has been used in the present study to enhance and recognize spatial patterns. In this study, the ADEOS-AVNIR (multi-band) image in 16m x 16m resolution and Landsat TM (multi-band) image in 30m x 30m resolution are merged with a SPIN-2 (panchromatic) image in 2m x 2m resolution. The result is a multi-spectral image with improved spatial resolution, i.e., 2m x 2m, which can be used for both visual interpretation and digital image processing in detail (Maps 33, 34, 42, and so on).

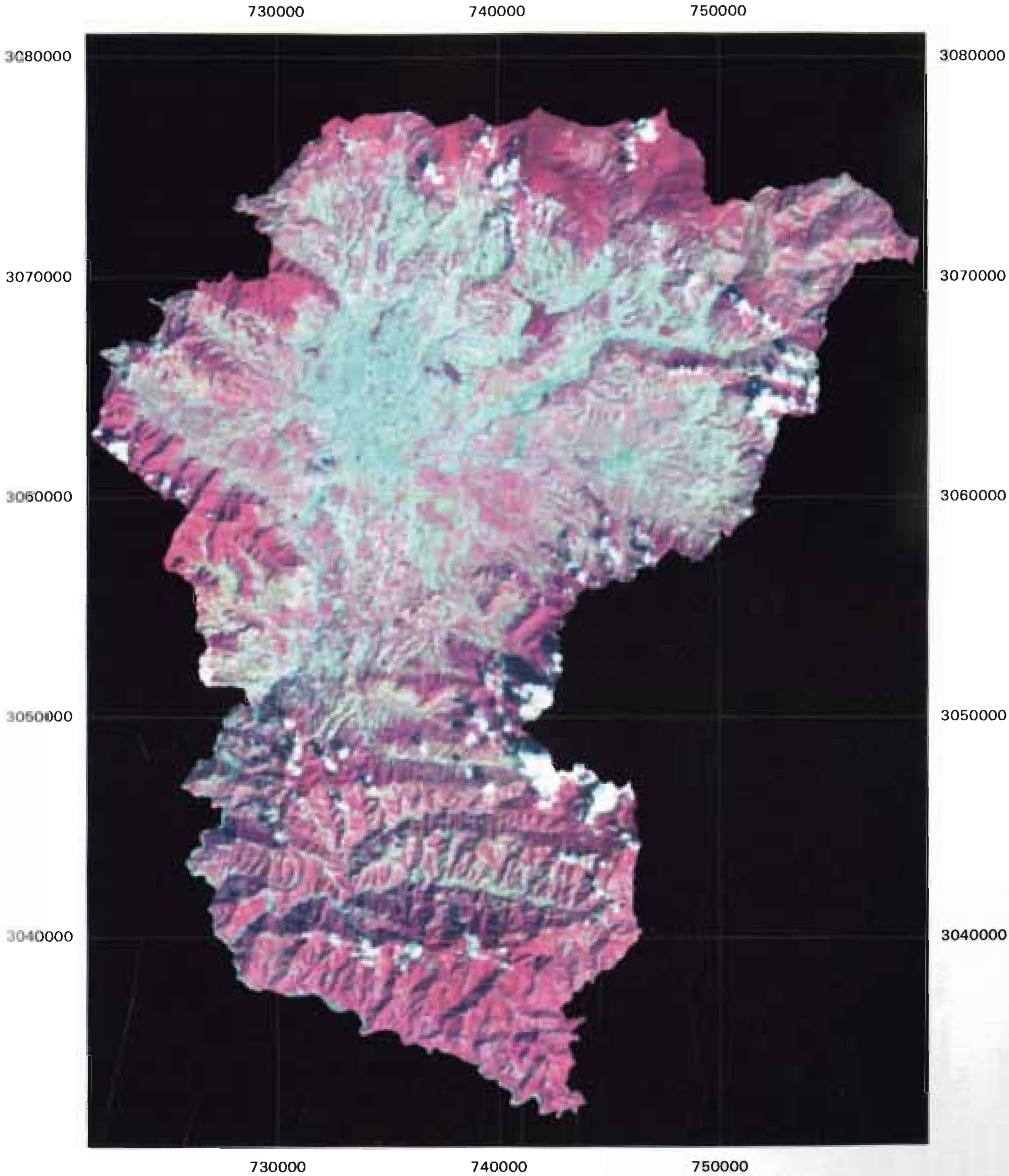
7.3.4 Image Draping

Image draping is another important function of digital image processing. This involves overlapping a satellite image or any raster-based GIS data over a DEM. This is useful for gaining a realistic perspective and carrying out analyses such as visibility analysis. Several maps were prepared by draping different satellite images and land-cover maps over a DEM to provide a visual impact of the landscape (e.g. Maps 24, 26, 28, 30, 33, 37, 39, 41, and so on).

List of Maps Prepared from Satellite Image Database

Map 23

The False Colour Composite (Red:4, Green:3, Blue:2) of Landsat-TM image, 1998 Kathmandu Valley, Nepal



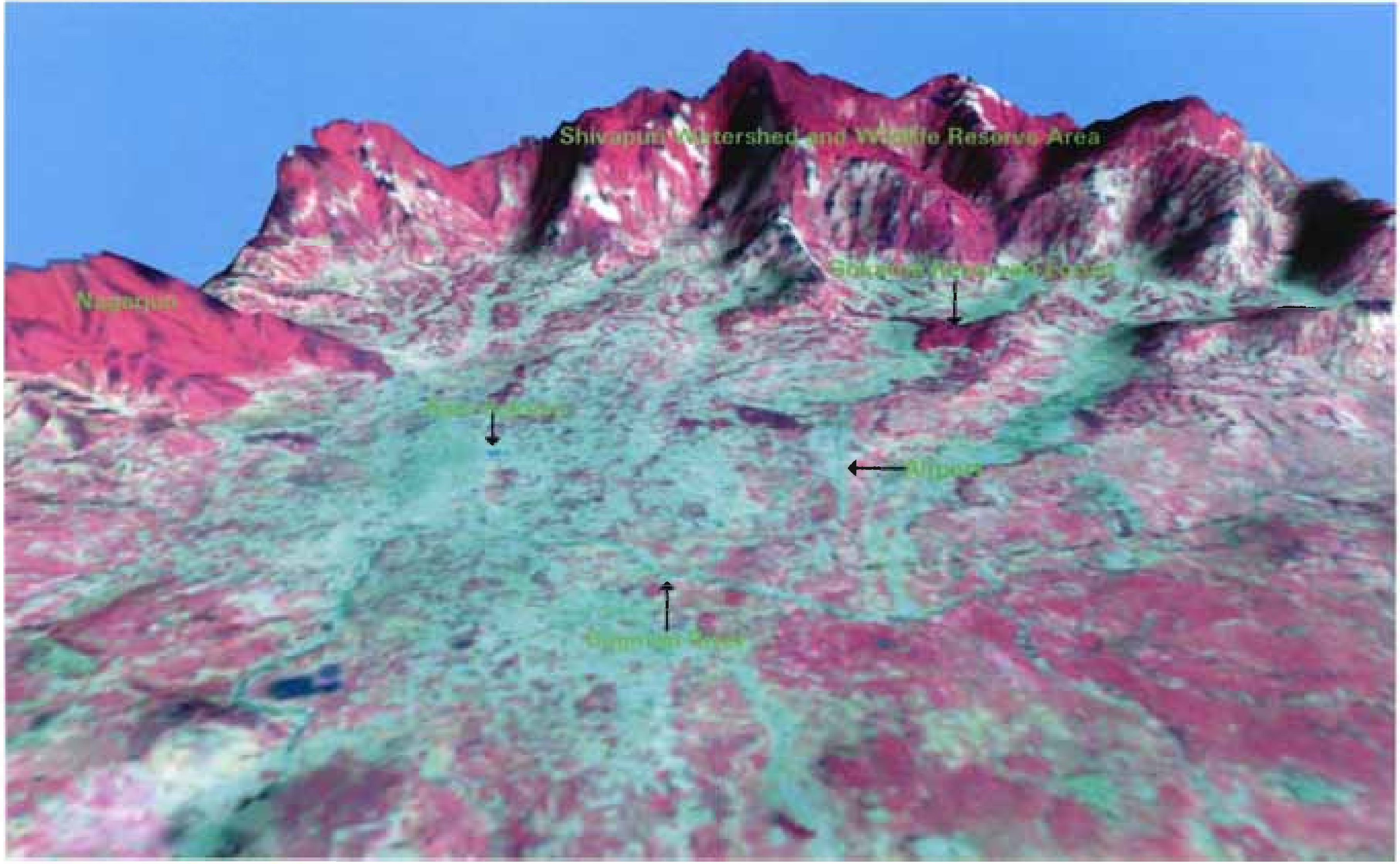
Spatial Resolution: 30m
Date Acquired : 11th October, 1988
Geo-referenced to: UTM
Spheroid: Everest
Zone: 45; Datum: Everest
Origin: 84 00 00 E, 26 15 00 N
False Co-ordinates of Origin: 400000m E, 0m N

Scale
5 0 5 Kilometres

ICIMOD
MENRIS '99

Map 24

False Colour Composite (Red:4, Green: 3, Blue:2) of Landsat-TM Image Draped on DEM, 1988
Kathmandu Valley, Nepal



Spatial Resolution: 30 metres
Date Acquired: 11th October, 1988
Geo-referenced to UTM
Spheroid: Everest
Zone: 45; Datum: Everest

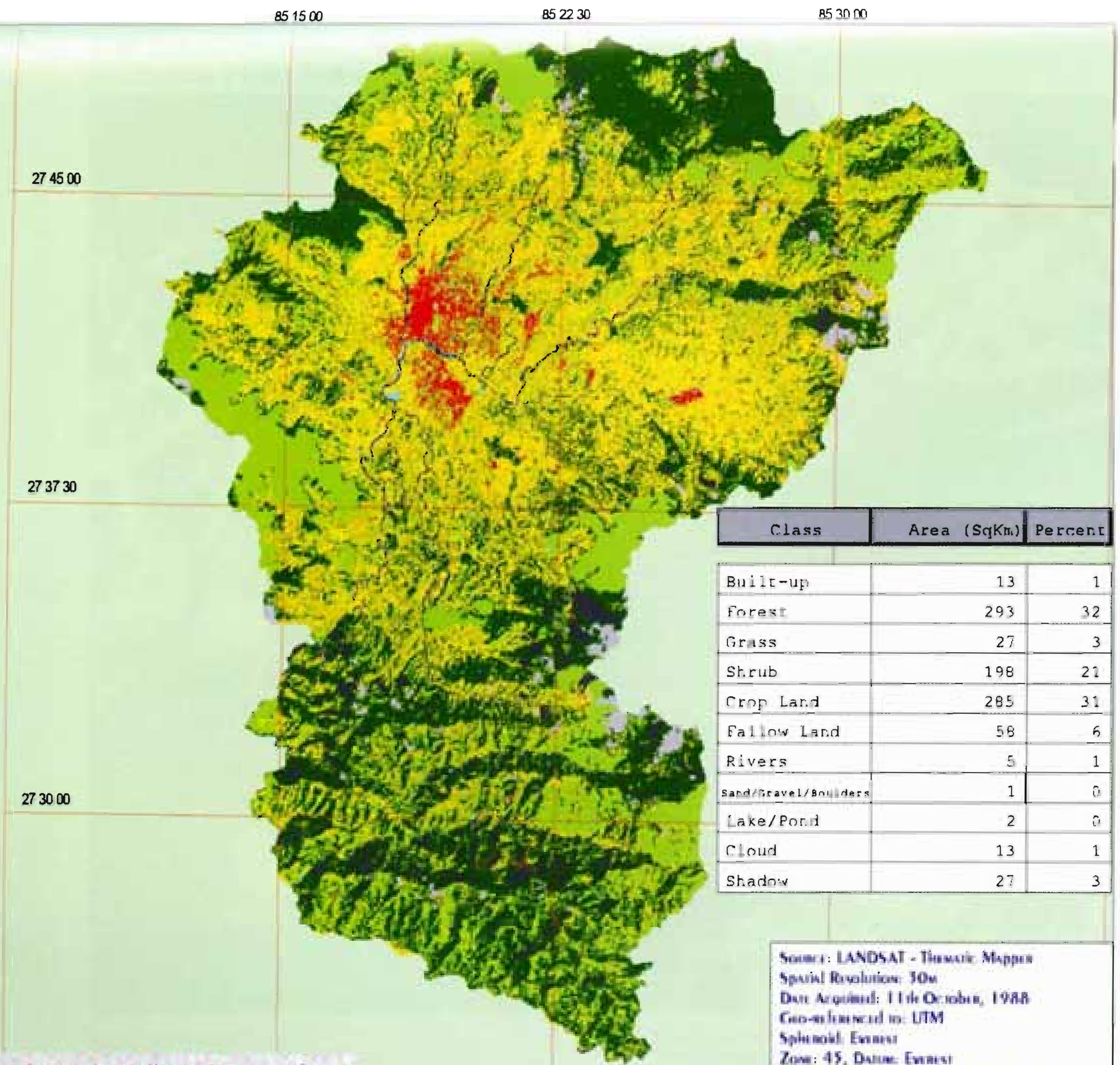
Above Ground Level (AGL): 1600 metres
Above Sea Level (ASL): 3000 metres
Field of View (FOV): 75 degrees
Azimuth: 375 degrees
Exaggeration: 4

MENRIS '99

Kathmandu Valley

Map 25

Land Cover Based On Landsat-TM Image, 1988



Legend

- Built-up
- Forest
- Grass
- Shrub
- Crop Land
- Fallow Land
- Rivers
- Sand/Gravel/Boulder
- Lake/Pond
- Cloud
- Shadow

Class	Area (SqKm)	Percent
Built-up	13	1
Forest	293	32
Grass	27	3
Shrub	198	21
Crop Land	285	31
Fallow Land	58	6
Rivers	5	1
Sand/Gravel/Boulders	1	0
Lake/Pond	2	0
Cloud	13	1
Shadow	27	3

5 0 5 Kilometres

Scale: 1:275,000

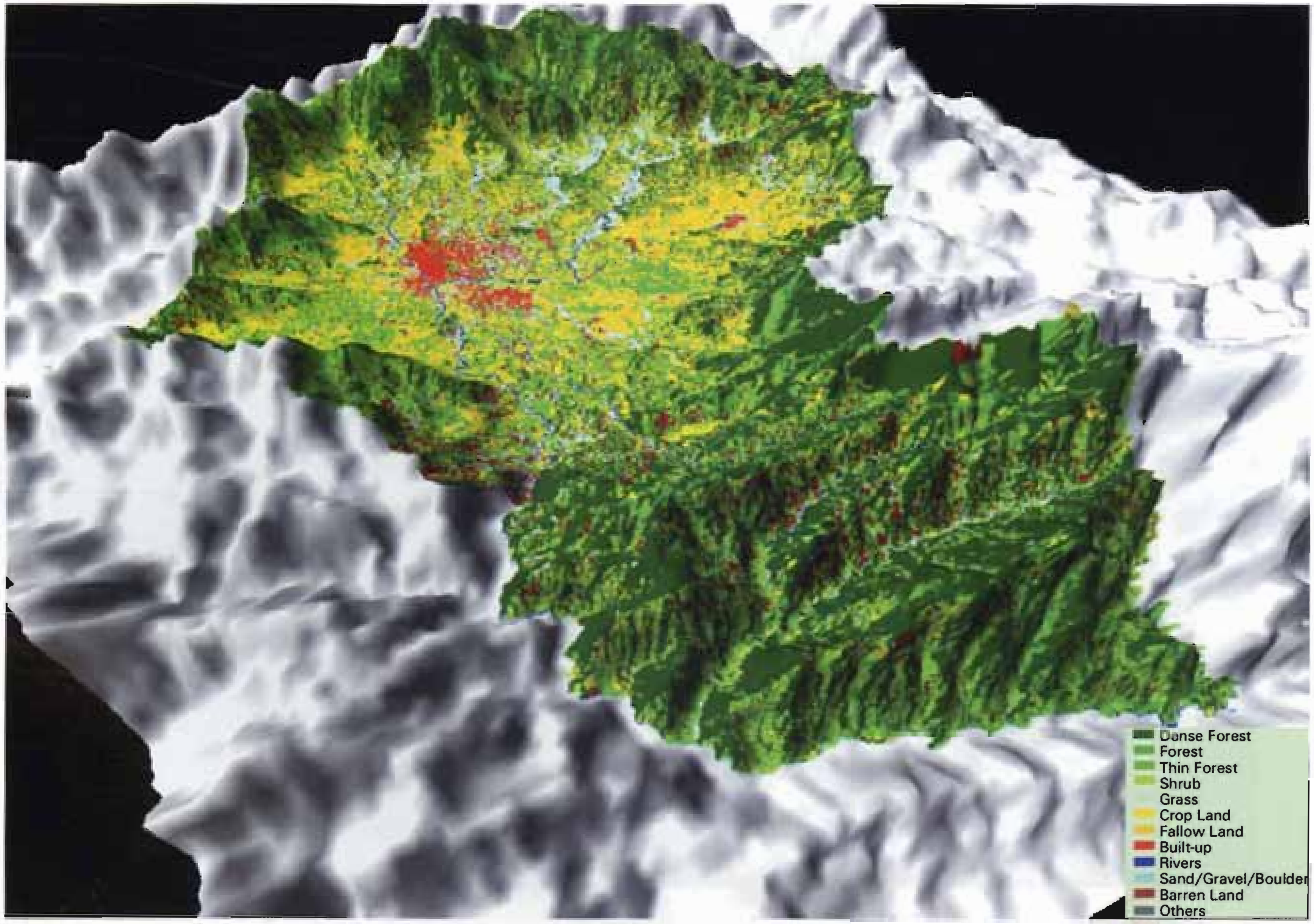
Source: LANDSAT - Thematic Mapper
Spatial Resolution: 30m
Date Acquired: 11th October, 1988
Geo-referenced to: UTM
Spheroid: Everest
Zone: 45, Datum: Everest
Origin: 84 00 00 E, 26 15 00 N
False Coordinates of Origin: 400000m E, 0m N

ICIMOD
MENRIS '99

Kathmandu Valley GIS Database

Map 26

Land Cover Based on Landsat-TM, 1988, Image Draped on DEM
Kathmandu Valley, Nepal



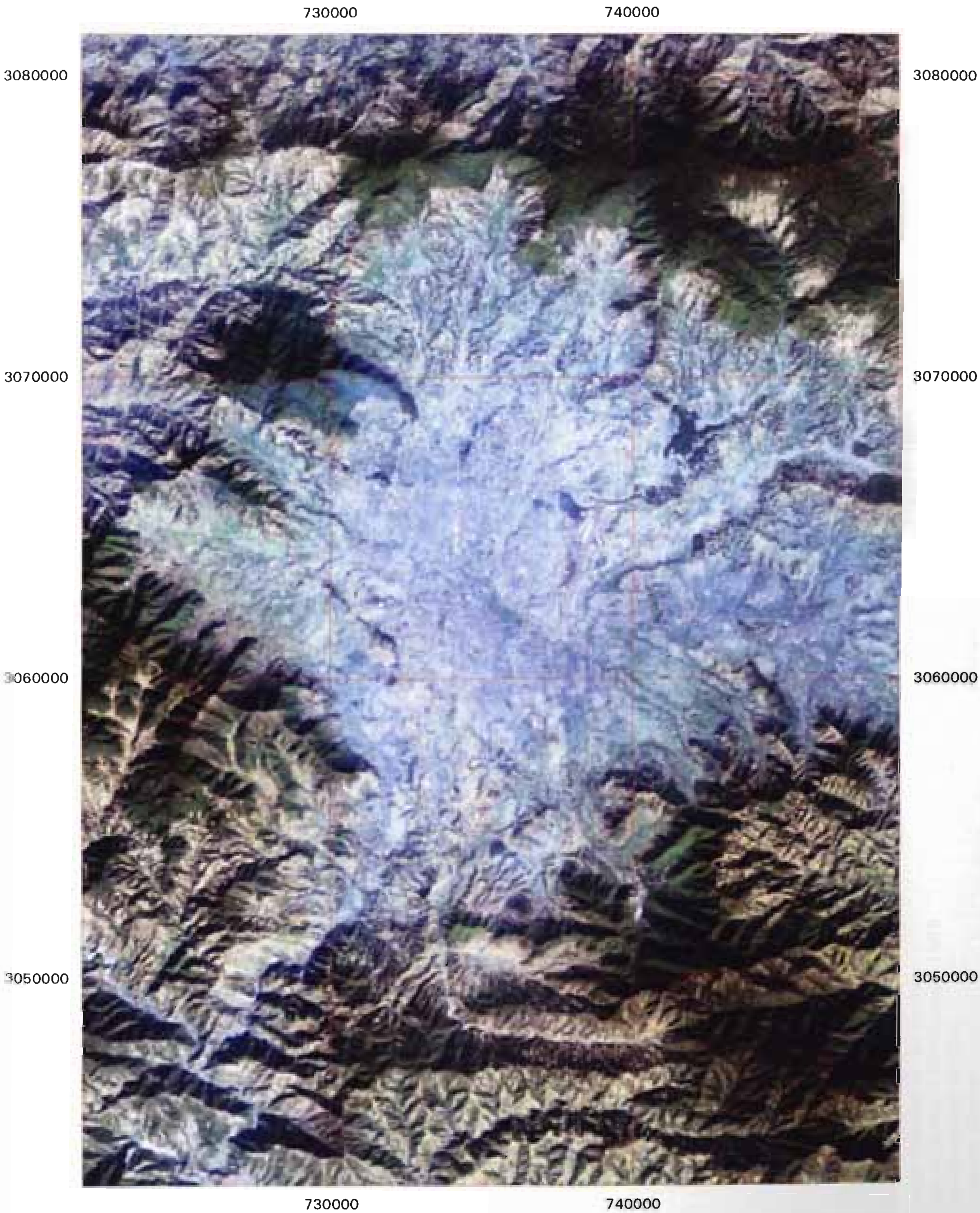
Spatial Resolution: 30 metres
Date Acquired: 11th October, 1988
Geo-referenced to UTM
Spheroid: Everest
Zone: 45, Datum: Everest

Above Ground Level (AGL): 6710 metres
Above Sea Level (ASL): 8000 metres
Field of View (FOV): 75 degrees
Azimuth: 33 degrees
Exaggeration: 6

ICIMOD
MENRIS '99

Map 27

True Colour Composite (Red:3, Green:2, Blue:1) of ADEOS-AVNIR Image, 1997 Kathmandu Valley, Nepal



Spatial Resolution: 16 metres
Date Acquired: 11th January, 1997
Geo-referenced to UTM
Spheroid: Everest
Zone: 45; Datum: Everest
Origin: 84 00 00 E, 26 15 00 N
False Coordinates of Origin: 400000m E, 0m N

Scale

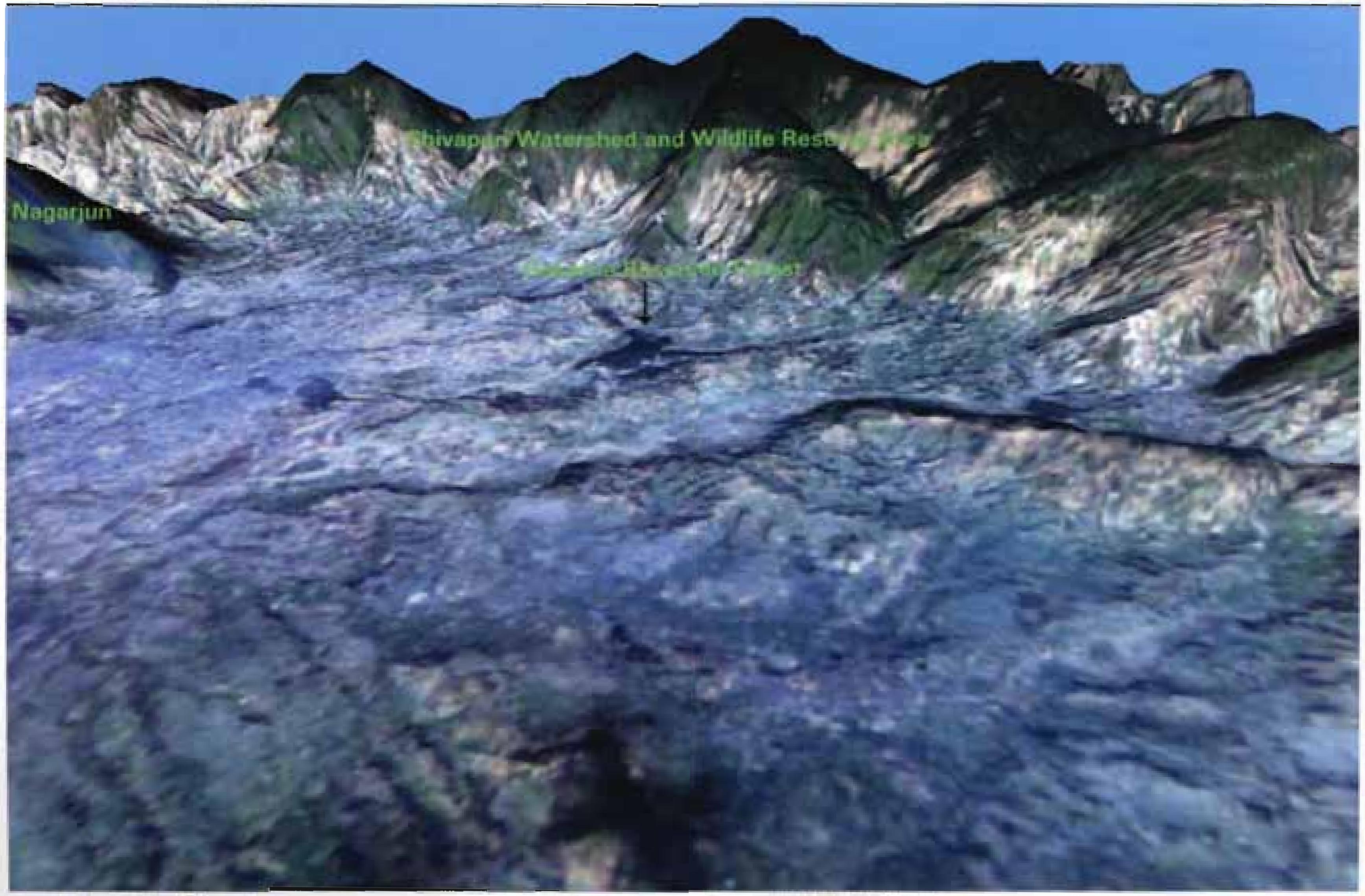
5 0 Kilometres

ICIMOD
MENRIS '99

Map 28

True Colour Composite of ADEOS-AVNIR Image Draped on DEM, 1997 Kathmandu Valley, Nepal

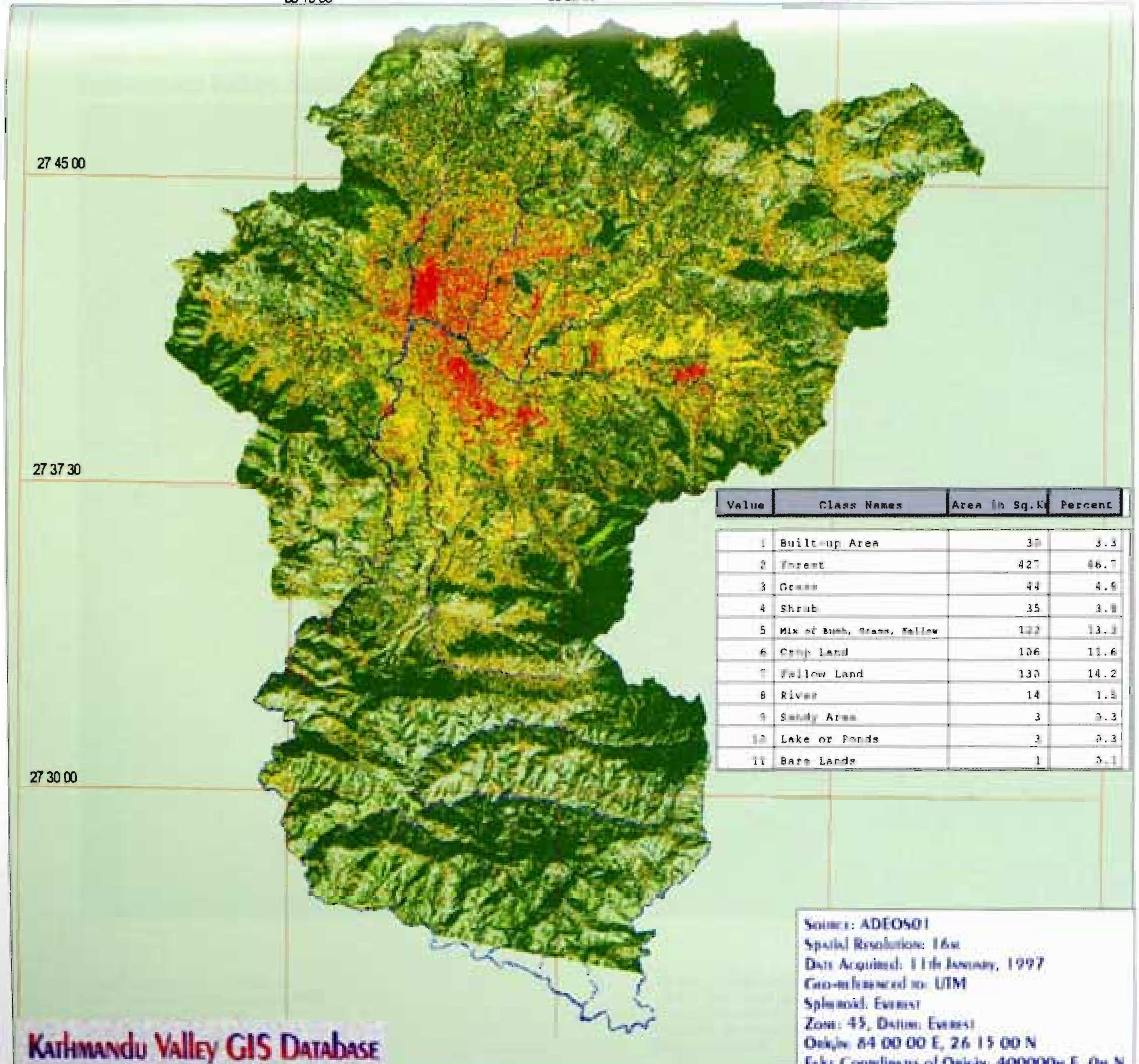
Kathmandu Valley, Nepal



Spatial Resolution: 30 metres
Date Acquired: 11th October, 1988
Geo-referenced to UTM
Spheroid: Everest
Zone: 45; Datum: Everest

Above Ground Level (AGL): 1503metres
Above Sea Level (ASL): 3000 metres
Field of View (FOV): 85degrees
Azimuth: 345 degrees
Exaggeration: 4

ICIMOD
MENRIS '99



Value	Class Names	Area in Sq.Km	Percent
1	Built-up Area	30	3.3
2	Forest	427	46.7
3	Grass	44	4.9
4	Shrub	35	3.8
5	Mix of Bush, Grass, Fallow	122	13.3
6	Crop Land	106	11.6
7	Fallow Land	130	14.2
8	River	14	1.5
9	Sandy Area	3	0.3
10	Lake or Ponds	3	0.3
11	Bare Lands	1	0.1

Source: ADEOS01
Spatial Resolution: 16m
Date Acquired: 11th January, 1997
Geo-referenced to: UTM
Spheroid: Everest
Zone: 45, Datum: Everest
Origin: 84 00 00 E, 26 15 00 N
False Coordinates of Origin: 400000m E, 0m N

Kathmandu Valley

Map 29
Land Cover Based on ADEOS-AVNIR Image, 1997

Legend

Land Cover Class
- Built-up Area
- Forest
- Grass
- Shrub
- Mixed (bush, grass, fallow)
- Crop Land
- Fallow Land
- River
- Sandy Area
- Lake or Ponds
- Bare Lands
- No Data

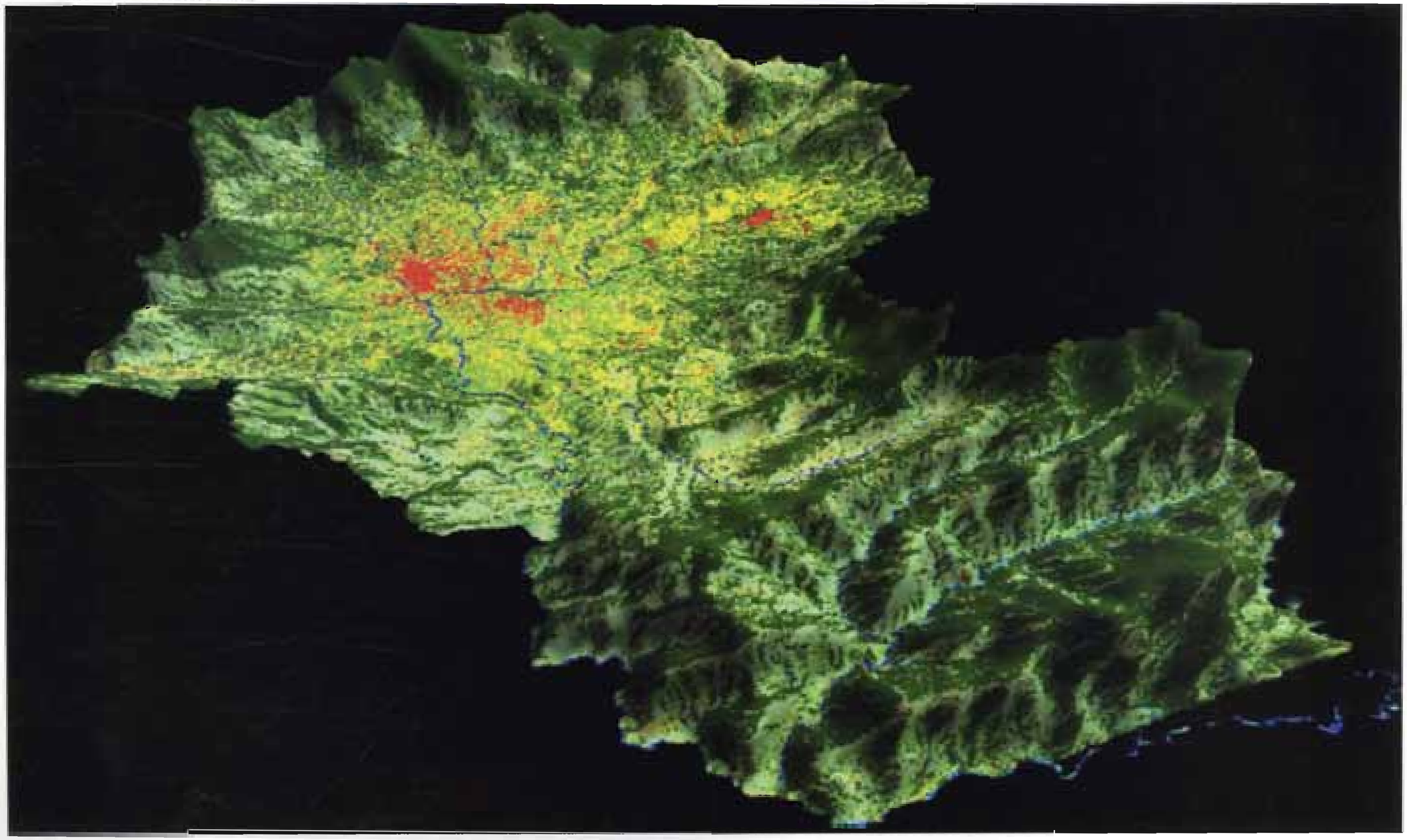
5 0 5 Kilometres

Scale: 1:275,000

ICIMOD
MENRIS '99

Map 30

Land Cover Based on ADEOS-AVNIR Image, 1997, Draped on DEM
Kathmandu Valley, Nepal



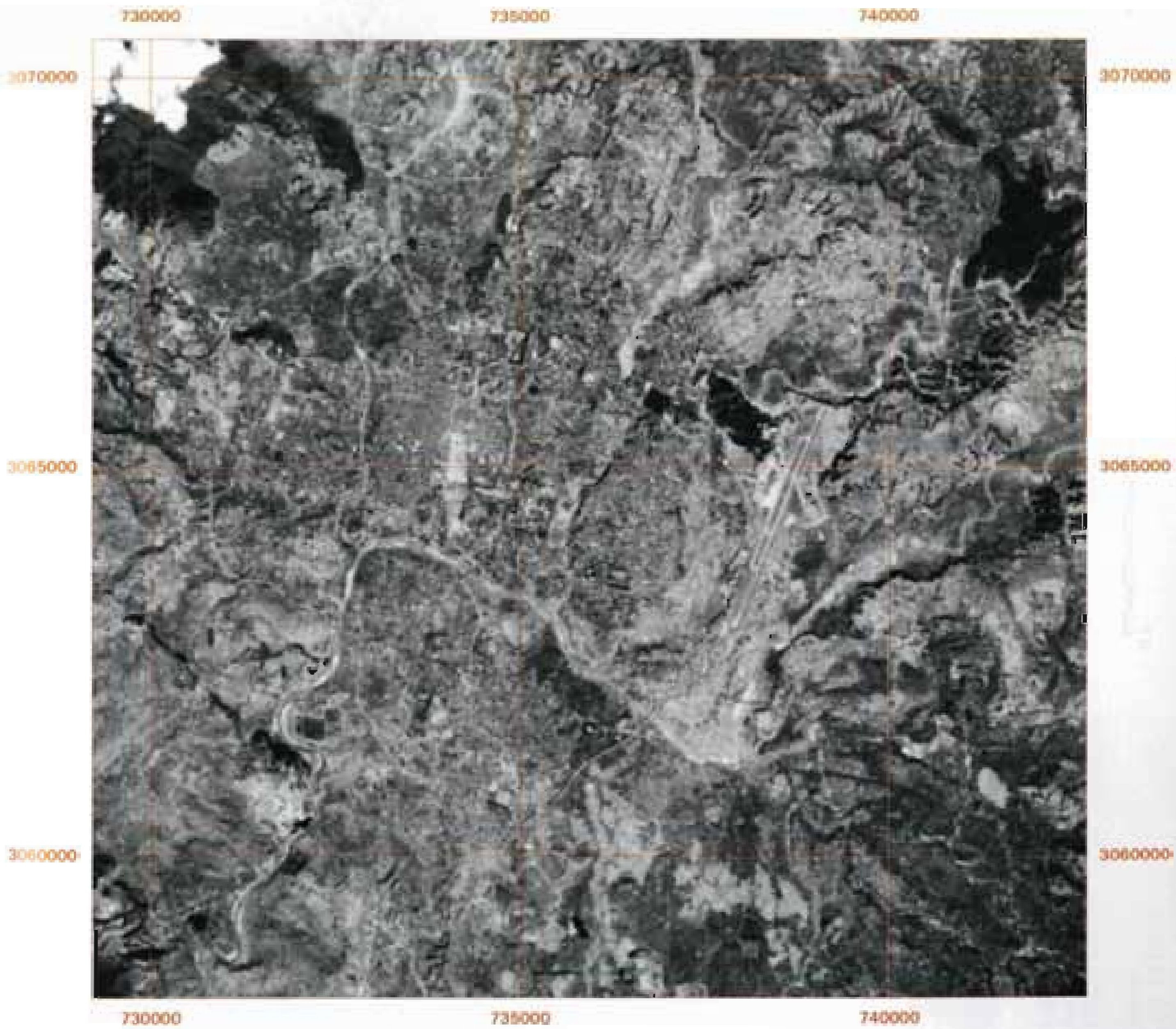
Spatial Resolution: 16 metres
Date Acquired: 11th January, 1997
Geo-referenced to UTM
Spheroid: Everest
Zone: 45; Datum: Everest

Above Ground Level (AGL): 6557 metres
Above Sea Level (ASL): 3776 metres
Field of View (FOV): 75 degrees
Azimuth: 38 degrees
Exaggeration: 4

ICIMOD
MENRIS '99

Map 31

SPIN-2 Two Metre KVR-1000 Image, 1991
Kathmandu Valley, Nepal



Spatial Resolution: 1.99992 metres
Date Acquired: 5th February, 1991
Geo-referenced to UTM
Spheroid: Everest
Zone: 45; Datum: Everest
Origin: 84 00 00 E, 26 15 00 N
False Co-ordinates of Origin: 400000m E, 0m N

Scale

2 0 Kilometres

ICIMOD
MENRIS '99

Map 32

SPIN-2 Two Metre KVR-1000 Image, 1991 (Core Urban Area)
Kathmandu Valley, Nepal

Spatial Resolution: 1.99992 metres
Date Acquired: 5th February, 1991
Geo-referenced to UTM
Spheroid: Everest
Zone: 45; Datum: Everest
Origin: 84 00 00 E, 26 15 00 N
False Coordinates of Origin: 400000m E, 0m N

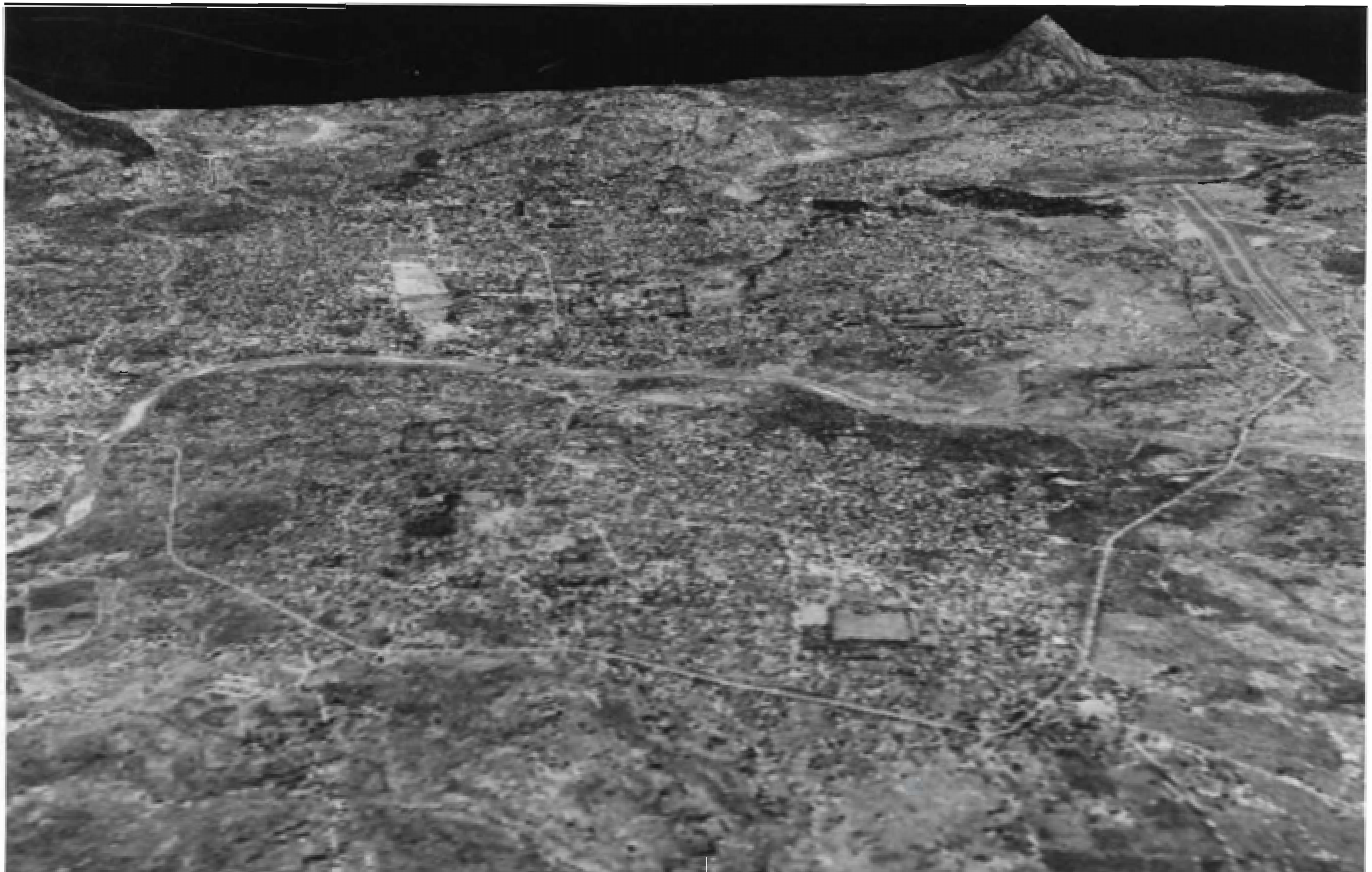
Scale

0.5 — 0 Kilometres

ICIMOD
MENRIS '99

Map 33

SPIN-2 Two-metre KVR-1000 Image, 1991, Draped on DEM
Kathmandu Valley, Nepal



Spatial Resolution: 1.99992 metres
Date Acquired: 5th February, 1991
Geo-referenced to UTM
Spheroid: Everest
Zone: 45; Datum: Everest

Above Ground Level (AGL): 800 metres
Above Sea Level (ASL): 2000 metres
Field of View (FOV): 50 degrees
Azimuth: 2 degrees
Exaggeration: 4

ICIMOD MENRIS '99

Map 34

SPIN-2 Two Metre KVR-1000 Image, 1991, Merged with ADEOS-AVNIR Image, 1997 (Part 1)
Kathmandu Valley, Nepal

Spatial Resolution: 2 metres.
Dates Acquired:
SPIN-2: 5th Feb., 1991
AVNIR: 11th Jan., 1997
Geo-referenced to UTM
Spheroid: Everest.
Zone: 45, Datum: Everest
Origin: 84 00 00 E, 26 15 00 N
False Co-ordinates of Origin: 400000m E, 0m N

Scale

0.5 0 Kilometres

ICIMOD

ENRIS '99

Map 35

SPIN-2 Two Metre KVR-1000 Image, 1991, Merged with ADEOS-AVNIR Image, 1997 (Part 2)
Kathmandu Valley, Nepal

Spatial Resolution: 2 metres
Dates Acquired:
SPIN-2: 5th Feb., 1991
AVNIR: 11th Jan., 1997
Georeferenced to UTM
Spheroid: Everest,
Zone: 45, Datum: Everest
Origin: 84 00 00 E, 26 15 C0 N
False Co-ordinates of Origin: 400000m E, 0m N

Scale

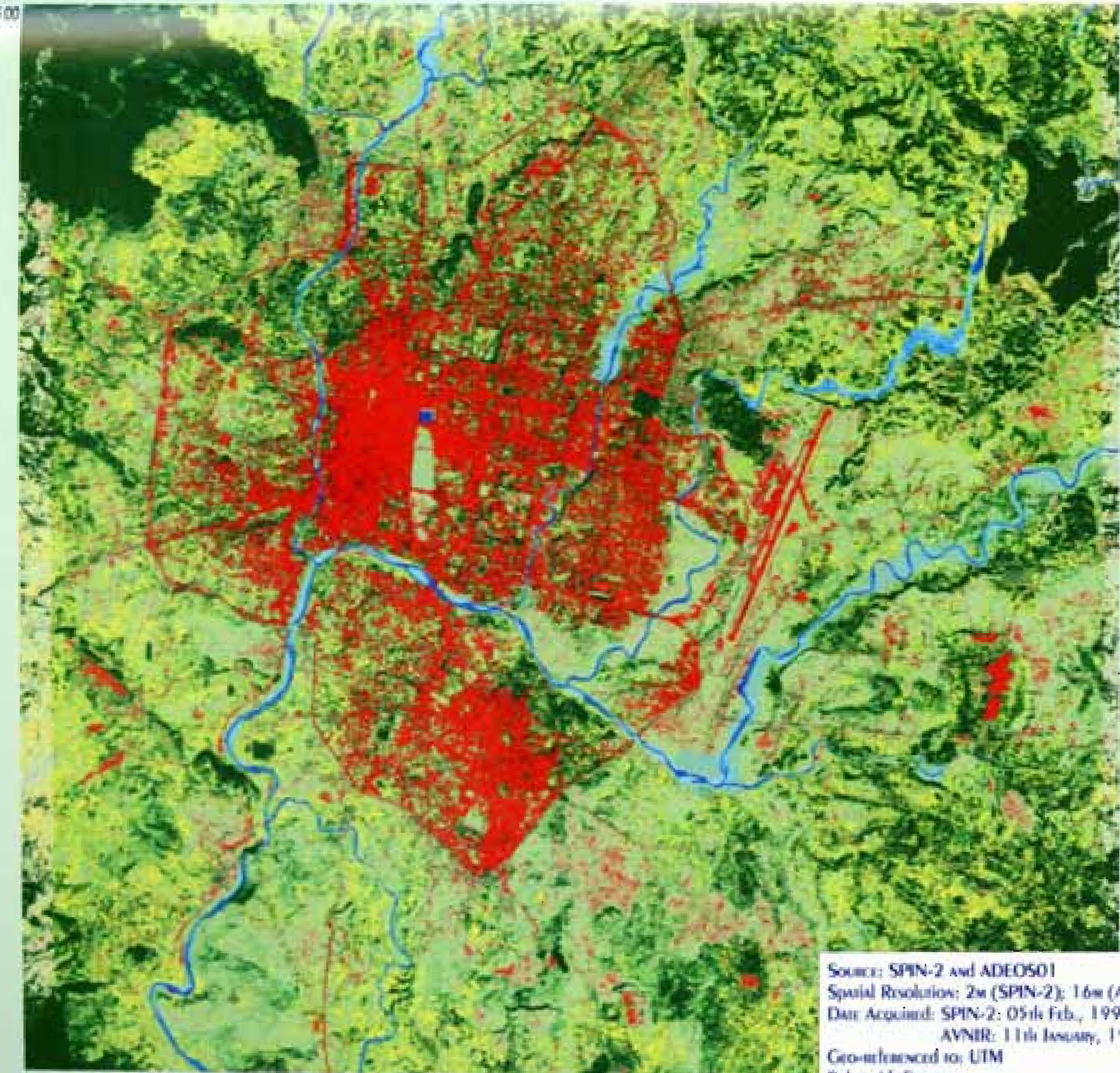
0.5 0 0.5 Kilometres

ICIMOD
MENRIS '99

Kathmandu Valley

Map 36

Land Cover Based On Merged SPIN-2 Image, 1991 and ADEOS-AVNIR Image, 1997



Legend

Land Cover Classes

- Built-up
- Forest
- Grass
- Shrub
- Crop Land
- Fallow Land
- Rivers
- Sandy Area

1 0 1 2 Kilometres

Scale: 1:80,000

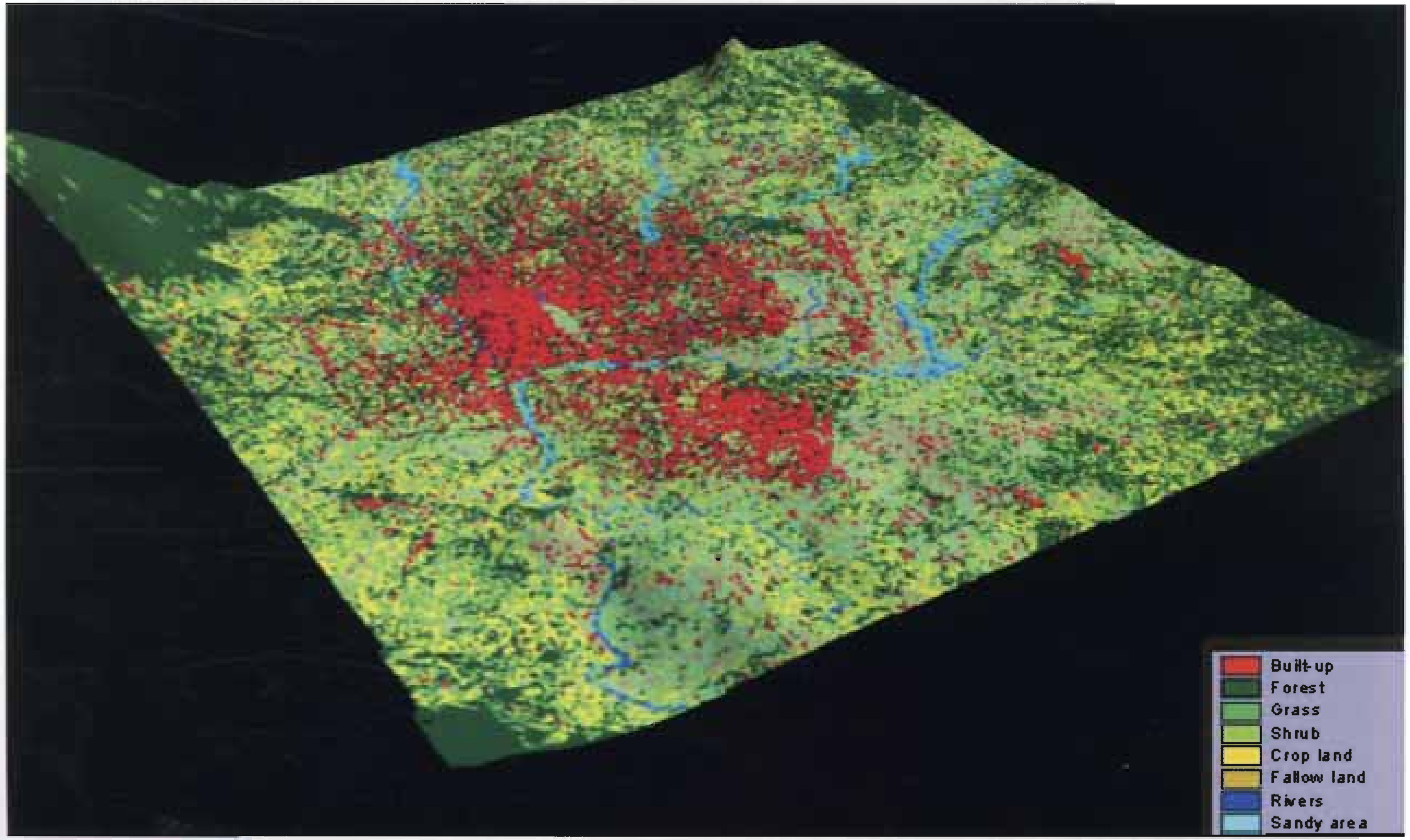
Source: SPIN-2 and ADEOS01
Spatial Resolution: 2m (SPIN-2); 16m (AVNIR)
Date Acquired: SPIN-2: 05th Feb., 1991
AVNIR: 11th January, 1997
Geo-referenced to: UTM
Spheroid: Everest
Zone: 45, Datum: Everest
Origin: 84 00 00 E, 26 15 00 N
False Coordinates of Origin: 400000m E, 0m N

ICIMOD MENRIS '99

Kathmandu Valley GIS Database

Map 37

Land Cover Based on Merged SPIN-2 Image, 1991 and ADEOS-AVNIR Image, 1997, Draped on DEM Kathmandu Valley, Nepal



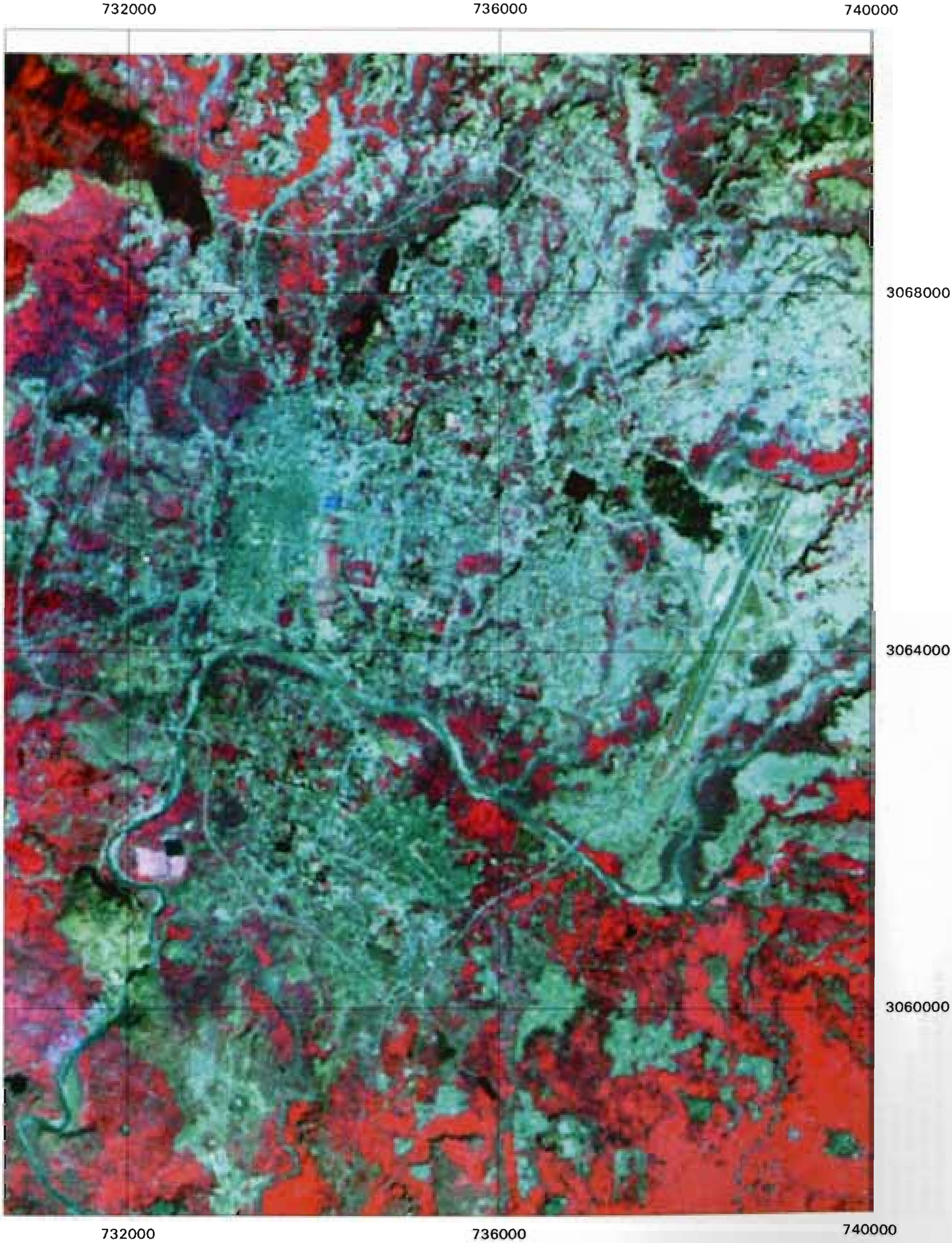
Output Spatial Resolution: 2 metres
Dates Acquired:
SPIN-2: 5th Feb., 1991
AVNIR: 11th Jan., 1997
Geo-referenced to UTM
Spheroid: Everest
Zone: 45; Datum: Everest

Above Ground Level (AGL): 2652 metres
Above Sea Level (ASL): 4122 metres
Field of View: 65 degrees
Azimuth: 33 degrees
Exaggeration: 4

ICIMOD
MENRIS '99

Map 38

False Colour Composite (R3 G2 B1) of SPOT-XS HRV1 Image, 1986
Kathmandu Valley, Nepal



Spatial Resolution: 20 metres
Date Acquired: 12th March, 1986
Geo-referenced to UTM
Spheroid: Everest
Zone: 45; Datum: Everest
Origin: 84 00 00 E, 26 15 00 N
False Co-ordinates of Origin: 400000m E, 0m N

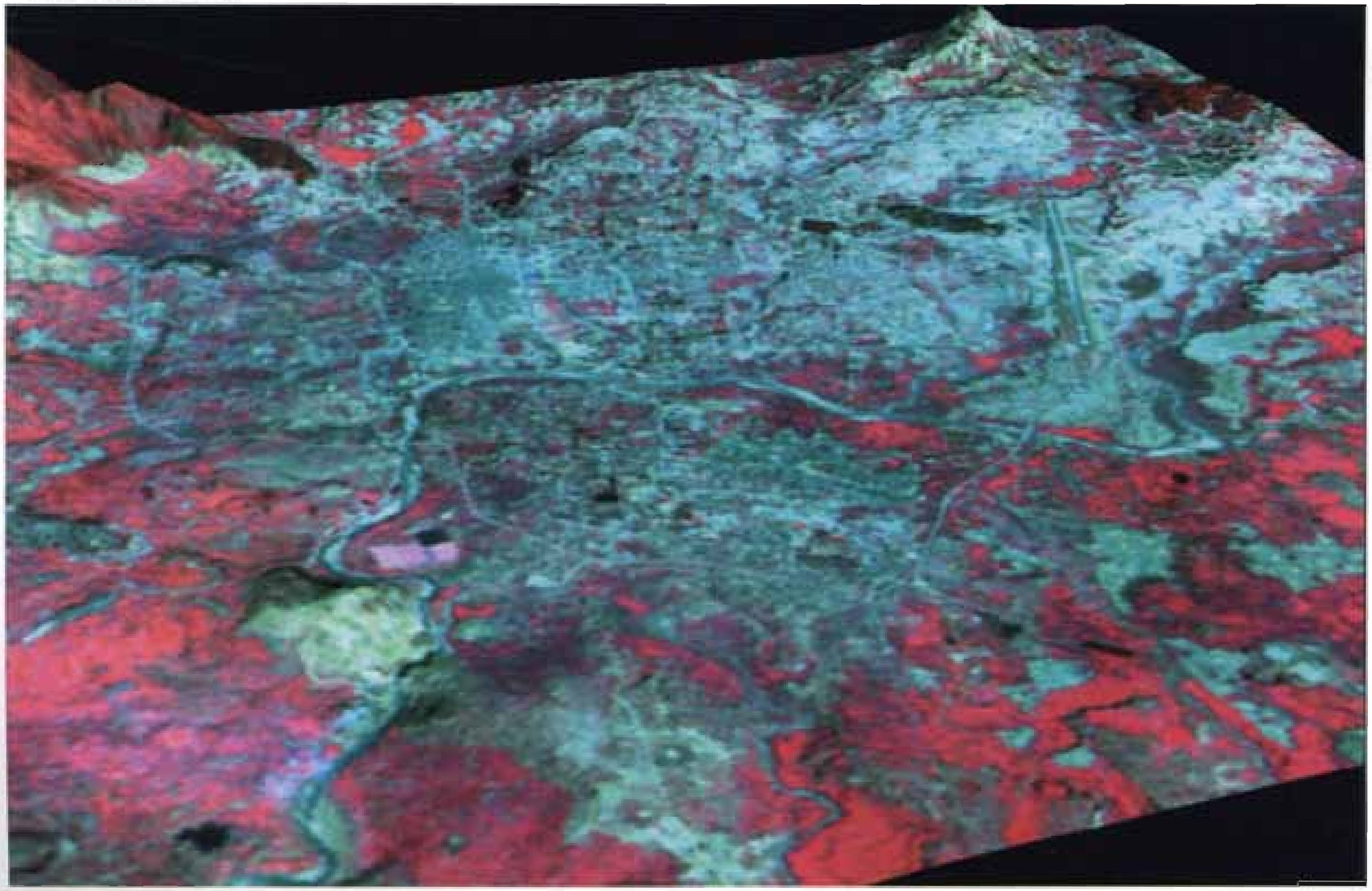
Scale

2 0 Kilometres

ICIMOD
MENRIS '99

Map 39

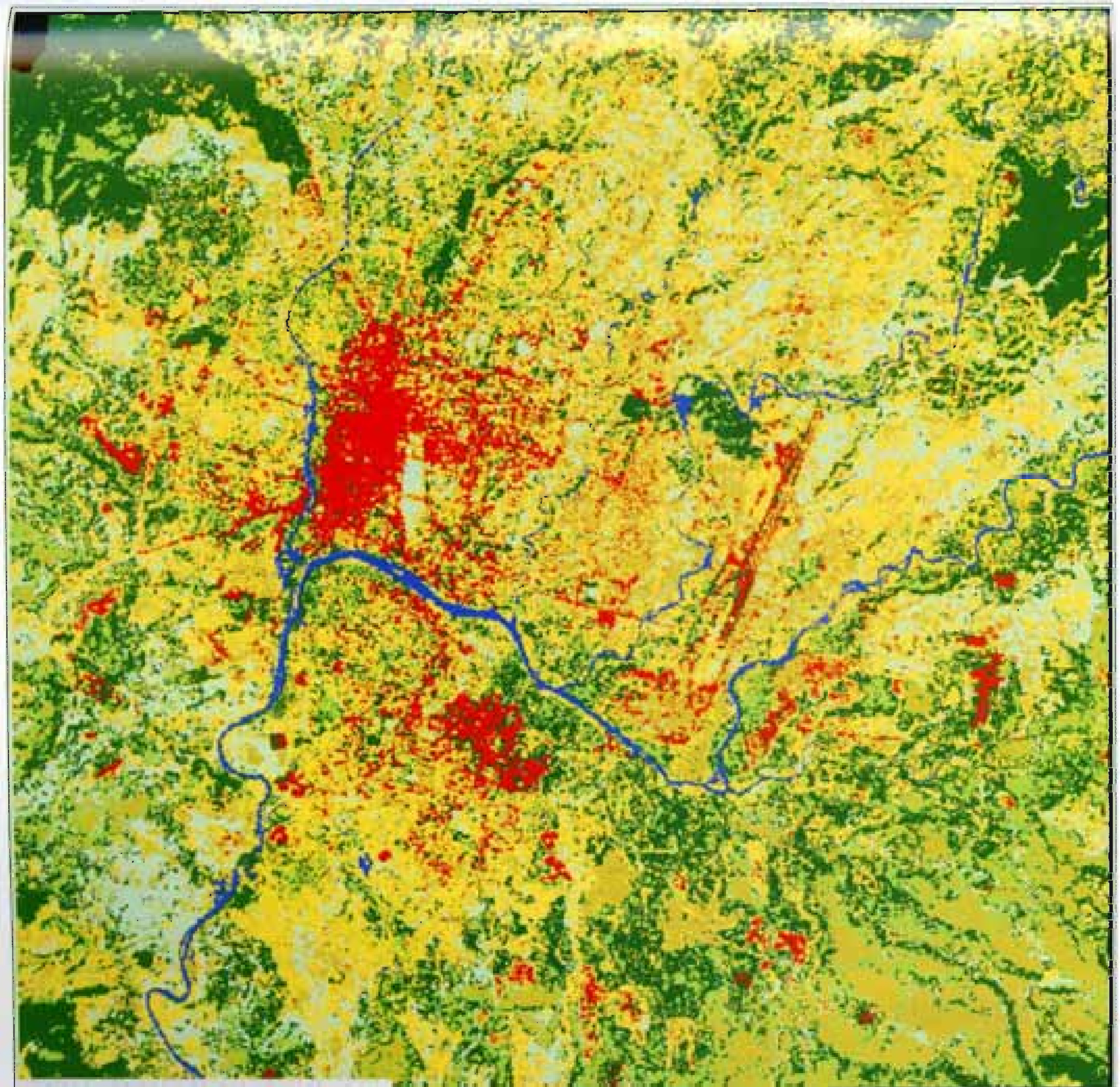
False Colour Composite (FCC) of SPOT-XS HRV1 Image, 1986, Draped on DEM Kathmandu Valley, Nepal



Spatial Resolution: 20 metres
Date Acquired: 12th March, 1986
Geo-referenced to UTM
Spheroid: Everest
Zone: 45; Datum: Everest
Origin: 85 00 00 E, 26 15 00 N
False Coordinates: 400000m E, 0m N

Above Ground Level (AGL): 1800 metres
Above Sea Level (ASL): 2678 metres
Field of View (FOV): 50 degrees
Azimuth: 39 degrees
Exaggeration: 4

ICIMOD
MENRIS '99



KATHMANDU VALLEY

Map 40

Land Cover Based on SPOT XS HRV1 Image, 1986

Legend

Legend	Count	Area_sq.km.	Percent
Built-up Area	24887	10	5.65
Forest	96852	39	22.03
Grass	51806	21	11.86
Shrub	53987	22	12.43
Crop Land	103167	41	23.16
Fallow Land	101879	41	23.16
Water Body	6595	3	1.69

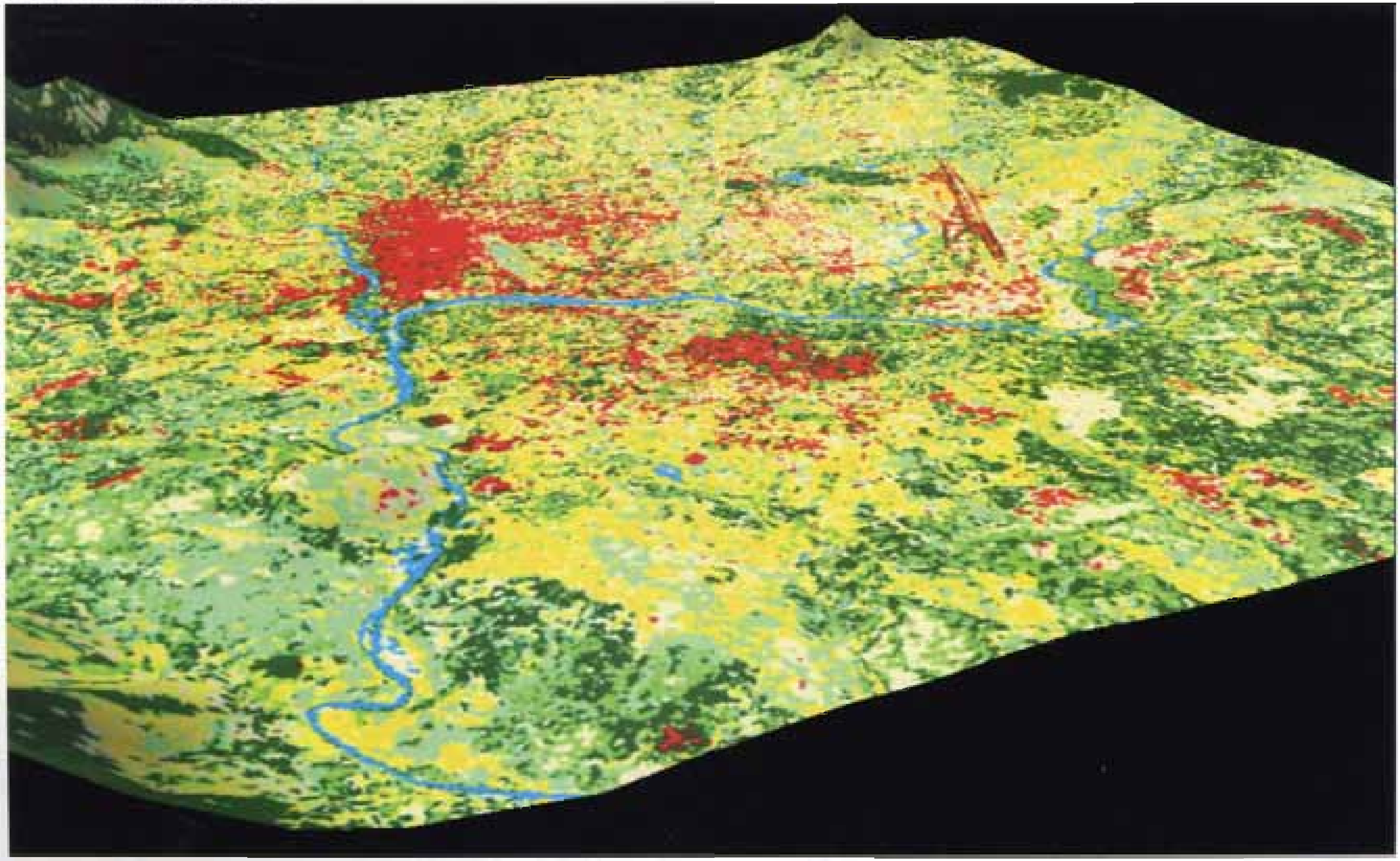
1 0 1 Kilometres

Image Extent: LLX: 729233 LLY: 3057748
URX: 742623 URY: 307068537
Source: SPOT-XS HRV1 Satellite Image
Date Acquired: 12th March, 1986 (20m)
Geo-referenced to: UTM; Output Cell size: 20m
Spheroid: Everest
Zone: 45; Datum: Everest
Origin: 84 00 00 E, 26 15 00 N
False Coordinates of Origin: 400000m E, 0m N

ICIMOD
MENRIS '99

Map 41

Land Cover Based on SPOT-XS HRV1 Image, 1986, Draped on DEM Kathmandu Valley, Nepal



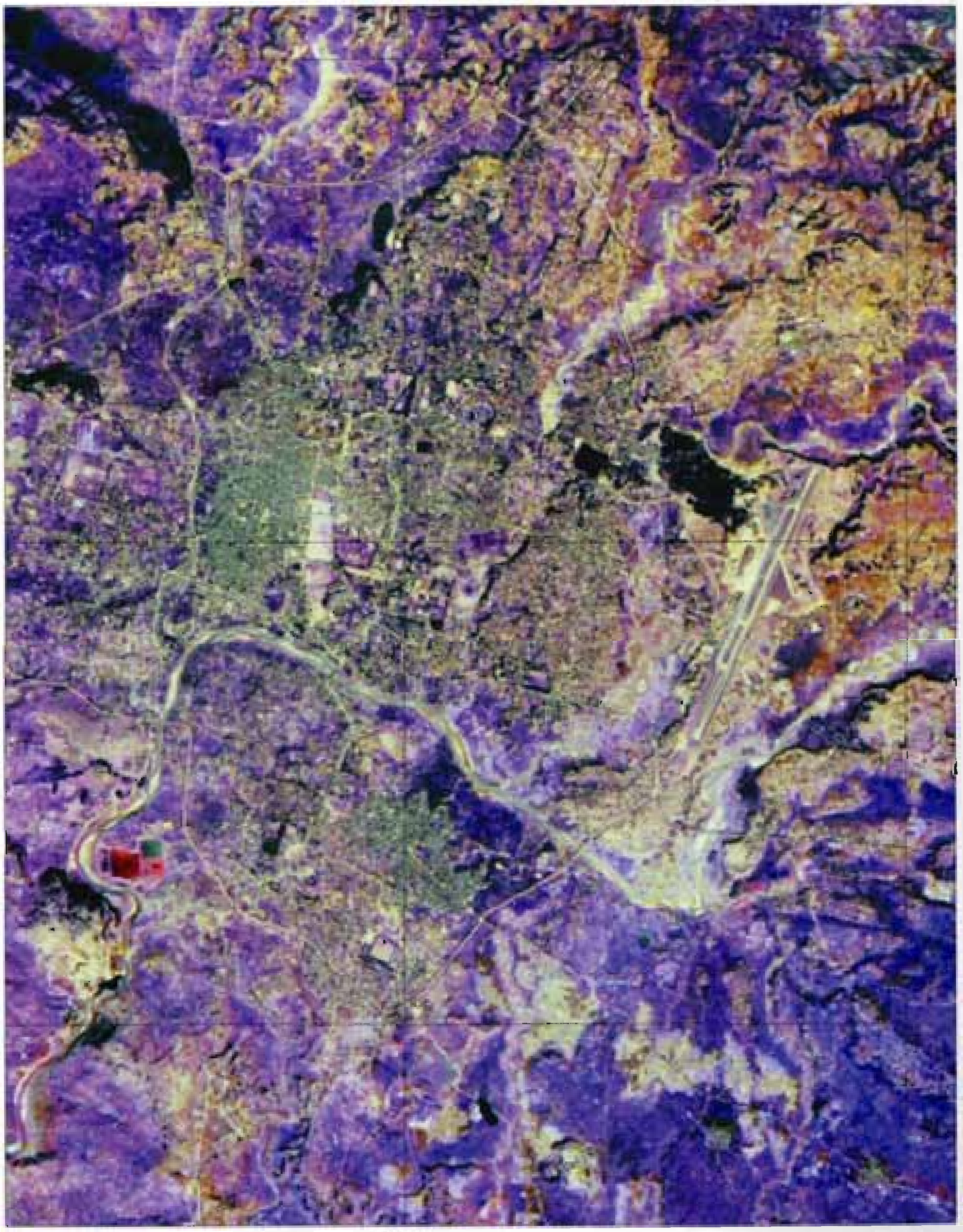
Spatial Resolution: 20 metres
Date Acquired: 12th March, 1986
Geo-referenced to UTM
Spheroid: Everest
Zone: 45; Datum: Everest
Origin: 84 00 00 E, 26 15 00 N
False Co-ordinates of Origin: 400000m E, 0m N

Above Ground Level (AGL): 1435 metres
Above Sea Level (ASL): 2806 metres
Field of View (FOV): 50 degrees
Azimuth: 25 degrees
Exaggeration: 4

ICIMOD
MENRIS '99

Map 42

Merged (SPIN-2, 1991, and SPOT-XS, 1986) Image
Kathmandu Valley, Nepal

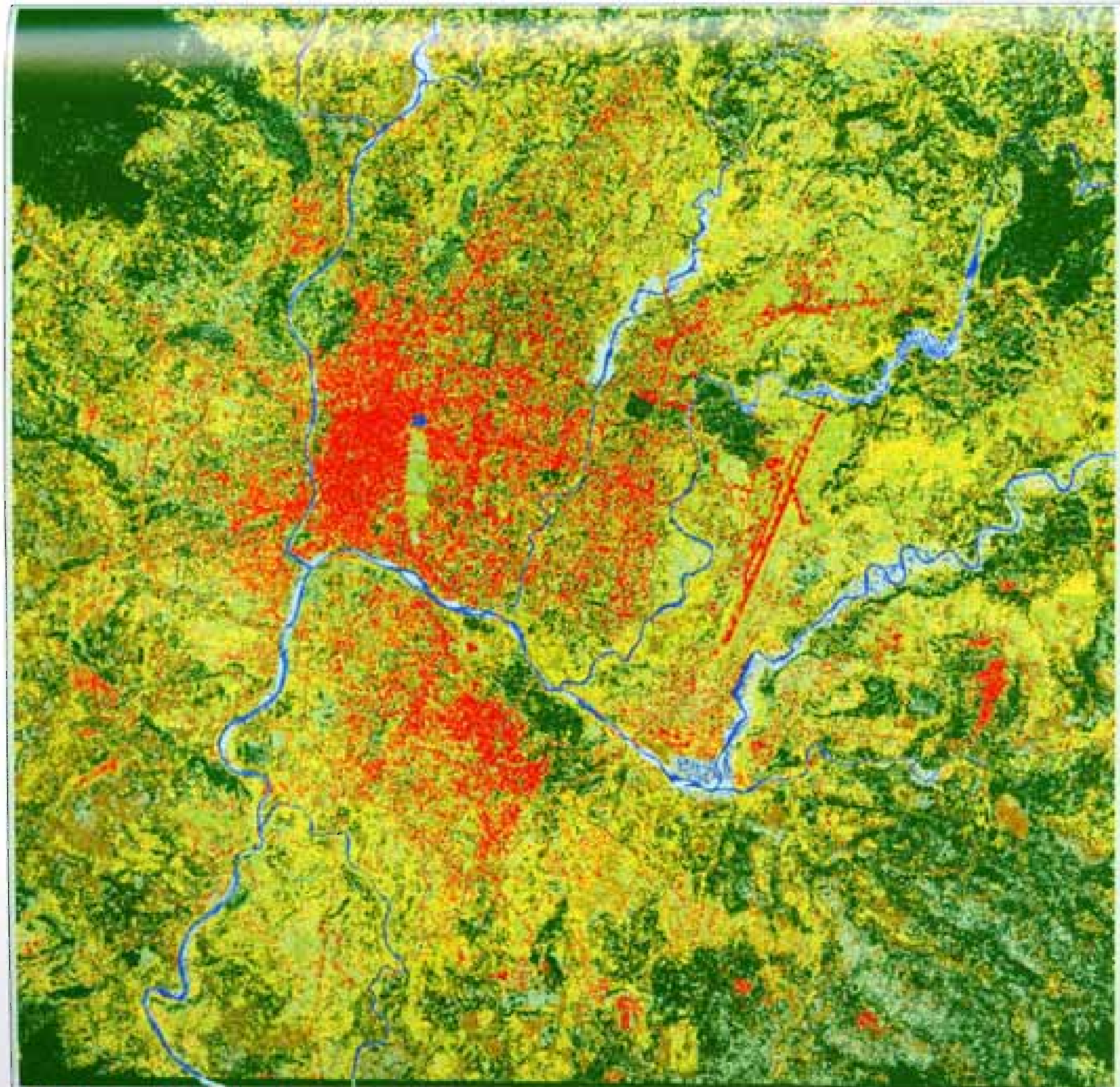


Output Resolution: 2 metres
Dates Acquired: SPIN-2: 5th February, 1991
SPOT-XS: 12th March, 1986
Geo-referenced to: UTM
Spheroid: Everest
Zone: 45; Datum: Everest
Origin: 84 00 00 E, 26 15 00 N
False Coordinates of Origin: 400000m E, 0m N

Scale

2 0 Kilometres

ICIMOD
MENRIS '99



Kathmandu Valley GIS Database

Kathmandu Valley

Map 43

Land Cover Based on Merged SPIN-2 Image, 1991 and SPOT-XS HRV1 Image, 1986

Legend

- Built-up Area
- Forest
- Grass
- Shrub
- Crop Land
- Fallow Land
- River
- Sand/Gravel/Boulder

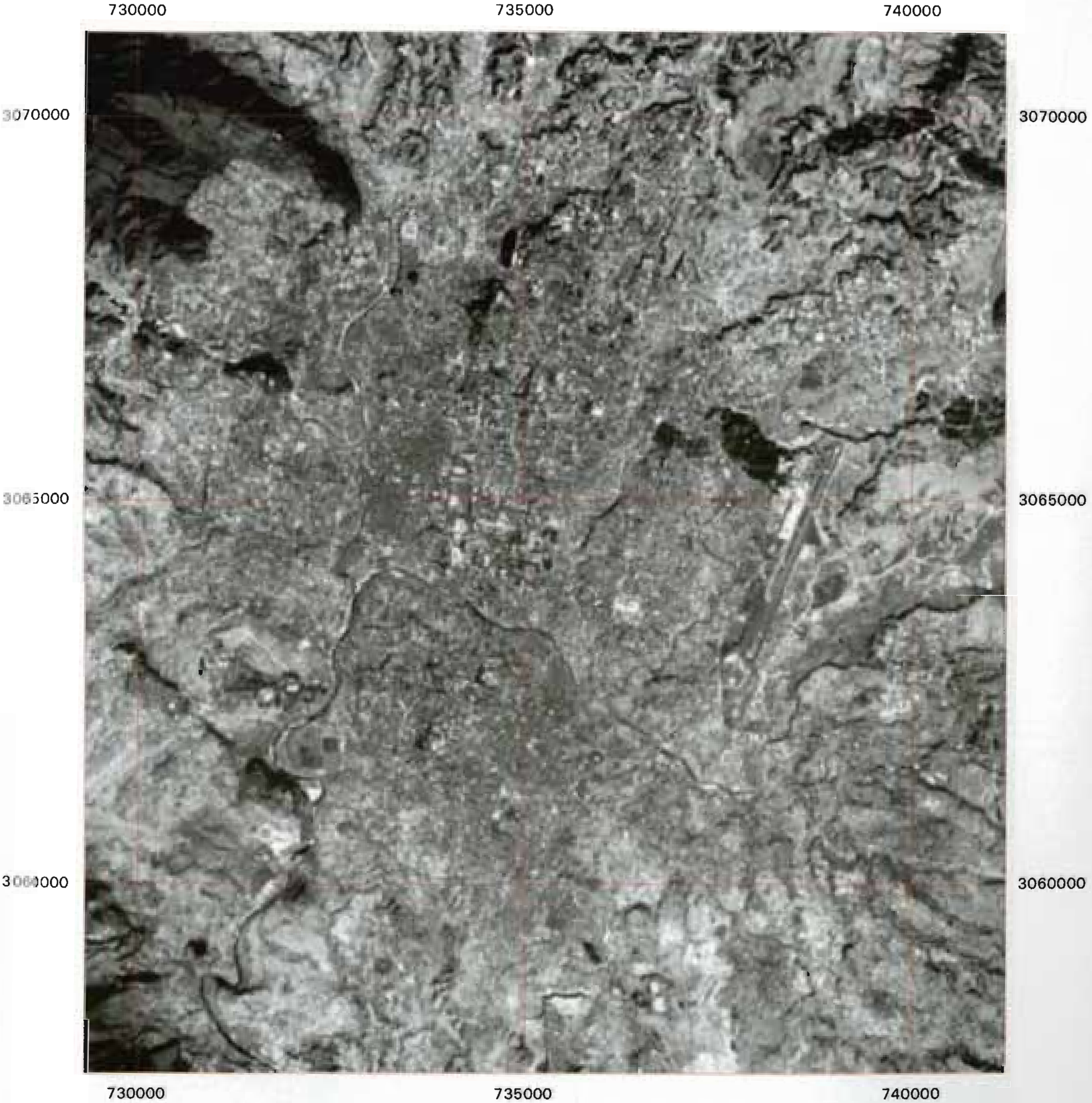
2 0 2 Kilometres

Image Extent: LLX: 729233 LLY: 3057748
URX: 742623 URY: 307068537
Source: SPIN-2 and SPOT-XS HRV1 Satellite Image
Dates Acquired: SPIN-2: 05th Feb., 1991 (2m)
SPOT-XS: 12th March, 1986 (20m)
Geo-referenced to: UTM; Output Cell size: 2m
Spheroid: Everest
Zone: 45; Datum: Everest
Origin: 84 00 00 E, 26 15 00 N
False Coordinates of Origin: 400000m E, 0m N

ICIMOD
MENRIS '99

Map 44

IRS-C Satellite Image, 1996
Kathmandu Valley, Nepal



Spatial Resolution: 5.6 metres
Date Acquired: 23rd November, 1996
Geo-referenced to UTM
Spheroid: Everest
Zone: 45; Datum: Everest
Origin: 84 00 00 E, 26 15 00 N
False Coordinates of Origin: 400,000m E, 0m N

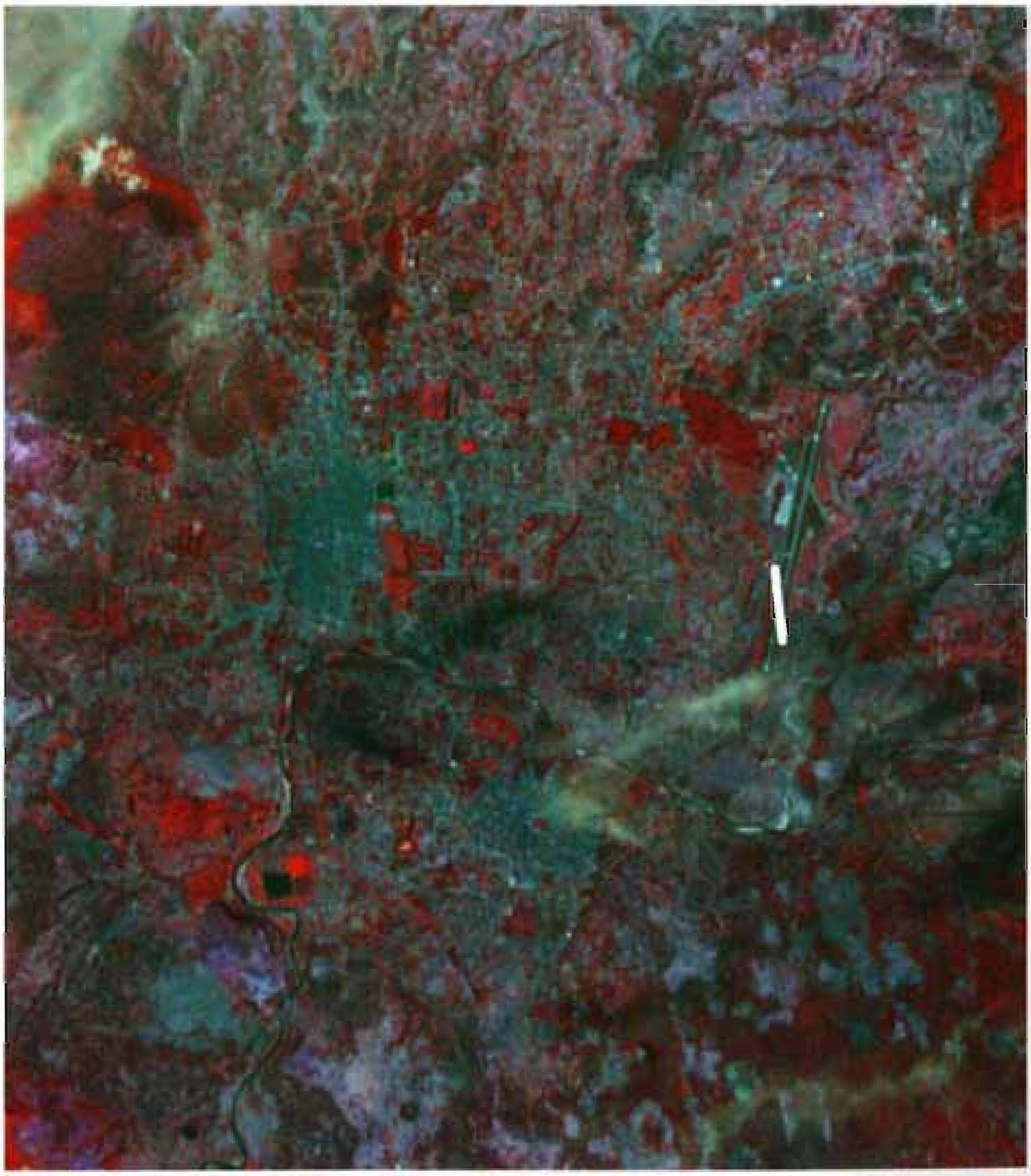
Scale

2 — 0 Kilometres

ICIMOD
MENRIS '99

Map 45

False Colour Composite (R3 G2 B1) of SPOT-XS HRV1 Image, 1991
Kathmandu Valley, Nepal



Spatial Resolution: 20 metres
Date Acquired: 05th May, 1991
Geo-referenced to: None

ICIMOD
MENRIS '99

Map 46

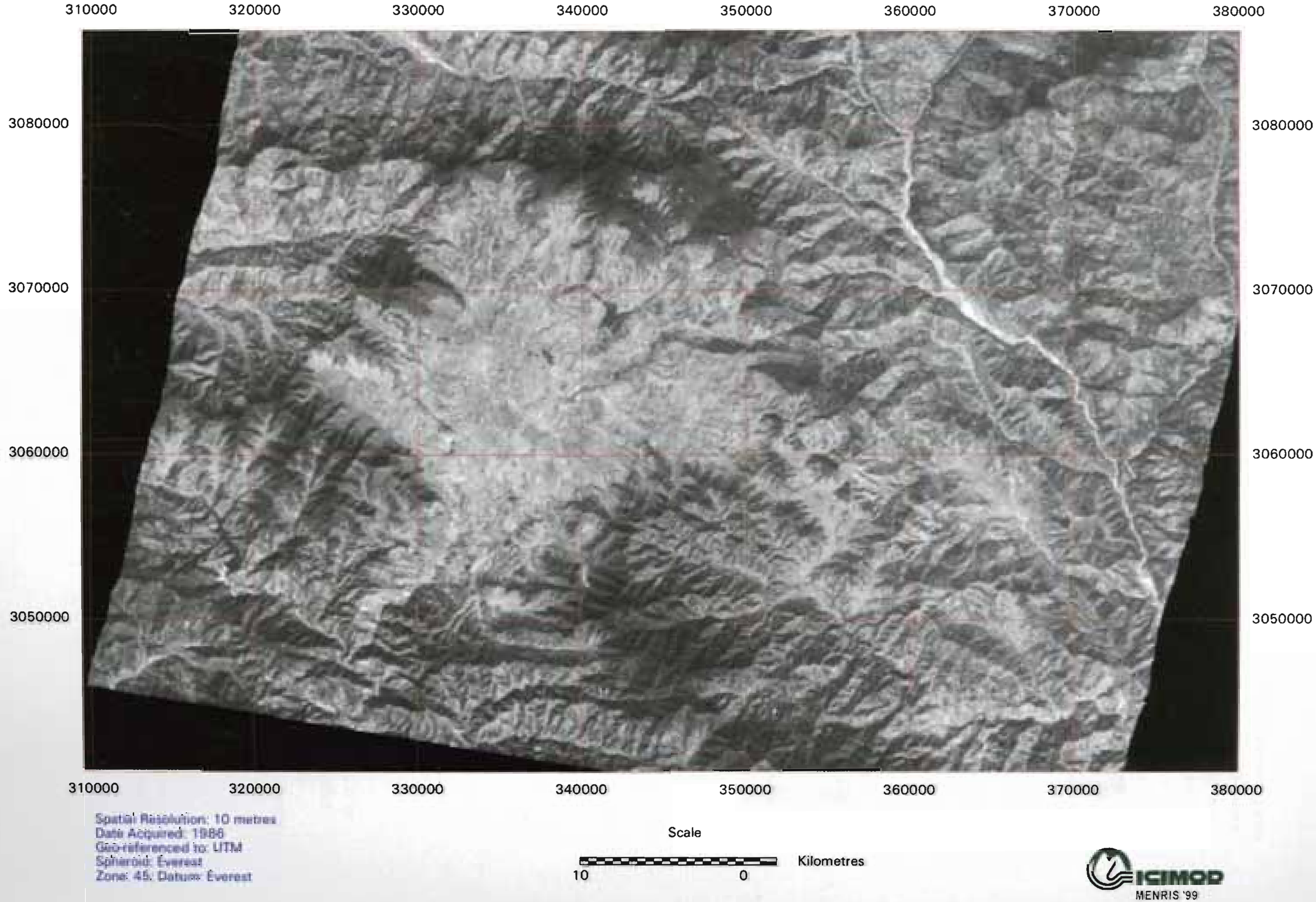
False Colour Composite (R3 G2 B1) of SPOT-XS HRV1 Image, 1994
Kathmandu Valley, Nepal

Spatial Resolution: 20m
Date Acquired: 12th December, 1994
Geo-referenced to: None

ICIMOD
MENRIS '99

Map 47

SPOT-PAN Ortho Image, 1986
Kathmandu Valley, Nepal



7.4 Integrated GIS Database

Each of the various GIS data layers mentioned in the above sections is converted into a raster-based structure using 10-metre cell sizes. All layers are registered into the Universal Transverse Mercator (UTM) geographic coordinate system. All spatial data, including digitised thematic maps and satellite images and tabular data have been integrated into a single information system, and spatial indices have been created to link different data sets using their spatial locations. The overall methodology employed to create an integrated GIS Database is depicted in Figure 7. Based on this, an integrated spatial database has been established using workstation-based Arc/Info 7.0.3 and Arcview 3.1 software. Satellite images were processed in workstation-based ERDAS Imagine 8.3.1 software.

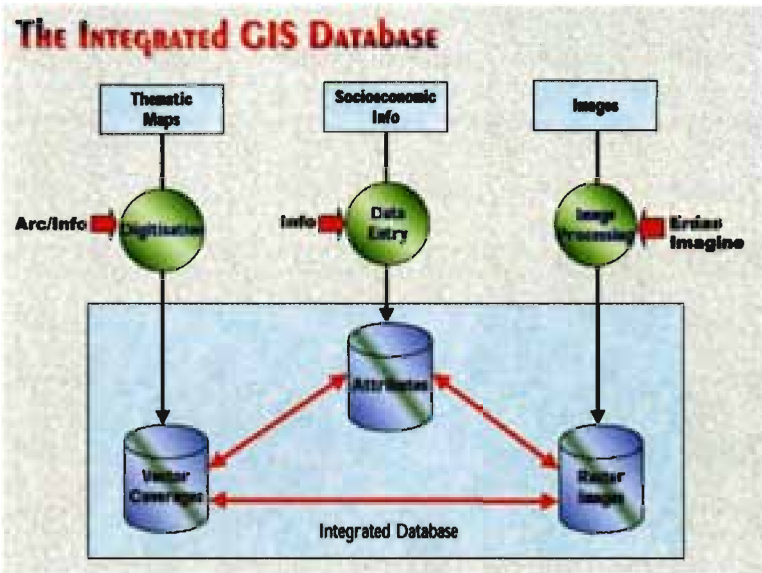


Figure 7: **The Integrated Database**

Developing databases takes a lot of time and resources, normally production cost is 70 per cent or more for most GIS projects. The integrated database developed can be used by many organizations for different applications such as natural resource management, environmental and urban applications, and so on. However, the database may be far from complete depending upon the particular application, but it encourages a building block approach to database development, management, and revision. In the next section, some of the potential applications using GIS and related technologies are shown, but merely for demonstration purposes rather than as comprehensive applications. Many applications can be developed once a comprehensive database is in place.

8. POTENTIAL GIS APPLICATIONS

8.1 Potential GIS Application I: Cost Distance Modelling

8.1.1 Background

The spatial complexity of the mountain environment requires particular attention in order to assess the cost of travelling in different directions through an area of high relief. The cost distance analysis is a standard function of GIS and involves calculation of a distance surface from a given location. The source location is generally a feature or a point on a raster grid.

8.1.2 Objective

The main objective of this application is to demonstrate the potential of GIS for cost distance modelling, i.e., proposing an environmentally least costly path in a mountain area.

8.1.3 Pilot Area

The Nagarjun forest, located north west of the Kathmandu Valley, has been selected as the pilot area for this application. The altitude of the area varies from 1,386 m, near the base, to 2,097m at the top (Jamachowk). The area is covered for the most part with hardwood forest, mixed forest, deciduous or coniferous forest, shrub land, and grassland. At present, there is a road to the top, but it is in a poor condition. So, this study looked at other alternatives, i.e., to construct a road at least cost to the environment.

Data Used

The following data on the pilot area were used for this study:

- Land-use data on a scale of 1:50,000 (Figure 8)
- Digital Elevation Model (DEM) at a resolution of 10 metres (Figure 9)
- Location of top and base

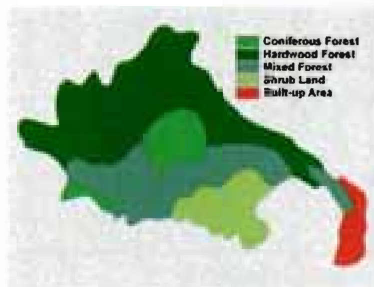


Figure 8: **Existing Land Cover Map of the Study Area**

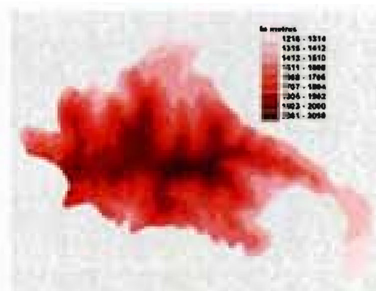


Figure 9: **Digital Elevation Model (DEM) of the Study Area**

Methodology

First of all, the vector data, i.e., land-use data, base point, and top point were entered in raster format in the same resolution as that of the DEM. From the available data sets, the following spatial criteria have been established for the analysis:

- If the land-cover type is grass or shrub, the environmental cost will be less than it would be for an area of forest.
- The higher the slope, the higher the environmental cost.
- The southern aspect is preferable because other aspects incur higher costs.

Based on the above criteria, the qualitative cost for land cover, qualitative cost for slope, and qualitative cost for aspects have been calculated using a GIS linear combination model. Different types of land cover offer varying degrees of friction. It is evident that, from the point of view of the environment and the cost, forested areas are more difficult to traverse than agricultural areas or grassland. So, different values (1 – 100) were assigned for each type of land-cover class depending upon the preference, as given in Table 5.

Table 5 : **Weight Score Values for Land-cover Classes**

Land Cover Type	Value	Score
Hardwood Forest	1	40
Coniferous Forest	2	20
Mixed Forest	3	30
Shrub Land	4	5
Urban	5	0

A slope map (Figure 10) of the pilot area was derived from DEM and reclassified into 10 different slope classes. The weightages of score value were assigned to different slope classes ranging from 1 to 100, reflecting the actual human energy required to cross each slope pixel; i.e., the steeper the slope, the higher the weightage (Table 6). An aspect map (Figure 11) was also derived from the DEM and reclassified into 9 different classes. Low score value was assigned to the preferable aspects (Table 7). Generally, the southern aspect is

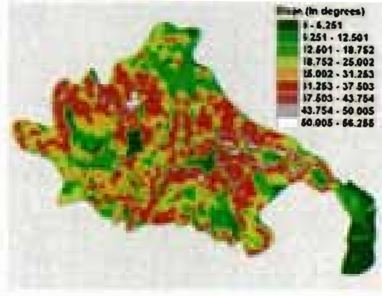


Figure 10: **Slope Map**

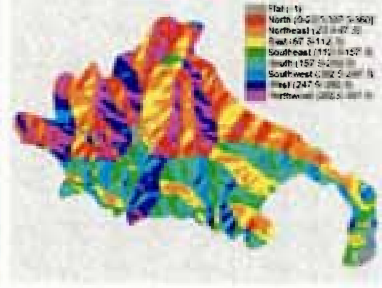


Figure 11: **Aspect Map**

Table 6: **Weight Score Values for Slope Classes**

Slope Classes	Old Value	Score
0 – 5	1	1
5 – 10	2	10
10 – 20	3	20
20 – 30	4	30
30 – 40	5	40
40 – 50	6	50
50 – 60	7	60
60 – 70	8	70
70 – 80	9	80
80 – 90	10	90

Table 7: **Weight Score Values for Aspect Classes**

Aspects	Old Value	Score Value
Flat	-1	0
North	0-22.5, 337.5-360	20
North East	22.5-67.5	30
East	67.5-112.5	40
South East	112.5- 157.5	15
South	157.5-202.5	10
South West	202.5-247.5	15
West	247.5-292.5	50
North West	292.5-337.5	60

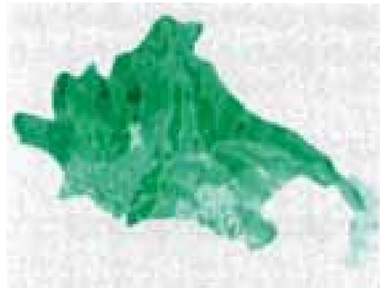


Figure 12: **Cost Surface**

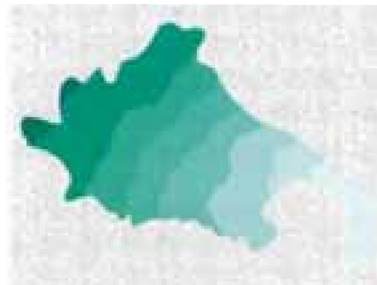


Figure 13: **Accumulated Cost Distance**

preferred for this kind of analysis, because the soils of other aspects normally contain moisture leading to a high risk of failure.

The qualitative costs for land cover, slope, and aspects were combined to produce cost surface (Figure 12). A grid of the base point and cost surface was used to calculate the accumulated cost distance (Figure 13), representing the cost for each cell to traverse from the source cell (base point). It spreads from a cell into the neighbouring cell of lowest cost, adding up the distance of weighted costs as it traverses along. The accumulated cost distance and the top (destination) point were used to calculate the least cost path to move from the source to the destination point. Figure 14 below shows the proposed road using this cost distance modelling method. This application illustrates the cost distance modelling function of GIS. However, in mountain areas, many other parameters, including socioeconomic parameters, need to be considered. Such complex analyses are possible using GIS.

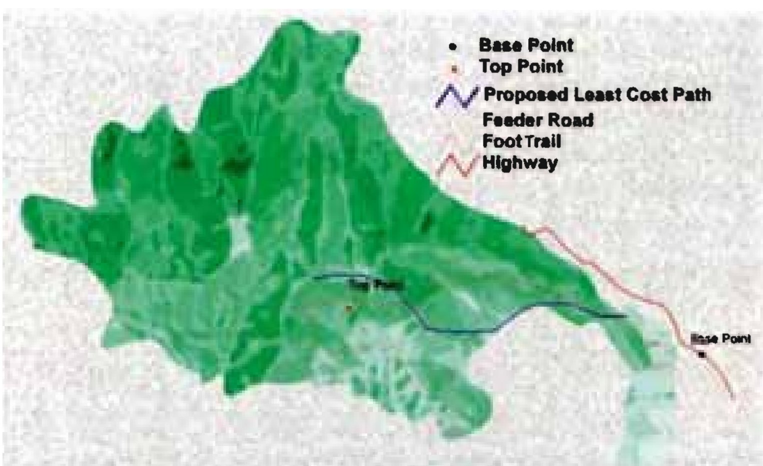


Figure 14: **Proposed Environmentally Least Cost Path**

8.2 Potential GIS Application II: Land-cover Change Analysis and Urban Growth Detection

8.2.1 Background

The rapid growth of population generates increasing competition for the land and the use of its resources. This situation makes the study of land cover and land use an important subject in the development planning process. Information on changes in land cover is of particular importance when such changes could lead to continual degradation of the land in the long run. Derivation of land cover through classical methods is costly, time-consuming, and subject to a variety of errors of different types and sources. Recent developments in GIS and related technologies have led to the establishment of accurate and up-to-date information on the status and pattern of land-cover dynamics.

8.2.2 Objective

The main objective of this application is to demonstrate the potential of GIS and remote-sensing technology for generating land-cover maps in a temporal series from various sources, enabling us to detect land-cover changes over time. This application also evaluates the effectiveness of satellite images of various resolutions (including very high resolution) taken at different times in the production of land-cover maps. It also evaluates the effectiveness of such images in detecting change.

8.2.3 Land-cover Changes between 1978 and 1995

Study Area, Data Description, Methodology, and the Result

The study area was considered to be all three districts of Kathmandu Valley: Kathmandu, Lalitpur, and Bhaktapur. The total area is about 927 sq. km. A land-use/-cover map on a scale of 1:50,000 (LRMP1978), published by the Land Resource Mapping Project, (LRMP) and a topographic map on a scale of 1:25,000 (HMG/FINNIDA1995), published by the Survey Department in cooperation with the Finnish International Development Agency, (FINNIDA) were used for analysis. These maps were digitised using PC Arc/Info and transformed into UTM coordinates. The digital data thus generated were generalised into the same standard major land-cover classes, and depicted in rasters at resolutions of 10 metres. The analysis was carried out using UNIX-based Arc/Info. It was customised using Arc Macro Language (AML) programming, and output maps were produced using ArcView GIS software. The major land-cover changes taking place between 1978 and 1995 are given in Table 8, and shown in Map 48.

Table 8 : **Matrix of Land-cover Change between 1978-1995 (area in sq. km.)**

1978 ↓ / 1995 → Value	Built-up	Forest	Grass	Shrub	Agricu-lture
10	20.167	0.109	1.215	0.000	7.593
20	0.053	205.741	0.000	20.143	42.587
30	0.053	47.489	0.000	5.253	51.809
40	0.000	40.596	0.000	27.113	25.662
50	8.746	28.736	0.149	4.40.	374.765

The result shows that grassland, shrub land, and agricultural land have been converted into forest, and some agricultural land has been converted into built-up area. However, the results show no significant land-cover conversion. The result also shows mistaken classifications of land-cover classes, e.g., conversion of built-up to other classes, and it is apparent that different scales of maps are not suitable for this kind of analysis. This scale is too small to capture urban land-cover changes. In the following sections, attempts have been made to use different satellite images to complement spatial data sets through time series' data and to validate these data to analyse land-cover change.

8.2.4 Land-cover Changes between 1988 and 1997

Study Area, Data Description, Methodology, and the Result

The study area was the three districts of Kathmandu Valley: Kathmandu, Lalitpur, and Bhaktapur. The total area is about 927 sq. km. A Landsat TM image (30m) dated 11th October, 1988, and an ADEOS-AVNIR M image (16m), dated 11th January, 1997, were used for the analysis.

Both images were rectified and geometrically corrected using the geodetic control points, and the digitised road and drainage networks were used from a topographic map on a scale of 1:25,000. The images are geo-referenced to the UTM coordinate system and re-sampled into 10 metre resolution. Supervised classification of both images was carried out to produce a land-cover map of 1988 and 1997, respectively. Difficulty was encountered in discriminating the features, e.g., urban and sand/gravel were encountered along the river side during digital image processing due to their similar spectral characterisations. Digital image classification had to be improved and this was done through extensive field visits, by defining and applying certain knowledge-based rules, neighbourhood classification, and by masking operations. Knowledge-based rules pertained to pixel classification: *if the pixels are classified as built-up area in 1988, but the same pixels are classified as agriculture in 1995, then classify them as agriculture for 1988*. The masking operations were mainly carried out for river and water body features. Digital image processing was carried out on ERDAS Imagine 8.3.1 and change analysis on UNIX based Arc/Info. The customisation was done using Arc Macro Language (AML) programming, and output maps were produced with ArcView GIS software. The main land-cover changes derived from the analysis are given in Table 9, and shown in Map 49.

Table 9: Matrix of Land-cover Change between 1988-1997 (area in sq. km.)

1988 \ 1997 Classes	Built-up	Forest	Grass	Shrub	Agriculture	Others
Built-up	12.012	0.383	0.219	0.000	0.000	0.000
Forest	1.184	203.335	19.378	9.252	48.393	4.146
Grass	1.052	5.857	7.275	0.337	11.98	0.636
Shrub	0.448	79.598	56.881	19.409	34.953	1.798
Agriculture	7.650	99.223	78.894	5.148	143.49	7.795
Fallow Land	0.517	34.221	2.181	0.446	5.259	4.953

The result shows that the agricultural area has been subject to significant conversion into built-up area, forest, grass, and shrub land; and forest has been converted to agricultural area to a significant degree.

8.2.5 Land-cover Changes between 1986 and 1997

Study Area, Data Description, Methodology, and the Result

The increasing use of high-resolution satellite images prompted attempts to evaluate the usefulness of high-resolution satellite images to detect urban land-cover changes. The SPIN-2 KVR 1000 satellite image (with 2-metre resolution), dated 5th February 1991, was used for this purpose. The acquired SPIN-2 image covers only the core urban areas of Kathmandu and Lalitpur districts and their surroundings. The coverage of the SPIN-2 image used in this application is given below.

LLX: 729233 LLY: 3057748 (UTM)
URX: 742623 URY: 3070685 (UTM)

The SPIN-2 image was merged with SPOT-XS (20-metre resolution), dated 12th March 1986, and ADEOS-AVNIR (with 16-metre resolution), dated 11th January 1997.

Supervised classification of both the merged images produced land-cover maps of 1986 and 1997. Based on these images, analysis of urban land-cover changes from 1986 to 1997 took place. The main land-cover changes derived from the analysis are given in Table 10, and shown in Map 50.

Table 10: Matrix of Land-cover Change between 1986-1997 (area in sq. km.)

1986 \ 1997 Classes	Built-up	Forest	Grass	Shrub	Crop Land	Fallow Land
Built-up	17.449	0.000	0.000	0.000	0.000	0.000
Forest	1.152	41.079	0.847	3.306	8.094	0.549
Grass	1.051	5.789	2.822	3.225	5.653	4.191
Shrub	2.343	0.250	9.009	3.223	2.677	9.048
Crop Land	2.753	1.960	12.386	7.278	8.729	6.932
Fallow Land	0.258	0.033	1.863	2.065	1.460	2.520

8.2.6 Limitations

Remote sensing images are interesting in themselves, but the value of the data increases substantially if the discernible patterns in the image can be related to recognisable objects or patterns observed on the ground or portrayed on topographical and thematic maps. Data extracted from remote sensing may yield very important information about the earth, but, its value can only be realised if it is integrated with other spatial data.

Many issues need to be considered in processing satellite images for land-cover mapping and in analysing land-cover change. In the present study, different types of satellite imagery taken on different dates have been used for this kind of analysis and problems have been encountered with them. Based on this experience, some important issues are summarised below.

- **Mis-classification of pixels**: One of the main disadvantages of remote-sensing technology is that mis-classification of pixel values occurs due to similarities in spectral characterisation. Improvement by extensive field verification and integration with GIS is needed. Improvement of the classification for urban features and sand/gravel mainly was carried out by this study.

- **Different resolutions**: Analysis was carried out using Landsat-TM and ADEOS-AVNIR images, with resolutions of 30 and 16 m, respectively, and both images were re-sampled to 10 m resolutions. Firstly, the use of images of different resolutions does not produce accurate results, and, secondly, some information will be lost during the re-sampling process. Hence it is preferable to use images of the same resolution.

- **Different seasons**: Satellite images used in this study were taken on different dates and in different seasons. Natural and spatial phenomena obviously differ, e.g., different agricultural commodities in different seasons, different types of or high/low densities of vegetation, and so on. So, using satellite images from different dates and different seasons can lead to inaccuracies.

- **Definition of land-cover classes**: Classification also varies depending upon the definition of land-cover classes. For instance, on topographic maps, grasslands, such as the stadium or Tundikhel(parade ground), are generalised into the 'built-up' classification, whereas in remote-sensing images, they are discernible as grassland.

8.3 Urban Growth Detection

Over the years, satellite-based remote sensing data have been used successfully for mapping, monitoring, planning, and development of urban sprawl, urban land use, and urban environment. With high spatial resolution satellite images, it is now possible to explore, either singly or in combination, the different urban land uses, survey, and planning; for example urban housing, urban utilities, urban land-use change detection, and so on. The Urban growth detection between 1978-1995 and 1988-1997 is shown in Maps 51 and 52 respectively

Table 11: Urban Growth in Kathmandu Valley Derived from Various Data Sources

Dates	Source of Analysis	Growth (sq. km.)
1978 – 1995	LRMP and topographic map 1:25K (*Whole of Kathmandu, Lalitpur, and Bhaktapur districts*)	9
1988 – 1997	Landsat TM '88, and ADEOS AVNIR, 1997 (*Whole of Kathmandu, Lalitpur, and Bhaktapur districts*)	10.86
1986 – 1997	Merged SPIN-2 and SPOT-XS, and Merged SPIN-2 and ADEOS-AVNIR (*Only core urban area*)	7.6

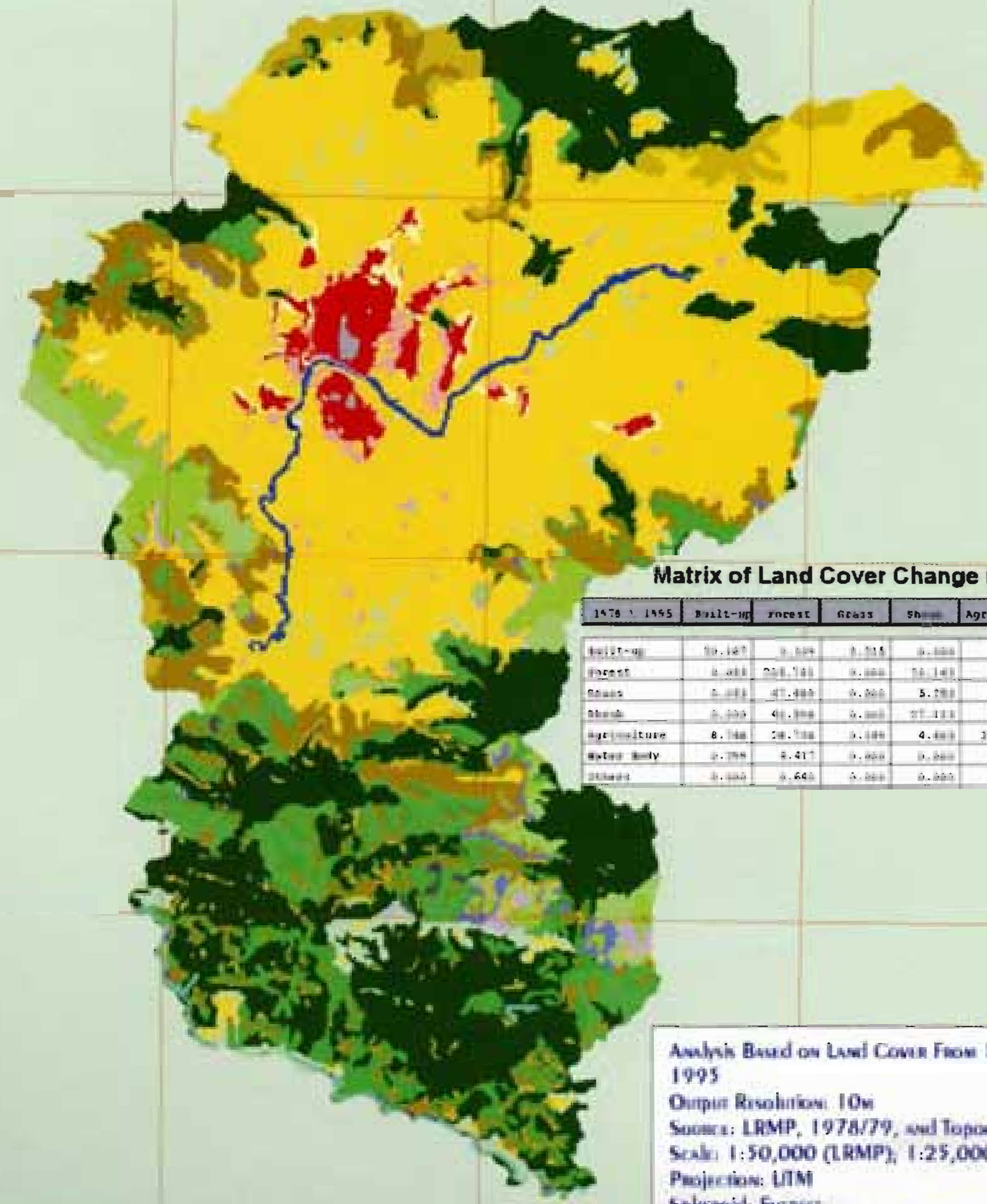
The present application demonstrates the potential of GIS and remote-sensing techniques to provide regular assessments of urban expansion between various dates using topographic maps and satellite images. Based on the outcome of the analysis, as described in

Sections 1, 2, and 3, respectively, an analysis of spatial and temporal urban growth expansion was carried out. Again, considering the slopes as the main factor, some areas unsuitable for urban development, particularly on higher slopes, were identified (see Map 53).

List of Maps Prepared from Land Cover Change Analysis and Urban Growth Detection

Kathmandu Valley

Map 48
Land Cover Change between 1978-1995



Matrix of Land Cover Change (Area in Sq.Km.)

1978 \ 1995	Built-up	Forest	Grass	Shrub	Agriculture	Water Body	Others
Built-up	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Forest	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.016
Grass	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Shrub	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Agriculture	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Water Body	[illegible]	0.417	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Others	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Analysis Based on Land Cover From 1978/79 and 1995
Output Resolution: 10m
Source: LRMP, 1978/79, and Topographic Map, 1995
Scale: 1:50,000 (LRMP); 1:25,000 (Topographic map)
Projection: UTM
Spheroid: Everest
Origin: 84 00 00 E, 26 15 00 N
False Coordinates of Origin: 400000m E, 0m N

Legend

- Agriculture to Agriculture
- Agriculture to Built-up
- Agriculture to Forest
- Agriculture to Grass
- Agriculture to Others
- Agriculture to Shrub
- Agriculture to Water Body
- Built-up to Agriculture
- Built-up to Built-up
- Built-up to Forest
- Built-up to Grass
- Built-up to Water Body
- Forest to Agriculture
- Forest to Built-up
- Forest to Forest
- Forest to Others
- Forest to Shrub
- Grass to Agriculture
- Grass to Built-up
- Grass to Forest
- Grass to Others
- Grass to Shrub
- Others to Agriculture
- Others to Forest
- Shrub to Agriculture
- Shrub to Forest
- Shrub to Others
- Shrub to Shrub
- Water Body to Agriculture
- Water Body to Built-up
- Water Body to Forest
- Water Body to Water Body

Scale 1:300,000

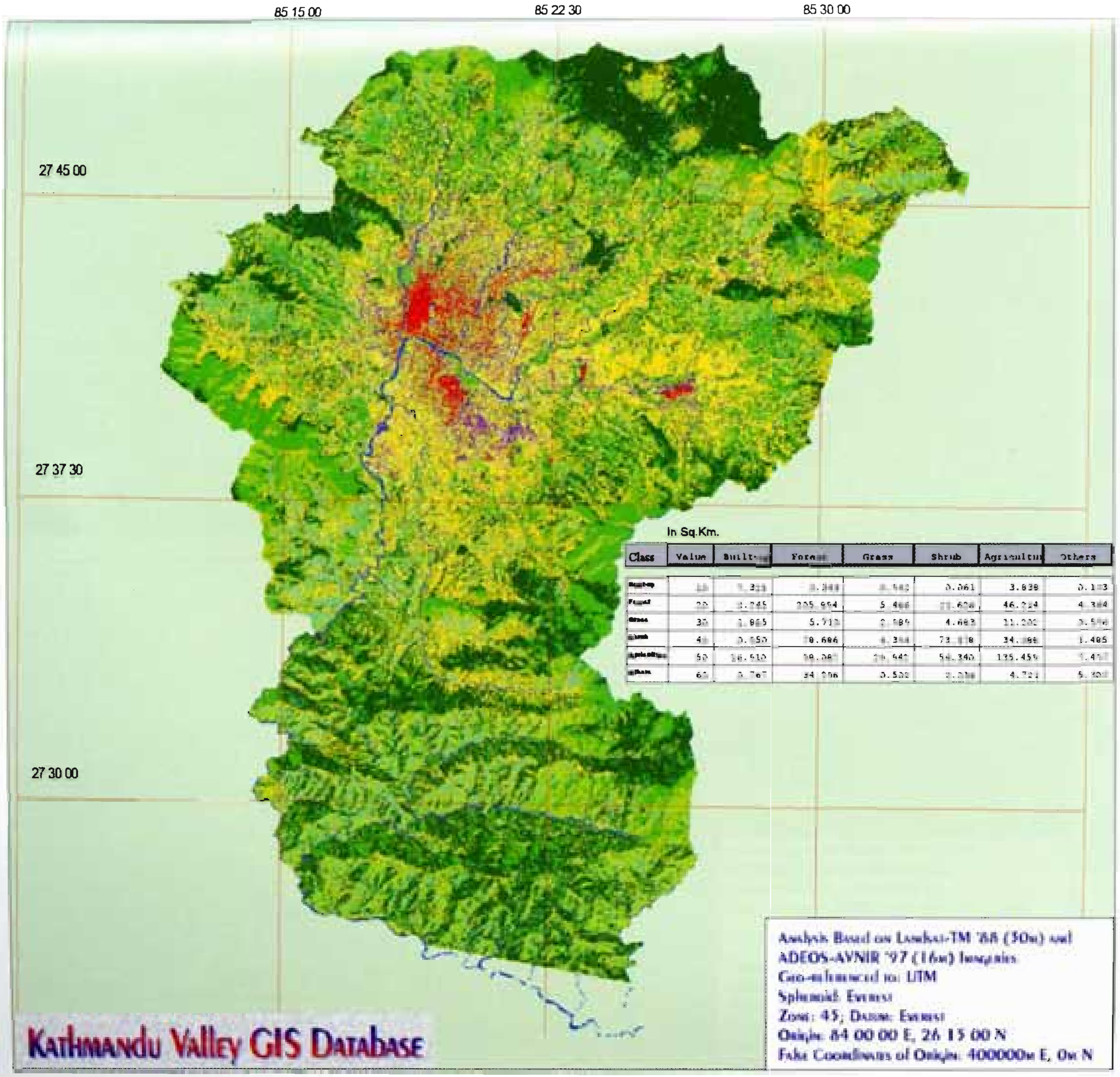
ICIMOD MENRIS '99

Kathmandu Valley GIS Database

Kathmandu Valley

Map 49

Land Cover Change between 1988-1997



In Sq.Km.

Class	Value	Built-up	Forest	Grass	Shrub	Agriculture	Others
Built-up	10	[illegible]	[illegible]	[illegible]	0.061	3.838	[illegible]
Forest	20	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Grass	30	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Shrub	40	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1.485
Agriculture	50	[illegible]	[illegible]	[illegible]	54.340	135.455	[illegible]
Others	60	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

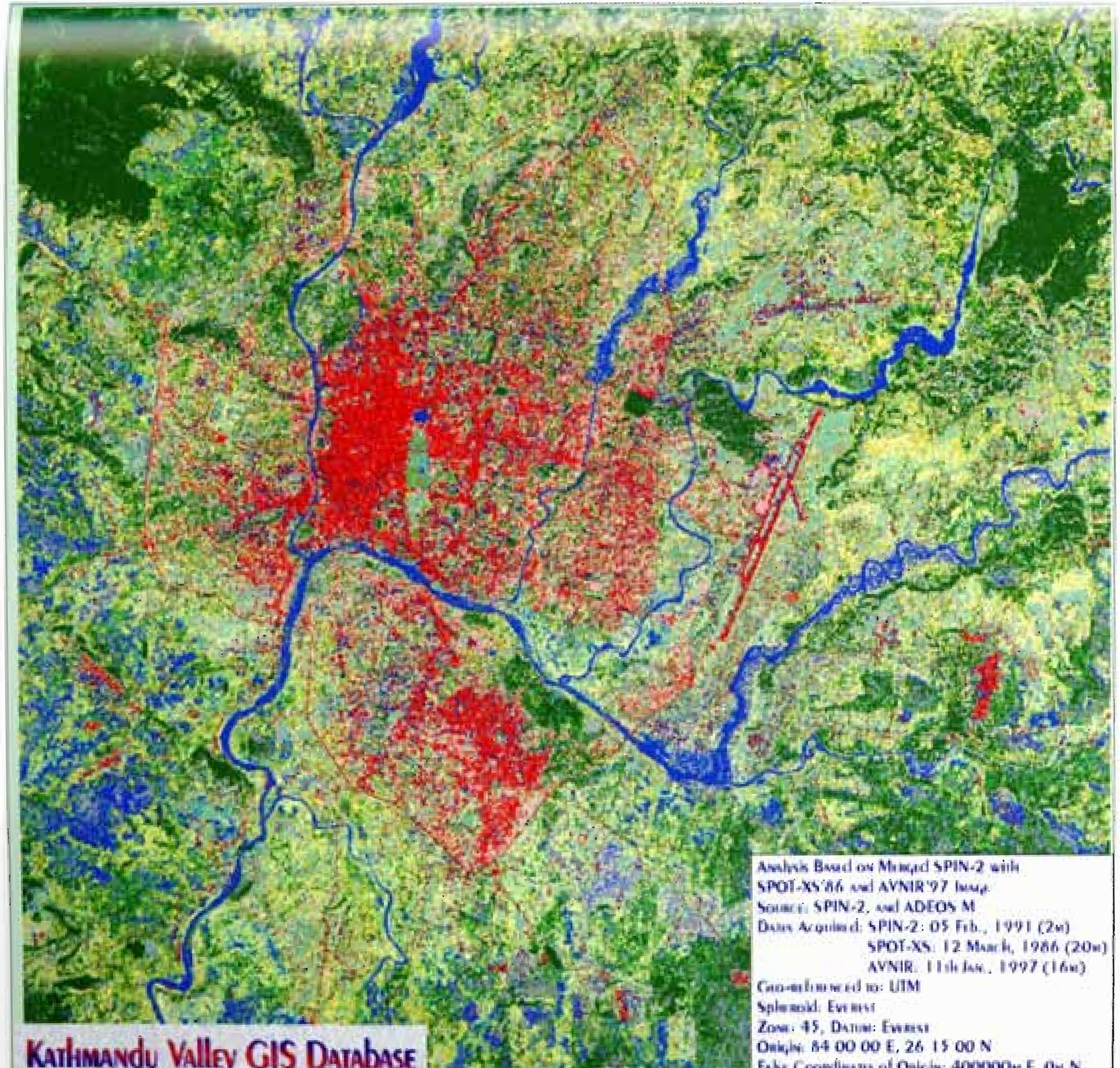
Legend

- Built-up to Built-up
- Others to Built-up
- Forest to Forest
- Others to Forest
- Grass to Grass
- Others to Grass
- Shrub to Shrub
- Others to Shrub
- Agriculture to Agriculture
- Others to Agriculture
- Others

5 0 5 Kilometres

Scale: 1:275,000

ICIMOD MENRIS '99



Kathmandu Valley

Map 50

Land Cover Changed on Merged SPIN-2 with SPOT XS, 1986 and AVNIR, 1997 Image

Legend

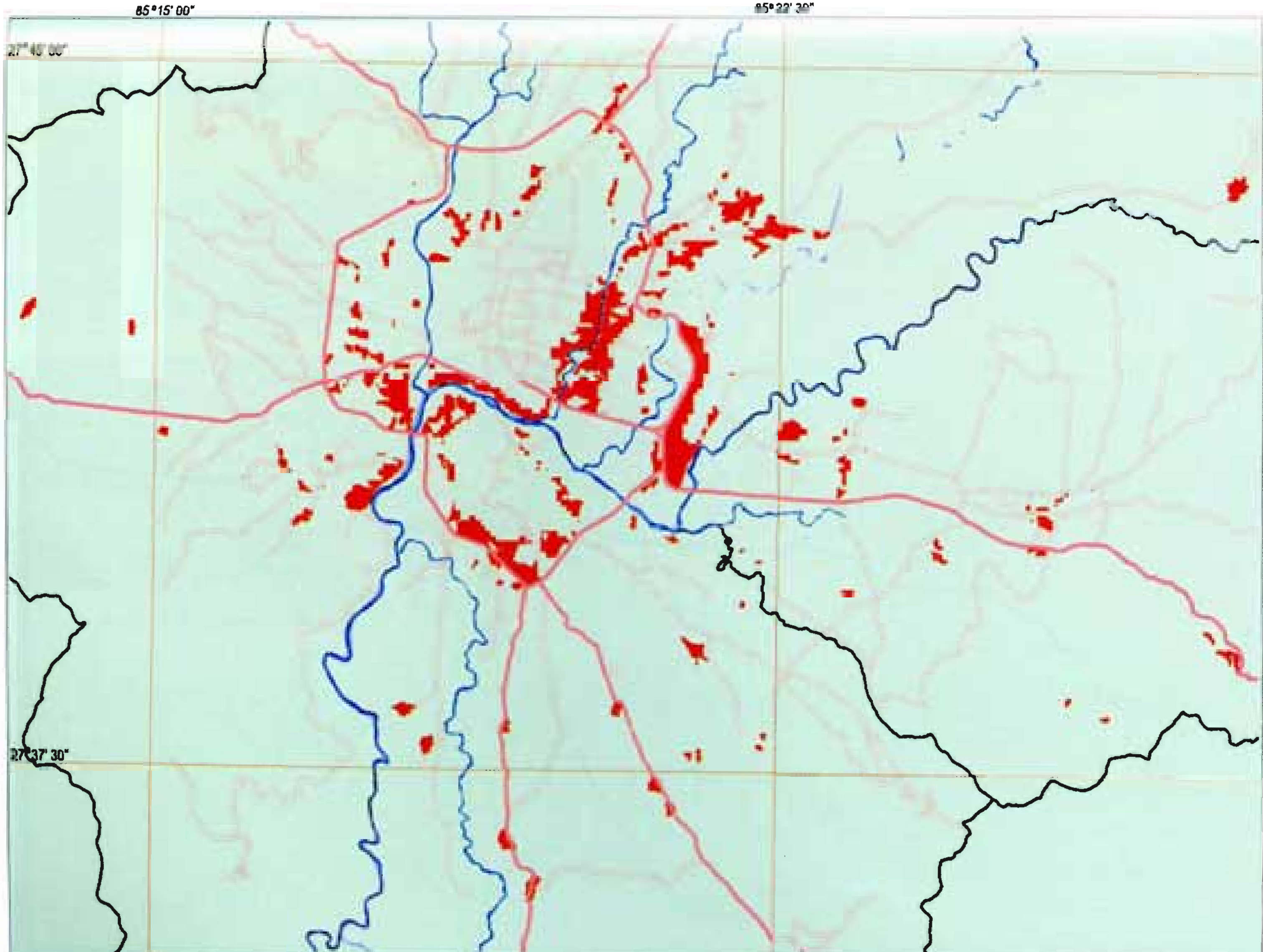
- Built-up to Built-up
- Others to Built-up
- Forest to Others
- Forest to Forest
- Grass to Others
- Grass to Grass
- Shrub to Others
- Shrub to Shrub
- Agriculture to Others
- Agriculture to Agriculture
- Others

2 0 2 Kilometres

ICIMOD
MENRIS '99

Kathmandu Valley

Map 51
Urban Growth between 1978-1995



Legend

- Urban Growth
- Sandy Area
- Water Body
- Highway
- Major Road
- District Boundary

Value	Count	Area_Sq.Km.
1	91499	9.15

2 0 2 Kilometres

Scale 1:100,000

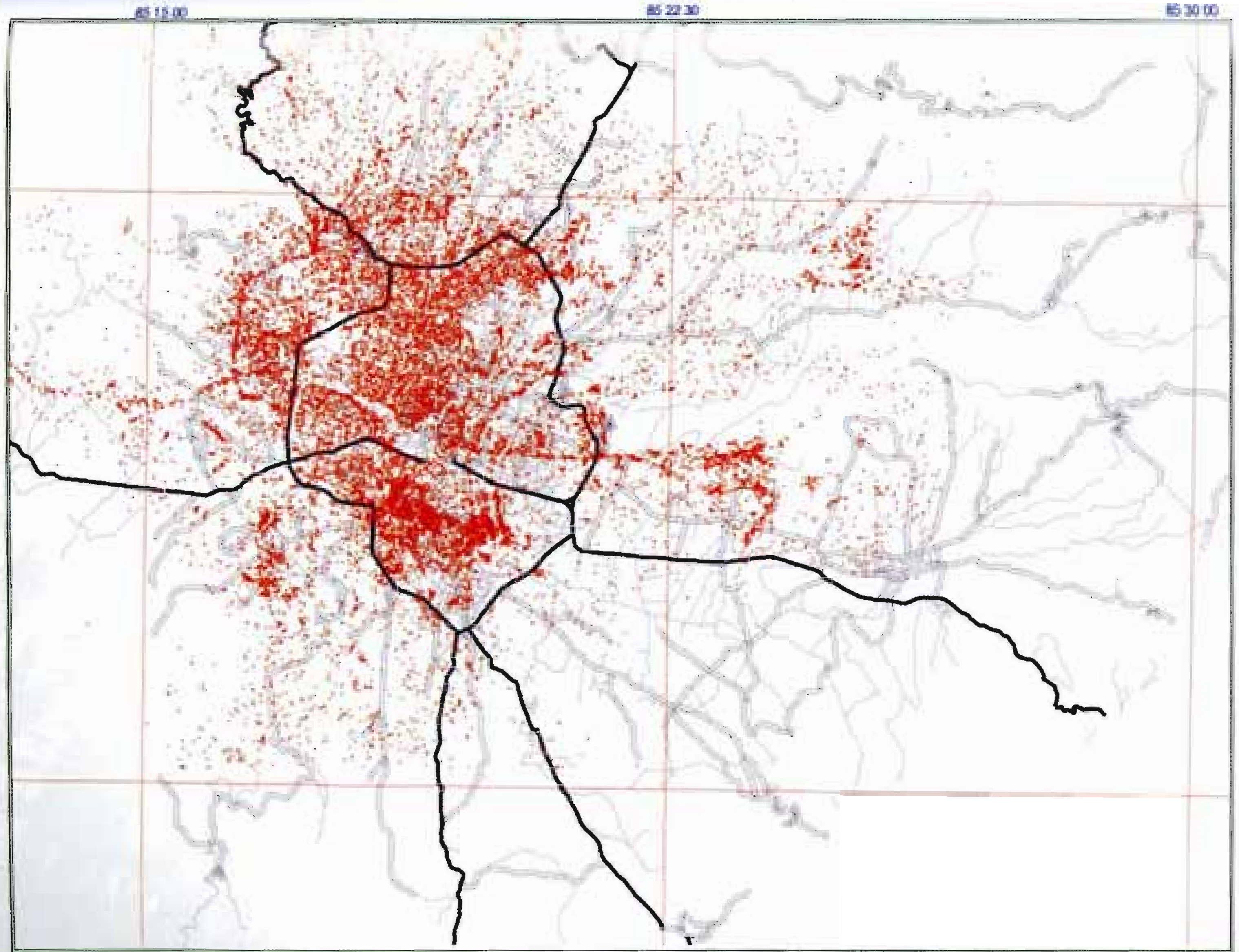
Analysis Based on Land Cover From 1978/79 and 1995
Output Resolution: 10m
Source: LRMP, 1978/79, and Topographic Map, 1995
Scale: 1:50,000 (LRMP); 1:25,000 (Topographic map)
Projection: UTM
Spheroid: Everest
Origin: 84 00 00 E, 26 15 00 N
False Coordinates of Origin: 400000m E, 0m N

ICIMOD
MENRIS '99

Kathmandu Valley

Map 52

Urban Growth between 1988 - 1997



Legend

- Urban Growth
- Highway
- Major Road

Value	Count	Area in Sq.Km.
1	25266	22.8

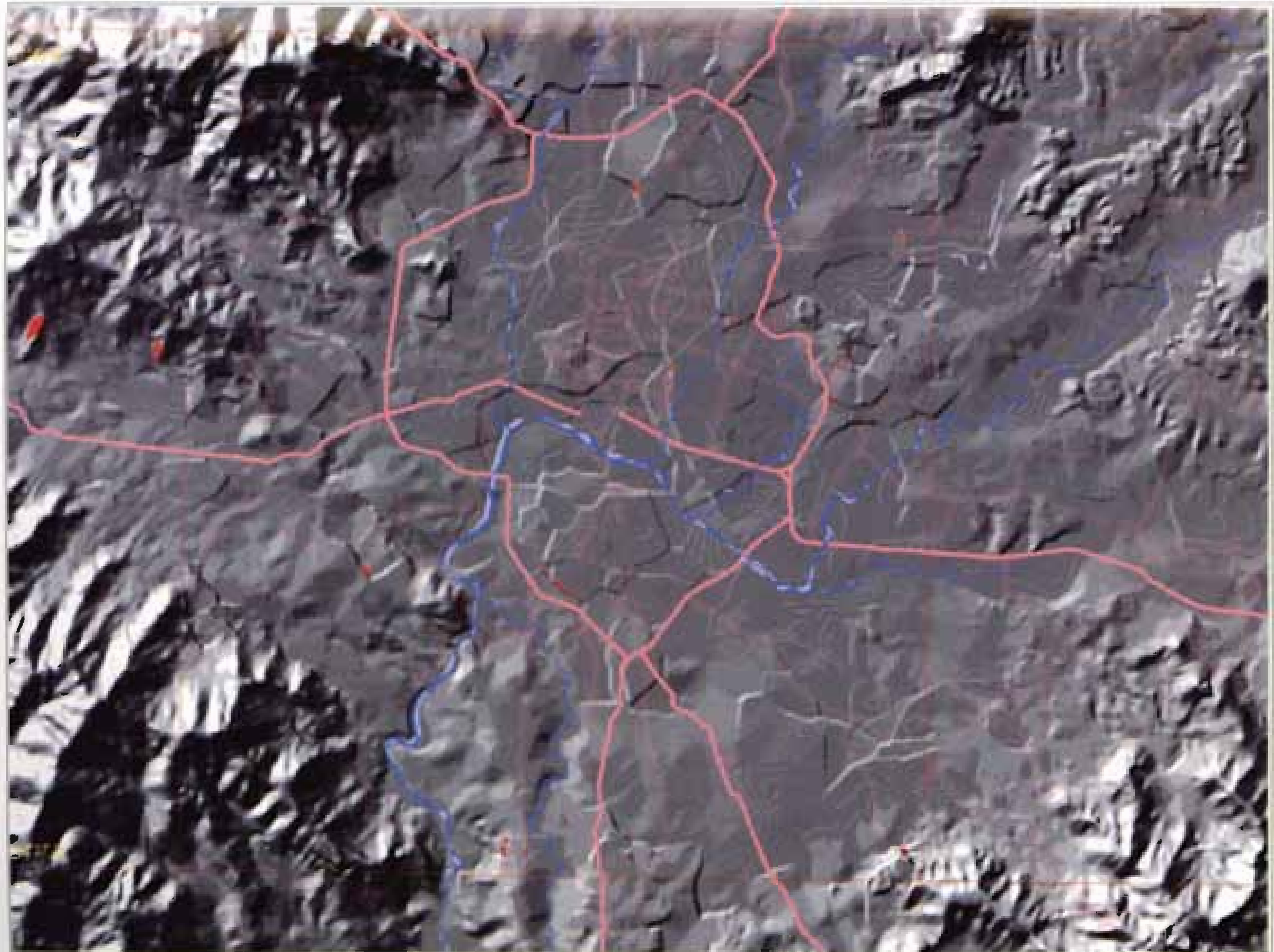
2 0 2 Kilometres

Scale: 1:125,000

Analysis Based on Landsat-TM '88 (30m) and ADEOS-AVNIR '97 (16m) Image
Geo-referenced to: UTM
Spheroid: Everest
Zone: 45, Datum: Everest
Origin: 84 00 00 E, 26 15 00 N
False Coordinates of Origin: 400000m E, 0m N

ICIMOD MENRIS '99

Kathmandu Valley GIS Database



Kathmandu Valley GIS Database

Analysis Based on Land Cover Data From 1995 and DEM
Output Resolution: 10m
Source: Topographic Map, 1995
Scale: 1:25,000 (Topographic map)
Projection: UTM
Spheroid: Everest
Origin: 84 00 00 E, 26 15 00 N
False Coordinates of Origin: 400000m E, 0m N

Kathmandu Valley

Map 53
Hazard-prone Urban Growth between 1978-1995

Legend

- Hazard-prone Urban Growth
- Sandy Area
- Water Body
- Highway
- Major Road

Value	Count	Area_Sq.M.
1	2174	217400

2 0 2 Kilometres
Scale 1:90,000

ICIMOD
MENRIS '99

8.4 Potential of GIS Application III: Suitability Analysis

GIS tools and techniques can be used to perform the complex spatial analyses that provide qualitative as well as quantitative assessments of current situations and trends. For instance, identifying suitable areas for locating new schools; identifying suitable areas for different types of agricultural commodities and vegetable farming; identifying suitable areas for locating carpet industries; identifying areas that should be encouraged for future urban expansion or which are not suitable for urban expansion, and so on.

The suitability analyses have been carried out on the basis of the Kathmandu Valley GIS database to demonstrate the potential of GIS applications in real life situations; and these have been categorised below. It is to be noted that the criterion for each suitability analysis varies depending upon experts' knowledge and their preferences and the status of the area. However, standard criteria have been defined for each analysis for demonstration purposes, and these may or may not be suitable for the whole of the Kathmandu Valley.

- **Agricultural land under the most unsuitable farming systems** (Maps 54 and 55) - This analysis identifies agricultural areas on high slopes that are normally not suitable for agricultural farming systems, but which could be useful for other purposes, e.g., forestation. In this study, the existing agricultural areas that have slopes of more than 30 degrees are considered under this class.

- **Land suitable for forestry and fruit framing** (Map 56) - This analysis identifies areas suitable for forestry and fruit farming – considering that these lands are not easily accessible to main roads and are not suitable for agriculture. In the study, the agricultural areas that are not irrigated, having slopes of more than five degrees and three kilometres away from the main road, are considered.

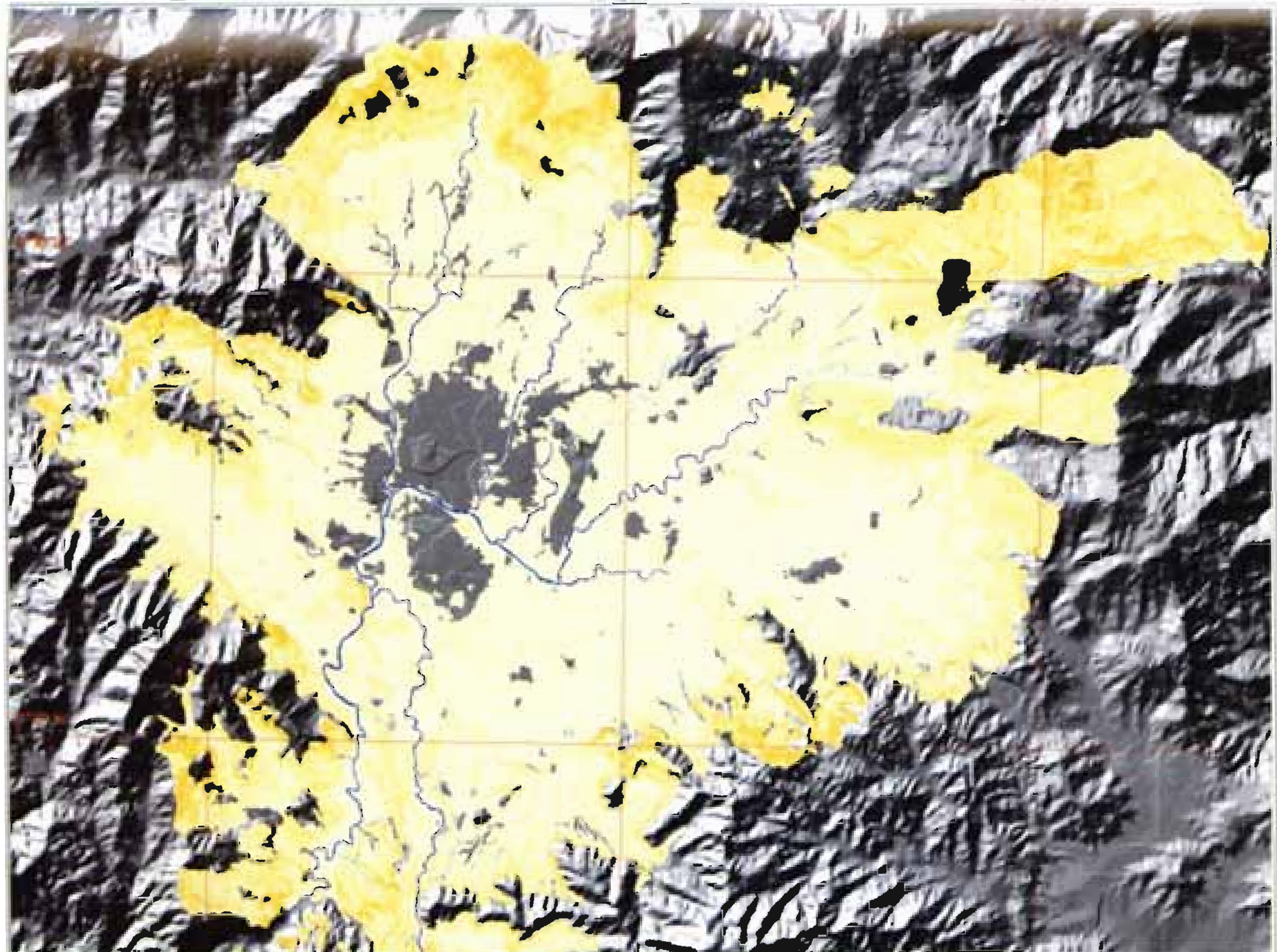
- **Land suitable for cereal and cash crops** (Map 57) - This analysis identifies areas that are suitable for cereal and cash crops – considering that these are prime agricultural areas close to main roads. In this study, such land is identified based on agricultural areas with slopes less than five degrees as prime land within two kilometres from the main roads.

- **Land suitable for non-arable crops** (Map 58) - This analysis identifies agricultural areas that are suitable for non-arable crops. Such land is available unirrigated agricultural areas with moderately sloping (> 5 degree) land not easily accessible from the main roads (4 km away from the main roads).

- **Areas suitable for carpet industries** (Map 59) - This analysis identifies areas that are suitable for locating carpet industries, considering that it is strictly prohibited to locate carpet industries within the core urban area (for instance, within the ring road area in this study). This analysis also considers other factors such as preference for low elevations (below 1,500 m), closeness to the riverside (within 100 to 500 metres) , and closeness to main roads (within one km from the main road). Field verification was carried out using a GPS to identify the existing carpet industries in the valley. This verification was overlaid with the area identified as suitable and the present existing carpet industries; thus showing present areas vs suitable areas for carpet industries.

- **Endangered Forest** (Map 60) - This analysis identifies the forests, except projected forests that are very close to existing settlments considering that these forests could be lost into some other land use types by the expansion of settlments. In this analysis, the existing forests within three kilometres from the settlements are identified as endangered forest.

List of Maps Prepared from Suitability Analysis



Kathmandu Valley

Map 54

Agricultural Lands by Slope Category, 1995

Legend

Agricultural Land by Slope Category (In Degrees)

- Below 5
- 5 - 15
- 15 - 25
- 25 - 30
- 30 - 40
- 40 - 50
- 50 - 55
- 55 - 60
- Above 60
- Sandy Area
- Water Body

Value	Class	Area_Sq_Km
1	Below 5 deg	[illegible]
2	5 - 15 deg	[illegible]
3	15 - 25 deg	89.4513
4	25 - 30 deg	[illegible]
5	30 - 40 deg	[illegible]
6	40 - 50 deg	[illegible]
7	50 - 55 deg	[illegible]
8	55 - 60 deg	0.3251

2 0 2 Kilometers

Scale 1:160,000

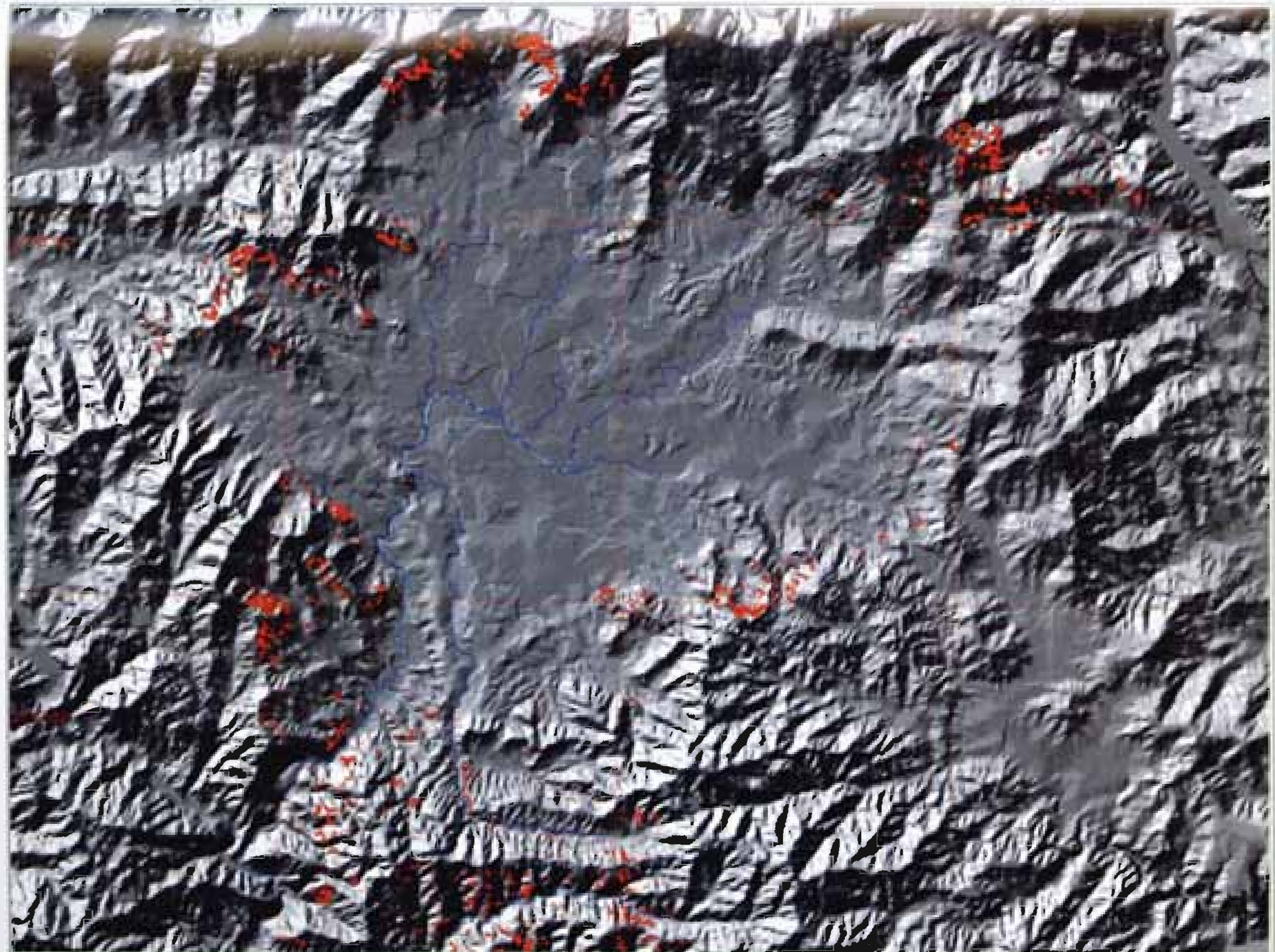
ICIMOD MENRIS '99

Analysis Based on Land Cover Data From 1995 and DEM
Output Resolution: 10m
Source: Topographic Map, 1995
Scale: 1:25,000 (Topographic map)
Projection: UTM
Spheroid: Everest
Origin: 84 00 00 E, 26 15 00 N
False Coordinates of Origin: 400000m E, 0m N

Kathmandu Valley GIS Database

Kathmandu Valley

Map 55
Agricultural Lands under Most Unsuitable Farming Systems, 1995



Legend

- Unsuitable Farming Systems
- Sandy Area
- Water Body

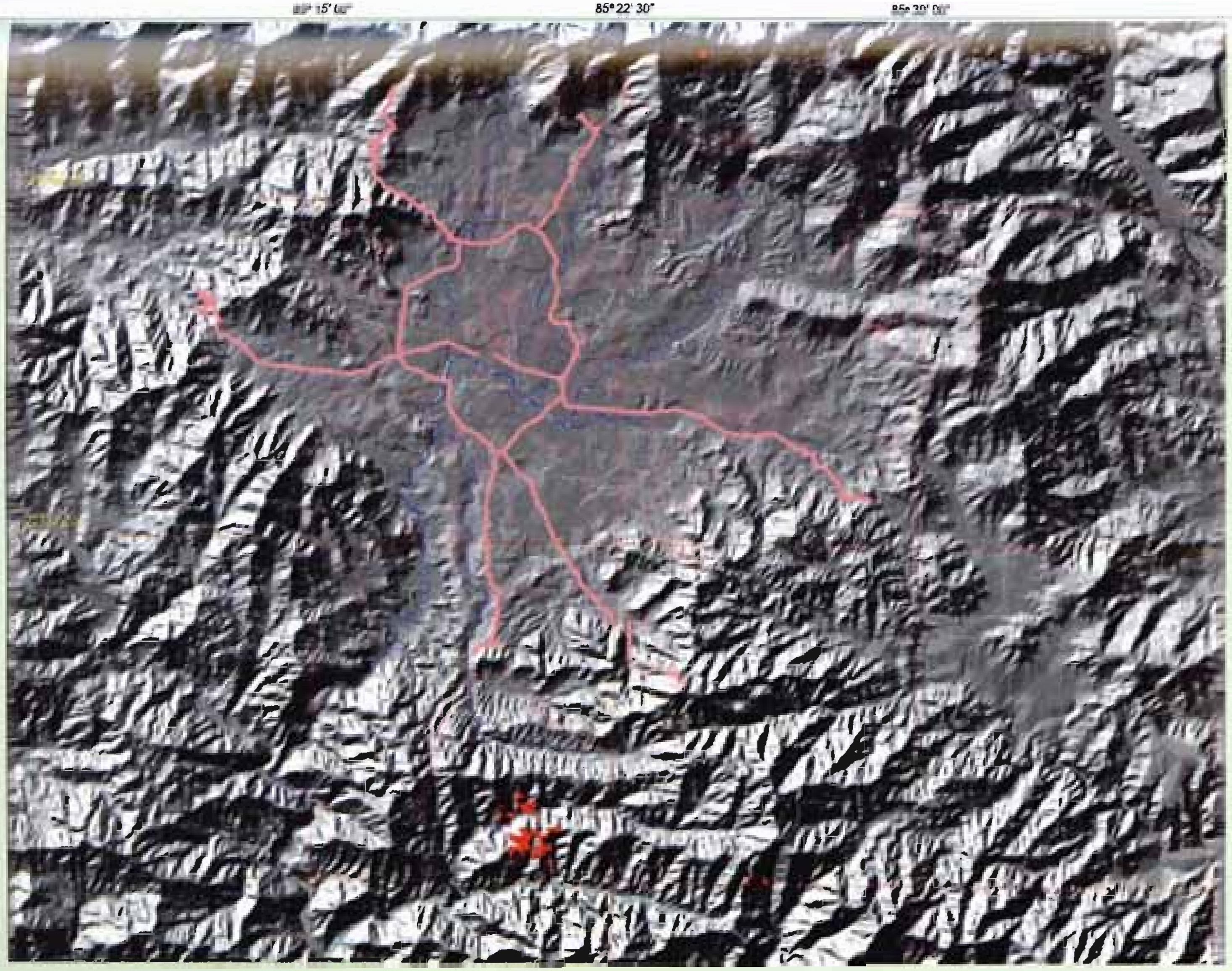
Value	Count	Area Sq.Km
1	198640	20

5 0 5 Kilometres

Scale 1:200,000

Analysis Based on Land Cover Data From 1995 and DEM
Output Resolution: 10m
Source: Topographic Map, 1995
Scale: 1:25,000 (Topographic map)
Projection: UTM
Spheroid: Everest
Origin: 84 00 00 E, 26 15 00 N
False Coordinates of Origin: 400000m E, 0m N

ICIMOD MENRIS '99



Kathmandu Valley

Map 56
Lands Suitable for Forestry and Fruit Farming, 1995

Legend

- Lands Suitable for Forest and Fruit Farmings
- Sandy Area
- Water Body
- Highway
- Major Road

Value	Count	Area_Sq.Km.
1	17354	1.7

4 0 4 Kilometres

Scale 1:225,000

ICIMOD
MENRIS 99

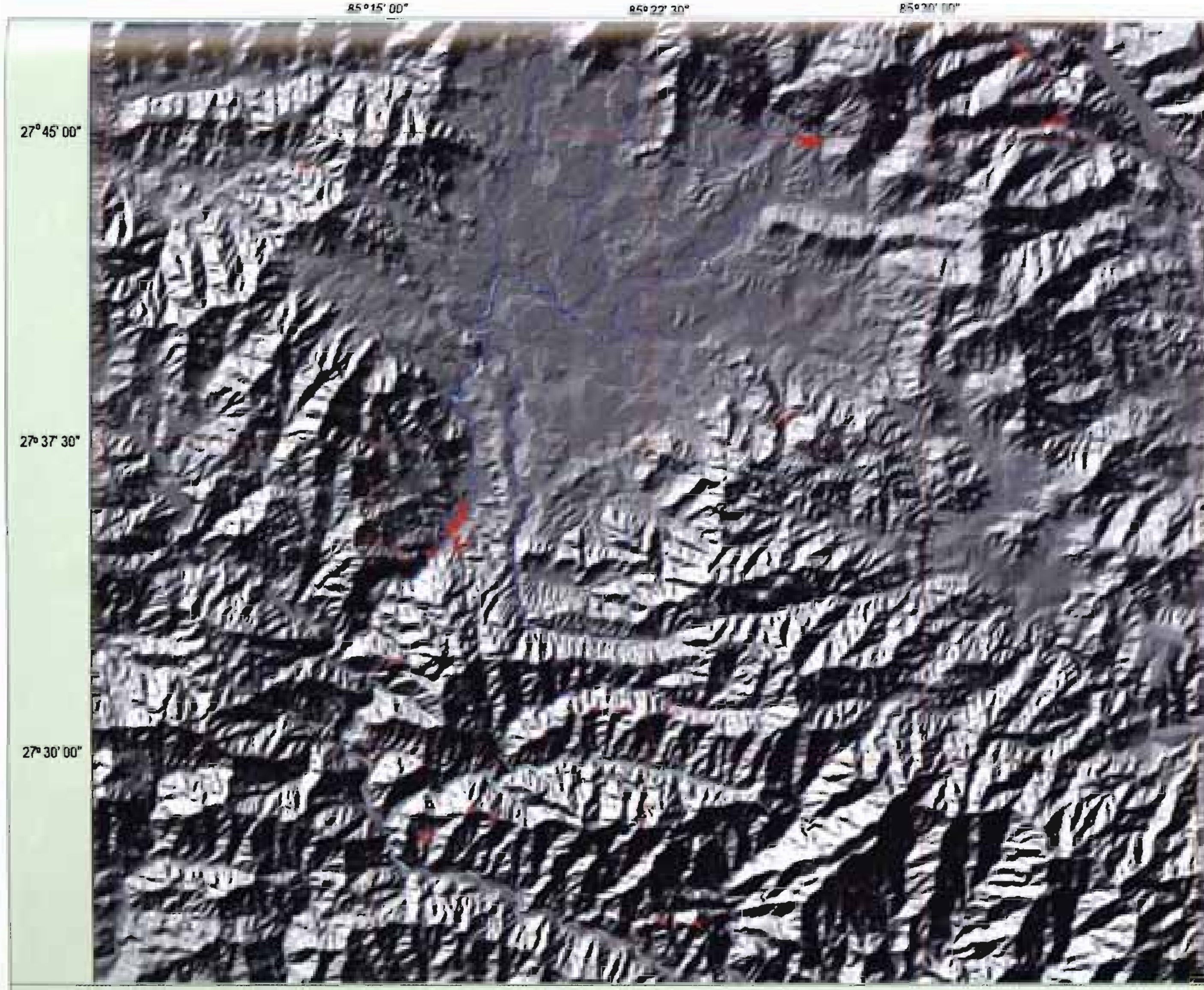
Analysis Based on Land Cover Data From 1995 and DEM
Output Resolution: 10m
Source: Topographic Map, 1995
Scale: 1:25,000 (Topographic map)
Projection: UTM
Spheroid: Everest
Origin: 84 00 00 E, 26 15 00 N
False Coordinates of Origin: 400000m E, 0m N

Kathmandu Valley GIS Database

Kathmandu Valley

Map 57

Land Suitable for Cereal and Cash Crops, 1995



Legend

- Land Suitable for Cereal & Cash Crops
- Sandy Area
- Water Body

Value	Count	Area in Sq.m.
1	26300	2630000

5 0 5 Kilometres

Scale 1:250,000

Analysis Based on Topographic Data From 1995 and DEM
Output Resolution: 10m
Source: Topographic Map, 1995
Scale: 1:25,000
Projection: UTM
Spheroid: Everest
Origin: 84 00 00 E, 26 15 00 N
False Coordinates of Origin: 400000m E, 0m N

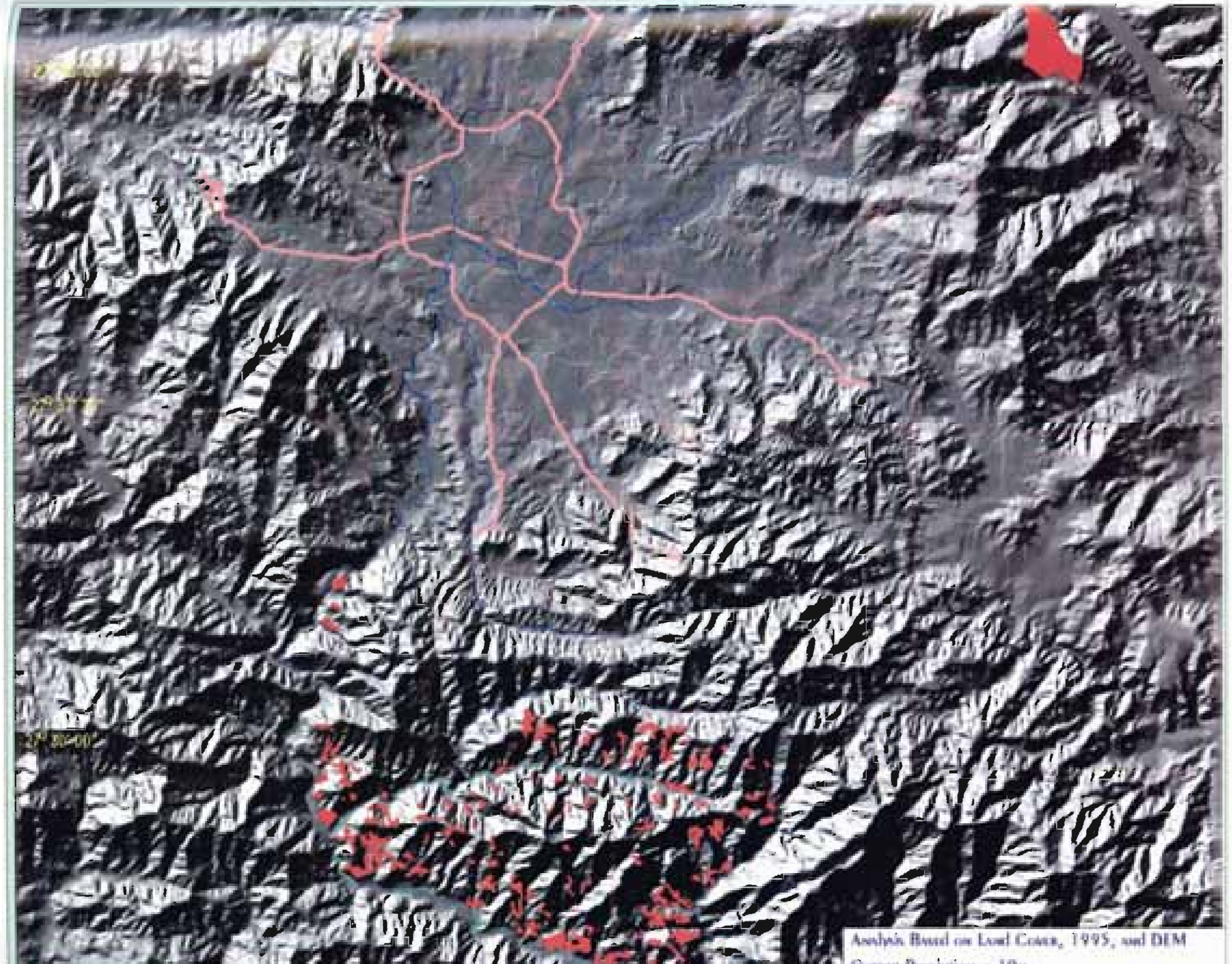
ICIMOD
MENRIS '99

Kathmandu Valley GIS Database

Kathmandu Valley

Map 58

Land Suitable for Non-arable Crops



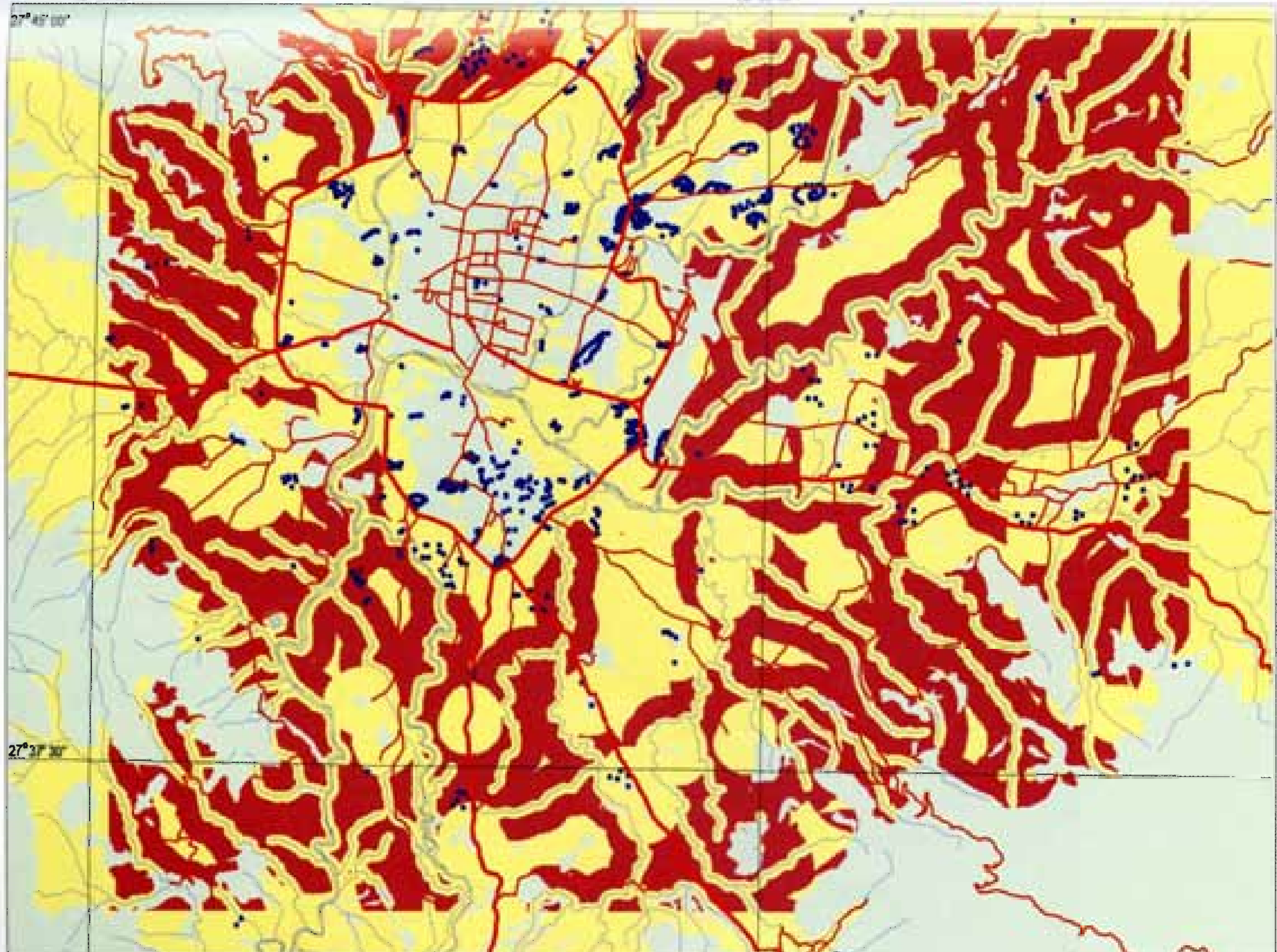
Legend

- Lands Suitable for Non-arable Crops
- Sandy Area
- Water Body
- Highway
- Major Road
- Feeder Road
- Foot Trails
- Minor Foot Trails

3 0 3 Kilometres

Analysis Based on Land Cover, 1995, and DEM
Output Resolution = 10m
Source: Topographic Map, 1995
Scale: 1:25,000
Projection: UTM
Spheroid: Everest
Origin: 84 00 00 E, 26 15 00 N
False Coordinates of Origin: 400000m E, 0m N

ICIMOD
MENRIS '99



Analysis Based on Field Data and Land Cover Data, 1995
Source: Topographic Map, 1995
Scale: 1:25,000
Projection: UTM
Spheroid: Everest
Origin: 84 00 00 E, 26 15 00 N
False Coordinates of Origin: 400000m E, 0m N

Kathmandu Valley GIS Database

Kathmandu Valley

Map 59

Areas Suitable vs Existing Carpet Industries

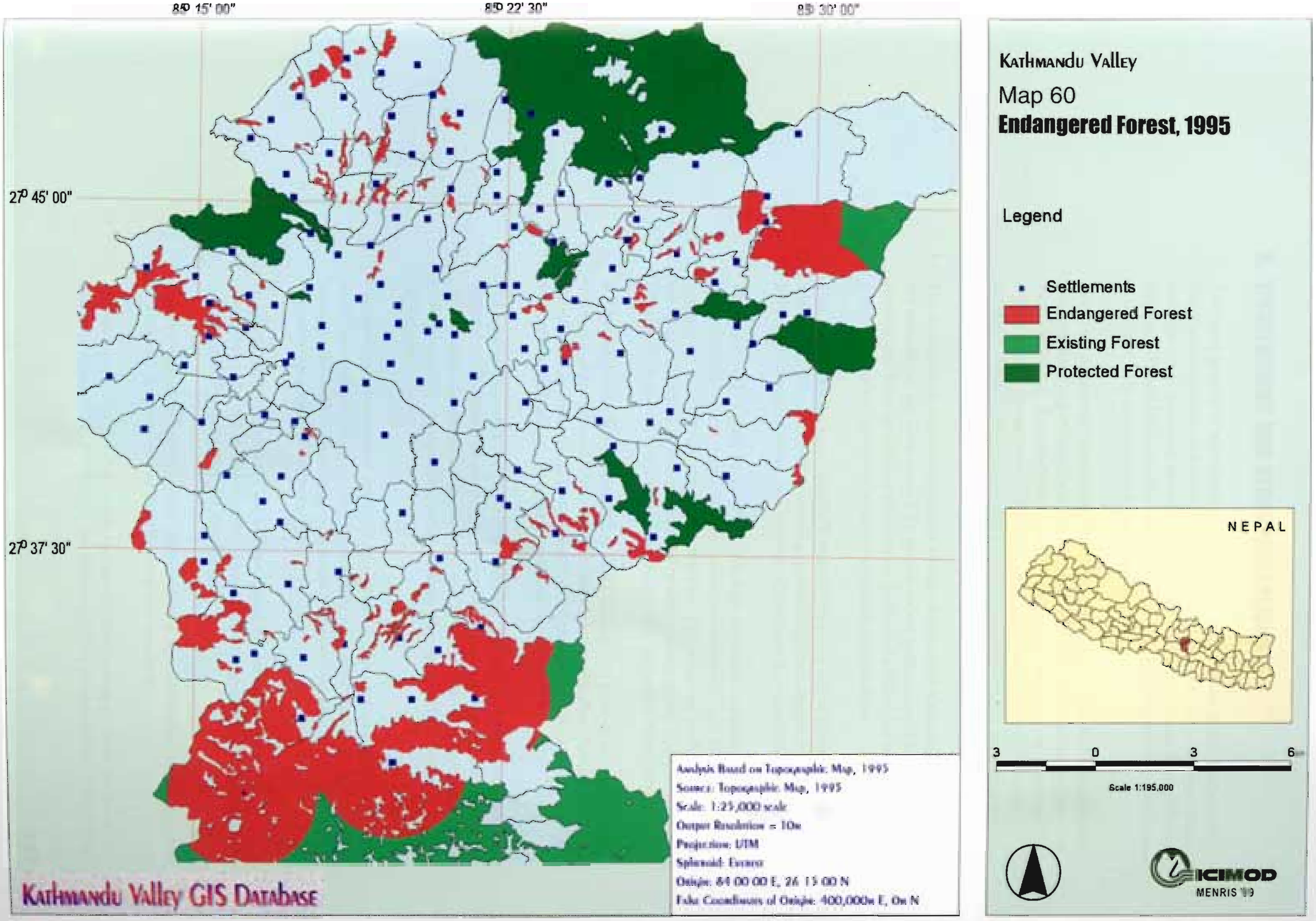
Legend

- Highway
- Major Roads
- Rivers
- Existing Carpet Industries
- Area Suitable for Locating Carpet Industries
- Agricultural Area

2 0 2 Kilometres

Scale 1:100,000

ICIMOD
MENRIS '99


85° 15' 00"
85° 22' 30"
85° 30' 00"
27° 45' 00"
27° 37' 30"
Kathmandu Valley
Map 60
Endangered Forest, 1995
Legend
Settlements
Endangered Forest
Existing Forest
Protected Forest
NEPAL
3 0 3 6
Scale 1:195,000
ICIMOD
MENRIS '99
Analysis Based on Topographic Map, 1995
Source: Topographic Map, 1995
Scale: 1:25,000 scale
Output Resolution = 10m
Projection: UTM
Spheroid: Everest
Origin: 84 00 00 E, 26 15 00 N
False Coordinates of Origin: 400,000m E, 0m N
Kathmandu Valley GIS Database

9. CONCLUSIONS AND RECOMMENDATIONS

- The rapid growth in population and haphazard urbanisation render Kathmandu Valley's environment and development extremely complex. To understand them and to arrive at solutions, planners and analysts need accurate data from different sources. GIS and RS technologies are methods that help integrate disparate sources of data and help analyse them to gain a realistic picture.

- There are numerous research and development studies on the Kathmandu Valley, but systematic organization and documentation of data and information have not been carried out. As a result much of the data and information are scattered. Each project studies certain aspects discretely in its own way, leading to different standards. Most of the studies do not pay adequate attention to designing and managing a database and their capability for doing so is weak.

- The spatial and temporal dimensions of data of the entire Kathmandu Valley are not available in the form needed by specific urban applications. The demand for accurate and homogeneous spatial data on Kathmandu Valley has been realised by government as well as research and development organizations.

- This study has tried a new approach to establish a core digital database of the Kathmandu Valley. It seeks to encourage a building block approach to development, management, and revision of databases in a complementary manner.

- The emergence of different satellites with high resolution capability provides the means to complement spatial data for urban environments, such as that of the Kathmandu Valley, at less cost than in the past. The study has established a sound topographic database of Kathmandu Valley with accompanying maps. It made as full a use as possible of remote-sensing images and integrated them into GIS.

- It is hoped that the Kathmandu Valley GIS Database will provide a foundation for research and development organizations, thus avoiding needless duplication in future. It is also intended to provide a source of reference for digital databases of the Kathmandu Valley for the many organizations working with GIS.

- The maps presented in this publication visualise and raise awareness about existing digital data. Therefore, to encourage and improve the exchange of information, the publication and database can be obtained in CD-ROM. The digital database can be made available to organizations at cost. (Please refer to Annex 5 of this publication.)

- The applications presented in this study will increase awareness about the usefulness of digital databases and demonstrate what can be achieved with GIS and related technologies. This is its purpose and it was not intended as a comprehensive application in itself.

- The study wishes to promote use of basic spatial datasets as common denominators for use by line agencies. Generally, more than 70 per cent of the cost involved in GIS goes to database development.

- The study hopes to sensitise senior executives and decision-makers about the need for a sound policy on database development and standards.

- The concept of a Spatial Data Infrastructure (SDI) is evolving - from the local, national, regional to global levels - for different GIS implementations. The SDI is perceived as a mix, i.e., technology, policies, resources, and people, that brings access and responsible use of geospatial data under one umbrella.

- Today, GIS technology is seen as an infrastructure and the nature of GIS implementation has changed as organizations have seen the need to integrate with other information systems. The time has come to be proactive towards establishment of such an infrastructure if the investment in GIS is to be worthwhile.

- Organizations concerned with generation, sharing, and use of spatial data, such as national mapping agencies and relevant stakeholders, need to be prepared to adopt the technology. This calls forth for a new paradigm at the institutional and policy levels in order to provide the supportive services needed to ensure that the information derived meets user needs.

- At the national level, it is inevitable that efforts should be underway to formulate a strategy for a National Spatial Data Infrastructure (NSDI) in order to benefit from the prevailing GIS technology in a comprehensive manner.

- In using GIS and remote sensing to provide a basic spatial database of the Kathmandu Valley, the authors perceived that, in a concrete way, it would facilitate the establishment of a conducive environment and amenable infrastructure for spatial information in the Kathmandu Valley.

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ANNEX 1

GLOSSARY OF TECHNICAL TERMS

AM/FM

Automated Mapping and Facilities' Management—Term used to describe the digital mapping systems used in utilities such as water or electricity supply companies.

Analogue Maps

Paper maps.

Attribute

Non-spatial, descriptive characteristic of a real-world phenomenon. Often a measurement or value associated with spatial locations.

Buffer

A corridor of a specified width defined parallel to lines or around polygons. Buffering is the process of defining the corridor and drawing the new geometry to delimit it.

Coverage

A collection of data describing spatial features stored in the same map file (primarily used by ESRI in ARC/INFO systems).

Database

An organized, integrated collection of data collated for common fact or purpose.

Data Base Management System (DBMS)

A collection of computer software used to organize and access the information in a database.

Data Capture

Encoding of data, or the conversion of map data to digital data—both spatial and non-spatial aspects.

Data Dictionary

This contains information about definition, structure, and usage of data in a database. No data are actually kept here.

Data Model

An abstraction of the real world that incorporates only those properties thought to be relevant to the application in hand. Also, a set of guidelines for the representation and logical organization of data in a database, consisting of named logical units of data and the relationships between them. In GIS this term usually refers to a set of spatial features with associated characteristics.

Data Quality

The quality of the data measured in relation to the actual phenomena measured at source.

Dataset

A named collection of logically related features arranged in a prescribed format.

DEM

Digital Elevation Model: a digital representation of a surface as a regular grid of elevation values.

Digital Map Data

A collection of digital information about real-world spatial phenomena.

DTM
Digital Terrain Model: a digital representation of ground surface relief enhanced by the addition of topographic information.

Digitiser
A device (usually electronic) for coding point locations on a graphic image or map to plane (x, y) coordinates.

Geographic Information (GI)
Information that can be related to a location (defined in terms of point, line, and area), particularly information on natural phenomena, cultural or human resources.

Geographical Information Systems (GIS)
Tools for collecting, storing, retrieving at will, transforming and displaying spatial data from the real world for a particular set of circumstances (Burrough 1986)

GIS form an information technology package which stores, analyses, and displays both spatial and non-spatial data (Parker 1988)

- A decision support system involving the integration of spatially referenced data in a problem- solving environment (Cowan 1988)

Global Positioning System (GPS)
A GPS is a position-fixing system that uses the time taken for signals to travel from at least three GPS satellites in a known orbit to a receiver on the ground.

Image Processing
Encompasses all the various operations that can be applied to image or raster format data. These include image compression, restoration, enhancement, rectification, preprocessing, quantization, spatial filtering, and other image pattern recognition techniques.

Interpolation
The procedure of estimating the values of unknown points on a surface from the values of a number of points of known value.

LIS
Land Information System: a system for handling land ownership (cadastral) data.

Network Analysis
Analytical techniques concerned with the relationships between locations on a network, capacities of network systems, and the best location for facilities on a network.

Pixel
Short for PICture ELement, i.e., the smallest discrete element that makes up an image. It may represent either a small square or portion of the Earth's surface, scanned by satellite or aircraft, a portion of a graphics' image sensed by an optical scanner or an individual dot on a screen.

Raster Data
Data expressed as an array of pixels with the spatial position implicit in the ordering of the pixels.

Relational Database
A database of tables that can be linked together through common attributes.

Remote Sensing

The technique of obtaining data about the environment and surface of the earth from a distance, e.g., from an aircraft or satellite.

Resolution

Level of discrimination in the representation of objects, generally spatial.

Scale

The ratio or fraction between the distance on a map, chart, or photograph and the corresponding distance on the surface of the Earth.

Spatial Analysis

Analytical techniques associated with the study of locations of geographical phenomena together with their spatial dimensions.

Spatial Data

Data relating to the location of geographical phenomena together with their spatial dimensions.

Supervised Classification

This is the method of generating spectral signatures for image classification, in which the analyst is durectly involved in the pattern recognition process. Usually, supervised classification requires the analyst to select training samples from the data which represents patterns to be classified.

Terrain Modelling

The creation of a realistic terrain representation for computer display.

TIN

Triangular Irregular Network: the most equilateral set of triangles possible joining a set of points.

Topographic Map

A map showing the features that describe the surface of a particular place or region.

Triangulation

The interconnection of all points within an area to form a set of reproducible triangles.

Unsupervised Classification

This is a computer-automated method of pattern recognition in which some parameters are specified by the user and are used to uncover statistical patterns that are inherent in the data.

Vector Data

A description of spatial phenomena based upon geometry.

Vectorisation

The process of converting raster data into vector form.

ANNEX 2

DATA DICTIONARY OF KATHMANDU VALLEY GIS DATABASE

ThemeName CONTOUR	**Description** Index contours at 20 m interval	**Type** Shape: Arc	**UniqueItem** Kvco16-id	**Source** Topographic map	**Scale** 1:25K
SourceDate 1995	**Projection** UTM	**Spheroid** Everest	**Origin** 84° 00' 00"E, 26° 15' 00"N	**False Easting** 400000m	**False Northing** 0m

Xmin 714632.625	**Ymin** 3028469	**Xmax** 764657.625	**Ymax** 3084497

Covered Map Sheets
2785-01d,02c,02d,03c,05b,06a,06b,07a,06d,06c,06d,07c,09b,10a,10b,10c

Lookup Table/Description of Items

Item	Description
KVCO16_ID	Elevation in metre (20 m interval)

Quicklook Image

ThemeName	Description	Type	UniqueItem	Source	Scale
LANDUSE95	Land use and land cover, 1995	Shape: Poly	Landuse_id	Topographic map	1:25K
SourceDate	**Projection**	**Spheroid**	**Origin**	**False Easting**	**False Northing**
1995	UTM	Everest	84° 00' 00"E, 26° 15' 00"N	400000m	0m

Xmin	Ymin	Xmax	Ymax
714632.625	3028469	764657.625	3084497

Covered Map Sheets
2785-01d,02c,02d,03c,05b,06a,06b,07a,06d,06c,06d,07c,09b,10a,10b,10c

Lookup Table/Description of Items

Landuse_ID	Class
2	Built-up
3	Forest
5	Agriculture
7	Open Field
12	HMG Secretariat
15	Royal Palace
20	Water Body
25	Institutional Area
30	Airport
106	Brick Factory
120	Industrial Area
121	Shrub Land
129	Soil Cliff

Quicklook Image

ThemeName	Description	Type	UniqueItem	Source	Scale
LCAP	Land capability, 1978	Shape: Poly	Gen_code	LRMP	1:50K
SourceDate	**Projection**	**Spheroid**	**Origin**	**False Easting**	**False Northing**
1978/79	UTM	Everest	84° 00' 00"E, 26° 15' 00"N	400000m	0m

Xmin	Ymin	Xmax	Ymax
714632.625	3028469	764657.625	3084497

Covered Map Sheets
72E5, 72E9, 72E2, 72E6, 72E3, 72E7

Lookup Table/Description of Items

Gen_Code	Gen_Class	Description
1	Class I	Slope: nearly level (< 1 degree)
2	Class II	Slope: gentle (1-5 degree); soils; deep and well drained
3	Class III	Slope: moderate to steep (5-30 degree); soils: 50-100 cm deep and well drained
4	Class IV	Slope: too steep for terracing (>30 degree); soils: >20 cm deep and well to imper fectly drained
6	Class VI	Slope: very steep (40-50 degree) or varied slope (<40 deg); soils: varried depth and drainage or <20 cm deep
8	Class VIII	Riverbeds

Quicklook Image

ThemeName	Description	Type	UniqueItem	Source	Scale
Land Use 78	Land use and land cover of 1978/79	Shape: Poly	Class	LRMP	1:50K
SourceDate	**Projection**	**Spheroid**	**Origin**	**False Easting**	**False Northing**
1978/79	UTM	Everest	84° 00' 00"E, 26° 15' 00"N	400000m	0m

Xmin	Ymin	Xmax	Ymax
714632.625	3028469	764657.625	3084497

Covered Map Sheets
72E5, 72E9, 72E2, 72E6, 72E3, 72E7

Lookup Table/Description of Items

Code	Class	Gen_Code	Gen_Class
1	Forest	1	Forest
2	Shrub	2	Shrub
3	Pasture	3	Paster
4	River	4	Water Body
5	Urban	5	Urban
6	Tars, Alluvial, Fans	6	Agriculture
7	Hill Slope Level	6	Agriculture
8	Valley floors	6	Agriculture

Quicklook Image

ThemeName	Description	Type	UniqueItem	Source	Scale
LSYS	Land systems, 1978	Shape: Poly	Lsys2-id	LRMP	1:50K
SourceDate	**Projection**	**Spheroid**	**Origin**	**False Easting**	**False Northing**
1978/79	UTM	Everest	84° 00' 00"E, 26° 15' 00"N	400000m	0m

Xmin	Ymin	Xmax	Ymax
714632.625	3028469	764657.625	3084497

Covered Map Sheets
72E5, 72E9, 72E2, 72E6, 72E3, 72E7

Lookup Table/Description of Items

LSYS2_ID	Texture	Slopes	Region	Landunit
5	Loamy Skeletal		B	5
7	Loamy Skeletal	<20°	B	7
8	Loamy Skeletal	>20°	B	8
9	Loamy Skeletal		C	9
41	Sandy/Cobbly	<1°	B	4a
53	Loamy Skeletal	1-5°	C	Midd
91				
92	Loamy/Bouldery	<1°	C	9b
93	Loamy/Bouldery	1-5°	C	Midd
101	Loamy	0-5°	C	10a
102	Loamy	0-5°	C	10b
111	Loamy Skeletal	<30°	C	11
121	Loamy Skeletal	>30°	C	12

Quicklook Image

ThemeName	Description	Type	UniqueItem	Source	Scale
POLLUTION	Sources of ruver water pollution	Shape: Point	Riv_pollut	Field verification	1:25K
SourceDate	**Projection**	**Spheroid**	**Origin**	**False Easting**	**False Northing**
1998	UTM	Everest	84° 00' 00"E, 26° 15' 00"N	400000m	0m

Xmin	Ymin	Xmax	Ymax
714632.625	3028469	764657.625	3084497

Covered Map Sheets
2785-01d,02c,02d,03c,05b,06a,06b,07a,06d,06c,06d,07c,09b,10a,10b,10c

Lookup Table/Description of Items

RIV_POLUT	Name	PHOTO	TYPE	PICTURE
101	Teku Kalopool	25-28	Sanitary Sewer Outfill	polu10.tif
102	Bishnumati	24-26	Sanitary Sewer Outfill	polu4.tif
103	Shobhabhagwati	29-31	Sanitary Sewer Outfill	polu2.tif
104	Balgangaghat	27-28	Sanitary Sewer Outfill	polu3.tif
106	Kalmochan Ghat	21-23	Sanitary Sewer Outfill	polu7.tif
108	Aryaghat	7-10	Sanitary Sewer Outfill	polu9.tif
109	Gaurighat	11-12	Sanitary Sewer Outfill	polu8.tif
110	Manohara khola	13-15	Sanitary Sewer Outfill	polu5.tif
112	Swayambhu	32-36	Sanitary Sewer Outfill	
300	Balkhu	16-20	Industrial Water Pollution	polu6.tif
305	Gongabu	4-6	Industrial Water Pollution	polu1.tif
207	Maitidevi-gausala po	29	Storm Sewer Outfill	polu1.tif
311	Chupinghat	30-32	Industrial Water Pollution	polu11.tif

Quicklook Image

ThemeName	Description	Type	UniqueItem	Source	Scale
Drainage	Major rivers	Shape: Polygon	Riv16ma-id	Topographic map	1:25K
SourceDate	**Projection**	**Spheroid**	**Origin**	**False Easting**	**False Northing**
1995	UTM	Everest	84° 00' 00"E, 26° 15' 00"N	400000m	0m

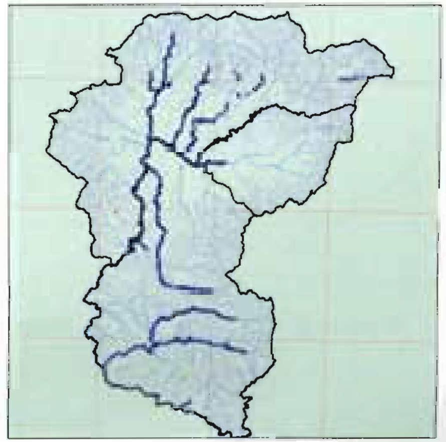
Xmin	Ymin	Xmax	Ymax
714632.625	3028469	764657.625	3084497

Covered Map Sheets
2785-01d,02c,02d,03c,05b,06a,06b,07a,06d,06c,06d,07c,09b,10a,10b,10c

Lookup Table/Description of Items

Riv16ma_id	Class
0	Graticule lines
4	Water body
5	Sandy area

Quicklook Image



ThemeName ROAD	**Description** Road network	**Type** Shape: Arc	**UniqueItem** Road_ID	**Source** Topographic map	**Scale** 1:25K
SourceDate 1995	**Projection** UTM	**Spheroid** Everest	**Origin** 84° 00' 00"E, 26° 15' 00"N	**False Easting** 400000m	**False Northing** 0m
Xmin 714632.625	**Ymin** 3028469		**Xmax** 764657.625	**Ymax** 3084497	

Covered Map Sheets
2785-01d,02c,02d,03c,05b,06a,06b,07a,06d,06c,06d,07c,09b,10a,10b,10c

Lookup Table/Description of Items

ROAD_ID	ROAD_TYPE
1	Highway
2	Major Road
3	Feeder Road
4	Foot Trails
5	Minor Foot Trails

Quicklook Image

ThemeName	Description	Type	UniqueItem	Source	Scale
SERVICES	Location of services	Shape: Point	Services-id	Topographic map	1:25K
SourceDate	**Projection**	**Spheroid**	**Origin**	**False Easting**	**False Northing**
1995	UTM	Everest	84° 00' 00"E, 26° 15' 00"N	400000m	0m

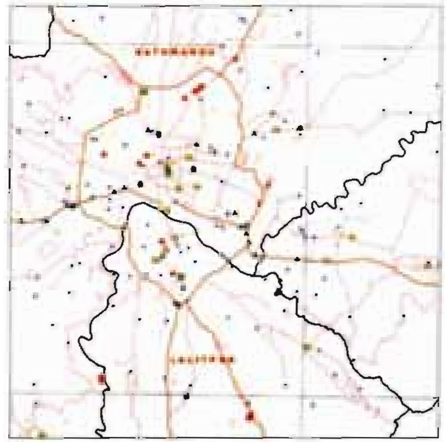
Xmin	Ymin	Xmax	Ymax
714632.625	3028469	764657.625	3084497

Covered Map Sheets
2785-01d,02c,02d,03c,05b,06a,06b,07a,06d,06c,06d,07c,09b,10a,10b,10c

Lookup Table/Description of Items

SERVICES_I	COUNT	TYPE
1	22	Post Office
2	26	Mosque
5	468	School
7	208	Temple/Stupa
9	19	Hospital
11	40	Mane
15	31	Petroal Pump
19	1	Church
20	5	Bus Terminal
21	1	Others
22	6	Others
23	28	Transformer Station

Quicklook Image



ThemeName	Description	Type	UniqueItem	Source	Scale
SPOT	Spot height	Shape: Point	Kvco16-id	Topographic map	1:25K
SourceDate	**Projection**	**Spheroid**	**Origin**	**False Easting**	**False Northing**
1995	UTM	Everest	84° 00' 00"E, 26° 15' 00"N	400000m	0m

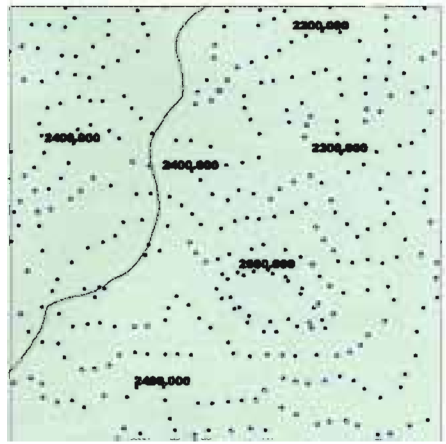
Xmin	Ymin	Xmax	Ymax
714632.625	3028469	764657.625	3084497

Covered Map Sheets
2785-01d,02c,02d,03c,05b,06a,06b,07a,06d,06c,06d,07c,09b,10a,10b,10c

Lookup Table/Description of Items

Items(s)	Description
KVCO16_ID	Elevation value of each location (spot) in metre

Quicklook Image



ThemeName	Description	Type	UniqueItem	Source	Scale
VDC	Village Development Committee	Shape: Polygon	ID	Topographic map	1:25K
SourceDate	**Projection**	**Spheroid**	**Origin**	**False Easting**	**False Northing**
1995	UTM	Everest	84° 00' 00"E, 26° 15' 00"N	400000m	0m

Xmin	Ymin	Xmax	Ymax
714632.625	3028469	764657.625	3084497

Covered Map Sheets

2785-01d,02c,02d,03c,05b,06a,06b,07a,06d,06c,06d,07c,09b,10a,10b,10c

Lookup Table/Description of Items

Item(s)	Description
ID	Unique ID number per each VDC
Name	Name of VDC
TPOPU	Total population per VDC
MALE	Male population per VDC
FEMALE	Female population per VDC
HHOLD	Distribution household per VDC
DENSITY	Population per sq. km. Per VDC
P_MALE	Percentage of males per VDC
P_FEMALE	Percentage of females per VDC

Quicklook Image

Theme Name HLSHD2	**Description** Hillshade of DEM	**Theme Type** GRID	**Cell Size** 10m	**Unique Item** VALUE
Rows 5604	**Columns** 5004	**Xmin** 714630	**Ymin** 73008460	**Xmax** 764670
Ymax 3084500	**Type** Integer	**Origin** 84° 00' 00"E, 26° 15' 00"N	**False Easting** 400000m	**False Northing** 0m

Item Description
VALUE = Intenstiy of colour; COUNT = No. of Pixels

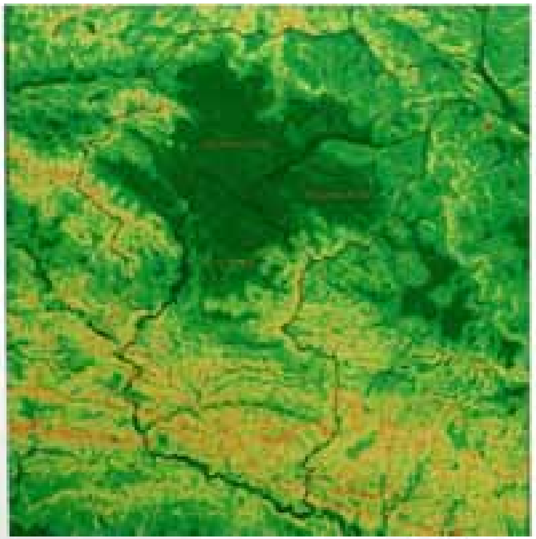
Quick Look Image

Theme Name SLOPE	**Description** Slope information	**Theme Type** GRID	**Cell Size** 10m	**Unique Item** VALUE
Rows 5604	**Columns** 5004	**Xmin** 714630	**Ymin** 73008460	**Xmax** 764670
Ymax 3084500	**Type** Integer	**Origin** 84° 00' 00"E, 26° 15' 00"N	**False Easting** 400000m	**False Northing** 0m

Item Description

VALUE = Slopes in degrees; COUNT = No. of Pixels

Quick Look Image



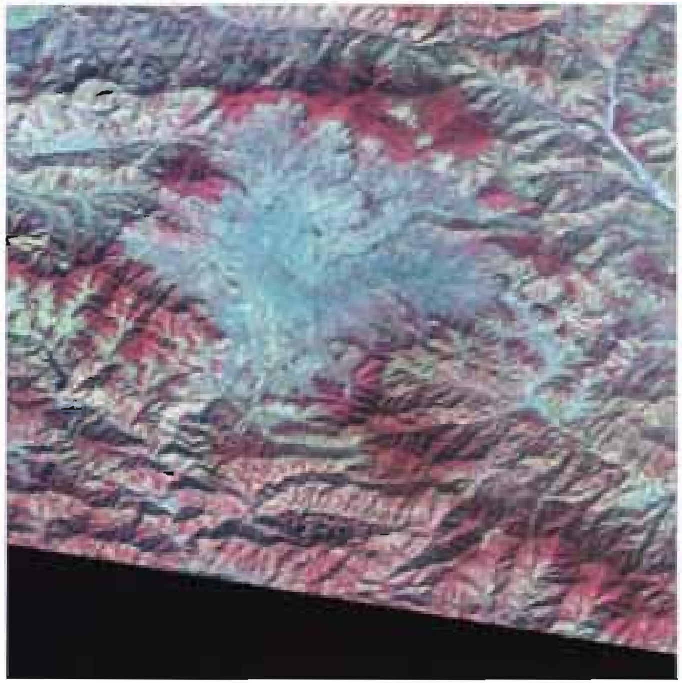
ImageFileName AVNRGEO.Img	**SatelliteSensor** AVNIR M	**Resolution** 16m	**ResampledTo** 10m	**Format** Imagine
Acquired Date 11-Jan-1997	**Country** Nepal	**Area** Kathmandu	**Number of Layers** 4 (Band1:Band4)	**Source** ADEOS

GeoreferencedTo UTM	**Spheroid** Everest	**Origin** 84° 00' 00"E, 26° 15' 00"N	**Datum** Everest	**False Easting** 400000m	**False Northing** 0m

Rows 5004	**Columns** 5605
ULX 714635	**ULY** 3084495
LRX 764665	**LRY** 3028455
Storage SPCD#01	
Quality Good	

File Size: 111,641KB

Quick Look:



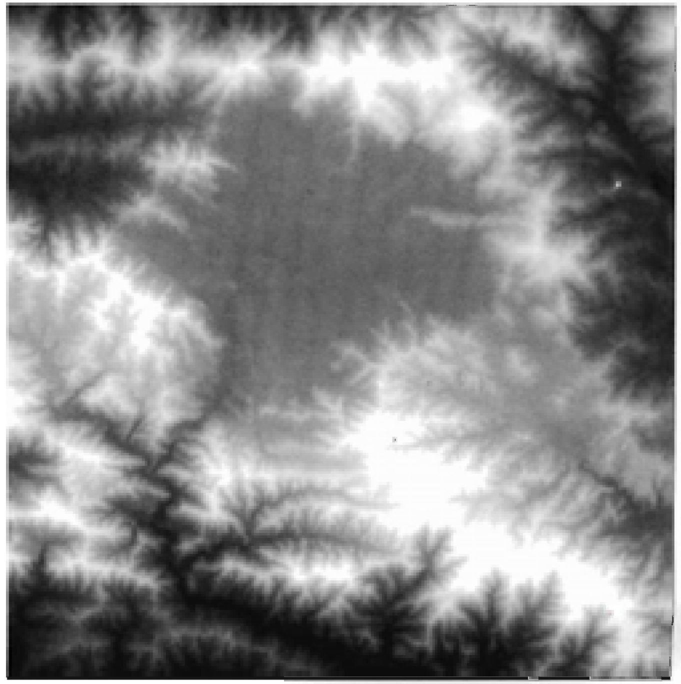
ImageFileName	SatelliteSensor	Resolution	ResampledTo	Format
DEM10KTM.Img	Derived by interpolation	10m	10m	Imagine
Acquired Date	**Country**	**Area**	**Number of Layers**	**Source**
08-Apr-1998	Nepal	Kathmandu	1	MENRIS

GeoreferencedTo	Spheroid	Origin	Datum	False Easting	False Northing
UTM	Everest	84° 00' 00"E, 26° 15' 00"N	Everest	400000m	0m

Rows	Columns
5004	5604
ULX	**ULY**
714635	3084495
LRX	**LRY**
764665	3028465
Storage	
SPCD#01/19	
Quality	
Good	

File Size: 55,723KB

Quick Look:



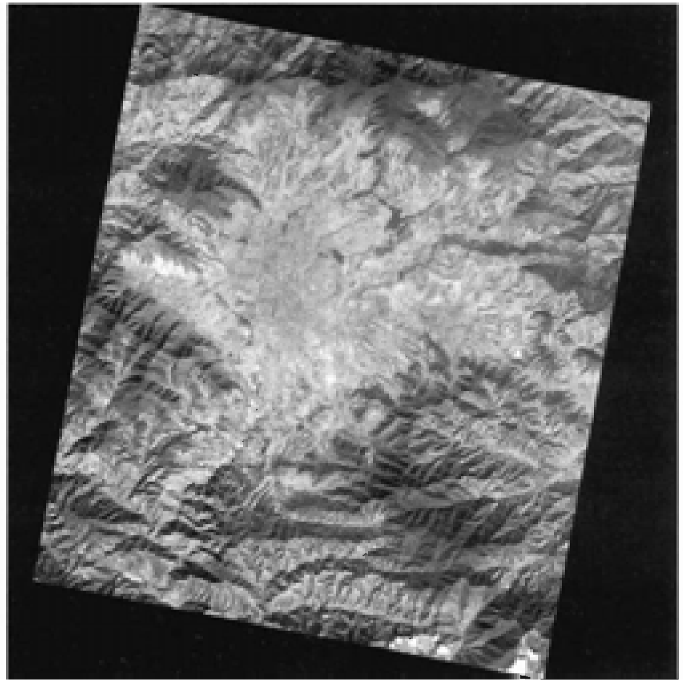
ImageFileName IRS1C-GEO1.Img	**SatelliteSensor** IRS1-C	**Resolution** 5.6m	**ResampledTo** 5.6m	**Format** Imagine
Acquired Date 23-Nov-1996	**Country** Nepal	**Area** Kathmandu	**Number of Layers** 1	**Source** NRSA-NDC

GeoreferencedTo UTM	**Spheroid** Everest	**Origin** 84° 00' 00"E, 26° 15' 00"N	**Datum** Everest	**False Easting** 400000m	**False Northing** 0m

Rows 7385	**Columns** 8015
ULX 717545	**ULY** 3082465
LRX 758895	**LRY** 3037586
Storage SPCD#09	
Quality Good	

File Size: 60,079KB

Quick Look:



ImageFileName	SatelliteSensor	Resolution	ResampledTo	Format
SPIN-GEO.Img	KVR 1000 camera system	2m	2m	Imagine
Acquired Date	**Country**	**Area**	**Number of Layers**	**Source**
05-Feb-1991	Nepal	Kathmandu	1	SPIN-2

GeoreferencedTo	Spheroid	Origin	Datum	False Easting	False Northing
UTM	Everest	84° 00' 00"E, 26° 15' 00"N	Everest	400000m	0m

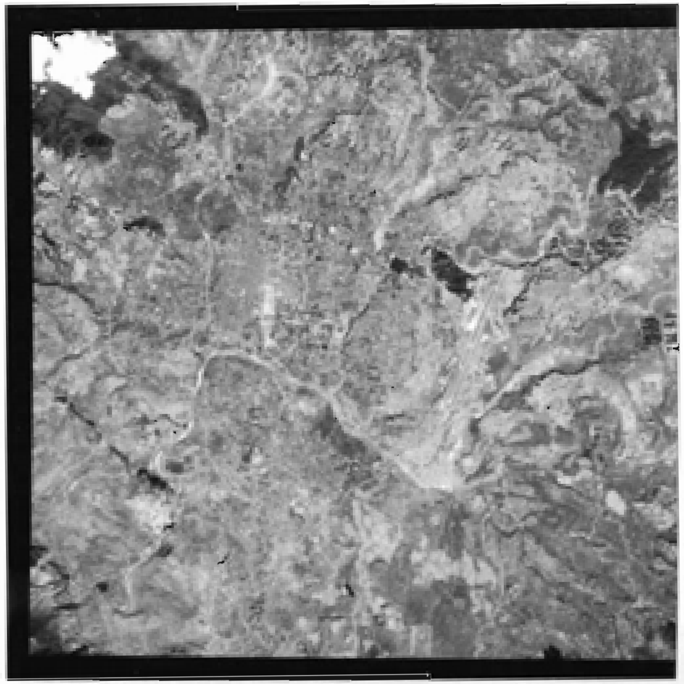
Rows	Columns
7024	6834
ULX	**ULY**
728652	3071088
LRX	**LRY**
742698	3057422

Storage
SPCD#02

Quality
Good; About 2% cloud

File Size: 48,382KB

Quick Look:

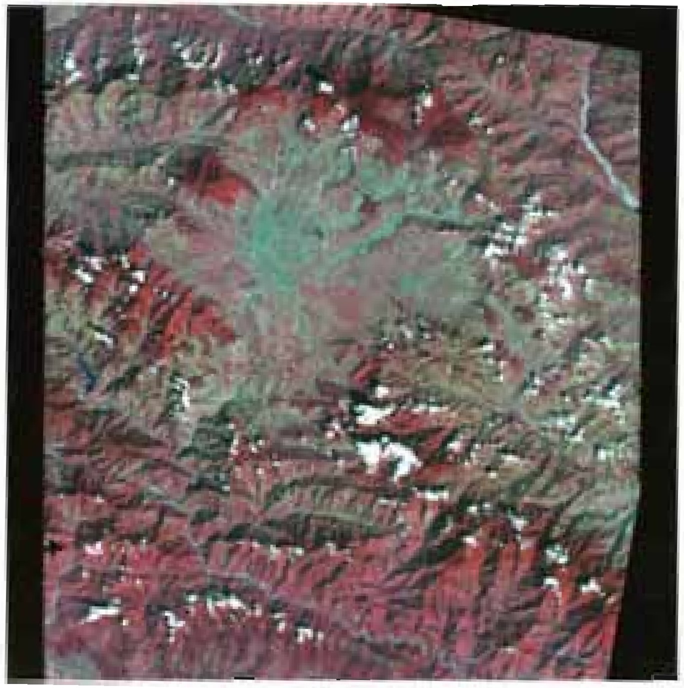


ImageFileName TMGEO.Img	**SatelliteSensor** Landsat-TM	**Resolution** 30m	**ResampledTo** 10m	**Format** Imagine
Acquired Date 11-Oct-1988	**Country** Nepal	**Area** Kathmandu	**Number of Layers** 7 (Band1:Band7)	**Source** Landsat

GeoreferencedTo UTM	**Spheroid** Everest	**Origin** 84° 00' 00"E, 26° 15' 00"N	**Datum** Everest	**False Easting** 400000m	**False Northing** 0m

Rows 4961	**Columns** 5587
ULX 714881	**ULY** 3084552
LRX 764485	**LRY** 3028693
Storage SPCD#01/19	
Quality Good, About 2% cloud	
File Size: 192,883KB	

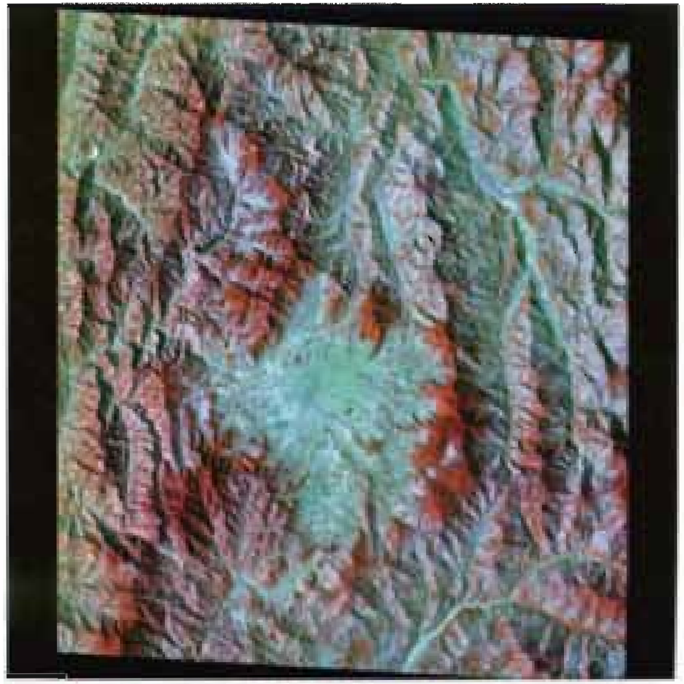
Quick Look:



ImageFileName SPOTXS091294	**SatelliteSensor** SPOT	**Resolution** 20m		**ResampledTo** 20m	**Format** Imagine
Acquired Date 09-Dec-1994	**Country** Nepal	**Area** Kathmandu		**Number of Layers** 3 (Band1:Band3)	**Source** SPOT
GeoreferencedTo None	**Spheroid** N/A	**Origin** 84° 00' 00"E, 26° 15' 00"N	**Datum** Everest	**False Easting** 400000m	**False Northing** 0m

Rows 3522	**Columns** 2997
ULX	**ULY**
LRX	**LRY**
Storage SPCD#20	
Quality Good	
File Size: 31,706KB	

Quick Look:



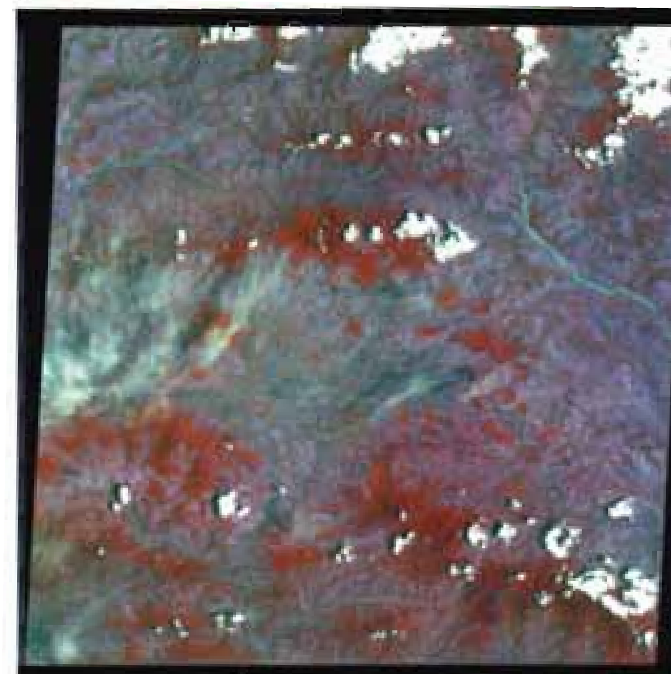
ImageFileName SPOTXS050591	**SatelliteSensor** SPOT	**Resolution** 20m	**ResampledTo** 20m	**Format** Imagine
Acquired Date 05-May-1991	**Country** Nepal	**Area** Kathmandu	**Number of Layers** 3 (Band1:Band3)	**Source** SPOT

GeoreferencedTo None	**Spheroid** N/A	**Origin** 84° 00' 00"E, 26° 15' 00"N	**Datum** Everest	**False Easting** 400000m	**False Northing** 0m

Rows 3169	**Columns** 3004
ULX	**ULY**
LRX	**LRY**
Storage SPCD#20	
Quality Good, about 4% cloud	

File Size: 28,311KB

Quick Look:



ImageFileName SPOTPAN.Img	**SatelliteSensor** SPOT	**Resolution** 10m	**ResampledTo** 10m	**Format** Imagine
Acquired Date Nov-07-1986	**Country** Nepal	**Area** Kathmandu/Southern Terai	**Number of Layers** 1	**Source** SPOT

GeoreferencedTo No	**Spheroid** No	**Origin** 84° 00' 00"E, 26° 15' 00"N	**Datum** Everest	**False Easting** 400000m	**False Northing** 0m

Rows 6000	**Columns** 6000
ULX -	**ULY** -
LRX -	**LRY** -
Storage SPCD#19	
Quality Good	

File Size: 35,515KB

Quick Look:

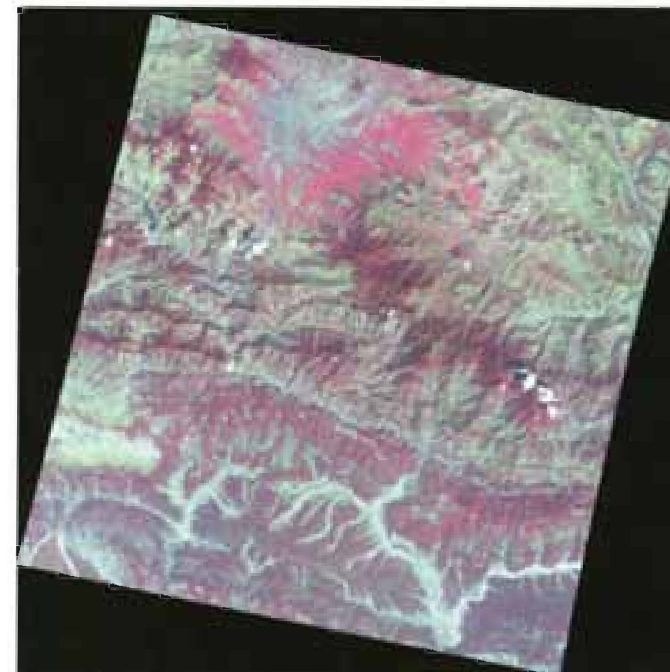
ImageFileName GEOSPOTXS.Img	**SatelliteSensor** SPOT HRV1	**Resolution** 20m	**ResampledTo** 20m	**Format** Imagine
Acquired Date 12-Mar-1986	**Country** Nepal	**Area** Kathmandu, Southern Terai	**Number of Layers** 3 (Band1:Band3)	**Source** SPOT

GeoreferencedTo UTM	**Spheroid** Everest	**Origin** 84° 00' 00"E, 26° 15' 00"N	**Datum** Everest	**False Easting** 400000m	**False Northing** 0m

Rows 3782	**Columns** 3566
ULX 703501	**ULY** 3076203
LRX 779121	**LRY** 3004903
Storage SPCD#19	
Quality Good	

File Size: 40,480KB

Quick Look:



ImageFileName	SatelliteSensor	Resolution	ResampledTo	Format
ORTHO.Img	SPOT-PAN	10m	10m	Imagine
Acquired Date	**Country**	**Area**	**Number of Layers**	**Source**
07-Nov-1986	Nepal	Kathmandu	1	SPOT

GeoreferencedTo	Spheroid	Origin	Datum	False Easting	False Northing
UTM		84° 00' 00"E, 26° 15' 00"N	Everest	400000m	0m

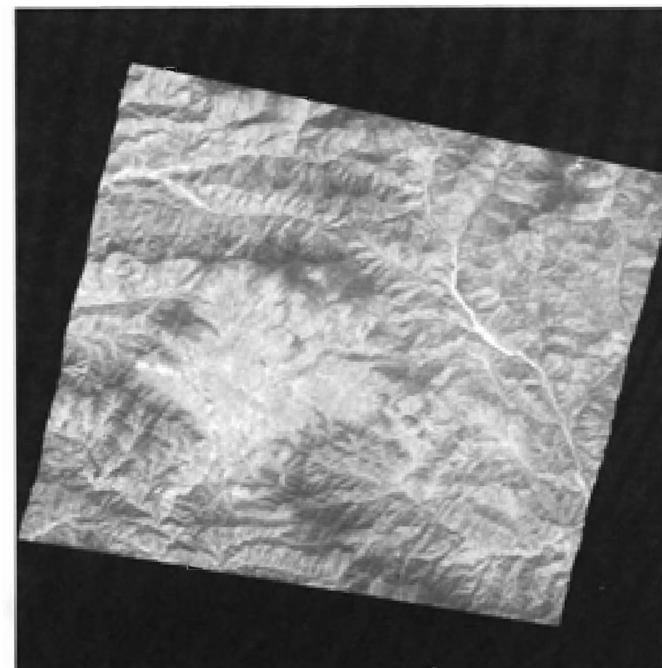
Rows	Columns
6600	7700
ULX	**ULY**
309005	3100995
LRX	**LRY**
385995	3035005

Storage

Quality
Good

File Size: 50,516KB

Quick Look:



ANNEX 3
MAPS OF THE KATHMANDU VALLEY

The Department of Survey last produced a 'Map Inventory of Nepal' in 1980.It gives a comprehensive list of maps available at that time. The following information has been compiled with the help of the Department of Survey as a source of reference for GIS users. Attempts have been made to give accurate and comprehensive information. However, ICIMOD cannot guarantee the accuracy of the information. For further details, please contact the Department of Survey. On our part, we are simply providing a list of maps available.

Mile Scale Topographic Map

This series of maps was produced by the Survey of India for the whole of Nepal.

Map Size	39 cm x 44 cm (approximately)
Contour Intervals	100 feet
Production Date	1947 & 1954
Source	Survey of India
Projection	Polyconic
Sheet Nos.	72E/1, 2 5, 6, 10 (five sheets)
Area Coverage	Surrounding Hills

1:50,000 Scale Topographic Map

This map was compiled from aerial photographs on a scale of 1:10,000 (Schneider Maps) stereo plotted by Aermap Company, Florence. The field work was carried out jointly by the Department of Housing and Physical Planning, Survey Department, and SATA, Nepal.

Map Size	63.5 cm x 56 cm
Contour Intervals	40 metres
Production Date	1971
Source	E. Schneider (Lech / Austria)
Projection	Not mentioned
Sheet Nos.	one
Area Coverage	Surrounding Hills

1:25,000 Scale Topographic Map (FINNMAP)

This series of maps was produced with the support of the Government of Finland FINNMAP) based on aerial photographs taken in 1992 on a scale of 1:50,000.

Map Size	49.3 cm x 55.3 cm (ground area coverage 7' 30" X 7' 30")
Contour Intervals	20 metres
Production Date	1996
Source	Department of Survey, HMG
Projection	Modified Universal Transverse Mercator (UTM)
Sheet Nos.	2785 02C; 02D; 03C; 05B; 05D; 06A; 06B; 06C; 06D; 07A; 09B; 10A; and 2785 10B (13 Sheets)
Area Coverage	12.25 X 12.5 Kilometres

1:10,000 Scale Map (Schneider Map)

This series of maps was produced from aerial photographs taken by E. Schneider on a scale of 1:20,000 in 1971.

Toposheet Size	79 cm x 69,5 cm. (ground area coverage 4' x 4')
Contour Intervals	10 metres
Production Date	1977
Source	E. Schneider (Lech / Austria)
Projection	Not mentioned
Sheet Nos.	72E5; 72E6; 72E7; 72E9; 72 E10; and 72E2 (7 sheets)
Area Coverage	12.25 X 12.5 Kilometres

1:2,000 Scale Map (DWSS/UNDP)

This series of maps was produced by Binnie and Partners, London, with UNDP support through a project for the Department of Water Supply and Sanitation.

Map Size	90cm x 60 cm.
Contour Intervals	1 metre
No. of Sheets	50

1:2,000 Map (NTC/Danida)

This series of maps was produced with the assistance of DANIDA for the Nepal Telecommunication Corporation with the aerial photographs taken in 1992 on a scale of 1:5,000. The Kathmandu Valley Urban Development Project (KUDP) of the Department of Housing and Urban Planning (DHUD) has tried to convert them into appropriate digital format for urban application.

1:2,000 Metropolitan Map (DOS)

There are several maps produced by the Department of Survey of metropolitan areas of the Kathmandu Valley. Also, a digital ortho-photo of the Kathmandu Valley is being prepared with the help of FINNMAP for the Census 2001 project.

Greater Kathmandu Mapping Project (KMC/EU)

Kathmandu Metropolitan Corporation (KMC) has established a 'Greater Kathmandu Mapping Project' supported by the European Union (EU) to map the Kathmandu Valley. The project's aim is to take another complete set of aerial photographs on a larger scale and for digital production.

Aerial Photographs of the Kathmandu Valley

Photography	Scale	Camera Type/ Details	Calibration Date	Remarks
LRMP 11-1-1978	1:50,000	ZEISS 8.5123 MAG 11617, Super XX LENS 123809,85.47 mm, D-123838		Covers Inside Ring Road Only
LRMP 12-5-1979	1:50,000	WICD RC-10, MAG 286, DX 2405 LENS SAG # 2022, 87.87 mm, 500 NM		
TOPO 28-10-1981	1:8,000	RC-10 No. 3310 LENS: NAG 7153; 213.78 mm		Covers Inside Ring Road Only
TOPO 27-3-1987	1:10,000	WILD 15/4 UAG- RC 10 NY. 13012.153.23		Covers Inside Ring Road Only
TOPO 6-12-1989	1:20,000	WILD 15/4 uAG Wild RC 10 NY 13012.153.23		
NTC (DANIDA) 16-3-1992	1:10,000	ZEISS 153 00		
ENTMP (FINNMAP) November 1992	1:50,000	WILD 15/4 UAG –F Wild RC 20 NY 13158, 153,19 mm	14-09-1992	
ENTMP (FINNMAP) 3-2-1995	1:4,000	WILD RC-10, 4 UAG NY 13012 F-153.23		Airport Area Only
Census, 1998	1:15,000	RC – 30 LENS 15/4 UAG – S LENS No. 13215 F- 152.857 mm	28-09-1998	

Note: Further details can be obtained from the Department of Survey

ANNEX 4

OPTICAL SENSOR SYSTEM CHARACTERISTICS OF EARTH RESOURCE SATELLITES

Satellite System	LANDSAT 4/5	LANDSAT 4/5	SPOT	ADEOS	IRS-1C
Optical Sensor System (launch dates)	**MSS** (1982 L.SAT-4) (1985 L.SAT-5)	**TM** (1982 L.SAT-4) (1984 L.SAT-5)	**XS** (1986 SPOT-1) (1990 SPOT-2) (1993 SPOT-3)	**AVNIR** (1996 ADEOS-1)	**LISS-III** (1995 IRS-1C)
Sensor Altitude	Landsat1,2,3=900 km Landsat 4, 5 =705km	705 km	832 km	800 km	817 km
Spatial Resolution	80 m	30 m	20 m	16 m	24 m
Temporal Resolution (Revisit Cycle) (in days)	16	16	20 (nadir)	41 (nadir)	24 (nadir)
Radiometric Resolution (bytes per pixel)	6 bytes (scaled to 7 or 8 bytes during ground processing)	8 bytes	8 bytest		7 bytesit
Swath Width	185 km scene area = 185*170	185 km scene area = 185*170	60 km	80 km	141 km
Off-nadir viewing (side-look) capability for the (PAN) Panchromatic mode for stereo image data acquisition)			**SPOT PAN** (10 m resolution) 0.51 - 0.73 μm 3-day revisit capability	**ADEOS AVNIR PAN** (8 m resolution) 0.52 - 0.72 μm	**IRS-1C PAN** (6 m resolution) (70 km swath width) 0.50 - 0.70 μm (6 bytest)
Spectral Resolution (Number of Bands)	Four	Seven	Three	Four	Four
Blue		0.45 – 0.52		0.40 - 0.50	
Green	0.50 - 0.60	0.53 – 0.61	0.50 - 0.59	0.52 - 0.62	0.52 - 0.59
Red	0.60 - 0.70	0.62 – 0.69	0.62 - 0.68	0.62 - 0.72	0.62 - 0.68
NIR	0.70 - 0.80	0.78 – 0.90	0.78 - 0.88		0.77 - 0.86
NIR	0.80 - 1.10			0.82 - 0.92	
IIR		1.57 – 1.78			1.55 - 1.75
IIR		2.10 – 2.35			
IIR (MIR)					
IIR (MIR)					
ThIR		10.45 - 11.66			
FIR					

ANNEX 5

DATA ACCESS AND AVAILABILITY

All the data used in this publication and the text in full are available in an interactive CD-ROM. The CD-ROM contains the following information and datasets.

- Full Publication

The entire publication has been packaged in HTML format. It can be accessed by using Internet Explorer 3.0 or a later version. All the maps used in this CD-ROM are in JPG format.

- Topopgraphic Database with ArcExplorer Browser

The topographic database on a scale of 1:25,000 is in Arcview Shapefile format. The ArcExplorer, which is software provided free of cost by ESRI, is packaged along with the CD-ROM to facilitate viewing. Appropriate views have been created for browsing the database; however, users may wish to create their own views and produce outputs as desired. The satellite images used in the publication are available in JPG format only.

- Executable Data Dictionary in Microsoft Access Database Format

Documentation of different GIS data layers, both topographic and satellite images, has been developed in a Microsoft Access database package, thus providing metadata (data about data) of the Kathmandu Valley GIS database.

It is our intention to make the Kathmandu Valley GIS Database available to a wide public and to encourage information exchange among research and development communities, thereby closing data gaps and eliminating duplication of efforts.

Note: Data quality assessment or authentication of datasets was beyond the scope of this study and emphasis was given to accessibility and availability of data. ICIMOD-MENRIS is not responsible for any conclusions drawn from the datasets in whatsoever form.

Those interested can contact ICIMOD-MENRIS.

Basanta Shrestha or Sushil Pradhan
email: basanta@icimod.org.np or sushil@icimod.org.np
Telephone: +977 1 525313 ext. 552/553
Fax: +977 1 536747/524509

about the authors

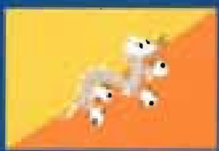
Mr. Basanta Shrestha has an M.Eng. in Computer Science from the Asian Institute of Technology, Bangkok, Thailand and a B.Eng. in Electrical and Electronic Engineering from Madras University, India. He has extensive experience in the field of Information Technology and applications. He joined ICIMOD in 1990 and is currently involved in Geographical Information Systems' technology, Remote Sensing technology, and Global Positioning Systems' technology. Through different programmes at ICIMOD, he has contributed to improving information technology infrastructure and access to information in the HKH region. He has also published five reports and numerous papers on various aspects of these technologies and their applications. He realised the concept of and produced the ICIMOD CD-ROM containing about 180 publications.

Mr. Sushil Pradhan has an MSc. in Geo-Information Systems (GIS) for Rural Application from Wageningen Agricultural University and the International Institute for Aerospace Survey and Earth Sciences (ITC), The Netherlands. He has a post-graduate diploma in Geo-Information Systems and Computer Information Systems from the International Statistics Programs Centre/US Bureau of Census, in cooperation with Washington University, Washington, D.C., USA. He joined ICIMOD in 1994 and is currently involved in the application of 3-S (GIS, RS, GPS) technologies in various programmes of ICIMOD. He has published a report 'GIS Database of Key Indicators of Sustainable Mountain Development in Nepal' and a paper on 'Integration of GIS, Remote Sensing, and Area Frame Sampling for Crop Acreage Estimation'.

Participating Countries of the Hindu Kush-Himalayan Region

Afghanistan

Bangladesh

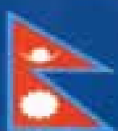


Bhutan

China

India

Myanmar



Nepal

Pakistan

International Centre for Integrated Mountain Development
4/80 Jawalakhel, GPO Box 3226
Kathmandu, Nepal

Telephone
+977 1 525313

Fax
+977 1 524509
+977 1 536747

e-mail
distri@icimod.org.np

Web site
http://www.icimod.org.sg

Cable
ICIMOD NEPAL