UNIVERSITY OF NAIROBI

GIS IN FACILITIES MANAGEMENT:

A Case Study of the U-block at the Kenya Polytechnic University College

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DECLARATION

Project Title: **GIS IN FACILITIES MANAGEMENT:**

A Case Study of the U-block at the Kenya Polytechnic University College

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I confirm that the work contained in this MSc. project report has been composed solely by myself and has not been accepted in any previous application for a degree. All sources of information have been specifically acknowledged.

Signed ....[signature]....

Date....16-06-2009....

ABSTRACT

GIS-based Facility Management Systems (FMS) offer several advantages over the traditional analogue mode and/or Computer-Aided Design (CAD)-based systems. For instance, they can integrate a campus location and facility management (building, floor and room location) into one package. The integration simplifies the querying of such data.

The Kenya Polytechnic University College's mode of manual space inventory does not provide for querying the available data for the purpose of quick decision making; neither does it provide for a structured storage system. The objective of this study is therefore to develop, using an existing GIS tool kit, a method of setting up a typical geo-database for organising digital data so as to facilitate information management, its visualization and illustration.

In this project, a GIS database for the U-Block of the Kenya Polytechnic University College has been created. As a result of time constraint, it was not possible to have a GIS database for every building of the College. From the U-Block database, one is able to extract information on space, such as the amount space available, the department to which some space is assigned, or even the maximum number of students a room can accommodate (stations)

By integrating the different U-Block floor plans, the attribute tables and the room pictures, it is possible to easily manipulate the data and display different views of the rooms, based on usage and assignment to departments.

On the basis of this success of the U-Block database, it is recommended that a geo-database for the entire College be established. Such an intranet-based system should permit the linking of the various building floor plans, facilities data and the general base map layers, which should then be accessed through some standard browser for visualization and reporting of space utilization across the entire College.

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CODING AND ABBREVIATIONS

Code/Abbreviation	Meaning
BulbsQty	Number of bulbs in a room
DoorsN0	Number of doors for a room
WindsNo	Number of windows for a room
PortsQty	Number of communication ports in a room
SktsQty	Number of sockets in a room
WTapsQty	Number of water taps in a room
FL_ID	Floor level identifier
RM_ID	Room identifier
ST_ID	Staff member Identifying number
ST_FName	First name of staff member
ST_MName	Middle name of staff member
ST_LName	Last name of staff member
ST_Design	Staff Designation
CATE	Category
Dept_ID	Department Identifier
$OP_{n\ (n=1,2,3\ldots)}$	Open Space
$V_{n\ (n=1,2,3\ldots)}$	Void
FURN_ID	Furniture Identifier
FURN_NAME	Furniture Name
EQUIP_ID	Equipment Identifier
HOD	Head of Department
DHOD	Deputy Head of Department

EQUIP_NAME	Equipment Name
CNAME	Course Name
COM	Common
B&CE	Building and Civil Engineering
SecL_Qty	Number of Security Lights
TSC	Teachers Service Commission
BOG	Board of Governors

CHAPTER ONE: INTRODUCTION

1.1 Background

Often organizations such as government departments, municipalities, and universities have responsibilities over several constructed facilities like buildings, roads, railways and sewage lines, water, power and telephone lines, parks as well as other equipment necessary for the maintenance of the facilities. To manage such facilities often involves the linkage of a property asset management database to some form of large-scale digital map. Before the advent of the computer technology, the utility industry always relied on hardcopy maps to manage such facilities. However, with time, physical maps deteriorate, get lost or are misfiled. Where available, similar records are kept at different departments - (thus creating a waste of storage space); accessibility to data becomes insecure or impossible altogether. These shortcomings call for new tools and strategies, to not only drive down management costs, but also to improve on space management (Meyers, 1999).

The development and expansion of an institution's constructed facilities makes management of the same difficult. The development and subsequent expansion of the institution's constructed facilities has aggravates the difficulties of managing them. Fortunately for such institutions or organizations, for example Kenya Polytechnic University College, we now have Facilities Management Systems (FMS) which are capable of handling the massive data being generated from these facilities. The data may be about the facilities themselves or the people and processes involved. These FMS are generally integrated with some form of Geographic Information Systems (GIS) queries. The integration becomes crucial in facilities management application where the idea is to place spatial and attribute data in the hands of those who make decisions about how a utility can be maximized at minimum costs.

1.2 Statement of the Problem

The Kenya Polytechnic University College still relies on the old system of organizing, retrieving and updating hardcopy facility drawings, where available. There is no coordinated system for storing, accessing and updating the available documents related to the physical infrastructure of the institution. As shown in Fig.

1.1, the College owns facilities scattered within the City of Nairobi. Other than the main administrative centre and the campus along Haile Selassie Avenue, the Polytechnic also has structures located at the community area, South 'B' as well as in South 'C', all in Nairobi.

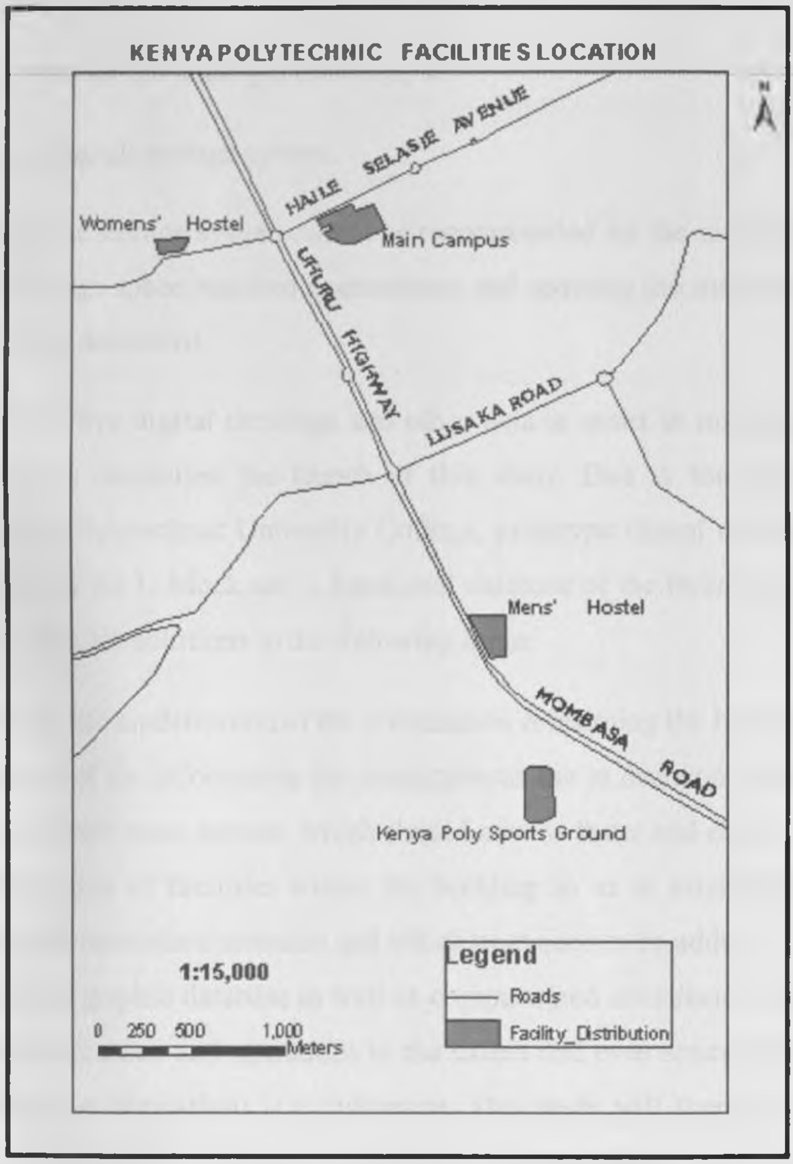


Fig 1.1: Site Location for the Kenya Polytechnic Facilities

The expansive town Campus and the other assets are all managed and maintained from the Principal's office, assisted by a poorly equipped maintenance unit, also within the town Campus. The system of managing these facilities is based on hardcopy paper maps, scattered in various offices in different departments. As a result, it is difficult to find relevant documents when needed. Indeed, in the year 2003, when an extension was to be put up on the U-block, some drawings had to be sourced from the City Council of Nairobi archives. Such a short-coming could have been avoided if there was:

- a central store for the analogue drawings, or
- a softcopy (digital) storage system.

However, an analogue storage system cannot be recommended for the institution for the fact that the storage space required is enormous and updating the maps requires re-drawing the entire document.

The absence of effective digital drawings and other data to assist in managing the institution's facilities necessited the launch of this study. Due to the expansive nature of the Kenya Polytechnic University College, prototype digital drawings of the different floors of the U-block and a functional database of the building will be produced so as to provide solutions in the following areas:

- updating and modification of the information concerning the building,
- Retrieval of the information for instantaneous use in decision making by the university management, which should now be faster and easier.
- Identification of facilities within the building so as to establish which ones need immediate attention and which ones need to be added.

Lack of a centralized graphic database as well as computerized inventories of the U-Block hampers maintenance and operations to the extent that even space utilization (in terms of classroom allocation) is a nightmare. This study will therefore be of great help to this institution in that room utilization and maintenance decisions will be improved.

1.3 Objectives

The aim of this study is to develop, using an existing GIS tool kit, a method of setting up a typical geo-database for organizing digital data so as to facilitate information management, visualization and illustration, decision-making and project organization in the process of Facilities Management. The study entails developing an integrated GIS database system of the U-block of the Kenya Polytechnic

University College which will enable the institution's management to have better methods of resource utilization (e.g. space utilization) at the institution. The specific objectives of the project are therefore to:

(i) Identify the service utilities, e.g. bulbs, power sockets, water taps etc. within the U-Block, which can sustain the proper management of the facilities of the institution. These utilities can then be monitored and reported on frequently for performance improvement.

(ii) Employ the selected service utilities in a GIS environment and test the capability of the system to create reports.

(iii) Select appropriate GIS-based tools

(iv) Create a GIS conceptual database schema for facilities management

1.4 Significance of the Project

The successful design and implementation of such a GIS database management system will provide answers to such questions as:

- which GIS-based tools are available for FM? What can these tools do? What developments can be expected in the future?
- How can GIS techniques be involved in the process of facilities management?
- What are the benefits and limitations of a GIS database for FM?
- How can a typical database for FM be constructed?

The end product of this project is therefore a geodatabase for facilities management for the U-Block of the Kenya Polytechnic University College, Nairobi. The database is built to illustrate the current capabilities of GIS-based tools.

1.5 Scope

A major portion of this project is on conceptual modelling of a GIS database for facilities management. The aim of the project is to produce a conceptual and logical model that fully takes into account the critical aspects of GIS database design in aiding FM. It does not propose to develop a new GIS tool. Instead, the project is intended to assist users in selecting the proper GIS software packages as tools in GIS design.

This project is geared towards setting up a GIS database system to aid in facilities management rather than on how to use GIS technology to conduct a facilities management project.

1.5.1 The work Plan

Data and information required for this project study is scattered at different offices including the Principal's office, the maintenance office, the office of the Head of the Department of Building and Civil Engineering and the College's architect's office. It is therefore required that all this be assembled together and then combined with data directly collected from the field. To achieve this, the scope of the project covered the following operations:

(i) capturing the locational and attribute data for the U-block for the purposes of geo-referencing the floor plans and by extension, rooms;

(ii) designing and creating a database using a combination of Access, ArcviewGIS3.3, ArcGIS and Excel software.

1.5.2 Study Area

The Kenya Polytechnic University College (Fig. 1.2) was established in 1961, first as a middle-level training college and then as a University College in August, 2007. The town Campus (geographical coordinates: between 01˚17′24″ and 01°17′35″S; and between 36˚49′25 and 36°49′31″E), is located near the City of Nairobi Central Business District.

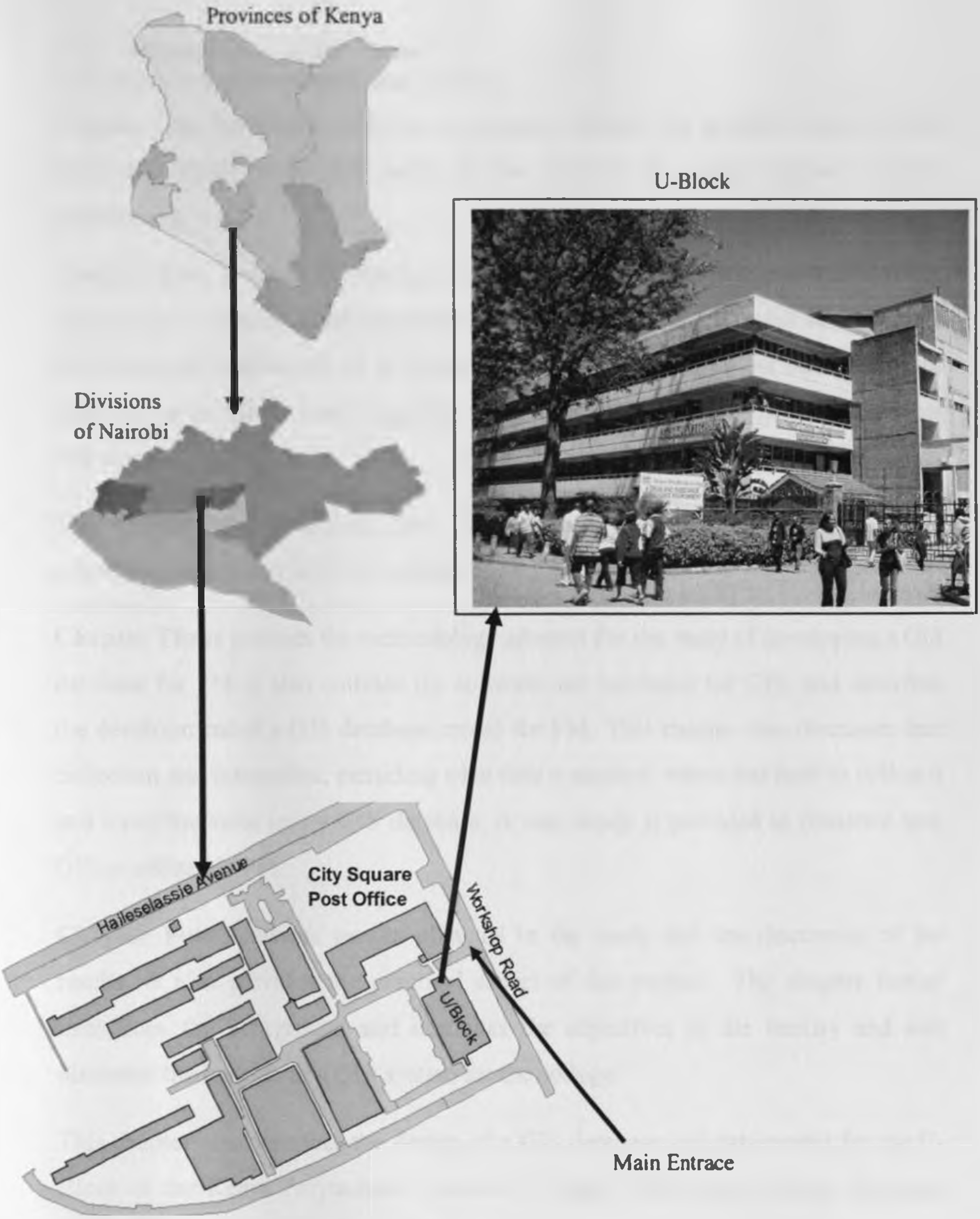


Fig. 1.2: Kenya Polytechnic

1.5.3 Organisation of the report

The project report consists of five chapters

Chapter One Introduces facilities management defines the problem statement and states the objectives of the study. It also outlines the study approach and its contribution.

Chapter Two provides the background to GIS and facilities management (FM). Definitions of 'Facilities Management' and 'GIS' are provided. Also reviewed are the traditional approaches of facilities management, as well as an outline of GIS applications in various fields, together with a discussion of some GIS data, concepts and terms.

The chapter also describes the various GIS techniques used in facilities management, together with the process of facilities management.

Chapter Three presents the methodology adopted for the study of developing a GIS database for FM. It also outlines the software and hardware for GIS, and describes the development of a GIS database model for FM. This chapter also discusses data collection and integration, including what data is needed, where and how to collect it and input the same into a GIS database. A case study is provided to illustrate how GIS is utilized in FM.

Chapter Four, presents results obtained in the study and the discussion of the results. It also provides the practical aspect of the project. The chapter further introduces the background and describes the objectives of the facility and also discusses the benefits of a GIS system for the college.

This chapter also describes the design of a GIS database and data model for the U-Block of the Kenya Polytechnic University College. The chapter finally discusses the GIS implementation of the database system.

Chapter Five presents conclusions and recommendations arising from the study.

CHAPTER TWO: LITERATURE REVIEW

2.1 Facilities Management

A facility is a building or place that provides a particular service or is used for a particular industry. It may be a space or an office or suite of offices; a floor or group of floors within a building; a single building or a group of buildings or structures, which may be in an urban setting or freestanding in a suburban or rural setting. The structures or buildings may be a part of a complex or office park or campus. A facility can also be thought of as a support service or physical resource of an institution which is key to the institution's business, for example, bulbs and water taps (Bruce, B. et al (2006*)*.

Facilities, therefore, include such structures as grocery stores, auto shops, sports complexes, jails, office buildings, hospitals, hotels, retail establishments, roads, pipelines and all other revenue-generating or government institutions (*Kenneth, 1995)*). Kenya Polytechnic University College fits in the category of government institutions.

2.1.1 Definition of Facilities Management

Facilities management (also referred to as Asset management) encompasses all activities related to keeping a complex set-up of structures, people and processes operating. In an institution such as the Kenya Polytechnic University College, the purpose of facilities management would be to maintain proper operations of its buildings as physical resources. Facilities management could therefore be considered as a general term for the management of the space and assets contained within buildings and structures (Alexander, 2004). Here assets refer to floor areas, room areas, vertical penetrations such as lift shafts, and stairwells, as well as people or employees.

Due to the complexity of facilities and their characteristics, an integrating system that brings together both the spatial and the non-spatial data is required. Such a Facilities Management System (FMS) would then be said to cover the planning, control and management of buildings for optimum utilization of real estate, infrastructure, and maintenance.

FMS would therefore be utilized, for instance, when one needs to know how many rooms there are on a floor of a building or how many desks and chairs there are in those rooms. Facilities Management Systems also help in determining the number of stations in a room. 'Number of stations' is an expression that identifies the capacity of a room for selected room-use categories. The concept of stations is an important one for classrooms, laboratories and other similar spaces, since it can help in determining the number of occupants a particular space (room) is designed to accommodate. This information is vital for comparing the designed capacity to the actual utilization or in assigning or scheduling the space.

2.1.2 Developments in Facilities mapping and Management

Modern methods of managing facilities involve the application of integrating technologies such as GIS to bring together resources and activities to support decision-making in an organization (Wyatt, 2003). Management of facilities consists of such activities as inventory, inspection and maintenance, with more emphasis on graphical detail or precision. This shortcoming of dealing with only graphics has however been mitigated by the introduction of automated mapping technology which generally, utilizes limited database management systems (DBMS) technology (Barret, 2003) to relate tabular data to mapped area, for production of statistical or choropleth maps.

The problems of handling data manually (either as maps or as tables), necessitated the introduction of Automated Mapping (AM) and Facilities Management (FM). This was the realization that there was need to relate computerized tabular data with a data layer containing the local geography, e.g. rooms and specialized utility information such as telephone posts, bulbs and power sockets (Montgomery, 1993). During 1960s, 1970s and 1980s, special AM systems that could help organizations manage their facilities based on Database Management Systems (DBMS) technologies were developed.

The combination of the functionalities in AM, FM and GIS result in an AM/FM/GIS system which moves facilities management beyond mapping to analysis and management of not only space, but the utility network as whole. It is necessary to note that facilities management is simply a specific GIS application that deals with utility facilities (Fig. 2.1).

The main function of any AM/FM/GIS is to spatially model facilities and store the attributes of these entities in a Relational Database Management System (RDMS) for purposes of analysis, response to queries and creation of maps or some form of report. The attendant GIS tools can be applied to room-sized assets and other properties. Information about such facilities is then used to support maintenance and operation, property management (i.e. acquisition, disposal, refurbishments, and redevelopment), human resources, capital planning inventory services and information services (Wyatt et al, 2003).

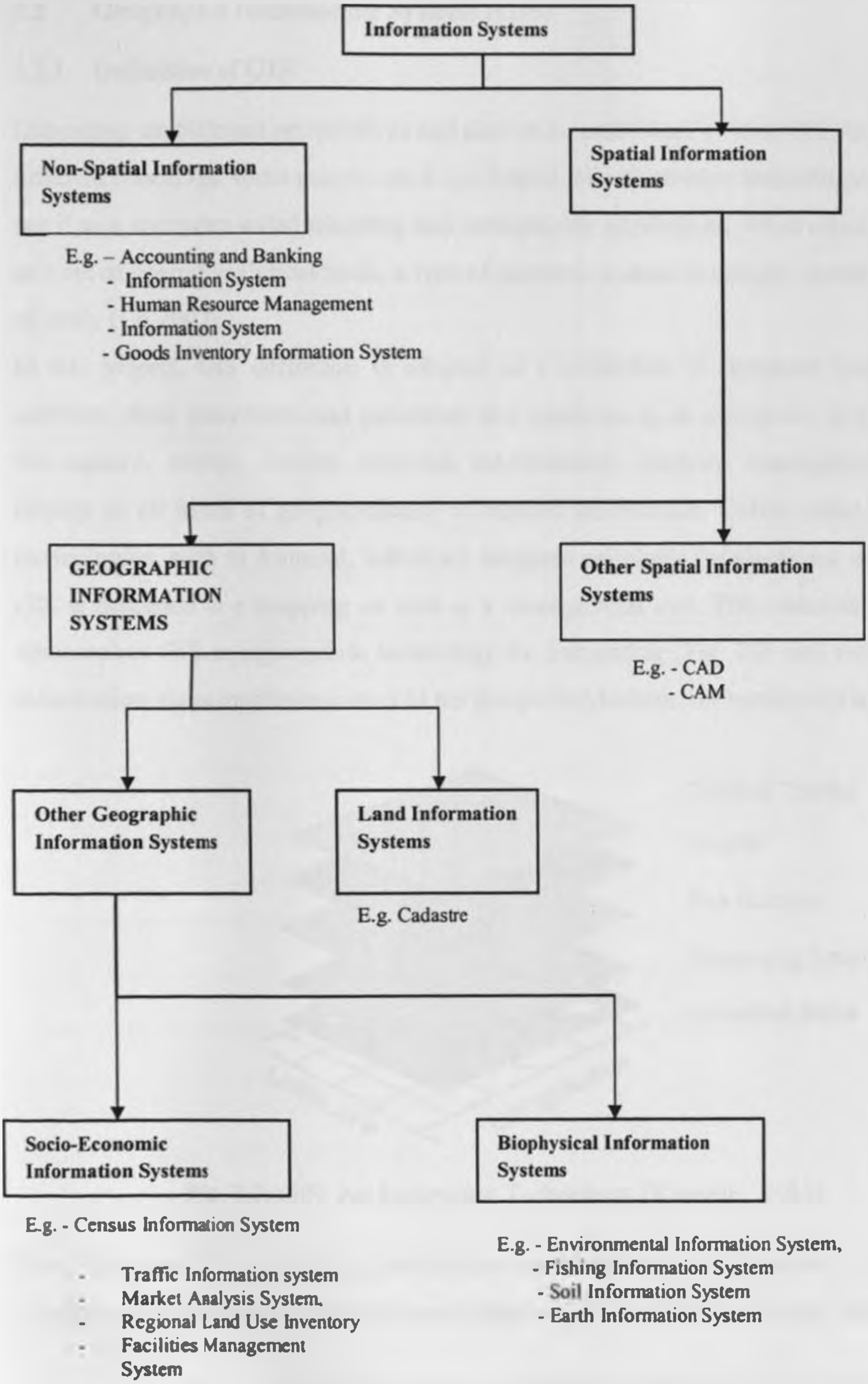


Fig. 2.1: Typology of Information Systems (Lo, 2004)

2.2 Geographic Information Systems (GIS)

2.2.1 Definition of GIS

Depending on different perspectives and also on an individual's view, GIS may have different meanings; some people see it as a branch of information technology; others see it as a computer-aided mapping and cartographic application, while others see it as a set of spatial-analytical tools, a type of database system or simply another field of study (Lo,2002).

In this project, GIS definition is adopted as a collection of computer hardware, software, data, procedures and personnel that functions as an automated system for the capture, storage, update, retrieval, manipulation, analysis, management and display of all forms of geographically referenced information. Unlike other related technologies, such as Autocad, which are designed primarily for electronic drafting, GIS is designed as a mapping as well as a management tool. This characteristic is what makes GIS an appropriate technology for integrating (Fig. 2.2) and managing information about institutions such as the Kenya Polytechnic University College.

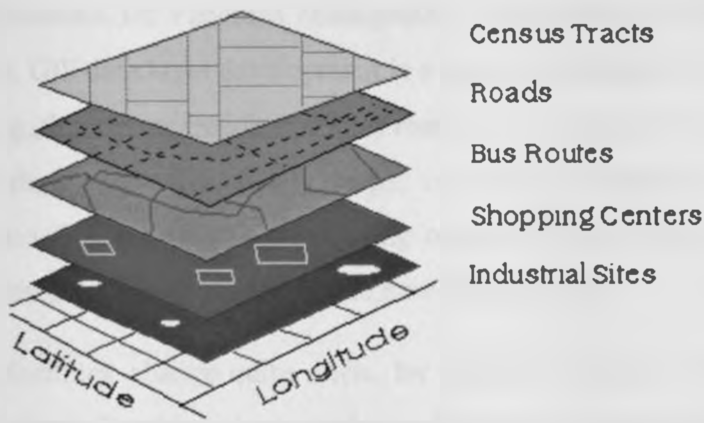


Fig. 2.2: GIS: An Integrating Technology (*Kenneth.*, 1995)

The following GIS technology distinctions are identified as appropriate tools for integrating an institution's spatial data (**Eckstein, 2007 and Onsrud et al, 1996**):

(i) GIS stores data in a database, together with the associated map graphic. This characteristic allows the creation of intelligent maps, more efficient storage, and retrieval of data, spatial analysis and other benefits.

(ii) The data model used with GIS Software allows for specialized functions and analyses, such as the ability to map features topologically. This is the characteristic which allows for spatial analysis such as proximity analysis, buffering, spatial queries etc.

(iii) Data is referenced to an established coordinate system, which allows relations to be established between different maps and databases

(iv) GIS software may be used as a data integrator; a functionality that provides the ability to tie together a number of different software tools into one spatial data management system.

From the foregoing paragraphs, it is clear that there are numerous possibilities on how GIS can be used, among them as a facilities management tool.

2.2.2 GIS Data and Concepts

In developing a GIS database for Facilities Management, preparation of GIS data layers is a pre-requisite. GIS data layer development is a process of digitally creating real world features (e.g., buildings, building floors, roads, water areas). The layers can be created from digitizing off hardcopy maps, converting Computer Aided Design (CAD) data into GIS formats, or from using remotely sensed data (aerial photographs, satellite imagery) to extract and create new GIS data sets.

GIS data concerning facilities change quite often, for instance blowing of bulbs, change of offices and others. Tracking, documenting and reporting of these changes, therefore becomes an everyday reality for many organizations. To optimize these functions, GIS technology has been utilized.

2.2.3 GIS Applications

The use of GIS in the public sector has increased over the last couple of decades. More recently, GIS has been used in a variety of fields such as crime prevention, health care, urban replanning, environmental policy as well as traffic control (Valcik, 2003). As a practical tool for improving work processes, the GIS technology has many possibilities of application; for instance, rather than physically walk to a building to determine what type of light bulb needs replacement, this information can easily be accessed from a database. All that is required is a click on a specific fixture shown on a map, e.g. a room, and a range of applicable information could be displayed, including the bulb type.

For large and expanding organizations, room space management is a major issue, which, for example, in 1995, space management led to the mapping of a building housing the Healthcare Trust facility at Bristol, United Kingdom (Wyatt et al, 2003). The internal room layout of the Bristol facility was mapped and the attribute data collected in order to assist with space planning at the hospital. After capture, the floor plans and room-specific attribute data could then be viewed and analyzed and displayed (if required), as thematic or choropleth map, indicating room use.

At the University of Minnesota, in the United States of America, managing a floor space of approximately $2.2km^2$ in an institution of 80,000 students and staff, utilizing 1000 buildings, proved difficult. A Facilities Management System was therefore designed to help human resources, university services, telecommunications and other departments that used spatial identifiers (building or room numbers) as a primary method of organizing data. The GIS system so designed provided information on occupancy, size, programmes, accessibility etc. which could be linked to other departmental systems. A graphical navigation and query interface linked a number of floor plans and campus maps with thousands of database records. The purpose of the campus maps was to provide information on buildings while floor plans provided information on rooms.

A recent application of facilities management took place in Egypt (Sobeih, 2005), where the Ministry of Education initiated a project to develop a GIS that provided information on the status of educational buildings. The project consisted of basic statistical demographic data on gender, age, administrative division, geographical area and level of education. Another layer included school maps, quality control and electronic archiving, while the third layer consisted of project monitoring, specialized programs analyzing the building's requirements, planning for studies and class scheduling.

The foregoing discussion portrays the management of space as an important element in facilities management. Neglect of management of buildings and facilities will impact on an organization's performance. Buildings and facilities have the potential of enhancing performance by contributing towards the provision of optimum working and business environment (Atkins, 2005).

GIS was applied in a different manner at the Davis Campus of the University of California and at the District of Columbia (Kilical, 1996). In the case of the Davis Campus, the GIS was developed for purposes of physical, environmental and capital planning, whereas in the District of Columbia, the GIS was developed to manage school and administrative land and building facilities.

2.3 Geographic Information Systems Technology in Facilities Management.

2.3.1 Information Technology in Facilities Management

Facilities Management (FM) has become a focus of attention for both the academics and the practitioners (Atkin, 2005). The former view it as a rapidly developing field that offers, among others, rich sources of data that can be used to explain or develop theories about how buildings and other constructed facilities are managed. The latter regard it as an opportunity for business or as a means for controlling operational costs, depending on whether there is a primary interest in providing FM services or in processing them. GIS is only one of the many information technologies (IT) that have transformed the ways geographic data have been used to conduct research and contribute to society.

2.3.2 The Process of Facilities Management

Facilities Management is not a one-time event, but a continuous process. Events like office moves, floor maintenance and remodelling of a facility occur regularly.

The basic materials within the process of facilities management are maps of the facilities and other physical characteristics of the local environment. Through the characterization of these maps at different stages, it becomes easy to visualize the various management processes.

FM is, therefore, all about planning and managing the various events which constitute the life cycle of a facility. It encompasses distinct but linked stages (life cycles):

- Concept,

- Development,
- Implementation,
- Operations and Maintenance, and
- Renewal or Termination.

During the conceptual stage, the idea of a facility is articulated and the planning and design of the project started (Dhruv, 2006). This stage includes activities of preliminary Research and Development (R&D) which consists of verification of needs and requirements; assessment of technical feasibility, costs, benefits and risks; development of conceptual design; exploration of funding partnership, and definition of conceptual (as opposed to final cost) schedule and performance goals.

Under the development stage, project planning and design are completed and a proposal submitted, after which the project moves to the Implementation stage, where the project plan is executed.

Implementation entails construction and/or acquisition, system integration, commissioning, testing, acceptance, transition to operation and management of these efforts.

The fourth stage, Operations and Maintenance (O & M), on which this project is anchored, means the use of the facility for its intended purpose. At this level, often referred to as micro level facility management, is the maintenance and operations planning. As shown in Fig. 2.3, this is the stage at which five important processes take centre-stage: planning, managing, maintaining, rationalizing and accounting for all the services associated to a facility, while at the same time trying to reduce the associated costs (Robeel, 2006). For an educational institution, the O&M stage includes work required to support and conduct all forms of educational activities so as to ensure that the facility operates efficiently and cost-effectively.

Like any other project, a facility has a time lifespan. The O&M stage also acts as a feedback stage, so that at the last stage, Renewal or Termination, decisions regarding continued support of the facility are made. FM will be used to determine whether the facility will be renewed, upgraded or terminated.

Fig. 2.3: FM Process **(Dhruv, 2006)**

2.3.3 GIS Technologies in the Process of Facilities Management

A variety of technologies and information sources are involved in the process of Facilities Management. The use of GIS in the public sector has increased over the last couple of years. A GIS utilizes automated mapping and DBMS technology to relate data to digital maps and to allow for the creation, storage, maintenance retrieval, analysis, and the display of the various geographic and tabular information in question.

As already indicated, the power of GIS technology is in its ability to integrate database operations with visualization and analysis offered by a digital map interface. In FM, the technology is effectively used to manage such records as as-built drawings, parcel information, utility data and facility use data. This ensures that such critical records receive effective protection from deterioration.

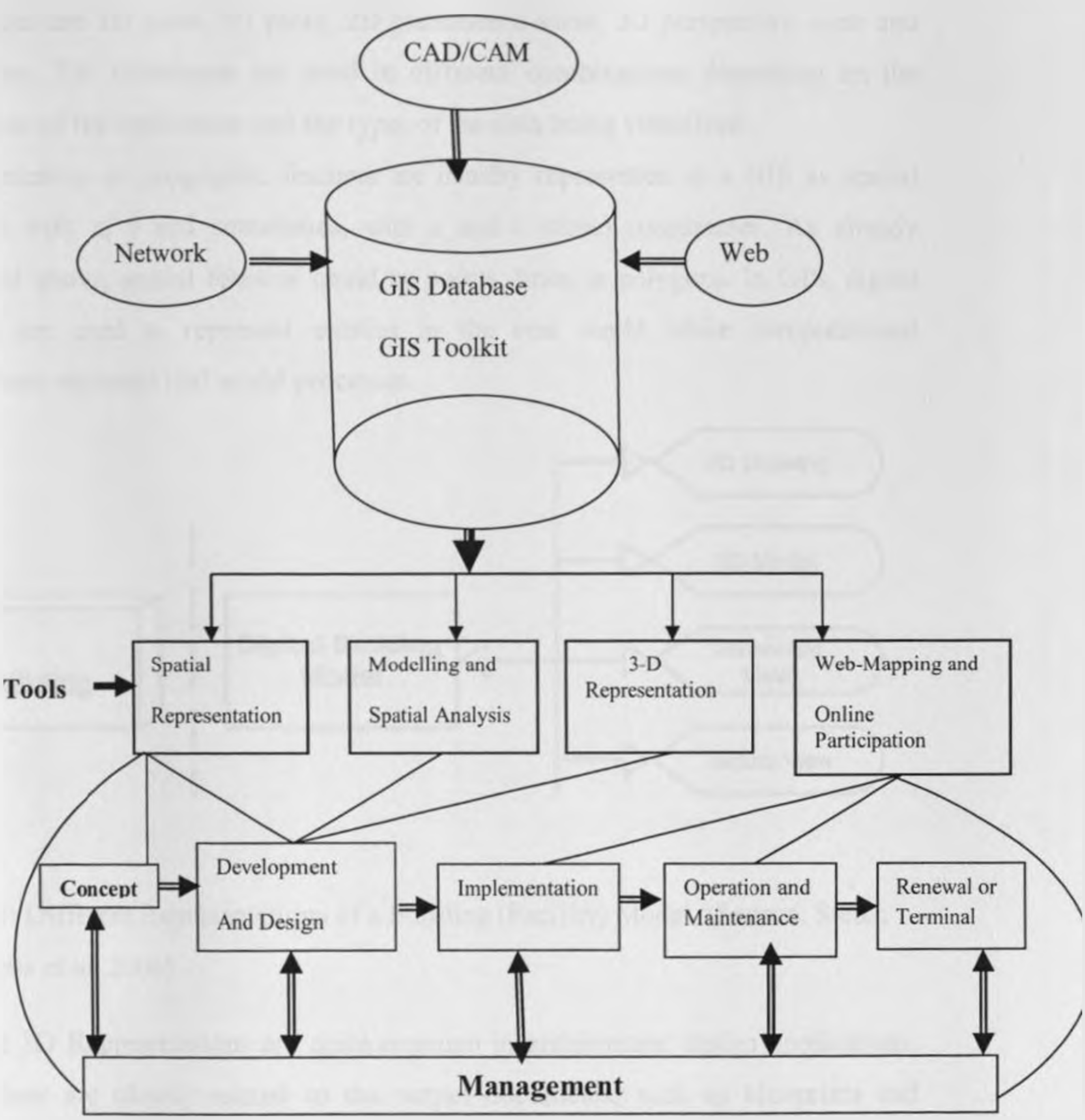


Fig. 2.4: Computer Technologies in the process of FM (Source: Zhitao, 2003)

Fig. 2.4 shows some technologies connected within GIS to develop four aspects of digital tools that can be used in the process of FM, as explained in the following sections.

2.3.4 Spatial Representation

The goal of data representation in GIS is to provide spatial characterization of thematic 'layers' at desired scales and level of detail (Karl, 2006). The representation is usually an abstraction of reality, for instance, a point representing a city or a line representing a highway. Visualization of such geographic information can be done using a variety of techniques (Lo, 2002). The commonest five of these techniques are 2D plots, 3D plots, 2D planimetric view, 3D perspective view and animation. The techniques are used in different combinations depending on the objectives of the application and the types of the data being visualized.

Representation of geographic features are usually represented in a GIS as spatial features with x, y and sometimes, with z and t (time) coordinates. As already indicated above, spatial features could be points, lines or polygons. In GIS, digital objects are used to represent entities in the real world while computational procedures represent real world processes.

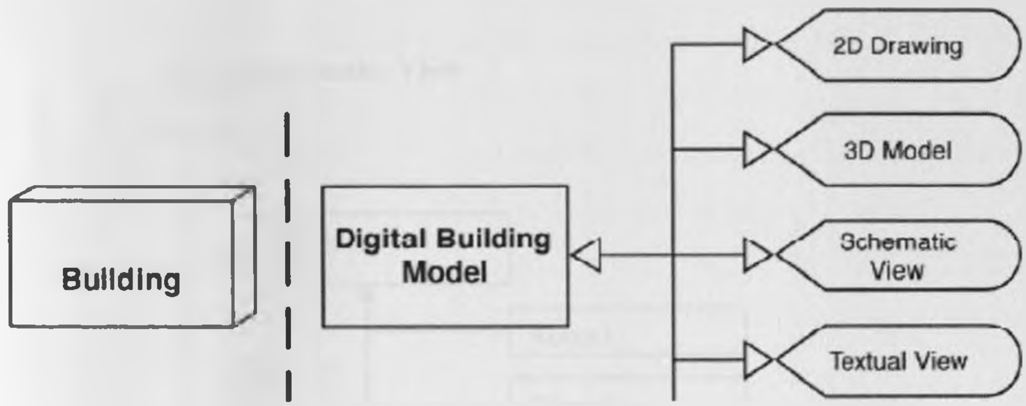


Fig. 2.5: Different Representations of a Building (Facility) Model. (Source: Stefan Boeykens et al ,2006)

2D and 3D Representations are quite common in architectural design applications, since they are closely related to the output documents, such as blueprints and perspective images. A Schematic view (Fig. 3.4) is a conceptual view on objects and their relationships. Hierarchic views ((Fig. 3.5) display parent-child relations and show which elements are dependent from other elements. Both these Figures are visual representations, showing information that is almost impossible to decipher from regular 2D or 3D Representations.

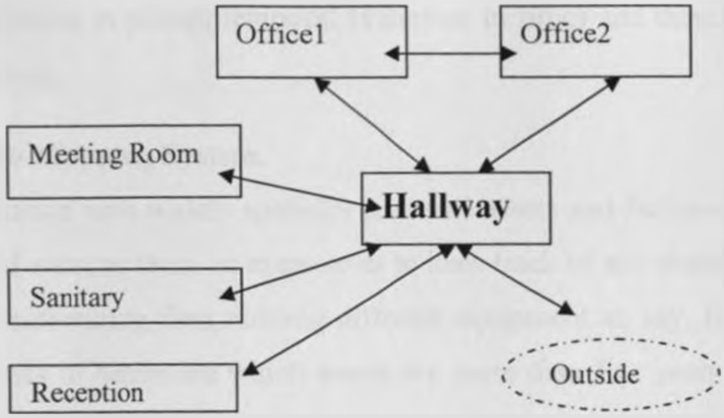


Fig. 2.6: Schematic View

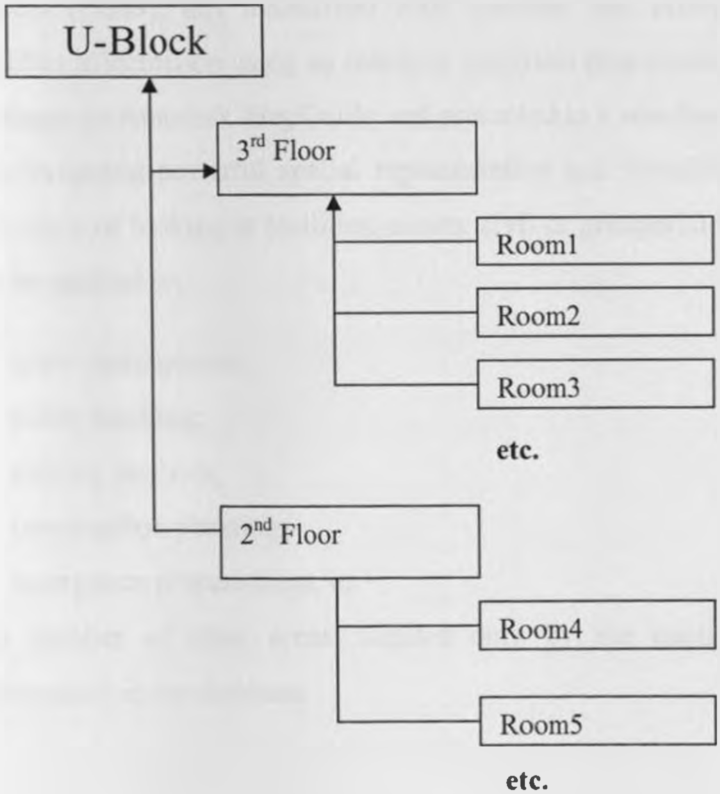


Fig. 2.7: Hierarchical View

2.3.5 Three Dimensional Representation

3D representation is an expression commonly used to define the ability of making a virtual world, using 3D computer models so to give people a feeling of reality in the imaginary (virtual) world. In the traditional design process, designers always use perspective renders to express their design and planning ideas (Teicholz, 2001). The components of the three dimensions of the real world that are so visualized are the spatial (variation in place), temporal (variation in time) and thematic (variation in characteristics).

2.3.6 Web-Mapping System.

An organization with widely spatially scattered assets and facilities requires means and ways of viewing them on maps so as to keep track of any changes. For instance, a large manufacturing firm running different equipment at, say, five sites across a country needs to determine which assets are more than five years old so that they can forecast for the next year's equipment purchase or maintenance budget (Myung-Hee et al, 2000). Using web-based application such as Online Spatial Information System (OSIS), any authorized staff member can access and query asset and facilities information using an intuitive graphical presentation system based on such packages as Autodesk MapGuide and presented in a standard web browser.

The foregoing powerful spatial representation and visualization capability permits new ways of looking at facilities, assets, civil or geospatial information. Such views can be applied to:

- space management;
- utility tracking;
- parking analysis;
- construction planning;
- emergence preparedness, or

any number of other areas, limited only by the quality and quantity of the information in the database

CHAPTER THREE:METHODOLOGY

3.1 Definition of goals and objectives

The steps to follow in structuring institutional facilities data and how to perform these steps and eventually show why those steps should be taken in that particular order will be described in this chapter. The end result will be a working institutional database. The process of achieving this will entail database design, data collection, its input as well as its conversion. The two major components of this facilities management system that will not be avoided are the software and hardware. Without the two, there will be no computer-based GIS database systems.

Like any other academic institution, Kenya Polytechnic University College is increasingly facing challenges to improve the management of its support services. These services are vital for providing better quality outputs to meet the needs of its students, academic staff, customers and visitors. Better co-ordination between core activities and support services within the institution's facilities means that the College can respond faster and more effectively to those demands for services.

The facilities of such an institution include a great deal of information or data. The work of this Facilities Management System is therefore to establish an integrated resources infrastructure and management approach that will enable the institution to support the delivery of core activities and meet the clearly identified and agreed needs of its customers. The best way of integrating resources within this kind of institution is that of composing a sound database. It is therefore important to identify the information needed, with goals and objectives acting as determinants of the critical data that will be recorded in the resulting GIS Database.

In designing a database for the U-block of the Kenya Polytechnic University College, it is necessary to trace the right kind of information. In other words, examine not only the current needs, but also what might be of importance in the long run. On that account, such considerations as file management, data tracking, data selection, data conversion as well as data retrieval will be necessary. Also to be considered are the required flexibility, documentation, customer involvement, inventory vs. transaction, capacity vs. speed and the breadth and control of the information.

3.2 GIS Database Design

The foundation of any GIS is its database. A GIS is an empty shell until an appropriate database is assembled. A database is defined as a unified computer-based collection of data, shared by authorized users, with the capacity for controlled definition, retrieval, manipulation and presentation of data within it (Derek, 1999). The objective of collecting and maintaining information in a database is to relate facts and situations that were previously separate; for instance in the case of facilities management, a database acts as the meeting point of spatial data (floors and room space and their characteristics.

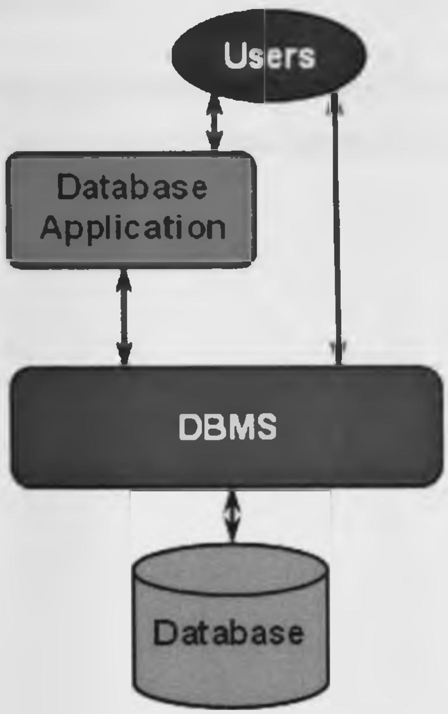


Fig. 3.1: The components of a database system. (Gerald, 1998)

In an institutional set-up, decisions about the institution's funding, renovation, modernization, and infrastructure improvements need to be supported by high quality and timely data. This requires that there be a framework for collecting, evaluating, and maintaining institutional data which will then be used to answer important policy questions about the institution's facilities. This demands that there be a complete and current institutional facilities database system (with its attendant components as shown in Fig. 3.1), that should be able to answer questions concerning: the inventory, condition, utilization, management, and funding of the public institution in question.

Database design is the activity of specifying the schema of a database in a given data model (description or view of the real world) (Sikha, 2003). Here, data schema is defined as the structure of a database that:

(i) captures data types, relationships and constraints in data;
(ii) is independent of any application programme; and
(iii) changes infrequently

The phases of designing the Kenya Polytechnic University College database will follow database the fairly standard format shown in Fig. 3.2.

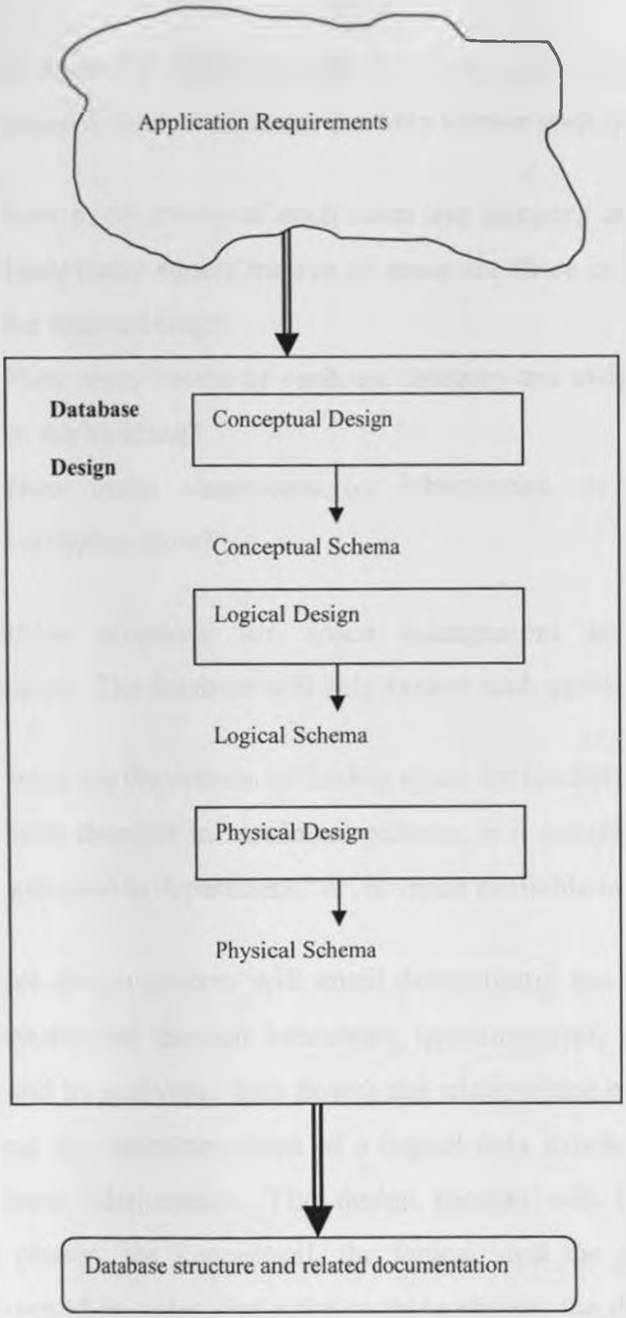


Fig. 3.2: Database Design Phases (Source: Gerald, 1998)

Possible uses of an institutional database for institutional planning and management include:

1. Detailed room-by-room listing for each floor. Such reports for floors will answer questions such as:

   - what is the use of each room?
   - What is each room's floor area and number of stations?
   - To what department is the room assigned?

2. Summaries for building/floor by room use category and departmental assignment. Such summaries can help answer such questions as:

   - how many rooms of each room use category are there in the building? How many square metres of space are there in each room use category for that building?
   - How many rooms of each use category are assigned to each department in the building?
   - How many classrooms (or laboratories, or offices, etc) does the institution have?

3. facilities inventory for space management and facility management decisions. The database will help answer such questions as:

   - what are the options of finding space for teacher "X"?
   - with the shift in enrolment patterns, is it possible for some of the space assigned to department "A" be made available to department "B"? etc.

Our database design process will entail determining: the data to be stored in the database (established through interviews, questionnaires, observing existing work processes, and by analyzing data flows), the relationships between the different data elements and the superimposition of a logical data structure upon the data on the basis of these relationships. The design process will be carried out in three sequential phases: the conceptual, the logical, and the physical data modelling phases. It should be noted that prior to these phases, the data to be stored must be known.

In the conceptual data modelling phase (see Fig. 3.2), the aim is to describe the information used by the Kenya Polytechnic University College in a way which is not governed by implementation-level issues and details. At this stage, it should be easy even for non-technical staff to contribute to discussions. A common method of analysis involves identifying:

1. the entities (persons, places, things etc) which the organization has to deal with;

2. the attributes – the items of information which characterize and describe these entities; and
3. the relationships between entities which exist and must be taken into account when processing information.

Once the relationships and dependencies amongst the various pieces of information are determined, the data will be arranged into a logical structure which will then be mapped into storage objects supported by the database management system (DBMS) in question. For instance, in relational databases, the storage objects are tables which store data in rows and columns. Out of the U-block room inventory carried out, nine normalized tables have been created.

The physical design of the database specifies the physical configuration of the database on the storage media. This includes detailed specification of data elements, data types, indexing options and other parameters residing in the DBMS data dictionary.

Once the floor and room information has been collected and structured, the resulting database will be able to provide a variety of reports for the institution's use, and where appropriate, for inter-institutional, system-wide or national surveys. This database would also be able to support ad hoc inquiries in support of space management and facilities management activities. For many purposes, graphical presentations can convey the intended message more effectively than tabular arrays of data and hence the necessity of reporting room usage in map form.

3.3 Data Collection

The Kenya Polytechnic University College has very few architectural drawings of most structures (buildings). The U-block is no exception on this. Only drawings of the 1st and 3rd floors of the said U-block could be located in the Head of Department's office. To generate layers for all the floors, it will be necessary to re-generate them from one of the existing drawings by digitizing. In any case, this is inevitable considering that several modifications have been carried out on the internal structure of the facility due to the increasing demand for space, for the learners as well as for teaching and non-teaching staff.

Data collection will involve an initial compilation of a set of room data, including assigning unique identifiers to the rooms and scaling building and room dimensions from the few available drawings. The College has not yet set up an electronic CAD storage system for ease of drawing maintenance. No attempt has been made to digitize the existing drawings, or even for the up-coming structures. In electronic form, such drawings could easily be kept up to date with subsequent renovations. They could also be linked with inventory files so that it is possible to update both files simultaneously.

For this project, the internal room layout of the U-block is mapped through digitization and the attribute data collected in order to assist with space planning and management at the Kenya Polytechnic University College. The four-storey building comprises a ground floor and three upper floors. The floor plans (after digitization) and the room-specific data are viewed and analyzed using GIS software.

The rooms for each floor of the building will be mapped in separate layers within the ArcView GIS. This will allow the creation of thematic or choropleth maps for purposes of illustrating the following:

- room use, e.g. reception, workshop etc
- any of the attribute data stored in the database for each floor.

A number of rooms are no longer being used for what they were initially intended. During the inventory, it is essential to check the use of each room. Any discrepancies between drawings and the actual rooms will be corrected hence providing an opportunity to update the floor plan drawings.

3.4 Data Input and Conversion

The Kenya Polytechnic University College database will be constituted by two different types of data, namely graphic and non-graphic. These will have to be developed and reformatted in the database. The process of carrying out the exercise will require substantial investments in terms of personnel, time and financial resources. However, the developments in GIS have now enabled the provision of data input and conversion tools with GIS capabilities. The alternative will be to contract out the data input and conversion to a competent firm as happened to the School Mapping Project in Kenya.

Four types of data entry and conversion in GIS data development have been described in (Van, 1991) as:

- Photogrammetric compilation and digitizing using an analytical stereoplotter,
- Automation of existing maps using a digitizer or scanner,
- Keyboard entry of data, and
- Transfer of existing digital data.

For the current project, the two methods used for the input and conversion were digitization of the existing architectural drawings and the linking of the resulting spatial data with the non-graphic data. The main application software that will be used for the purpose will be ArcView GIS and/or ArcGIS, Microsoft Access or Microsoft Excel, which provide most operations of data input and conversion. The operations will include graphic processing capabilities that allow users to digitize and edit maps, geo-database management that includes capabilities to input and manage non-graphic data associated with map features, and conversion tools to transfer files with different formats, for example, from Ms Access to ArcView.

3.5 Software and Hardware

The software discussed here is that provided with GIS capabilities for mapping, management and analysis of geographic data. Such a package should have the following four components; that for:
- geographic processing,
- database management(DBMS),
- graphic user interface(GUI), and that with
- spatial analysis capabilities.

Geographic processing capabilities allow for data entry, editing, display and plotting of features and maps. The DBMS handles the storage and retrieval of non-graphic data linked with graphic features. The GIS software, therefore, provide for analytical tools such as query, buffer and geocode, which are used to create intelligent digital maps for purposes of analysis and querying for more information or for presentation.

In this FM project, the two main GIS software packages used are ArcView and ArcGIS, together with MS Access and, to some degree, Excel. The combined functionalities of these packages are able to provide for geographic processing, DBMS, spatial analysis and GUI through plugs or extensions that add and improve functionality to the packages.

On the other hand, hardware is any physical device that is used as part of a computer system. A standard hardware infrastructure includes the components of data input (e.g. copying maps by manual tracing on digitizer tables, keyboard entry, CD-ROM and tape readers, scanners, GPS and networks such as internet); data management and analysis, and output (e.g. display on computer monitor, sophisticated maps and virtual reality). Other output devices include plotters, CD-ROM or DVD disk, depending on the eventual use of the product in question.

CHAPTER FOUR: RESULTS AND DISCUSSION

4.1 Introduction

The aim of this project was to develop an integrated GIS of the U-block of the Kenya Polytechnic University College, and to use the system so developed to make recommendations to the institution's management on cost-effective methods of utilizing its resources. Based on this, the previous chapters of this report have discussed not only the GIS technologies aiding in the traditional processes of facilities management, but also the efficiency of the GIS tools used in FM, together with the methods of geo-database system design for FM. In this chapter, GIS is used to create a geo-database for the U-block of the Kenya Polytechnic University College for purposes of space planning and management.

4.2 Background

The U-block building of the Kenya Polytechnic University College has several rooms, at least 70 excluding the partitioning of the toilets at the different floor levels. The ground floor has 22 rooms, the first floor 19, the second floor 17, and the third floor 14. In total, ten uses have been identified:

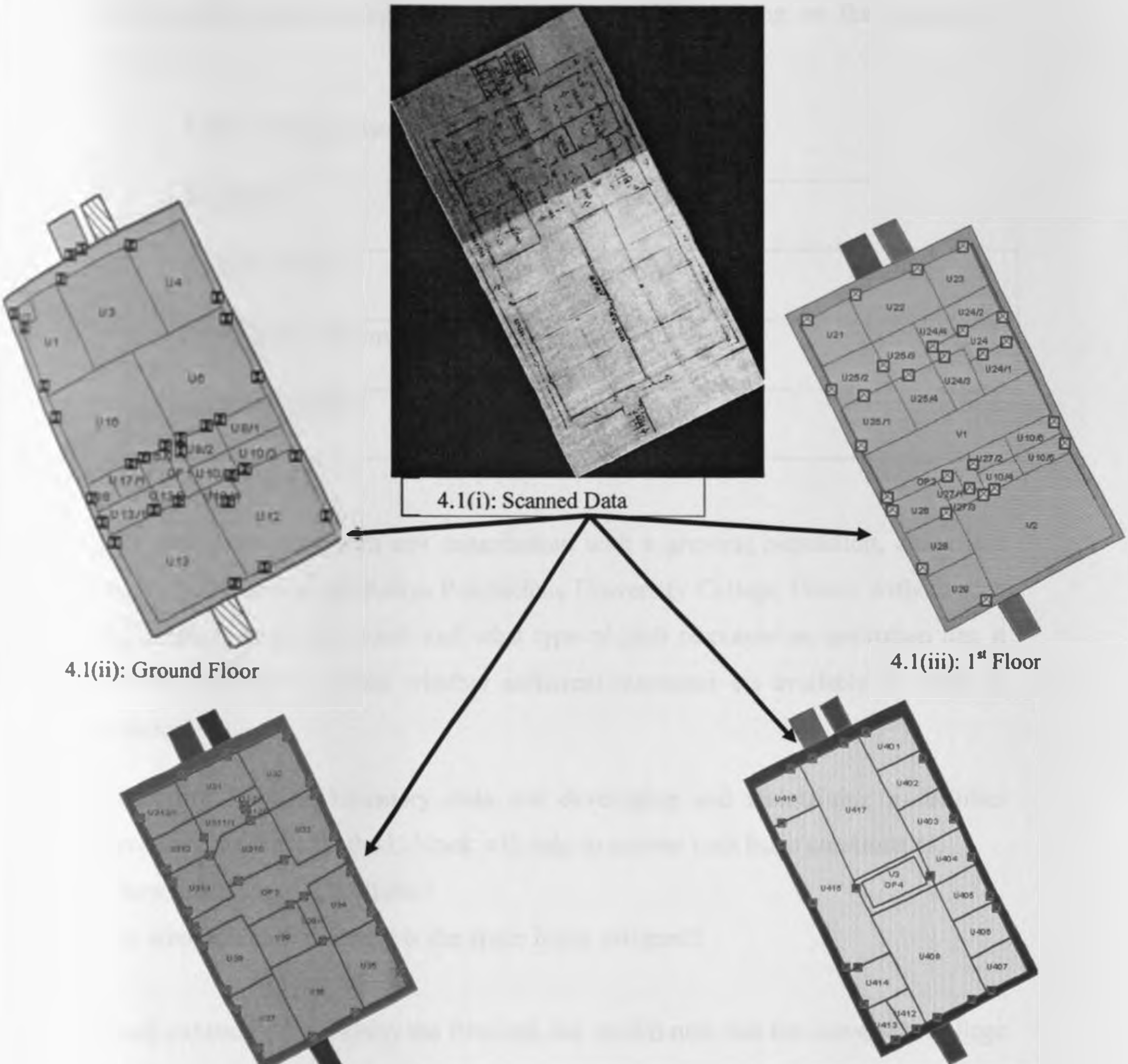
- Workshop,
- Laboratory,
- Office,
- Classroom,
- Open space,
- Reception,
- Canteen,
- Staffroom,
- Corridor,
- Store,
- Toilets,
- Kitchen,
- Lecture Theatre,
- Examination room.

Some of the rooms are assigned to specific departments while others are common to not only the two departments which occupy the building, but to others as well. Each of these rooms may be having service utilities such as water, electricity, telecommunication network and others. Different types of furniture and equipment may also be found in the rooms (Tables 4.3(ii) and 4.3(iv)). All the utility services, furniture and equipment are treated as attributes to the spatial data of rooms and floors. For ease of identification, various codes have been assigned to the various attributes as already indicated in the referenced tables above.

4.3 Data Collection and Analysis

Only old floor plans, dated 1974 and 1993 respectively, for the 1st and 3rd floors were available for the U-block. It was decided to use the 1st floor plan (after scanning it) to reconstruct all the other floors (Fig. 4.1) in digital format, using ArcView. It did not matter which floor plan was used, as both maintained the external extent and the lengths between columns remained the same.

Next, data pertaining to all the rooms within the building was collected. This data included the room's identity code and its area computed automatically by use of the Structured Query Language (SQL) query, the number of light bulbs per room, the number of power sockets in a room, the number of water taps in a room, the number of doors and windows per room, the floor level as well as the number of telecommunication ports in a room. Also collected were the numbers of security lights per floor including those in the male and female toilets.



4.1(i): Scanned Data

4.1(ii): Ground Floor

4.1(iii): 1st Floor

4.1(iv): 2nd Floor

4.1(v): 3rd Floor

Fig.: 4.1: U-Block Floor Plans

Scale: 1:750

As a result of digitizing, room spaces which were supposed to be equal in area show slight differences (Table1: Compare rooms: lecture theatre and Examination room on 3rd floor and (U36+U39+U39/1 on 2nd floor) as one. This would be as a result of difficulties in maintaining positional accuracy when picking on the features to digitize.

Table 1: Comparison of Areas

Room(s)	Area (m^2)
Lecture Theatre	178.500
Examination Room	184.890
U36+U39+U39/1	190.051

Just like is the case with any organization with a growing population, space is a primary resource of the Kenya Polytechnic University College. Hence without such information as to how much and what type of such resources an institution has, it will be difficult to assess whether sufficient resources are available to fulfil its mission.

Gathering facilities inventory data and developing and maintaining a facilities inventory database for the U-block will help to answer such basic questions as:
- how much space is available?
- to who/ which department is the space being assigned?

Such questions, particularly the first one, are crucial now that the university College is gearing to absorb extra students for the degree programmes in addition to the current diploma students. This will increase the student population thus increasing the demand for room space.

(Newfert, 2002) has proposed student and staff space requirements in a higher institution of learning as follows:

(i) Amount of space per student:
  - seating in comfort- $0.95m^2$
  - cramped conditions- $0.60m^2$

(ii) Offices for academic staff;
  - Professor – $22m^2$

- Lecturer – $15m^2$
- Assistant – $20m^2$
- Typist – $15m^2$

The amount of space per student/academic staff depends on:

- Type of seat,
- Depth of writing shelf, and
- The rake of the floor.

4.4 Database Design

Database design addresses the contents, specifications, relationships, and sources of data to be incorporated into the GIS database. It consists of phases that contain steps which guide the designer in the appropriate techniques at each stage of the project, and also helps to plan, manage, control and evaluate the development of a database. A data design can be thought as an approach for analyzing and modelling a set of requirements for a database in a standardized and organized manner.

The phases involved in database design are requirement collection and analysis (for purposes of documenting the data requirements of the users and the functional requirements of the database system), the conceptual design (aimed at describing the information used by an organization in a way which is not governed by implementation-level issues and details), the logical design (in which the conceptual data model is transformed into a standard form), and the physical design (at which stage we define the physical structure of the database).

4.4.1 Application Requirements and Analysis

The database developed in this project is meant to serve specific needs of the institution, such as monitoring the availability of space and frequency of maintenance of certain service utilities.

Currently, there is no laid down policy on how to generate policy documents, forms, reports and organisational charts, which are key areas of application in decision making in the running of the facilities in the institution. The existing information flow is such that if there is anything to be reported on the state of a room and the requirements there-in, then a staff member, through the Head of Department, places a requisition either to the maintenance Unit or to the Stores for action. Depending on the nature of the transaction required, the response time can be inordinately long. It is on this basis that respondents to queries put to the teaching and non-teaching staff within the U-block was affirmative that it is high time a faster system was put in place to enhance not only the reporting of issues, but also improve on the response time.

4.4.2 Conceptualization of the Problem

This stage of the database design was meant to describe the spatial and non-spatial information used by the Kenya Polytechnic University College in making decisions on facilities management aspects. Taking the U-block as a study case, the necessary entities, their relationships and the associated entity and relationship attributes were identified. A detailed data model commonly referred to as Entity-Relationship Diagram (ERD), (Fig. 4.2.), was then produced, identifying the important organizational data relevant to the envisaged database for management of the U-block. The logical data model then mapped the conceptual data model, based on the already targeted relational data model.

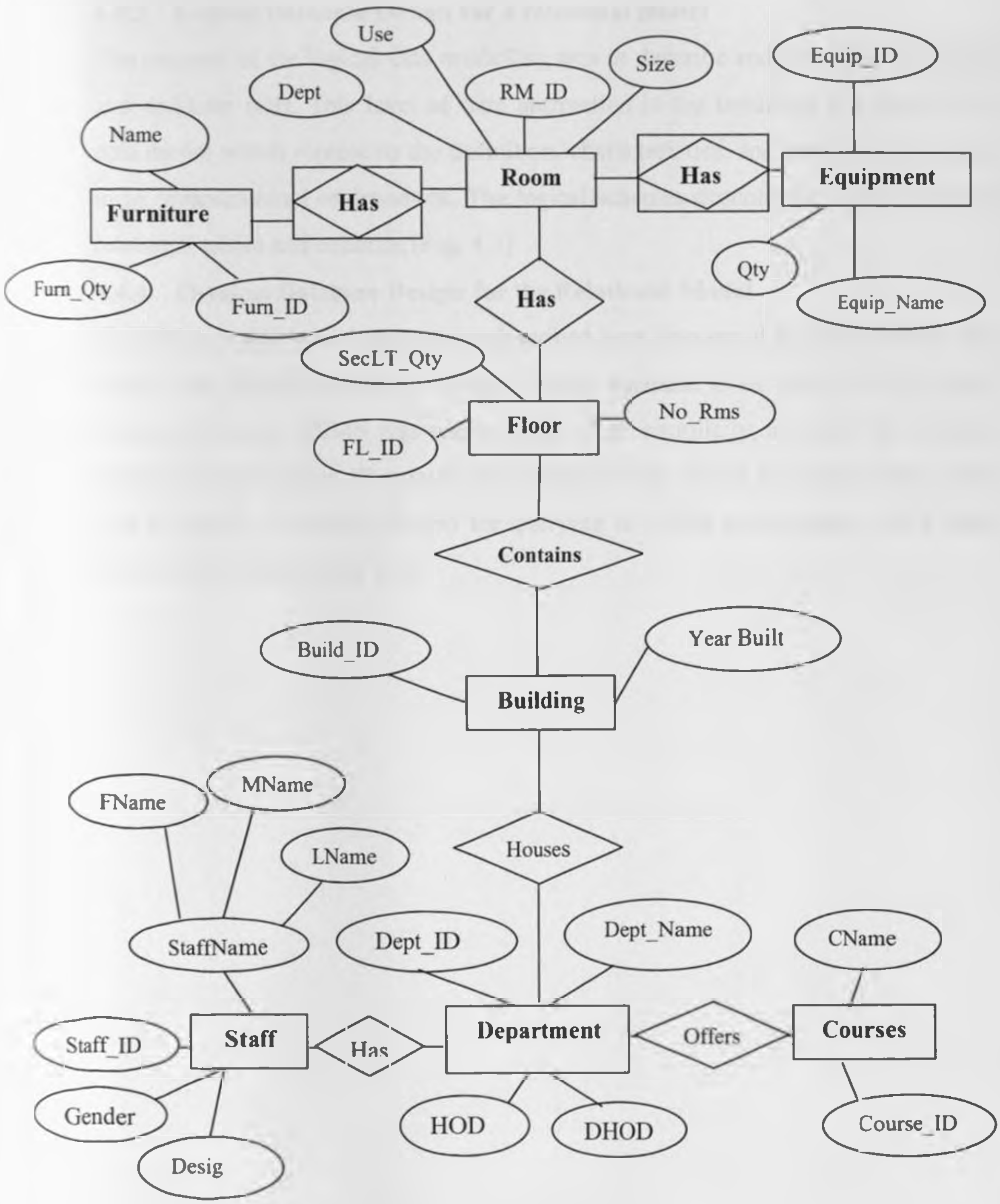


Fig. 4.2: U-Block Conceptual Model

4.4.3 Logical Database Design for a relational model

The purpose of the logical data modelling was to describe end-user data to systems and end-user staff. This level of data abstraction is the technique that results in a data model which represents the definition, characteristics, and relationships of data in an organizational environment. The logical schemas describe the data in terms of relational tables and columns (Fig. 4.3)

4.4.4 Physical Database Design for the Relational Model

The Physical database design phase described how data could be stored on the disk drives. The physical structure of the U-block database is an output of this phase. Microsoft Access DBMS was selected, due to its simplicity, to create the database tables and build tables. The database would be either linked or joined to the spatial data (U-Block rooms and floors) for querying in a GIS environment, using either ArcView or ArcGIS (Fig. 4.4)

Courses : Table

COURSE_ID	CNAME	DEPT_ID
[illegible]	Diploma in Building	B&CE
Cs305	Diploma in Civil Egineering	B&CE
Cs307	Diploma in Architecture	B&CE
Cs308	Diploma in Quantity Survey	B&CE
Cs310	Diploma in Highways	B&CE
Cs401	Higher Diploma in Construction(Beconomics Option)	B&CE
CS402	Higher Diploma in Construction(Structure Option)	B&CE
Cs406	Higher Diploma in Construction(B&CE Option)	B&CE
Sl401107	Higher Diploma in Land Surveying	S&M
Ss303106	Diploma in Land Surveying	S&M
St301107	Diploma in Technology(Geoinformatics)	S&M

4.3(i)

Furniture : Table

FURN_ID	FURN_NAME
[illegible]	Stool
02	Chair
03	Desk
04	Cabinet
05	File/General Shelf
06	Fridge

4.3(ii)

Staff : Table

ST_ID	ST_FNAME	ST_MNAME	ST_LNAME	ST_DESIGN	CATE	RM_ID	DEPT_ID	GENDER
[illegible]	David	Kabui	Kagia	Technician	BOG	U3	B&CE	M
098N00110	Andrew	K	Makau	Cleaner	BOG	U415	B&CE	M
098N00137	Janet	Chepkemoi	Chume	Cleaner	BOG	U24	B&CE	F
098N00152	Samwel	Keya	Lughano	Artisan	BOG	U16	B&CE	M
098N00160	Stephen	Mulwa	Ngolia	Cleaner	BOG	U6	B&CE	M
098N00196	Regina	M	Ndolu	Messenger	BOG	U24	B&CE	F
098N00216	Clement	Argwinge	Odia	Cleaner	BOG	U16	B&CE	M
098N00256	Henry	Onyango	Otenga	Cleaner	BOG	U312	B&CE	M
098N00290	Jane	W	Njuguna	Typist	BOG	U24	B&CE	F
098N00344	Mary		Mbithe	Typist	BOG	U24	S&M	F
098N00386	John		Mwangi	Technician	BOG	U39/1	S&M	M
099N00014	Anjelina	Akoth	Obeno	Cleaner	BOG	U24	B&CE	F
100N00022	Dismas	Mukoto	Lusichi	Technician	BOG	U312/3	S&M	M
102N00041	Margret	Wanjiru	Kihara	Cleaner	BOG	U13	B&CE	F
104N00001	Jackton	Kaire	Odongo	Technician	BOG	U/1	S&M	M
108N00001	Edwin	Omondi	Oyolla	Technician	BOG	U310	B&CE	M
108N00152	Paul	Mutiso	Musau	Technician	BOG	U4	B&CE	M
120236	Jackson	Simiyu	Wangili	DHOD	TSC	U2	S&M	M
[illegible]	[illegible]	[illegible]	[illegible]	Teacher	TSC	[illegible]	S&M	M

Record: 1 of 62

4.3(iii)

Floors : Table

FL_ID	RMS_NO	SECLIGHTS_NO
0	18	12
1	18	12
2	18	12
3	14	22
0	0	0

4.3(iv)

Room_Equipment : Table

RM_ID	EQUIP_ID	QTY
[illegible]	002	1
U1	003	1
U1	004	1
U1	005	1
U1	006	2
U1	007	2
U1	008	1
U12	042	1
U12	043	1
U12	044	1
U12	045	1
U12	046	1
U13	034	1
U13	036	3
U16	027	1
U16	028	1
U16	029	1
U16	030	1
U16	031	1

Record: 1 of 61

4.3(v)

Room_Furniture : Table

RM_ID	FURN_ID	FURN_Qty
[illegible]	02	2
U10/1	03	1
U10/2	02	2
U10/2	03	1
U10/2	04	1
U10/3	04	1
U10/4	02	1
U10/4	03	3
U10/4	04	1
U10/5	02	8
U10/5	03	6
U10/6	02	8
U10/6	03	5
U12	01	3
U12	02	4
U12	03	2
U13	01	5
U13	02	17
U13	03	17

Record: 1 of 199

4.3(vi)

EQUIP_ID	EQUIPNAME
[illegible]	Computer
002	B8
003	A9
004	Contact printer
005	Multiplex
006	Mistri Photo Mapper
007	Kern Plotter
008	Radial Plotter
009	Universal Testing Machine
010	Aggregate Crushing Value
011	Aggregate Impact Machine
012	Balance 15kg Automatic
013	Balance Platform
014	Balanve Avery
015	Balance Self indicating
016	Compression
017	Compacting Factor
018	Oven
019	Permeability Apparatus
020	Sieve Shaker

Record: 1 of 50

4.3(vii)

Departments : Table

DEPT_ID	DEPTNAME	HOD	DHOD
B&CE	Builoding and Civil Engineering	Mwangi	Ondiwa
S&M	Surveying and Mapping	Chika	Wangili

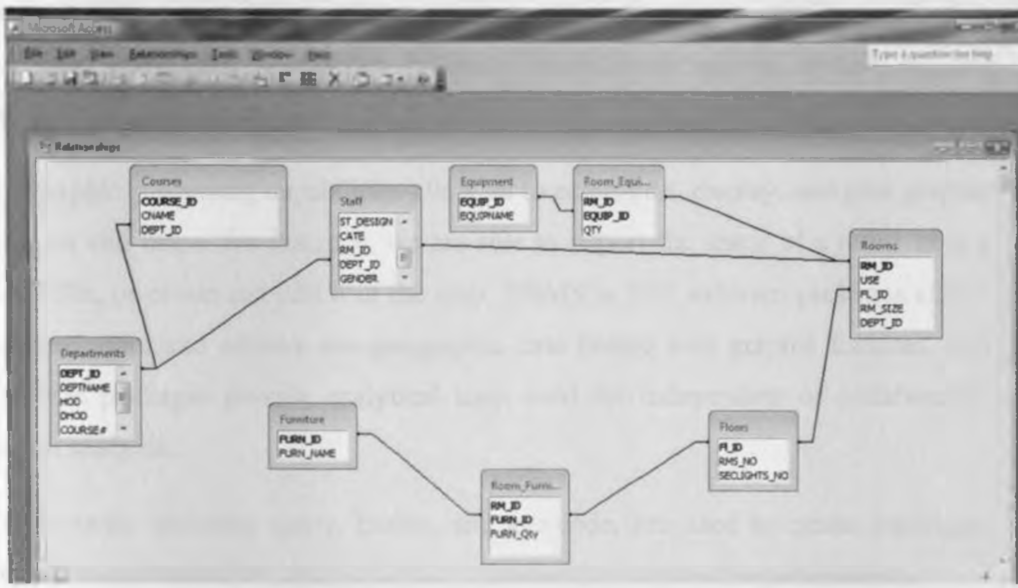
4.3(viii)

Rooms : Table

RM_ID	USE	BulbsQty	DoorsNo	WindsNo	PortsQty	SktsQty	WTapsQty	FL_ID
OP2	Open Space	1	1	1	0	0	0	1
OP3	Open Space	6	4	0	0	0	0	2
OP4	Open Space	4	2	2	0	2	0	0
U1	Laboratory	7	1	3	3	3	1	0
U10/1	Office	1	2	1	0	1	0	0
U10/2	Office	2	1	2	3	6	1	0
U10/3	Store	1	2	3	4	1	0	0
U10/4	Office	1	1	2	0	1	0	1
U10/5	Classroom	2	1	2	0	1	2	1
U10/6	classroom	2	1	1	0	1	2	1
U12	Maintenance Workshop	12	4	6	0	6	2	0
U13	Workshop	12	1	1	2	6	0	0
U13/1	Tools Store	1	2	1	6	1	0	0
U13/2	Office	1	2	1	6	1	0	0
U13/3	Open Space	1	2	2	0	1	0	0
U16/2	Tools Store	1	2	0	0	1	0	0
U17/1	Office	1	1	1	0	1	0	0
U2	Office	1	1	1	1	1	0	0
U21	Classroom	4	1	2	0	2	0	0
U22	Classroom	4	1	2	0	2	0	0
U23	Classroom	4	1	2	0	2	0	0
U24	Reception	1	1	1	1	2	0	1
U24/1	Office	2	2	2	3	3	0	1
U24/2	Office	2	1	2	3	3	0	1
U24/3	Store/Computer	1	1	2	2	2	0	1
U24/4	Office	1	2	2	1	1	0	1
U25/1	Staffroom	2	2	2	5	5	0	1
U25/2	Staffroom	2	2	2	5	5	0	1

4.3 (ix)

Fig.4.3: Logical Tables



4.4: Linked Tables

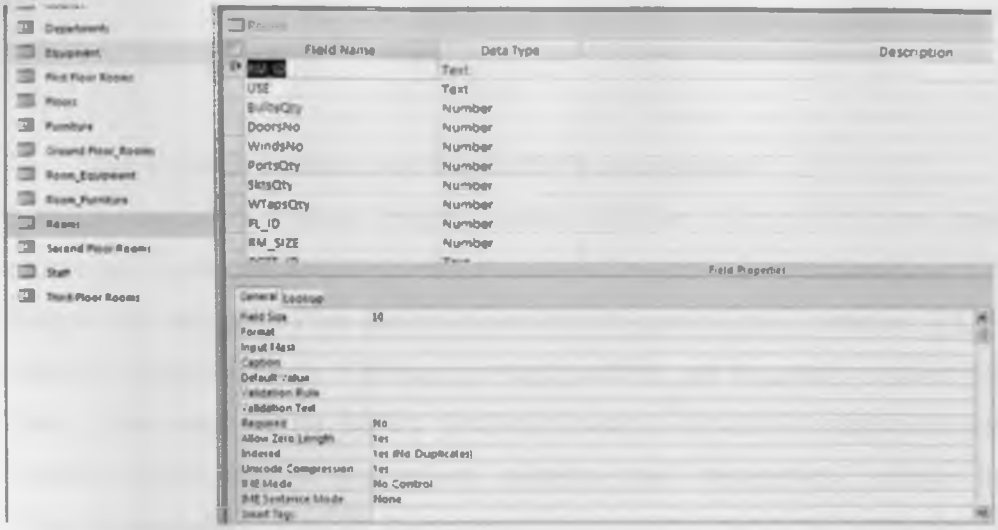


Fig. 4.5: Physical Database Design

4.5 Software and hardware

The software we discuss here refers to GIS application software that is provided in the form of software packages. These packages, consisting of multiple programs, are integrated to provide a variety of capabilities for mapping, management, and analysis of geographic data. There are four main components of GIS application software: geographic processing, database management system, spatial analysis utilities, and graphic user interface (GUI).

Geographic processing capabilities allow us to enter, edit, display, and plot graphic features and maps. For instance, we are able to import the shape of a room from a CAD file, or create and edit it in the map. DBMS in GIS software packages allows users to store and retrieve non-geographic data linked with graphic features. GIS software packages provide analytical tools used for independent or collaborative spatial analysis.

These tools, including query, buffer, and geo-code, are used to create intelligent digital maps to analyze, query for more information, or print for presentation.

In the GIS application of FM, two main GIS software packages, ArcView and ArcGIS , together with MS Access (which create and manage the non-graphic database) have been selected as the core software. The two GIS packages provide capabilities in geographic processing, DBMS, spatial analysis and GUI. They also have several extensions such as the 3D Analyst and Geo-processing that add and improve functionality to the package.

4.6 The U-block database and the facility's management

With the completed database design, together with the collected floor and room information, it was possible to provide a variety of reports for institutional use. The database also supports ad hoc inquiries in relation to general space management, for instance, critical appraisal of spaces to which students are frequently exposed like library, classroom, etc for factors circulation pattern, furniture arrangements etc. Possible applications for institutional planning and management include the following examples:

(i) Reports by floors: This is a room-by-room listing for each floor. Through this, we are able to answer such questions as:

- What is the use of each room? (Fig. 4.5)
- What is each room's floor area and number of stations? (Fig. 4.6)
- To which department is a room assigned? (Fig. 4.7)

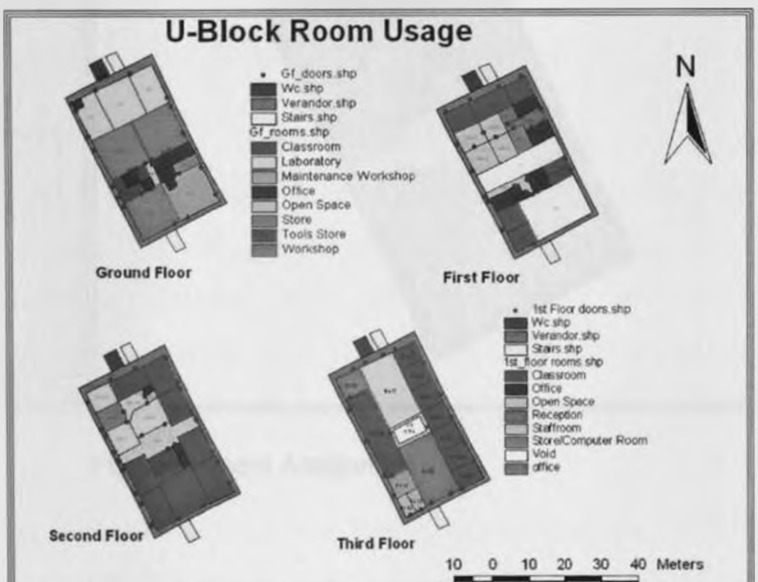
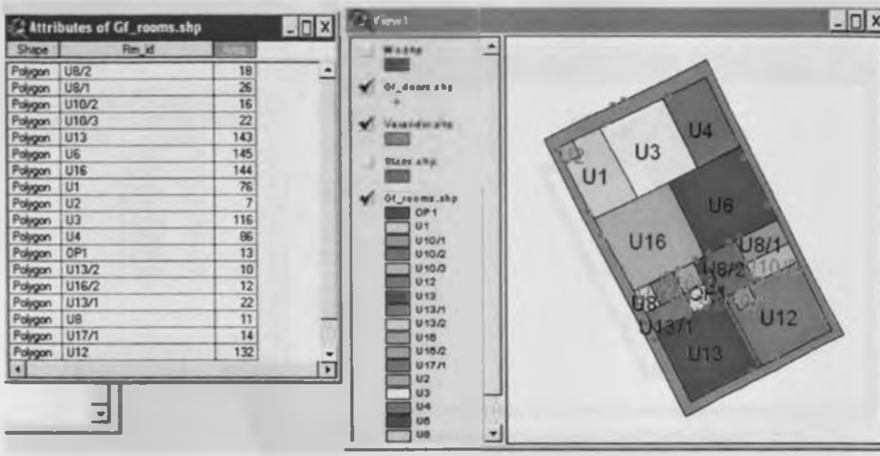


Fig. 4.6: Room utilization



Shape	Rm_id	Area
Polygon	U8/2	18
Polygon	U8/1	26
Polygon	U10/2	16
Polygon	U10/3	22
Polygon	U13	143
Polygon	U6	145
Polygon	U16	144
Polygon	U1	76
Polygon	U2	7
Polygon	U3	116
Polygon	U4	86
Polygon	OP1	13
Polygon	U13/2	10
Polygon	U16/2	12
Polygon	U13/1	22
Polygon	U8	11
Polygon	U17/1	14
Polygon	U12	132

Fig. 4.7: Area of Rooms

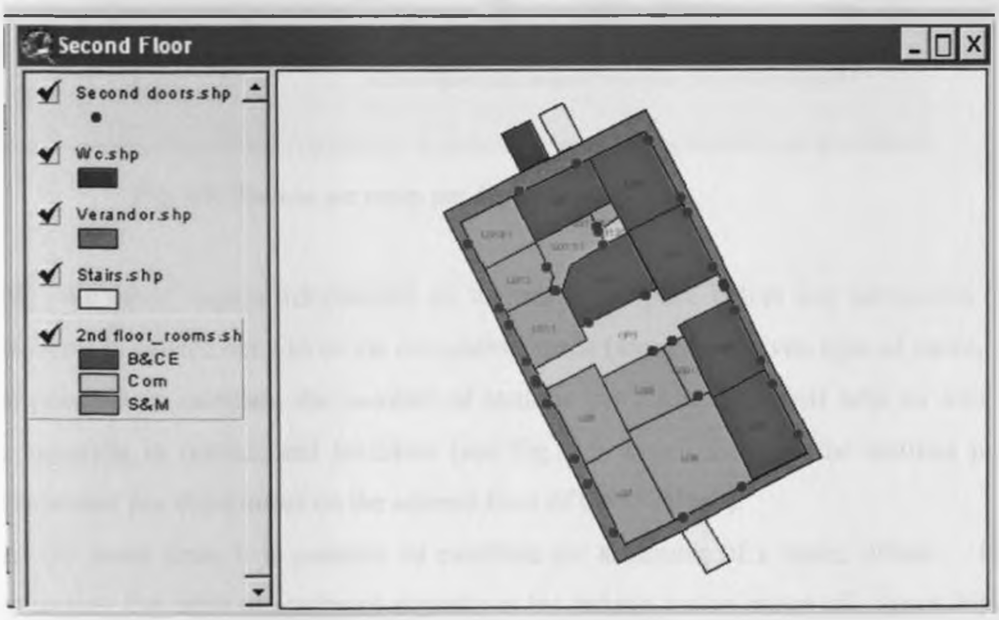


Fig. 4.8: Room Assignment

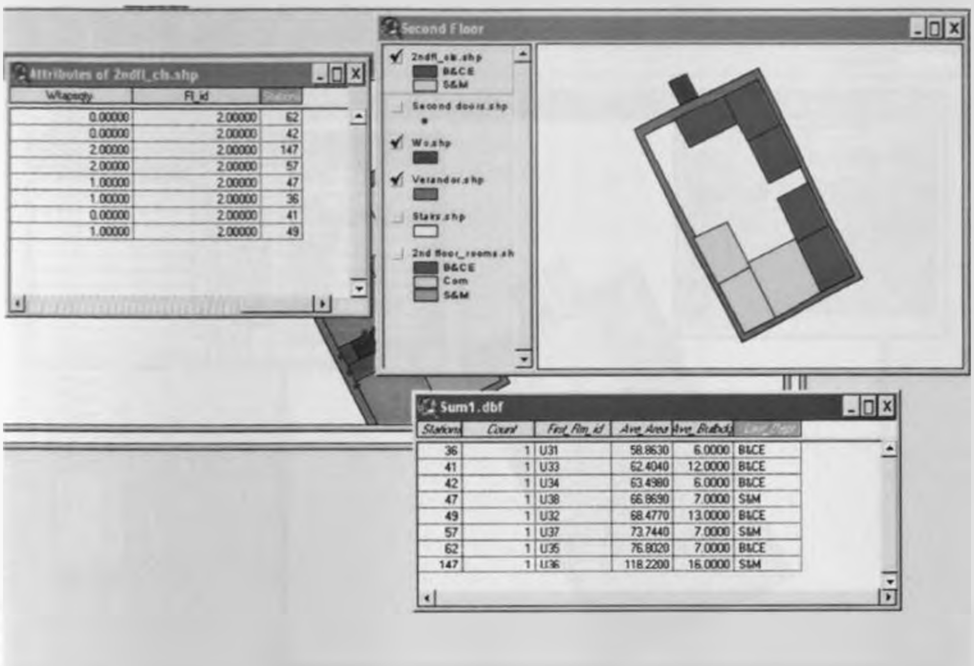


Fig. 4.9: Stations per room per department

(ii) We often require information on the available space before any admission of students is carried out. Given the circulation space (area) for a given type of room, it is possible to calculate the number of stations per class. This will help us avoid congestion in institutional facilities (see Fig. 4.9 which displays the stations per classroom per department on the second floor of the U-Block).

At the same time, it is possible to establish the attributes of a room, either by accessing the table of attributes directly or by linking to the image of some kind (Fig. 4.10).

Most of the tables in the U-block database were prepared in MS Access while we have tables directly established by the various themes (floor rooms). To query the room attribute tables, it is necessary to link the spatial and non-spatial tables. For instance, to query for a room whose use is maintenance workshop, we could get the results shown in figure4.11.

Fig. 4.10: Tabular and Scenery visualization of room data

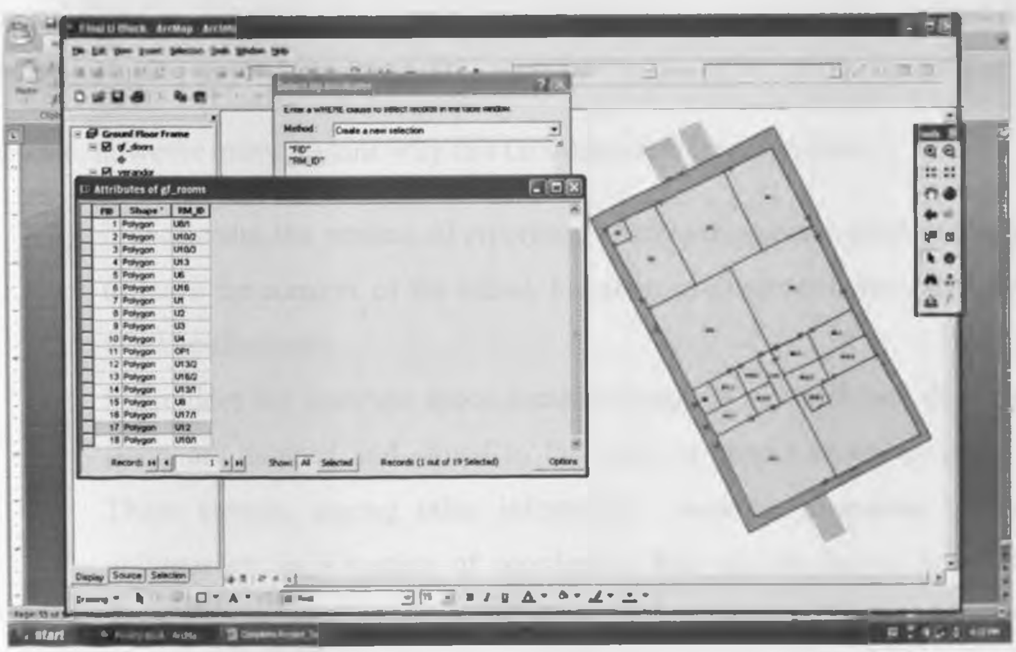


Fig.4.11: Using the 'Relate' function in ArcMap to generate queries

CHAPTER FIVE: CONCLUSION AND RECOMMENDATIONS

5.1 Conclusions

The database prepared in this project is a localised one, which should act as prototype for the future management of the Kenya Polytechnic University College. As indicated in the introduction of this project, the institution is expanding, both in terms of population, as well as in its facilities distribution.

The development of a new space inventory database poses a number of challenges. Among these include the problems created when importing tables from one application to the other, for example from MS Access to ArcView or ArcGIS. A minor omission or commission such as specifying the length of a data field could disrupt the process.

Creating this spatial database demanded the cooperation with other departments as well as with a number of non-teaching staff and other colleagues. It was difficult to convince some of them that the project was simply an academic one but with implications of re-designing the current spatial data management. Many wanted to benefit financially beyond my means.

There are, however many reasons why this GIS database should be used:

- it accelerates the process of reporting, as the management does not have to leave the comfort of the office, but press a computer button and gets what he/she wants.
- It provides for accurate space measurements, as all facilities, floor by floor, are mapped and stored in the form of shapefiles or coverages. These contain, among other information, accurate parameters, areas, volumes etc in a system of coordinates that can be drawn from the software. The use of these coordinates gives the spatial files an accuracy that regular non-spatial files cannot deliver, especially when obtaining areas of odd-shaped rooms and capturing not only assignable space but also non-assignable space such as tool stores.

The GIS database provides easy accessibility and use to data. With the interconnectivity of the GIS to a facilities Inventory database, personnel and equipment inventory database, personnel and equipment inventory can be geo-referenced to the floor plans. This means personnel can be assigned to multiple rooms such as departmental offices or laboratories; likewise, multiple personnel can be assigned to a single room such as a staffroom. Departmental assignment can also be illustrated by feeding information from the database to the GIS. The provision of such reporting capability to security and emergency units helps them to know who is actually in a particular room. The capability could also allow the university administrators to determine who controls space by visual reference to floor plans that are colour coded by departmental assignment.

Finally, GIS database offers error control mechanisms in that when inputting data into the system, for instance when scheduling, if a room does not exist in the geo-database, it cannot be selected.

5.2 Recommendations

Kenya Polytechnic University College does not have a structured method of initiating, conducting, reporting and maintaining the institution's facilities inventory. This has made it difficult to know what facilities exist and where. It is therefore recommended

a. that a method be developed to enable the institution to:
   (i) measure the ability of its space to meet the requirements of its current programmes,
   (ii) assess the current operational costs of its facilities (maintenance, utilities, cleaning), and
   (iii) start planning early for the future space needs.

b. that a secure intranet-based Facilities Data Information System for the entire College be developed. The system should be able to permit building floor plans, facilities data and general base map layers to be linked and accessed through some standard browser.

c. an intranet-based system for visualizing and reporting on space utilization across the campus should be designed and developed. Such a Space Management System should:
   (i) be able to link campus maps and room plans to a database of space utilization and space characteristics,
   (ii) provide for reporting and charting capabilities,

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Appendix A: Tables

A-1: Rooms

Rooms									
USE	BulbsQty	DoorsNo	WindsNo	PortsNo	SktsQty	WTapsQty	FL_ID	RM_SIZE	DEPT_ID
Laboratory	7	1	3	3	3	1	0	0	S&M
Office	1	2	1	0	1	0	0	0	COM
Office	2	1	2	3	6	1	0	0	COM
Store	1	2	3	4	1	0	0	0	COM
Office	1	1	2	0	1	0	1	0	COM
Classroom	2	1	2	0	1	2	1	0	B&CE
classroom	2	1	1	0	1	2	1	0	B&CE
Maintenance Workshop	12	4	6	0	6	2	0	0	COM
Workshop	12	1	1	2	6	0	0	0	B&CE
Tools Store	1	2	1	6	1	0	0	0	B&CE
Office	1	2	1	6	1	0	0	0	B&CE
Open Space	1	2	2	0	1	0	0	0	B&CE
Tools Store	1	2	0	0	1	0	0	0	B&CE
Office	1	1	1	0	1	0	0	0	B&CE
Office	1	1	1	1	1	0	0	0	S&M
Classroom	4	1	2	0	2	0	0	0	B&CE
Classroom	4	1	2	0	2	0	0	0	B&CE
Classroom	4	1	2	0	2	0	0	0	B&CE
Reception	1	1	1	1	2	0	1	0	COM
Office	2	2	2	3	3	0	1	0	S&M
Office	2	1	2	3	3	0	1	0	B&CE
Store/Computer	1	1	2	2	2	0	1	0	B&CE
Office	1	2	2	1	1	0	1	0	B&CE
Staffroom	2	2	2	5	5	0	1	0	COM
Staffroom	2	2	2	5	5	0	1	0	COM
Staffroom	2	1	1	0	3	1	1	0	COM
Staffroom	2	1	2	6	6	0	1	0	COM
office	2	1	1	0	1	0	1	0	B&CE
Corridor	1	1	1	0	0	0	1	0	COM
Office	1	1	1	0	1	0	1	0	B&CE
Office	2	1	1	0	1	0	1	0	B&CE
Office	1	1	1	0	1	0	1	0	B&CE
Classroom	2	1	1	0	1	0	1	0	B&CE
Classroom	4	1	2	0	2	0	1	0	B&CE
Laboratory	12	2	4	0	6	9	0	0	B&CE

Rooms										
ID	USE	BulbsQty	DoorsNo	WindsNo	PortsNo	SktsQty	WTapsQty	FL_ID	RM_SIZE	DEPT_ID
	Classroom	6	2	4	0	4	1	2	0	B&CE
	Laboratory	8	3	4	16	4	1	2	0	B&CE
	Laboratory	6	2	3	0	3	0	2	0	S&M
/1	Laboratory	2	3	2	6	6	0	2	0	S&M
	Staffroom	4	2	3	0	2	0	2	0	Com
/1	Laboratory	6	1	3	0	4	0	2	0	S&M
/3	Server room	1	1	1	1	1	0	2	0	COM
/4	Office	1	1	1	1	1	1	2	0	S&M
33	Classroom	13	2	7	0	6	1	2	0	B&CE
	Classroom	6	2	3	0	4	0	2	0	B&CE
	Classroom	7	2	5	0	3	0	2	0	B&CE
	Classroom	16	2	3	0	18	2	2	0	S&M
	Classroom	7	2	5	0	2	2	2	0	S&M
	Classroom	7	2	3	0	2	1	2	0	S&M
	Store	7	1	5	0	2	0	2	0	S&M
1	Office	6	1	3	0	3	0	2	0	S&M
2	Corridor	3	1	1	0	2	0	2	0	COM
	Laboratory	9	2	4	0	4	7	0	0	B&CE
1	Classroom	4	1	2	0	1	0	3	0	B&CE
2	Classroom	4	1	1	0	2	0	3	0	B&CE
3	Classroom	3	1	1	0	1	0	3	0	B&CE
4	Classroom	4	1	4	0	2	0	3	0	S&M
5	Classroom	4	1	1	0	2	0	3	0	B&CE
6	Classroom	4	1	1	0	2	0	3	0	B&CE
7	Classroom	6	1	2	0	2	0	3	0	B&CE
8	Lecture Theatre	18	2	3	0	4	0	3	0	COM
2	Women's Toilet	2	1	4	0	0	3	3	0	COM
3	Men's Toilet	2	1	4	0	0	3	3	0	COM
4	Kitchen	2	2	1	0	3	1	3	0	COM
5	Staff Canteen	8	2	4	0	4	1	3	0	COM
6	Staffroom	4	2	2	0	1	0	3	0	COM
7	Examination Room	15	2	4	0	[redacted]	[redacted]	3	[redacted]	COM
	Workshop	6	2	4	0	3	[redacted]	[redacted]	[redacted]	[redacted]
	Classroom	1	1	1	0	1	0	[redacted]	[redacted]	[redacted]
1	Office	2	1	1	0	1	2	[redacted]	[redacted]	[redacted]
2	Office	2	1	1	0	1	0	0	[redacted]	[redacted]
	Workshop	8	1	3	0	4	3	0	[redacted]	[redacted]

A-2: Floors

Floors		
Fl_ID	RMS_NO	SECLIGHTS_NO
0	18	12
1	18	12
2	18	12
3	14	22

A-3: Staff

Staff								
ST_ID	ST_FNAME	ST_MNAME	ST_LNAME	ST_DESIGN	CATE	RM_ID	DEPT_ID	GENDI
098N00049	David	Kabui	Kagia	Technician	BOG	U3	B&CE	M
098N00110	Andrew	K	Makau	Cleaner	BOG	U415	B&CE	M
098N00137	Janet	Chepkemoi	Chumo	Cleaner	BOG	U24	B&CE	F
098N00152	Samwel	Keya	Lughano	Artisan	BOG	U16	B&CE	M
098N00160	Stephen	Mulwa	Ngolia	Cleaner	BOG	U6	B&CE	M
098N00190	Regina	M	Nduku	Messenger	BOG	U24	B&CE	F
098N00216	Clement	Argwinge	Odia	Cleaner	BOG	U16	B&CE	M
098N00250	Henry	Onyango	Otenga	Cleaner	BOG	U312	B&CE	M
098N00290	Jane	W	Njuguna	Typist	BOG	U24	B&CE	[illegible]
098N00344	Mary		Mbithe	Typist	BOG	U24	S&M	[illegible]
098N00386	John		Mwangi	Technician	BOG	U39/1	S&M	[illegible]
099N00014	Anjelina	Akoth	Otieno	Cleaner	BOG	U24	B&CE	[illegible]
100N00022	Dismas	Mukoto	Lusichi	Technician	BOG	U312/3	S&M	[illegible]
102N00041	Margret	Wanjiru	Kihara	Cleaner	BOG	U13	B&CE	[illegible]
104N00001	Jackton	Kaire	Odongo	Technician	BOG	U/1	S&M	[illegible]
106N00001	Edwin	Omondi	Oyolla	Technician	BOG	U310	B&CE	[illegible]
108N00152	Paul	Mutiso	Musau	Technician	BOG	U4	B&CE	[illegible]
128238	Jackson	Simiyu	Wangili	DHOD	TSC	U2	S&M	[illegible]
174817	Hilary	Iwalat	Oluku	Teacher	TSC	U416	S&M	M
207411	Gordon	Wamboga	Aura	Teacher	TSC	U25/1	B&CE	M
207477	Anthony	Macharia	Gatune	Teacher	TSC	U25/1	B&CE	M
224020	Alpheus	Ondiwa	Onyango	DHOD	TSC	U24/4	B&CE	M
238115	Paul	Kimani	Kairu	Teacher	TSC	U27/2	B&CE	M
238118	Bernard	Kihoro	Kirembu	Teacher	TSC	U25/2	B&CE	M
238125	Philip	Ouma	Ronny	Teacher	TSC	U25/2	B&CE	M
239109	Peter	Kinyanjui	Njenga	Teacher	TSC	U27/1	B&CE	M
239253	Francis	Muthee	Mwangi	HOD	TSC	U24/2	B&CE	M

Staff								
ST_ID	ST_FNAME	ST_MNAME	ST_LNAME	ST_DESIGN	CATE	RM_ID	DEPT_ID	GEND
271406	Elly	Okewe	Ajigoh	Teacher	TSC	U26	B&CE	M
277824	Absolom	Vugigi	Lamka	Teacher	TSC	U25/2	B&CE	M
279243	Robert	Kinyanjui	Ndegwa	Teacher	TSC	U25/1	B&CE	M
293566	Peter	Kasau	Mutune	Teacher	TSC	U25/1	B&CE	M
297500	Betsy	Wesonga	Wanjala	Teacher	TSC	U312	S&M	F
297994	Jackson	Muoki	Mbato	Teacher	TSC	U26	B&CE	M
298615	Nathan	Mweu	Muli	Teacher	TSC	U25/1	B&CE	M
298657	James	Jaoko	Kayako	Teacher	TSC	U312	S&M	M
298859	Isaac	James	Kuria	Teacher	TSC	U25/2	B&CE	M
308787	Erastus	Gitari	Njeru	Teacher	TSC	U25/1	B&CE	M
312644	Emma	Njoki	Muringi	Teacher	TSC	U25/2	B&CE	F
312649	Edmund	Mithamo	Muthigani	Teacher	TSC	U25/4	B&CE	M
314051	Richard	Peter	Mbote	Teacher	TSC	U8/2	B&CE	M
314434	Joseph	George	King'ori	Teacher	TSC	U25/2	B&CE	M
316763	George	Karina	Karara	Teacher	TSC	U312	S&M	M
318839	Ronald	Ogutu	Sungu	Teacher	TSC	U25/1	B&CE	M
319713	Patrick	Kyaka	Kimeu	Teacher	TSC	U25/2	S&M	M
325443	Beatrice	Akinyi	Chika	HOD	TSC	U24/1	S&M	F
330663	Michael	Maunda	Wanyonyi	Teacher	TSC	U25/1	B&CE	M
336787	Onabiria	Omukaga	Panyako	Teacher	TSC	U25/2	B&CE	M
342155	Mishael	Arumba	Motuka	Teacher	TSC	U25/4	S&M	M
349643	Moses	Makumi	Kane	Teacher	TSC	U25/4	B&CE	M
352106	Linus	Ayoyi	Shabola	Teacher	TSC	U312/4	S&M	[illegible]
352245	Naomi	Kinaru	Gichunge	Teacher	TSC	U416	S&M	[illegible]
356889	Michael	Muchiri	Mwangi	Teacher	TSC	U25/2	B&C[illegible]	[illegible]
358297	Gabriel	Abang'ga	Owenda	Teacher	TSC	U312	S&M	[illegible]
363438	Joseph	Mwaura	Karanja	Teacher	TSC	U27/2	B&C[illegible]	[illegible]
363439	Margaret	Njoki	Ndungo	Teacher	TSC	U8/2	B&C[illegible]	[illegible]
364727	Richard	Moses	Onchaga	Teacher	TSC	U312	S&M	[illegible]
365049	Samwel	Kariuki	Ngunyi	Teacher	TSC	U27/3	B&C[illegible]	[illegible]
380349	Juliet	Gathoni	Muiga	Teacher	TSC	U8/2	B&CE	F
380362	Peter	Njagi	Githinji	Teacher	TSC	U25/4	B&CE	M
390245	Peter	Nyon'ga	Nyarige	Teacher	TSC	U312	S&M	M
417281	Felix	Omondi	Mark	Teacher	TSC	U25/4	B&CE	[illegible]
458767	Reuben	Kamau	Kabbau	Teacher	TSC	U25/1	B&CE	[illegible]

A-4: Courses

Courses		
COURSE_ID	**CNAME**	**DEPT_ID**
Cs304	Diploma in Building	B&CE
Cs305	Diploma in Civil Egineering	B&CE
Cs307	Diploma in Architecture	B&CE
Cs308	Diploma in Quantity Survey	B&CE
Cs310	Diploma in Highways	B&CE
Cs401	Higher Diploma in Construction(Beconomics Option)	B&CE
CS402	Higher Diploma in Construction(Structure Option)	B&CE
Cs406	Higher Diploma in Construction(B&CE Option)	B&CE
Sf401107	Higher Diploma in Land Surveying	S&M
Ss303106	Diploma in Land Surveying	S&M
St301107	Diploma in Technology(Geoinformatics)	S&M

A-5: Departments

Departments			
DEPT_ID	**DEPTNAME**	**HOD**	**DHOD**
B&CE	Building and Civil Engineering	Mwangi	Ondiwa
S&M	Surveying and Mapping	Chika	Wangili

A-6: Equipment

Equipment	
EQUIP_ID	**EQUIPNAME**
001	Computer
002	B8
003	A9
004	Contact printer
005	Multiplex
006	Mistri Photo Mapper
007	Kein Plotter
008	Radial Plotter
009	Universal Testing Machine
010	Aggregate Crushing Value
011	Aggregate Impact Machine
012	Balance 15kg Automatic
013	Balance Platform
014	Balanve Avery

Equipment	
EQUIP_ID	EQUIPNAME
015	Balance Self indicating
016	Compression
017	Compacting Factor
018	Oven
019	Permeability Apparatus
020	Sieve Shaker
021	Tensometer
022	Vibrating Table(Motor)
023	Vibrating Table(Cube)
024	Vee-Bee Consistometer
025	Humidity Chamber
026	Riffle Boxes
027	Water Heater
028	Threader
029	Solar Funnel
030	Metal Cutter
031	Thrall
032	Metal Shaper
033	Welder
034	Cutter Machine
035	Cross Cutter
036	Drying Oven
037	Shearbox
038	Flownet Dam
039	CBR Apparatus
040	Ballon Density Apparatus
041	Travial Apparatus
042	Grinder
043	Spindle
044	Rip Machine
045	Bensor
046	Jorrofin
047	Server
048	Plotter
049	Printer
050	Semi-Automatic Balance

A-7: Furniture

Furniture	
FURN_ID	**FURN_NAME**
01	Stool
02	Chair
03	Desk
04	Cabinet
05	File/General Shelf
06	Fridge

A-8: Room and Equipment ID

Room_Equipment		
RM_ID	**EQUIP_ID**	**QTY**
U1	002	1
U1	003	1
U1	004	1
U1	005	1
U1	006	2
U1	007	2
U1	008	1
U12	042	1
U12	043	1
U12	044	1
U12	045	1
U12	046	1
U13	034	1
U13	035	3
U16	027	1
U16	028	1
U16	029	1
U16	030	1
U16	031	1
U16	032	1
U16	033	1
U2	001	1
U24/1	001	2
U24/1	049	1
U24/2	001	2
U24/2	049	1

Room_Equipment		
RM_ID	EQUIP_ID	QTY
U24/3	001	3
U24/3	049	1
U3	009	1
U3	010	1
U3	011	1
U3	012	1
U3	013	1
U3	014	1
U3	015	1
U3	016	1
U3	017	1
U3	018	1
U3	019	1
U3	020	1
U3	021	1
U3	022	1
U3	023	1
U3	024	1
U3	025	1
U3	026	3
U310	001	17
U310	049	1
U311	001	20
U311/2	001	6
U311/2	048	1
U312/3	047	1
U312/4	001	1
U312/4	049	2
U4	036	1
U4	037	1
U4	038	1
U4	039	3
U4	040	1
U4	041	1
U4	050	1

A-9: **Room and Furniture ID**

Room_Furniture		
RM_ID	FURN_ID	FURN_Qty
U10/1	02	2
U10/1	03	1
U10/2	02	2
U10/2	03	1
U10/2	04	1
U10/3	04	1
U10/4	02	1
U10/4	03	3
U10/4	04	1
U10/5	02	8
U10/5	03	6
U10/6	02	8
U10/6	03	5
U12	01	3
U12	02	4
U12	03	2
U13	01	5
U13	02	17
U13	03	12
U13	04	2
U13/1	03	1
U13/1	04	1
U13/2	02	2
U13/2	04	1
U16	01	8
U16	02	15
U16	03	31
U16	04	1
U16/2	04	1
U17/1	02	1
U17/1	03	1
U17/1	04	2
U17/1	05	2
U2	02	3
U2	03	2
U2	04	1
U2	05	2

Room_Furniture		
RM_ID	FURN_ID	FURN_Qty
U24	02	5
U24	03	4
U24	04	1
U24/1	02	4
U24/1	03	2
U24/1	04	4
U24/1	05	2
U24/2	02	4
U24/2	03	2
U24/2	04	1
U24/2	05	2
U24/3	02	4
U24/3	03	1
U24/3	04	1
U24/3	05	8
U24/4	02	2
U24/4	03	1
U24/4	04	1
U25/1	02	17
U25/1	03	11
U25/1	04	4
U25/1	05	4
U25/2	01	1
U25/2	02	12
U25/2	03	8
U25/2	04	3
U25/2	05	1
U25/3	02	14
U25/3	03	3
U25/3	04	4
U25/4	02	13
U25/4	03	8
U25/4	04	4
U25/4	05	3
U26	01	1
U26	02	8
U26	03	5
U26	04	2
U26	05	4

Room_Furniture		
RM_ID	FURN_ID	FURN_Qty
U27/1	02	2
U27/1	03	2
U27/1	04	2
U27/1	05	2
U27/2	02	3
U27/2	03	1
U27/2	05	1
U27/3	02	2
U27/3	03	1
U27/3	04	1
U27/3	05	2
U28	01	2
U28	02	28
U28	03	11
U29	01	2
U29	02	13
U29	03	13
U3	01	4
U3	02	2
U3	03	5
U3	04	3
U31	01	13
U31	03	8
U310	02	20
U310	03	5
U310	04	3
U311	02	18
U311	03	5
U312	02	10
U312	03	8
U312	04	1
U312/1	01	1
U312/1	02	5
U312/1	03	10
U312/1	05	1
U312/2	02	7
U312/2	03	2
U312/2	04	1
U312/2	05	1

Room_Furniture		
RM_ID	FURN_ID	FURN_Qty
U312/3	05	2
U312/4	02	2
U312/4	03	1
U312/4	04	1
U312/4	05	6
U32	01	14
U32	03	8
U33	01	18
U33	03	7
U34	01	15
U34	02	28
U34	03	8
U35	01	16
U35	02	1
U35	03	8
U36	01	2
U36	02	36
U36	03	16
U36	04	1
U37	01	18
U37	03	9
U38	01	13
U38	02	3
U38	03	11
U39	01	1
U39	02	1
U39	03	2
U39	04	2
U39	05	4
U39/1	02	1
U39/1	03	1
U39/1	04	1
U39/1	05	1
U4	01	13
U4	03	10
U4	04	1
U401	01	20
U401	02	2
U401	03	9

Room_Furniture		
RM_ID	FURN_ID	FURN_Qty
U402	01	1
U402	02	16
U402	03	11
U403	01	1
U403	02	17
U403	03	8
U404	01	3
U404	02	28
U404	03	15
U405	01	1
U405	02	21
U405	03	20
U406	01	2
U406	02	18
U406	03	18
U407	01	2
U407	02	19
U407	03	20
U408	01	2
U408	02	36
U408	03	20
U414	02	4
U414	03	1
U414	04	2
U415	02	126
U415	03	15
U416	01	1
U416	02	6
U416	03	6
U417	01	10
U417	02	28
U417	03	30
U6	01	2
U6	02	17
U6	03	6
U6	04	2
U8	02	4
U8	03	4
U8/1	02	2

Room_Furniture		
RM_ID	FURN_ID	FURN_Qty
U8/1	03	1
U8/1	04	1
U8/2	01	1
U8/2	02	4
U8/2	03	2
U8/2	04	2

Appendix B: Maps/Plans

B-1: Location of Kenya Polytechnic Facilities

B-2: Data Source map

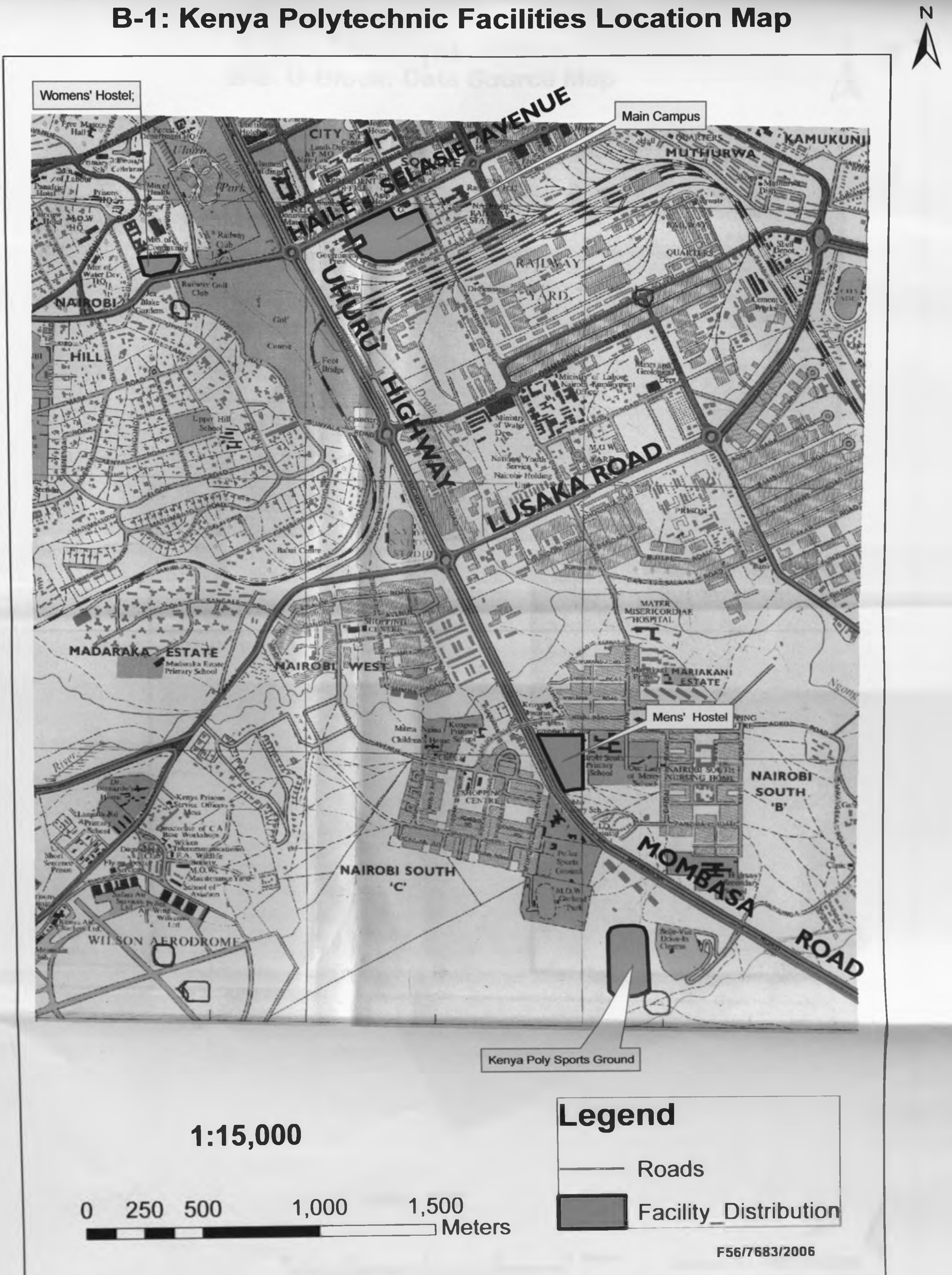
B-3: Ground Floor plan

B-4: 1st Floor plan

B-5: 2nd Floor Plan

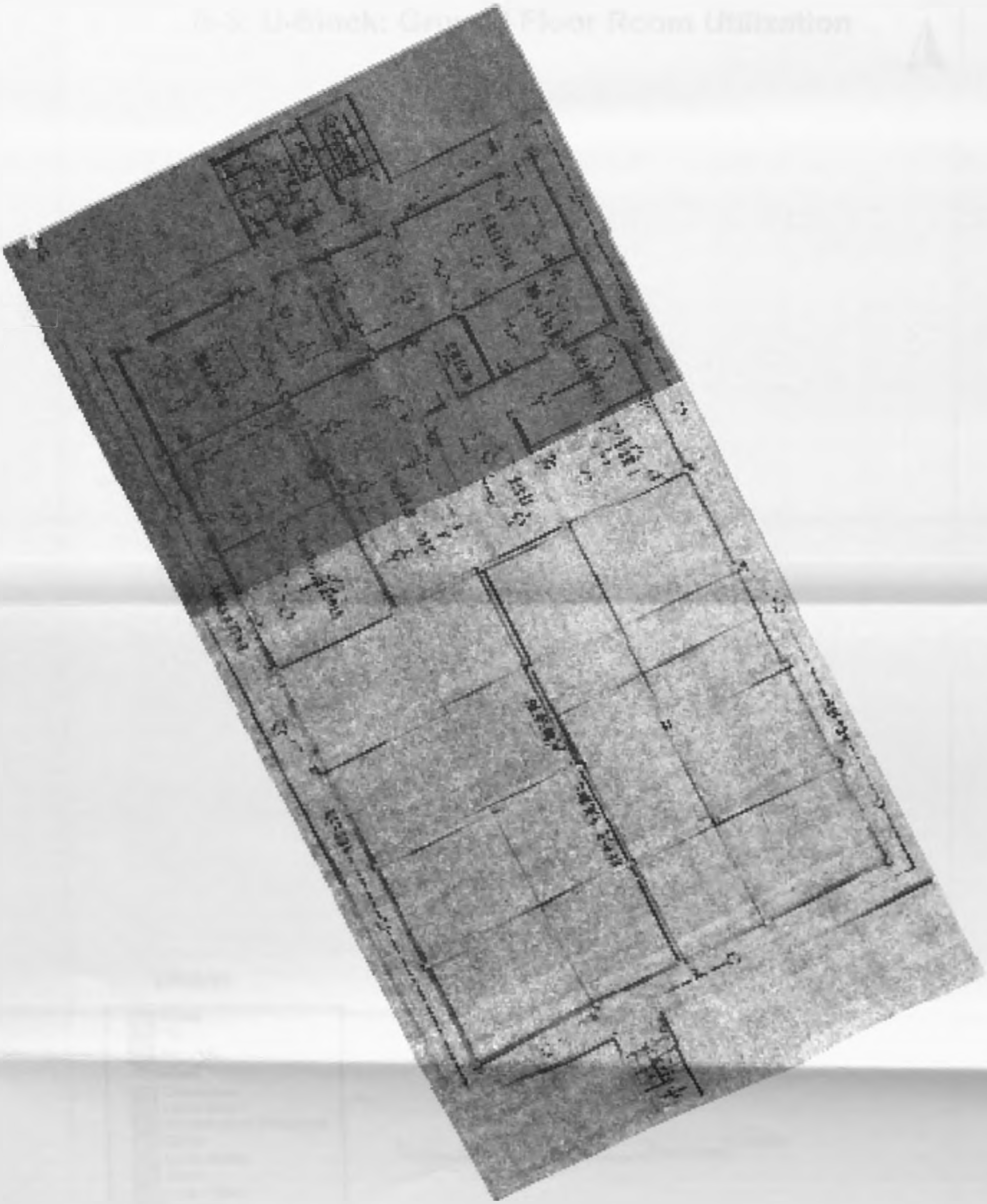
B-6: 3rd Floor Plan

B-1: Kenya Polytechnic Facilities Location Map



F56/7683/2006

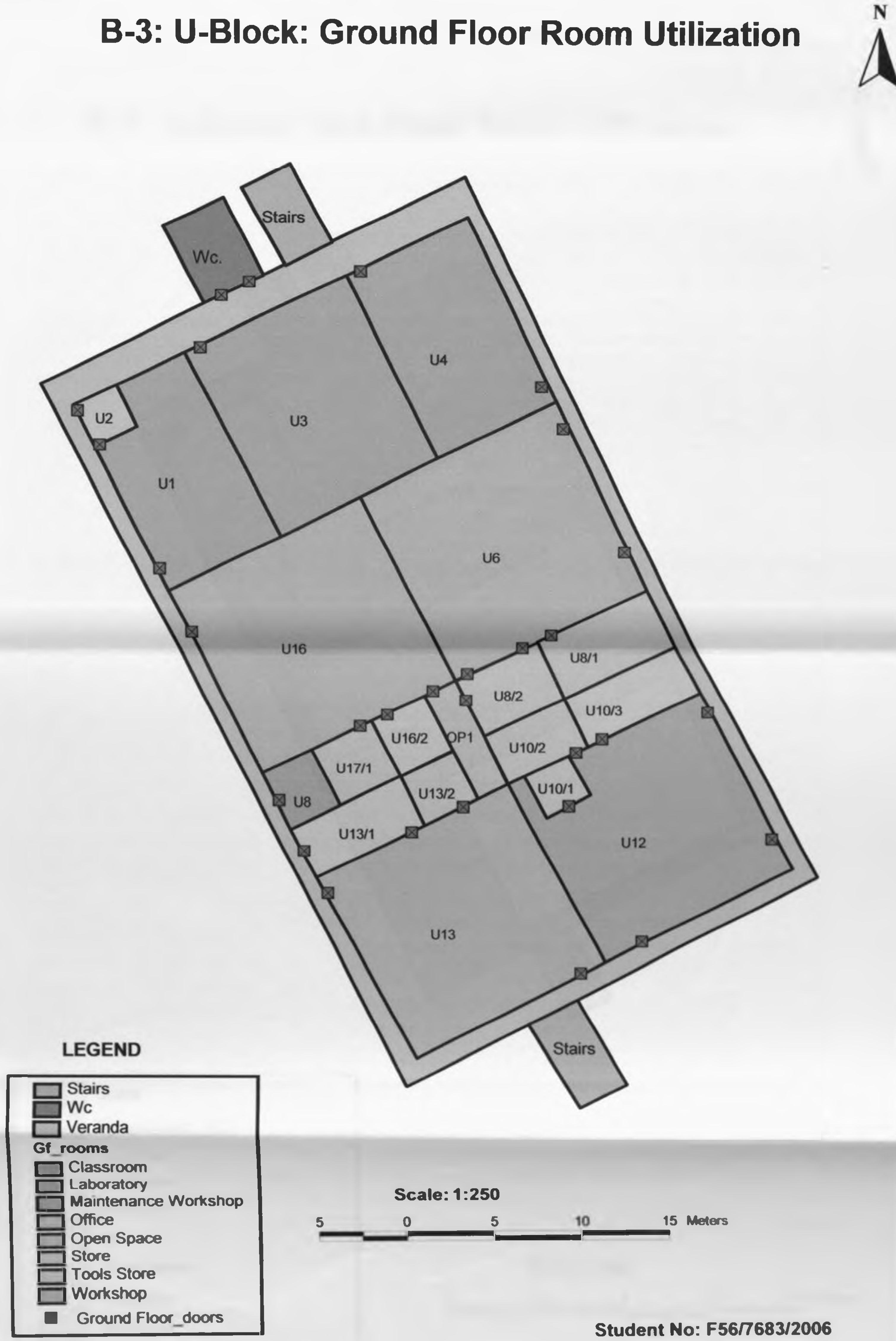
B-2: U-Block: Data Source Map



Scale: 1:250

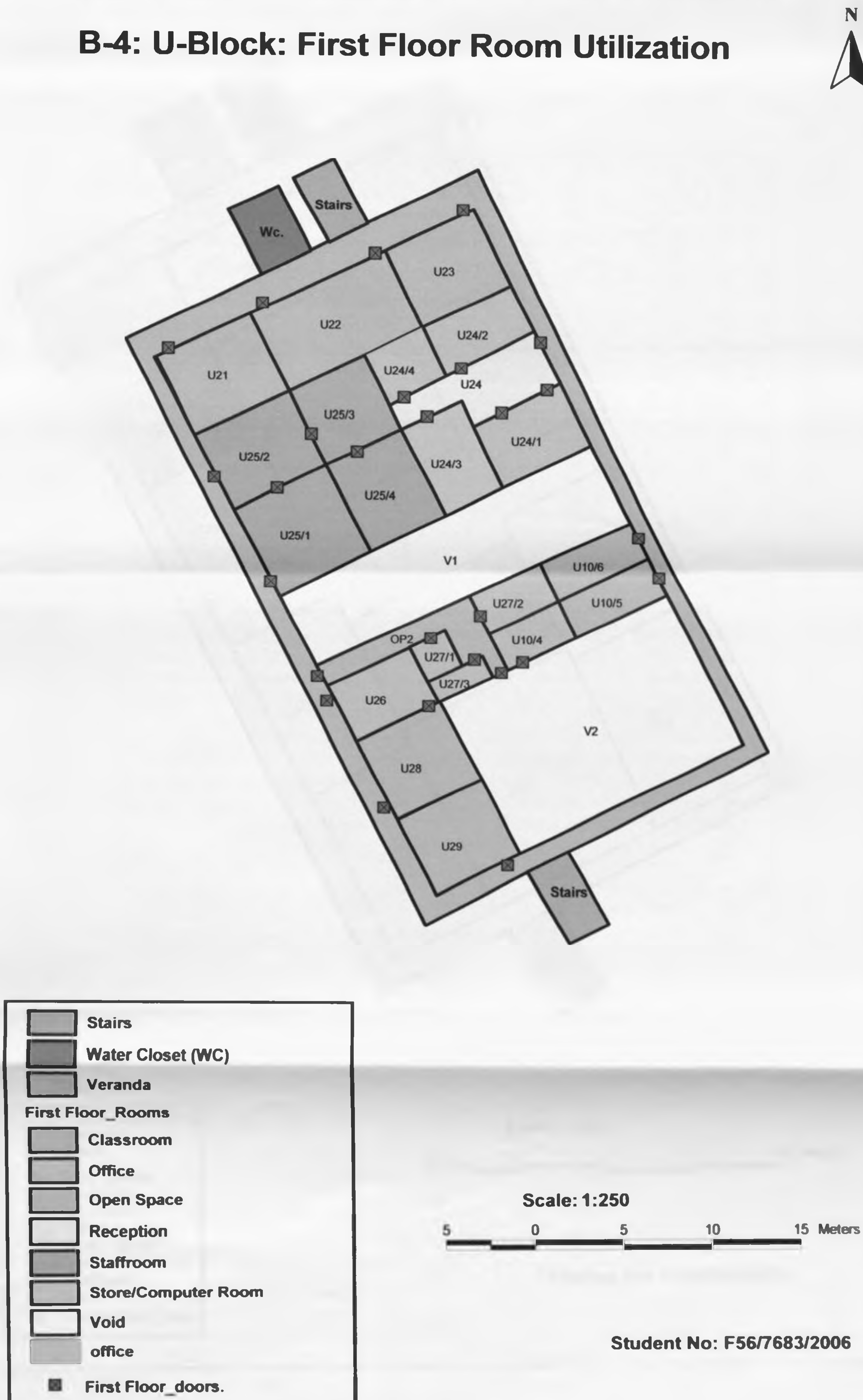
Student No: F56/7683/2006

B-3: U-Block: Ground Floor Room Utilization



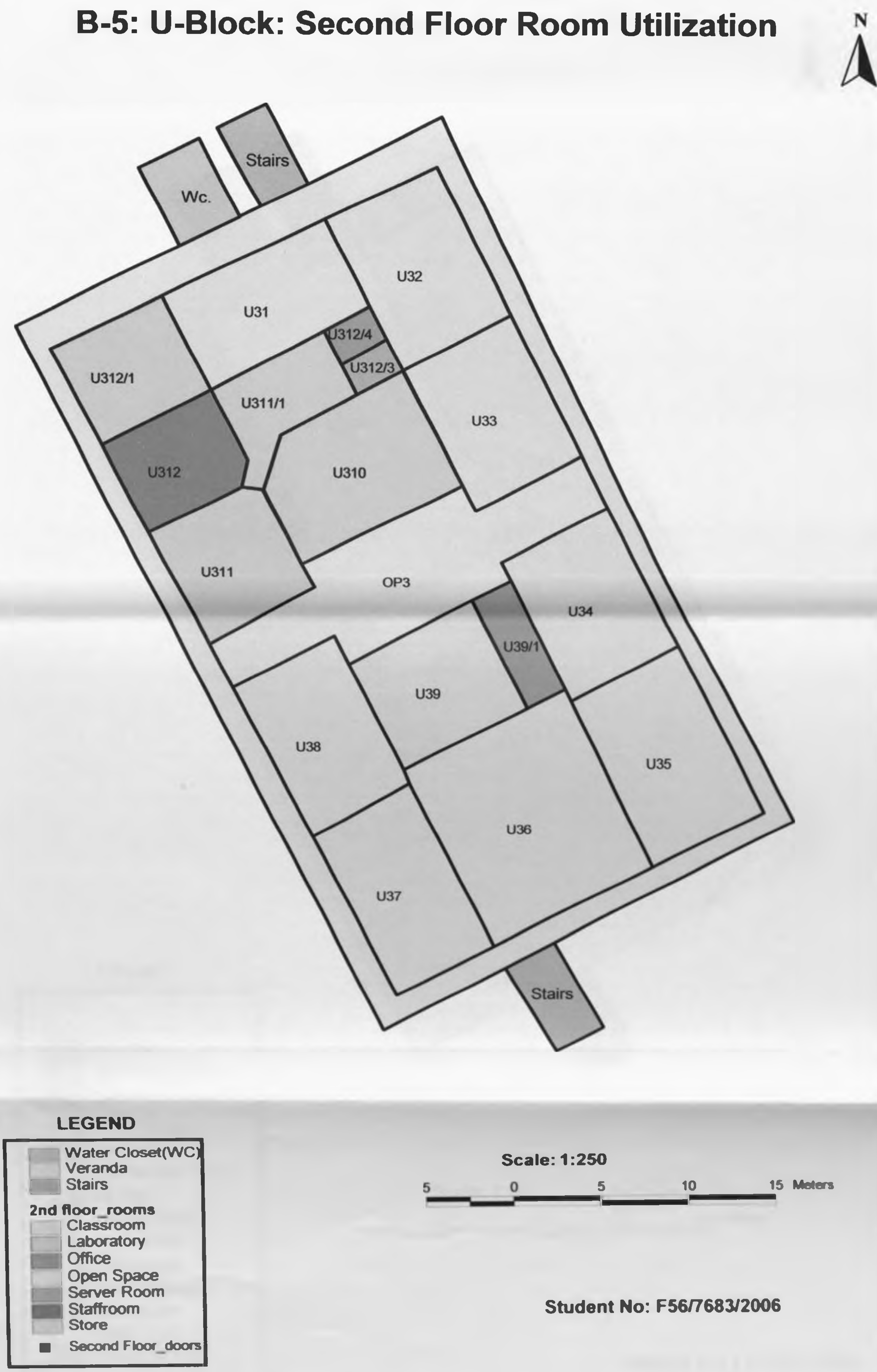
Student No: F56/7683/2006

B-4: U-Block: First Floor Room Utilization



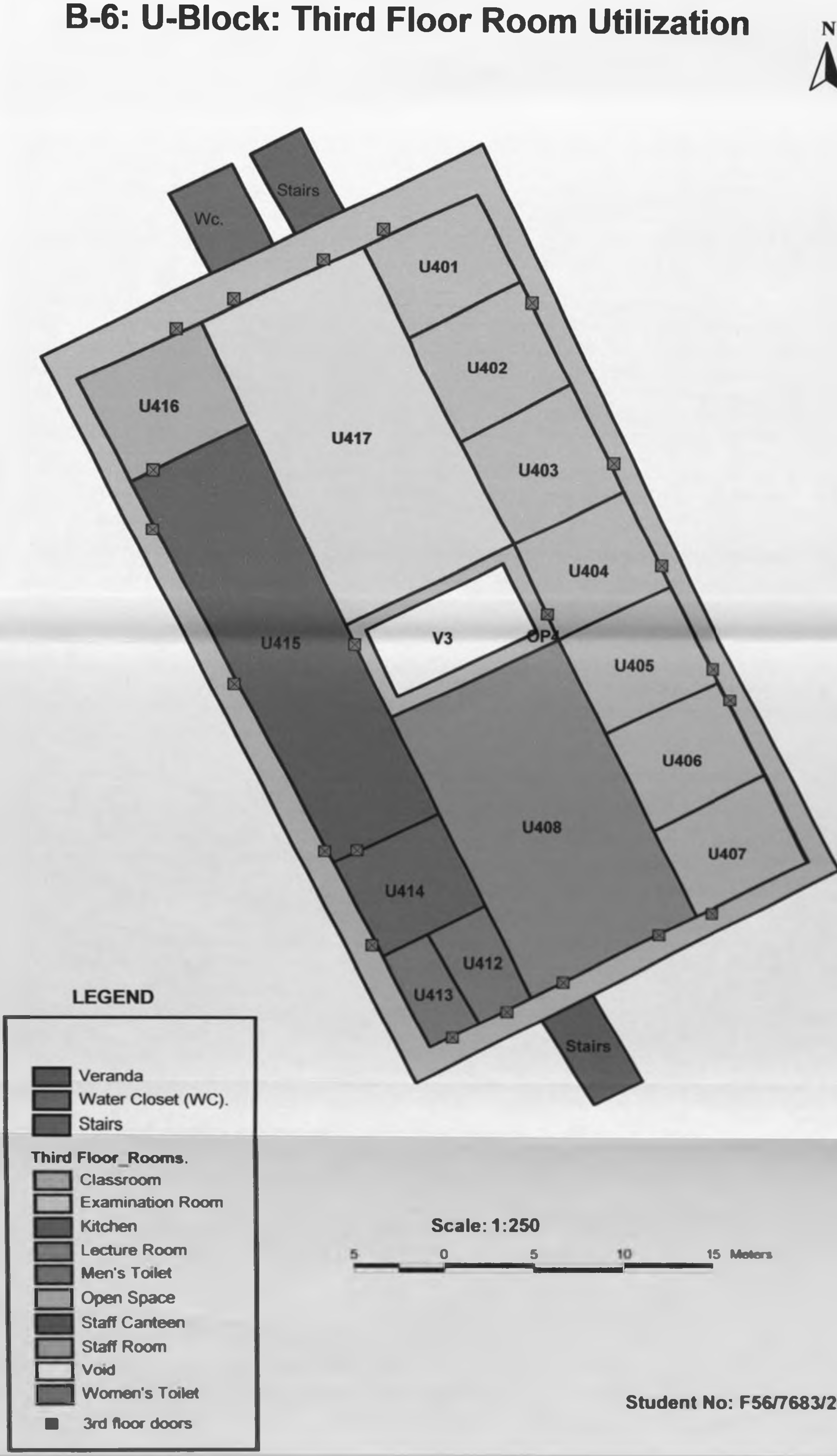
Student No: F56/7683/2006

B-5: U-Block: Second Floor Room Utilization



Student No: F56/7683/2006

B-6: U-Block: Third Floor Room Utilization



Student No: F56/7683/2006