‘CONCEPTS OF BUILDING AUTOMATION SYSTEMS AND ITS EFFECT ON REAL PROPERTY VALUES’

(CASE STUDY OF COMMERCIAL BUILDINGS, WESTLANDS, NAIROBI, KENYA)

SUBMITTED BY:

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THE UNIVERSITY OF NAIROBI

MAY 2014
DECLARATION

I, Karanja Bernadette Wambui, hereby declare that this project is my original work and has not been presented for award of a degree in any other university.

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DEDICATION

This project is dedicated to my parents, Mr and Mrs Karanja, my endless fountain of support and inspiration.
**ACKNOWLEDGEMENTS**

I wish to sincerely express my gratitude and appreciation to all those who have helped in the completion of this project, through valuable input and support.

Special thanks to God for his wisdom and grace, which has guided me throughout the undertaking of Bachelor of Real Estate and this research project and to my parents who have offered me love, inspiration, moral and financial support throughout my life.

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Thank you very much and God bless you.
ABSTRACT

With future trends in architecture and design moving towards zero energy consumption in homes and buildings, strategies have been developed through science, technology and innovation, all directed towards use of energy effectively, at minimal operations and cost. One of these strategies has been through use of Building Automation Systems. BAS refers to a system of network integrated computer components that automatically control a wide range of building operations such as lighting, security and access control, Heating Ventilation and Air Conditioning, fire and life safety, Building Management Systems, audio-visual systems and more. Accordingly, this study sought to explore the concepts of building automation systems and their effect on real property values, investigate on the process of building automation in Kenya, with specific regard to the social, environmental, legal and technological considerations that guide the process and finally examine the factors influencing the need for and the growth of building automation systems in Kenya.

The study findings indicate that building automation systems have a positive effect on real property values in Kenya as there is an increase in rental values and lowered operating and maintenance costs which leads to a higher net rent, reflecting an increase in building value when capitalized. The considerations that guide the automation process are identified as: - legal considerations which encompass the existing laws that touch on BAS; technological considerations which touch on the useful life of the systems which in turn affects the long term marketability and flexibility of an automated building as well as its operating and maintenance costs; social considerations which include end comfort, convenience, safety and security of the occupants; economic considerations majorly entail the cost of acquisition, installation and maintenance of the systems while environmental considerations include the short term and long term effects that the use of automation systems may have on the environment and its sustainability.

The factors influencing the need for and the growth of building automation systems include: - ease of work in monitoring and controlling of building functions; energy efficiency associated with use of BAS; comfort, convenience, security and safety experienced by occupants of automated buildings; cost savings realized through lowering
of operating and maintenance costs and higher demand for space in the building which increases the occupancy rate and offers faster return on investment to the developers.
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ABBREVIATIONS

ADVSSB - Advanced Sensors for Smart Buildings
BAS - Building Automation Systems
BEMS - Building Energy Management Systems
BMS - Building Management Systems
BOS - Building Operating System
CAGR - Compound Annual Growth Rate
CB - Conventional Building
CBAS - Commercial Building Automation Systems
CCTV - Closed Circuit Television Camera
CSR - Corporate Social Responsibility
EIBG - European Intelligent Building Group
EMS - Energy Management System
HVAC - Heating, Ventilation and Air Conditioning
IB - Intelligent Buildings
IBI - Intelligent Buildings Institute
ILC - Intelligent Lighting Controls
IP - Internet Protocol
IT - Information Technology
**KNBS** - Kenya National Bureau of Statistics

**LED** - Light Emitting Diode

**NIST** - National Institute of Standards and Technology

**NMR** - Nairobi Metropolitan Region

**PC** - Personal Computer

**PPP** - Public Private Partnerships

**REITs** - Real Estate Investment Trusts

**ROI** - Return on Investment

**SB** - Smart Buildings

**SBNC** - Smart Buildings Networking and Communications

**SC** - Smart Cities
CHAPTER 1

1.1. INTRODUCTION

This study seeks to explore the concept of building automation systems and its effect on real property values. In addition, it will investigate on the process of building automation in Kenya, with particular regard to the social, economic, environmental, legal and technological considerations that guide the process and finally examine the factors influencing the need for and the growth of building automation systems in Kenya.

Chapter 1 introduces the topic of research, concepts of building automation systems, and explains the background of the research by highlighting relevant definitions and factors that have influenced the need for and growth of BAS. The main research issues including the problem statement, research questions, research objectives, research hypothesis, study area and scope are also addressed. Finally, there is the justification of the research and organisation of the study.

1.2. BACKGROUND INFORMATION

A conventional building is one that traditionally separates building systems or functions such as temperature control, energy management, fire and security.

Building Automation refers to the use of computer and information technology to control building appliances and features as well as the advanced functionality provided by the control system of an automated building (Gerhart, 1999). The control system is a computerized intelligent network of electronic devices designed to monitor and control the mechanical, electronic and lighting systems in a building (‘Building Automation Systems’, Wikipedia, 6th Nov 2013).

A Building Automation System (BAS) is a centralized, interlinked network of hardware and software which monitors and controls the environment in various types of property for example commercial, residential, industrial, institutional, recreational and special purpose facilities (‘Building Automation Systems’, Wikipedia, 6th Nov 2013). A BAS performs
many functions among them ensuring operational performance of a facility as well as the comfort and safety of building occupants. Buildings are fitted with such control systems at any age, whether during new construction or refurbishment and renovations where replacement of an out-dated control system is done. A building that is controlled by a building automation system is often referred to as an intelligent building or a smart home/smart house (‘Building Automation Systems’, Wikipedia, 6th Nov 2013).

An intelligent building, according to the Intelligent Building Institute (IBI) is one that provides a productive and cost effective environment through optimisation of its four basic elements: structure, systems, services and management, and the interrelationship between them. The European Intelligent Building Group defines an intelligent building as one that ‘incorporates the best available concepts, materials, systems and technologies; integrating these to achieve a building which meets or exceeds the performance requirements of the building stakeholders which include the owners, managers and users as well as the local and global community.’

For many individuals, a building is more than the mere fulfilment of shelter as a basic need; it is an expression of self, investment, privacy and most of all a safe haven in which business owners, property managers and occupants can experience ultimate comfort, convenience, safety, security, long term flexibility and marketability (IBI, 2010). The intelligent building seeks to provide for more than just the traditional factors that tenants would look for in a building, among them, plinth area, quality finishes, parking spaces, standby generators, underground water tanks, location, neighbouring amenities and price among others.

The concept of building automation has recently taken an upward trend in the Kenyan real estate market as evidenced by the number of new developments that are embracing the concept. Such systems can range from simple remote control of lighting and temperature to complex computer/micro controller based networks with varying degrees of intelligence and automation (Harper et al, 2003) (Gerhart, 1999). This study shall focus on the systems aspect of intelligent buildings with specific regard to five building automation systems:
Heating Ventilation and air conditioning (HVAC), lighting, fire and life safety controls, security and access controls and building management systems.

1.3. PROBLEM STATEMENT

The Housing and Real Estate sector has faced tremendous technological improvements in the recent past bringing with it significant changes in building structure, systems, services and management. A combination of the factors has brought about the era of automated and intelligent buildings, which have been established to be energy efficient, a factor that is now an objective for most countries. For example, in the United States, the 2010 version of American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) 90.1 will soon become a required minimum for all state building codes. Once this code is adopted, occupancy sensors and photo sensors will be required in many space types and a high bar will be set for overall lighting energy reduction (ILC, Navigant Consulting, 2013). In Europe, the European commission has set an 80% target for all European homes to be equipped with smart metres by the year 2020 while in China, the 12th Five-Year Plan (2011-2015) sets strong targets for energy efficiency (ILC, Navigant Consulting, 2013). In Kenya, Vision 2030, which is a medium term goal, recognizes the role of science, technology and innovation and aims to have advanced in technology such that other countries look up to us for technology solutions (Vision 2030, 2007).

Future trends in architecture and design are moving towards zero energy consumption in homes and buildings and as a result, strategies are being developed through science, technology and innovation, all directed towards this focus. Architects have recognized that every building and home is unique in energy consumption levels and therefore building automation systems are being implemented to manage resources such as energy effectively, at minimal operations and cost (Navigant research, 30th Jan 2014).

Building automation systems are part of the systems aspect of intelligent buildings as per the definition of an intelligent building by the IBI. BAS are incorporated in buildings through heating ventilation and air conditioning (HVAC), lighting, fire and life safety controls, security and access controls and building management systems. The resulting
solutions are aimed at reducing approximately 12% of the total global energy use by the commercial sector (Navigant research, 30th Jan 2014).

In order to fully appreciate building automation systems, there is need to understand the legal, environmental, social, and economic as well as the technological considerations that guide the adoption of such a system. Also, there is need to understand the effects of such a system in the Housing and Real Estate sector using parameters of value, as well as the factors that necessitate its integration in buildings.

The global market for commercial BAS is generally driven by new and retrofit commercial building construction and by the energy efficiency requirements applied to this construction. Renewed economic growth and accelerating energy efficiency targets for commercial buildings are combining to offer significant market growth opportunities for BAS (Navigant Research, 30th Jan 2014). Additionally, the adoption of new embedded computing, communications, sensing, and software technologies is fundamentally changing the underlying products and services within the commercial BAS market, presenting risks and rewards for various industry stakeholders. Navigant Research forecasts that global commercial BAS revenue will grow from $58.1 billion in 2013 to $100.8 billion in 2021 (Navigant Research, 30th Jan 2014).

According to the Business Daily 24th September 2009, a smart home can save the developer up to 25% of cost. Initial stages of investing may be high because of purchasing the equipment but the payback in the long term will be substantial as it offers new services, generates more revenue and cuts costs. Research by Dimension Data, an IT company, found that deploying an integrated building approach results in 30% operational costs reduction. With the recent advancements in technology and internet, both government and private enterprises are increasingly seeking for ways to harness the full potential of the internet in the homes, office premises and public buildings with building automation systems already being widely used in other countries among them USA, UK and South Africa.

According to a study done by Charles Otieno Ogutu, University of Nairobi, 2011, there has been a low uptake of intelligent building technologies in Kenyan commercial properties.
He however noted that the effective demand was high and anticipated for a significant increase with increasing awareness of the technology. He also established that the intelligent buildings in Kenya at the time was largely owed to international organisations that have embraced the concept in their buildings and this has led to newer developments embracing the technology in order to respond to the growing demand and need for intelligent workspaces which are achievable through incorporation of building automation systems.

There is immediate need for commercial buildings to adopt building automation system technologies in order to obtain benefits identified by Ogutu 2011 such as reduction in operation and maintenance costs, higher rental values, higher occupancy rates, remote and centralized monitoring of the building and energy efficiency among others. Various professionals in the building and construction industry as well as the general public, need to be aware of the latest technological advancements in the construction industry, the process of building automation and the regulations that guide the process.

In order to achieve an upward trend in the development of automated buildings, it is important to know and evaluate the effects of BAS on real property value as well as the rationale for its integration in buildings and homes, especially with the increasing demand for smart homes and intelligent buildings around the world.

1.4. **RESEARCH QUESTIONS**

1. What is the effect of building automation systems on real property values in Kenya?
2. What are the primary social, economic, environmental, legal and technological considerations that guide the process of building automation?
3. What are the factors influencing the need for and the growth of building automation in Kenya?
1.5. **RESEARCH OBJECTIVES**

1. To establish the effects of building automation systems on real property values in Kenya.
2. To investigate on the process of building automation with regards to the social, economic, environmental, legal and technological considerations that guide the process.
3. To examine the factors influencing the need for and the growth of building automation systems in Kenya.

1.6. **RESEARCH HYPOTHESIS**

The research hypotheses to be tested are:

- **H₀**: The incorporation of Building Automation Systems in buildings does not increase the value of real property in Kenya.

- **Hₐ**: The incorporation of Building Automation Systems in buildings increases the value of real property in Kenya.

1.7. **STUDY AREA AND SCOPE**

The study seeks to establish the effects of building automation systems on real property values in Kenya, investigate on the process of building automation in Kenya, with specific regard to the social, economic, environmental, legal and technological considerations that guide the process and finally it seeks to examine the factors influencing the need for and the growth of building automation in Kenya.

This research will employ a case study approach that will be limited to five commercial properties in Westlands sub district of Nairobi County, Kenya for the following reasons: - their implementation of building automation systems that are on a larger scale than other buildings, time limitations owing to the short period of the study and the likely prospect of the building managers/owners having and wilfully sharing the required information.
Purposive sampling will be used to identify the buildings which will then be subjected to a rigorous study.

1.8. **RESEARCH ASSUMPTIONS**

For the purpose of this study, it shall be assumed that the data collected from primary sources such as building automation providers/consultants, registered professionals, building tenants and other relevant stakeholders in the building industry is credible while that which is obtained from secondary sources will be assumed to have been collected and analysed accurately and is hence reliable.

1.9. **JUSTIFICATION FOR THE RESEARCH**

With the ever increasing hype of it being a digital age where anything one can think of can be achieved through information technology, it is not a wonder to see that there has been a considerable trend in development of intelligent buildings and generally building automation in Kenya and the world at large. This has been further propelled by the unveiling of smart phones, computers and tablets which can carry out quite a number of tasks among them controlling, monitoring, activating and deactivating the building automation systems installed from anywhere in the world.

In the past few years, the real estate market in Kenya has been experiencing a boom. This can be evidenced by the increasing number of off-plan purchases of developments, increase in property sales prices, influx of foreign nationals into the local property market and also the rapid development of areas that are near major towns. This has been partly boosted by the Government of Kenya which has proposed to set up a Nairobi Metropolitan Region with the aim of decongesting and easing the transaction of business in the central business district. The proposed Nairobi Metropolitan Region extends to an area of over 32,000 square Kilometres to cover a total of four Counties, Nairobi included. The other three Counties substantially depend on the County of Nairobi for employment and economic activities and include: - Machakos County, Kiambu County and Kajiado County.
These towns have seen tremendous growth in settlement and population and it has now become difficult to separate Nairobi from the wider Nairobi Metropolitan Region. Nairobi’s population has grown significantly from 350,000 in 1963 to 3,138,369 in 2009 with a population density of 4,515 persons per square Kilometre. This is despite having a small land area of only 695.1 square Kilometres. The total population in Nairobi alone is projected to hit the 8 million mark by the year 2030 (KNBS, 2010).

According to a study done by Estate Agents Knight Frank and Citi Private Wealth, it was established that Nairobi was the best performing prime residential market in the world. Values in the city grew up by 25% in 2011 leaving behind luxury hotspots such as London, Miami and Hong Kong behind. This is however based on growth and not value. Coastal hotspots such as Mombasa, Malindi and Lamu occupied the second position in The Wealth Report 2012 recording a 20% price growth in luxury residential properties. These are statistics that can be improved further if developers are aware of current technological trends in the housing sector and incorporate more building automation systems in future developments.

In order to stand out and succeed in the very competitive real estate market that is characterized by a high demand and low supply, developers have incorporated building automation systems in their developments establishing the concepts of smart homes and intelligent buildings so as to offer something that would attract and retain tenants and at the same time offer them value for their money.

This study seeks to establish the effects of building automation systems on real property values in Kenya, investigate on the process of building automation in Kenya, with specific regard to the social, economic, environmental, legal and technological considerations that guide the process and finally it seeks to examine the factors influencing the need for and the growth of building automation in Kenya. It is also aimed at enlightening the stakeholders involved both in private and public sectors on the necessity for movement into the building automation era for Kenya to be a leading trendsetter in technology through smart homes and intelligent buildings in Africa as proposed in the Vision 2030 of 2007.
The sector once well nurtured can enhance regional development all over Kenya through the creation of jobs and acquisition of revenue through taxes levied on the building automation systems. It can also lead to better productivity at work especially for working parents who will be at ease knowing that they can find out what is going on at home at the touch of a button. Increased security that is brought about by the building automation systems will attract more investments in the country as investors will not be afraid of risking or losing their wealth. With limited research having been conducted in Kenya with regards to building automation and intelligent buildings.smart homes, there is need for more research to establish the changing needs of consumers’ preferences and how to improve on the existing technology in buildings.

1.10. ORGANISATION OF THE STUDY

The research project will be organized into five chapters namely:

Chapter 1 of this study gives the introduction and background of the research problem, the study objectives and the research questions involved, the hypothesis, assumptions made, scope of the study, organisation of the study and justification for the research.

Chapter 2 delves on previous literature that has been written on the study area, building automation systems, with reference to its history, relevant definitions and technology aspects of building automation systems with a case study of Commerzbank headquarters in Germany which has employed aspects of building automation and intelligence such as lighting, HVAC, and building management systems. It also highlights the effects of building automation systems on the real estate market in Kenya and the considerations for building automation systems with specific regard to the legal framework, environment, social issues, technology and economic aspects. Factors influencing the need for and the growth of building automation systems in Kenya are also examined.

Chapter 3 outlines the study area of the research, Westlands, with specific insight on its history, geographic features, and socio economic features. The research methodology that will be used in the collection and analysis of data, a description of the research design,
research tools, study population, instruments of data collection and procedures of data collection and analysis is also given.

Chapter 4 gives an in depth analysis and presentation of the data collected during field study to enable drawing of meaningful inferences. Descriptive statistical methods are used to analyse the data while instruments of data presentation used include tables, pie charts and photographs.

Chapter 5 summarizes the findings of the research based on the research objectives, gives a conclusion and makes recommendations based on the findings. A hypothesis testing is also carried out to determine whether to accept or reject the null hypothesis and areas of further research are suggested to cover areas that were not included in this study.
CHAPTER 2

2.0. LITERATURE REVIEW

2.1. INTRODUCTION

Building Automation Systems (BAS) increase the interaction of mechanical sub-systems within a building and reduce energy consumption as well as allowing for off-site building control which ensures occupants comfort and ease in property and facilities management. Currently, there are numerous building subsystems controlled by BAS among them lighting control systems, air conditioning and heating, alarms and security systems, audio-visual systems, water systems of heating and cooling and shading amongst others (‘Building Automation Systems’, Wikipedia, 6th Nov 2013). Building Automation Systems use computer-based monitoring to coordinate, organize, and optimize the above mentioned building control sub-systems.

For a building automation system to attain its intended purpose of maximum user control, emphasis should be put on the proper functioning of computer hardware and software by identifying the potential benefits and practical/technical limitations early. The intended operator of the system should then be identified, implying that building designers, contractors, property managers and end users should work hand in hand for the success of BAS.

Building automation control has come a long way in recent years, dating back from proprietary systems and protocols to standard-compliant architecture that is backward and forward compatible. The modern BAS provides remote monitoring and alerting capabilities that can warn operators of a system of component failure, an abnormal condition or an increase in system energy consumption within a building. Such alerts are not restricted by geographical boundaries and this allows for off-site monitoring beyond borders or after hours ensuring timely response and correction.
2.2. METHODOLOGY OF THE REVIEW

The research literature chosen for this chapter focuses on building automation systems with reference to its history, relevant definitions and technology aspects of building automation systems with a case study of Commerzbank headquarters in Germany which has employed aspects of building automation and intelligence such as lighting, HVAC, and building management systems. It also highlights the effects of building automation systems on the real estate market in Kenya and the considerations for building automation systems with specific regard to the legal framework, environment, social issues, technology and economic aspects. Factors influencing the need for and the growth of building automation systems in Kenya are also examined.

2.3. DEFINITION OF KEY TERMS

There are several key words that are used in this research and a brief definition is required to fully understand their meaning. The terms include: - real estate, value, conventional buildings, building automation systems (BAS), smart homes and smart buildings, office automation and intelligent buildings (IB).

2.3.1. REAL ESTATE

Real estate refers to land and buildings and includes: - land and all things permanently attached to it, fixtures to land either natural such as trees and bushes or manmade such as fences and buildings, anything attached or incidental to land that benefits the land owner for example easements, and anything else that is considered immovable by law.

2.3.2. VALUE

Value is the monetary worth of a property, good or service to buyers and sellers at a given time. It is an expression of the present worth of future benefits that accrue to real property ownership. Market value is the estimated amount for which a property should exchange on the date of the valuation between a willing buyer and a willing seller in an arm’s length transaction after property marketing wherein the parties has each acted knowledgeably, prudently and without compulsion (International Valuation Standards).
2.3.3. CONVENTIONAL BUILDING

A conventional building is one that traditionally separates building systems or functions such as temperature control, energy management, fire and security.

2.3.4. BUILDING AUTOMATION SYSTEMS (BAS)

BAS refers to a system of network integrated computer components that automatically control a wide range of building operations such as lighting, access control, HVAC, fire protection, audio-visual systems security and more (‘Building Automation Systems’, Wikipedia, 6th Nov 2013). It has centralized, interlinked networks that have hardware and software, which monitor and control the environment in all types of facilities. The automation system conserves energy, lightens loads, and ensures that the facilities operate efficiently and that the building occupants are comfortable and safe. Basically, building automation begins with control of mechanical, electrical, and plumbing systems. A building controlled by a BAS is often referred to as an intelligent building, smart building or a smart home (‘Building Automation Systems’, Wikipedia, 6th Nov 2013).

2.3.5. SMART HOMES

This is an extension of building automation to homes. It is also referred to as domotics which is a discipline that investigates how to realize an intelligent home environment (ercim-news, 14th Jan 2014). A smart home is one that incorporates advanced automation systems to provide the inhabitants with sophisticated monitoring and control over home appliances and their functions. For instance, a smart home may control lighting, temperature, security, doors and windows as well as maintain an inventory of products recording their usage through bar codes and prepare a shopping list. The UK Department of Trade and Industry defined a smart home as “A dwelling incorporating a communications network that connects the key electrical appliances and services, and allows them to be remotely controlled, monitored, or accessed”.

2.3.6. SMART BUILDINGS

This is the integration of building technology and energy systems in buildings. Smart buildings are a reflection of technological advancements and convergence of building systems. They provide information about a building or space that is within a building to allow the owner or occupants of the building to manage it.

2.3.7. OFFICE AUTOMATION

This refers to the ‘varied computer machinery and software used to digitally create, collect, store, manipulate and relay office information needed for accomplishing basic tasks. The basic activities of an office automation system comprise: raw data storage, electronic transfer, and the management of electronic business information (‘Office Automation’, Wikipedia, 12th Jan 2014).

2.3.8. INTELLIGENT BUILDING

This is a building in which the building fabric, space, services, and information systems can respond in an efficient manner to the initial and changing demands of the owner, the occupier, and the environment. According to the European Intelligent Building Group (EIBG), an intelligent building is one that incorporates the best available concepts, materials, systems and technologies, integrating these to achieve a building that meets and/or exceeds the expectations of the stakeholders in its productive and cost effective performance. The stakeholders include the owners, managers, occupants, local as well as the global community.

Lim (1995) looked into factors an ‘Intelligent Building’ should have in order to be considered an intelligent building. He asserted that the building should be at least able to control various systems like air-conditioning, lighting and others and be able to manage them in the most energy efficient manner concluding that it is important to have BAS in an ‘Intelligent Building’.

Arkin and Paciuk (1997) evaluate the intelligence of a building according to the level of systems integration. They postulate that a building is considered to be intelligent only
when it is able to provide an environment and the means for optimal utilization of the building according to its designation. They further hypothesize that in order to achieve an intelligent building, various building systems such as lighting, air-conditioning, communication systems and others, are required to be equipped in the building. These systems must be able to integrate with the building structures in order to function well in the building and therefore all these systems integration has to be properly planned from the initial design stage of the building.

According to Atkin (1998) as quoted in Wigginton and Harris (2004), an intelligent building ought to:- know what is happening inside and immediately outside the building, decide the most efficient way of providing a convenient, comfortable and productive environment for the occupants, be responsive to user needs and climate and afford better integration with information technology and within the systems.

2.4. BUILDING AUTOMATION SYSTEMS IN THE WORLD REAL ESTATE MARKET

The market for commercial building automation products and services is mature, and yet the penetration rate of most modern technologies remains relatively low - except for in the largest and newest buildings (‘Commercial Building Automation Systems’, Navigant Consulting, 2013). According to a research on commercial building automation systems by Navigant Consulting 2013, building control systems are usually not changed unless a building undergoes a significant renovation, which may happen only every few decades. Hence, despite the availability of digital controls for many years, much of the existing building stock is still dependent on older technologies. Moreover, most BASs have been proprietary in nature, with single vendors providing and maintaining the systems for each customer. As a result, the terms BAS, BMS, and energy management system (EMS) lack clear industry definitions, leading to some level of confusion among industry participants.

It was further established by Navigant Consulting that commercial buildings account for approximately 12% of the world’s final energy consumption, and the need to optimise energy use in addition to the industry revolution in energy efficient lighting towards adoption of light-emitting diode (LED) technology has put a spotlight on BAS and is
opening new opportunities for advanced network lighting controls. Even with these changes, the commercial building automation market remains very dependent on rates of new construction and building renovation, which in turn are driven by overall economic conditions in each world region. The world market has been negatively affected by the 2008 financial crisis and is only now beginning to experience a modest, but accelerating recovery (‘Commercial Building Automation Systems’, Navigant Consulting, 2013).

Forecast Global revenue for commercial BASs is expected to grow at a relatively robust 6.6% compound annual growth rate (CAGR) over the period of 2012 through 2021, driven primarily by a slow but accelerating economic recovery for new construction and energy efficiency retrofits. North America is currently the largest market for commercial BASs. However, growth in Europe (8.2% CAGR) and Asia Pacific (8.3% CAGR) will allow these regions to surpass North America in terms of commercial building automation revenue by 2021 (‘Commercial Building Automation Systems’, Navigant Consulting, 2013).

2.5. ANALYSIS OF THE GLOBAL TRENDS DRIVING TECHNOLOGY INNOVATION IN REAL ESTATE

In the 21st century, digital technology accelerates our ability to affect real estate values. Technology is changing how we design and construct buildings and building fabrics, how we operate and maintain them as well as how the occupants experience and use them. Also, there are some other global trends that real estate experts need to examine and engage in. Government, corporations, and consumers today are more aware of and taking action on areas such as energy and climate change, air and water pollution, resource depletion, human health, safety issues, waste disposal, and biodiversity.

In fact, it was established that buildings consume 50 percent of the world's energy and the energy consumption of IT equipment in buildings is increasing significantly (Cabling-Install, 12th Jan 2014). Of the above concerns, environmental sustainability has proven to be a major global trend. Corporations across the world are adopting standards and implementing initiatives to improve the environmental performance of their operations. In
fact, major corporations especially those in the building and construction industry, are aligning global business strategies to address these trends through:-

- **Green building Standards** - A green building refers to a structure and using process that is environmentally responsible and resource-efficient throughout a building's life-cycle: from siting to design, construction, operation, maintenance, renovation, and demolition (‘Green Buildings’, Wikipedia, 30th Jan 2014).

- **Environmental management systems** - This is a structured framework meant to manage an organizations environmental impacts. The impacts vary with organizations and include wastes, emissions, energy use, transport, and consumption of materials.

- **Citizenship, corporate responsibility and reporting** - citizenship and corporate responsibility policy acts as a built-in and a self-regulating mechanism that ensures businesses monitor and comply with the spirit of law, ethical standards and international norms.

- **Environmental initiatives** - These are policies that are aimed to improve the environmental conditions. Global warming has awakened a call for corrective measures on the environment and such initiatives include planting trees for air purification.

The real estate, design, and construction industry has been exploring the concept of an intelligent building since the 1970s. In the 1970s, computer driven technologies influenced office and building automation and were incorporated into the physical fabric of buildings (Anil Bhasin, Vice president of Cisco India & SAARC). Today, most vendors are emphasizing on delivering intelligence driven infrastructure to businesses using the "Network as the Platform". This is aimed at facilitating the transformation of the real estate industry.

## 2.6. TECHNOLOGY TRENDS OF BUILDING AUTOMATION SYSTEMS

There are several systems of intelligent buildings incorporated in buildings, the most prominent being BAS and EMS. This study shall focus on BAS that are incorporated in

Of the five subsystems mentioned, it has been established by research that HVAC and Lighting are among the highest contributors of energy use in buildings with an approximate figure of 80% energy consumption. With technology features of BAS, this energy use has been evidenced to reduce significantly. According to a study done by Navigant Consulting in 2013 on advanced sensors for smart buildings, it was established that commercial buildings represent a huge source of energy use and that for most part, the buildings are inefficient because majority of the sensors currently used in BASs for example HVAC systems and lighting control are considered to be incapable of making intelligent decisions in real-time. An example of such energy inefficiency is the current sensors employed in HVAC systems that cannot determine the number of people in a room at a given time is given and as a result, airflow is at maximum capacity almost all of the time.

For a building to be truly considered intelligent, it must be able to automate the operation of its various subsystems with minimal human interference and to respond to constantly changing characteristics and create an environment that is both more productive for its occupants and more operationally efficient for its owners. New smart occupancy sensors can identify where people are located and how space is being used to make sure energy used to heat the building is not wasted. This not only saves money, it also maximizes employee comfort (‘Advanced Sensors for Smart Buildings’, Navigant Consulting, 2013). The various building sub systems are discussed as follows:

2.6.1. LIGHTING CONTROL SYSTEMS

BAS’s allows for all lighting to be controlled centrally and can be switched on, off or dimmed at a pre-defined time, depending on occupancy, daylight availability, and alarm conditions or in relation to the weather/geographic conditions outside the building. The occupied - unoccupied lighting control is a time-based program that schedules the on/off
time of lights for a building or zone to coincide with the occupancy schedules. Another way to reduce the costs associated with lighting is to control the level of lighting in a building. Lighting level control is accomplished by two different methods: multi-level lighting and modulated lighting.

Lighting controls can be either stand alone, room dependant types, or larger networked systems, where the dimmer units are fitted in an electrical cupboard and operated by a network of external devices like sensors and control panels (Introduction to Intelligent Buildings, Nikolaou et al). The concept behind these controls is to operate lighting automatically according to the function of an area, the time of day, ambient light levels, or occupancy. An important aspect of lighting is programmability which is the ability to remember lighting levels as a series of settings. These settings, also known as scenes, can be recalled automatically by the dimmer system or by the central building control system. Intelligent lighting controls have many advantages over manual ones, including convenience, creating ambience, increased design flexibility, energy saving, reduced lamp replacement costs and security.

Lighting can play an important part in security, deterring intruders whether the property is occupied or not. Low levels of illumination can be programmed to operate at night in certain rooms or hallways. When the building is unoccupied, levels can be selected that copy normal usage. This can be by time clock or by selecting a vacation mode. Dimmed or selectively switched levels of illumination will save energy and is more effective than leaving lighting on or using simple plug in timers (Introduction to Intelligent Buildings, Nikolaou et al).

The market for lighting controls in commercial buildings has expanded and transformed radically in recent years. Demand for local controls, such as occupancy sensors and photo sensors, as well as networked controls, is on the rise as adoption rates of light-emitting diode (LED) lighting begin to hike and controls technology improves and becomes less expensive. (ILC, Navigant Consulting 2013).
2.6.2. HEATING VENTILATION AND AIR CONDITIONING SYSTEMS (HVAC)

HVAC can consume up to more than half of the total energy of a building and thus energy conserving operations in buildings require control systems for Heating, Ventilating, and Air Conditioning. According to Nikolaou et al, the HVAC control system should be designed in order to be able to sustain a comfortable building interior environment, to maintain acceptable indoor air quality, to be as simple and inexpensive as possible and yet to meet HVAC system operation criteria reliably for the system lifetime and to result in efficient HVAC system operation under all conditions. HVAC systems like lighting, respond automatically or manually to various stimuli in the environment like weather, time of day, building occupancy or alarm conditions as in the case of a fire.

2.6.3. SECURITY AND ACCESS CONTROL SYSTEMS

Security is an issue that is of major concern to many people not only in Kenya, but in the world at large. Security systems such as closed circuit television cameras (CCTV) once integrated with building automation systems, are able to offer building surveillance at all times with records being simultaneously stored on backup files in a central control room for reference if need be. Security systems include CCTV, alarm systems, and intruder alarms for example magnetic contacts for doors and windows and movement detectors. Access once granted disarms the alarm zone automatically and in case of burglary, the system gives an alarm, which is relayed through the building operating system to the service centre and/or to specified mobile phones (NIST, 2006).

Access control is concerned with determining only the allowed activities of legitimate users by requiring an authentication mechanism such as a password which reflects the clearance level of personnel in the building. The objectives of an access control system are to protect system resources against inappropriate or undesired user access. Access control systems when integrated with building automation, lighting controls and other security systems are able to provide access to only those who are allowed according to programmed time schedules and credentials. This greatly boosts security of the building and its
occupants. Access control can be through proximity readers, control nodes, electronic keys or electronic locks (NIST, 2006).

2.6.4. FIRE AND LIFE SAFETY SYSTEMS

According to Busbby (2001), there are many reasons for integrating fire alarm systems with other building automation and control systems as in the case of door locks and HVAC fan and damper controls for smoke management. Among the reasons given by Busbby include: - smoke control, single - seat access to building information, easier maintenance, sharing sensor data, obtaining information about the location of people during an emergency, and providing infrastructure for new technology to improve performance and safety.

Integrated building systems have in the past relied on relays controlled by the fire alarm system to override the normal controls. This normally involved constant-volume HVAC systems and required only on/off control of fans and dampers to be moved to fully open or fully closed positions. Modern HVAC systems however require variable air volume systems, which are used to reduce energy consumption. These systems require sophisticated control algorithms to operate either a continuously variable-speed fan or inlet guide vanes to control the static pressure in the supply air duct. Variable-air volume boxes control the airflow from the supply duct into individual rooms by modulating dampers. The control algorithms for these systems are complicated and require interlocks and safeties to prevent over stressing duct- work in the event that dampers do not open when fans are turned on (Busbby, 2001).

New sensors are being developed that can recognize various contaminants in the air that can represent a fire signature or a hazardous contaminant that poses a life safety threat. In an integrated system, these sensors could be used by the HVAC control system to control ventilation rates with no adverse impact on their life safety functions. Multiple uses for the same information will make it more cost-effective to implement new sensor technology for example, in some buildings; access control systems monitor the location of building occupants. Providing access to this information to the life safety systems could be very
helpful in an emergency as emergency response personnel would know where to look for occupants who need to be evacuated. They could also reduce the risk to themselves by avoiding dangerous areas where no people are present (Busbby, 2001).

Research is now underway at the National Institute of Standards and Technology (NIST) to develop a new generation of smart fire alarm panels that can make use of sensor data from an integrated system to calculate heat release rates in a fire. Using this information, a fire model in the panel can predict how the fire will grow and spread. Emergency response personnel can then use these predictions to plan a strategy for fighting the fire. It could even be transmitted by the building systems to fire stations or fire trucks so that planning can begin before emergency personnel reach the site. This could significantly improve response time, saving lives and reducing property loss (Busbby, 2001).

2.6.5. BUILDING MANAGEMENT SYSTEMS

A Building Management System (BMS) is a computer-based control system installed in buildings that controls and monitors the building’s mechanical and electrical equipment such as ventilation, lighting, power systems, fire systems, and security systems. A BMS consists of software and hardware; the software program, usually configured in a hierarchical manner, can be proprietary, use Internet protocols or open standards (‘Building Management Systems’ Wikipedia, 14th Jan 2014).

Building Management Systems are most commonly implemented in large projects with extensive mechanical, electrical, and plumbing systems. Systems linked to a BMS typically represent 40% of a building’s energy usage; if lighting is included, this number approaches 70%. BMS systems are a critical component to managing energy demand. Improperly configured BMS systems are believed to account for 20% of building energy usage, or approximately 8% of total energy usage in the United States (‘Building Management Systems’ Wikipedia, 14th Jan 2014).

Building Management Systems are linked to security and access control systems or fire alarm and life safety systems for coordinated response to emergency situations like fires or invasions.
2.7. **BUILDING AUTOMATION SYSTEMS AND TALL BUILDINGS**

It is generally acceptable that tall buildings have to be automated. This is mostly in terms of security and access control systems, lighting, heating, ventilation and air conditioning and fire and life safety systems owing to the large number of people accommodated in high rise buildings whether commercial or residential. The energy consumption of high rise buildings is also significantly larger as compared to low rise developments and the use of BAS helps in reducing the high energy costs through mechanisms such as lighting control and HVAC systems and this saves the building owner major costs. In Kenya, the planning and building regulations of 2009 are in support of this and state that every building comprising six or more storeys above the ground level shall be provided with one or more passenger lifts and where the provisions for natural ventilation cannot be met, it requires that any person intending to erect a building submit an arrangement of mechanical means of ventilation which shall be capable of supplying fresh air to all parts of such room at a rate of not less than 5 changes of air per hour and such artificial lighting and ventilation as the authority may approve.

2.8. **WORLD PRACTICE ON BUILDING AUTOMATION SYSTEMS**

It is important to examine what the world practice is with regards to building automation systems. Many buildings in developed countries have adopted the systems and are now focusing on intelligence aspects. To illustrate the world practice, a case study example of Commerzbank headquarters in Germany shall be highlighted with specific focus on its HVAC, Lighting and Building Management Systems.

Commerzbank headquarters is a high rise office building in Frankfurt, Germany that was completed in May 1997 from 1994 when construction began. It has a floor count of 56 and total floor area of 109,200 m² According to Wigginton (2002), the building has an intelligence aspect in that it has incorporated motor-driven sashes, controlled by the central BMS, to the external windows and the atrium. The windows can be closed by the BMS in unfavourable conditions and air conditioning automatically activated. Lighting in the office areas is controlled automatically according to daylight penetration and occupancy while
night cooling can be instigated through the motorized opening of windows on summer nights.

To provide heating during cold spells, which is predicted not to exceed 17% of the operating cycle, it is anticipated that there will be a degree of passive solar build-up between the outer single glazed screen and the double-glazed opening light. When the air conditioning is operational, heat from the return air is recycled to preheat incoming fresh air (Wigginton, 2002).

Cooling is facilitated by a computerized BMS that enables night cooling of the concrete floor slabs through the opening of motorized perimeter windows. Local cooling is provided during the day by means of a water-based chilled ceiling system (Wigginton, 2002).

Ventilation is through motorized windows which accounts for nearly 60% of the total hours of usage. In periods of excessive heat or cold, each 12 storey village is provided with its own backup air handling unit to supply fresh air mechanically. These include supply and extract fans, thermal wheels, filters, cooling coils, heating coils, a humidifier and fresh air/recirculation dampers. A mechanical air supply and exhaust system serves the central corridor zones of each storey at all times (Wigginton, 2002).

Daylighting is provided through natural lighting directly through the windows and indirectly to offices facing the gardens that are lit both from the side and above. Artificial lighting can be dimmed in response to variations in daylight levels on both the external and atrium facades. Lights in corridors and offices are activated automatically by movement sensors. Each window incorporates a motorized blind for solar shading, permitting individual control of solar admittance (Wigginton, 2002).

According to Wigginton 2002, the BMS monitors numerous sensors and has full control over the internal climate system. It is operated according to the number of people in the building, the usage of the system and the outdoor climate. It can reduce the quantities of supply and exhaust air and completely deactivate the air conditioning for parts of the building not being used.
The computer determines the optimum position of the external sun shading, the motorized windows, chilled ceilings, air conditioning and perimeter heating. The BMS is zoned into 12 storey village units and is informed by weather stations at four levels. The system monitors nine sensors in each of the internal gardens, adjusting temperatures and activating underfloor heating in these areas during cold weather (Wigginton, 2002).

The control network enables full occupant override when the external climate is appropriate, which is decided by the BMS in consultation with data describing the external weather conditions. User intervention to vary heat, air and light permeability is provided by an enhanced ‘light switch panel’ which facilitates control of light, temperature, window opening and blind positions (Wigginton, 2002).

The implementation of BAS systems in Commerzbank Headquarters is a typical scenario in many parts of the world especially in developed countries such as United States of America, Europe, Asia and even Australia.

2.9. EFFECTS OF BAS ON THE REAL ESTATE MARKET

Building Automation Systems have various effects on the real estate market among them: - energy efficiency, user efficiency and comfort, increased safety, commercial job loss, sustainability and innovations, reduction in operating and maintenance costs, higher occupancy rates and proactive management of building services among others.

The future of power generation depends largely on what can be saved than what can be produced. With the high rate of population increase, energy sources are facing great pressure since energy demand is scaling higher and higher each day. The questions therefore are; how can blackouts be prevented? How can energy consumption be reduced?

Primarily, BAS is used to control systems and monitor status of activities in a building. It has many data points at its heart that report whether the systems are operating within the set design parameters or not. It has critical alarms that are sent to pagers carried by facility staff. The building automation system turns certain systems to standby mode when not in use. For instance, rooms that are energy intensive and require constant air changes can be
operated using the building automation systems. When not in use, their support systems can automatically be scaled down. By constantly monitoring zones and prevailing temperatures, building automation systems help to conserve energy.

Energy reduction by the building automation system has attracted great returns on investments to building owners. This heightens the demand for intelligent buildings and in particular building automation systems. As a result, the real estate market is gaining high momentum in the economy as every investor seeks to invest there, with the high return to investment being the main motivator. However, the key determinant for energy savings and reduced environmental impact depends on several things: operational analysis, systems design, user training, and data collection and administration.

Building automation systems have controls (HVAC) that increase the comfort of users. The HVAC is complex with many components that are designed and arranged in such a way to produce heating, cooling, and ventilation. It uses the principles of heat transfer, fluid mechanics, and thermodynamics. In addition to making the building comfortable for the users, the HVAC also makes the building healthy for its occupants. It responds to internal and external conditions of the building in its operation. These conditions include the weather, time of the day, occupancy of the building as well as the use of spaces within the building. It also performs an optimal calculation based on the building occupancy history. Building automation systems also have management tools that further increase user efficiency.

Security is a major concern for not only citizens, but also the government itself. It is a key consideration for any occupant seeking a building. Today, building automation has greatly increased safety in building and this attracts investors in this market. Building automation systems have access control systems that enhance safety of building occupants by allowing only those with required credentials access. However, the controls require integration with other systems such as video surveillance and HVAC. The systems have an electronic control access system that controls access to non-public areas where authentication is required. They have a system that detects intrusion in such areas and a manual authentication system that is used in case connectivity is unavailable. These systems use
access cards or biometric authentication at the entry points of such areas such as doors and windows and this increases the degree of safety in commercial buildings.

Babel Buster records that after the tragic fire that happened in 1980s in a hotel in Las Vegas, there was recognition that occupants are exposed to smoke inhalation in case of fire. Currently, there are smoke control systems that are mostly installed in high-rise buildings, hospitals, theatres, arenas and other public assembly areas. These systems raise alarm in case of any smoke detected thus enhances security in these buildings. Better management is also attained with building automation systems as the system can be controlled easily and from anywhere therefore, allowing the user to manage facilities without much hassle. Most of these systems have a master digital remote control that enables them to operate the system easily.

As with most technological advancements, building automation systems too lead to loss of commercial jobs. In the absence of the automated systems, personnel would be employed to operate the various parts buildings. For instance, in absence of the automated authentication systems, security personnel would have to be hired to control access of the non-public areas. Building automation systems eliminates such personnel and thus the loss of commercial jobs in the real estate market.

Technology is very dynamic and new innovations are being made daily. This creates fear in that the current building automation systems may become obsolete quickly and therefore, require replacement. This hinders some investors from investing in BAS as they perceive this to be an increase in terms of cost.

Ogutu (2011) notes that operation and maintenance costs in intelligent buildings are significantly lower compared to conventional buildings. He cites reduction of personnel hired for maintenance of the building and efficient energy use which translates to lower costs as the reasons for overall reduction in costs.

Owing to increased security in intelligent buildings, responsive environment that is user friendly and energy efficiency which saves cost, Ogutu (2011) reports that there was
increased occupancy rates in intelligent buildings which was likely to enhance revenue and in turn the return on investment of the developers.

Ogutu (2011) notes that in intelligent buildings, the flow of information between the building systems and its users are high, allowing for faster attendance to problems by the property manager as they arise. This is through a feedback mechanism that sends a short message to the property manager and an electronic mail to the service provider alerting them of the problem.

2.10. FACTORS THAT CONTRIBUTE TO THE GROWTH OF BAS

The market for networked building controls is increasing, as building owners and operators realize the cost savings available through automated and integrated control of every major building system. The market is being given further incentive by increasing energy prices and the growing utilization of simple-to-use, web-based dashboards used in the IT world (‘Smart Buildings Networking and Communications’, Navigant Research, 2014).

According to a report by Navigant Consulting done in early 2014, integrated building management and building automation systems (BASs) rely on building-wide networks of sensors, switches, fans, alarms, and other devices to provide a real-time view of the current state of a building. They also use powerful software tools to make adjustments that can improve the safety and efficiency of a building’s systems and improve the comfort of occupants.

Energy management associated with BAS is a key factor associated with its growth. It was established by Navigant consulting that commercial buildings consume approximately 23% of all electricity globally and as a result, most countries in the world are focused on bringing their buildings up to par on an energy efficient front through refurbishments and new construction, as well as integrating advanced IT-level control functions for easier and more efficient data analysis and system management.

It was also established by Navigant Consulting that the convergence of IT and building automation is driving the growth of the networked building controls market. Increasingly,
building automation controls and field devices are being fitted with Internet Protocol (IP) capability in order to utilize the same protocols and infrastructure equipment as the IT network. IT-like interfaces, such as web-based management control interfaces that can be viewed and controlled via smartphones, tablets, or PCs, also make it easier to monitor, manage, and analyse this data (‘Smart Buildings Networking and Communications’, Navigant Research, 2014).

Issues surrounding technical compatibility and device costs also influence the growth of BAS because local installers often make the choice of technology based on specific insights or financial incentives, rather than via a master contractor making product decisions from a holistic network view (‘Smart Buildings Networking and Communications’, Navigant Research, 2014).

The need to maintain occupants comfort and the ease in controlling and maintaining the systems also contributes to the growth of BAS since there is greater demand for the control systems and in turn, supply for them is increased.

In some countries, regulatory initiatives are encouraging the development of intelligent building market. For example the European commission has set a target of 80% of European homes to be equipped with smart metres by 2020. The increase of initiatives and partnerships like joint ventures and public private partnerships (PPPs) has also influenced the adoption of BAS technologies.

2.11. CONSIDERATIONS FOR A BUILDING AUTOMATION SYSTEM

2.11.1. LEGAL REQUIREMENTS

There are legal requirements that every building undergoing new construction or refurbishments with regards to BAS should undertake. In Kenya, there are various Acts of parliament that highlight on the standards and expectations to be met as well as provide guidelines on BAS. The legislations include Kenya Planning and Building Regulations 2009, Vision 2030 of 2007 and the Housing Bill 2009.
KENYA PLANNING AND BUILDING REGULATIONS 2009

The Kenya Planning and Building Regulations of 2009 require that the design, planning and the supervision of the erection of any building or structure or the performance of it, shall be done by a person who is registered, has specific qualifications/certificates or training of a specific nature which is acceptable to the National Planning and Building Authority, Kenya. It is also required that an application shall be made to The Authority for authorization to erect any building and such work shall not be started until access is granted.

It further states that any person intending to erect any building shall submit to the National Planning and Building Authority the following plans and particulars, together with one application:- location plan, site plan, drainage installation drawing, fire installation drawing, particulars of any existing building which is to be demolished and details of the method of demolition to be used and such plans and particulars as may be required by the authority in respect of:- general structural arrangements, subject to any requirement contained in these Regulations with regard to design of the structural system, general arrangement of artificial ventilation, fire protection plan, any certificate contemplated in these Regulations and any other particulars (Kenya Planning and Building Regulations, 2009).

The Kenya planning and building regulations acknowledges the fact that development in the building industry is a dynamic process and with passage of time, new materials and technologies become available, design methods are refined and innovative building systems and techniques are introduced, as such, Planning and Building Regulations cannot remain static. The Regulations encourage the use of innovative designs, new materials and new construction methods; to optimize on resources and to enhance adherence to planning and building standards such that buildings are designed and built in such a way that persons may live and work in a healthy, safe and convenient environment (Kenya Planning and Building Regulations, 2009).

With regards to fire and life safety, the planning and building regulations of 2009 require that any person intending to erect a building submit a fire installation drawing and a fire
protection plan. In addition to that, every building comprising 6 or more storeys above the ground level shall be provided with one or more passenger lifts and every building exceeding six storeys in height shall be provided with at least one lift, designed and installed to be used by firemen in the event of a fire. The protection of occupants or users therein is ensured and that provision is made for the safe evacuation of such occupants or users (Kenya Planning and Building Regulations, 2009).

With regards to HVAC, the planning and building regulations of 2009 provides that every building intended to be used as an office or for habitation shall be provided with effectual means of lighting and ventilation without detriment to health, safety and without causing nuisance. It further states that all rooms should be naturally lit and well ventilated unless where owing to the position, level or unsuitable surroundings, the provisions for natural ventilation cannot be met. In such situations, it requires that any person intending to erect a building submit an arrangement of mechanical means of ventilation which shall be capable of supplying fresh air to all parts of such room at a rate of not less than 5 changes of air per hour and such artificial lighting and ventilation as the authority may approve (Kenya Planning and Building Regulations, 2009).

Where in the opinion of The Authority compliance with the provisions of these regulations will not secure adequate ventilation, it is a requirement that the room be provided with additional ventilation by means of an aperture or airshaft communicating directly with the open air, having an unobstructed sectional area of not less than 0.015m², a fanlight which opens to a ventilated lobby or corridor or such other means of ventilation as shall be approved by it (Kenya Planning and Building Regulations, 2009).

The Planning and Building Regulations of 2009 provide that in every building or part thereof in which electricity is installed for lighting; the system shall include at least one terminal point for lighting in every room having a floor area of 2m² or more and in every bathroom, water closet, entrance vestibule, hall, passage and stairway terminal landing. It further states that every light at a stairway terminal landing shall, unless automatic switching devices are installed, be controlled by switches at such landing and at any other terminal landing thereof (Kenya Planning and Building Regulations, 2009).
KENYA VISION 2030, 2007

Kenya Vision 2030 is a relatively new long-term development blueprint for the country that is motivated by collective aspiration for a much better society than the one we have today, by the year 2030. Its aim is to have a globally competitive and prosperous country with a high quality of life by 2030 by transforming Kenya into “a newly-industrialising, middle income country providing a high quality of life to all its citizens in a clean and secure environment” (Vision 2030, 2007).

The Vision is anchored on three key pillars: Economic, Social, and Political Governance. The economic pillar aims to achieve an economic growth rate of 10 per cent per annum and sustaining the same till 2030 in order to generate more resources to address the Millennium Development Goals. The social pillar seeks to create just, cohesive and equitable social development in a clean and secure environment. The political pillar aims to realise an issue-based, people-centred, result-oriented and accountable democratic system (Vision 2030, 2007).

One of the foundations for vision 2030 that is in line with BAS is Science, Technology and Innovation. Vision 2030 proposes intensified application of science, technology and innovation to raise productivity and efficiency levels across the three pillars. It recognises the critical role played by research and development in accelerating economic development in all the newly industrialising countries of the world. The Government will create the STI policy framework to support Vision 2030. More resources will be devoted to scientific research, technical capabilities of the workforce, and in raising the quality of teaching mathematics, science and technology in schools, polytechnics and universities (Vision 2030, 2007).

THE HOUSING BILL 2009

The Housing Bill of 2009 is an act of Parliament to provide for the effective coordination, facilitation, capacity building and monitoring of the housing and human settlement sector. It establishes the Kenya Housing Authority and the National Social Housing and
Infrastructure Fund for the provision of housing and for connected purposes (Housing Bill, 2009).

The Kenya Housing Authority is mandated to promote research on housing, building materials and technologies, and shall in that regard:– collaborate with other institutions in the funding and coordination of research, advise the minister on recommendations to the Ministry of Finance on tax concessions in respect of building materials from time to time to better housing construction costs, ensure that new technologies and building materials are tested and certified by relevant institutions to uphold set standards, promote wider adoption and application of building by-laws and planning regulations as revised from time to time, promote use of indigenous architecture that is suitable to local environments and promote the adaptation of internationally acceptable measurement criteria to help set appropriate standards for housing development and to enable monitoring of progress (Housing Bill, 2009).

2.11.2. ENVIRONMENTAL CONSIDERATION

Buildings are large entities and as such, they impact upon the environment in various ways. Present day designs clearly consume large quantities of physical resources such as materials, energy and money in their construction and maintenance and use. Before installing BAS, one should consider the environmental impacts of the building during its entire life cycle.

Environmental considerations and energy efficiency should be part of building design and purchasing criteria, balanced appropriately with other important criteria, such as product safety, price, performance and availability.

Energy efficiency and environmental performance should be evaluated using a “system” approach, focusing on how individual components interact within the building system and identifying options with the greatest potential for improving energy efficiency and reducing overall environmental effects.
The effectiveness of a BAS in terms of space conservation is also another major environmental consideration. A BAS should utilize the available space and allow for future expansion.

2.11.3. SOCIAL CONSIDERATION

Effects of a BAS on the society are a major consideration. Building Automation Systems are meant to improve the comfort of occupants. However, these systems should not affect the occupants and the society as a whole in the course of their usage. For example the materials used when installing the BAS should not cause any health hazard such as emitting radiations or noise which might affect the health of the occupants.

The design should be one which provides a healthy indoor environment for building occupants. Healthy indoor environment refers to ventilation, the ability of the occupants to control temperature, the amount of available natural daylight, and low levels of air pollution chemicals in building materials, paints, BAS and adhesives.

Citizenship and corporate responsibility policy acts is also a major consideration when installing BAS in offices. It is a built-in and a self-regulating mechanism that ensures businesses monitor and comply with the spirit of law, ethical standards and international norms.

2.11.4. TECHNOLOGICAL CONSIDERATION

Building Automation Systems such as heating/ventilation/air-conditioning (HVAC), security, lighting and communications, use some form of information technology networking for management and control. The technologies for connecting, managing and automating building systems include servers for hosting management software and controllers for floor-level settings. Components can include a wide variety of endpoint devices such as desktop computers, lighting bulbs and tubes, variable air boxes, surveillance cameras and interactive lobby kiosks. Network infrastructure including cabling, switches, connectors and related protocols are also required.
Under technological consideration one should first consider the energy available, the cost of installing and maintaining a certain technology and the flexibility of the technology, this is to allow for upgrading and incorporation of other systems in future.

Every building system (HVAC, lighting, security, and communications) uses some form of IT networking for management and control. The technologies for connecting, managing, and automating building systems include servers for hosting management software and controllers for floor level settings. By using a Unified Physical Infrastructure approach, enterprises can align, converge, and optimize critical systems – communication, computing, control, power and security – to build a smarter, unified business foundation and meet sustainability goals. This approach enables the use of an open standards-based, service-oriented architecture framework and is designed to deliver tangible infrastructure and business process improvements (Panduit, 2010).

**2.11.5. ECONOMIC CONSIDERATION**

An important consideration to make economically is in terms of cost. Cost is inclusive of the software and hardware systems that need to be put in place, their installation, maintenance and replacement costs as well as the useful economic life so as to plan ahead for its obsolescence and the costs expected as a result of embracing newer technology. Training of relevant personnel is also an important aspect of costs as they are the ones who use and maintain the systems. Older or less-skilled employees who are used to manual methods might find it difficult to operate and adjust to automatic processes. This could require additional training which could be time-consuming.

**2.12. THE FUTURE OF BAS – SMART CITIES**

The smart city concept has caught the imagination of city leaders around the world because cities have always been places where decisions and fortunes are made and the future invented. Today, cities are the focal point for the most significant trends of the century (‘Smart Cities’, Navigant Consulting, 2013).

It is estimated by Navigant Consulting that between 2010 and 2050, the number of people living in cities will increase from 3.6 billion to 6.3 billion. By 2025, there will be 37
megacities with populations of over 10 million; 22 of those cities will be in Asia. The impact of this expansion is already evident in the urban population on the global economy, as seen in the demand for infrastructure and resources, and on new thinking about how cities are designed and managed. Over the coming decades, cities will play an even larger role in defining the state of the planet (‘Smart Cities’, Navigant Consulting, 2013).

According to Navigant Research’s definition, a smart city is characterized by the integration of technology into a strategic approach to sustainability, citizen well-being, and economic development. As such, smart cities cannot be understood as a normal market. An incredible diversity of customers, suppliers, technologies, and requirements fall under the concept. The smart city should be seen as a complex union of several existing markets, as well as the driver for new, emergent solutions that span several of these traditional domains (‘Smart Cities’, Navigant Consulting, 2013).

The rapid expansion of the urban population in the world’s developing countries is the primary driver for the interest in developing new approaches to city development and the use of smart technologies to improve efficiency and reduce costs. A new focus is emerging on the role of cities in North America and Europe as these economies come to terms with the impact of globalization on their industries and economies (‘Smart Cities’, Navigant Consulting, 2013).

A common principle is that a smart city is a sustainable city. Cities are responsible for around 70% of global energy consumption and greenhouse gas (GHG) emissions. Organizations like the C40 Cities Climate Leadership Group have played an important part in showing how cities can play a vital role in addressing environmental issues. Indeed, cities have often exceeded the commitments of national governments for reductions in GHG emissions and improved environmental stewardship. New technologies and new approaches to policy development and operations management are enabling cities to meet global and local environmental targets (‘Smart Cities’, Navigant Consulting, 2013).

City leaders are coming to terms with changing nature of the relationship between government and citizens. Technology has enabled new forms of communications about social issues between citizens – and between citizens and government. Crowdsourcing
solutions for urban problems through online engagement are also becoming a common element in many city regeneration programs (‘Smart Cities’, Navigant Consulting, 2013).

One of the barriers faced in development of a smart city is developing effective financial models: Funding remains the critical issue for large-scale deployment of smart city solutions. The development of a range of financial models that allow cities to invest in innovation will be crucial to the next phase of this market. For this reason, interest in what types of new service models will be most appropriate is increasing. Citywide agreements with energy management companies are already being developed for building improvements and we could see these models extend into other areas of energy efficiency, such as public lighting systems (‘Smart Cities’, Navigant Consulting, 2013).

A broad perspective on the operations of a smart city is vital not only to ensure that environmental targets are met, but also to get maximum benefit from investments. Pilot projects and isolated new developments have a role to play as models of what can be achieved and as spurs to innovation, but they need to be put in the context of an integrated vision of what a city is trying to achieve (‘Smart Cities’, Navigant Consulting, 2013).

2.13. CONCLUSION

The real estate market has grown tremendously in the past few years, especially with the embrace of technology in building materials and management. The demand for intelligent buildings and building automation systems by tenants has been on the rise and developers are still struggling to embrace the concept wholeheartedly. As a result, there is growing pressure on developers to ensure that their buildings are equipped building automation systems.

In the literature review, several aspects of BAS have been critically examined with specific regards to the state of Building Automation Systems in the world real estate market, an analysis of the global trends driving technology innovation in real estate, technology trends of BAS, world practice with regards to BAS, effects of BAS on the real estate market, factors that contribute to growth of building automation systems, consideration for BAS systems and the future of BAS.
It has been established by Navigant Consulting that commercial buildings account for approximately 12% of the world’s final energy consumption, and the need to optimise energy use is one of the many factors accelerating the growth of BAS systems in the world. The rapid expansion of the urban population in the world’s developing countries is also a primary driver for the interest in developing new approaches to buildings and the use of smart technologies to improve efficiency and reduce costs.

The City of Santa Fe is a great example of expanding from efficiency to renewable energy. Mayor David Coss envisioned Santa Fe being sustainability and renewable energy city and also a renewable energy capital of the United States. The city focused and laid emphasis first on efficiency and it is an example of a future-thinking energy strategy. Nick Schiavo, the Director of Public Utilities, added that of the total energy usage of the city, 24.9% would be generated from renewable sources. Kenya too can follow this strategy and lay more emphasis on conserving energy, especially in homes and offices through use of building automation systems which have been proved worldwide to be an efficient technology that will immensely contribute to energy conservation.

Trends in the development of automated buildings in Kenya indicate that there has been an increasing but slow rate of adoption. The slight increase is attributed to factors such as cost savings and energy efficiency associated with integrated control of building systems, convergence of information technology and building technology, the technical compatibility of BAS and user needs which ensures occupants comfort and convenience, increase of initiatives between public and private investors and the change in consumer tastes and preferences to automated buildings. The factors that make BAS adoption be at a slower rate in Kenya compared to developed countries include high device costs, lack of proper legislative and regulatory framework, lack of documented local experience making it a fairly risky venture and the lack of awareness of the benefits of BAS by property developers.

Technology trends of building automation systems have been identified to include lighting control systems, heating ventilation and air conditioning, security and access control systems, fire and life safety systems and building management systems. In Kenya, the legal
frameworks that support BAS include Kenya Planning and Building Regulations 2009, Vision 2030 of 2007, and the Housing Bill 2009. The current laws are however general in their stipulations of embracing new technology in buildings and there is urgent need for development of a framework that encompasses the specific requirements and standards that should be met in automated buildings.

The main objective of this research is to find out the effects of building automation systems on real property values. This is an important aspect that needs to be studied in order to make valid conclusions that developers in Kenya can rely upon in their appreciation of the true essence and entirety of BAS and the various benefits it provides to the developers as well as the occupants. Such conclusions would also enable more public awareness on concepts of BAS and this would lead to its widespread adoption if the benefits far outweigh the shortcomings that may be encountered.
CHAPTER 3

3.0. CASE STUDY AND RESEARCH METHODOLOGY

3.1. INTRODUCTION

This chapter outlines the study area of the research, Westlands, with specific insight on its history, geographic features, and socio economic features. The research methodology that will be used in the collection and analysis of data, a description of the research design, research tools, study population, instruments of data collection and procedures of data collection and analysis is also given.

3.2. RESEARCH METHODOLOGY

Kumar (2005) describes research methodology as an operational framework within which certain facts are placed so that their meaning may be seen more clearly. It describes in detail how the research process was conducted and outlines data collection procedures, measurements and analysis used to accomplish the research objectives.

3.2.1. RESEARCH DESIGN

A research design is the logical sequence that connects the empirical data to a study’s initial research question and ultimately to its conclusions (Yin, 2003). Nachmias & Nachmias (1992) quoted in Yin (2003) defines a research design as a plan that guides the investigator in the process of collecting, analysing and interpreting observations. It further states that it is a logical process model of proof that allows the researcher to draw inferences concerning causal relations among the variables under investigation.

Selltiz et al (1962) quoted in Kothari (2004) defines research design as the arrangement of conditions for collection and analysis of data, in a manner that aims to combine relevance to the research purpose with economy in procedure. It is further defined as the conceptual structure in which research is conducted and constitutes a blueprint for the collection, measurement and analysis of data.
This research aims at investigating on the effects of building automation systems on real property values and the first step is design of the case study where research questions, hypothesis and objectives are established. The second step is literature review in relevance to the identified objectives. The third step is conducting of the case study through data collection. The fourth step is analysis of the case study data and lastly writing the case report and research implications.

3.2.2. METHODS OF DATA COLLECTION

There are generally two approaches of data collection: primary data which is gotten first hand, and secondary data which is gathered from second hand sources. Yin (2003) suggests that data required when using a case study research can come from six sources namely: - documents, archival records, interviews, direct observation, participant observation and physical artefacts.

In this study, primary data was collected through a combination of structured and unstructured questionnaires to property developers and property and facilities managers, interviews to supplement responses from the questionnaires and observation combined with taking photos to identify the building automation systems employed in the buildings. Secondary data was obtained from books, journals, reports, newspapers, government publications and the internet.

3.2.3. RESEARCH TOOLS

Research tools are developed to help the researcher collect data from the required sources. In this study, questionnaires, interview schedules, observational forms, camera, pen and notebook were used.

QUESTIONNAIRES

Questionnaires are commonly used to obtain important information about a population. Each item in the questionnaire is developed to address a specific objective, research question or hypothesis of the study. A well thought out questionnaire should not confuse the respondents, discourage them or leave out important information required in the study (Mugenda, 2003).
Questionnaires can either be structured or unstructured. Structured questionnaires also referred to as closed-ended questionnaires consist of questions that are accompanied by a list of all possible alternatives from which respondents select the answer that best describes their situation. Unstructured questionnaires also referred to as open-ended questionnaires consist of questions which give the respondent complete freedom of response in their own words (Mugenda, 2003).

The questionnaires used in this study combine both the structured and unstructured types of questionnaires and were individually presented to the respondents for filling after the purpose of the inquiry was explained to them. The filled questionnaires were later picked up at an agreed time with the respondents.

The information to be collected from the questionnaires include the effects of building automation systems on real property value, the consideration one makes when choosing a BAS and the factors that have influenced the need and growth of building automation in Kenya. The questionnaires were selected as a tool for data collection as they minimize interviewer bias, have a high response rate and the benefit of personal contact.

**INTERVIEWS**

An interview is an oral administration of a questionnaire or an interview schedule done face to face, via telephone or email. In this research, semi structured interviews were used so as to offer flexibility of response from the various respondents, offer a high response rate and provide in depth data with the opportunity to correct misunderstanding and incompleteness.

**PARTICIPANT OBSERVATION**

Active observation of the various building automation systems together with taking of photographs was used as a tool of data collection. Observation is useful in helping to gather information that is not obtainable from other sources and aids in enhanced understanding of the elements under study.
3.3. STUDY POPULATION

A population refers to an entire group of individuals, events or objects having common observable characteristics (Mugenda, 2003). All buildings that have employed building automation systems in Westlands Sub-district of Nairobi County form the study population (N).

3.3.1. SAMPLING TECHNIQUE

A sample is an accessible subgroup of the population selected from a study so as to be a representation of the whole population with the relevant characteristics (Mugenda, 2003). Sampling therefore is the process of selecting a subgroup to represent the population from which inferences are drawn about the entire population.

In this study, purposive sampling was used so as to achieve the objectives of the study based on who can give the best information on the topic of research. Building Automation Systems is a fairly new concept in Kenya and only a minority of buildings having embraced the concept. With this being a pioneer study, purposive sampling was identified as the best method for data collection as it permits an understanding of the concepts of BAS and its effects on real property value from the selected cases. Accordingly, four cases in Westlands sub district were selected. The criteria for selection was buildings that exhibited elements of what is considered to be best practice in Building Automation Systems and which would be a true representation of all automated buildings.

3.4. THE CASE STUDY

A case study according to Mugenda (2003) is an in-depth investigation of an individual, group, institution or phenomenon. Most case studies are based on the premise that a case can be located that is typical of many other cases. The primary purpose of a case study is to determine factors and relationships among the factors that have resulted in the behaviour under study (Mugenda, 2003). Kumar (2005) describes a case study design as an approach to studying a social phenomenon through analysis of individual cases that gives an opportunity for intensive analysis so that generalizations may be made, that are applicable
to other cases of the same type. In this particular research, the purpose of the case study is to determine whether building automation systems affect real property value.

Westlands Sub-district of Nairobi County has been selected as the case study area, because it is a commercial centre that has in the recent past shown a rise in office space developments that are considered to be modern and state of the art in terms of technology employed in the buildings. Within Westlands sub district, five commercial properties will be selected for the following reasons: their implementation of building automation systems that are on a larger scale than other buildings, time limitations owing to the short period of the study and the likely prospect of the building managers/owners having and wilfully sharing the required information.

3.5. **BACKGROUND OF THE STUDY AREA**

3.5.1. **KENYA OVERVIEW**

Kenya has a total land area of 581,313.2 Square Kilometres. As of the 2009 population census, the total population was 38,610,097, the total number of households 8,767,954 and the density per person 66 per square Kilometre (KNBS, 2010). This is likely to have increased with over four years having already elapsed. Kenya is the world's forty-seventh largest country and it lies between latitudes 5°N and 5°S, and longitudes 34° and 42°E (‘County Edition’, 20th March, 2014).

Kenya's climate varies from tropical along the coast to temperate inland to arid in the North and North-East parts of the country. Since it lies along the equator, Kenya receives a great deal of sunshine all year round although it is usually cool at night and early in the morning. The ‘long rains’ season occurs from March/April to May/June while the ‘short rains’ season occurs from October to November/December. The rainfall is sometimes heavy and often falls in the afternoons and evenings. The temperature remains high throughout these months of tropical rain. The hottest period is February and March, leading into the season of the long rains, while the coldest is in July and August (‘County Edition’, 20th March, 2014).
3.5.2. NAIROBI COUNTY OVERVIEW

Nairobi County is Kenya’s capital and largest city. It was founded in the year 2013 on the same boundaries as Nairobi Province, after Kenya’s eight provinces were subdivided into forty seven counties. It is composed of seventeen parliamentary constituencies. Nairobi’s population has grown significantly from 350,000 in 1963 to 3,138,369 in 2009 with a population density of 4,515 persons per square Kilometre. This is despite having a small land area of only 695.1 square Kilometres. The total population in Nairobi alone is projected to hit the 8 million mark by the year 2030 (Kenya National Bureau of Statistics, 2010).

3.5.3. WESTLANDS

According to the 2009 population census, Westlands has a total land area of 97 square kilometres, a density per person of 2,537.52 and a total population of 247,102 (KNBS, 2009). It is one of the eight administrative divisions of Nairobi County. In addition, it is a vibrant commercial centre that has been able to attract businesses away from the Central Business District owing to more office space being readily available.

Westlands is located 3.1 Kilometres by road, north-west of Nairobi’s Central Business District via Uhuru Highway, Chiromo Road and Waiyaki Way. It was a residential district during the colonial period which ended in 1963 after Kenya attained independence. From the year 1990 to around 2000, land and office space in the CBD of Nairobi became scarce and expensive and as a result, most businesses relocated to Westlands and Upper Hill areas. The land there was favoured as it was close to the city centre yet away from traffic congestion and overpopulation (‘Westlands’, Wikipedia, 20th March, 2014).

At 1,795 metres above sea level, Nairobi’s Westlands area enjoys a moderate climate. Under the Köppen climate classification, it has a subtropical highland climate. In the June/July season, temperature can drop to 10 degrees Celsius while from December to March, temperatures average the mid-twenties during the day. The mean maximum temperature for this period is 24 degrees Celsius. There are two rainy seasons but rainfall can be moderate. The cloudiest part of the year is just after the first rainy season. As Nairobi is situated close to the equator, the differences between the wet and dry seasons are
minimal and the timing of sunrise and sunset varies little throughout the year. (County Edition 20\(^{th}\) March, 2014).

3.6. BACKGROUND INFORMATION ON CASE BUILDINGS

3.6.1. SKYPARK PLAZA

Skypark Plaza is a sophisticated ten storey office development of approximately 60,000 sq. ft. located along Waiyaki Way and opposite Sarit Centre from Parklands Road. It has incorporated state of the art features such as a helipad, panoramic lifts, back-up generators, security systems, access control systems, fire and life safety systems as well as HVAC (SJR properties, 15\(^{th}\) March 2014).

3.6.2. 9 WEST

9 West is an ultra-modern building located in the heart of Westlands Central Business District at the junction of Lower Kabete and Ring Road Parklands overlooking Sarit Centre and Sankara Hotel. It is easily accessed by public and private transport. The development is an eleven storey office building that offers three levels of retail space and a further nine levels of office floors designed for maximum efficiency with flexible open plan space for any combination of private offices, workstations, large and small meeting rooms to create a comfortable and balanced working environment (Knight Frank Kenya, 15\(^{th}\) March 2014).

3.6.3. THE WEST END - BARCLAYS

The West End - Barclays is located along Waiyaki Way. The area is well served by both public and private transport and offers close proximity to the Nairobi Central Business District and Westlands commercial centre. The development is seven storeys and comprises of two basement levels. The office spaces offer amenities such as provision for installation of air conditioning, passenger lifts, access control and CCTV surveillance system, fire alarm and detection system, standby generator and underground water storage.

3.6.4. SAFARICOM CARE CENTRE

Safaricom care centre is a modern building located on Waiyaki Way that boasts of amenities such as lighting control systems, HVAC, security systems, access control
systems fire and life safety systems and an integrated BMS which manages all the building functions.

3.6.5. PACIS CENTRE

Pacis Centre is a five storey office block, situated along Waiyaki Way, Westlands opposite Lion Place. It offers easy access to all local facilities and amenities including shopping malls, restaurants, banks, hospitals and bars. The development boasts of amenities such as passenger lifts, suspended ceilings that facilitate for the installation of air conditioning, standby generator, security check and CCTV surveillance, 24 hour security, ample underground water storage, fire alarm and detection system, generous onsite parking provision and direct link from the main fibre optic. The building is intended for use by Pacis Insurance Ltd, with an additional 3600m$^2$ office spaces available for letting. However, it is envisioned that Pacis Insurance Limited will eventually occupy the entire building (Knight Frank Kenya, 15th March 2014).

3.7. DATA PROCESSING, ANALYSIS AND PRESENTATION

Data processing will be carried out after all the relevant data has been collected. Analysis of the data collected will be done using descriptive statistics in the form of percentages and tables. This is because descriptive statistics offers a systematic collection, analysis and interpretation of data in order to meet the required research objectives. Data presentation techniques will vary depending on the nature of data to be collected. The instruments for data presentation will be tables, pie charts and photographs.

3.8. LIMITATIONS OF THE STUDY

Several problems were encountered by the researcher during the conducting of this study. Some of the challenges include:

1) Some of the respondents declined to answer the questionnaires citing confidentiality of their tenants.

2) Owing to the short period of the study, there was a deficiency in time.

3) Some of the property managers did not allow taking of photographs, alluding to it being infringement of their tenants’ privacy.
4) There was difficulty in accessing some of the stakeholders due to their busy schedules.

3.9. CONCLUSION

This study employed a case study approach, where purposive sampling was used to identify buildings based on the researcher’s judgement as to which buildings were able to offer the best fit of buildings equipped with BAS. The research design adopted a five step process that entailed: - design of the case study where research questions, hypothesis and objectives are established, literature review in relevance to the identified objectives, conducting of the case study through data collection, analysis of the case study data and finally writing of the case report and research implications.

Methods of data collection used in the study include: - primary data and secondary data. Primary data was collected through structured questionnaires to property developers, Valuers and property managers. Interviews to supplement responses from the questionnaires and observation were undertaken in combination with taking photos to visually identify the building automation systems employed in the buildings. Secondary data was obtained from books, journals, reports, newspapers, government publications and the internet.

The case studies were identified with the help of real estate professionals who were able to point out buildings that were leading trendsetters in their employment of building automation systems. The case studies were then subjected to rigorous study using tools of data collection such as questionnaires, interview schedules and observational forms.
CHAPTER 4

4.0. DATA ANALYSIS AND PRESENTATION

4.1. INTRODUCTION

This chapter deals with an in depth analysis and presentation of the data collected during field study to enable drawing of meaningful inferences. The study sought to identify the concepts of building automation systems and its effect on real property value, investigate on the considerations for building automation systems and to identify the factors that influence the need for and the growth on building automation in Kenya. Descriptive statistical methods are used to analyse the data while instruments of data presentation used include tables, pie charts and photographs.

4.2. RESPONSE TO QUESTIONNAIRES

Table 4.1 below summarizes the general response to questionnaires.

TABLE 4.1: RESPONSE TO QUESTIONNAIRES

<table>
<thead>
<tr>
<th>Respondent</th>
<th>Questionnaires Issued</th>
<th>Questionnaires Returned</th>
<th>Response Rate %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valuers</td>
<td>5</td>
<td>5</td>
<td>100</td>
</tr>
<tr>
<td>Property Managers</td>
<td>5</td>
<td>5</td>
<td>100</td>
</tr>
<tr>
<td>Property Developers</td>
<td>5</td>
<td>2</td>
<td>40</td>
</tr>
<tr>
<td>Total</td>
<td>15</td>
<td>12</td>
<td>80</td>
</tr>
</tbody>
</table>

Source: Field Survey, March 2014

The average response rate is \([(12/15)\times100]\) =80%

The questionnaires were issued to three categories of respondents: - valuers, property managers and property developers. The property developer’s response rate was low as they were not willing to share information with regards to their properties.
A response rate of 60% is considered good, while 70% is very good according to Mugenda and Mugenda (2003). 80% therefore is considered very good and ample for data analysis and reporting with subsequent drawing of conclusions.

4.3. DATA PRESENTATION AND ANALYSIS

Five ultra-modern buildings located in Westlands were identified and used as the case studies for this study. These five buildings form the basis of the data collection process in order to identify the concepts of building automation systems and its effect on real property values, identify the considerations for building automation systems and the factors that influence the need for and the growth on building automation in Kenya. Participant observation and use of interview schedules for follow up questions as well as photographs were the methods employed to ensure adequacy of data for analysis.

4.3.1. LEVEL OF ADOPTION OF BAS IN KENYA

The opinions of valuers, developers and property managers was sought on the current level of adoption of BAS technology in Kenya, their responses are as in chart 4.1 below.

**CHART 4.1: LEVEL OF ADOPTION OF BAS IN KENYA**

![Pie chart showing the level of adoption of BAS in Kenya]

Source: Field Survey, March 2014
A response rate of 41.7% agreed that the rate of adoption of BAS in Kenya was low, 33.3% that it was moderate while 25% rated it as high. This response indicates that uptake of BAS in construction of buildings is still low, and there is need for more public awareness.

### 4.3.2. TRENDS IN THE ADOPTION OF BAS TECHNOLOGY

When respondents were further probed on the trends in adoption of BAS, a majority of 66.7% agreed that it was increasing while 33.3% said that it was constant. Table 4.2 below depicts this response.

#### TABLE 4.2: TRENDS IN THE DEMAND AND ADOPTION OF BAS TECHNOLOGY

<table>
<thead>
<tr>
<th>What has been the trend of demand and adoption of BAS technology you are familiar with?</th>
<th>Response (n=12)</th>
<th>Percentage %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Increasing</td>
<td>8</td>
<td>66.7</td>
</tr>
<tr>
<td>Constant</td>
<td>4</td>
<td>33.3</td>
</tr>
<tr>
<td>Decreasing</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

Source: Field Survey, March 2014

### 4.3.3. FACTORS INFLUENCING THE ADOPTION OF BAS

Respondents were asked about the factors that have influenced the adoption of BAS technology in Kenya based on their rating of the adoption of BAS in Kenya. Of the 66.7% who said it was increasing, 50% attributed it to cost savings, 75% to energy efficiency, 66.7% to the technical compatibility of BAS and user needs, 83.3% to comfort and ease of using the system while 100% attributed it to changes in consumer tastes, preferences and style. 8.3% of the respondents gave an additional factor that BAS improves the grade of the building making it more attractive to stable tenants.

Of the 33.3% who responded that the trend of adoption of BAS in Kenya was constant, 83.3% attributed it to high device costs, 66.7% to lack of proper and legislative framework, 66.7% to lack of documented local experience making it a risky venture and 88.3%
attribute it to the lack of awareness of the benefits of BAS. The responses are illustrated in table 4.3 below:

**TABLE 4.3: FACTORS INFLUENCING THE ADOPTION OF BAS**

<table>
<thead>
<tr>
<th>Reasons for adoption of BAS technology</th>
<th>Response (n=12)</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cost savings</td>
<td>6</td>
<td>50</td>
</tr>
<tr>
<td>Energy efficiency</td>
<td>9</td>
<td>75</td>
</tr>
<tr>
<td>Technical compatibility of BAS and user needs</td>
<td>8</td>
<td>66.7</td>
</tr>
<tr>
<td>High device costs</td>
<td>10</td>
<td>83.3</td>
</tr>
<tr>
<td>Lack of proper and legislative framework</td>
<td>8</td>
<td>66.7</td>
</tr>
<tr>
<td>Comfort and ease of using the system</td>
<td>10</td>
<td>83.3</td>
</tr>
<tr>
<td>Lack of documented local experience making it a risky venture</td>
<td>8</td>
<td>66.7</td>
</tr>
<tr>
<td>Lack of awareness of the benefits of BAS</td>
<td>10</td>
<td>88.3</td>
</tr>
<tr>
<td>Changes in consumer tastes, preferences and style</td>
<td>12</td>
<td>100</td>
</tr>
<tr>
<td>Increases the grade of the building</td>
<td>1</td>
<td>8.3</td>
</tr>
</tbody>
</table>

Source: Field Survey, March 2014

**4.3.4. NEED FOR A SHIFT FROM CONVENTIONAL TO AUTOMATED BUILDINGS**

Respondents were asked whether there is need for a shift from conventional to automated buildings. 92% of the respondents said yes citing that BAS has many benefits such as operational efficiency in terms of cost and energy, ease of work as it enables real time monitoring of building systems and reduces the need for human intervention, ensuring comfort of the occupants and modernization of the world, which necessitates Kenya to follow world trends and also adopt the systems.

8% answered no citing that there is no need for a shift as automation is expensive and will increase rental costs which will be passed on to the tenants as developers will need to
recover the money invested in acquisition and maintenance of such systems. Chart 4.2 below depicts this response.

**CHART 4.2: NEED FOR A SHIFT FROM CONVENTIONAL TO AUTOMATED BUILDINGS**

![Chart 4.2: Need for a Shift from Conventional to Automated Buildings](chart_image)

Source: Field Survey, March 2014

**4.3.5. WHAT NEEDS TO BE DONE TO FACILITATE THE WIDESPREAD ADOPTION OF BAS IN KENYA**

Respondents were asked about what needs to be done to facilitate the widespread adoption of BAS in Kenya. 100% responded that lowering the cost of BAS either directly through market prices or indirectly through tax waivers and introduction of BAS courses in institutions of higher learning would facilitate its widespread adoption. 88.3% said that there should be establishment of specific laws regulating BAS in Kenya, 66.7% said that financial incentives should be given to developers, 91.7% that there should be public awareness initiatives on the need for and the benefits of BAS while 75% agreed that there should be rigorous advertisements by BAS service providers in relevant media. Table 4.4 depicts this response.
TABLE 4.4: WHAT NEEDS TO BE DONE TO FACILITATE THE WIDESPREAD ADOPTION OF BAS IN KENYA

<table>
<thead>
<tr>
<th>What needs to be done to facilitate the widespread adoption of BAS in Kenya?</th>
<th>Response (n=12)</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lowering the cost of BAS directly or through tax waivers</td>
<td>12</td>
<td>100</td>
</tr>
<tr>
<td>Establishment of specific laws regulating BAS</td>
<td>10</td>
<td>83.3</td>
</tr>
<tr>
<td>Financial incentives to property developers</td>
<td>8</td>
<td>66.7</td>
</tr>
<tr>
<td>Introduction of BAS courses in institutions of higher learning</td>
<td>12</td>
<td>100</td>
</tr>
<tr>
<td>Public awareness initiatives on the need for and benefits of BAS</td>
<td>11</td>
<td>91.7</td>
</tr>
<tr>
<td>Increasing advertisements in relevant media by BAS service providers</td>
<td>9</td>
<td>75</td>
</tr>
</tbody>
</table>

Source: Field Survey, March 2014

4.3.6. INCORPORATION OF BAS IN BUILDINGS

Property managers from the five selected case buildings were asked about which features the buildings had incorporated and their responses, together with an observational checklist that the researcher had prepared is as depicted in table 4.5 below

TABLE 4.5: INCORPORATION OF BAS IN BUILDINGS

<table>
<thead>
<tr>
<th>BAS subsystem</th>
<th>Response (n=5)</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lighting Control Systems</td>
<td>4</td>
<td>80</td>
</tr>
<tr>
<td>Heating Ventilation and Air Conditioning</td>
<td>2</td>
<td>40</td>
</tr>
<tr>
<td>Access control systems</td>
<td>5</td>
<td>100</td>
</tr>
<tr>
<td>Security Control Systems</td>
<td>5</td>
<td>100</td>
</tr>
<tr>
<td>Fire and Life Safety Systems</td>
<td>5</td>
<td>100</td>
</tr>
<tr>
<td>Building Management Systems</td>
<td>3</td>
<td>60</td>
</tr>
<tr>
<td>Utility Monitoring Systems</td>
<td>1</td>
<td>20</td>
</tr>
</tbody>
</table>

Source: Field Survey, March 2014
LIGHTING CONTROL SYSTEMS

Lighting control systems in the buildings registered an 80% adoption rate and they range from occupancy sensitive lighting which is activated by motion sensors fitted in the spaces, daylight sensitive lighting for security lights fitted at the perimeter wall which are built-in with photocell receptors that indicate the amount of light available and automatically light when it gets dark, LED lighting. The lighting control systems are controlled by a single centralized interface that is able to detect any problems with any of the lighting controls and send a timely message to the property managers. The property managers indicated that the use of such lighting control systems have been able reduce energy consumption which is reflected by lower electricity bills and also leads to efficiency in terms of there being automatic lighting of security lights which is especially helpful during off peak hours when they are not around, but are comfortable since they know that everything is running well. Figure 4.1 and 4.2 illustrate some of the lighting control systems adopted.

Figure 4.1: Lighting Occupancy Sensor

Figure 4.2: Daylight Sensor

Source: Field Survey, March 2014

HEATING VENTILATION AND AIR CONDITIONING SYSTEMS

Heating ventilation and Air Conditioning Systems indicated a 40% adoption rate with only two buildings having incorporated them. The two buildings that have incorporated them are single tenant occupancy buildings and this has been done by the tenants for comfort of their employees and not the developers. The HVAC is able to automatically provide
ambient temperature depending on the overall temperature conditions of the room, for example when it is hot, a cooling effect is provided while when it is cold, a warming effect is provided. The HVAC can also be manually set to be within certain ranges of temperature, and when it is above or beyond the set temperature range, it automatically sends a message to the property manager about the temperature conditions in a room and they are able to adjust it from the control panel. Figure 4.3 illustrates an extract fan incorporated in one of the buildings.

The remaining three buildings are multi-tenant spaces and have not incorporated HVAC, although provision has been left for adoption of the systems by tenants at their will. The low incorporation of HVAC may be attributed to the fact that Westlands area of Kenya enjoys a subtropical highland climate which is moderate throughout the year and thus developers don’t see much need for it.

Figure 4.3: Extract Fan

![Extract Fan](source_image)

Source: Field Survey, March 2014

SECURITY AND ACCESS CONTROL SYSTEMS

Security and access control systems both recorded 100% adoption by all the buildings as security is one of the key services that tenants look for before letting space. Security systems incorporated range from CCTV cameras with centralized control and monitoring screens, while access control systems range from biometric card or fingerprint readers and gate barriers. The access control systems only allow permitted persons to access certain spaces by use of cards or fingerprints and once access has been granted, the BMS is able to
monitor their movement, by recording which card was used at what time, to enter what space, and the details of the card owner. Figure 4.4, 4.5 and 4.10 illustrates CCTV cameras that are used while figure 4.6, 4.7, 4.8, 4.9 and 4.11 illustrates the access controls.

Figure 4.4: Speed Dome CCTV

Source: Field Survey, March 2014

Figure 4.5: Dome CCTV

Source: Field Survey, March 2014

Figure 4.6: Card Reader

Source: Field Survey, March 2014

Figure 4.7: Centralized Access Control System

Source: Field Survey, March 2014
FIRE AND LIFE SAFETY SYSTEMS

Fire and life safety systems are incorporated in 100% of the buildings and this is majorly attributable to the Building Code and the Kenya Planning and Building Regulations of 2009 which explicitly provide that any person intending to erect a building, to submit a fire installation drawing and a fire protection plan. In addition to that, every building comprising 6 or more storeys above the ground level is required to be provided with one or more passenger lifts and every building exceeding six storeys in height be provided with at least one lift, designed and installed to be used by firemen in the event of a fire.
The fire and life safety systems include detection and control systems. The detection systems include smoke detectors and the fire alarm which serves as both a detection and control system as it alerts the occupants of the building and fire brigade as well activate sprinkler systems for basement levels. The sprinkler systems incorporated are served by an automated water pump that monitors the levels of water in the tank and automatically starts the pump when a certain level of the tank is reached and stops the pump when the tank is full. This helps in ensuring a constant supply of water for daily use and in the event of a fire as well as minimizes wastage caused by overflowing of the tank. A fire control panel is also located at a central point where one can identify exactly which fire alarm has gone off and take appropriate measures to control the fire. Figure 4.12, 4.13 and 4.14 illustrate some of the fire and life safety systems employed.

Figure 4.12: Fire Control Panel

Source: Field Survey, March 2014

Figure 4.13: Fire Alarm System

Source: Field Survey, March 2014

Figure 4.14: Smoke Detector

Source: Field Survey, March 2014

Figure 4.15: Sprinkler System

Source: Field Survey, March 2014
BUILDING MANAGEMENT SYSTEMS

60% of the buildings had incorporated BMS which enables central monitoring, control and integration of all the building systems such as lighting, HVAC, security and access control and fire systems. The BMS also enables offsite monitoring of the building systems through smartphones and tablets where notifications are delivered to the property manager and the maintenance managers of the system in case of a breakdown or malfunction of the system.
UTILITY MONITORING SYSTEMS

One of the case buildings had incorporated water utility monitoring systems, accounting for 20% of adoption of BAS system. Such utility monitoring systems include sensor taps, sensor based toilets and automatic hand driers. The sensor taps automatically detect motion when hands are placed under the tap and this leads to discharge of water from the tap. When the hands are removed, the tap automatically stops flow of the water. The sensor based toilets are also motion sensitive and give an allowance of 10 to 15 seconds after a person has left before it automatically flushes. Such water monitoring systems allow for efficient use of water as wastage is reduced. Figure 4.20, 4.21, 4.22 and 4.23 illustrate these systems.

Figure 4.20: Sensor Toilet

Figure 4.21: Sensor based Urinals

Source: Field Survey, March 2014

Figure 4.22: Sensor Tap

Figure 4.23: Automatic Hand Drier

Source: Field Survey, March 2014

Sensors
4.3.7. EFFECT OF BAS TO THE BUILDING VALUE

The respondents in the valuer category were further probed on their opinion as to the weighting of each building automation system to the value and their response is as illustrated in chart 4.3.

CHART 4.3: EFFECT OF BAS TO BUILDING VALUE

The response indicates that the major contributors to building value are security and access control systems, fire and life safety systems and lighting control systems. Building management systems and HVAC were found to have a slight increase in building value as they are not in much demand and hence are not incorporated in buildings on a large scale.
4.3.8. COMPARISON OF THE RENTAL PRICES BETWEEN AUTOMATED BUILDINGS AND CONVENTIONAL BUILDINGS

Respondents were asked to compare the rental prices between conventional buildings and automated buildings. 83.3% agreed that the rents achieved are higher as the building is of a higher grade and thus able to attract high end clientele who are more concerned about the amenities as opposed to price. This response is illustrated in table 4.6 below.

**TABLE 4.6: RENTAL VALUE OF AUTOMATED BUILDINGS COMPARED TO CONVENTIONAL BUILDINGS**

<table>
<thead>
<tr>
<th>How is the rental value of automated buildings compared to conventional buildings?</th>
<th>Response (n=12)</th>
<th>Percentage %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Higher</td>
<td>10</td>
<td>83.3</td>
</tr>
<tr>
<td>Lower</td>
<td>1</td>
<td>8.3</td>
</tr>
<tr>
<td>Equivalent</td>
<td>1</td>
<td>8.3</td>
</tr>
</tbody>
</table>

Source: Field Survey, March 2014

4.3.9. EFFECT OF BAS ON OPERATING AND MAINTENANCE COSTS OF BUILDINGS

Respondents were asked about the effect of BAS on the operating and maintenance costs of the building and 60% agreed that the costs decrease. This was majorly attributed to systems such as utility monitoring and lighting which significantly reduces energy consumption. 40% agreed that costs increase alluding to HVAC systems which consume a relatively high amount of energy and to the lack of local maintenance experts to repair the systems in cases of malfunction, where international experts are consulted and this makes the system costly to operate and maintain. These responses are as indicated in chart 4.4.
4.3.10. CONTROL OF THE BUILDING AUTOMATION SYSTEMS

Respondents from the Property Managers category were asked if they are able to set and control parameters of the BAS systems and 100% responded yes. When further asked who was able to control the systems, it was established that only persons with authorization were able to do so. 60% of the buildings were reported to be able to centrally control and monitor the building systems. Table 4.7 depicts this response.

TABLE 4.7: CONTROL OF BAS SYSTEMS

<table>
<thead>
<tr>
<th>Are you able to set and control the parameters of the BAS systems?</th>
<th>Response (n=5)</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>5</td>
<td>100</td>
</tr>
<tr>
<td>No</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

Source: Field Survey, March 2014

4.3.11. EFFECT OF BAS ON DEMAND FOR SPACE

Respondents were asked what the effect of BAS incorporation in buildings had on the demand for space and 79% agreed that there was an increase as 100% of the buildings recorded an occupancy rate of 90%-100%. This increase is further indicated by number of
enquiries about the property, duration that the property takes in the market before full occupancy and the charging of higher rents per square foot. 21% agreed that demand was constant, attributing this to similar location of automated and conventional buildings which make the rents charged to be almost equivalent. Chart 4.5 depicts this response.

**CHART 4.5: EFFECT OF BAS ON DEMAND FOR SPACE**

![Chart 4.5: Effect of BAS on Demand for Space](image)

Source: Field Survey, March 2014

4.3.12. **DEMAND FOR BUILDING AUTOMATION SYSTEMS**

Respondents from property managers and developers category were asked to rank the order of demand by tenants and importance attributed to various building systems with 35 points indicating extreme demand, 30 points high demand, 25 points moderate demand, 20 points slight demand and 15 points no demand. Fire safety was found to be most important, accruing 33 points, followed by security with a total of 32 points, followed by lighting and access control systems each with 31 points. HVAC accrued a total of 27 points while Building Management Systems had 23 points indicating that there is little importance attached to HVAC and BMS by tenants. Table 4.8 depicts this response.
### TABLE 4.8: DEMAND FOR BAS SYSTEMS BY TENANTS

<table>
<thead>
<tr>
<th>Which BAS subsystem is most sought after by prospective tenants?</th>
<th>Response (35 points)</th>
<th>Percentage %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lighting control systems</td>
<td>31</td>
<td>88.6</td>
</tr>
<tr>
<td>HVAC</td>
<td>27</td>
<td>77.1</td>
</tr>
<tr>
<td>Security control systems</td>
<td>32</td>
<td>91.4</td>
</tr>
<tr>
<td>Access control systems</td>
<td>31</td>
<td>88.6</td>
</tr>
<tr>
<td>Fire and life safety systems</td>
<td>33</td>
<td>94.3</td>
</tr>
<tr>
<td>Building Management Systems</td>
<td>23</td>
<td>65.7</td>
</tr>
</tbody>
</table>

Source: Field Survey, March 2014

### 4.3.13. IDENTIFICATION OF POTENTIAL TENANTS

Property developers were asked about when they identify potential tenants and 100% indicated that it is not a static process as tenants were identified at all stages of the construction, if identified before construction, 100% agreed that the actual construction would be to suit the needs of the tenant.

### TABLE 4.10: IDENTIFICATION OF TENANTS

<table>
<thead>
<tr>
<th>When do you identify potential tenants?</th>
<th>Response (n=2)</th>
<th>Percentage %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Before construction</td>
<td>2</td>
<td>100</td>
</tr>
<tr>
<td>During construction</td>
<td>2</td>
<td>100</td>
</tr>
<tr>
<td>After construction</td>
<td>2</td>
<td>100</td>
</tr>
</tbody>
</table>

Source: Field Survey, March 2014

### 4.3.14. CONSIDERATIONS FOR CHOOSING BAS

Respondents were asked what considerations one should make before choosing a BAS system and 100% indicated that long term flexibility and marketability of the building would be a key factor as it ensures the building stays timely and relevant with changing technological periods. 88.3% agreed that impacts of BAS on the environment, end comfort, convenience and security of the occupants and the cost of installation and maintenance of
BAS would be important considerations while 75% agreed that the cost of training personnel to manage the BAS and the expected cash flow revenue vis-à-vis costs of installation of the BAS would be important factors. 66.7% agreed that their considerations would be based on local availability of the BAS and legal and regulatory requirements. These responses are as in table 4.9 below.

**TABLE 4.9: CONSIDERATIONS FOR CHOOSING BAS**

<table>
<thead>
<tr>
<th>What are the considerations one should make before choosing a BAS system</th>
<th>Response (n=12)</th>
<th>Percentage %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Legal and regulatory requirements</td>
<td>8</td>
<td>66.7</td>
</tr>
<tr>
<td>Impacts of BAS on the environment</td>
<td>10</td>
<td>83.3</td>
</tr>
<tr>
<td>End comfort, convenience and security of the occupants</td>
<td>10</td>
<td>83.3</td>
</tr>
<tr>
<td>Long term flexibility and marketability of the building</td>
<td>12</td>
<td>100</td>
</tr>
<tr>
<td>The cost of installation and maintenance of the BAS</td>
<td>10</td>
<td>83.3</td>
</tr>
<tr>
<td>Cost of training personnel to manage the BAS</td>
<td>9</td>
<td>75</td>
</tr>
<tr>
<td>Expected cash flow revenue vis-à-vis costs of installation of the BAS</td>
<td>9</td>
<td>75</td>
</tr>
<tr>
<td>Local availability of the BAS technology</td>
<td>8</td>
<td>66.7</td>
</tr>
</tbody>
</table>

Source: Field Survey, March 2014

4.3.15. **CREATING A BALANCE BETWEEN BAS COSTS AND FINAL RENT**

Developers were asked about how they create a trade-off between the costs incurred in acquisition, installation and maintenance of BAS and the final rent charged to the tenants, 100% responded that it was through proper conduction of a feasibility study at the planning stage which ensures that the right market is targeted and after complete construction, flexibility in the charging of rent at above market rate as the buildings offer amenities and
services that are not in other buildings, and they are therefore able to recover their costs and make profit

4.4. CONCLUSION

The findings indicate that building automation systems have a positive effect on real property values in Kenya as there is an increase in rental values and lowered operating and maintenance costs which leads to a higher net rent, reflecting an increase in building value when capitalized.

The considerations that guide the automation process are: - legal considerations which encompass the existing laws that touch on BAS, technological considerations include useful life of the systems which affects the long term marketability and flexibility of an automated building as well as the operating and maintenance costs, social considerations include end comfort, convenience, safety and security of the occupants, economic considerations majorly entail the cost of acquisition, installation and maintenance of the systems while environmental considerations include the short term and long term effects that the use of automation systems may have on the environment and its sustainability.

The factors influencing the need for and the growth of building automation systems include: - ease of work in monitoring and controlling building functions, energy efficiency associated with use of BAS; comfort, convenience, security and safety experienced by occupants of automated buildings; cost savings realized through lowering of operating and maintenance costs and higher demand for space in the building which increases the occupancy rate and offers faster return on investment to the developers.
CHAPTER 5

5.0. CONCLUSIONS, SUMMARY OF FINDINGS AND RECOMMENDATIONS

5.1. INTRODUCTION

This study set out to explore the concepts of building automation systems and how they affect real property values, investigate on the process of building automation in Kenya, with specific regard to the social, environmental, legal and technological considerations that guide the process and finally it sought to examine the factors influencing the need for and the growth of building automation systems in Kenya.

The specific objectives of the study were: - to establish the effect of building automation systems on real property values in Kenya, to investigate on the process of building automation with regards to the social, economic, environmental, legal and technological considerations that guide the process and to examine the factors influencing the need for and the growth of building automation in Kenya.

This chapter summarizes the findings of the research based on the above objectives, gives a conclusion and makes recommendations based on the findings. Areas of further research are also suggested to cover areas that were not included in this study.

5.2. SUMMARY OF FINDINGS AND CONCLUSIONS

The field study revealed that the level of adoption of Building Automation Systems in commercial buildings in Kenya is still low and this was mainly attributed to high device costs in terms of acquisition, installation and maintenance, lack of awareness of the benefits of BAS, lack of proper legislative and regulatory frameworks and the lack of documented local experience making BAS incorporation a risky venture.

However, it was noted that the trend of adoption was increasing and projections indicate the likelihood of more adoption with increasing awareness. The increasing trend is as a result of benefits of BAS, which were established to be cost savings, energy efficiency, technical compatibility of BAS and user needs, comfort and ease of using the system and changes in consumer tastes, preferences and style. It was further established that BAS
increases the grade of the building and this is able to attract high end clients who are considered to offer stability of rents to the property owners.

It was established that there is a need for a shift from conventional to automated buildings as they are operationally efficient in terms of cost and energy, they ease work through real time monitoring of the building systems which reduces need for human intervention and they ensure comfort, convenience and safety of the occupants.

To facilitate the widespread adoption of BAS in Kenya, its cost needs to be lowered directly through market prices or indirectly through fiscal incentives such as tax reliefs. Also establishment of specific laws regulating BAS, provision of financial incentives to property developers, introduction of BAS courses in institutions of higher learning, increasing of advertisements in relevant media by BAS service providers as well as increasing public awareness initiatives on the need for and the benefits of BAS are likely to facilitate the increase in adoption of BAS systems in Kenya.

The BAS systems incorporated in the buildings were found to be state of the art and in accordance with the world practice on automation of buildings. The incorporated systems were found to include: - lighting control systems, Heating Ventilation and Air Conditioning, Access control systems, security control systems, fire and life safety systems, building management systems and utility monitoring systems. The property managers of the buildings and other authorized persons are able to set and control the parameters of the identified BAS systems.

Building Automation Systems were found to increase building value owing to the achievement of higher rents by automated buildings and lower operating and maintenance costs, which increase the net income receivable from an automated building in comparison to a conventional building and in turn, the value. Security control systems, access control systems, lighting control systems and fire and life safety systems were identified as the major contributors that increase value.

The incorporation of BAS in buildings was established to increase the demand for office space as the buildings that had incorporated it took less time in the market before full
occupancy, had a high number of enquiries about space in the building and were able to charge above market rents as the grade of the building increases with adoption of BAS.

Tenants were reported to rank fire and life safety systems as the most important automation system, followed by security, access control and lighting. Building Management Systems and HVAC were found to be the least important to tenants and this was reflected by their slight demand.

Considerations for choosing a Building Automation System was found to be majorly dependent on long term flexibility and marketability of the building, impacts of BAS on the environment, end comfort, convenience and security of the occupants and the costs of acquisition, installation and maintenance of the BAS. Other reasons include costs of training personnel to manage the BAS, expected cash flow revenue vis-à-vis costs of installation of the BAS, legal and regulatory requirements and local availability of the BAS technology.

5.3. ACHIEVEMENT OF OBJECTIVES

The study has successfully identified and met the three objectives as follows:

TO INVESTIGATE ON THE PROCESS OF BUILDING AUTOMATION WITH REGARDS TO THE SOCIAL, ECONOMIC, ENVIRONMENTAL, LEGAL AND TECHNOLOGICAL CONSIDERATIONS THAT GUIDE THE PROCESS

This objective was achieved through relevant review of literature and field study. It was established that the legal considerations encompass the existing laws and frameworks that touch on BAS which include the Housing Bill of 2009, Kenya planning and Building Regulations of 2009 and the Vision 2030 while the technological considerations include useful life of the systems which affects the long term marketability and flexibility of an automated building as well as the operating and maintenance costs. The social considerations were found to include end comfort, convenience, safety and security of the occupants while the economic considerations majorly entailed cost of acquisition, installation and maintenance of the systems. Finally, the environmental considerations
were identified as the short term and long term effects that the use of automation systems may have on the environment and sustainability.

**TO ESTABLISH THE EFFECT OF BUILDING AUTOMATION SYSTEMS ON REAL PROPERTY VALUES IN KENYA**

This objective has been achieved through relevant review of literature as well as field study, which established that building automation systems have a positive effect on real property values in Kenya as there is an increase in rental values from automated buildings compared to conventional buildings. Higher rents coupled with lower operating and maintenance costs leads to a higher net rent which when capitalized, leads to an increase in building value.

**TO EXAMINE THE FACTORS INFLUENCING THE NEED FOR AND THE GROWTH OF BUILDING AUTOMATION SYSTEMS IN KENYA**

This objective has been achieved through literature review and field study. It was established that the factors influencing the need for and the growth of building automation systems are consistent with the benefits experienced by automated buildings and these include: - ease of work in monitoring and controlling building functions, energy efficiency associated with use of BAS; comfort, convenience, security and safety experienced by occupants of automated buildings; cost savings realized through lowering of operating and maintenance costs and higher demand for space in the building which increases the occupancy rate and offers faster return on investment.

**5.4. HYPOTHESIS TESTING**

The study sought to test the following hypothesis: -

\( H_0: \) The incorporation of Building Automation Systems in buildings does not increase the value of real property in Kenya.

\( H_A: \) The incorporation of Building Automation Systems in buildings increases the value of real property in Kenya.
Based on the findings of the research, it can be clearly deduced that building automation systems increase real property value as there are higher rents achieved coupled with lower operating and maintenance costs, leading to a higher net income which when capitalized, results to a higher value. The null hypothesis is thus rejected and the study accepts the alternative hypothesis.

5.5. RECOMMENDATIONS

Based on the findings of the research and the conclusions, the following recommendations are offered:

Since the current rate of adoption of BAS in Kenya is still low, there is need for public awareness on Building Automation Systems with special emphasis to the developers who should be made aware of the various benefits that BAS has to offer. In addition, the laws touching on Building Automation Systems should be revised and made to be more specific with regards to automation systems as in the case of fire control systems. This will encourage more developers to adopt the systems in their buildings and energy efficiency will be achieved in the country.

The managers of buildings that have incorporated automation systems should keep proper records of the benefits and challenges that they have encountered in the use of such systems so as to provide a comprehensive account of Building Automation Systems in practice which can help in creating public awareness among the developers.

Finally, the cost of Building Automation Systems needs to be lowered as this is one of the major hindrances preventing its adoption on a large scale. Moreover, there needs to be local availability of Building Automation Systems and skilled labour who have the relevant expertise and technical knowhow of installing and maintaining the automation systems, so as to further reduce maintenance costs.
5.6. AREAS OF FURTHER STUDY

This study suggests further research to be done on the following:

1. Carry out a study to identify building automation systems in residential buildings and the extent of its adoption in Kenya.
2. Carry out a comparative study between automated buildings and green buildings, and establish a convergence/divergence point.
3. Carry out a study to establish the relationship between building automation systems use and sustainability.


Population Distribution by Sex, Place of Residence and Type of Settlement, 


APPENDIX

APPENDIX 1: QUESTIONNAIRE TO PROPERTY MANAGERS

Dear Sir/Madam,

I am Bernadette Wambui Karanja, a fourth year student pursuing a Bachelor of Real Estate in the Department of Real Estate and Construction Management at the University of Nairobi Registration Number B04/35938/2010. I am carrying out a research in partial fulfilment of the requirements of the degree programme on ‘Concepts of Building Automation Systems and its effect on real property values’. Access to any kind of material required to complete the research is highly appreciated. All information provided herein is confidential and will be used for academic research purposes only.

A Building Automation System (BAS) is a system of network integrated computer components that automatically control a wide range of building operations such as lighting, security and access control, Heating Ventilation and Air Conditioning (HVAC), fire and life safety, Building Management Systems (BMS), audio-visual systems and more.

Please tick [✓] or [×], answer ‘YES’ or ‘NO’ and where there are no choices, kindly fill in the blank spaces provided.

1. Name of Building: ……………………………………………………………………...
2. Name of Property Management Firm: (optional)……………………………………….
3. How can you rate the level of adoption of Building Automation Systems in Kenya?
   □ High   □ Moderate   □ Low
4. What has been the trend of demand and adoption of BAS technology you are familiar with?
   □ Increasing   □ Constant   □ Decreasing
5. In your opinion, what has influenced the trend noted in Q4 in adoption of BAS technology?

(Kindly tick all the alternatives that apply.)
(a) Cost savings associated with integrated control of building systems.
(b) Energy efficiency associated with integrated control of building systems.
(c) Convergence of Information Technology and Building Technology.
(d) Technical compatibility of BAS and user needs.
(e) Increase of initiatives and partnerships between public and private investors.
(f) High device costs.
(g) Lack of proper legislative and regulatory framework.
(h) Comfort and ease of controlling and maintaining the systems.
(i) Lack of documented local experience making it a risky venture.
(j) Lack of awareness of the benefits of Building Automation Systems.
(k) Changes in consumer tastes, preferences and style.
(l) Other

6. Do you think there is need for a shift from conventional to automated buildings?

☐ Yes ☐ No

Please explain your answer:

7. In your opinion, what needs to be done to facilitate widespread adoption of Building Automation Systems in Kenya?

(a) Tax waivers on Building Automation Systems.
(b) Specific laws guiding and regulating the process of building automation.
(c) Financial incentives to property developers of automated buildings.
(d) Introduction of BAS courses in institutions of higher learning.
(e) Public awareness initiatives on the need and benefits of BAS.
(f) Lowering the cost of Building Automation Systems.
(g) Increase publicity by rigorous advertisement in the media.
8. Are the following subsystems of BAS incorporated in the building?

<table>
<thead>
<tr>
<th>Subsystem</th>
<th>Yes</th>
<th>No</th>
<th>Not Sure</th>
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</thead>
<tbody>
<tr>
<td>(a) Lighting control systems</td>
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<td>(b) Heating Ventilation and Air Conditioning systems</td>
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<td>(c) Security systems</td>
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<td>(d) Access Control systems</td>
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<td>(e) Fire and life safety systems</td>
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<td>(f) Building Management Systems</td>
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</table>

9. What is the effect of the above subsystems to the value of the building?

- Increase
- Decrease
- No Effect

Please explain your answer .............................................................

10. How is the rental value of the building compared to other similar conventional buildings?

- Higher
- Lower
- Equivalent

What is the actual difference in value and why is this? ..................................................

11. Are you able to set and control parameters of BAS subsystems?

- Yes
- No
- Don’t know

If yes, can such controls be overridden by anyone in the facility?

- Yes
- No
- Don’t know
If No, please explain: ..........................................................................................................................
.......................................................................................................................................................
.......................................................................................................................................................

12. Does the building automation system allow for remote and centralized control and monitoring of the building subsystems?
   ☐ Yes ☐ No ☐ Don’t know
   If yes, has the remote and centralized control provided early detection and diagnosis of problems in building services?
   ☐ Yes ☐ No ☐ Don’t know
   If yes, has this resulted in automatic preparation of maintenance activities?
   ☐ Yes ☐ No ☐ Don’t know

13. What is the occupancy rate of the building?
   ☐ 90%-100% ☐ 70%-80% ☐ 50%-60% ☐ None of the above
   If none of the above in Q13 above, please specify.................................................................
..........................................................................................................................................................

14. What is the effect of BAS on the demand for space in the building?
   ☐ Increase ☐ Decrease ☐ No effect
   If increase, what are the indicators of increased demand for office space in the building?
   *(Kindly tick all the alternatives that apply.)*
   (a) Duration that the property takes in the market before full occupancy ☐
   (b) Number of enquiries ☐
   (c) Number of applicants ☐
   (d) Number of potential tenants’ visits to the building ☐
   (e) Higher rent per square foot ☐
   (f) Other (please specify)...........................................................................................................
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15. The following is a list of building automation subsystems. Which feature is most sought after by prospective tenants?

*(Kindly tick appropriate rank on a scale of 1-5.)*

1 - Not important  2 - Slightly important  3 - Moderately important  
4 - Very Important  5 - Extremely important

<table>
<thead>
<tr>
<th>BAS System</th>
<th>1</th>
<th>2</th>
<th>3</th>
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<tbody>
<tr>
<td>1. Lighting control systems</td>
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<td>2. HVAC</td>
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<td>6. Building Management Systems</td>
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</table>

16. What is the effect of building automation on the operating and maintenance costs of the building?

- [ ] Increase
- [ ] Constant
- [ ] Decrease
- [ ] Don’t know

17. What are the considerations one should make before choosing a building automation system?

*(Kindly tick all the alternatives that apply.)*

(a) Legal and regulatory requirements
(b) Impacts of the BAS on the environment
(c) End comfort, convenience and security of the occupants
(d) Long term flexibility and marketability of the building
(e) The cost of installation and maintenance of the BAS
(f) Cost of training personnel to manage the BAS
(g) Expected cash flow revenue vis-à-vis costs of BAS.
(h) Local availability of the BAS technology
(i) Other ........................................................................................................................................
.........................................................................................................................................................

THANK YOU VERY MUCH
APPENDIX 2: QUESTIONNAIRE TO PROPERTY DEVELOPERS

Dear Sir/Madam,

I am Bernadette Wambui Karanja, a fourth year student pursuing a Bachelor of Real Estate in the Department of Real Estate and Construction Management at the University of Nairobi Registration Number B04/35938/2010. I am carrying out a research in partial fulfilment of the requirements of the degree programme on ‘Concepts of Building Automation Systems and its effect on real property values’. Access to any kind of material required to complete the research is highly appreciated.

All information provided herein is confidential and will be used for academic research purposes only.

A Building Automation System (BAS) is a system of network integrated computer components that automatically control a wide range of building operations such as lighting, security and access control, Heating Ventilation and Air Conditioning (HVAC), fire and life safety, Building Management Systems (BMS), audio-visual systems and more.

Please tick [✓] or [×], answer ‘YES’ or ‘NO’ and where there are no choices, kindly fill in the blank spaces provided.

1. Name of Building: ……………………………………………………………………

2. Name of Property Development Firm: (optional)…………………………………...

3. How can you rate the level of adoption of Building Automation Systems in Kenya?
   - [ ] High
   - [ ] Moderate
   - [ ] Low

4. What has been the trend in demand and adoption of BAS technology you are familiar with?
   - (a) Increasing [ ]
   - (b) Constant [ ]
   - (c) Reducing [ ]
5. In your opinion, what has influenced the trend noted in Q4 in adoption of BAS technology?

(Kindly tick all the alternatives that apply.)
(a) Cost savings associated with integrated control of building systems.
(b) Energy efficiency associated with integrated control of building systems.
(c) Convergence of Information Technology and Building Technology.
(d) Technical compatibility of BAS and user needs.
(e) Increase of initiatives and partnerships between public and private investors.
(f) High device costs.
(g) Lack of proper legislative and regulatory framework.
(h) Comfort and ease of controlling and maintaining the systems.
(i) Lack of documented local experience making it a risky venture.
(j) Lack of awareness of the benefits of Building Automation Systems.
(k) Changes in consumer tastes, preferences and style.
(l) Other

6. Do you think there is need for a shift from conventional to automated buildings?

☐ Yes  ☐ No

Please explain your answer:

7. In your opinion, what needs to be done to facilitate widespread adoption of Building Automation Systems in Kenya?

(a) Tax waivers on Building Automation Systems.
(b) Specific laws guiding and regulating the process of building automation.
(c) Financial incentives to property developers of automated buildings.
(d) Introduction of BAS courses in institutions of higher learning.
(e) Public awareness initiatives on the need and benefits of BAS.
8. Are the following subsystems of BAS incorporated in the building?

   (a) Lighting control systems
   (b) Heating Ventilation and Air Conditioning systems
   (c) Security systems
   (d) Access Control systems
   (e) Fire and life safety systems
   (f) Building Management Systems

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<thead>
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<th>Yes</th>
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9. What is the effect of the above subsystems to the value of the building?

   □ Increase   □ Decrease   □ No Effect

   Please explain your answer .................................................................
   ...........................................................................................................
   ...........................................................................................................

10. How is the rental value of the building compared to other similar conventional buildings?

    □ Higher   □ Lower   □ Equivalent

    What is the actual difference in value and why is this? ..........................
    ...........................................................................................................
    ...........................................................................................................
    ...........................................................................................................

11. What is the current occupancy rate of the building?

    □ 90%-100%   □ 70%-80%   □ 50%-60%   □ None of the above

    If none of the above, please specify..................................................................
    ...........................................................................................................
    ...........................................................................................................

12. What is the effect of BAS on demand for office space in the building?

☐ Increase  ☐ Decrease  ☐ No Effect

If increase, what are the indicators of increased demand for office space in the building?

*(Kindly tick all the alternatives that apply.)*

(a) Duration that the property takes in the market before full occupancy  
(b) Number of enquiries  
(c) Number of applicants  
(d) Number of potential tenants’ visits to the building  
(e) Higher rent per square foot  
(f) Other (please specify) …………………………………………………………………………………
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13. When do you identify potential tenants?

☐ Before construction  ☐ During construction  ☐ After construction

If before construction, do you develop the building to suit the needs of the identified tenants?

☐ Yes  ☐ No

14. The following is a list of building automation subsystems. To what extent is each feature demanded by tenants for incorporation in buildings?

*(Kindly tick appropriate rank on a scale of 1-5.)*

<table>
<thead>
<tr>
<th>BAS Subsystem</th>
<th>1</th>
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<td>6. Building Management Systems</td>
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</tbody>
</table>
15. How do you create a balance between the installation costs of BAS and the final rent price charged to tenants? …………………………………………………………………………………
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16. What is the effect of building automation on the operating and maintenance costs of the building?
   - [ ] Increase
   - [ ] Constant
   - [ ] Decrease
   - [ ] Don’t know

17. What considerations should one make before choosing a building automation system?
   (Kindly tick all the alternatives that apply.)
   (a) Legal and regulatory requirements
   (b) Impacts of the BAS on the environment
   (c) End comfort, convenience and security of the occupants
   (d) Long term flexibility and marketability of the building
   (e) The cost of installation and maintenance of the BAS
   (f) Cost of training personnel to manage the BAS
   (g) Expected cash flow revenue vis-à-vis costs of BAS.
   (h) Local availability of the BAS technology
   (i) Other ………………………………………………………………………………………………

THANK YOU VERY MUCH
APPENDIX 3: QUESTIONNAIRE TO VALUERS

Dear Sir/Madam,

I am Bernadette Wambui Karanja, a fourth year student pursuing a Bachelor of Real Estate in the Department of Real Estate and Construction Management at the University of Nairobi Registration Number B04/35938/2010. I am carrying out a research in partial fulfilment of the requirements of the degree programme on ‘Concepts of Building Automation Systems and its effect on real property values’. Access to any kind of material required to complete the research is highly appreciated.

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Please tick [✓] or [✗], answer ‘YES’ or ‘NO’ and where there are no choices, kindly fill in the blank spaces provided.

1. How can you rate the level of adoption of Building Automation Systems in Kenya?
   [  ] High  [  ] Moderate  [  ] Low

2. What has been the trend in demand and adoption of BAS technology you are familiar with?
   (a) Increasing
   (b) Constant
   (c) Reducing
3. In your opinion, what has influenced the trend noted in Q2 in adoption of BAS technology?

*(Kindly tick all the alternatives that apply.)*

(a) Cost savings associated with integrated control of building systems.
(b) Energy efficiency associated with integrated control of building systems.
(c) Convergence of Information Technology and Building Technology.
(d) Technical compatibility of BAS and user needs.
(e) Increase of initiatives and partnerships between public and private investors.
(f) High Device costs.
(g) Lack of proper legislative and regulatory framework.
(h) Comfort and ease of controlling and maintaining the systems.
(i) Lack of documented local experience making it a risky venture.
(j) Lack of awareness of the benefits of Building Automation Systems.
(k) Changes in consumer tastes, preferences and style.
(l) Other  

4. Do you think there is need for a shift from conventional to automated buildings?

[ ] Yes  [ ] No

Please explain your answer: .................................................................

.................................................................................................

.................................................................................................

5. In your opinion, what needs to be done to facilitate widespread adoption of Building Automation Systems in Kenya?

*(Kindly tick all the alternatives that apply.)*

(a) Tax waivers on Building Automation Systems.
(b) Specific laws guiding and regulating the process of building automation.
(c) Financial incentives to property developers of automated buildings.
(d) Introduction of BAS courses in institutions of higher learning.
(e) Public awareness initiatives on the need and benefits of BAS.
(f) Lowering the cost of Building Automation Systems.
(g) Increase publicity by rigorous advertisement in the media.
6. What is the effect of building automation systems on the value of buildings?

- [ ] Increase  
- [ ] Decrease  
- [ ] No Effect

Please explain your answer

What is the weighted impact of each building subsystem to the building value?

(Kindly tick appropriate rank on a scale of 1-5.)

1 - No increase  
2 - Slight increase  
3 - Moderate increase  
4 - High increase  
5 - Extreme increase

<table>
<thead>
<tr>
<th>BAS Subsystem</th>
<th>1</th>
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</table>

7. In your experience, how is the rental value of automated buildings compared to other similar but conventional buildings?

- [ ] Higher  
- [ ] Lower  
- [ ] Equivalent

What is the actual difference in value and why is this?

8. In your opinion, what is the effect of BAS on demand for space in a building?

- [ ] Increase  
- [ ] Decrease  
- [ ] No Effect

If increase, what are the indicators of increased demand for office space in the building?

(Kindly tick all the alternatives that apply.)

(a) Duration that the property takes in the market before full occupancy
(b) Number of enquiries
(c) Number of applicants
(d) Number of potential tenants’ visits to the building
(e) Higher rent per square foot
(f) Other (please specify)……………………………………………………………………
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9. What is the effect of building automation on the operating and maintenance costs of a building?
   ☐ Increase ☐ Constant ☐ Decrease ☐ Don’t know
   Please explain………………………………………………………………………………
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10. What considerations should one make before choosing a building automation system?
    (Kindly tick all the alternatives that apply.)
    (a) Legal and regulatory requirements
    (b) Impacts of the BAS on the environment
    (c) End comfort, convenience and security of the occupants
    (d) Long term flexibility and marketability of the building
    (e) The cost of installation and maintenance of the BAS
    (f) Cost of training personnel to manage the BAS
    (g) Expected cash flow revenue vis-à-vis costs of BAS.
    (h) Local availability of the BAS technology
    (i) Other ……………………………………………………………………………......
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THANK YOU VERY MUCH
APPENDIX 4: BUILDING AUTOMATION SYSTEM MODEL

Source: fm magazine.com.au
APPENDIX 5: STRUCTURE OF AN INTELLIGENT BUILDING

Source: emeraldinsight.com