URBAN PLANNING AND AIRPORTS:

LAND USE COMPATIBILITY FOR OPTIMAL DEVELOPMENT OF MALINDI AIRPORT.

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DECLARATION

This thesis is my original work and has not been presented for a Degree in any other university.

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DEDICATION

This work is dedicated to wife Fatuma and my children Yusra, Abdirahman and Nasra for their love, inspiration, tolerance and support all through the period of my study.

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ABSTRACT

The problem of incompatible land uses around airports is a critical one which has been allowed to develop largely through the inadequate provision of appropriate planning measures. Malindi Airport which was originally located in relatively open area has become surrounded by residential and commercial developments. The diffusion of urban population has brought more people in proximity with the airport. In addition, the increased activities from airport operation and airport development are limited by inadequate land for expansion.

The research objectives were to establish the various land uses within the vicinity of Malindi Airport and their impact on the Airport; to investigate the impact of the airport on the land uses within its vicinity; to determine land requirement for the ultimate development of Malindi Airport; and lastly, to propose appropriate measures for integrating Malindi Airport with other land uses.

The research methodology involved literature review, primary and secondary data collection, data analysis, interpretation and synthesis and subsequent recommendations to address land use compatibility problems facing Malindi Airport. Approaches to land –use planning around Schiphol, Melbourne and Washington Dulles International Airports have been reviewed as case studies for benchmarking. Primary data collection involved household questionnaires, interview with key informants and survey of existing land uses by field observation. Sampling procedures as propounded in the Central Limit Theorem were used to arrive at the sample size, whereas the individual elements of the sample were selected through random sampling technique.

The study established that existing land use structure within the proximity of the airport imposes limitations to the growth of the airport to accommodate long haul aircraft and that the airport is a nuisance due to noise, air and water pollution among other negative impacts.

The study recommends land use compatibility measures through integrated development plans, building codes and zoning plans. Compatibility measures will seek to mitigate the negative effect of the airport operations and address airspace safety and protection. It proposes the relocation of Malindi-Ganda road (C103) for the extension of runway 07/25 from 1.2km to 2.4 km for the ultimate development of the airport. Lastly, the study proposes an action plan with objectives, expected results and institutions responsible for implementation.

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LIST OF ACRONYMS

ANEF	Australian Noise Exposure Forecast
APA	American Planning Association
ADF	Automated Direction Finding
ATC	Air Traffic Control
dB	Decibel
DME	Direction Measuring Equipment
DNL	Day-Night Level
DTM	Digital Terrain Model
FAA	Federal Aviation Administration
IATA	International Air Transport Association
ICAO	International Civil aviation Organization
JKIA	Jomo Kenyatta International Airport
KAA	Kenya Airports Authority
KCAA	Kenya Civil Aviation Authority
Ke	Kosten-Eenheid
MTOW	Maximum Certified Takeoff Weight.
MHz	Mega hertz
NAVAIDS	Navigational Aids
NDB	Non-Directional Beacon
RIM	Registry Index Map
SPSS	Statistical Package for Social Scientists
VHF	Very High Frequency
VOR	VHF Omni-Directional Range

CHAPTER ONE
INTRODUCTION

1.1 Background to the Study

The history of development appears to fall into four major stages, each of which has been dominated by the principal mode of transportation of the time. The period of dominant water transportation, the age of pioneering rail transportation, the time of emerging automobile transportation and the current stage of growing air transportation (Conway,1980). Transportation helps shape an area's economic health and quality of life. Not only does the transportation system provide for the mobility of people and goods, it also influences patterns of growth and economic activity by providing access to land. The transport system affects public policy concerns like air quality, environmental resource consumption, social equity, land use, urban growth, economic development, safety, and security. Transportation planning requires developing strategies for operating, managing, maintaining, and financing transportation systems in such a way as to advance the area's long-term goals.

The airplane is now the dominant mode of transportation for a great many people and businesses. Airports provide significant employment and economic benefits to communities through the movement of people and goods, promotion of tourism and trade, stimulation of business development, and the opportunity for a wide variety of jobs. The flying public and local communities do not readily discern the huge size and scale of economic development that airports provide and stimulate. However, most of the development to be found today around airports is disorderly and unplanned. At large airports, problems of noise, congestion and other environmental influences have already reached crisis proportions. Fiona (1980) argues that there is an urgent need, therefore to look at the planning and development process, not just for airports, but also for airport communities and cities.

One of the main challenges facing aviation today is the encroachment of incompatible land uses near and around airports. Ward (2010) defines Airport –compatible land uses are those land uses that can coexist with a nearby airport without either constraining the safe and efficient operation of the airport or exposing people living or working nearby to unacceptable levels of noise or hazards. Compatibility concerns include any airport impact that adversely affects the livability of surrounding communities, as well as nay community characteristic that can adversely affect the viability of an airport. Development of incompatible land uses can degrade airport operations, impede airport expansion, and reduce quality of life for airport neighbors. The compatibility concerns and the type of land use help determine the level of compatibility a given land use has with its surrounding environs. While general types of land uses are typically considered to be compatible or incompatible ,it is important to evaluate each use independently ,since certain factors can cause what may be usually be seen as compatible to be incompatible and vice versa.

Putnam (1952) states that the problem of community encroachment on Airports is a critical one which has been allowed to develop largely through the inadequate provision of appropriate planning measures. Airports which were originally sited in relatively open areas have become surrounded by residential and commercial developments. The simultaneous advancement in aeronautical technology and diffusion of the urban population has brought more people in contact with an increased influence from airport operation. The Airport has acquired an unfavorable reputation, has been criticized as a nuisance, and the location of new facilities have been opposed by citizens who reside in the vicinity of the proposed airport.

Most people are familiar with the negatives associated with proximity to an airport. The effects generated by airports affecting adjacent properties may include: noise, vibration, smell, light, low-flying aircraft, safety risks – real and perceived, future increases in airport operations. However, fewer people understand the effect that adjacent land uses can have on airport activities. Development around an airport can reduce land available for operations and safety areas create obstructions to the airspace needed for aircraft to safely approach and depart the runway, reduce clear airspace needed to support advanced technologies, and generate opposition to existing and future airport activities.

These land use conflicts often degrade usefulness of an airport and have severe consequences for communities. Ultimately, incompatible development reduces opportunity for economic development, reduces transportation access, reduces the value of public investment in airport infrastructure, and reduces quality of life for communities.

The links between community planning and airport planning are necessary and often overlooked (APA, 2010). If an airport is to be fully useful and effective, it must be carefully and regularly considered in urban and regional planning process; conversely, airport planning must understand and consider the needs and concerns of the communities that surround, abut, and make use of the airport. Physical planners must incorporate an existing airport must plan and its findings into the comprehensive plans or upon the completion of an airport must plan, the airport authority must turn to the urban planners to implement compatible land-use ordinances and regulations that support the airport vision.

The premise of this study is that neither of these approaches is truly successful unless airport planners and Urban planners work as partners during the development of the planning process in order to weave the community vision, strategies, and values together with those embedded in airport planning. Ward (2010) state that the quality of the intersection between airport planning and urban planning is evident in the compatibility of the airport's surrounding land uses. Ideally, planners and airports would have standing lines of communication that provides continual opportunities for interaction and coordination on land- use planning ,planning, and airport related issues. Unfortunately, the reality in most municipalities is that this sort of communication does not exist. Airport planning and urban planning are often completed through separate efforts, with each making little consideration of the plans or needs of the other. Consequently the resulting plans are often at odds and can create contradictory approaches to development.

The airport planning problem is twofold; first, the airport must be sited to provide the most economical construction, adequate approach protection and integrated surface transportation to the urban region. Second, the airport location must be compatible with other community activities and through its operation must not unduly jeopardize the adjacent residents.

The most effective tool to secure an advantageous location is the integration of the airport plan into the comprehensive community or regional plan, the planning process must be supplemented by zoning legislation in the immediate vicinity of the airport and the purchase of the property and navigation easements at the ends of runway.

The need for some public control of land in the vicinity of an airport was recognized in the early history of civil aviation (ICAO,2010). In general, these early measures were usually concerned with height control of possible hazards or obstacles to flight into or out of airports. Also recognized was the need to control potentially conflicting activities, such as: activities that could cause electrical interference with radio communications and navigation aids; lights that might confuse pilots in the clear interpretation of aeronautical lights; and the production of smoke that reduces visibility.

Although litigation regarding aircraft noise did occur in the early 1960s, it was only after the widespread introduction of commercial turbo-jet aircraft that the compatibility of land use with noise exposure in the vicinity of airports became a major consideration. Today, aircraft noise is probably the most significant form of pollution caused by aircraft operation and is therefore a major factor influencing land-use planning in the vicinity of airports. Airports can operate with limited environmental impact by incorporating environmental management plans and procedures with land-use planning. In the past, environmental management has concentrated on pollution abatement or control by finding ways to dispose of waste after it has been produced. More recently, organizations have been shifting toward pollution prevention, which focuses on reducing or eliminating the need for pollution control. Pollution prevention includes practices that reduce the use of hazardous and non-hazardous materials, energy, water or other resources. Anticipatory action is used to preempt the need for control or remedy. ICAO (2010) states that the requirement for land-use planning in the vicinity of an airport is twofold, namely: to provide for airport needs such as obstacle limitation areas and future airport development, and to ensure minimal interference to the environment and the public by locating residential areas away from zones subject to excessive noise or other pollution and by preserving parklands.

Kenya has three international airports, four major domestic airports, and more than 400 smaller aerodromes and airstrips that contributes significantly to its economy and serves a variety of roles and functions (KAA,2010). These airports/airstrips provide unique transportation access as part of a country’s multi-modal transportation system. They are crucial on a county, national, and global level as they efficiently move people and goods, promote business and commerce, and contribute to a better quality of life. They serve a wide range of transportation, economic and emergency activities, including: business travel, tourism, freight, express, and mail services, agricultural, disaster management, emergency medical transportation, aviation-related business, search and rescue, access to remote communities.

1.2 Statement to the Problem

The general task of physical planning and design is to translate the social and economic aims of development into physical patterns of land use. Airport planning is an integral part of an area-wide comprehensive planning programme. The location, size and configuration of the airport need to be coordinated with patterns of residential, industrial, commercial, agricultural and other land uses of the area, taking into account the effects of the airport on people, flora, fauna, the atmosphere, water courses, air quality, soil pollution and other facets of the environment (ICAO,2002). The compatibility of an airport with its environs is an ideal that can be achieved by proper planning of the airport, control of pollution-generating sources, and land use planning of the area surrounding the airport. The aim is to provide the best possible conditions for the needs of the airport, the community in the surrounding area and the ecology of the environment.

Within the comprehensive planning framework, airport development and operations should be coordinated with the planning, policies and programs for the area where the airport is located. In this way, the social and economic impact, along with the environmental effects of the airport, can be evaluated to ensure to the greatest extent possible that the airport environs are compatible with the airport and, conversely, that the physical development and use of the airport is compatible with the existing and proposed patterns of land use. To the extent that technical considerations permit a choice, decisions on runway alignment and other airport development should take into account their potential effects on the environment in order to prevent or minimize environmental conflicts. In effect, "land-use control" is a term which describes only a portion of the total planning process, and even highly innovative controls can have little impact unless they are imposed within the context of sound policies and careful planning. "Land-use planning" or "planning for compatible land uses which takes into account the needs of airport development" more adequately describes the process of achieving an optimum relationship between an airport and its environs (ICAO, 2002).

Kenya Airports Authority (KAA) operates a coordinated network of airport facilities in the country with each airport having a specific role. In this regard KAA has a National Airport System Plan (NASP) first prepared in 1993 and which is regularly updated in line with changes in traffic growth and characteristics. In the above plan, Jomo Kenyatta International Airport (JKIA), Moi international Airport, Mombasa and Eldoret international Airport are operated as international airport whereas Wilson, Malindi, Ukunda and Lamu are operated as major domestic airports that serve as feeder airports to the international airports. Airports expansion is identified as a flagship project in Vision 2030 and in 2014-15 budget the government has allocated Ksh 1.65B for on-going upgrading of Kisumu,Isiolo and Malindi Airports and construction of two new airports in Mandera and Suneka (Kisii).

The Malindi Airport was located at some distance from the town where land was relatively cheap and runway approaches were unobstructed by natural features. There was no critical requirement for the airports to be located close to the urban center because passenger flights were few and freight shipments were rare. The principal commercial service was the tourism. The aircraft mix required little space for landing and take-offs and were operated within limited space. Technological advancements embodied in new aircraft designs produced bigger and faster models which required larger airport facilities and more air space in which to negotiate an approach to the runway. As the aviation industry grew other related activities were attracted to the airport site and commercial and residential construction followed. During the period 1979-2009 the population of Malindi town grew from 28,123 to 118,265. This parallel development and wide use of the automobile precipitated a dispersion of the population and formation of a commuting public. This has led to land use conflicts between the Airport and other land uses.

The Malindi Airport land measure 100.6 ha with a primary runway of 1402m long and 30 m wide which cannot accommodate long haul jet aircraft (B767) to enable direct international charter flights with seat capacity of about 200 from Europe to Malindi. The current terminal building of total floor area 300 square meters is not adequate at the current level of traffic levels and experiences congestion at peak hour. In view of the above, the Government through vide Gazette Notice No.6404 of 25th October 1999 gave notice to intention to acquire several parcels of land for expansion of Malindi Airport. However, the process has not been finalized to date.

Over the years, physical development plans prepared by the governments have only minimally recognized the implications of planning for airports and off-site, airport-related development. Local land use planning as a method of determining appropriate (and inappropriate) use of properties around airports should be an integral part of the land use policy and regulatory tools used by airports and local land use planners. Land use decisions that conflict with aviation activity and airport facilities have resulted in undue constraints being placed on an airport. In order to enable this sector of the economy to continue to expand, to provide for a wide variety of job opportunities for local citizens, and to meet the needs of the traveling public, it is vitally important that airports operate in an environment that maximizes the compatibility of the airport with off-airport development.

The main purpose of this research is to examine land use compatibility around the proximity of the airport for optimal physical development of Malindi Airport.

1.3 Research Questions

This study sought to answer the following questions:

(a) What are the various land uses within the vicinity of Malindi Airport and their impact on the Airport?

(b) What is impact of Malindi Airport on other land uses within its vicinity?

(c) What is the land requirement for the ultimate development of Malindi Airport?

(d) How can airport planning principles integrated in the physical development of the land uses within the vicinity of the Airport?

1.4 Research Objectives

The objectives of this study are:

(a) To establish the various land uses within the vicinity of Malindi Airport and their impact on the Airport.

(b) To investigate the impact of the airport on the land uses within its vicinity.

(c) To determine land requirement for the ultimate development of Malindi Airport

(d) To propose appropriate measures for integrating Malindi Airport with its neighborhoods.

1.5 Research Hypothesis

The Study is guided by the following hypothesis:

"The physical development of Malindi airport is limited by incompatible land uses within the proximity of the Airport"

1.6 Significance of the Study

Community encroachment on airport sites is not a factor which was incorporated in the original site selection but is a process which has been allowed to develop through the inadequate provision of appropriate planning measures (Bezilla,2009). Community encroachment on airport sites is continuing to increase and will limit expansion of major airports unless immediately corrective measures are taken to control land uses surrounding airports. The design and planning of new airports will be particularly sensitive and it will be incumbent upon the urban planner to insure that any proposed airport location will meet public acceptance. It is unsound economics to allow public investment in airports to be jeopardized by the elimination of expansion possibilities. The anticipated development of major airstrip in the 47 counties will intensify this critical problem.

The encroachment of communities on airport has adverse effect on the expansion possibilities of the airport but presents a more serious problem to adjacent residential developments. It is a known fact that noise, hazard and vibrations are some of the many causative agents in the formation of blighted areas. Persons who object to these nuisances leave the afflicted areas and the residences are occupied by persons of lesser financial means who do not provide the dwelling with the required degree of maintenance.

Thus, land values tend to depreciate and a transition develops towards the formation of a blighted area. This sequence of events have occurred near railroad tracks, elevated railways and heavily travelled city streets. It remains to be seen if air traffic in the vicinity of airports will have the same effect.

The research will assist county governments, airport managers and land use planners who have an airport within their jurisdiction on airport land use compatibility for the ultimate development of the airports. It will identify the importance of airport land use compatibility planning, summarizes the issues involved in achieving compatibility, presents a variety of methods which have been used to attain land use compatibility in other countries and describes the responsibilities involved in implementing land use compatibility measures. It is also important for every airport manager to understand land use compatibility issues and land use regulations. The research will also provide an overview of airport planning and development so that local land use planners and their elected officials can understand the airport planning process.

Finally, the research not only presents a discussion of land use compatibility issues, but it also identifies opportunities for coordination of both the airport planning and land use planning processes. It is critical that these two planning processes be integrated /coordinated as much as possible.

1.7 Scope and Limitations of the Study

International Civil Aviation organization (ICAO) and Federal Aviation Authority (FAA) have established a series of obstacle limitation surfaces that define the limits to which objects may project into airspace to ensure and preserve the safety of operations in the airspace in the immediate vicinity of airports. ICAO and FAA through advisory circulars have recommended compatible land uses around airports. These internationally recommended planning practices detailed in Chapter 2 shall delimit the theoretical scope. The study will be conducted in the area to the north of Malindi Airport extending 1 kilometer from the threshold of runway 17 bounded by the approach path.

This research was carried out within a specified period and with limited resources. To overcome constraints, a manageable and representative sample that will minimize systematic and random errors will be selected. This is to ensure validity and reliability of results. Four research assistants were trained on how to administer the household questionnaire for purposes time management.

1.8 Definition of Key Terms and Concepts

This section defines key terms that will be used in the study.

1.8.1 Urban Planning and Land uses.

Urban planning in a broader sense refers to planning the spatial structure of activities and land uses in an urban area. The land uses are the ways people utilize land to meet their needs. The use to which land is put in urban areas is therefore often influenced by availability of infrastructure and service networks.

The land uses and activities take place on land and occupy space. They also interact and interrelate with each other in space, hence, the need for a spatial pattern to guide their operations. The planned spatial pattern is supposed to ameliorate the pattern that may exist. This is done through land use planning which consequently brings about improvement in that spatial arrangement to facilitate more efficient and effective operation in response to human needs.

1.8.2 Aeroplane reference field length

The minimum field length required for take-off at maximum certificated take-off mass, sea level, standard atmospheric conditions, still air and zero runway slope. Field length means balanced field length for aeroplanes, if applicable, or take-off distance in other cases.

1.8.3 Dependent parallel approaches

Simultaneous approaches to parallel or near-parallel instrument runways where radar separation minima between aircraft on adjacent extended runway center lines are prescribed.

1.8.4 General aviation

All civil aviation operations other than scheduled air services and non- scheduled air transport operations for remuneration or hire.

1.8.5 Usability factor

The percentage time during which the use of a runway or system of runways is not restricted because of the cross- wind component.

1.8.6 Aerotropolis

An urban complex whose layout, infrastructure and economy are centered on an airport**.** The airport city is functions as the multimodal core of the aerotropolis, in the way that the central business district does to the metropolis.

1.9 Organization of the study

This study is divided into five chapters each contributing to the major objective of supplying information and insight into the topic and in facilitating data analysis and solution to the identified challenges.

Chapter One: Introduction: This chapter introduces the research topic and its problem statement. It includes the research objectives, hypothesis, scope of the study and organization of the study.

Chapter Two: Literature Review and Conceptual Framework: This chapter entails the review of the related literature with an aim of establishing theoretical background of the study. This chapter is to set a foundation upon which data is to be collected and analyzed.

Chapter Three: Approaches to Land -Use Planning Around Airports. This chapter reviews case studies on land use planning around Schiphol Airport, Melbourne and Washington Dulles International Airport for benchmarking. Lessons are drawn from the case studies that inform the discussions towards land use compatibility in Malindi Airport.

Chapter Four : Study Area and Methodology: This chapter gives information on the location, developments of the study area, research design and methodology.

Chapter Five : Towards Sustainable Physical Development of Malindi Airport-Discussions of Research Findings: This chapter gives the findings and data analysis and presentation from the field survey conducted during the research study. It includes findings from observations and interactions, findings from the questionnaires administered to the respondents and key informants.

Chapter Six: Conclusions and Recommendations: This is the final Chapter and it represents the conclusions, hypothesis testing, and the recommendations and provides suggestions for further study.

CHAPTER TWO
LITERATURE REVIEW AND THE CONCEPTUAL FRAMEWORK

2.1 Introduction

Transportation system is fundamental and necessary component to the economy of any region. The movement of people and goods leads to trade and commerce between markets, which in turn, lead to jobs, earnings, and overall economic benefit for a community's residents. Even though there are a variety of transportation modes, such as automobiles, trucks, ships and railroads, perhaps no other mode has a significant an impact on intercity trade and commerce than aviation. Travel in the aviation system allows for intercontinental travel of large volumes of passengers and cargos in relatively short periods. Access to markets around the world has resulted in the largest communities reaping extraordinary economic benefit. Airports are gateways to nations' aviation system, providing access to air transportation for the surrounding community. Commercial air carriers provide access to air transportation between major metropolitan areas of the country. Thousands of smaller cities, towns and villages have access to aviation by way of airports serving general aviation.

The airport has become vital to growth of business and industry in a community by providing air access for companies that must meet demands of supply, competitions and expanding marketing areas. Communities without airports or sufficient air service have limitations placed on their capacity for economic growth.

Airports, related aviation, and non-aviation business located at the airport represent a major source of employment for many communities around the country. The wages and salaries paid by airport related business can have a significant direct effect on the local economy by providing means to purchase goods and services while generating tax revenue as well. Local payrolls are not only a measure of an airport's economic benefit to community. In addition, employee expenditure generate successive waves of additional employment and purchases that are more difficult to measure but nevertheless substantial.

In addition to the local direct economic activity generated by the regular expenditure of resident employees, the airport also stimulates the economy indirectly through the use of local services for air cargo, food catering to airlines, aircraft maintenance, and ground transportation on and around the airport. Regular purchase of fuel, supplies, equipment, and other services from local distributors inject additional income in to local community. Finally earnings from direct and indirect economic generators further act to recycle money within the local community, dollars pass from one person to another. The multiplier effect operates in all cities as aviation-related dollars are channeled throughout the community.

An airport provides an additional asset to the general economy by generating billions of dollars by year in state and local taxes. These tax dollars increase the revenue available for projects and services to benefit the residents of each state and community. Whether the extra tax dollars improve the state highway system, beautify state parks, or help prevent tax increase, airport-generated tax dollars work for everyone.

Cities with good airport facilities also profit from tourist and convention business. This can represent substantial revenues for hotels, restaurants, retail stores, sports and night clubs sightseeing, rental cars and local transportation, among others. The amount of convention business varies with size of the city, but even smaller communities show a sizable income from this area.

Beyond the benefits that an airport brings to the community as transportation facility and as a local industry, the airport has become a significant factor in the determination of real estate values in adjacent areas. Land located near airports almost always increases in value as local economy begins to benefit from the presence of the airport. Land developers consistently seek land near airports, and it follows inexorably that a new airport will inspire extensive construction around it.

The ‘Airport City’ concept acknowledges the notion that large airports take the characteristics of a real city. They develop non-aeronautical services far beyond the core business of providing a location for passengers. Airports have not only become catalyst for employment and economic growth, but they have attracted a full range of businesses to the airport vicinity, which are reminiscent of the way seaports and river deltas become centers of economic activity in past centuries. Modern airports are becoming meeting places and indeed a destination in their own right, with corporations scheduling meetings at or near airports to maximize the available time of their managers. Many hotel chains report that airport hotels are among their most profitable properties, due not only to high demand for rooms, but for revenues generated from conference services and catering. Airport cities are usually located only partially on land belonging to the airport, but also on off-airport land, a situation which many entail land use planning

2.2 The components of an airport

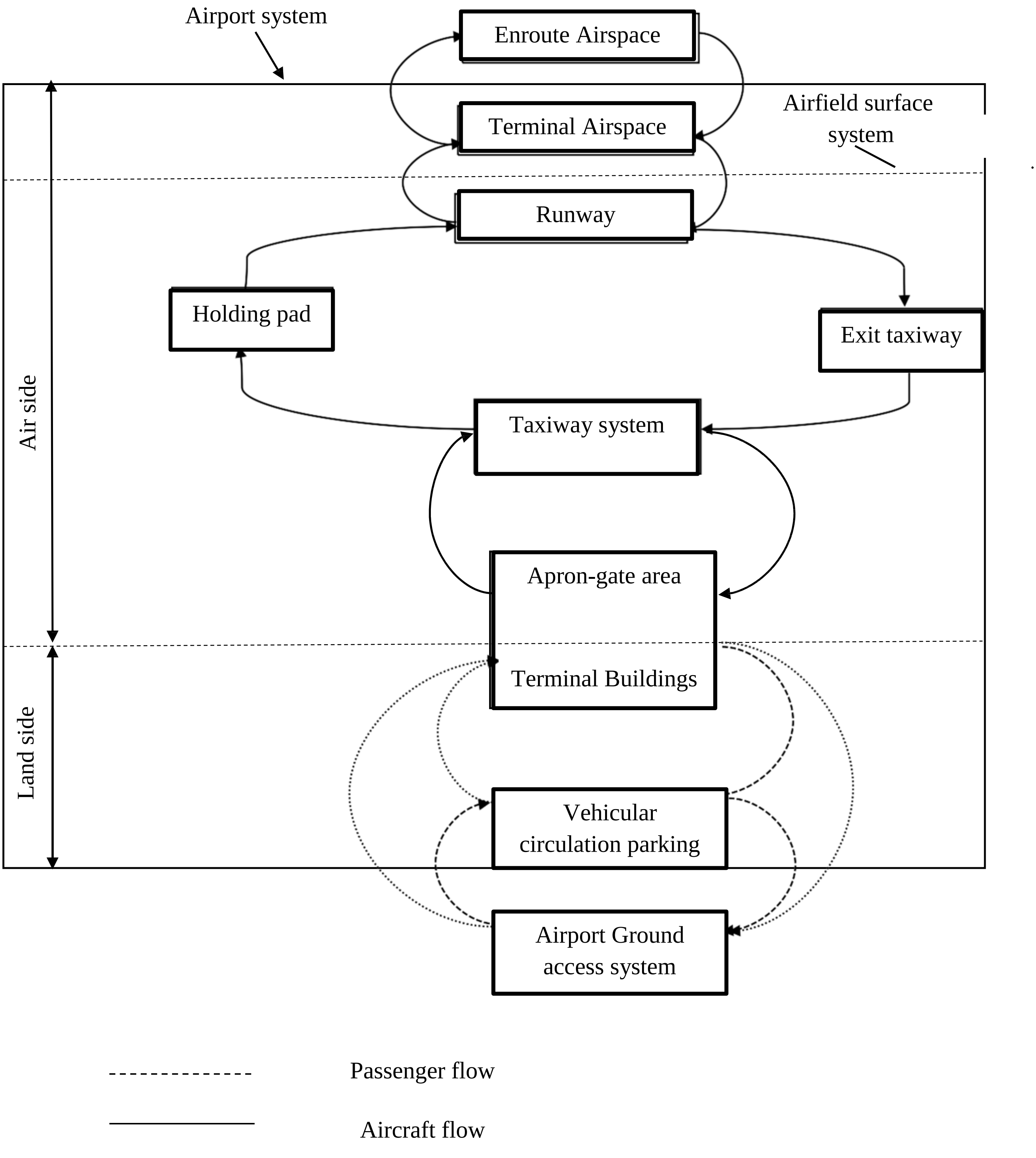
An airport is a complex transportation facility, designed to serve aircraft, passengers, cargo and surface vehicles. Each of these users is served by different components of an airport. The components of an airport are typically place into two categories.

The airside of an airport is planned and managed to accommodate the movement of aircraft around the airport as well as to and from the air. The airside components of an airport are further categorized as being part of local airspace or airfield. The airport's airfield components include all the facilities located on the physical property of the airport to facilitate aircraft operations. The airspace surrounding an airport is simply the area, off the ground, surrounding the airport, where aircraft maneuver after takeoff, prior to landing, or even merely to pass through on the way to another airport (Wells and Seth,2004).

The landside components of an airport are planned and managed to accommodate the movement of ground-based vehicles, passengers, cargo and support services such as fire and rescue. These components are further categorized to reflect specific users being served. The airport terminal component is primarily designed to facilitate the movement of passengers and luggage from the landside to aircraft on the airside. The airport's ground access components accommodates the movement of the ground-based vehicles to and from the surrounding metropolitan area, as well as between the various buildings found on the airport property.

No matter what the size or category of an airport, each of the above components is necessary to properly move people from one metropolitan area to using air transportation. The components of an airport are planned in a manner that allows for the proper 'flow' from one component to another. An example of a typical 'flow' between components is illustrated in figure 1 below, it further identifies some of the facilities located on airfield and ground access components of the airport.

Figure 1: Components of the Airport System



Source: Wells and Seth, 2004.

2.3 Airport Site Selection

The selection of a new aerodrome or an enlargement of an existing one represents extensive investment and building works. It is therefore necessary to design the entire aerodrome project for the longest time period possible (Kazada and Caves, 2008). The maximum possibilities of airport development in the proposed locality should be considered within the limits of the airport's critical constraints. As well as ensuring that the capacity and operational requirements are met safely, the issues concerning the airport and its surroundings should be considered, particularly the impact of the airport on the nearby population and environment. The locality selected for the airport and orientation of the runway system should facilitate a long – term development of the airport at the lowest cost in terms of money and social impacts.

Selection of a suitable site for the airport should begin with an assessment of any existing airport and its site. It is nearly always easier to modify an existing airport than to create a new one on land that has previously had a different land use designation. The assessment is made in the light of the prospective passenger market, its growth rate and any limitation of the growth resulting from, for example, a demographic shift of population. Therefore the prognosis of the growth of a number of passengers and volume of air cargo in the catchment area of the airport is one key element in planning the airport development.

After the proposed airport's size and layout has been approximately determined by a preliminary study, possible sites for the development of the airport are assessed in several steps, the principal ones being:

i. approximate determination of the required land area
ii. assessment of the factors affecting the airport location
iii. preliminary selection of possible localities
iv. survey of individual sites
v. assessment of impacts on the environment
vi. revaluation of the site layout drawings
vii. estimate of costs, revenues and discounted cash flow
viii. final selection and assessment of the preferred site
ix. Elaboration of the final report and recommendations.

The same procedure is followed in principle when assessing the development of an existing airport, though some of the steps may be omitted. The number, location and orientation of the runways and of the taxiway system should meet the following criteria:

i. The airport usability factor is at least 95% , considering the losses which would result from the un availability of the airport due to crosswind component.
ii. Obstacle restrictions defined by the obstacle clearance limits should be respected.
iii. Ideally, the final capacity of the runway system should meet the predicted demand in the typical peak hour traffic in the far future.
iv. The site should be considered from the viewpoint of achieving a functional layout of the aerodrome facilities, ground transport access to the airport and the urban development plans in the airport vicinity should be efficient and sustainable. The site should also be in accordance with local and regional land use plans.

2.4 Airport Classification Codes

ICAO uses classification schemes to develop a two-element reference code for each airport. For any type of aircraft, the first element of the ICAO code is determined by the aircraft reference runway length, the minimum field length required by that aircraft for takeoff at maximum certificated takeoff weight (MTOW), sea level, standard atmospheric conditions, no wind, and level runway. The second element is determined by the more demanding of two physical characteristics of the aircraft: its wingspan and the distance between the outside edges of the wheels of the main gear. The reference code of an airport thus corresponds to the code for the most demanding type of aircraft ("critical aircraft") served by the airport in each element. In an analogous way, the FAA uses aircraft approach speed to determine the first element of its reference code and wingspan to determine the second. The aircraft approach speed is defined as 1.3 times the stall speed in the aircraft's landing configuration at maximum landing weight.

Table 1: Airport Classification Codes

Code element 1		Code element 2	
Code No.	Aeroplane reference Field length	Code letter	Wing Span
1	Less than 800m	A	Up to but not including 15m
2	800m up to but not including 1200m	B	15m up to but not including 24m
3	1200m up to but not including 1800m	C	24m up to but not including 36m.
4	1 800m and over	D	36m up to but not including 52m.
		E	52m up to but not including 65m
		F	65m up to but not including 80m

Source: ICAO Annex14, Volume 1.

When it comes to the first element of the ICAO reference code, virtually all the major commercial airports have airport code number 4. The most demanding aircraft types using these airports almost always have a reference field length greater than 1800 m. The second element of the ICAO reference code, for all practical purposes, is determined by the wingspan of the most demanding aircraft at major airports. This is because, for the existing types of important commercial jet aircraft, the distance between the outside edges of the wheels never places these aircraft in a code letter category higher than the one to which they would be assigned based on their wingspan.

The second code element is the one that largely determines the geometric design standards at airports, because it reflects the physical characteristics of aircraft, using wingspan as the primary indicator of aircraft size. Since (1) any airport will be classified in the same way by the ICAO on the basis of wing span, and (2) the dimensional standards used by the FAA and ICAO for each reference code are usually either identical or very similar, it makes little difference in most instances whether an airport is designed to FAA or ICAO standards.

Planners and designers of new airports or of major improvements to existing ones have to make the critical decision of what airport reference code they should design for. Building for a more demanding aircraft than necessary means incurring unnecessary capital and maintenance costs: the dimensions of runways, taxiways, and aprons and the separations between them will be larger than required. On the other hand, it may be even costlier to "under design" the airport. If airlines try to initiate service to/from an airport with a type of aircraft that the airport is not designed to handle, then this service must either be denied, or arrangements must be made to accept that aircraft under some special handling provisions, or the airport's facilities must be modified to make them compatible with the aircraft in question. The first two choices are unattractive in the long run, especially if the popularity of the aircraft in question increases over time. The third choice can be very expensive and disruptive if adequate provisions were not made at the outset for the possibility of re-dimensioning airfield facilities in the future.

The geometric design should provide, whenever the land area available makes this feasible, for future adjustments of the geometric characteristics of the airfield to accept larger aircraft than an airport was originally built for. To follow such a strategy, airport designers and planners should be aware of the full foreseeable range of potential aircraft sizes and associated design standards.

2.5 Runway Designation and Classification

Every runway is identified by a two-digit number, which indicates the magnetic azimuth of the runway in the direction of operations to the nearest 10°. For example, a runway with a magnetic azimuth of 224° is designated and marked as "Runway 22" (for 220°). Obviously, the identification numbers at the two ends of any given runway will differ by 18. For instance, the opposite end of Runway 22 is designated as Runway 04, and the runway may be referred to as "Runway 04/22."

In the case of two parallel runways, the letters R, for right, and L, for left, are added to distinguish between the runways. Thus, JKIA master plan has two close parallel runways (one exiting and a proposed) designated as 06R and 06L when the runways are operated and, respectively, as 24L and 24R. If three parallel runways exist, the letter C, for center is used. If four parallel runways are present, then one pair is marked to the nearest 10°, with the additional indications R and L, and the other to the next nearest 10°, with the additional indications R and L.

For the purpose of specifying design standards, runways are also classified as non-instrument and instrument. A non-instrument (or visual) runway is intended for the operation of aircraft using visual approach procedures. An instrument runway permits the operation of aircraft using instrument approach procedures. Instrument runways are further subdivided into non precision and precision approach. A non-precision runway has visual aids and, at a minimum, a navigation aid that provides at least directional guidance adequate for a straight-in approach. A precision approach runway allows operations with a decision height and visibility corresponding to Category I, or II, or III limits.

The construction of systems of intersecting runways is usually motivated by the requirement to provide adequate coverage for crosswinds at an airport. Landings and take offs are typically conducted into the wind. For instance, during times when the wind is from the north, runways with a northerly orientation, if available, will be preferred over others, and landings and takeoffs will be performed in a generally south-to-north direction. When any given runway is in use, the crosswind component is the component of the surface wind velocity vector that is perpendicular to the runway centerline. Its magnitude can be computed easily by multiplying the speed of the prevailing wind by the sine of the angle between the wind direction and the runway centerline. The ICAO specifies that a runway should not be used if the crosswind component exceeds (ICAO, 1999):

- 19 km/h (10.5 knots) for airplanes whose reference field length is less than 1200 m
- 24 km/h (13 knots) for airplanes whose reference field length is 1200-1499 m
- 37 km/h (20 knots) for airplanes whose reference field length is 1500 m or greater, except that with poor braking action (for instance, when the runway surface is wet) the limit is 24 km/h (13 knots)

Both the ICAO and the FAA recommend that the number and orientation of runways should be such that crosswind coverage (or the airport usability factor in ICAO terminology) is at least 95 percent. In other words, the percentage of time during which the use of a runway system is restricted because of crosswinds should be less than 5 percent. Note, however, that the 95 percent target may still leave approximately 18 days per year without crosswind coverage. For many major airports, this may not be acceptable. In practice, these airports usually provide runways in a sufficient number of orientations, when needed, to ensure usability factors higher than 95 percent. National civil aviation authorities, in fact, may impose more stringent cross-wind coverage requirements than 95 percent at the principal airports of their countries.

Airport designers use historical wind statistics collected at an airport's site to determine the orientation of the runways that should be provided to achieve adequate crosswind coverage. Wind roses provide a convenient way for summarizing these statistics graphically.

Wind analyses are important both in the design of new airports and in any analysis of the effects of winds and weather on existing airports. For this reason, the FAA and the ICAO recommend that extensive historical wind records be analyzed, preferably covering up to 10 consecutive years.

2.6 Airport land requirements

Airfields largely determine the total land area occupied by an airport and play a critical role in determining the airport's functionality and capacity. How much land area is actually occupied by an airfield depends on many factors. Principal among them are: the number, orientation, and geometry of the runways, including length, separations between parallel runways, airport reference codes selected for the purposes of airfield design, the location of the landside facilities relative to the airside facilities and the additional land area held in reserve for future expansion or to provide a "buffer" zone for mitigation of noise and other environmental effects.

The airfield takes up most of the land area occupied by an airport. Depending on the size of the airport, the landside facilities (passenger buildings, cargo areas, on-site access roads, car parking, etc.) typically take up only between 5 and 20 percent of the total land area, with the larger percentages applying to airports with small land areas. The other 80-95 percent is dedicated to the complex of runways, taxiways and aprons. The number of runways needed to serve air traffic demand is a critical factor in determining land area requirements for airfields.

2.7 Runway Design Length

The approach for deciding on the appropriate length of the runway (or runways) to be provided at an airport follows directly from the preceding discussion. The airport designer must select the most demanding aircraft type (critical aircraft) to be accommodated by a runway and the conditions of use by that critical aircraft. The runway length that will accommodate that aircraft under these conditions is then computed. "Conditions of use" essentially mean:

- The longest nonstop distance (stage length) to be flown by the critical aircraft from/to the runway; and
- The most demanding environmental conditions during runway use, such as the mean daily temperature for the hottest month of the year at the airport.

The FAA suggests (FAA, 1990) that the critical airplane/flight combination should be a service operating for at least 250 days in a year—for instance, a flight scheduled on a Monday-through-Friday basis every week. A better approach is to identify target markets that an airport should be designed to serve as part of its long-term strategy and design, but not necessarily build, accordingly. It should be emphasized, however, that such target markets should be chosen realistically. Several secondary airports in Europe built runways long enough to serve scheduled intercontinental flights to the United States with Boeing 747 aircraft. Such flights never materialized**.**

Another common mistake in selecting runway lengths is building too many very long runways. Consider an airport with two parallel runways in its primary, direction of runway operations. At least in the early phases of the airport's development, the airport operator may not wish to construct both runways to equal length, if the number of flights requiring a long runway is not large. For example, building one of the runways to a length of 3600 m (11,800 ft) and the other to 2700 m (8900 ft) may be perfectly adequate for an airport at sea level in an area with non-extreme temperatures. The long runway is sufficient for the takeoff of practically any long-range flight, while the shorter one is adequate for nearly any short- and medium-range flight. The two runways then can share all operations, except for long-range flights, which must be assigned to the long runway. If long-range traffic grows to the point where two long runways are necessary, then the shorter runway can be lengthened assuming adequate planning exists for this eventuality.

2.8 Obstacles Limitation Surfaces

To ensure and preserve the safety of operations in the airspace in the immediate vicinity of airports, both the ICAO and the FAA have established a series of obstacle limitation surfaces that define the limits to which objects may project into airspace (Fig 2).These surfaces protect approaches to runaways, takeoffs, and missed approaches (“balked landings") from obstructions. Objects that penetrate these surfaces are considered obstacles to air navigation and should be removed when possible. An obstacle can be any fixed or mobile object, including terrain, natural objects such as trees, and man-made ones such as antennas or buildings.

Obstacle limitation surfaces are very important to aviation safety. They provide guidance for zoning restrictions on the height of buildings, antennas, and other structures near airports. They may also play a major role in determining the construction costs of new airports when these are located in difficult terrain. More than 50 million m^3 of soil, rocks, and other materials had to be removed from hills around the site of the new airport at Athens/Venizelos in order to remove obstacles to air navigation as per Annex 14 of ICAO. (1999)

The obstacle limitation surfaces defined by the ICAO are discussed here below:

The inner horizontal surface is a horizontal plane in an airport and its environs. It should normally be a circle whose radius depends on the type of runaway (s) available (non-instrument approach, non-precision approach, or precision approach). The circle is centered at the airport’s reference point, the designated geographical location of the airport. The height of the inner horizontal surface is 45 m (ICAO, Annex 14) above the established elevation of the airport.

The conical surface projects upward at a slope of 5 percent from the periphery of the inner horizontal surface to a specified height above that surface. That height depends on the type of runway(s) available.

The approach surface, as the name suggests, protects the approach to the runway from obstructions. In planar view, it looks like a trapezoid inclined relative to the horizontal plane and may have a first section and a second section of different slopes. For non-precision or precision approaches with code number 3 or 4, the approach surface has a horizontal section. In these cases, a 3-km first section begins 60 m from the runway threshold with a slope of 2 percent. This is followed by a 3.6-km second section with an upward slope of 2.5 percent and finally by a horizontal section (at an elevation of 150 m) with -a length of 8.4 km. The total length of these three sections is 15 km (~= 9 mi), although in some cases it may be even longer (ICAO, 1999).

There are transitional surfaces on either side of the runway and of the approach surface which slopes upward and outwards to the height of the inner horizontal surface. The elevation of any point at the lower edge of the approach surfaces is given by either the elevation of the approach surface at that point (when the point is along the side of the approach surface) or by the elevation of the runway strip at that point (when the point is along the strip).

For precision approach runways, an inner approach surface and associated inner transitional surfaces are also defined. The inner approach surface protects the part of the approach closest to the runway threshold, while the inner transitional surfaces are the controlling obstacle limitation surfaces for navigation aids, aircraft, and other vehicles that must be near the runway. The inner transitional surfaces are not to be penetrated except for frangible objects.

The balked landing surface is also defined for precision approach runaways. It provides an obstacle-free volume of airspace at the back end of the approach runaway. When a runaway can be used for precision approaches from both directions, the approach surface provided at the opposite end of the runway, with a first-section slope of 2, 5 or 2 percent, is more restrictive than the balked landing surface that requires a 4 or 3-33 percent slope. This means that a balked landing surface at both ends of the runway is provided by default in such cases.

Finally, the takeoff climb surface is an inclined plane intended to prevent obstructions to the paths of departing aircraft near a runway.

Table 2: Dimensions and slopes of obstacle limitation surfaces-Approach runways

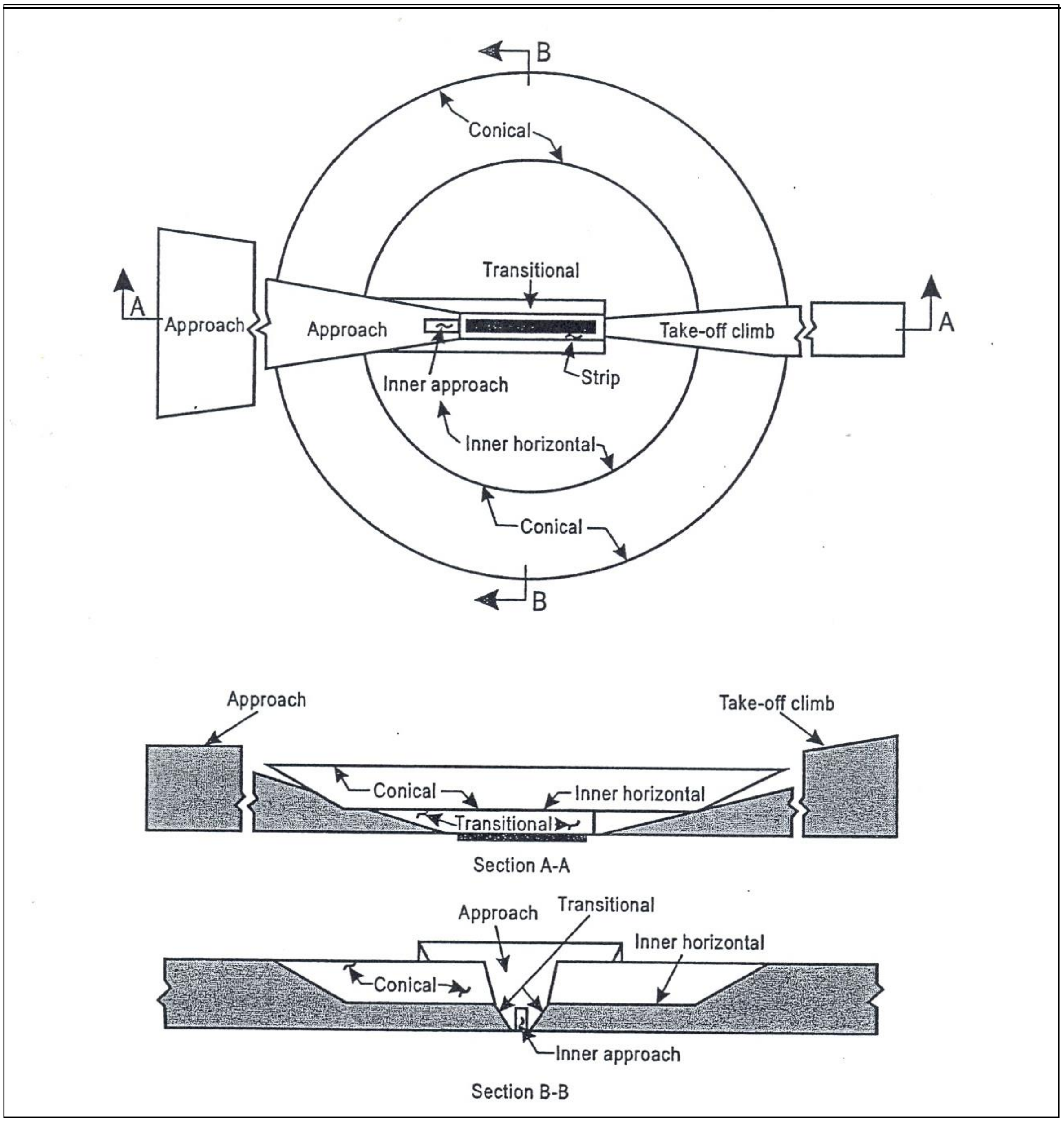
APPROACH RUNWAYS

	RUNWAY CLASSIFICATION									
	Non-instrument				Non-precision approach			Precision approach category I		Precision approach category II or III
	Code number				Code number			Code number		Code number
Surface and dimensions[a]	1	2	3	4	1,2	3	4	1,2	3,4	3,4
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
CONICAL										
Slope	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%
Height	35 m	55 m	75 m	100 m	60 m	75 m	100 m	60 m	100 m	100 m
INNER HORIZONTAL										
Height	45 m	45 m	45 m	45 m	45 m	45 m	45 m	45 m	45 m	45 m
Radius	2 000 m	2 500 m	4 000 m	4 000 m	3 500 m	4 000 m	4 000 m	3 500 m	4 000 m	4 000 m
INNER APPROACH										
Width	—	—	—	—	—	—	—	90 m	120 m[e]	120 m[e]
Distance from threshold	—	—	—	—	—	—	—	60 m	60 m	60 m
Length	—	—	—	—	—	—	—	900 m	900 m	900 m
Slope								2.5%	2%	2%
APPROACH										
Length of inner edge	60 m	80 m	150 m	150 m	150 m	300 m	300 m	150 m	300 m	300 m
Distance from threshold	30 m	60 m	60 m	60 m	60 m	60 m	60 m	60 m	60 m	60 m
Divergence (each side)	10%	10%	10%	10%	15%	15%	15%	15%	15%	15%
First section										
Length	1 600 m	2 500 m	3 000 m	3 000 m	2 500 m	3 000 m	3 000 m	3 000 m	3 000 m	3 000 m
Slope	5%	4%	3.33%	2.5%	3.33%	2%	2%	2.5%	2%	2%
Second section										
Length	—	—	—	—	—	3 600 m[b]	3 600 m[b]	12 000 m	3 600 m[b]	3 600 m[b]
Slope	—	—	—	—	—	2.5%	2.5%	3%	2.5%	2.5%
Horizontal section										
Length	—	—	—	—	—	8 400 m[b]	8 400 m[b]	—	8 400 m[b]	8 400 m[b]
Total length	—	—	—	—	—	15 000 m	15 000 m	15 000 m	15 000 m	15 000 m
TRANSITIONAL										
Slope	20%	20%	14.3%	14.3%	20%	14.3%	14.3%	14.3%	14.3%	14.3%
INNER TRANSITIONAL										
Slope	—	—	—	—	—	—	—	40%	33.3%	33.3%
BALKED LANDING SURFACE										
Length of inner edge	—	—	—	—	—	—	—	90 m	120 m[e]	120 m[e]
Distance from threshold	—	—	—	—	—	—	—	c	1 800 m[d]	1 800 m[d]
Divergence (each side)	—	—	—	—	—	—	—	10%	10%	10%
Slope	—	—	—	—	—	—	—	4%	3.33%	3.33%

a. All dimensions are measured horizontally unless specified otherwise.
b. Variable length (see 4.2.9 or 4.2.17).
c. Distance to the end of strip.
d. Or end of runway whichever is less.
e. Where the code letter is F (Column (3) of Table 1-1), the width is increased to 155 m.

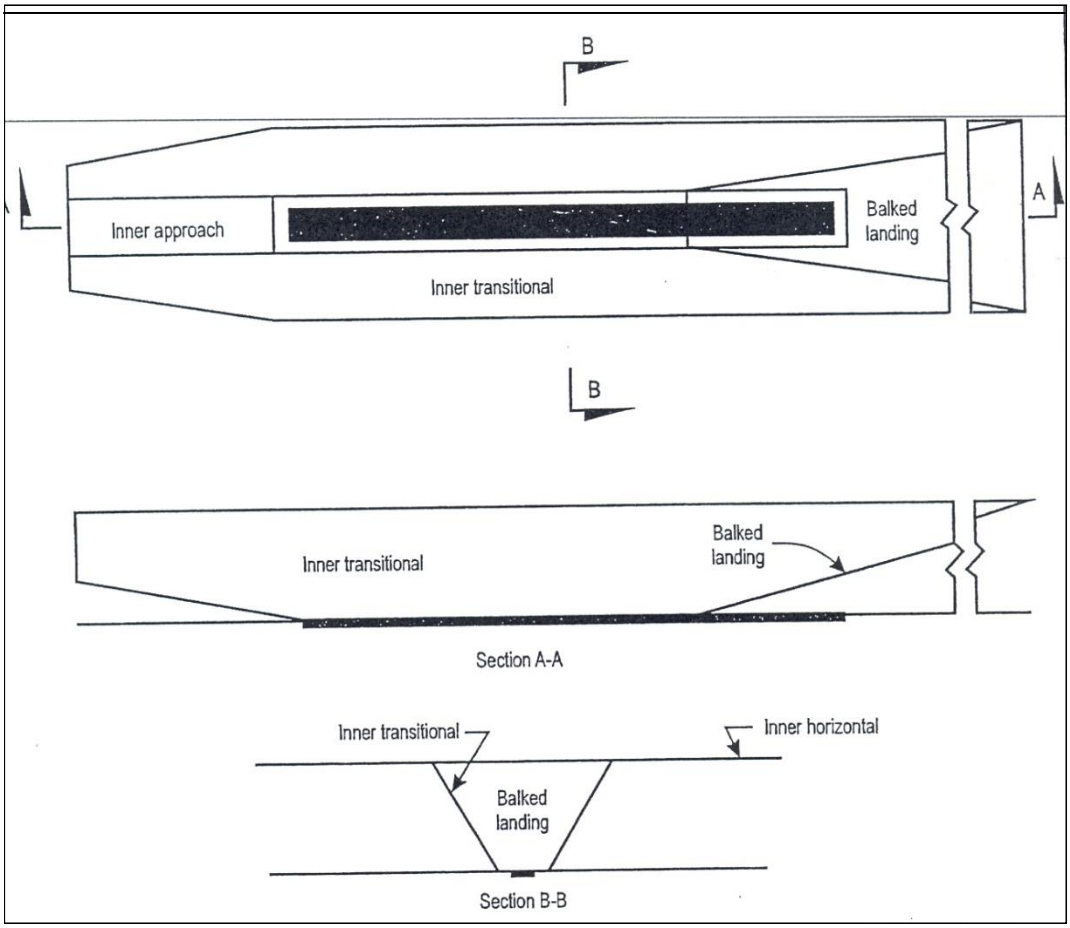
Source: Aerodromes. Annex 14 to the International Civil Aviation Convention, Volume I, 4th edition, Montreal: International Civil Aviation Organization, July 2004.

Figure 2: Obstacle Limitation Surfaces



Source: Aerodromes. Annex 14 to the International Civil Aviation Convention, Volume I, 4th edition, Montreal: International Civil Aviation Organization, July 2004.

Figure 3: Obstacle Limitation Surfaces



Source: Annex 14 to the International Civil Aviation Convention, Volume I, 4th edition, Montreal: International Civil Aviation Organization, July 2004.

2.9 Airport Planning

The compatibility of an airport with its environs is made possible by proper planning of the airport, control of pollution generating sources and land use planning of the area surrounding the airport. The aim is to provide the best possible conditions for the needs of the airport, community in the surrounding area and the ecology of the environment.

Airport planning must be recognized as an integral part of an area wide comprehensive planning programme. The location, size and configuration of the airport need to be coordinated with patterns of residential, industrial, commercial, agricultural and other land uses of the area, taking into account the effects of the airport on the people, flora, fauna, the atmosphere, water courses and other facets of the environment.

2.10 Need for Land Use Planning

There is need to control land in the vicinity of the airports in order to ensure that possible height hazards or obstructions to flight into or out of airports are minimized. Experiences on non-conforming purposes or land uses have indicated the need for control. Experiences such as:

a. Uses which may cause electrical interference with radio communications and navigational aids
b. Lights which might confuse pilots in the clear interpretation of aeronautical lights and
c. Smoke which reduces visibility.

The compatibility of land use with noise exposure in the vicinity of airport did not become a major consideration until the early 1960's, a few years after the wide-spread introduction of commercial turbo-jet aircraft operations, although litigation regarding aircraft noise was not infrequent before that time. Today aircraft noise is probably the most significant influence on land use planning in the vicinity of airports.

The requirement for land use planning in the vicinity of the airport is twofold, namely:

a. To provide for airport needs, for example, obstacle limitation areas and future airport development and
b. To ensures minimal interference to the environment and the public, for example by locating residential areas away from zones subject to excessive noise or other pollution, by preserving parklands, etc.

2.11 Considerations in Airport Planning

A number of considerations need to be taken when planning for airports.

Atmospheric pollution: Emissions from aircraft and ground vehicle engines, incinerators, terminal buildings and other sources contribute to the air pollution in the vicinity of airports.

Flora and Fauna: Utilization of land for airport purposes inevitably creates disturbances to flora and fauna. Airport development works frequently entails clearing and cutting back of trees and other vegetation; changes to the topography of the land and interference with watershed patterns. The airports may destroy the natural habitat and feeding grounds of wildlife and may eradicate or deplete certain flora important to the ecological balance of the area. Another important consideration is the prevalence and habits of birds in the area and the associated risk of aircraft bird strikes. Bird hazards at proposed new airports can be minimized by careful selection of the site to avoid established bird migration routes and areas naturally attractive to bird and by using the land surrounding the airport for purposes that will not attract concentrations of birds to the area.

Soil Erosion: As a consequence of vegetation clearing and interference with watershed pattern, land on an airport, or within its vicinity, may be vulnerable to soil erosion by the natural elements and to a limited degree by aircraft jet blast. This can mostly be prevented by replanting. In arid areas it may be necessary to take artificial erosion protection measures such as facing of escarpments, paving of taxiway flanks and lining of drains.

Streams, lakes and the sea: Contaminants may enter streams or waterways from airport drainage systems and eventually run into lakes or the sea. These contaminants originate from ground vehicles and airport washing, terminal services, aircraft servicing, pavement cleaning and airport maintenance and construction work. Particular consideration should be given to possible water pollution during construction phase. Activities such as clearing of vegetation causes an increase in the amount of soil carried into streams. Pest control which involves the use of sprays introduces long life toxic chemicals into the water. Fuel spillage from equipment and chemicals employed in building and pavement construction work can also contribute to upset the hydrological balance of waterways in the area. Changes to the natural drainage patterns of an area may occur due to construction of an airport. This may in turn overtax certain streams and give rise to flooding. In other cases due to diversion of flow, streams may be dried up.

Noise: The intensity and nature of aircraft engine noise is quite variable depending on the engine type and the nature of the operation being undertaken. Noise nuisance associated with an airport is also closely related to frequency of aircraft operations and their diurnal distribution i.e. noise at night is more a nuisance than in the daytime. High levels of noise are most undesirable.

Noise is a particular health hazard to employees who because of their duties, are subjected to long durations of intense aircraft noise. Strict precautionary measures are necessary for these people, such as mandatory usage of acoustical protective devices. The repercussions of excessive airport noise in residential areas are primarily of a social and behavioral nature.

Trees may be planted to screen certain areas from some airport noise. Good protection against ground run up noise might be expected from judiciously planted trees. When proposing trees to be used for the development of a sound insulating forest consideration should be given to species which:

(a) Are suitable to the climatic conditions of the airport site
(b) Have effective sound insulation properties (e.g. do not shed their leaves or needles grow rapidly and densely.
(c) Do not generate a bird hazard and
(d) Are easy to care for after their growth (e.g. normally healthy and not readily affected by blight or noxious insects etc.

Environmental Impact Assessment (EIA): Detailed study of the impact of airport development on the environment is an essential part of the assessment for any major project. Social ecological impacts should be investigated fully before work is undertaken or, in the case of a new airport, when its site is being selected. Environmental impact studies, depending on the nature of the project, take into account the following considerations:

i. Compatibility with community including health, transport and social implications
ii. Influence on ecology including effects of pollution, preservation of flora and fauna and
iii. Means of overcoming any problems.

Table 3: Typical Compatibles Land Use around Airports

Examples of compatible land uses or developments	ZONE		
	A Unrestricted land uses and developments	B Some restrictions on land uses and developments	C Most land uses and developments not permitted
agricultural Crop farming	━━━	━━━	━━━
Industrial Machine shop	━━━	━━━	━
Commercial - Ware housing and shipping - Office and banking	━━━ ━━━	━━━ ━	━
Residential - Low density housing	━━━		
Public facilities - Schools	━		

Source: ICAO,1999

<u>Notes</u>

(a) The length of the bar indicates where the uses might be permitted without restriction in relation to aircraft noise exposure only, and excluding other planning considerations. With respect to certain uses, e.g. housing, commercial - development might be allowed in a zone of higher restriction when other planning considerations indicate a need and where suitable building techniques, sound insulation, etc., can reduce the aircraft noise exposure to an acceptable level

(b) In the special cases of activities dependent on speech communication, e.g. schools or requiring more stringent standards, e.g. certain hospital activities, additional restrictions may be required to take account of absolute noise levels as well as building construction. The zones will require to be defined against a noise exposure scale and in their application will need to take account of local and national needs.

2.12 Land uses around the airport

The responsibility for developing land around the airport so as to maximize the compatibility between airport activity and surrounding activities, and minimize the impact of noise and other environmental problems, lies with the local governmental bodies. The more political entities that are involved, the more complicated the coordination process becomes.

In the past, the most common approach to controlling land uses around the airport was zoning. Airports and their surrounding areas become involved in two types of zoning. The first type of zoning is height and hazard zoning, which protects the airport and its approaches from obstructions to aviation while restricting certain elements of community growth. FAR Part 77—Objects Affecting Navigable Airspace is the basis for height and hazard zoning.

The second type of zoning is land use zoning. This type of zoning has several shortcomings. First, it is not retroactive and does not affect preexisting uses that might conflict with airport operations. Second, jurisdictions with zoning powers (usually cities, towns, or counties) might not take effective zoning action. This is partly because the airport might affect several jurisdictions and coordination of zoning is difficult. Or the airport might be located in a rural area where the county lacks zoning powers and the sponsoring city might not be able to zone outside its political boundaries. Another problem is that the interest of the community is not always consistent with the needs and interests of the aviation industry. The locality might want more tax base, population growth, and rising land values, all of which are not often consistent with the need to preserve the land around the airport for other than residential uses.

Another approach to land use planning around the airport is subdivision regulations. Provisions can be written into the regulations prohibiting residential construction in intense noise-exposure areas. These areas can be determined by acoustical studies prior to development. Insulation requirements can be made a part of the local building codes, without which the building permits cannot be issued.

Finally, another alternative in controlling land use around the airport is the relocation of residences and other incompatible uses. Often urban renewal funds are available for this purpose.

2.13 Policy and Legal framework

This section reviews relevant policies and legislations that will guide the implementation and administration of this project and especially land use planning.

2.13.1 The Physical Planning Act (Cap 286), 1996

This act of parliament provides for the preparation and implementation of physical development plans. It emphasizes the need for local physical development plans to provide the framework for development control, land use planning and other planning issues. This act empowers local authorities to grant development approvals, formulate building by-laws and carry out development control in their areas of jurisdiction. All development planning applications for airports therefore, have to be submitted to the respective local authorities for consent.

2.13.2 The Local Government Act ,Cap 265 (Repealed)

The local authorities are mandated to grant development plan approvals for all land under their jurisdiction. Working with the Kenya Civil Aviation authority and the Kenya Airports Authority, they control developments in areas around airports in order to ensure that all neighboring developments are compatible rather than conflicting.

Section 166 gives local authorities mandate to prohibit and control the development and use of land and buildings in the interest of proper and orderly development of its area of jurisdiction. Local authorities were empowered to formulate building by-laws and relevant guidelines or development control regulations for their areas of jurisdiction.

2.13.3 The Environmental Management and Co-Ordination Act, 1999

This Act established the National Environmental Management Authority as the institution responsible for execution of requirements stipulated in the Act. The Act stipulates that any airport or airfield development should include an EIA before commencement of any works.

2.13.4 The Kenya Civil Aviation Act (Cap 394)

This Act established the Kenya Civil Aviation Authority which provides accurate, timely, comprehensive and relevant air transport information for planning and decision making purposes**.**

KCAA's main role is to safeguard security and safety in the aviation sector especially as regards airspace. Development applications inside the airport or its immediate environs are scrutinized by KCAA to ensure that desired heights are achieved. It also ensures that there are no obstructions or animal hazard on flight approaches.

Section 9 (1) and (2) of the Act confers powers on the Minister for Transport and Communication to prohibit an erection within a declared area, of any building or structure above a specified height, where he considers it to be in the interests of the safety of air navigation.

2.13.5 The Kenya Airports Authority Act (Cap 395)

This Act establishes the Kenya Airports Authority (KAA) and outlines its functions. It empowers KAA to administer land in its jurisdiction, control and prohibit development. KAA is also empowered to grant permission to developers in the airports environs to ensure development does not interfere with aerodrome operations. KAA is mandated to establish and manage airports. It has direct control of land under its jurisdiction. It works in co-ordination with local authorities to ensure proper land use planning in the immediate environs of airports.

2.13.6 Vision 2030 (Kenya)

The Vision 2030 proposes a 50 year Integrated National Transport Master Plan which will have an integral component of institutional capacity building to manage roads, airport, sea ports and land transport systems with a view to improving efficiency and effectiveness of service delivery and enhancing revenue-earning capabilities. The rehabilitation and maintenance of airstrips and airport expansion and modernization is also cited as one of the flagship projects.

2.13.7 The International Civil Aviation Organization (ICAO)

Formed in 1944, ICAO is the main international organization that deals with civil aviation. Its signatories are required to adhere to specific standards and regulations in order to ensure that civil aviation is developed in a safe and orderly manner. Specific standards and guidelines governing land use planning are set; dealing with land use issues and environmental management in and around airports. The airport planning manual part two details out land uses compatible with the airport and planning tools to be adapted for compatible land use planning in and around airports. Other ICAO manuals also give standards for construction and expansion of airport and general civil aviation operations.

2.13.8 International Air Transport Association (IATA)

This is an international association of scheduled carriers in international air transportation. The airlines it represents are the main users of airports therefore they affect airport planning with regard to design and development to ensure effective, safe, efficient and secure air transport. It sets standards for runway length depending on type and size of aircraft and also the area to be left for a clearway in airports. The noise levels of aircraft also influence the type of land uses around the airport.

2.13.9. Airport Land Use Planning Tools

These include the physical development plans, the building code, local authority by-laws, and development control guidelines and various planning regulations by KAA.

2.13.10 The Building Code

It regulates the character and nature of buildings and associated works. It however fails to clearly give the functional and structural aspects of buildings in and around airports (under review).

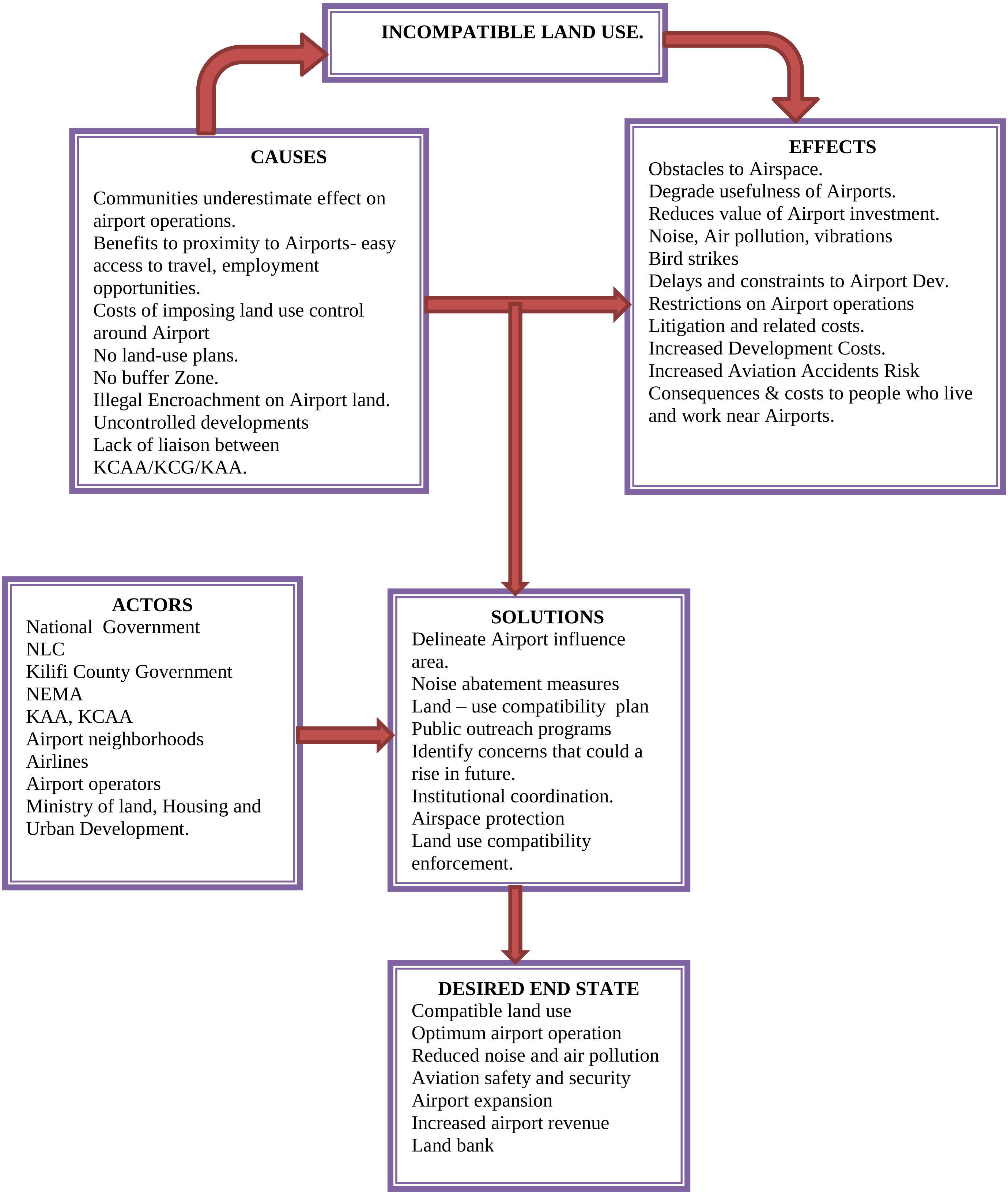
2.13.11 The Physical Planning Handbook (2008)

The handbook recognizes that airports are major environmental pollutants and that they also disrupt the ecology of a place. Safety and noise compatibility are some of the concerns highlighted in the handbook and the land uses around airports are zoned according to such considerations. The standards and guidelines in this handbook have been adopted from ICAO guidelines on land use planning. The handbook however fails to detail out specific standards to be adapted for airport land use planning in the country, like demarcation of noise zones, insulation of buildings and heights to be observed around the airport.

2.14 Conceptual Framework

The conceptual framework explains the process of incompatible land uses that limits the expansion and operations of the Airport, leading to unsustainable physical development of the Airport. The second stage aims at transforming the existing situation to more desirable state. The following issues, as illustrated in the schematic diagram, have emerged from this chapter's discussion and are considered the underpinning concepts that have guided this study.

Figure 4: Conceptual framework



Source: Author, 2014

CHAPTER THREE

APPROCHES TO LAND-USE PLANNING AROUND AIRPORTS-CASES STUDIES

3.1 Overview

The International Civil Aviation Authority identified Schiphol Airport ,The Netherlands, Melbourne Airport ,Australia and Washington Dulles International Airport as three cases of effective land use management around airports. This chapter reviews airport planning practices in these three airports and there application in Kenya ,especially in Malindi Airport. The experiences in the case studies provide major lessons towards land use compatibility for the optimal physical developments of airports.

3.2 Amsterdam/Schiphol Airport, The Netherlands

According to the ICAO Schiphol Airport have been in operation since 19 September 1916. It was initially a military airfield, but was converted to commercial operations shortly after World War I (in 1919). Thus, for more than 80 years, the airport has occupied the same location in the east corner of reclaimed land from the former Haarlemmermeer, just 10 km from the centre of the city of Amsterdam. During these 80 years, the airport grew from a small grass landing area of 190 acres to a 5 000-acre airport with 4 major runways and a traffic volume of more than 350 000 aircraft movements, carrying over 30 million passengers and 1 million tons of freight in 1997. Further development will include a new fifth runway and extension of the terminal to achieve a capacity of more than 40 million passengers, along with significant improvement of the environmental situation. (ICAO, 2004).

The further development of the airport, along with the development of the surrounding communities where large numbers of new houses were needed after World War II, created serious noise problems at the end of the 1960s, when the first commercial jet aircraft arrived. In 1967, a special committee advised the Government to introduce a method to assess aircraft noise and to establish noise zones around the airport, with maximum noise levels based on the results of a public survey. Houses and other noise-sensitive buildings situated within these noise zones were to be insulated, and new developments were not to be allowed. The Aviation Act was amended accordingly (in 1978) to give a legal basis for noise zoning, with the result that noise zoning became mandatory around all airports (civil and military) in the Netherlands. The Government prepared a Structural Outline Plan for Civil Aviation (1979), which laid down its policy with respect to the development of aviation and environmental capacity. In this Plan (approved in Parliament in 1988), designated noise zones were published for all airports. Local authorities were required to respect these noise zones when drawing up their own development plans. (ICAO,2004).

In 1991, a policy agreement on the future development of the airport and its surroundings was reached between the national government, local authorities, Schiphol Airport, the national airline KLM and the railways. This document listed more than 100 anti-noise and anti-pollution measures to improve living conditions in the region as well as to improve access between the airport and the region by new road and rail infrastructure.

The final decision on building the fifth runway (in an area west of the airport between Amsterdam and Haarlem that had been kept free of housing development based on earlier agreements between the Government and local authorities) was reached in 1995 after lengthy public discussions based on various case studies on the future of Schiphol Airport. This final decision is subject to the condition that the total environmental impact should improve or at least not be worse than in 1990. A survey of the health situation of the people living in the region had also been carried out and will be repeated every five years.

Regarding aircraft noise, the target is to have no more than 10 000 houses within the legal 35Ke noise contour of the new five-runway system. Because of the new noise-impacted area covered by the fifth runway, the area of the 35Ke noise contour for the five-runway system is much larger than that for the four-runway system. However, owing to the far-sighted policy of keeping the area free of housing development, the total number of houses could be reduced from some 15 000 within the noise contour of the four-runway system down to 10 000 for the five-runway system, despite the expected growth in traffic volume.

Other measures taken are further increase in landing fees for noisy aircraft and operational restrictions for certain aircraft types during evening and night-time periods to ensure the non-infringement of the legal noise zones.

Third party risk around airports is another important issue. External safety zones are established in the same way as noise zones. These zones describe the risk for people who live around the airport of being killed in an aircraft accident over a one-year period.

External safety zones have been established around Schiphol Airport for accident risk rates. Within the safety zones, a construction ban is in effect for new houses and office buildings. In the highest risk areas, all houses will have to be demolished before 2015; this means that based on a recent survey, 87 houses around Schiphol Airport will have to be demolished.

A noise-insulation programme for houses and other noise-sensitive buildings situated within the legal noise zones involves about 14 000 buildings, apart from the 4 500 buildings that have already been insulated since the start of the first insulation programme in 1983.

The total costs of this programme (demolition of houses within the 65Ke contour included) amount to more than 750 million guilders. These costs are to be recovered by noise charges levied on the airlines. Meanwhile, the costs of demolishing houses within the safety zone are estimated at 30 million guilders. (ICAO, 2004).

The total expenses for new infrastructure and new commercial and industrial development in the Schiphol area, including landscaping, will be about 280 million guilders, of which 150 million guilders will be financed by the Government. All other costs are to be raised by the airport, project developers, etc., with a small contribution from the European Community.

3.3 Melbourne- Australia

According to ICAO Australia has an extensive land-use planning experience. Residential buildings have been constructed within the 25 and above ANEF (Australian Noise Exposure

Forecast) contour. As communities become better informed and more aware of issues such as aircraft noise, they have put greater pressure on local authorities to carry out appropriate land-use planning and on aviation authorities and airlines to implement noise-abatement practices.

In Australia, residential buildings have been located around airports for many years and more recent developments have occurred. To remedy this situation, the interests of the people who have already invested in the locality have to be balanced with the arrangements for potential interested parties. This conflict of interest issue is one that confronts some airports and there are no easy solutions for the local authorities and State governments who are responsible for land-use planning around airports.

Where inappropriate development has occurred, experience has shown that pressure has been brought to bear on airports in relation to certain flight tracks of arriving and departing aircraft, and calls for curfews are not uncommon. Australia is considering developing and providing additional information to the community, such as provide data on the flight paths of aircraft using the airport. This may be a useful supplement to the ANEF contours to better inform the communities around airports before commitment to residential buildings is made. Melbourne Airport is a major domestic and international airport, with some 156 000 aircraft movements. Because it was developed in the early 1970s from a largely green field site and appropriate planning/zoning practices were already in place by that time, the Melbourne Airport provides one of the better outcomes of effective land use planning in areas around airports in Australia (DOC 9184. ICAO, 2004).

The land-use control system in place reflects an integrated approach adopted jointly by the airport operator, the State government and the local authorities around the airport. The State government has introduced a system of overlay controls for residential and other developments which are carried out by the local authorities around the airport in concert with the airport operator. The overlay controls largely reflect the ANEF contours, residential and similar developments are precluded from certain noise-affected areas. For the broader area expanding out to the equivalent of approximately 25 ANEF, local authorities have to refer certain development applications to the airport operator whose decision on whether the application should be approved has to be applied by the local authorities. This decision can be appealed through the Administrative Appeals Tribunal. As a result of this system, there is only limited amount of residential or other development around this airport which is inconsistent with the Australian Standard.

3.4 Washington Dulles International airport/United States

Washington Dulles International Airport, which opened in November 1962, is located in Fairfax and Loudon Counties, Virginia, about 50 km west of downtown Washington D.C.(DOC 9184 ICAO,2004). Today, Dulles is the primary international gateway serving the U.S. capital and handles approximately 300 000 operations annually with its three-runway layout. With five runways planned for the future, the annual operations will probably exceed 740 000. As one of the first major airports to be designed and built after the advent of the commercial jet age, Dulles was planned with aircraft noise in mind. The airfield, which is approximately 4 500 ha (or 45 million m2), includes noise-buffer areas extending 2 400 m between the ends of the runways and the perimeter fence. The selected airport site and the vast majority of its surrounding land were farmland. This proved beneficial at the time of the original airport development and in the subsequent years when the use of the neighboring land was decided by local government action. (DOC 9184 ICAO, 2004).

For most of its early years, Dulles was underutilized, operating some international and transcontinental service, but very little short- and medium-range services. Deregulation changed everything. In the early 1980s, Dulles grew rapidly as new airlines began to serve Washington D.C. Since flight operations at Washington National Airport were, and are still, limited by the High Density Rule of the Federal Aviation Administration (FAA), almost all of the new services operate at Dulles. While pleased with the stable growth trend and realizing that the airport is adequately equipped to handle the growth, officials at the airport and in local government also recognized that appropriate off-airport land-use planning was necessary to ensure sustained growth at Dulles, the local region’s primary economic resource. The Counties of Loudon and Fairfax and airport management understood that conflicts could occur when residential and other noise-sensitive land uses are in close proximity to the airport. Accordingly, the planning staffs of the Counties and the airport were tasked to come up with a land-use plan that would provide an environment where both the airport and its surrounding properties could be developed in the region's best interest. The objective was to develop a set of land-use rules, tailored to the special needs of each county that would prevent incompatible land use of the environs around the airport. As a result of this regional effort, undertaken over the past 12 years, the airport and its neighboring jurisdictions are reaping the benefits of the growth without having to restrict flight operations. Loudon County, which had a great deal of undeveloped land near the airport, adopted very aggressive Land-use restrictions. The County defined the areas subject to the restrictions with Day-Night Level (DNL) contours based on long-range forecasts, using the planned five runway configuration and 740 000 annual operations.(DOC 9184,ICAO,2004)

Fairfax County zoning prohibits new residential development within the DNL 75 contour. The comprehensive plan, which heavily influences decisions on proposed changes to existing land use, recommends against any new residential development within the DNL 60 contour.

3.5 Lessons Learnt

The following major lessons come out clearly from the case studies:

- Establishment of noise zones around the airport, with maximum noise levels based on the results of a public survey. Houses and other noise-sensitive buildings situated within these noise zones to be insulated.
- The establishment of a legal basis for noise zoning, to ensure l that noise zoning around all airports became mandatory in a country
- The National Government to prepare National Airports System Plan which lays down its policy with respect to the development of aviation and environmental capacity. In this Plan ,designated noise zones are published for all airports. Local authorities are then required to respect these noise zones when drawing up their own development plans.
- Policy agreement on the future development of the airport and its surroundings should be reached between the national government, local authorities, Airport Authority

- The listing of anti-noise and anti-pollution measures to improve living conditions in the region as well as to improve access between the airport and the region by new road and rail infrastructure.
- The decision to expand airports in built up area should be reached after lengthy public discussions based on various case studies on the future of the Airport. This final decision should be subject to the condition that the total environmental impact should improve or at least not be worse than before the expansion . A survey of the health situation of the people living in the region had also been carried out and will be repeated every five years.
- The land-use control system to reflect an integrated approach adopted jointly by the airport operator, the State government and the local authorities around the airport. The use of geographical Information System control developments which are carried out by the local authorities around the airport in concert with the airport operator.
- Land acquisitions and avigation easements are some of the instruments that have been employed to resolve land use conflicts around airports.
- Integrating airports needs in urban and regional planning .

CHAPTER FOUR
STUDY AREA AND METHODOLOGY

4. 1 Location of the study area

Malindi town is located about 120 kilometers northeast of Mombasa town, south west of the mouth of Galana River. Administratively, it's located within Malindi Division, Kilifi County and Coast region . Malindi Airport is located 2.5 Km west of Malindi Town. It is to the North of Mombasa-Malindi highway road. The airport is located at an elevation of 22.6 meters above mean sea level. There are no natural obstructions to the airport and the airspace offers clear visibility all year round. The Airport serves the tourist circuit of North Coast and dates back to 1950's when it started as a private airstrip at the present Eden rock hotel. The construction of the existing terminal building started in 1957 and operations switched from Eden rock to the present site. Air traffic control services started in 1963 after the completion of the present Air traffic control tower.

4.2 Existing Airport Facilities

The following airside facilities of the Malindi Airport are discussed below:

4.2.1 Runways

The Malindi Airport has two intersecting runways. Runway 17-35 is 1,402 m long and 30 m wide while Runway 08-26, the smaller intersecting runway, is 1,008 m long and 20 m wide. Runway 17 is used 70% for landings and departing depending on favorable wind conditions. Runway 35 is used 30% primarily for light aircraft to land.(KAA,2005)

4.2.2 Taxiways

There is one taxiway that connects the only apron to the runway facility. The apron has an area of 4,500 m2 and can hold 3 aircraft.

4.2.3 Non-Directional Beacon

A Non-Directional Beacon (NDB) is a low or medium frequency radio beacon transmitting non- directional signals whereby the pilot of an aircraft equipped with automated direction finding (ADF) equipment can determine the bearing to or from the radio beacon and "home in" or track to or from the station. The NDB operates on radio frequency 309 kHz. Its two-letter identifier is ML.

4.2.4 Precision Approach Slope Indicators (PAPI)

The PAPI is a system of lights arranged to provide visual descent guidance information during the approach to a runway. The visual glide path of the PAPI provides safe obstruction clearance within plus or minus 10 degrees of the extended runway centerline and to four nautical miles from the runway threshold. PAPI light units are installed in a single row of two units. The systems have an effective visual range of approximately five miles during the day and up to twenty miles at night. Runway 17-35 has PAPI lighting system.

4.2.5 VOR/DME

A VHF Omni-Directional Range/Distance Measuring Equipment (VOR/DME) facility is one of the most fundamental electronic navigational aid serving the global airspace system .The facility operates on frequency 113.3 MHz. The DME antenna serving Malindi Airport is located at an elevation of 20 m. The facility is located at a close proximity of the airport, along Runway 35 approach.

4.2.6 Passenger Terminal Building

The Malindi terminal building is inadequately sized for the number of passengers it processes. The building has a small pre-boarding area, two check-in counters without baggage support and a small departure lounge. There are no arrival facilities and baggage is collected before entering the building. A new terminal has been designed to replace the existing one.

4.2.7 Air Traffic Control Tower (ATC)

The air traffic control tower does not have a view of the ends of the runways. The structure needs to be raised. The needs of the air traffic control tower include bird problems due to the location of a dump site on the approach path and limited visibility due to the height of ATC which needs to be addressed immediately. There are obstructions along the approach surface.

4.2.8 Access Road Network

The access road to the terminal building is about 200 m from the main Malindi-Mombasa tarmac road. A toll gate is within 50 m from the main road and is manned by regular police. The road is a two-lane single carriageway. Installation of street lights to the road leading to the airport has been halted due to the fact that it was inside the approach funnel.

4.2.9 Vehicular Parking

The existing car park is very small and hardly accommodates more than 10 vehicles. Most vehicles park on the open space to the south of the existing car park.

4.2.10 Electrical System

The electrical system comprises of Kenya Power and Lighting Company (KPLC) overhead 33kV line along Mombasa –Malindi Road. The KPLC substation is located to the South West of the Terminal Building. The substation consists of an outdoor step-down transformer rated at 33kV/415V, 100 kVA, which provides electrical power requirements for the airport via an underground cable to the airport switch room adjacent to the ATC Building. In addition the airport has standby diesel generator set rated at 100kVA. Kenya Power and Lighting Company (KPLC) overhead 11kV line. The current power supply by Kenya Power and Lighting Company Ltd is adequate but unreliable due to frequent power outages.

4.2.11 Water Supply and Sewage

Malindi Town is supplied with water by Malindi Water and Sewerage Company. A 75 mm diameter branch pipe supplies water to the Malindi Airport. This latter pipe crosses runway

08/26. There is no elevated water storage facility. The water supply to the airport is direct from the mains. Two old PVC water tanks are installed inside the passenger terminal building. Firefighting water is stored in an underground reservoir of capacity about 65 m3. The water supply quality, volume and pressure are reported to be unreliable. Effluent from the terminal building and other administrative buildings flows into a septic tank located south of the passenger terminal building. The septic tank is too small for the present usage.

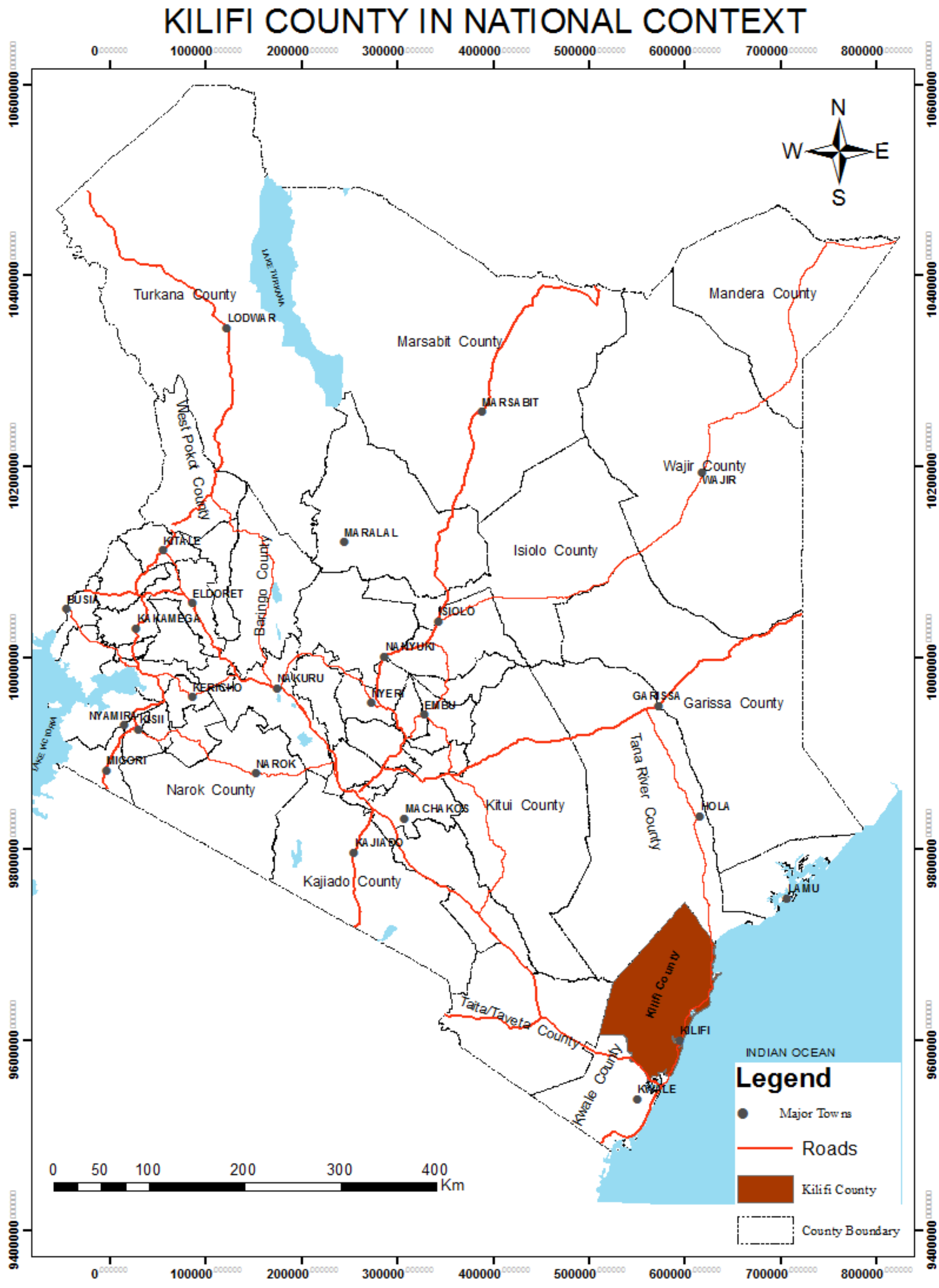
4.2.12 Solid Waste Disposal

There is a comparatively good solid waste management practice at the airport. There's a series of garbage bins placed at strategic locations around the airport. Garbage is collected from the terminal areas and other building at a frequency of 3 days and then placed at a central area. This is then burnt at a location a few metres from the buildings area.

4.2.13 Other Support Facilities

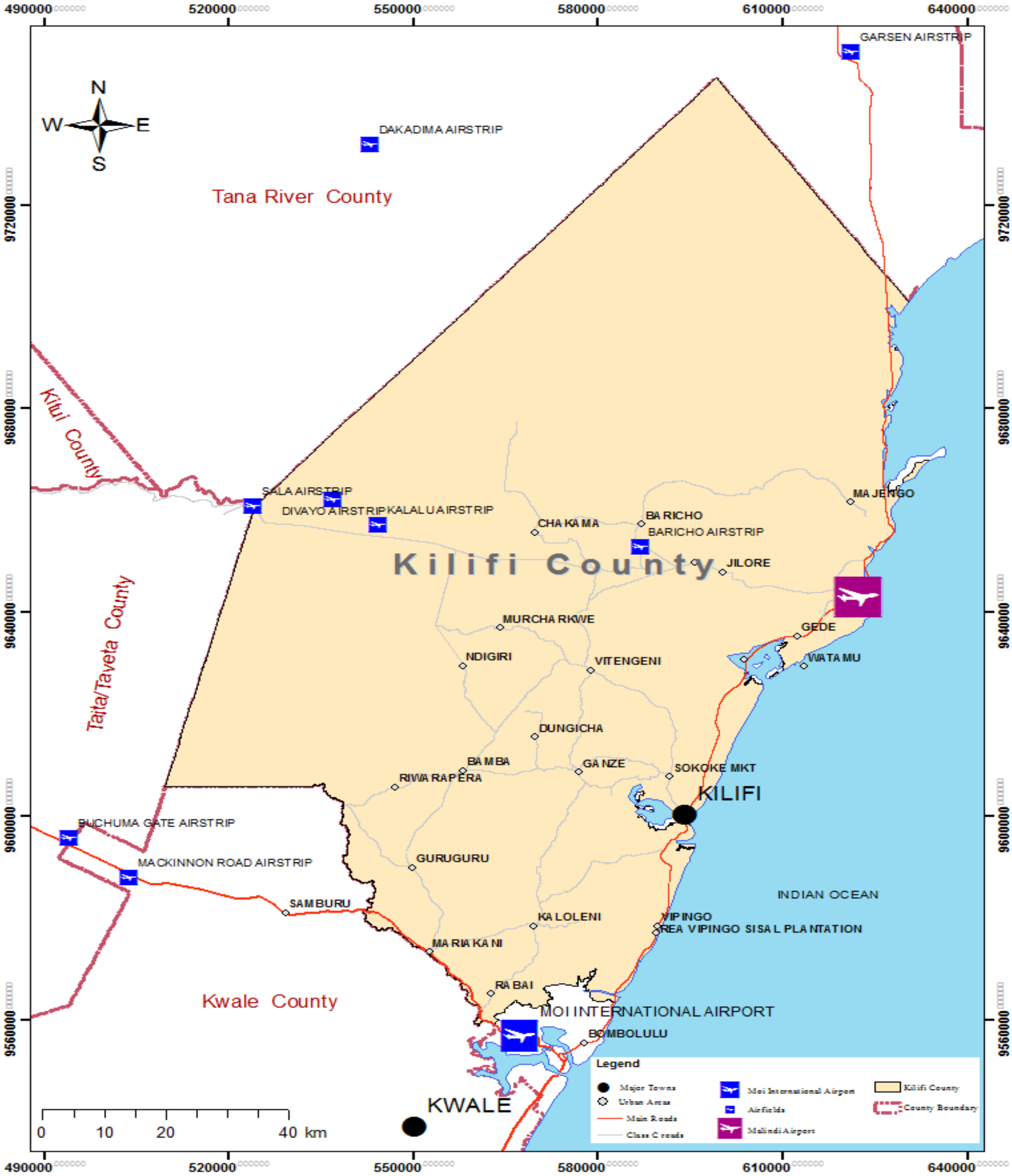
The airport has Air Rescue Fire Fighting facility (ARFF), and a fuel farm that supply Jet fuel.

Map 1: Kilifi County in the National Context



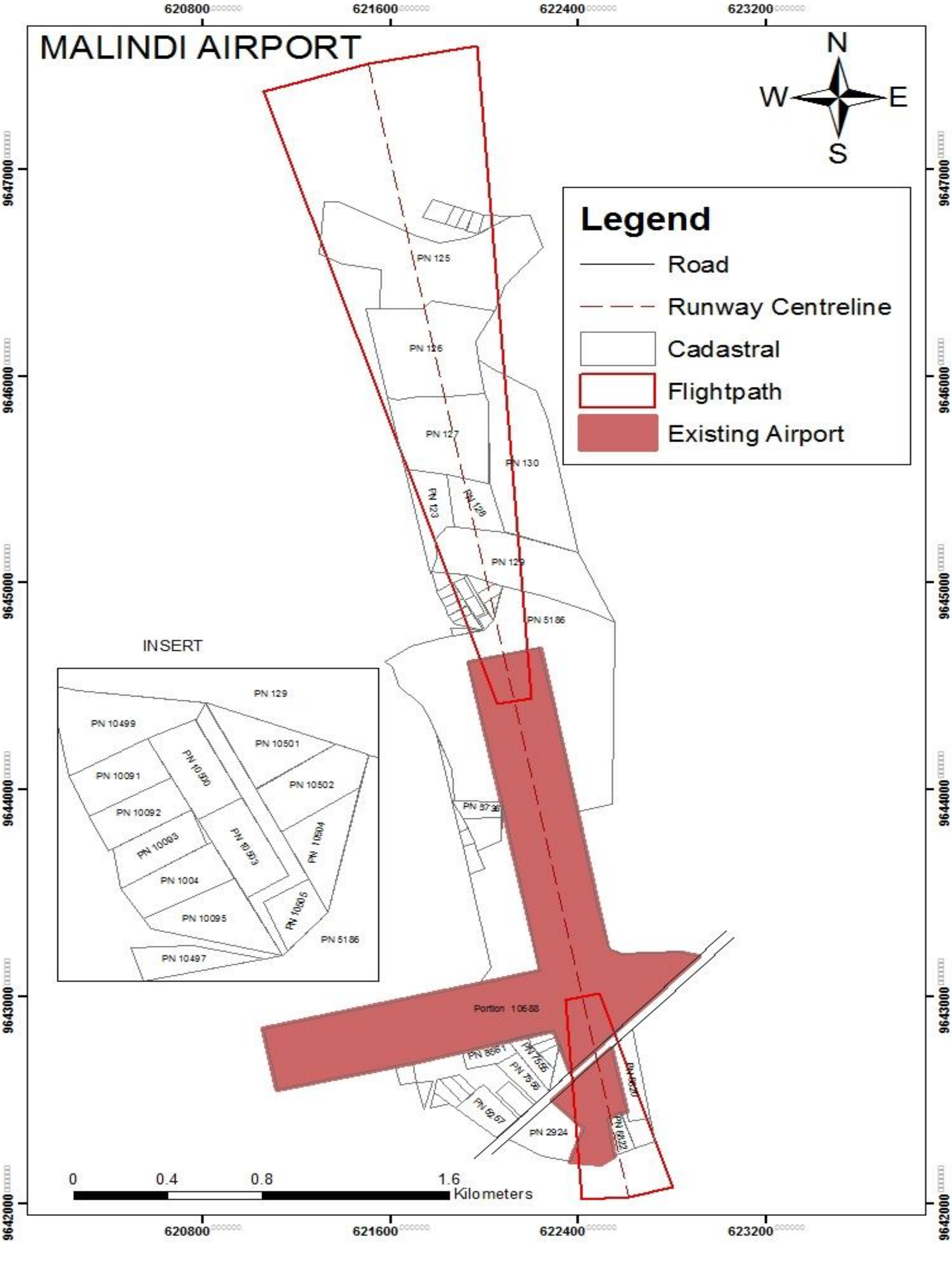
Source: KIPPRA, 2014

Map 2: Malindi Airport in the context of Kilifi County



Source: KIPPRA, 2014

Map 3: Study Area



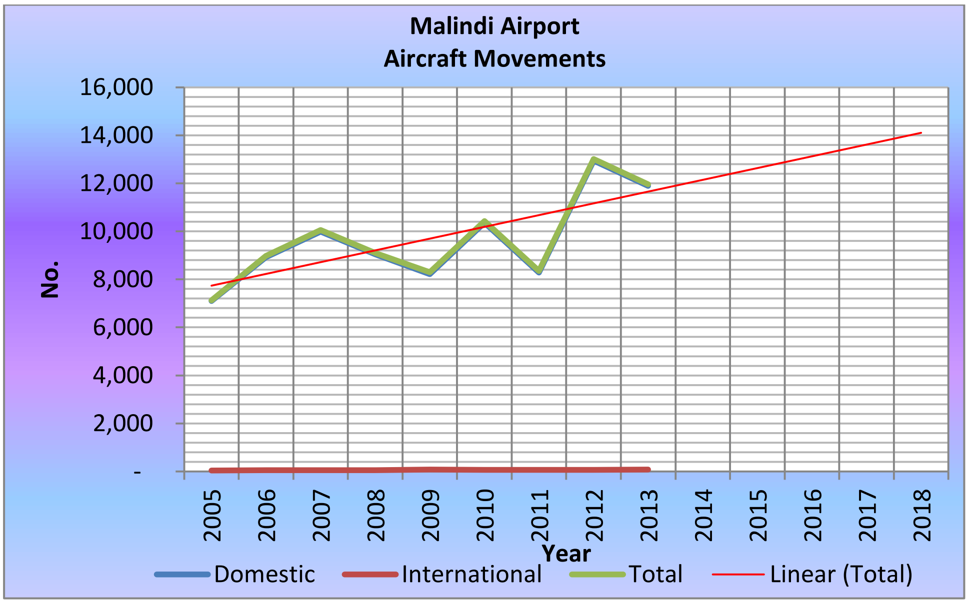
Source: Author, 2014

Table 4: Traffic performance

											Actual
		Year	2005	2006	2007	2008	2009	2010	2011	2012	2013
Aircraft		Landings	3,531	4,526	5,036	4,549	4,120	5,205	4,157	6,486	5,928
		Take-offs	3,564	4,392	4,959	4,490	4,093	5,159	4,126	6,462	5,960
	Domestic		7,095	8,918	9,995	9,039	8,213	10,364	8,283	12,948	11,888
		Landings	17	26	29	30	37	35	32	32	39
		Take-offs	17	26	25	24	41	35	30	32	37
	International		34	52	54	54	78	70	62	64	76
		Total Landings	3,548	4,552	5,065	4,579	4,157	5,240	4,189	6,518	5,967
		Total Take-offs	3,581	4,418	4,984	4,514	4,134	5,194	4,156	6,494	5,997
	Total		7,129	8,970	10,049	9,093	8,291	10,434	8,345	13,012	11,964
Pax		Arrivals	23,710	27,981	37,110	25,833	27,602	29,890	43,603	37,002	40,703
		Departures	23,248	28,457	36,773	26,014	28,717	30,463	43,518	37,421	40,475
	Domestic	Total	46,958	56,438	73,883	51,847	56,319	60,353	87,121	74,423	81,178
		Arrivals	37	81	90	77	97	140	117	127	146
		Departures	31	54	160	59	102	95	73	111	137
	International	Total	68	135	250	136	199	235	190	238	283
		Total arrivals	23,747	28,062	37,200	25,910	27,699	30,030	43,720	37,129	40,849
		Total departures	23,279	28,511	36,933	26,073	28,819	30,558	43,591	37,532	40,612
	Transit	Transit	8,859	11,219	14,768	15,671	23,213	22,911	21,482	13,986	14,266
	Total	Total	55,885	67,792	88,901	67,654	79,731	83,499	108,793	88,647	95,727

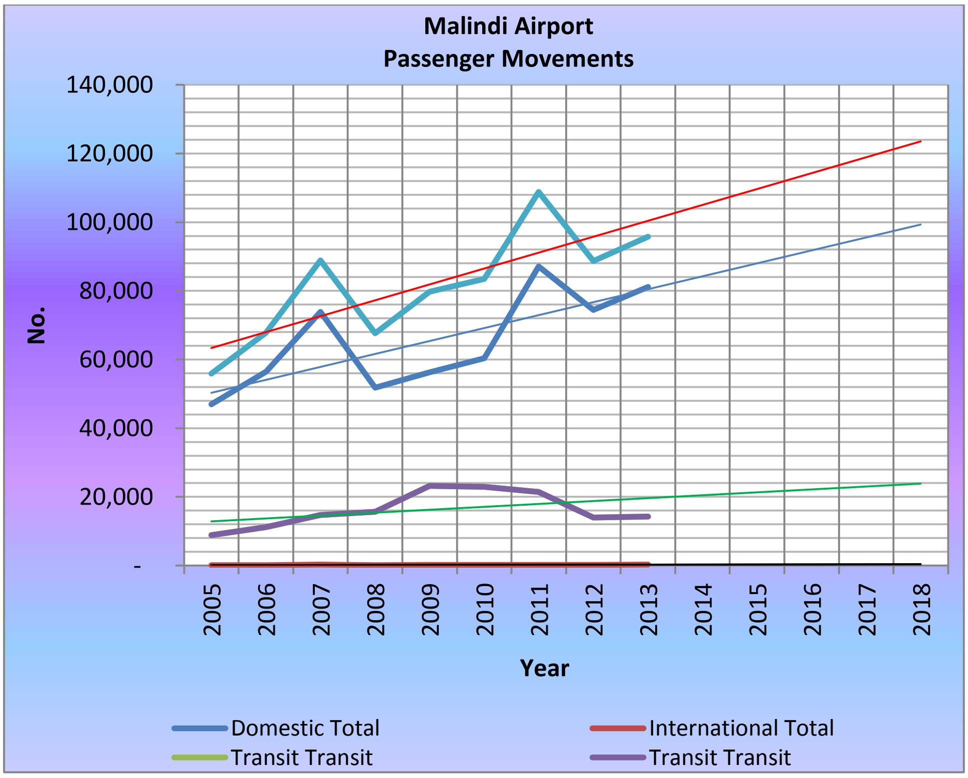
Source: KAA, 2014

Figure 5: Malindi Aircraft Movement (Actual and forecast)



Source: Field Survey, 2014

Figure 6: Malindi Passenger Movements



Source: Field Survey, 2014.

4.3 Research Design

Methodology is merely an operational framework within which certain facts are placed so that their meaning may be seen more clearly (Leedy, 1996). This chapter describes in detail how the research process will be conducted and outlines data collection procedures, measurement and analysis used to accomplish the research objectives. Leedy (1996) has defined research design as the visualization of the data and the problems associated with the employment of these data in the entire research project. Research design requires the researcher to have some structural concept, some idea of how the data will be secured and how they will be interpreted so as to meet the research objectives. Research has been classified in different ways by various authors. Gay (1981) classified research as the method of data analysis and purpose of the research. Borg and Gall (1997) classified research mainly by the method of data collection. Mugenda and Mugenda (1999) made the classification based on all the three criteria and noted that these broad classifications are not mutually exclusive and a researcher could use more than one classification.

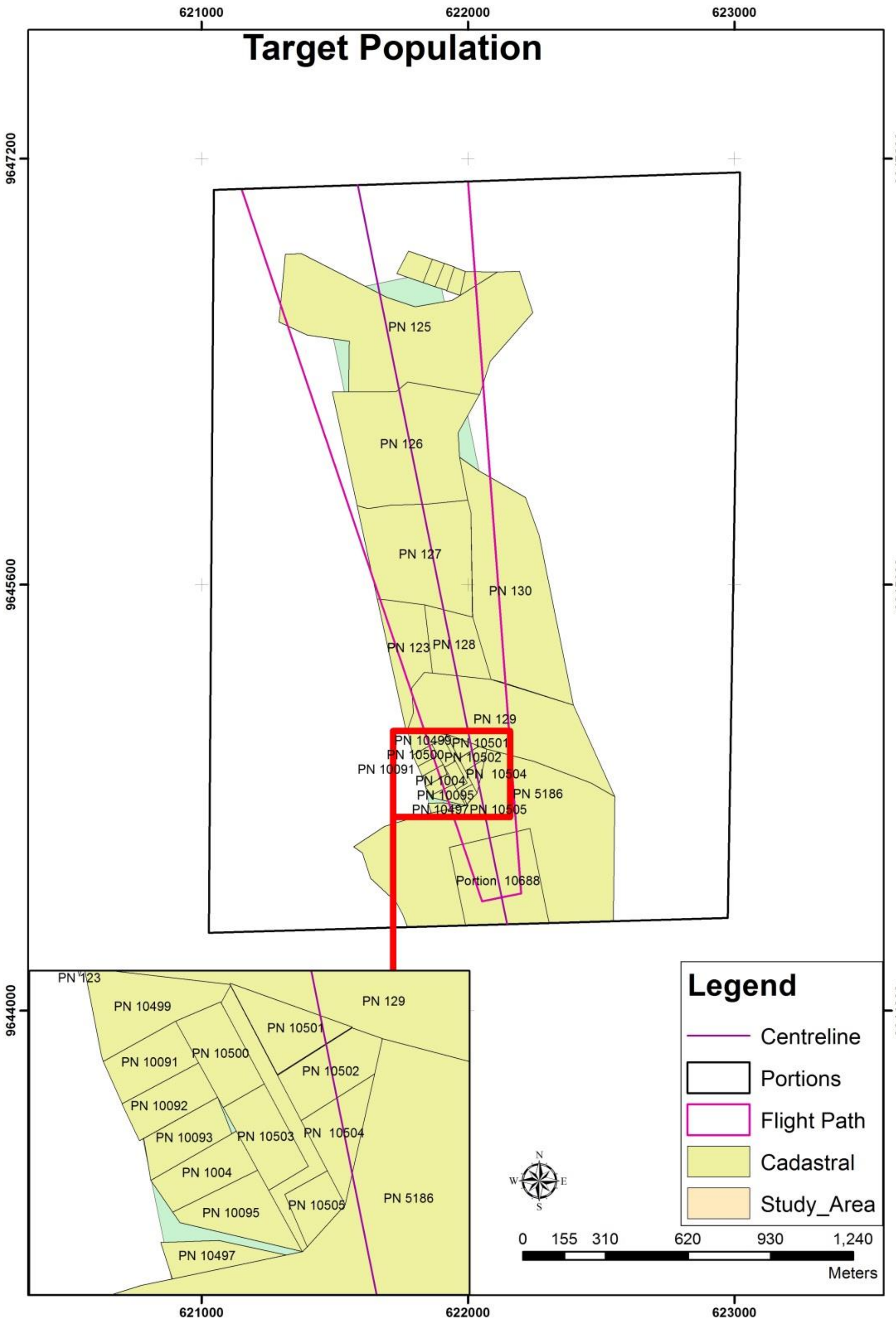
This is a descriptive research that aims to explore land use compatibility within the proximity of an Airport. It includes surveys and fact finding enquires of different kinds. The major purpose of descriptive research is description of the state of affairs as it exists at present. C.R. Kothari (2004). This being ex post facto research, there is no control of the variables and the research is only to report what has happened and to determine the causes mostly through qualitative approach. A case study approach has been chosen as the methodology of carrying out the research. Mugenda and Mugenda (1999) defines a case study approach as an in-depth investigation of an individual, group, institution or phenomenon and asserts that most case studies are based on the premise that a case can be located that is typical of many other cases.

4.4 Sampling Technique

Kothari (2004) defines sampling as the 'selection of some part of aggregate or totality on the basis of which a judgment or influence about the aggregate is made". Deciding on the sample or the segment of the population that is to be selected is imperative in any large population if the validity and reliability of the research is to be achieved. In most cases, it is not possible due to time or financial constraints to undertake an enumeration of the whole population. Besides, sampling remains the best way to allow for more accurate measurement.

The target population comprises all the parcels of land to the north of Malindi Airport extending 1 kilometer from the threshold of runway 17 bounded by the approach path. The choice of Malindi Airport is based on the fact that it has the high concentration of informal settlement with various land uses within its environ and thus forms a good representative of the other airports within the National Airport System Plan. A spatial scope is limited to the approach due to the stringent required for safety and operations of the Airport. The survey plan F/R No. 273/42 from survey of Kenya for Malindi Airport and abutting parcels of land is superimposed on the flight path as delimited by Legal Notice No. 60 of 21st April,1998. This shows that 25 portions of land fall within the study area however, ground survey revealed that the portions have further been subdivided into 513 parcels by the squatters which has been accepted as the target population.

Map 4: Flight Path and Population



Source: Survey of Kenya, 2014

Statistical procedures of the central Limit Theorem have been used to arrive at the sample size. Kothari (2004) ,quoting from Lipchitz and Schiller (1998),states that ,as a rule of thumb, the choice of sample size n ≥ 30,satisfies the requirements for most practical purposes even when the population is infinite. By accepting the above proposition, the researcher settled for a sample size of n=70 for each of the themes selected. The selections about which land parcels to be included in the 70 were effected through random numbers which are a standard feature in most statistics text books.

Table 4: A matrix showing data need analysis

Research question	**Data Type**	**Sources**	**Methods of Data Collection**	**Method of data Analysis**	**Expected**
1. What are the various land uses within the vicinity of Malindi Airport and their impact on the Airport	The existing land uses in the vicinity of Malindi Airport (variable: land Use. Height of structures)	Field Work. RCRM DPP.	Maps Aerial Photos Field work	G.I.S. SPSS. Charts Tables Photos	To establish the land uses /height of structures within the vicinity of the airport
2. What is the impact of the Airport on other land uses within its vicinity	Noise contour maps Airport layout plan Land use plans	KAA Field work Physical planning dept.	Maps Aerial photo Documents	G.I.S – ArcGis 10 spatial buffering	A map showing compatible/incompatible land uses within the study area

3. What is the land requirement for the ultimate development for Malindi Airport	Strategic Plans Development Plans Aircraft Mix	KAA Fieldwork	Maps Documents Photos	GIS	To establish area required for the airport expansion.
4. How can airport planning principles integrated in the physical development of the land uses within the vicinity of the Airport?	Land policy Legislation on Development control around Airports Institutions in Development control	National Land Commission K.A.A K.C.A.A Malindi County/NEMA	Literature Review Interview Documents	Synthesis of Information Content analysis	Policy & Institutional Framework Recommendations

Source: Author, 2014

The various land uses within the study area will be determined through observation. Purposive sampling method will also be used for Malindi Municipality officials, Ministry of Lands Housing and Urban Development and KAA officials because they also have information on the issues related to land use of the study area. One sample for each of the institutions will interviewed because they have the same source of information. The table below provides a summary of the type of sampling methods and different sample sizes for various categories.

Table 5: Summary of sampling methods and sizes of different categories

Category	Type of sampling	Sample size
Study area	Purposive Sampling	1
Plot owners	Random sampling	70
Institutions: KAA,MCG, KURA,CPO	Purposive sampling	1 for each

Source: Author, 2014

4.5 Data Collection

The data needs have been assessed in relation to set objectives .The needs included; land uses, impact of the airport on other land uses, land requirement for the ultimate development and measures for integrating the various land uses around Airports. The research data was obtained from both secondary and primary data sources.

4.5.1 Secondary data collection

The secondary data was obtained from various literatures on Airport and urban planning. This was mainly to provide the theoretical background on the problem. This involved library and desktop studies on the current knowledge on land use compatibility and its impact on airports.

This information is from published books, government documents and journals, acts of parliament, libraries, internet, government policy documents and reports, journals, publications and daily newspapers among others .Policy and strategy papers whose topics are of relevance to this research were also reviewed. Content analysis technique was the used to analyze qualitative data.

4.5.2 Primary Data Collection

The primary data methods included questionnaire, focused group discussions and interview schedules with selected key informants. One sets of questionnaires were be prepared and administered to Kenya Airport Authority, Kenya Civil Aviation Authority , Malindi County government . The main purpose of these target groups is to establish how these institutions control development within the vicinity of the airport and to find out laws and regulations on land use around the airport.

The second set of questionnaires was administered to the people living and working around the airport. This involved data collection through interview of the plot owner based questionnaires, focus group discussions and round table discussions sessions and interview schedules with Key informants. Other techniques include used of observations and taking of photographs. Observations will used to determine heights of obstacles within the obstacle limitation surfaces. Aerial Photographs and ground survey were be used to collect data on land use.

The procedures for primary data collection involving plot owners.

- **Formulation of a Draft Questionnaire:** The questionnaires was formulated with an aim of meeting the objectives of the study.
- **Data Coding:** At this stage all the possible outcomes of the questions was produced and coded at three main stages.
  - **a)** Draft data coding based on the possible outcomes of the draft questionnaire.
  - **b)** Revision of the data codes after the pilot test has been done and the questionnaire has been adjusted to address the weaknesses identified in the pilot test.
  - **c)** Final coding which was done once the data collection has been done and all possible outcomes of the questions have been established.

- **Hiring and Training of Research Assistants:** Four research assistants with a minimum of form four certificates were hired from the local community. They were then trained on the procedures for questionnaire administration. This was done two days before the actual data collection to enable them familiarize with the questionnaires.
- **Pilot Test:** Once the research assistants have been trained on administration of the questionnaires. The questionnaire was tested to evaluate time and cost of carrying out the data collection. The test enabled to identify weaknesses of the questionnaires through identifying ambiguous questions, vague questions, repetitive questions, unnecessary questions, extremely long questions etc. The pilot test demonstrated how well the

research assistants understood the process of data collection after which further training was carried out.

- **Finalization of the Questionnaires:** Once the weaknesses of the draft questionnaires have been identified, adjustments and correction were made accordingly to produce the final questionnaires.
- **Administration of the Questionnaires:** The plot based questionnaires was then administered for approximately week after necessary adjustments have been made on them.

4.5.3 Data Cleaning and Editing

Data cleaning and editing was carried out to ensure that information collected is organized for the purpose of data entry and to help fill in the gaps that were left by the research assistants during the data collection when the respondents might have been unwilling to provide certain information. Effort has however been made to minimize the occurrence of these gaps. The main method to be used in this is the *Plugs in technique* where the research assistants will insert answers to questions that were not answered in the definite *questionnaires*. The Plugs In were predetermined earlier based on the predicted response and experience after data collection. Data editing was done mainly to make corrections on the errors made during the filling of the questionnaires.

Coding and Data entry

The household questionnaire was coded and verified after the field survey. The procedure involved assigning a number to every category of answers for easy computer entry. During the coding exercise, the responses were changed from words to numeric by assigning them values rather than strings so as to translate the raw data into digits that could be counted and tabulated. This ensured easier frequency and descriptive statistical result runs.

The data entry into the computer involved creating a data matrix using the variables with the assigned names, variable lengths, definition of variable type and variable labels in statistical packages for social scientists (SPPS) software. The frequencies were then processed to facilitate data cleaning. The coded data was checked against errors that may have occurred partially arising from incorrect data entries, omissions of data or incomplete records. These was removed by cross checking the computer prints out against the original questionnaire before a second frequency run/processing is carried out

4.5.4 Data presentation and analysis

The analysis of data and interpretation of results is necessary to build up a model where relationships involved are brought out carefully to draw meaningful inferences. This ensures that results are seen in light of the research objectives. Data analysis entailed data verification and representation which was done through logical organization of data and tabulation.

The analysis involved collecting the relevant supporting documents and reviewing them against the primary data. The data analysis also involved using geographical Information systems (G.I.S) as a tool which facilitated the development of a spatial land use model of the study area and mapping of the obstacle limitation surfaces and land uses among others. GIS analysis also facilitated spatial analysis through buffering technique to determine noise contours.

Qualitative information from focused group discussions was analyzed by content analysis technique. Data presentation was done using frequency tables to show statistical distribution of variables using charts, percentages, graphs, maps and diagrams that simplify the data for ease of understanding. The outcomes or results are presented in figures, tables, diagrams, maps.

The data collected from the field surveys have been analyzed and synthesized for meaningful interpretation of research findings. This research involved both quantitative and qualitative methods of data analysis. Qualitative data has been be analyzed by use of logical or matrix analysis while quantitative data was analyzed through the use of SPSS and EXCEL programs to enable the production of analytical diagrams such as pie charts, bar graphs, histograms etc. for interpretation. In particular SPSS was used in data management, analysis and interpretation. The analyzed data is presented in form of this study report. Logical map overlays have been used to indicate the research project site and the distribution of various impacts of airport operations.

The inputting techniques to be used will involve the use of the SPSS and EXCEL programmes. Spatial data collected by the use of the GPS was inserted into existing base maps using the Geographic Information System (GIS) software. This was applied mainly in:

- Mapping of areas with massive or complete disregard to development laws.
- Mapping of areas which pose great threat to airport operations and the environment such as improper garbage damping areas.

4.6 Hypothesis Testing Approach

The hypothesis testing method adopted by this study is scenario analysis. According to Wikipedia (www.org/wiki/scenario analysis), Scenario analysis is a process of analyzing possible future events by considering alternative possible outcomes (scenarios). Scenario analysis has been used as tool to explore the 'what if' and 'What could be' rather than to focus on the narrow calculation of a single certain future (i.e., 'what will be.'). The analysis is designed to allow improved decision making by allowing more complete consideration of outcomes and their implication.

Duinker and Greig (2007) provide a summary of definitions of scenarios, ranging from " ..Conjectures about what might happen in the future" to the more comprehensive definition of a scenario as "a description of a possible set of events that might reasonably take place." The authors add that "the main purpose of developing scenarios is to stimulate thinking about possible occurrences, assumptions, relating these occurrences, possible opportunities and risks, and courses of action. The numerous definitions of scenarios are similar in that they are based on learning about potential alternative futures. It is important to recognize that scenarios are not predictions of the future, but instead present a reasonable range of potential outcomes. Duinker and Greig (2007) argue that the purpose of conducting scenario analysis is not to make predictions, but rather to allow the opportunity to challenge assumptions and to broaden perspectives.

Scenario analysis and scenario planning are at times used interchangeably. Scenario analysis brings together both scenario development and the principles of strategic management. It integrates scenario development with decision making. Scenario planning is described as “a technique to make decisions in the face of uncontrollable, irreducible uncertainty. Haroyd et al (2000) while quoting Peterson et al (2003) describes scenario planning as , “ a systematic method for thinking creatively about possible complex and uncertain futures. The central idea of scenario planning is to consider a variety of possible futures that include many of the important uncertainties in the system rather than to focus on the accurate prediction of a single outcome.”

Scenario analysis is often widely used in carrying out cumulative effects assessment which is a tool to evaluate the range of possible development trajectories and their impact on the economy, society and environment, and desired future outcomes. Cumulative effects are changes to the environment that are caused by an action in combination with other past, present and future human actions or phenomena.

Scenarios were first used in World War II as part of military strategic planning to imagine possible strategies for the battle. They have since used in a variety of fields including business planning, community management and environmental assessment. There are hundreds of examples of scenarios developed during the last 30 years or so. Some well-known examples include the millennium Assessment and the Intergovernmental Panel on Climate Change (IPCC) scenarios. Scenario analyses have also been used in the fields of economics, finance, politics or geo-politics.

From the foregoing, this study uses scenario analysis to test the hypothesis of the study. This is because land use planning is a process whose changes can only result in cumulative effects that may not necessarily be quantified. Besides this, the processes are administered by public sector organizations whose main motivation may be that of a social and political nature. As such, whereas on the one hand one may be in a position to measure level of compatibility it may difficult to compute statistically the effects of land use compatibility .As such it can only be left on the evaluator to assess the current scenario and make a future projection of what the effects might be to aid the decision makers on any policy changes that might be required.

4.7 Ethical Considerations

The research has been carried out with high levels of integrity and professionalism. Towards this end, following ethical questions were taken into consideration: honesty, objectivity/non biasness, integrity, carefulness, openness, respect for intellectual property, confidentiality, responsible publication, social responsibility, non-discrimination, competence, legality and human subjects' protection.

CHAPTER FIVE

TOWARDS SUSTAINABLE PHYSICAL DEVELOPMENT OF MALINDI AIRPORT. DISCUSSIONS OF RESEARCH FINDINGS

5.1 Introduction

The key objectives of this study were to establish the various land uses within the vicinity of Malindi Airport and their impact on the Airport, to investigate the impact of the airport on the various land uses within its vicinity, to determine land requirement for the development of the airport and the fourth objective is to propose appropriate measures for integrating Malindi Airport with its neighborhood. Airport land use compatibility is the reconciliation of how land development and airports function together. Airport compatible land uses are those uses that can coexist with a nearby airport without either constraining the safe and efficient operation of the airport or exposing people living or working nearby to unacceptable levels of noise or (safety) hazards. Compatibility concerns include any airport impact that adversely affects the livability of surrounding communities, as well as any community characteristic that can adversely affect the viability of an airport.

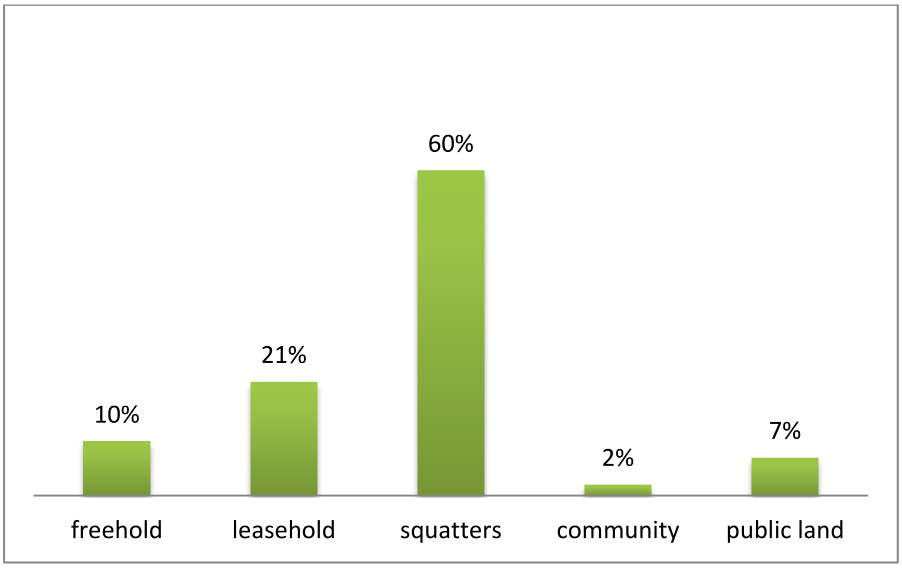
Incompatible development near the airport has led to a politically contentious relationship between the airport and the communities around. This chapter is an in-depth discussion on these objectives.

5.2 Land uses within the vicinity of the airport and their impact

5.2.1 Bird Strikes

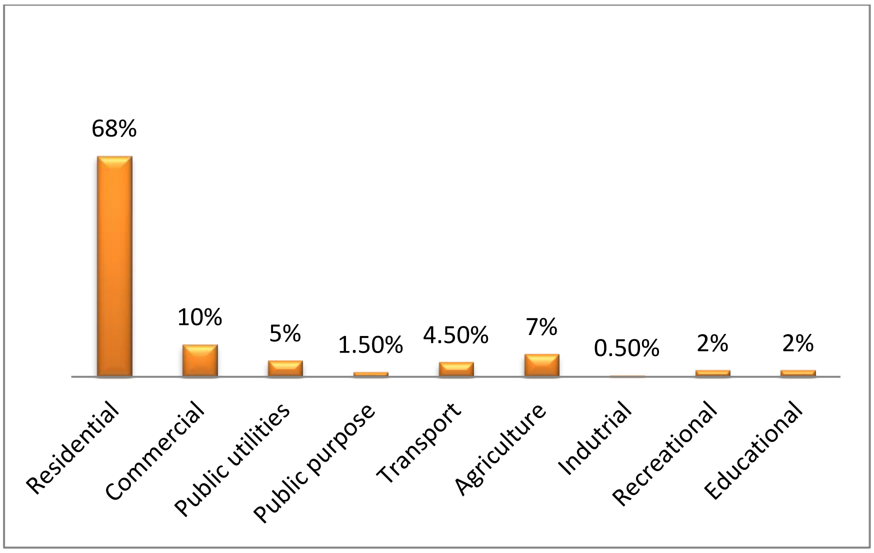
According to the field survey, residential land use is the dominant land use followed by commercial at 68% and 10% respectively (See Figure 3.1 below) while 60% of the respondents are squatters. The study area lacks a sewerage system and is characterized by poor garbage disposal methods with dumpsites that attract birds, which is a safety concern because of the increased chances of bird strikes during takeoff or landing. Bird strikes happen when birds collide with airborne planes. They are known to bring down even the large planes when the birds block air from flowing into the aircraft engine. With a plane moving at 500 km per hour, slight contact with a bird can send the aircraft tumbling to the ground or completely damage the engine. International aviation safety standards require that dumpsites and landfills must not be located within a radius of 13 km of an airport. Birds are attracted to dumpsites near the airport and in turn go to the airport for food, water, resting or shelter. Some birds may also be struck outside airport property; over a land use that attracts them such as is evident in the study area. In fact, 21 per cent of bird strikes reported to the ICAO IBIS system occurred "off airport". An "on airport" bird strike is that which occurs between 0 to 60 m (0 to 200 ft) (inclusive) on landing and 0 to 150 m (0 to 500 ft) (inclusive) on take-off (ICAO, 2009).

Chart 1: Chart showing types of land tenure in the area



Source: Field work, 2014

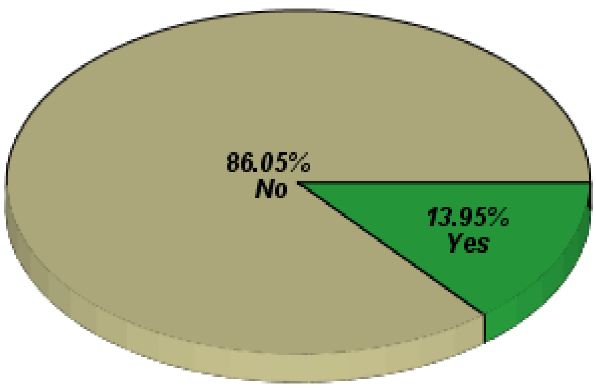
Chart 2: The distribution of land use within the study area.



Source: Field Survey, 2014

86% of those interviewed were not aware of Kenya Airports Authority Act, Kenya Civil Aviation Act and Physical Planning Act requirement to submit development proposals for guidance height limitations and land use around the airport. This has led to construction of residential units that infringe on the obstacle limitation surfaces within the declared areas within the vicinity of the airport.

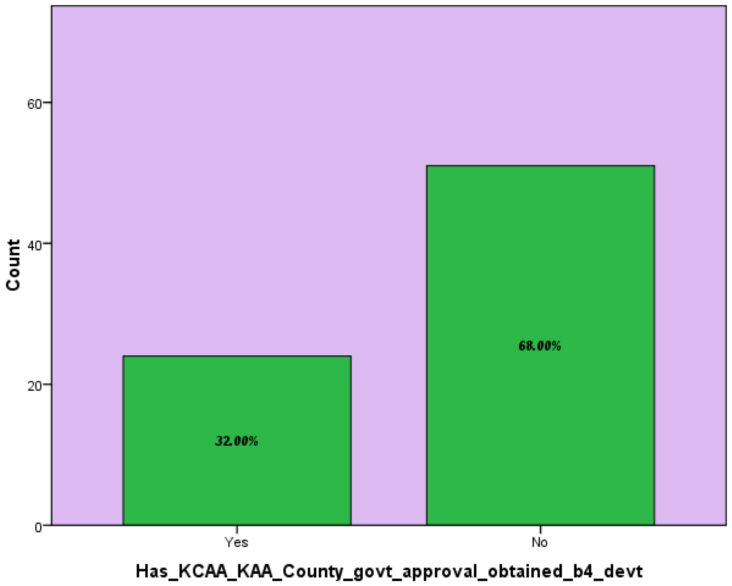
Chart 3: Are you aware if it is necessary to submit development proposals?



Source: Field work, 2014.

Of those who are aware of need to submit development proposals, only a mere 32% have obtained approval from relevant bodies such as Kenya Civil Aviation Authority (KCAA), Kenya Airports Authority (KAA) and county governments.

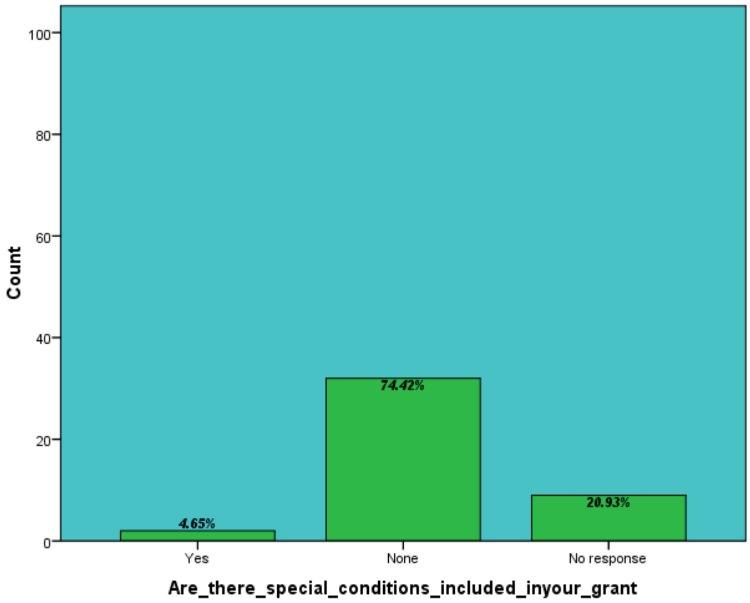
Chart 4: Have approvals been obtained from relevant bodies and government?



Source: Field work, 2014.

Due to their squatting nature, most of the residents, 74%, do not have special grants in their grants because they don't own the land.

Chart 5: Special grants



Source: Field work, 2014

5.2.2 Impact on Navigational Aids

There is encroachment of airport land around the VOR, south of Malindi –Mombasa Road. The residential developments are too close to PAPI and an electric power line traverses the flight funnel which affects the pilots during landing. (Plate 1: VHF Omni-directional range)

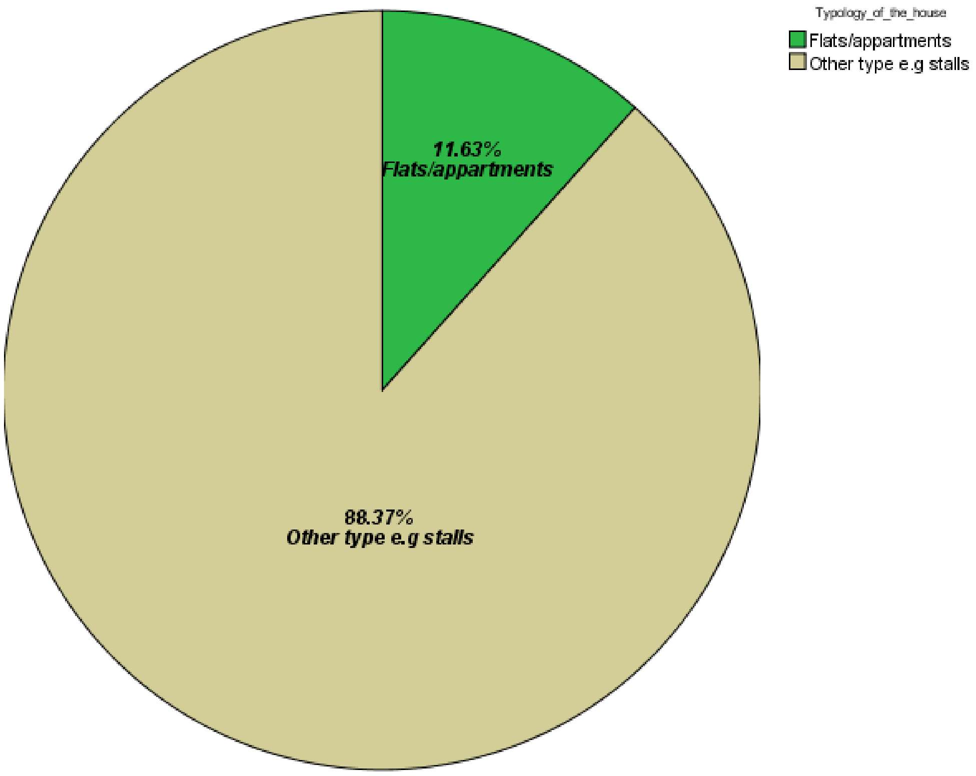
Plate 1: VHF Omni-directional range (VOR

Source Field Survey, 2014

5.2.3 Obstruction of airspace

11.67% of the land parcels have high rise developments and 74.42% developers did not have special conditions on development control on the grants. The fact that 86.05% of the respondents were not aware of the requirement to seek development approvals means that the area is likely to experience further developments without the advice of both KAA and KCAA on height limitations.

Chart 6: Types of housing typologies for residential and commercial premises



Source: Field Work, 2014

5.2.4 Limited expansion

A significant number of semi-permanent structures are well inside the airport boundary Part within the flight funnel and the centerline of the proposed extension of runway 17/35.

The Malindi – Gandi road (C103) is also located within the proposed extension of the runway, this means that the road has to be relocated which requires huge capital investment. The existing structure of the land use in Kibarani area imposes limitations to the growth of the airport. The runway 17/35 need to be expanded to accommodate long haul aircraft however it is restricted by the existing adjacent structures, so much so that further expansion of the airport cannot be accommodated.

As a solution, we may either demolish the surrounding built up areas to make more land available for expanding the business centre or we may select an alternative site for relocating the airport. Both solutions will demand heavy capital expenditure. The magnitude of the expenditures depends on the alternative solution taken. To overcome thresholds, investment costs, known as threshold costs have to be incurred. These investments must be committed before the land can be opened up for development of the airport. The cost of structural thresholds and land acquisition will be high.

Plate 2: Google image of Malindi Airport

Source: Google Earth, April 2014.

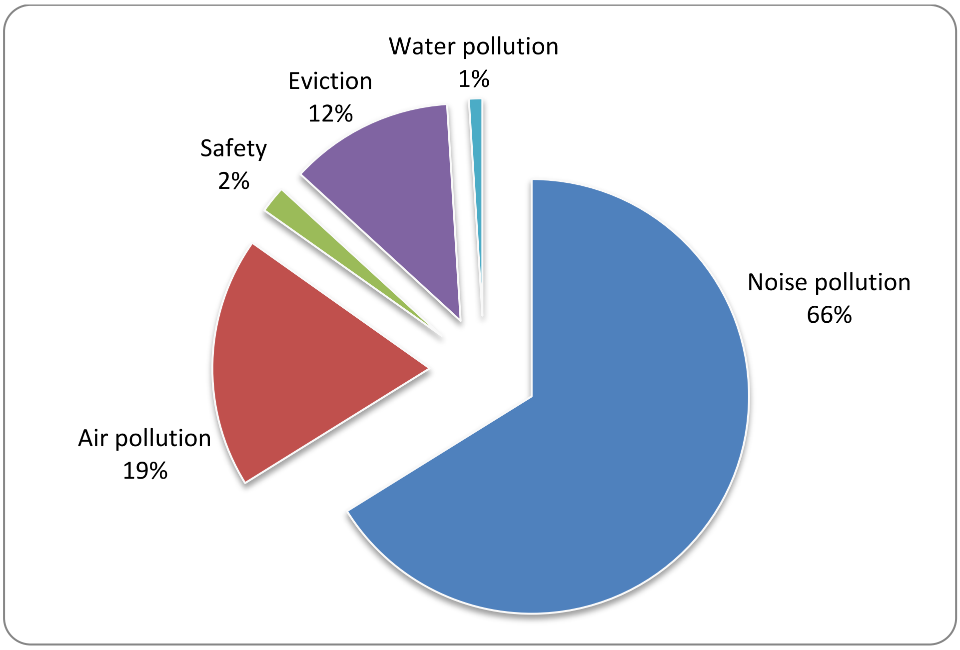
The concept of compatible land use planning is an outgrowth of the focus of attention on the environmental relationship between airports and their community neighbors. This planning concept is relatively simple and the results can be impressive but the implementation requires careful study and coordinated planning. Land use around airports can influence restrictions on aircraft flights as well as affect aircraft safety.

5.3 Impact of the Airport on Adjacent land uses

The study shows that these developments found within the neighborhood of the airport experience some effects due to their proximity to the airport. These effects are both positive and negative. Study area, being nicknamed as the 'Italian town', is famous with the Italian tourists flocking the coastal town. Therefore tourist related businesses are common in this town. At least 5% of the locals in such kind of businesses said that proximity to the airport boosts tourism and their businesses. Over 95% thought that the airport did not positively affect their developments or businesses.

Among the negative effects the airport has on the developments in its neighborhood, noise and air pollution were the dominant nuisance. The other negative impact is the fear of eviction.

Chart 7: Impact of airport



Source: Field survey, 2014

5.3.1 Noise

Noise, by definition, is sound that is loud, unpleasant, unexpected, or undesired. The sound produced by aircraft becomes noise when it disturbs people. The best way to minimize the adverse impact of noise is to separate people from that noise. Aircraft noise is greatest along the flight paths on which aircraft take off and land at airports. Ideally, these are the areas where noise-sensitive land uses should be excluded.

In this study 66.21% of the respondents identified noise as a negative impact of the airport. This is due to the fact that 68% of the land parcels are under residential use which is highly incompatible with airports due to noise exposure levels. The other incompatible land uses include public purposes (1.5%) and Educational land use (2%) such as schools and churches. Holy Ghost Mission (HGM) primary school, St. Andrew primary school are located adjacent to the Airport boundary fence as shown below. Noise effects include hearing loss, sleep disturbance, health problems, and annoyance and disturb learning environments.

Plate 3: Holy Ghost Mission (HGM) primary school adjacent to Malindi Airport

Source Field Survey, 2014

The establishment of noise-sensitive land uses in Malindi airport influence area exposes significant levels of aircraft noise, taking into account the characteristics of the airport and the community surrounding the airport. The basic strategy for achieving noise compatibility in the airport's vicinity is to limit development of land uses that are particularly sensitive to noise such as residential neighborhood, schools and churches. The most acceptable land uses are ones that either involve few people (especially people engaged in noise-sensitive activities) or generate significant noise levels themselves (such as other transportation facilities or some industrial uses).

Residential land uses as normally incompatible where the noise exposure exceeds 65 dB CNEL, a lower threshold of incompatibility is often appropriate particularly around airports in suburban or rural locations such as Malindi where the ambient noise levels are lower than those found in more urban areas. In places where the noise exposure is not so severe as to warrant exclusion of new residential development, the ideal strategy is to have very low densities-that is, parcels large enough that the dwelling can be placed in a less impacted part of the property. In urban areas, however, this strategy is seldom viable. The alternative for such locations is to encourage high-density, multi-family residential development with little, if any, outdoor areas, provided that the 45 dB CNEL interior noise standard and limitations based upon safety are not exceeded. Compared to single-family subdivisions, ambient noise levels are typically higher in multi-family developments, outdoor living space is less, and sound insulation features can be more easily added to the buildings. All of these factors tend to make aircraft noise less intrusive. Sound insulation is an important requirement for residential and other noise-sensitive indoor uses in high noise areas.

5.3.2 Safety

Compared to noise, safety is in many respects a more difficult concern to address in airport land use compatibility. A major reason for this difference is that safety address uncertain events that may occur with occasional aircraft operations, whereas noise deal with known, more or less predictable events which do occur with every aircraft operation. Because aircraft accidents happen infrequently and the time, place, and consequences of an individual accident’s occurrence cannot be predicted, the concept of risk is central to the assessment of safety compatibility.

The study revealed that 2% of the respondents were concerned about safety due to their proximity to the airport. To minimize the risks associated with potential aircraft accidents and emergency landings beyond the runway environment such land uses should be located far from the airport and a buffer zone provided to segregate incompatible land uses such as residential and educational land uses. There are two components to this objective:

Safety on the Ground: The most fundamental safety compatibility component is to provide for the safety of people and property on the ground in the event of an aircraft accident near an airport.

Safety for Aircraft Occupants: The other important component is to enhance the chances of survival of the occupants of an aircraft involved in an accident that takes place beyond the immediate runway environment.

Certain aspects of aircraft accidents are necessary to discuss in that they have a direct bearing on land use compatibility strategies. From the standpoint of land use planning, two variables determine the degree of risk posed by potential aircraft accidents: frequency and consequences.

The frequency variable measures *where* and *when* aircraft accidents occur in the vicinity of an airport. More specifically, these two elements can be described as follows:

Spatial Element: The spatial element describes *where* aircraft accidents can be expected to occur. The spatial element is the one most meaningfully applied to land use compatibility planning around an individual airport

Time Element: The time element adds a *when* variable to the assessment of accident frequency.

5.3.3 Air pollution

Air pollution refers to a condition of the air marked by the presence therein of one or more air contaminants that can: endanger the health, safety or welfare of persons; interfere with normal enjoyment of life or property; endanger the health of animal life; or cause damage to plant life or to property. 18.67% of the responds complained of air pollution .Air quality in the vicinity of airports is affected by aircraft engine emissions, emissions from airport motor vehicle and access traffic, and emissions from other sources.

Sources of pollution at airports include:

(a) Aircraft engine emissions, in which the principal pollutant is NOX, while other pollutants are CO, unburned hydrocarbons and smoke;

(b) Emissions from heating/power plants and incinerators, such as fires set for the purpose of training rescue and firefighting crews;
(c) Emissions from motor vehicles, notably from airport motor vehicles used by airport operators, air carriers and other businesses based at an airport; and
(d) emissions from access traffic comprising of passengers' and visitors' motor vehicles, cargo and delivery trucks, and service and public transport vehicles.

5.3.4 Water Pollution

Water pollution can result from direct or indirect discharge of substances into the aquatic environment, leading to alterations in the properties of the natural ecosystems and water chemistry and having subsequent effects on human health. Surface water is most often affected, as pollutants run off the airport pavements and enter into the streams, rivers, lakes, etc. However, sub-surface water may also become contaminated when leaks or spills of fluids seep through the soil into the ground water. 1% of the residents complained of water pollution at 'Ziwa la Funzi'.

Airports use a variety of chemicals in their day to- day operations. If not properly controlled, these contaminants may have harmful effects on nearby surface and/or subsurface (ground) water. Water contaminants at airports and their sources include fuel, from spills during refueling and leaks from pipes or tanks, fire suppressant chemicals and foams dispersed in firefighting exercises; dust, dirt and hydrocarbons from paved surfaces; and herbicides and pesticides.

5.3.5 Socio-economic impacts

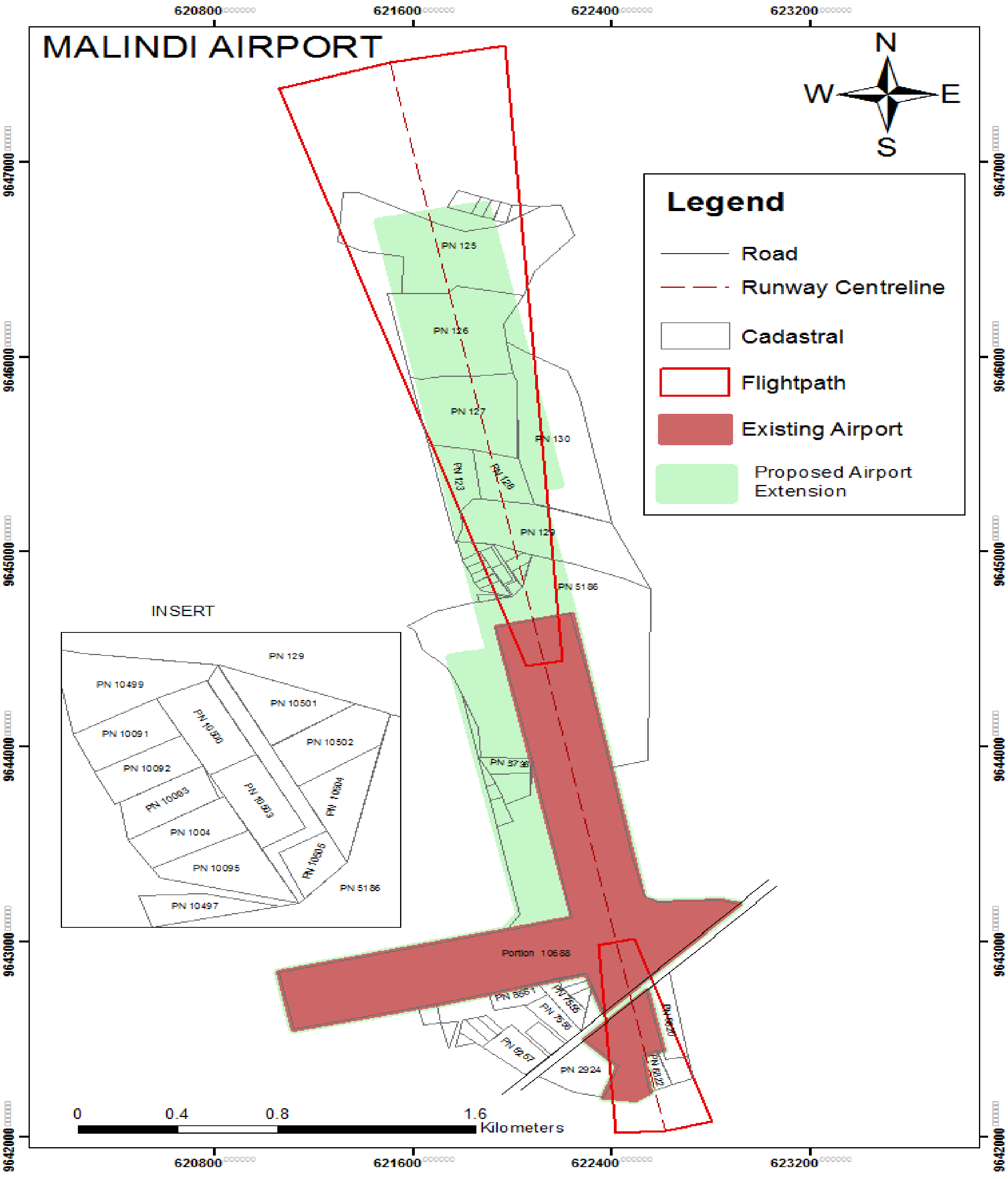
These include disruption of established communities due to eviction of squatters on airport land, necessity of relocations, and disruption of transportation pattern due to the need to detour Malindi-Ganda (C103) road because of runway extension. According to the survey 12% of the respondents were concerned about eviction

5.4 Land Requirements for the expansion of Malindi Airport

The existing structure of the land use in Kibarani area imposes limitations to the growth of the airport. The runway 17/35 need to be expanded to accommodate long haul aircraft however, it is restricted by the existing adjacent structures, so much so that further expansion of the airport cannot be accommodated.

As a solution, we may either demolish the surrounding built up areas to make more land available for expanding the airport or we may select an alternative site for relocating the airport. Both solutions will demand heavy capital expenditure. The magnitude of the expenditures depends on the alternative solution taken. To overcome this, threshold costs have to be incurred. These investments must be committed before the land can be opened up for development of the airport. The cost of structural thresholds become higher as land becomes more intensively used.

Map 5: Proposed Malindi Airport Extension



Source: Author, 2014

In order to determine the land requirement for Malindi airport it is necessary to make a selection of the critical aircraft. This selection is based on the present aircraft mix we want to analyze. The existing fleet with maximum flight distance and dimensions at Malindi Airport are: ATR 42 – 320,DHC-8 Dash 8-100 and Embraer ERJ 170. With regard to physical characteristics for airport configuration and design, the criterion of selection of the critical aircraft is based on the greatest runway length required for an aircraft. The critical aircraft in terms of runway length requirements, overall aircraft dimensions and pavement strength is the Embraer ERJ 170, classified as 4C which is likely to remain as critical aircraft for the next several years. Based on this proposition the required facilities are as follows:

i. Runway 17-35 to provide a total runway length of 2,100 m required by EMB170.
ii. Expanding runway width to 40 m in compliance with ICAO standards for airport code 4C.
iii. Expanding taxiway width to 18 m in compliance with ICAO standards for airport code 4C.

Malindi airport requires additional 159 Ha for the sustainable physical development of the airport.

5.4 Integrating Airport with its Environ

The Kilifi County Government has not yet prepared and adopted an integrated development plan which is a critical and effective part of the process of ensuring land use compatibility in and around airports. Local land use planning as a method of determining appropriate (and inappropriate) use of properties around airports should be an integral part of the land use policy and regulatory tools used by airports and local land use planners. Coordination during the early stages of Airport Master Planning and local land use planning is extremely critical for ensuring some level of land use compatibility. This coordination must occur before the creation, adoption, and implementation of both airport and local land use plans. Such coordination requires open dialogue and, at the least, some type of basic understanding of each other’s planning processes.

Arising from this findings, discussed here below are land use planning and regulatory tools available to Malindi County government to enhance land use airport land use compatibility.

5.4.1 Comprehensive Plans

The preparation and adoption of a comprehensive plan is a critical and effective part of the process of ensuring land use compatibility around airport facilities and should be the first step in developing bases for follow-up land regulatory tools. The plan can provide policy-makers, airport owners, land use regulators, developers, and the general citizenry with an understanding of the magnitude of the land use conflict problems and relevant solutions. In some instances, where development has not yet substantially occurred around an airport, the potential exists for the comprehensive land use plan to provide direction to new development. In areas where development has already been allowed to occur close to airport property, or where airport expansions have resulted in originally unforeseen potential conflicts with adjacent and surrounding properties, the plan can provide recommendations for how to mitigate such conflicts.

The land use planning element of the comprehensive plan is a very important step in recognizing and analyzing some of the issues of concern in and around airports. Through establishment of an "existing" land use map, specific properties around the airport can be inventoried, analyzed, and classified. An existing land use map should be created to depict the existing land uses.

Existing noise exposure contours can then be overlaid onto the existing land use map and other related spatial information, to discern the degree of noise exposure of properties in and around an airport. Availability of a Geographic Information System (G.I.S) which contains all topographic information, cadastral information, vegetation cover, and location of all telecommunication/other towers, will allow review and analysis of these many disparate pieces of important information which will be important as land use compatibility alternatives are studied.

5.4.2 Zoning Regulations

The use of zoning to control development around airport facilities has realized varied degrees of success. If put in place early enough, however, zoning can be an effective tool to help eliminate or reduce land uses that are not compatible with airports. The use of zoning to control development in and around airport facilities can realized success. Zoning should be put in place early enough zoning to help eliminate or reduce incompatible development and land uses around airports.

A determination needs to be made as to what specifically should be included in particular sections of the zoning ordinance. Some regulations to consider in the zoning include controls governing permitted uses, conditional uses, height, bulk, and intensity of developments around an airport.

5.4.3 Subdivision Regulation

Subdivision regulations are usually prepared, adopted and enforced through the actions of a local legislative body and/or a local planning commission. Subdivision plan review procedures provide an opportunity for jurisdictions to determine how and if a proposed subdivision design could contribute to the incompatibility of noise exposure in the airport environs.

5.4.4 Building Codes

While generally concerned with the functional or structural aspects of buildings or structures, building codes should contain special requirements for properties located in high noise exposure areas. Housing standards usually relate to the minimum that a home would have to meet in order to be decent, safe, and sanitary. To some extent, and in combination with building codes and performance standards, housing codes may serve as a basis for noise impacts to residential occupants.

5.4.5 Capital Improvement Programming

A capital improvement program is another tool used to assist local governments in realizing the goals, objectives, and recommendations of an adopted comprehensive plan. This programming tool could be used in a cooperative manner to encourage or discourage certain types of land development around airport facilities.

5.4.6 Infrastructure Extensions

Provision or extension of basic infrastructure elements such as water, sewer, and roadways can significantly affect the extent and direction of growth and development. Used in conjunction with comprehensive plans and Airport Master Plans can allow for land uses to take place in areas that are compatible with aviation facilities.

5.4.7 Transferable Development Rights (TDR) and Purchase of Development Rights (PDR)

Both TDR and PDR involve the relocation of development rights (through transfer or purchase) from one location to another. Either mechanism has the potential to allow airports to either avoid incompatible development or promote compatible development in specific noise-impacted areas.

5.4.8 Public Education and Awareness Programs

Airports or local planning agencies that expect a reasonable chance of success in their planning efforts must provide for public education and awareness in the planning process. Dissemination of information is a one-way flow of a desired message or philosophy. The type of audience may range from a very narrow one to the community at-large. Among the information dissemination opportunities are brochures, newsletters, paid advertising, newspaper inserts, and Internet Web pages.

5.5 Scenario Analysis

This is an analysis of possible future events by considering alternative possible scenarios. Scenario A refers to the possible out where there will be no planning intervention to address the current incompatible land uses around the airport. Scenario B obtains when there is planning intervention as shown in table 6.

Table 6: Scenario Analysis

Scenarios	**Cumulative Effect**
A: No Intervention Scenario: This scenario refers to a situation where there will be no intervention to mitigate the existing situation of incompatible land uses within the vicinity of the airport. Further developments within the protected surfaces of the airport.	Reduces the value of public investment in airport infrastructure. Degrade usefulness of the airport Reduces transportation access Reduces quality of life for communities Litigation arising from noise and air pollution.
B: Planning intervention Scenario: This scenario refers to land use planning around the airport for land use compatibility.	Expansion of airport. Improved quality of life for communities Increased opportunities for economic development

Source: Author, 2014

CHAPTER SIX
CONCLUSION AND RECOMMENDATIONS

6.1 Introduction

The study investigated land use compatibility for the optimum physical development of Malindi airport with view of provide the best possible conditions for the needs of the airport and the community in the surrounding area. The study specifically sought to establish the various land uses within the vicinity of Malindi Airport and their impact on the Airport, to investigate the impact of the airport on the various land uses within its vicinity, to determine land requirement for the development of the airport and the fourth objective was to propose appropriate measures for integrating Malindi Airport with its neighborhood. The study established that there are incompatible land uses within the airport influence area that negatively impact the airport operations, safety and expansion. Further the study established noise and air pollution from airport operations negatively affects the residential land uses around the airport.

6.2 Summary of Findings

Analysis of the study revealed that there is land use conflict between the airport and its neighborhood with 68% of the land parcels within the vicinity of the airport being residential. Residential land use is highly incompatible with airports due to noise exposure from aircraft movements and airport operations. The study further showed that schools are located adjacent to the airport which poses safety concern in the event of an aircraft accident near the airport. The study showed that 86% of the land owners were not aware of the requirement to seek development approvals from KCAA, KAA and the County government. This means that the area is likely to experience further development within the proximity of the airport.

The airport measures 100.57 Hectares that is inadequate for the expansion of the runway. The study showed that Malindi airport requires an additional 159 Hectares for physical development of the airport to upgrade the runway to code 4C. This is for the extension of the runway length from 1.4km to 2.4 km, expansion of the runway width to 40 meters and the taxiway width to 18meters in compliance with ICAO standards for code 4C aircrafts.

The study also revealed that Malindi County has no integrated development plan to guide physical developments around the airport, which has resulted in uncontrolled development within the proximity of the airport.

6.3 Land Use Compatibility and Airports

In view of these finding, the study recommends

- All future developments and land- use planning within the above radius be referred to KAA and KCAA for comments and approval. In the meantime, freeze any further uncoordinated developments along the extended centre-lines of the runways for safety reasons.
- Existing structures and on-going construction that penetrate the obstacle limitations surfaces (OLS) should be demolished or stopped. This is particularly urgent for structures coming up parallel to runway 07/25 and in the funnel of the extended centre-line of runway 08/25.
- The parcel of land next to the VOR is unsuitable for residential purposes and therefore the squatters should be relocated to alternative land outside the airport influence area.
- Malindi Airport came before the neighboring developments and therefore land use planning for the environs should revolve around the airport.
- The existing Malindi-Ganda road (C103) should be diverted beyond the proposed extended runway 07/25.
- Noise is a primary environmental cost associated with the development and use of any airport. Noise generation and abatement regulations should be published and enforced. The existing structures exposed to aircraft noise will have to resort to sound insulation as a means of reducing noise exposure.
- Agricultural land use should be encouraged on the existing agricultural land to the west of the Airport and the prison area.
- Avigation easements: When compulsory land acquisition is not necessary, an avigation easement should be executed with the land owners in order to secure the

airspace, runway approach and for noise compatibility programs. Such easement rights may consist of the right-of-flight of aircraft; the right to cause noise, dust, etc.; the right to remove all objects protruding into the airspace together with the right to prohibit future obstructions in the airspace; and the right of ingress/egress on the land to exercise the rights acquired. The easement may also contain any number of additional restrictions as the airport deems necessary.

- There is a need for Malindi integrated urban development master plan to provide an integrated urban development framework for coordinated physical development of Malindi municipality. The plan will seek to integrate all exiting sectorial plans in the municipality and align them to Vision 2030. The direction of urban development is not clearly defined as there is no urban development plan for Malindi Municipality

The following is a logical framework that is a proposed plan of action that has been put toward by the researcher after this study towards compatible land uses around Malindi Airport. It includes the activity to be done as a way forward, the objective of such an activity, the expected result, the institution responsible and the timelines.

Table 7: Action Plan

Activity	**Objective**	**Expected results**	**Responsibility**
Resettlement of Squatters	Recreate Land for Airport	Space for Airport Expansion	National Land Commission
Relocation of Malindi-Ganda Road (C103)	Extension of runway 07/25.	Alternative road	KENHA
Compulsory acquisition	Extension of runway 07/25	Accommodate long haul aircraft	K.A.A/N. L.C
Integrated Development	Development control within the vicinity of the airport	Land use compatibility	Kilifi County Government

Enforcement of Development control within the vicinity of the airport	Safety	Land use compatibility	K.A.A/ K.C.A.A/Kilifi County Government
Environmental control	Compatibility	Noise. Air pollution	NEMA

Source: Author, 2014.

6.4 Critical Areas of Further Research

While undertaking this study, the researcher has noted certain critical issues that are outside the scope of the study, but are crucial for the implementation of the research recommendations. Therefore, the study recommends two areas for further research; firstly, the Cost Benefit Analysis of the expansion of Malindi Airport and secondly, the Economic Impact of Malindi Airport on the economy of the country.

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APPENDICES

Appendix A: Interview Schedule- KAA

UNIVERSITY OF NAIROBI

DEPARTMENT OF URBAN AND REGIONAL PLANNING

LAND USE COMPATIBILITY FOR SUSTAINABLE PHYSICAL DEVELOPMENT OF MALINDI AIRPORT.

INTERVIEW SCHEDULE - KENYA AIRPORTS AUTHORITY (KAA/KCAA).

1. Name of Respondent ………………………………Tel. No………………………….
2. Title of job
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3. Duties of the officer
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4. a) Is there a physical development plan for Malindi Airport? I) yes ii) no
   b) If yes, when was it prepared?
   ……………………………………………………………………………………
   …….
5. Are development proposals within the immediate neighborhood of Malindi Airport submitted to KAA for comments before approval by Malindi Municipal Council?
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6. What are the requirements/criteria for development consent/Approval by KAA?
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7. What would you consider to be the land-use planning problems facing Malindi Airport?
    1) Illegal formal developments e.g. residential and commercial
    2) Illegal informal settlement e.g. squatter settlement
    3) High-rise development that obstructs pilots
    4) Lack of space for expansion for Airport
    5) Others (specify).

8. What would you consider to be possible causes to land use planning problems in Malindi Airport?
    1) Illegal allocation of public utility land
    2) Squatter settlements
    3) Lack of an effective policy framework by Municipal council of Malindi .
    4) Lack of a physical development plan for the airport
    5) Other (specify))

9. Does the airport take proactive steps to detect incompatible use of lands in the vicinity of the airport so that they remain compatible with airport operations?
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10. Does the airport take proactive steps to deter incompatible use of lands in the vicinity of the airport so that they remain compatible with airport operations?
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11. Does the airport take proactive steps to restrict incompatible use of lands in the vicinity of the airport so that they remain compatible with airport operations?
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12. Are all the current land uses in the vicinity of the airport over which the airport has jurisdiction compatible with airport uses?
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13. Do you have a copy of the latest approved Airport layout plan(ALP)?
....

14. Is the airport layout plan kept current ?
…..

15. Are all airport developments in conformance to the approved airport layout plan?

1) Yes 2) No.

If no, why?
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………………………………

16. Has non-conforming developments been reviewed and approved by the KCAA/KAA?
………………………………………………………………………………………………
………………………………………………………………………………………………
………………………………………………………………………………………………
………….

17. Is all dedicated airport land being used for the purpose intended by the grant agreement (title) ,i.e Aviation purposes?
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18. Do obstructions exist and are they documented ?
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19. Are obstructions under your control mitigated?

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20. For obstructions under you control, do you take action with the property owner to control them?
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21. For obstructions under you control, do you take action with the property owner to mitigate them?
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22. For obstructions under you control, do you take action with the property owner to eliminate them?
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23 Have plans for obstruction removal /mitigation been implemented?
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24. Are all existing reportable obstructions (natural or manmade) reflected on the Airport master plan?
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25. Do you have land uses off airport property that create any of the following compatibility concerns?

a) Land uses that attract wildlife.
b) Land uses that create visual obstructions
c) Tall structures

d) Noise-sensitive land uses other than residential
e) Residential developments
f) Concentrations of people

26. Do you have any formal land use compatibility plans for the area surrounding the airport?

1) Yes 2) No.

If yes what type?
....
....
....
....

27. What is regulated by zoning or other land use regulations?
a) No airport-specific zoning/land use regulations.
b) Concentrations of people.
c) Residential or other noise-sensitive land uses
d) Height/tall structures.
e) Visual obstructions
f) Wildlife attractants
g) Other

28. Do you have noise contour map? a) Yes b) No.

29. (a) Do you have a noise compatibility program in place?
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....
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b) Has it been helpful in addressing land use compatibility?
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……………………………………………………………………………………………
30. What proposals would you recommend for sustainable physical development of Malindi Airport?
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……………………………………………………………………………………………

THANK YOU

Appendix B: Developers Neighborhood Questionnaire

UNIVERSITY OF NAIROBI

DEPARTMENT OF URBAN AND REGIONAL PLANNING

LAND USE COMPATIBILITY FOR SUSTAINBALE PHYSICAL DEVELOPMENT OF MALINDI AIRPORT

INTERVIEW SCHEDULE - Developers (Neighborhood) Questionnaire

Questionnaire No. ………………Name of Interviewer………………………………

Telephone No…..…………………………………

Declaration:

Plot No/L.R No. . ……………… Land use ……………… Date of Interview ………

Questionnaire No. ………………………… Name of Interviewer ……………………

Location …………………………………… Sub-location …………………………………

1. Name of development/ investment.
   …………………………………………………………………………………………
   …………………………………………………………………………………………
   ………………………………

2. Type of investment/Development.
   …………………………………………………………………………………………
   …………………………………………………………………………………………
   ………………………………

3. When did you first establish your investment/development in this area?
   …………………………………………………………………………………………
   …………………………………………………………………………………………
   ………………………………

4. What factors attracted you in this area? (tick where applicable)
   a) Proximity to the Malindi Airport
   b) Proximity to road transport
   c) Availability of market
   d) Availability of land
   e) Availability of resources/labor
   f) Any other (specify)

5. Typology of the house
   i) Bungalow ii) Maissonettes
   iii) Flats /apartments iv) Any other (specify)

6. What is the type of land tenure for your property?

   1) Freehold
   2) Leasehold
   3) Public land
   4) Community land
   5) License/ Rental
   6) Squatter
   7) Others(specify)

7. What is the use?
   1) Agriculture
   2) Educational
   3) Commercial
   4) Residential
   5) Industrial
   6) Public Purpose (Specify)
   7) Public Utility
   8) Recreational

8. How does Malindi Airport contribute positively to your development?
   ……………………………………………………………………………………
   ……………………………………………………………………………………
   ……………………………………………………………………………………
9. How does Malindi Airport negatively affect your development?
   a. Noise
   b. Safety
   c. Over light
   d. Height limitations
   e. Air pollution
   f. Water pollution
   g. Others (specify)

10. Are you aware of when it is necessary to submit development proposal to KCAA/KAA/County Government?

    a) Yes b) No

11. Has KCAA/KAA/ County Government approval been obtained before development ?(Tick where applicable)

    a) Yes b) No.

12. Has KCAA/KAA approval been obtained before buying the property? (Tick where applicable)

    a) Yes b) No.

13. Are there any special conditions included in your grant (title)?
....
....
If so, have you complied with the special conditions? 1) Yes 2) No.

14. If no, why not?
....
....
....
....

15. What do you intend to do about it?..

THANK YOU

Appendix C: Interview schedule –Malindi County Government

UNIVERSITY OF NAIROBI

DEPARTMENT OF URBAN AND REGIONAL PLANNING

LAND USE COMPATIBILITY FOR SUSTAINBALE PHYSICAL DEVELOPMENT OF MALINDI AIRPORT

<u>Interview schedule –Malindi County Government</u>

Declaration: *This information is confidential and it will be used purely for plan preparation purpose only.*

1. Respondent name…………………………………………..Tel.No…………………….
2. Title of Job ……………………………………………………….
3. Duties of the officer/ Department ………………………………
4. Is there an existing physical development plan for Malindi Airport and the immediate environs? i) Yes ii) No.

5. When was it prepared?

6. Has it been implemented? i) Yes ii) No.

7. If no, why?
....
....

8. What are the requirements for physical development within the vicinity of the Airport?

9. Has your airport agency (KAA) worked with the municipal council to address short and long –term airport and community land use plans and regulations?

   i) Yes ii) No.

10. If yes, which issues have you jointly prepared or been involved with? Select all that apply
    i. Airport land use compatibility
    ii. Airport Master Plans
    iii. Economic Development
    iv. Others(Please specify)

11.Is Malindi Airport been designated as essential public facility in Malindi Physical Development Plan?

i)Yes ii) No iii) Unsure

12. If so, do the goals and policies address (select all that apply):

i. Noise
ii. Height Hazards
iii. Safety(Type of land use, density and intensity of use)
iv. Economic Development

13.Has your county or municipal adopted land use regulations, such as an Airport Overlay Zone, that address compatible land uses adjacent to airports

1)Yes 2) No 3) under development 4) Unsure.

14. If so, do land use regulations address (select all that apply):

i. Noise
ii. Height Hazards
iii. Safety(Type of land use, density and intensity of use)
iv. Economic Development

15.Does your Municipal require development adjacent to airports to convey navigation easements?

1) Yes 2) No 3) under development 4) Unsure

16. Does your Municipal require notice and acknowledgement to Purchasers (Airports, Aircraft Operations and Noise Disclosure)?

1) Yes 2) No 3) under development 4) Unsure

17. Has your Municipal adopted and implemented a specific Airport compatibility program for Malindi Airport?

1) Yes 2) No 3) Under Development 4) Unsure

18. If so, what criteria are used to determine compatibility?)

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…………………………………………………………………………………………………
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19. Are there other Municipal Jurisdictions affected by the operation of the Airport?

1)Yes 2) No. 3) Unsure

20. If so, how did you coordinate with these jurisdictions?)

For the following questions, please rate your plans and policies as (1) through (4) based on their effectiveness according to the following:

(1) Ineffectiveness,
(2) Low level of effectiveness,
(3) Medium level of effectiveness, and
(4) Highly effective.

21. How effective do you believe your compatibility plan is at accomplishing the goals of providing for compatibility land uses around the airport?

(1) Ineffective
(2) Low level effectiveness
(3) Medium level effectiveness
(4) Highly effective.

22. If you feel it is ineffective or at a low level of effectiveness, why is it so? Select all that apply

(1) Lack of enforcement
(2) Lack of understanding
(3) Lack of incentives
(4) Lack of penalties for non-compliance
(5) Inappropriate criteria for determining compatibility
(6) Lack of coordination between institutions
(7) Others(Please explain)

23. How effective do you believe your policies are at accomplishing the goals of providing for compatibility land uses around the airport?

(1) Ineffective
(2) Low level effectiveness
(3) Medium level effectiveness
(4) Highly effective.

24. If you feel it is ineffective or at a low level of effectiveness, why is it so? Select all that apply

(1) Lack of enforcement
(2) Lack of understanding
(3) Lack of incentives
(4) Lack of penalties for non-compliance
(5) Inappropriate criteria for determining compatibility
(6) Lack of coordination between institutions
(7) Others(Please explain)

25. How effective do you believe your land use regulations are at accomplishing the goals of providing for compatibility land uses around the airport?

(1) Ineffective
(2) Low level effectiveness

(3) Medium level effectiveness
(4) Highly effective

26. If you feel it is ineffective or at a low level of effectiveness, why is it so? Select all that apply

(1) Lack of enforcement
(2) Lack of understanding
(3) Lack of incentives
(4) Lack of penalties for non-compliance
(5) Inappropriate criteria for determining compatibility
(6) Lack of coordination between institutions
(7) Others(Please explain)

27. What are the major land-use planning problems facing Malindi Airport?

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28. What are the current mitigation measures against the land use problems at Malindi airport?

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29. What are the proposed mitigation measures against land use problems at Malindi airport?

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30. What proposals do you recommend for the sustainable physical development of Malindi Airport?

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………………………………………………………………………………………………
………………………………………………………………………………………………

THANK YOU

Appendix D: Land Acquisition Act (CAP 295)

KENYA GAZETTE NOTICE NO. 6404 OF 25TH OCTOBER,1999

Reg. No	Dam Contractor	Address
DB500/124	Skanska International	P.O. Box 61468, Nairobi.
DB500/142	Ministry of Water Resources	P.O. Box 30521, Nairobi.

K. G. CHESANG,
Director of Water Development.

GAZETTE NOTICE No. 6404

THE LAND ACQUISITION ACT

(*Cap.* 295)

THE MALINDI AIRPORT EXPANSION

INTENTION TO ACQUIRE LAND

IN PURSUANCE of section 6 (2) of the Land Acquisition Act, the Commissioner of Lands gives notice that the Government intends to acquire the following land for Malindi Airport expansion.

L.R. No.	*Locality*	*Registered Owner*	*Area to be Acquired in Hectares*
5257	Malindi	Industrial & Commercial Development Corporation	4.00
5780	Malindi	Cooper Motor Corporation	1.20
7556	Malindi	Philemon E. Mwaisaka	2.00
7555	Malindi	Philemon E. Mwaisaka	2.00
8411	Malindi	Philemon E. Mwaisaka	0.3988
9611	Malindi	Philemon E. Mwaisaka	0.4674
9610	Malindi	Philemon E. Mwaisaka	0.4674
8561	Malindi	Mombasa Holidings	2.00
8330	Malindi	Mombasa Holidings	0.9192
10139	Malindi	Lamu Breeze Investments Limited	0.4937
10506	Malindi	Lamu Breeze Investments Limited	0.694
10013	Malindi	Lamu Breeze Investments Limited	0.3915
1731/1	Malindi	Alfonse Saldamber and others	0.4051
1911	Malindi	Abubakar Bin Ahmed Bawazir	0.081

A plan showing the affected lands may be inspected during office hours at the office of the Commissioner of Lands, Ardhi House, Nairobi, or at the Mombasa Land Registry.

Dated the 25th October, 1999.

WILSON GACANJA,
Commissioner of Lands.

GAZETTE NOTICE No. 6405

THE KENYA POWER AND LIGHTING COMPANY LIMITED

SCHEDULE OF TARIFFS AND RATES, 1999, FOR SUPPLY OF ELECTRICITY

FUEL COST ADJUSTMENT

PURSUANT to clause 1 of part III of the schedule of tariffs and rates, 1999, notice is given that all prices for electrical energy specified in part II of the said schedule will be liable to a fuel cost adjustment of plus 97 cents per kWh. for all meter readings taken in November, 1999.

INFORMATION USED TO CALCULATE THE ADJUSTMENT

Power Station	*Fuel price in KSh./Kg. (Ci) in October, 1999*	*Variation from September, 1999 prices KSh./Kg. Increase (Decrease)*	*Units in kWh. (Gi)*
Kipevu Thermal	11.96	0.70	22,621,000
Kipevu Diesel	11.74	1.07	39,584,000
Kipevu Gas Turbine (I & II)	25.48	2.39	35,553,000
Kipevu Barge Mounted Gas Turbine	—	—	—
Nairobi South Gas Turbine	37.95	0.00	3,234,500
Nairobi South Diesel	17.24	0.17	26,969,400
Ruiru Diesel	—	—	—
Garissa Diesel	25.54	(0.19)	472,225
Lamu Diesel	34.25	0.00	365,915

Appendix E: The Civil Aviation Act (CAP 394)

LEGAL NOTICE NO. 60 OF 21st APRIL ,1998

PART IV

MALINDI AIRPORT

Sector One (Approach Funnel)

Construction of all structures is prohibited in the following areas except with the approval of the Director of Civil Aviation.

1. All that area in the vicinity of Malindi Airport containing runway 17/35 and bounded by straight lines joining the following co-ordinates:

(*a*) Longitude: 40° 05′ 42″E
Latitude: 03° 11′ 00″S;

(*b*) Longitude: 40° 06′ 30″E
Latitude: 03° 14′ 55″S;

(*c*) Longitude: 40° 06′ 00″E
Latitude: 03° 15′ 03″S;

(*d*) Longitude: 40° 05′ 12″E
Latitude: 03° 11′ 06″S.

2. All that area in the vicinity of Malindi Airport containing runway 08/26 and bounded by straight lines joining the following co-ordinates:

(*a*) Longitude: 40° 04′ 06″E
Latitude: 03° 13′ 48″S;

(*b*) Longitude: 40° 04′ 12″E
Latitude: 03° 14′ 18″S;

(*c*) Longitude: 40° 07′ 24″E
Latitude: 03° 13′ 42″S.

(*d*) Longitude: 40° 07′ 18″E
Latitude: 03° 13′ 12″S.

3. All that area to the North of Malindi Airport extending 15 km. from threshold runway 17 bounded by straight lines joining the following co-ordinates:

(*a*) Longitude: 40° 05′ 24″E
Latitude:- 03° 03′ 54″S;

(b) Longitude: 40° 05′ 42″E
Latitude: 03° 11″ 00″S;

(c) Longitude: 40° 05′ 12″E
Latitude: 03 11′ 06″S;

(d) Longitude: 40° 02′ 48″E
Latitude: 03° 04′ 24″S.

4. All that area to the South of Malindi Airport extending 15 km. from threshold runway 35 bounded by straight lines joining the following co-ordinates:

(a) Longitude: 40° 06′ 30″E
Latitude: 03° 14′ 55″S

(b) Longitude: 40° 08′ 54″E
Latitude: 03° 21′ 24″S;

(c) Longitude: 40° 06′ 18″E
Latitude: 03° 21′ 58″S;

(d) Longitude: 40° 06′ 00″E
Latitude: 03° 15′ 03″S.

Sector Two

Construction of any structure extending vertically above 25 metres above existing ground level is prohibited in the following area except with the approval of the Director of Civil Aviation.

All that area within a radius of 15 km. centred on the Aerodrome Reference point (ARP) but excluding the portion covered by sector one.

Sector Three

Construction of any structure extending vertically above 30 metres above existing ground level is prohibited in the following area except with the approval of the Director of Civil Aviation.

All that area within a radius of 15 km. centred on the Aerodrome Reference point (ARP) but excluding the portions covered by sector one and sector two.

Note.—The co-ordinates of ARP are:
Longitude: 40° 06′ 00″E
Latitude: 03° 13′ 00″S.

University of Nairobi

Department of Urban and Regional Planning

School of The Built Environment

P.O. Box 30197, 00100 GPO Nairobi, Kenya

e-mail:durp@uonbi.ac.ke

Ref: UON/CAE/DURP/6/8

Date: 3rd March, 2014

TO WHOM IT MAY CONCERN

RE: RASHID A. ABDULLAHI: REG. NO.B63/81347/12

This is to certify that the above named person is a registered MA student in Urban and Regional Planning in this Department, University of Nairobi. He has successfully completed his coursework.

As part of his studies, he is required to carry out research for his thesis entitled **"Land Use Compatibility for Sustainable Physical Development of Malindi Airport."** Any information provided will be handled confidentially for academic purposes only.

Any assistance accorded to him will be highly appreciated.

University Of Nairobi
Department Of Urban and Regional Planning.
Faculty Of Architecture, Design and Development

DR. SAMUEL V. OBIERO
CHAIRMAN,
DEPARTMENT OF URBAN & REGIONAL PLANNING

SVO/ewn