

**Study the compatibility of land uses surrounding international Airports  
(Case Study: Hurghada International Airport)**

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Received: November 13, 2020; Accepted: December 3, 2020 ; Available online December 20, 2020

**ABSTRACT**

This paper presents a framework and analytical studies to evaluate the impacts of airport locations on the surrounding urban area and land uses. This work is based on reviewing the impacts of some international airports on land uses and compared them with those of Hurghada International Airport in Egypt. The description of land use surrounding Hurghada International Airport was obtained from the general strategic plan for Hurghada City in 2015-2027, prepared by the General Authority for Urban Planning (GAUP). Compatibility factors that were used for evaluating the development of land use around airports are generally presented, as well as the criteria of these factors. Two main compatibility factors were applied, namely noise and safety, but the safety factor was applied only from a land-use point of view. The results of the present study indicated that some land uses are incompatible with the noise factor as well as other uses are incompatible with the safety factor in terms of the type of land use. For unused areas, the permitted and prohibited uses are mentioned relative to the location of each area within its safety zone.

**Keywords:** Planning land use, Safety zones; Noise compatibility criteria, Safety compatibility criteria, Hurghada International Airport.

**INTRODUCTION**

There is a mutual effect between airports and the surrounding communities, the researchers agreed that compatible land uses around airports and other several factors affect the operational airport performance (International Conference on Industrial Engineering and Operations Management, 2016). If a compatible land use plan for any airport does not exist, this will lead to incompatible land use around, as is the case in most of Egyptian airports. Unfortunately, there is no land use compatibility plans for the Red Sea Governorate's airports, which indicates to incompatibility land uses around that negatively affects the airport's operating capacity, as well as surrounding area's safety. The coordination and cooperation

absence between regional planners and the Airport Land Use Committee (ALUC) causes missing in Red Sea Governorate's airports land use compatibility plans. Likewise, regional planner's information absence about the concept, criteria and properties needed for determining the types of land uses around Egyptian airports, especially Red Sea Governorate's airports. To establish land use compatibility plans around Red Sea Governorate's airports it is necessary to study the current and future land uses based on the global criteria used. The land uses compatibility around Red Sea Governorate's airports are evaluated by studying a number of fields, namely: The first important field is the negative environmental impacts of the airport on its

surroundings and in particular, the impact of aircraft noise; and these negative uses cause impacts on the efficiency of airport operations, so it should be banned; Finally, the most important field that needs careful consideration is safety, which has direct physical impacts on aircraft as well as on people. In addition, long structures are one of the most dangerous elements affecting the safety of aircraft and people. This paper aims to establish Airports Land Use Compatibility Plans (ALUCP) to ensure compatible land uses around these airports.

### METHODOLOGY

This research is based on theoretical profound analysis that developed a framework and analytical studies to investigate impact of airport's locations on surrounding urban context and land uses types. The theoretical framework further refined based on reviewing some international case's studies results. This work discussed some airport's definitions, types of civil airports and identification of each type, the effect of airports on surrounding areas, and urban planning around airports and development. Also, the research presented types of land uses around airports and Compatibility factors that affect development of land use compatibility planning around airports. Finally, the proposed framework was applied on Hurghada International Airport as a case study.

### RESULTS AND DISCUSSION

#### 1. Land use planning surrounding airports

##### 1.1 Overview

Airports are unique facilities because they have unique locations requirements and produce noise which impact neighboring communities. Land use around airports are generally determined by Federal Aviation Administration (FAA) design and safety standards (FAA, 2004) which enforced by airport sponsor. Land use plan around is essential part of airports master plans and

integral part of area wide comprehensive planning program. Airports become involved in two types of zoning: First type is height and hazard zoning and the second type is land use zoning (Ms. Jacqueline, 2015).

#### 1.2 Airport definitions

Sustainable development planning land use: The meaning of sustainable development of planning land uses around airports, are a wide concept of planning that takes into consideration the economic, social, commercial and environmental planning of the local community. Also, it is not limited to urban planning only (Robert, 2009).

Compatibility factors: Are the factors that affect planning land uses around airports and include Noise compatibility; Safety compatibility; Airspace protection and Overflight (Caltrans, 2002).

Safety zones: The zones that are using for evaluating safety compatibility of planned land uses around each airport (DTOA, 2013).

Noise compatibility criteria: Are the noise levels for specific types of land use and it was established to prevent the development of noise-sensitive land uses in portions of the airports environ that are exposed to significant levels of aircraft noise (El Dorado Country Airport, 2012).

Safety compatibility criteria: Is the safety zone land use compatibility standards that restrict the development of land uses that could pose particular hazards to the public or to vulnerable populations in case of an aircraft accident, (Monterey Regional Airport, 2019).

Civil airport imaginary surfaces: The civil airport imaginary surfaces are established for each runway within the airport, the dimensions and slopes for each imaginary surface are based on the runway category and approach type. The purpose of

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establishing imaginary surfaces is to keep the aircraft operations safe (USAF, 2012).

Airport Land Use Compatibility Plan (ALUCP): Is a guidance document for the regulation of land uses around civil airports, it is prepared for the areas around airports, and it includes division of regions and the type of uses that do not conflict with the airport and do not affect its operational efficiency. It must be approved by the responsible authorities, and be updated successively (Caltrans, 2002).

Airport Influence Area (AIA): It is an important part of ALUCP. AIA is the area in which existing or future airport-related noise, overflight, safety and/or airspace

### 1.4 The effect of airports on surrounding areas

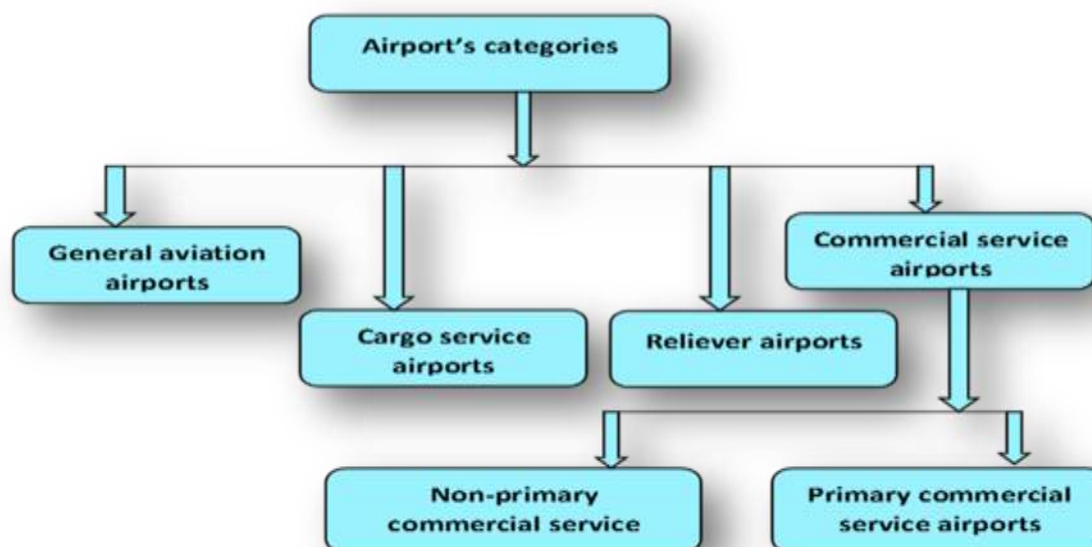
Area surrounding international airports is closely linked to the presence of the airport. These airports often become full-fledged economic and urban hubs within their metropolitan area. Airport areas are areas that their destiny linked to the presence of an international airport and the sustainable development of these airports faces main four challenges as shown in Figure (2) (SAA, 2018), Thus, all areas around airport are engaging in multiple interactions with their airports. Some of these interactions are positive: For instance, the airport activity generates economic benefits for the surrounding areas in terms of jobs, local taxes, famously, transportation network, etc. Conversely, airport activity also generates external negatives on surrounding

protection factors may significantly affect land uses or necessitate restrictions on those uses (Caltrans, 2002).

### 1.3 Types of civil airports and identification of each type

FAA classified airports by activities type as Commercial Service, Primary, Cargo Service, Reliever, and General Aviation Airports as shown in Figure (1). Five new categories for airports serving general aviation (includes non-primary commercial service, relievers and general aviation) were developed by FAA based on existing activity levels. The five new categories for airports were reported in Table (1) (FAA, 2019).

environment in terms of air and noise pollution, traffic congestion, agricultural land consumption, urban development, etc. Areas around airports are facing many challenges which need to be tackled on its regional scale. In view of all these challenges, airport authorities and local decision-makers around the world feel the need to obtain and share experiences and good practices with their peers from other countries, to develop their own airport areas in much more sustainable way (SAA, 2018). In 2015, the World Association of Major Cities (Metropolis) launched an initiative titled "Sustainable Airport Areas" by the Institute of Planning and Development of the Île-de-France Region (IAU). This initiative aims to create common ground of good practices related to airport areas sustainable development.



**Fig. 1: Airport categories by type activities according to FAA's**

Table 1: Airport categories by type activities according to FAA's current classification

No	Airport's categories	Definition of airport categories	Hub type
1	Primary commercial service airports	Airports that have more than 10,000 annual airlines passenger enplanements.	(Large– Medium - Small) Hub – Non hub
2	Non-primary commercial service airports	Airports that have annual airline passenger enplanements more than 2500 and less than 10000.	Non hub
2	Non-primary commercial service airports	Airports that have annual airline passenger enplanements more than 2500 and less than 10000.	Non hub
3	Reliever airports	Airports designated by the FAA to relieve congestion at commercial service airports and to provide improved general aviation access to the overall community.	-----
4	Cargo service airports	Airports that providing air transportation of cargo with total annual landed weight more than 100 million pounds.	-----
5	General aviation airports	Airports are public use airports that do not have scheduled service or have less than 2,500 annual airline passenger enplanements.	-----
5.1	National aviation airport	Airports support the national and state system by providing communities with access to national and international markets in multiple states and throughout the country.	-----
5.2	Regional aviation airport	Airports that support regional economies by connecting communities to statewide and interstate markets.	-----
5.3	Local aviation airport	Airports supplement communities by providing access to primarily intrastate and some interstate markets.	-----

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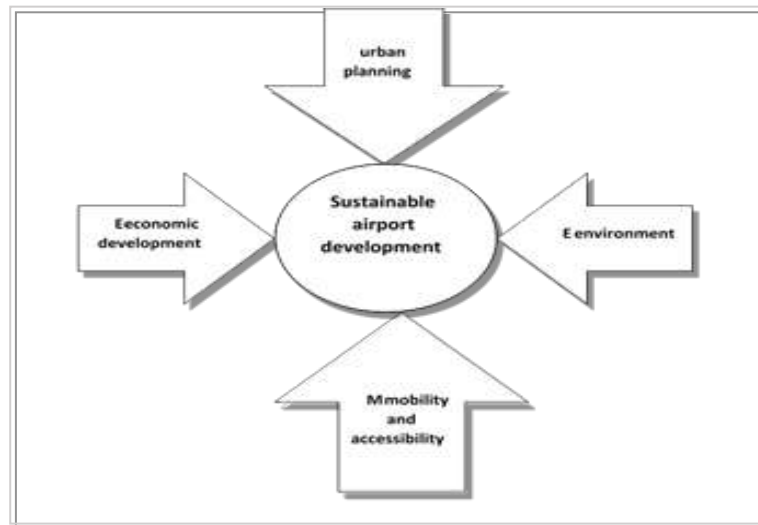


Fig. 2: Main four challenges for sustainable airport development (source: (Source: Institut d'a management Et' Urbanisme)

### 1.5 Urban planning around airports and sustainable development

#### 1.5.1 General

Urban planning around airports may not solve all the negative effects result from the airport activities but, it can help find a balance and determine the means for the realization of specific urban projects. Airport-centered urban development assumes different spatial forms, according to geographical position, economic development and business approach of airport operators. The main models or concepts of any airport related growth include: Airport City, Aerotropolis, Airport corridor and Airport Region as shown in Figure (3) (Île-de-France Region (IAU, 2014;Tim, 2014).

#### 1.5.2 Integrate the development of airport area international/regional strategic planning

To achieve this integration, the following recommendations must be taken into account (SAA, 2018):

- The airport area must be defined according to the development of the other metropolitan centers in the region.
- Urban development strategies of airport area must be brought into line with the regional transport policy to increase attractiveness of the whole region.
- It is important to Switch from fragmentation to integration of the airport area.

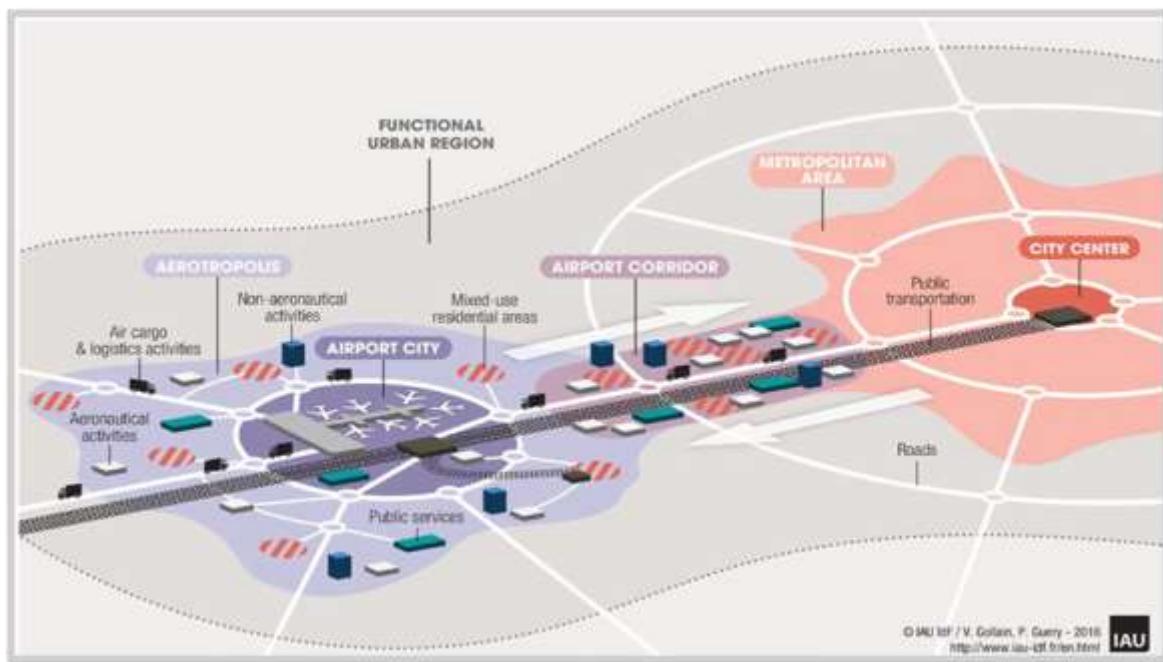


Fig. 3: Airport-centered urban development special forms. Source: Institut d'a management Et' Urbanisme)

### 1.5.3 Dynamic, flexible and adaptable urban planning

The airports have to adopt flexible dynamic approach allowing fast adaptation to the changing situations. Now a new strategic planning is being adopted worldwide. This forward-thinking strategic planning is dynamic, flexible, adaptable and offering a range of restricted options to achieve sustainable development to limit the unreasonable irreversible urbanization. Governance involving participation of local stakeholders is a key element for finding a sustainable urban development balance in the airport area. Dynamic strategic planning could be easily adjusted and modified over the time to actual conditions, in order to avoid negative situations. It defines flexible development over multiple levels but commits only the first stage, suggesting different options in the subsequent development stages. The future sustainable development plan has to be adaptable to a range of possible futures (Kwakkel *et al.* 2010).

### 1.5.4 Sustainable mobility and reliable multi-modal infrastructures

Mobility and transportation access are some of the main urban planning issues encountered in any airport areas around the world. Transport infrastructure is the necessary condition allowing the area development. Compact urban planning combined with Extensive urban planning based entirely on road access as well as recent massive passenger growth, have led to congested roads in many international airport areas (Tim, 2014). Compact urban planning combined with well dimensioned land use program are key elements allowing the development of public transportation in the airport area. A balance between metropolitan and local issues has to be achieved as well. The global transportation offer in the airport area has to take in consideration the existing network specificities, including all types of passenger groups from air-passengers to workers on staggered hours. After establishing a coherent transportation network, it is also important to develop a policy to discourage the use of personal parking at the airport (Tim, 2014).

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### **1.5.5 Spatial coherence and selective economic development of the airport area**

Airport areas are often regional selective urban development. Aviation organizing and activities variation are important for visibility and competitiveness of the entire airport area. Choosing selective growth on a high level is a key action allowing further development as well as reduction of the environmental impact. Many factors have to be considered while applying eclectic methods on the scale of the airport area: Analysis of located activity type, airport platform adjacent to the neighbor city as well as the public transport services and the traffic jams risk. It is also important to limit similar activities offer because they do not allow the achievement of qualitative economic performance (Tim, 2014).

### **1.5.6 Land is a scarce resource**

Airport areas are very attractive regions for economic development. However, air transport is the main function of airports and this function does not have to be corrupted through unreasonable land use. The fast growth of the airport areas has to be carefully framed to avoid the irreversible and unsustainable occupation of precious land. Natural and agricultural land is real richness and has to be considered an important heritage to preserve. The control of the land consumption can be achieved through reversible urban development allowing mutability of different zones: Activities, transport infrastructures, wasteland, residential...etc. The future model should not only integrate the creation of new activity zones but also the transformation of the existing ones and their requalification and clustering.

### **1.5.7 Design of the airport city as a mixed-use city**

Urban planning and design of airport cities must be accurate and flexible. Often perceived as “no-man’s land”,

airport areas are unattractive for living. There is a lack of urban amenities and services in these areas. Attractive housing must be existed into airport city to bring real inhabitants. Provision of appropriate street patterns, connectivity, and allocation of open spaces are main elements for succeeding in the transformation of the airport city to a real city (Tim, 2014).

## **2. Land uses surrounding airports and compatibility factors**

### **2.1 Overview**

The compatibility of airport land uses is important to both the local government and the airport. Ensuring this compatibility requires understanding how an airport functions and how it can impact or be impacted by the community that surrounds it. These resources help local governments, airports to understand their roles and offer ideas for compatible development (American Planning Association, 2010).

### **2.2 Compatible and incompatible land uses around airports**

#### **2.2.1 Airport compatible land uses**

Airport-compatible land uses are defined as 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 hazards (American Planning Association, 2010).

#### **2.2.2 Airport incompatible land uses**

All uses that are negatively affected by the presence of airport as a result of noise aircraft and unsafe uses as a result of exposure to aircraft accidents. Also, uses that have negatively impact on operational efficiency of airport (American Planning Association, 2010), (Federal Aviation Regulations, 2004),

- **Sensitive land uses:** It might a building, amenity area and outdoor space which use

For normal activities occurring at reasonable times. A sensitive land use may include: One or a combination use either residences or facilities where people sleep (e.g. single and multi-unit dwellings, nursing homes, hospitals, trailer parks, camping grounds, etc.), these uses are considered to be sensitive 24 hours/day; Permanent structure for non-facility related use, particularly of an institutional nature (e.g. schools, churches, community centers, day care centers); Certain outdoor recreational uses considered by a municipality or other level of government to be sensitive (e.g. trailer park, picnic area, etc.); and Certain agricultural operations considered as sensitive land use (e.g. cattle raising, mink farming, cash crops, orchards bird and wildlife habitats or sanctuaries).

- **Hazard land uses:** All uses that represent greatest threats to aviation in the airport Environment and also, that uses which have caused specific problems around airports (AC14-018, Civil Aviation Authority, Ghana, 2015) include Fish processing; Agriculture; Cattle feed lots; Garbage dumps and landfill sites; Factory roofs and parking lots; Theatres and food outlets; Wildlife refuges; Artificial and natural lakes; Golf- polo-courses; Animal farms; and Slaughter-houses. Lights that shine upward, such as those found in commercial areas or parking lots, are potentially hazardous since they can detract from a pilot's ability to identify an airport at night.

### 2.3 Types of land uses around airports

There are many types of land uses around airports for example (Residential land uses, Commercial land uses, Industrial land uses, Commercial and Industrial land uses, Public land uses, Recreational land uses, Natural land uses, Agricultural land uses, Highways and Railways land uses ...etc.) ,(Federal Aviation Regulations, 2004).

## 2.4 Compatibility factors

### 2.4.1 Overview

Compatibility between an airport and its environs must be evaluated in terms of four factors: Noise, overflight, Safety, and airspace. This section provides a general description of the compatibility factors and describes how they have been applied at any International Airport. Assessment of each of these factors is based principally upon the guidance contained in the Airport Land Use Planning Handbook.

### 2.4.2 Noise

**Noise and noise exposure:** Noise is defined by the World Health Organization (WHO) as unwanted sound. Physically, there is no difference between sound and noise. In the majority of cases noise is an annoyance and inconvenience affecting people's quality of life. Noise is one of the most basic airport land use compatibility concerns. It is the factor that typically receives the majority of attention (WHO, 2011). For the purposes of airport land use compatibility planning, noise generated by the operation of aircraft

To, from, and around an airport is primarily measured in terms of the cumulative noise levels of all aircraft operations. It is helpful to conceptualize the effects of noise by considering them in three groups: health effects, amenity effects and productivity and learning effects, as summarized in Figure (4).

### 2.4.3 Safety

Safety is in many respects a more difficult concern to address in airport land use compatibility policies than noise. A major reason for this difference is that safety policies address uncertain events which may occur with occasional aircraft operations, whereas noise policies deal with known, generally predictable events which occurs with every aircraft operation. Because aircraft accidents rarely happen and the time, place, and consequences of their occurrence cannot be predicted, the



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concept of risk is central to the assessment of safety compatibility. Safety criteria are defined in three ways. The FAA's Airport Design advisory circular (AC 150/5300-13) contains land use policies for runway protection zones.

### 2.4.4 Overflight

Overflight impacts are a combination of single-event noise impacts (e.g., speech interference or sleep disturbance) and the subjective experience of annoyance. At many airports, complaints often come from outside the noise contours. Indeed, heavily used flight corridors to and from metropolitan areas are known to generate noise complaints 50 miles or more from the associated airport. The new industries use one of the two strategies depending on the current pattern of development. First strategy, where airport's environs are free of sensitive uses (e.g., residences) and not already committed to this type of development, compatibility policies will favor retention of the non-sensitive uses (e.g., agriculture, industrial). Second strategy, where areas subject to overflights are already developed or are committed to sensitive uses, compatibility policies will favor a high-low strategy. The purpose of the

airspace protection policies is to ensure that structures and other uses do not cause hazards to aircraft in flight in the airport vicinity. Avoiding aircraft accidents caused by land use conditions could be achieved by committing land use safety compatibility around airports. The particular hazards of concern are: Airspace obstructions, wildlife hazards, particularly birds strike; and Land use characteristics which pose other potential hazards to flight by creating visual or electronic interference with air navigation (Federal Aviation Regulations, 2004),

### 2.4.5 Airspace protection

The purpose of the airspace protection policies is to ensure that structures and other uses do not cause hazards to aircraft in flight in the airport vicinity. Avoiding aircraft accidents caused by land use conditions could be achieved by committing land use safety compatibility around airports. The particular hazards of concern are: Airspace obstructions, wildlife hazards, particularly birds strike; and Land use characteristics which pose other potential hazards to flight by creating visual or electronic interference with air navigation (Federal Aviation Regulations, 2004).

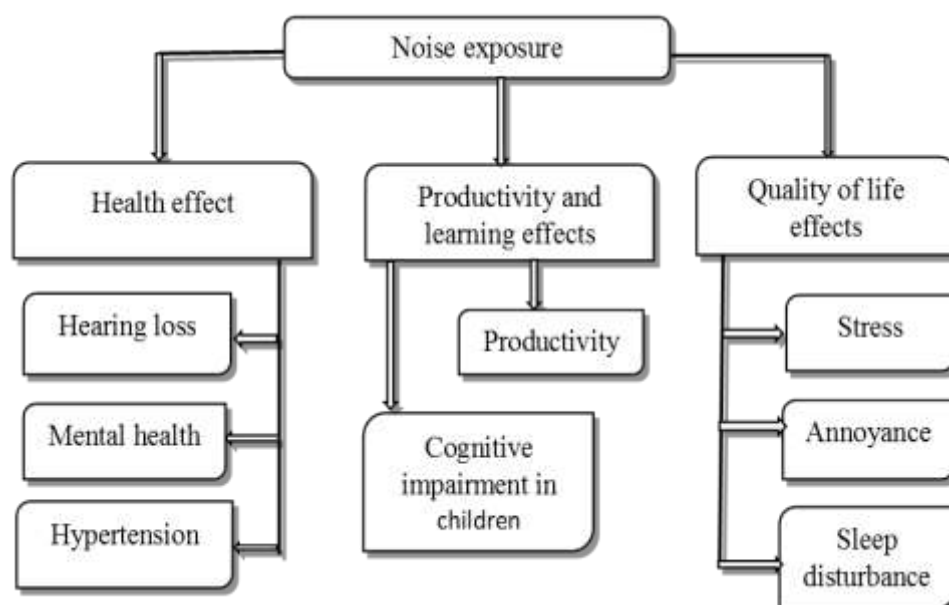


Figure 4: Summary effect of noise (source Airports Commission adapted using WHO, 2011)

## Applied case study- Hurghada International Airport

### 1. Overview

The Red Sea Governorate is considered one of the largest Egyptian governorates in terms of area. It is located on the coast of the Red Sea between latitudes 22 ° and 29 ° north and its length facing the coast about 1100 km and width between 80-350 km. The area of Red Sea Governorate is 203,685 km<sup>2</sup>. Red Sea Governorate has a wonderful coast that is a very important tourist element (The Red Sea Governorate, 2017). The Sea Governorate has many airports were collected (MiNTS, 2012), and listed in Table (2); shows the location of these airports. HRG is located in Hurghada Air Base, which has area of 2184945279 m<sup>2</sup>, 5 km (3 miles) southwest of the downtown of Hurghada City (El Dahar district).

No.	Red Sea Governorate Airports	Location	IATA Code	ICAO Code	Notes
1	Hurghada International Airport	Hurghada	HRG	HEGN	International
2	Marsa Alam International Airport	Marsa Alam	RMF	HEMA	B.O.T
3	El Gouna Airport	Hurghada	-----	HEGO	Private Airport
4	Baranis International Airport	South of Marsa Alam	-----	-----	Civil + Military
5	Ras Shokeir New Airport	Ras Shokeir	-----	-----	New

Table 2: List of Red Sea Governorate's airports in the (Source: Airport Information Technology)

### a. A summary of facilities found at HRG airport

A summary, of facilities include location, traffic pattern, ownership, operation, geometrical information about

Figure 5 shows the property boundary of HRG.

### 2. Hurghada International Airport (HRG)

HRG is located inland, 5 km southwest of the downtown of Hurghada City (El Dahar district), the location of HRG is at AD: 27.180381 N 33.807683 E Mid-Point of runway 34/16 on CL. It is located south of the city from the north (Hurghada) and south (Hotels Zone). The main take off /landing direction for HRG is from 34 to 16 and it is opened 24hrs, HRG is owned and operated by Egyptian Airports Company (EAC). It receives about 8062645 passengers per year from different nationalities. It is operated to receive different kinds of aircrafts types (Heavy - medium - light) & HRG services more than 40 airlines of different nationalities (DAFIF, 2019).



Figure 5: Property boundary of HRG airport (Source: Satellite image)

both airside and landside, available existing navigational aids/systems and weather and control aids at HRG airports were summarized in Table (3) after (AIP, 2018).

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**Table 3. Summary of facilities found at HRG airport.**

No.	Summary of facilities				
1	Ownership	Egyptian Airports Company (EAC)			
2	Airport Type – Operating Time	Public - 24 Hour Operations			
3	IATA Code	HRG			
4	ICAO Code	HEGN			
5	Elevation AMSL	52 ft / 16 m			
6	No. of Paved Runways	Two (Runway #1- Runway #2)			
7	Runway #1	Direction	Length	Width	Surface
		34L/16R	4000 m	60 m	Asphalt
8	Runway #2	34R/16L	4000 m	60 m	Asphalt
9	Traffic pattern	34L- Left /16R- Right and 34R- Right /16L- Lift			
10	Runway Code Number	Runway #1: (4) - Runway #2: (4)			
11	Visual approach of RWYs & Critical Aircraft	Visual not lower than 1-Mile (1 600 m), All Jets Category "D"			
12	Runways Navigation Aids				
	Runway#1 Approach Type	Precision Runway Instrument- Category 4-I and Instrument Landing System- ILS (RWY34)			
	Runway#2 Approach Type	Precision Runway Instrument- Category 4-I and Instrument Landing System- ILS (RWY34)			
13	Weather and Control Aids of Airport	Items	Condition		
			Yes	No	
		Limited Aviation Weather Reporting Station (LAWRS)	√		
		Lighted Wind Cone	√		
		Airport Traffic Control Tower (ATCT) – (Fully Equipped)	√		
	Automated Surface Observing System (ASOS)	√			
14	Airport Navigation Aids	Runway Edge Lights - High Intensity	√		
		Runway Markings (Good)	√		
		Non- Direction Beacon (NDB)	√		
		HIRL HIALS PAPI (3.0°)	√		
		RNAV (RWY34) and (RWY16)	√		
	DME/VOR (RWY34 and 16)	√			

**b. Existing and future land uses around HRGairport**

The General Authority for Urban Planning (GAUP) adopted the project of preparing the general strategic plan for Hurghada City in 2015 until 2027, the detailed strategic plan for Hurghada City, which illustrates the future land use planning until 2027 as shown in Figure 6.

**c. Compatibility Factors**

Airport's compatibility factors include following factors: Noise; Safety; Overflight and Airspace protection (EEAA, 1994), This part focus on compatibility between HRG airport and its environs during studying these three factors: Noise; Safety; and Airspace protection.



Fig. 6. Existing and future land uses around HRG airport

#### i. Noise

**Noise compatibility criteria:** According to the executive regulation of the Environmental Law No. 4 of 1994, the permissible limits of sound intensity and safe exposure periods were determined and listed in Table (4). Also, the Egyptian Environmental Affairs Agency recommended noise limits in different places of productive activities as listed in Table (4) (Mustafa *et al.*, 2007).

The land uses or activities mentioned in the Egyptian Environmental Law No. 4 of 1994 are limited and not enough for all uses that could be around

Egyptian airports. The Egyptian Laws related to Civil Aviation include: Civil Aviation Law No. 28 of 1981 and its executive 1/T for 1989; Law 92 of 2003; and Law 136 of 2010 amending some articles of the Civil Aviation Law. All these laws did not precisely determine the noise level compatible with land uses around Egyptian airports, which are compatible with the Egyptian Environmental Law No. 4 of 1994, as well as the requirements of the International Civil Aviation Organization (ICAO). The aircraft noise is defined in the law Civil

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Aviation Law No. 28 of 1981 and its executive 1/T for 1989 in Article 30. Table (6) was elicited from Tables 3 and 4, with title "Land-use compatibility with the

noise levels around Egyptian airports". This table is compatible with the Environmental Law No. 4 of 1994 and as well as the requirements of ICAO.

Table 3: Maximum permissible noise levels inside places of productive activities.  
Source: EEAA, 1994

Ng.	Place and Activity	Maximum Allowable Sound Level (dB)
1	Work premises with up to 8-hour shifts.	90
2	Places of work that require hearing signals and good audibility of speech.	80
3	Places of work with computers or typewriters or similar equipment.	70
4	Places of work for the follow up, measuring and adjustment of operations, with high performance.	65
5	Places of work for activities that require routine mental concentration.	60

Table 4: Maximum permissible limits noise intensity in different place activities. Source: EEAA, 1994

Ng.	Types of place activity	Permissible Limits for Noise Intensity (dB)					
		Day		Evening		Night	
		Min.	Max.	Min.	Max.	Min.	Max.
1	Heavy industrial areas.	60	70	55	65	50	60
2	Commercial, administrative, and downtown area.	55	65	50	60	45	55
3	Residential areas including some workshops or commercial businesses on public roads.	50	60	45	55	40	50
4	Residential areas in the city.	45	55	40	50	35	45
5	Residential suburbs having low traffic flow /Rural residential areas.	40	50	35	45	30	40
6	Hospitals and gardens.	35	45	30	40	25	35

Table 5: Land-use compatibility with the noise levels around Egyptian airports Source: The Egyptian Environmental Law No. 4 of 1994 and Elicitations of Researcher.

Types of land uses	Noise level (dB)			
	DNL ≤ 50	50 < DNL ≤ 60	60 < DNL ≤ 70	Above 70
<b>Industrial, commercial and administrative</b>				
<b>Industrial Uses</b>	Y	Y	Y	Y (4) / Y (0)
<b>Commercial</b>				
Hotels, motels, transient lodgings.	Y	Y	N	N
Wholesale trade, Retail	Y	Y	Y (1)	N
Finance, Insurance, Real estate services, Business services, and Repair services	Y	Y	Y (1)	N
<b>Administrative Uses</b>	Y	Y	Y (1)	N
<b>Residential</b>				
Residential in the city.	Y	Y	N	N
Residential including some workshops or commercial businesses.	Y	Y	Y (1)	N
Residential in suburbs and villas.	Y	Y (2)	N	N
<b>Educational Uses</b>				
Nursery School and Kindergarten.	Y	N	N	N
Schools, Universities, etc.	Y	Y (2)	N	N
Libraries and Study Areas	Y	N	N	N
<b>Health Uses</b>				
Hospitals (Wards and Theatres)	Y	10	20	N
Laboratories	Y	Y	Y (1)	N
Services Areas	Y	Y	Y	Y (0)
<b>Public Uses</b>				
Nursing homes, Hostels, and Child care centers	Y	10	20	N
Mosques, Churches, Auditoriums, and Concert halls.	Y	Y (2)	N	N
Parking Lots.	Y	Y	Y	N
Government buildings.	Y	Y	Y	N
Mining and Fishing Facilities.	Y	Y	Y	Y* (0)
<b>Agricultural Uses</b>				
Agricultural and Forestry.	Y	Y	Y	Y* (0)
Agricultural exhibits and Zoos.	Y	Y	Y	N
Livestock farming, animal breeding, animal shelters, and kennels	Y	Y	Y	N
<b>Recreational Uses</b>				
Stadiums, Gymnasiums, Parks, Amusement parks and Camping grounds.	Y	Y	Y	N
Golf camps, Riding clubs and Water parks.	Y	Y	Y	N

Y: Compatible Y\* (0): Compatible till 75 (dB) and without residential buildings. N: Incompatible  
Y (0): Compatible till 70 (dB) Y (1): Compatible till 65 (dB) Y (2): Compatible till 55 (dB)  
Y (3): Compatible till 45 (dB) Y (4): Compatible till 75 (dB) or 90 (dB) but duration of work not more than 8-hour /shift. 10 and 20 = Land use and related structures generally compatible; measures to achieve Noise Level Reduction (NLR) of 10, and 20 dB must be incorporated into design and construction of structure.

## Study the compatibility of land uses surrounding international Airports (Case Study: Hurghada International Airport)

### Noise measurements:

An extensive site measurement was selected to study HRG airport noise and its impact on Hurghada City (MCA, 2018). The purpose of these measurements was to investigate the noise exposure areas in the year 2020 as a result of the future expansion of the airport runways. These measurements were undertaken at key locations in the city, including points lying within the premises of the Hurghada airport. The aircraft noise was also modelled using the integrated noise model (INM) in order to simulate the current and

future noise levels based upon the forecasts increase in flight operations. Two runways are existing, aircraft traffic was split between the existing and new runway 16/34. The predicted noise contours in this case are somewhat broader due to the spreading of the aircraft operations among the two parallel runways. Figure (7) shows the prediction noise contour for the ten measurement locations till year 2020, in case of the aircraft operations are equal distributed between the two parallel runways.

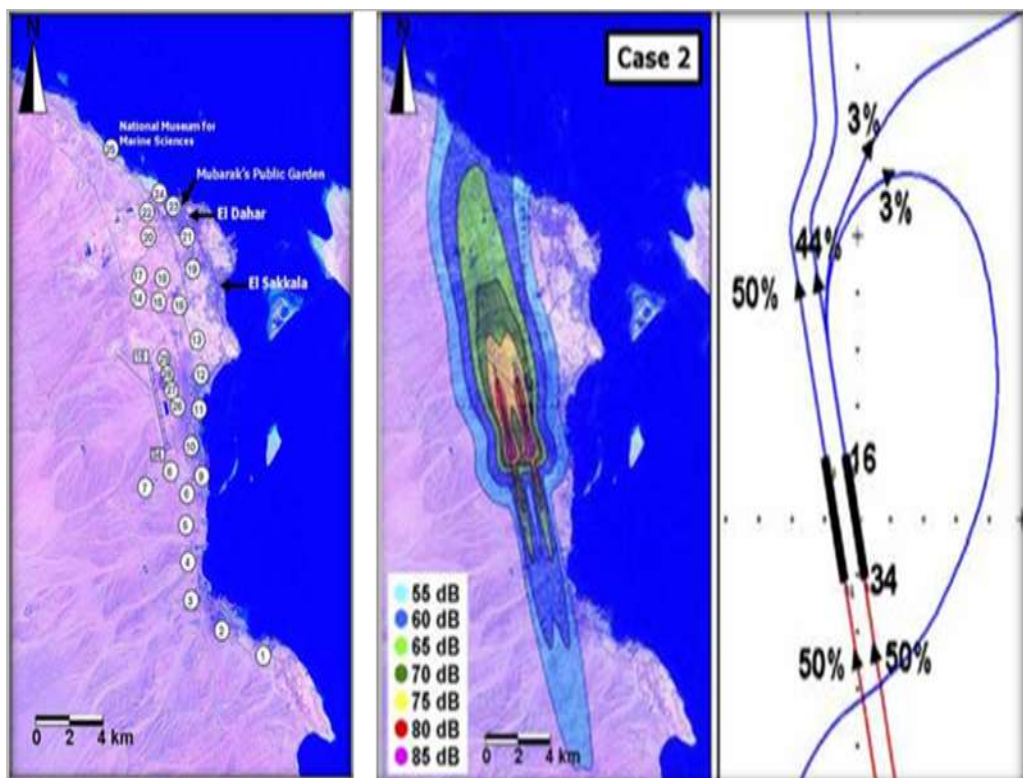


Fig. 7: Prediction noise contour till year 2020. Source: M.H. Arafa et al. / Applied Acoustics 68 (2007) 1373–1385.

### Noise evaluation:

Noise contour lines were signed on the current and future land use plan as shown in Figure (8). Also, the land uses

were evaluated in terms of the noise exposed to them, and the results were listed in Table (6).

Table 6: Land use compatibility with aircraft noise around HRG airport (Prepared by researcher)

Area Code No.	Exist / Proposed Land Use	DNL (dB) Local Regulation	DNL (dB) Measured	Evaluation	
				Comp.	Incomp.
1	HRG	-----	75	--	--
2	Administrative	≤ 65	55	√	
3A/ 3B	Unused land	-----	65 -60	--	--
3C	School and Mosque	≤ 55	60		√
4A/4B/4C	Specialized Facilities	≤ 65	65-60-55	√	
5A/5B/5C	Industrial Areas and Workshops	≤ 75	65-60-55	√	
6	Unused land	-----	55	--	--
6A/6B/6C	Tree Forest	≤ 75	65-60-55	√	
7A	Industrial Areas and Workshops	≤ 75	70	√	
7B	Industrial Areas and Workshops	≤ 75	65	√	
7C	Industrial Areasand Workshops	≤ 75	60	√	
7D	Industrial Areasand Workshops	≤ 75	55	√	
8	Unused land	-----	70	--	--
9A	Villas	≤ 55	70		√
9B-1	Mixed Residential	≤ 65	65	√	
9B-2	Church	≤ 55	65		√
9C	Mixed Residential	≤ 65	60	√	
10A/10B	Unused land	-----	65 -60	--	--
10C-1	Power Station	≤ 65	65	√	
10C-2	School	≤ 55	65		√
10D	Mixed Residential	≤ 65	60	√	
11A	School	≤ 55	60		√
11B	Residential - Buildings	≤ 60	55	√	
11C	Residential - Buildings	≤ 60	50	√	
12	Residential - Buildings	≤ 60	55	√	
13A	Administrative	≤ 65	60	√	
13B	Residential Buildings - Mosque	≤ 55	55	√	
13C	Hospitals	≤ 45	55		√
14	Unused land	-----	60	--	--
15	Tourist	≤ 60	60	√	
16	Hotels	≤ 60	55	√	
17	Tourist Villages	≤ 60	50	√	
18	Financial Center and Tourist Villages	≤ 60	60	√	
19A/19B	Unused land	-----	60 -55	--	--
20A	Tourist Villages	≤ 60	60	√	
20B	Residential - Buildings	≤ 60	55	√	
20C	Water Station	≤ 70	55	√	
21A/21B/21C	Unused land	--	60-55-55	--	--
22	Tourist	≤ 60	60	√	



Study the compatibility of land uses surrounding international Airports  
(Case Study: Hurghada International Airport)

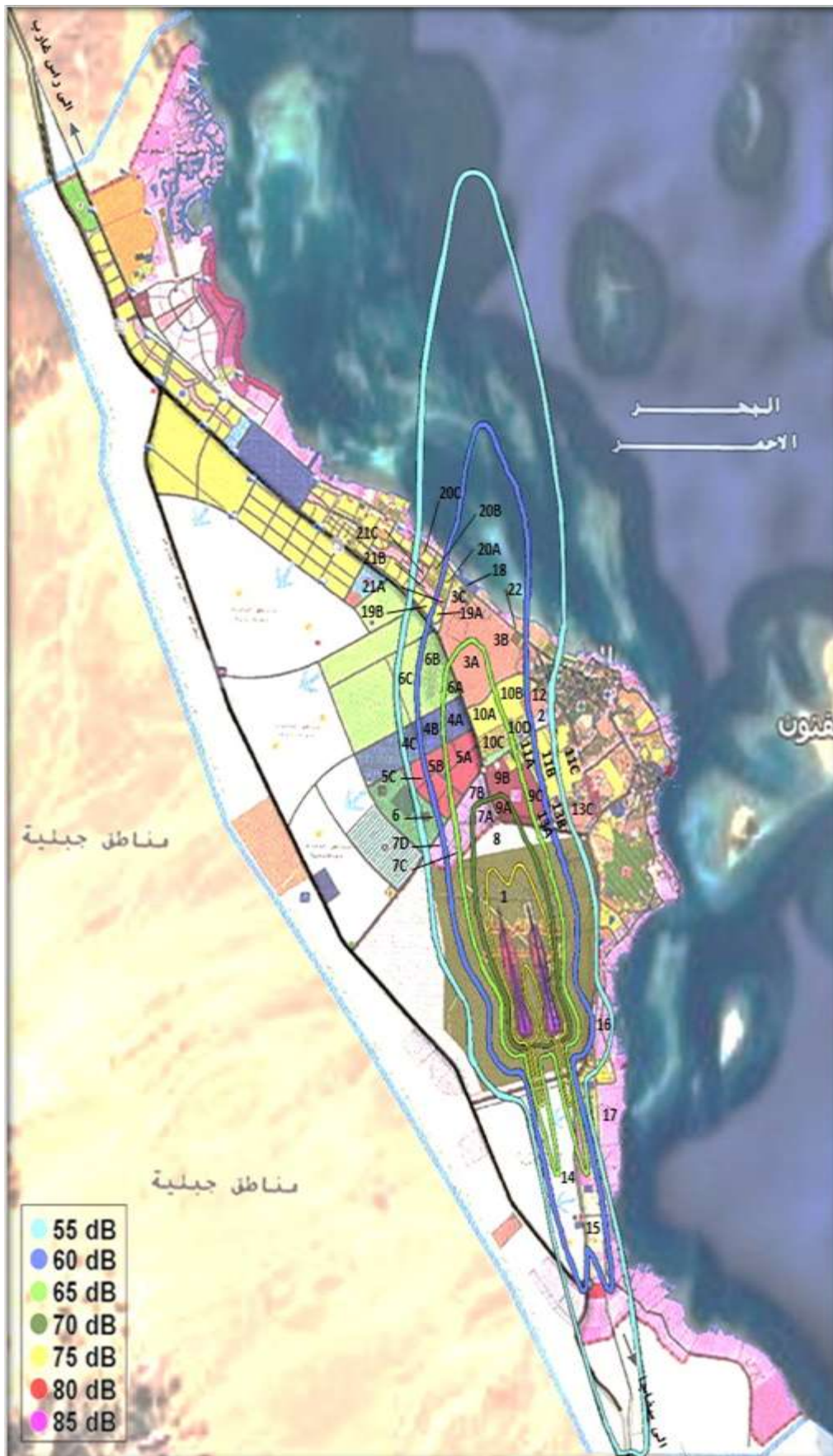


Fig. (8). Noise Compatibility Zones for the Environs of HRG airport Source: Prepared by Researcher.

**ii. Safety**

**Safety compatibility zones:** For general aviation airports, there exist six safety zones and two safety areas. The shapes and dimensions of the zones are largely based on accident data and other analyses

prepared by FAA, (Fig. 9). In case of HRG airport, there exist six safety zones, the dimensions and shape of safety zones of HRG airport as shown in Figure (10) (MCA, ECAA, 2016).

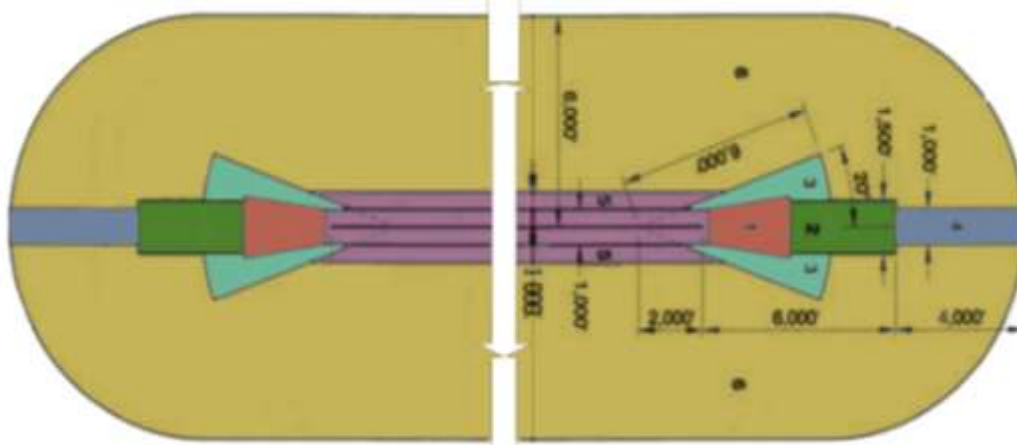


Fig. 9. Safety zones' dimensions and shape of general aviation airports Source: Prepared by Researcher.

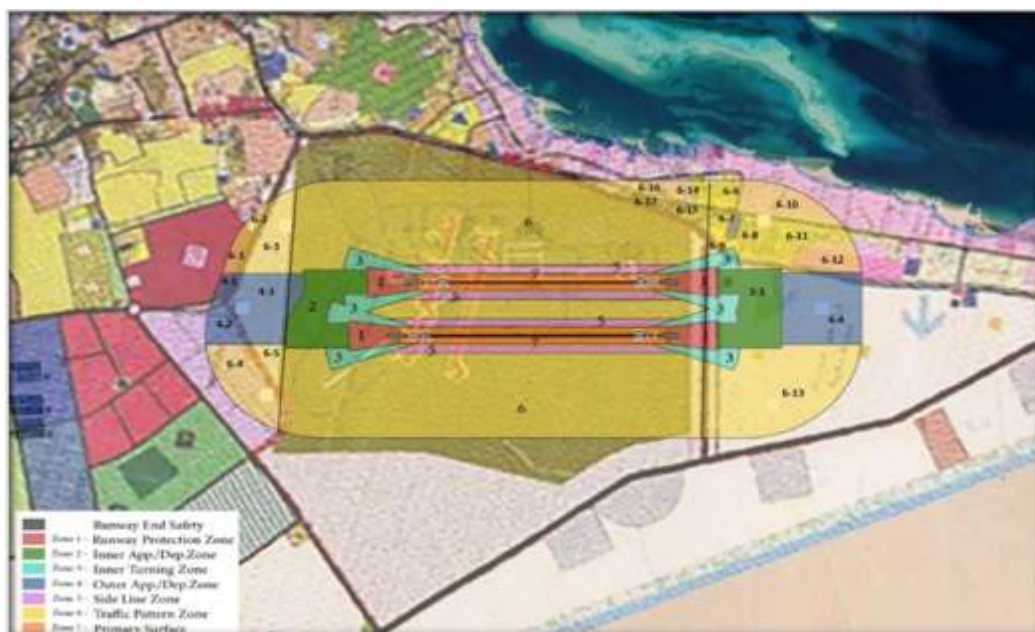


Fig.10. Safety zones' dimensions and shape of HRG airport. Source: Prepared by Researcher.

**Safety compatibility zones criteria:**

The map of safety compatibility zones identifies areas where distinct levels of risk exist. As a result of the distinct levels of risk in each safety compatibility zone, Airport Land Use Commission of

HRG airport should differentiate allowed and prohibited land uses around airport according to safety compatibility zones. Table (7) represents the prohibited and allowed uses in each safety compatibility zone (MCA, ECAA, 2016).

## Study the compatibility of land uses surrounding international Airports (Case Study: Hurghada International Airport)

Table 8. Prohibited and allowed uses in each safety compatibility zone. Source: Washington State Department of Transportation, 1999.

Safety zone		Prohibited and allowed uses
Zone 1	Runway Protection Zone	<ul style="list-style-type: none"> <li>-Prohibit all new structures</li> <li>-Prohibit residential land uses</li> <li>-Avoid non - residential uses</li> </ul>
Zone 2	Inner Approach/ Departure Zone	<ul style="list-style-type: none"> <li>-Prohibit hazardous uses (e.g. aboveground bulk fuel storage)</li> <li>-Prohibit children's schools, day care centers, hospitals, nursing homes</li> <li>-Prohibit residential uses except on large agricultural parcels</li> <li>-Limit non - residential uses to activities which attract few people (uses such as shopping centers, most eating establishments, theaters, meeting halls, multistory office buildings, and labor-intensive manufacturing plants unacceptable)</li> </ul>
Zone 3	Inner Turning Zone	<ul style="list-style-type: none"> <li>-Limit residential uses to very low densities (if not deemed unacceptable because of noise)</li> <li>-Avoid non - residential uses that have moderate / higher usage intensities (e.g., major shopping centers, fast food restaurants, theaters, meeting halls, buildings with more than three aboveground habitable floors are generally unacceptable)</li> <li>-Prohibit children's schools, large day care centers, hospitals, nursing homes</li> <li>-Avoid hazardous uses (e.g. aboveground bulk fuel storage)</li> </ul>
Zone 4	Outer Approach/ Departure Zone	<ul style="list-style-type: none"> <li>-In undeveloped areas, limit residential uses to very low densities (if not deemed unacceptable because of noise)</li> <li>-Avoid non - residential uses that have moderate / higher usage intensities (e.g., major shopping centers, fast food restaurants, theaters, meeting halls, buildings with more than three aboveground habitable floors are generally unacceptable)</li> <li>-Prohibit children's schools, large day care centers, hospitals, nursing homes</li> </ul>
Zone 5	Sideline Zone	<ul style="list-style-type: none"> <li>-Avoid residential uses unless airport related (noise usually also a factor)</li> <li>-Allow all common aviation-related activities provided that height-limit criteria are met</li> </ul>
Zone 5	Sideline Zone	<ul style="list-style-type: none"> <li>-Limit other nonresidential uses similarly to Zone 3, but with slightly higher usage intensities</li> <li>-Prohibit children's schools, large day care centers, hospitals, nursing homes</li> </ul>
Zone 6	Traffic Pattern Zone	<ul style="list-style-type: none"> <li>-Allow residential uses</li> <li>-Allow most non-residential uses; prohibit outdoor stadiums and similar uses with very high intensities</li> <li>-Void children's schools, large day care centers, hospitals, nursing homes</li> </ul>

### Safety evaluation:

Figure (10) shows the types of land uses within safety zones (Zone 2, Zone 4

and Zone 6), which are located outside HRG airport boundary. Also, types of land uses, the location of each type of land use

within safety zones and the compatibility (9).  
of land use with its zone are listed in Table

Table 9: Prohibited and allowed uses in each safety compatibility zone. Source: Prepared by Researcher.

Area Code No.	Existed / Proposed Land Use	Areas Zones Location	Height	Safety Analysis	
				Comp.	Incomp.
2-1	Unused Airport Land	Inner Approach/ Departure Zone	--	--	--
4-1	Unused Land	Outer Approach/ Departure Zone	--	--	--
4-2	Industrial Areas and Workshops	Outer Approach/ Departure Zone	+1	√	
4-3	Unused Land	Outer Approach/ Departure Zone	--	--	--
4-4	Treatment Station	Outer Approach/ Departure Zone	+4		√
4-5	Unused Land	Outer Approach/ Departure Zone	--	--	--
6-1	Administrative Buildings	Traffic Pattern Zone	without	√	
6-2	Residential Area (Mubarak - 8)	Traffic Pattern Zone	+4	√	
6-3	Unused Land	Traffic Pattern Zone	--	--	--
6-4	Industrial Areas and Workshops	Traffic Pattern Zone	+1	√	
6-5	Unused Land	Traffic Pattern Zone	--	--	--
6-6	Tourist Housing Village	Traffic Pattern Zone	+3	√	
6-7	Tourist Housing	Traffic Pattern Zone	+4	√	
6-8	Magawish District - Tourist Villages	Traffic Pattern Zone	+4	√	
6-9	Mosque	Traffic Pattern Zone	+3		√
6-10	Tourist Villages	Traffic Pattern Zone	+4	√	
6-11	Tourist Villages (Tourist Area)	Traffic Pattern Zone	+4	√	
6-12	Residential - Tourist	Traffic Pattern Zone	+4	√	
6-13	Unused Land	Traffic Pattern Zone	--	--	--
6-14	Tourist Villages	Traffic Pattern Zone	+4	√	
6-15	Villas Area	Traffic Pattern Zone	+1	√	
6-16	Residential Area - Condominiums	Traffic Pattern Zone	+4	√	
6-17	Mubarak Housing Area	Traffic Pattern Zone	+4	√	

## Study the compatibility of land uses surrounding international Airports (Case Study: Hurghada International Airport)

According to the impact noise study on areas surrounding HRG airport, there exist some land uses are incompatible with noise. For example, area 3-c which used as School and Mosque is incompatible with noise because measured DNL (dB) = 60 dB, while local regulation DNL (dB)  $\leq$  55 dB, Area 9-A which used as Villas is incompatible with noise because measured DNL (dB) = 70 Db, while local regulation DNL (dB)  $\leq$  55 dB, Area 9-B-2 which used as Church is incompatible with noise because measured DNL (dB) = 65 dB while local regulation DNL (dB)  $\leq$  55 dB, Area 10-C-2 which used as School is incompatible with noise because measured DNL (dB) = 60 dB. while local regulation DNL (dB)  $\leq$  55 dB, Area 10-C-2 which used as School is incompatible with noise because measured DNL (dB) = 60 dB while local regulation DNL (dB)  $\leq$  55 dB, Area 11-A which used as School is incompatible with noise because measured DNL (dB) = 60 dB while local regulation DNL (dB)  $\leq$  55 dB, , and area 13-C which used as Hospital is incompatible with noise because the measured DNL (dB) = 55 dB while local regulation DNL (dB)  $\leq$  45 dB.

According to the safety study on areas surrounding HRG airport, there exist some land uses are incompatible with safety. For example, area (2-1) which located in Inner Approach/ Departure Zone, the following uses are prohibited on it:

- Uses that create or cause interference with the operations of radio or electronic facilities on the airport.
- Uses that make it difficult for pilots to distinguish between airport lights and other lights, lead to glare in the eyes the pilots who use the airport.
- Churches, hospitals, schools, theaters, stadiums, hotels and motels, trailer courts campgrounds,

and other places of public or semipublic assembly.

- Any new uses on sites less than three acres in size; and Uses that create, attract, or bring together a site population that would exceed 15 times of the site acreage.

For unused areas which located in Outer Approach/ Departure Zone (4-1), (4-3), and (4-5), the following uses are prohibited:

- Non - residential uses that have moderate / higher usage intensities (e.g., major shopping centers, fast food restaurants, theaters, meeting halls, buildings with more than three aboveground habitable floors).
- Residential uses that have moderate / higher usage densities (if not deemed unacceptable because of noise).
- Children's schools, large day care centers, hospitals, nursing homes.

For area 4-4 (Treatment Station) which located in Outer Approach/ Departure Zone is incompatible with safety zone because its height more than three floors.

For unused areas (6-3, 6-5, and 6-13) which located in Traffic Pattern Zone, the following uses are prohibited:

- Stadiums and similar uses with very high intensities; and Children's schools, large day care centers, hospitals, nursing homes.

For area 6-9 (Mosque) which located in Traffic Pattern Zone is incompatible with safety zone because its use is high intensities

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## Study the compatibility of land uses surrounding international Airports (Case Study: Hurghada International Airport)

دراسة توافق إستخدامات الأراضي المحيطة بالمطارات الدولية: (دراسة حالة مطار الغردقة الدولي)

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### المستخلص

نظرا لان عمليات التنمية الحضرية تتميز بالديناميكية والتغير المستمر فلا بد ان يواكبه عملية خطط لادارة التنمية اللازمة بصفة عامة ودراسة ووضع خطط استراتيجية الخاصة بمناطق المطارات والمناطق المحيطة بها. لذا وجب عند دراسة تلك المناطق ان يتم دراستها بصورة مختلفة ومتميزة نظرا لوجود العديد من العوامل والتاثيرات السلبية التي تنتج من نتاج استعمال (المطارات). هدف البحث الرئيسي: يتمثل في دراسة توافق لتلك الاستخدامات المحيطة للمطارات لدفع عملية التنمية بشكل سليم يحقق اشترطات التنمية المستدامة لتلك المناطق. وقد اعتمد البحث في الدراسة علي المنهج العلمي التحليلي التوصيفي من خلال دراسة عملية تطوير وتخطيط توافق تلك الاستخدامات للاراضي المحيطة بالمطارات وتقييم مدي توافق من خلال التطبيق علي عاملين (تأثير الضوضاء والسلامة كما تم دراسة لجزئية بعامل الامان التي تؤثر علي نوعية الاستعمالات الاراضي بها. ومن ثم تم اتباع المنهج التطبيقي من خلال تحليل الوضع الراهن والرصد والتحليل للحالة التطبيقية (مطار الغردقة الدولي). للخروج بالاسس التصميمية لعملية تحديد استخدامات الاراضي لتلك المناطق وتحديد الاستخدامات المسموحة والمحظرة بها. كما يهدف البحث من خلال الدراسة التطبيقية والميدانية الي التوصل الي تحديد لتلك المعايير المختلفة المستنتجة من تلك الدراسة وتحديد الاستخدامات المتوافقة بكل منطقة حسب تحديد خصائصها وعناصرها المختلفة.

**الكلمات الدالة:** التخطيط المستدام لتطوير استخدامات الاراضي - عوامل التوافق - نطاقات الامان - خصائص توافق الضوضاء - خصائص توافق الامان - الاسطح التخيلية للمطار المدنية - خطة توافق استخدامات الاراضي للمطار - منطقة تأثير المطار.