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Abstract	Location of airports is a key factor for the sustainable and competitive development of the smart cities. Airport location projects influence many aspects, such as: growth of the city, manoeuvres of airlines, transport of passengers, and soil preservation. They also bring a variety of social, environmental and economic benefits. The location of an airport that comply with land use and airspace rules and regulations is of utmost importance. This paper presents the problem of: What is the best location of an airport in Ciudad Juarez? The designed a multi-criteria analysis approach to locate a new smart airport in a border area of Northern Mexico. The study bases on the model of indicators for the competitiveness of the city and inter-national regulations for locating airports in border areas. The study also bases on the medium smart airport model and considers four location alternatives: two to the Northwest (1) and (2), one to the Southeast (3) and the fourth in the South (4). We used TOPSIS multi-criteria model to obtain the best alternative to allow for the most convenient location. The analysis resulted in alternative 2, located to the northwest, being the best, followed by location 1 and location 4.

Keywords (separated by '-')	Airport location - Border regions - Multi-criteria analysis - Intelligent airports - Smart cities

What is the Best Location of a Smart Airport in Juarez, Mexico?

Aida-Yarira Reyes Escalante, Carlos Alberto Ochoa-Zezzati, Diego-Adiel Sandoval Chávez, and Karla-Stephania Venegas Ortiz

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1 Introduction

The optimal location of an airport is of the most important for smart cities because it greatly defines the competitive edge and long-term development. Such a decision involves a variety of actors ranging from government agencies, airlines, transport agencies, food services, reservation agencies, and tourism companies to local stakeholders.

2 Cities and Development

According to Dimuro [10] the cities went throughout three stages in their historic evolution. The first stage characterized for a high dependence on nature; during the second, cities experience the arrival of technology and urban sprawl; finally, during the third stage cities have come back to appreciate nature, particularly in public spaces.

Due to their entropic nature, urban cities consume a great deal of materials and energy just to maintain the order within them. As urban sprawl increases, the city needs additional amount of materials, fuel and public services. As a result of the urban metabolism, a great amount of degrades energy and waste are deposited in the environment [27, 30].

Two milestones were decisive for sustainability to become a premise for being a key competitive advantage for countries in a global market. One is the United Nations Conference on the Human Environment, also referred as to Stockholm Summit, which was held in 1972 to emphasize the need to address environmental deterioration. The other is a dossier that Club of Rome generated in which they warned about the eventual impact of the microelectronic industry. Both initiatives trigged the interest in sustainability and promoted public policy to address it at a high level. Since then, sustainability has been a critical issue which is considered a key factor in the decision-making process both in public as well as in private organizations [15, 23].

Very soon, the growing interest in sustainability brought a transgenerational commitment Left [19] mentioned that factors like entropic degradation, nature biochemical cycles, economic crisis and technological innovation are now issues that organization need to address to cope with sustainability demands. In addition, Baker [1] indicate that sustainability models must consider development seen as a whole, including regulations, governance, technology and policy. In order to be able to meet the difficulties of this new scenarios, it is imperative to stimulate innovation, creativity and experimentation [12].

3 Smart Cities: Competitive and Sustainable

Technological development as it concerns to public spaces reflects in the quality of these entities. Public space infrastructure and policy decant down to performance indicators for both urban and rural areas.

Lever [20] states that competitiveness is paramount for cities to promote investment and economic growth. Competitiveness among cities takes place for many reasons

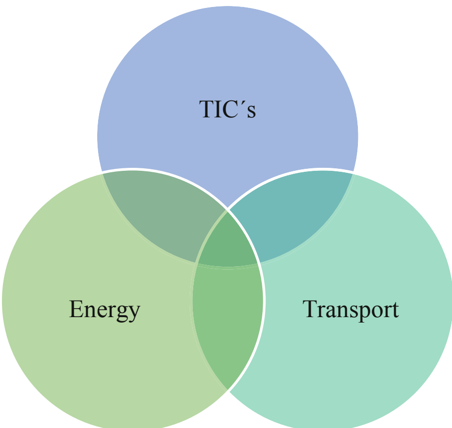
(a) To catch mobile investment for creating industrial jobs and commercial developments
(b) Economic growth measured as gross value added or Gross Economic Product (GEP), which includes growth of existing entities and the arrival of new ones.
(c) Populations level, based on income, human capital, demand and political power.
(d) Public funds at national or regional level.
(e) Distinctive events and infrastructure.

Cites with better competitiveness indexes achieve better market share. Initially, this vision concentrated at national level base natural resources, human skills, capita and productivity, but nowadays nations no longer compete, but cities [11].

A highly-wired, tele informational-based city is identified with the quality of intelligent [14]. In this kind of city government policy emphasizes sustainability when instrumenting long-term planning programs within which technology suppliers, government offices and academia conflux. This approach proves to be one of competitive shape that reinforces itself monitoring pertinent indicators, such as infrastructure systems, intelligent framework, urban space y renewable energies [16].

Hollands [16] Fig. 1 depicts the balance among energy, transportation and technologies of information (TICs). This portray gives place to the idea of the holistic

Fig. 1 Smart cities elements [14]



approach in the intelligent city when consider it as a multifunctional, complex system in which governance dictates the decision-making process [15].

According to Valderrama [31] there are six areas in which intelligent cities must focus: citizen participation, governance, mobility (all kinds, water, land and air) as a public service, attention to environmental issues, competitiveness and quality of life.

Transportation is crucial to attain sustainability in urban cities. Its importance reinforces the idea that vehicles automation and collective systems reduces vehicular park, thus improving sustainability. It is also important to increase commuter efficiency by establishing routes at an optimal velocity.

4 Intelligent Airports: Competitive and Sustainable

Design and location of new airports face increased regulations as customer's demand better services at lower cost. This calls for new, technology-based intelligent airports not only to meet customers' demands and expectations but also to position branding and reputation. An intelligent airport, optimally located reduces waste, promotes investment and is not energy-intensive,

The Central Intelligence Agency (CIA) reports there are 41,788 airports in 236 countries in the world. USA ranks first with 13,513; Brazil, México and Canada follow with 4,093, 1,714 and 1,467, respectively. Figure 2 shows the number of airports or airfields recognizable from the air. The runway(s) may be paved or unpaved and may include closed or abandoned installations [4].

The International Airport Council (AIC) reports that air traffic increased 6.6% in 2017 with respect to 2016. At the same time, international traffic increased 8.4%.

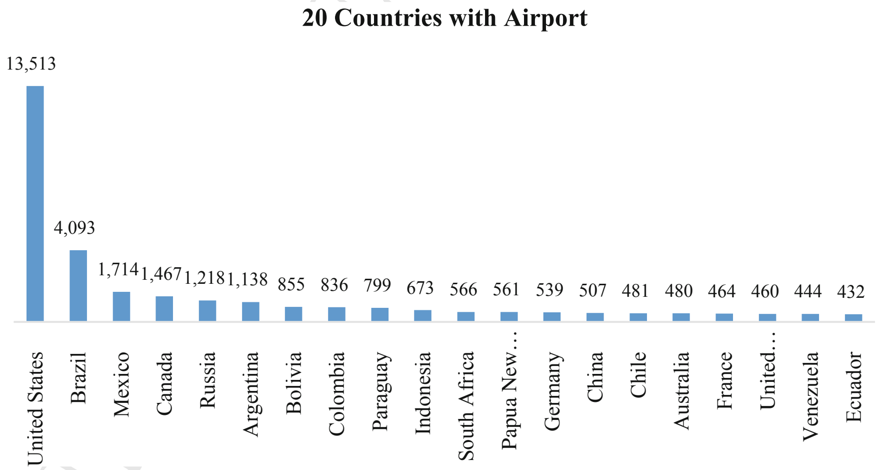


Fig. 2 List of 20 countries with Airports [4]

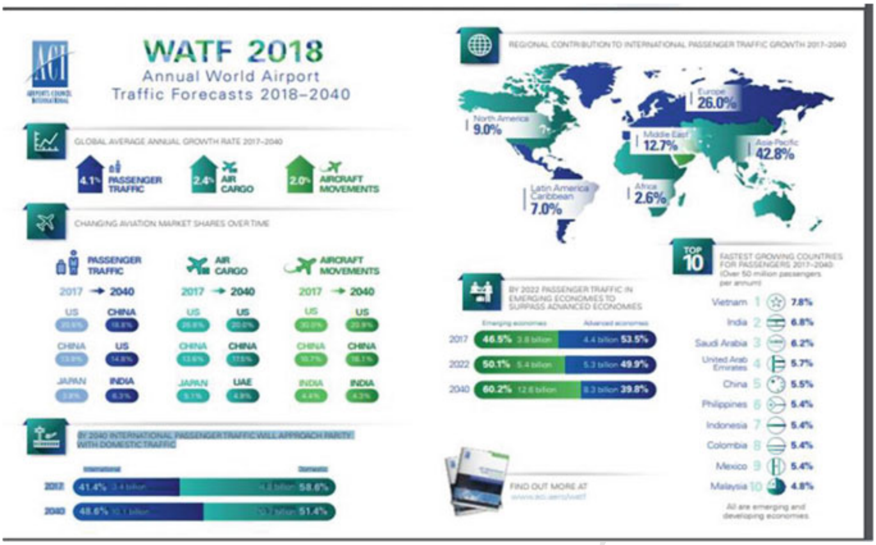


Fig. 3 Annual World Airport Traffic Forecast 2019, [4]

Due to operations consolidation, increased occupation and higher-capacity aircrafts, the number of flights had less dynamism with 2.4% of growth [4].

According to the Annual World Airport Traffic Forecast (WATF) 2018–2040, passenger transportation will increase from 2.4 to 4.2% for cargo flights and 2% for aircraft movements, this growth will be world-wide, see Fig. 3. Mexico expects a growth of 5.4% for both domestic and international flights, Fig. 3 [4].

The European Airport Trade Association (ACI Europe) releases its traffic report for July 2019, during which average passenger traffic in geographical Europe expanded by +2.2% compared with the same month in 2018. Standing at less than half the growth of the preceding month (June: +4.7%), this is the weakest monthly performance so far this year. Meanwhile, Freight traffic declined for the 9th month in a row at −2.3%. Growth in aircraft movement was subdued at +1.2%—compared to +3.8% at the start of the year [5].

Due to the importance of airports for competitive edge, the following research avenues have been identified:

(a) Airport privatization. Voguel [32] points out about the importance of private airports, including the impact of the investment process. After studying the airports in Saudi Arabia, Chaouk, Pagliari, Miyoshi [6] recommended a policy for future airport privatizations to increase market share and reduce losses.

(b) Analysis of airport impacts: Bringmann et al. [2] planned the study related about the cooperative arrangements between European airports by focusing on their financial intertwinement. The findings indicate a high degree of stability in investment relations in the airport industry over time. Further-more, it is suggested that the formation of inter-organisational linkages is facilitated by spatial proximity.

(c) Also, Gasco et al. [13] remark the noise is negative environmental effect that must be addressed when planning an airport. Martin-Domingo and Martín [21] analyses the airport mobile internet an innovation, also, studies the adoption of mobile Internet by airports. Using a new theoretical model, the study tests whether early adopters of mobile Internet for airports can be considered real innovators.

(d) Airport classifications: Mayer [22], indicted the airport classification based on cargo characteristics, 114 airports are grouped according to their cargo business characteristics. Applying a hierarchical cluster analysis, the paper uses absolute (cargo tonnage) and relative measures (share of cargo workload units, of freighter movements and of international cargo) to establish the reliance of different airport types and groupings on air cargo.

(e) Borders and requirements. Gasco et al. [13] also, Sulmona, Edgington and Denike [29] study the role of Advanced Border Controls at Canadian airports, with government between 1985 and 2010 and how this contributed to a balance between trade and national security imperatives.

(f) Tourism: Debbage [9] mentioned the international tourist arrivals accounts for approximately 25% of worldwide in The United States–European Union market, that landing slot policy and the manner in which airport capacity is allocated among airlines across the north Atlantic is likely to underpin the future geographic structure of the tourism industry.

5 Location Airport Analyses

The importance of the location of airports is derived from the development of air transport and the use of airspace in order to operate aircraft without the physical existence of the airport and land surface facilities. The air transport system is integrated by aircraft and airports, together they allow to offer the service to users who are mostly passengers, organizations, delivery services and movement of products. Airport facilities today seek to turn these into smart airports so as not to lag behind and ensure their market share by being competitive and novel.

The passenger terminal is one of the main elements of the cost of an airport's infrastructure, in addition to the current technological implementations, which offer it through service. There are a lot of airports in the world that have been built as architectural monuments sizes vary: large, medium-small, to small runways. Others have also been remodelled to stay in the market and passengers have become accustomed to a comfort ostentation of design and services, and there are investments in small airports such as ending them to vent the weight of airports large, and also, to have more mobility and access to the population in large cities or megacities.

Within international regulations there is the International Civil Aviation Convention signed in Chicago in December 1944, each participating State undertook to work together to achieve uniformity of regulations relating to features of airports and landing areas. This allows airports in their proposals for new designs to have the minimum established in the Convention and the application of all changes within the building.

Airport location-related research is scarce. Cheng-Lung Wu and Andy Lee [33] conducted a research related to the impact of airline alliance terminal co-location on airport operations and terminal development, they address questions about the notion of co-locating alliance carriers while benefits on the part of airlines are made, the tangible benefits to airport operators are less clear. Analyses cases of London Heathrow, Paris Charles de Gaulle and Tokyo Narita Airport, and applies their operational practices to a medium-sized airport in Asia Pacific to evaluate the universal applicability of alliance member co-location.

To the extent of our knowledge, a multicriteria approach has not been adopted for the location of an airport. Studies on the subject matter are perceived fragmented and incomplete. The research question is ¿what is the best location for new airport in Juarez, Mexico? Thus, the objective of this work is to determine such a location.

6 Juárez, Mexico Airport

Built in 1968 in an area of 4,736,247.74 m^2 (Fig. 4) Juarez, Mexico Abraham Gonzalez International Airport (CJS) has undergone several modifications and improves. CJS encompasses a series of modern facilities, including a new traffic control tower, a renovated track, hangars, lobby and a new telecommunications baseline. The carriers that operate in CJS are Vivaaerobus, Aeromexico, Volaris, Interjet, TAR, cargo airlines and private flights.

CJS experiences air saturation which causes frequent delays that lead to increased costs. These problems give place to the idea that a new airport is an urgent requirement for Juarez to continue being a competitive Smart city. AQ1

As the urban sprawl took place in Juarez, the airport saw itself surrounded by main avenues, habitational developments and manufacturing firms. These factors made impossible the airport to expand (see Figs. 5 and 6).

Restricted areas for the location of hovers are established according to the Secretary of Communications and Transport in 2016, are presented in Fig. 7 and the restrictions are documented in AIP of Mexico, see Fig. 8. The most restricted area is stablished base on the geographical land located on the South Oriented started on the km 20, this problem affected the visibility and is not approved to airports.

7 Method

The study relies on an exploratory analysis carried out in 2019 in Juarez, Mexico. We considered three different sectors: East, West and South. Also, this study involves a

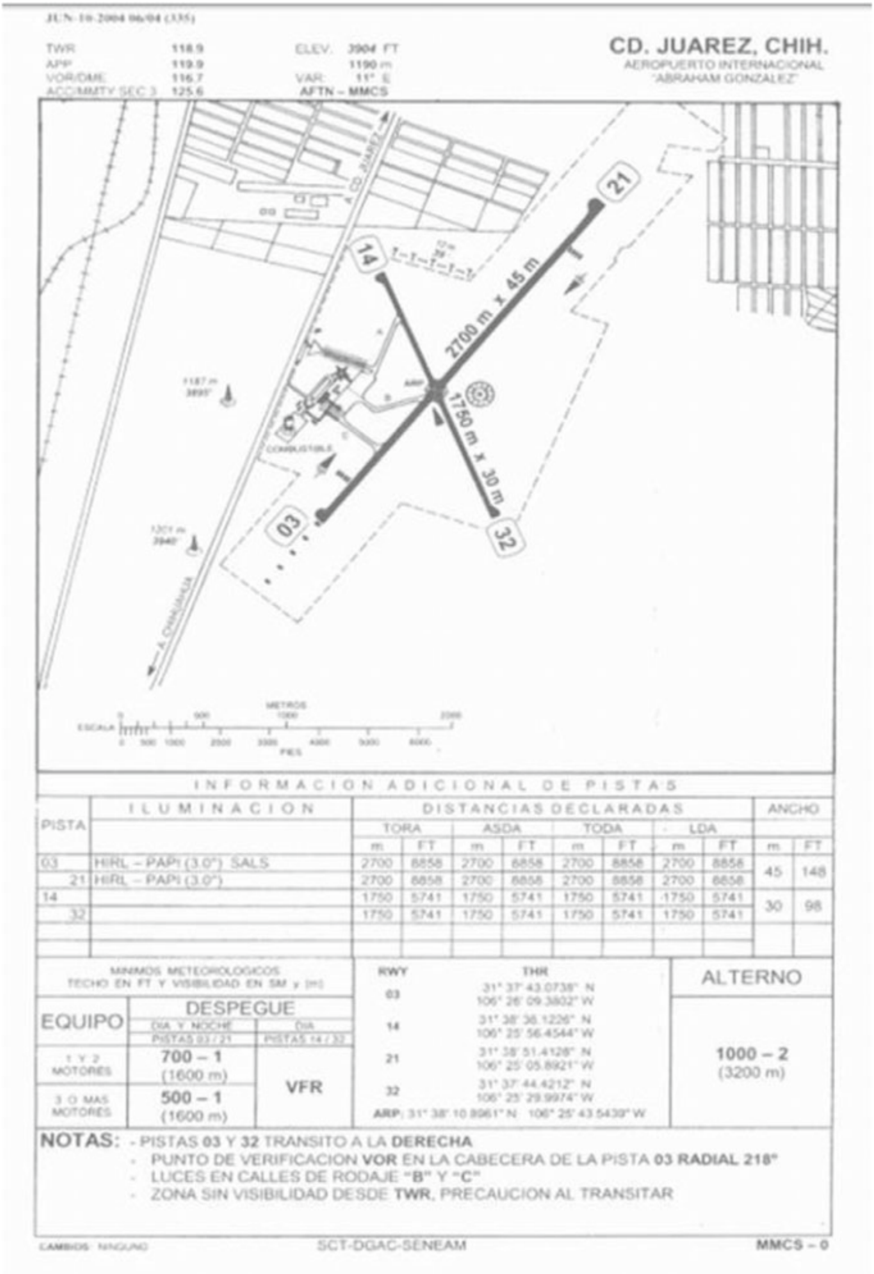


Fig. 4 International Abraham González Airport [3]

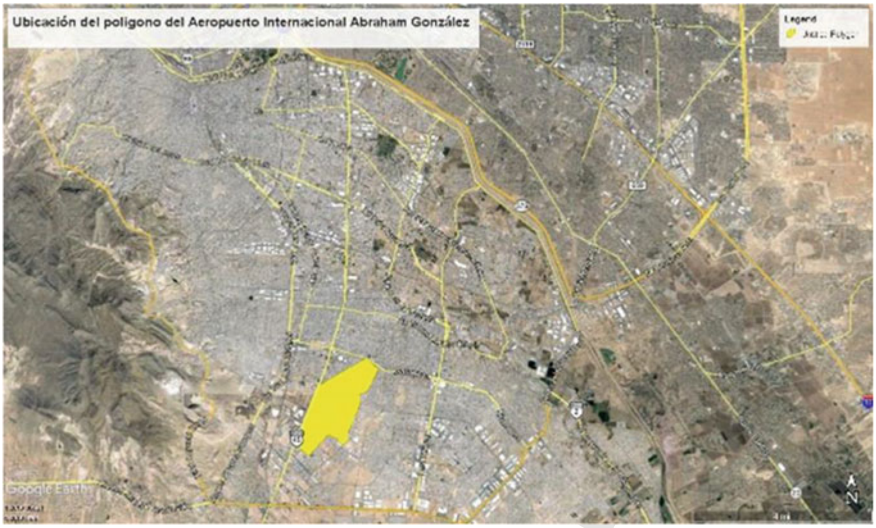


Fig. 5 Geography location International Abraham González Airport ("Google Earth," n.d.)

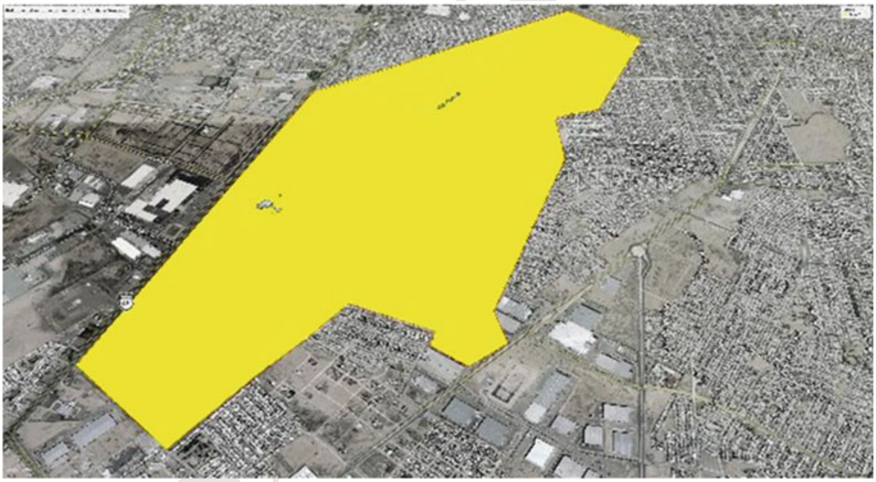


Fig. 6 Geography polygon ("Google Earth," n.d.)

quantitative design, adopting a multi-criteria decision methodology to determine a basis for planning the location of an International Smart AirPort.

In order to determine the category of the smart airport appropriated for Juarez, this work looked at different regions and their related airports. Four airports were considered: Changi (Singapur), Incheon (South Korea), Hamad (Doha) and Carrasco (Uruguay). After taking into account a set of factors the analysis concluded that the

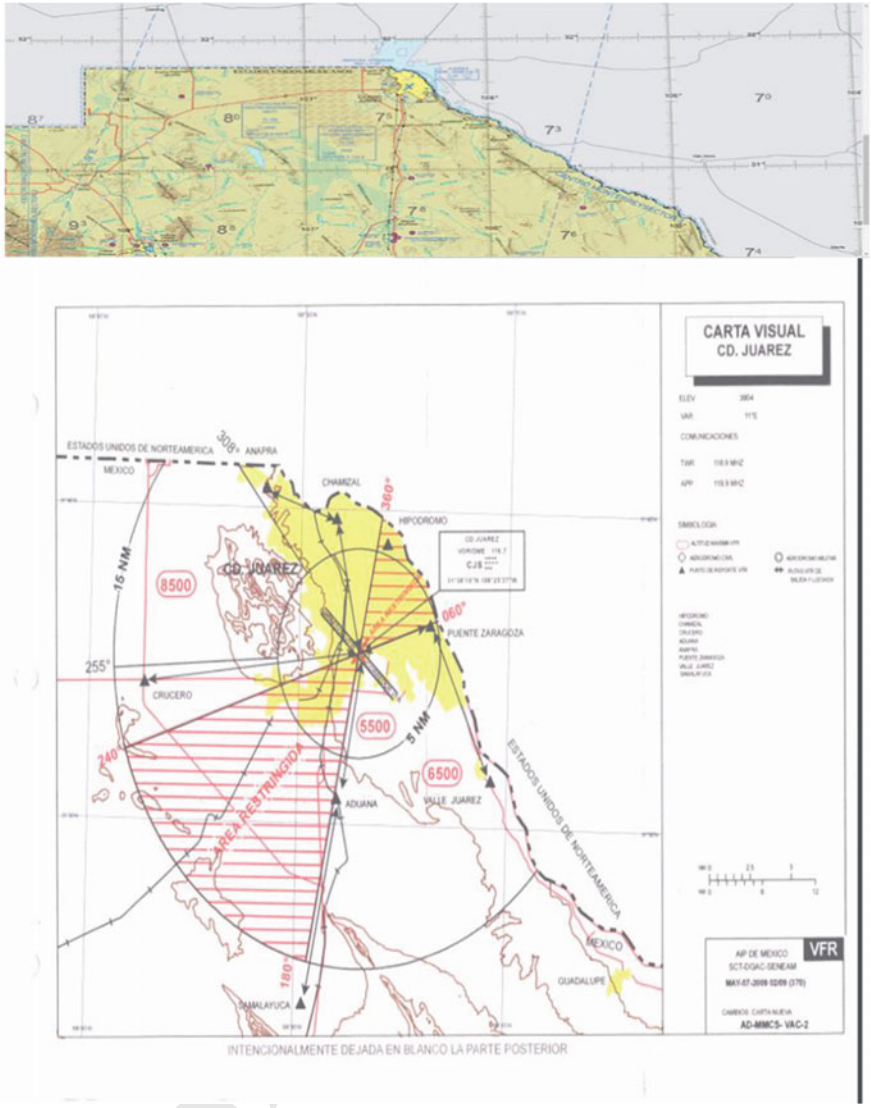


Fig. 7 Restricted Air Conditional Juarez Municipal (Secretaría de Transporte, 2016)

International Airport of Hamad (DOH) met the characteristics to be considered as the baseline for the study, (see Table 1).

The polygon dimension of DOH will be the reference to identify spaces beyond the restricted areas to locate a new airport in Juarez (see Figs. 9 and 10).

Multiple-criteria decision-making (MCDM) also referent as multiple-criteria decision analysis (MCDA) is a sub-discipline of operations research that explicitly evaluates multiple conflicting criteria in decision making. The MCDA is the

AIP DE MEXICO AD-MMCS VAC-0

REGLAS Y PROCEDIMIENTOS PARA VUELOS VFR CD JUAREZ.

1. Restricciones

a) Queda prohibido el vuelo VFR arriba de la(s) altitud(es) máxima(s) establecida(s) para cada sector, dentro de un radio de 15 millas náuticas del Aeropuerto MMCS.

b) No se permite el vuelo VFR dentro de las áreas restringidas N entre la radial 360° y radial 060° hasta la línea fronteriza, y S entre la radial 180° y radial 240° hasta 15 MN a menos que se encuentre con autorización del Control de Aeródromo (Torre de Control).

2. Zona de tránsito de aeródromo (ATZ).

a) Esta zona esta reservada para las aeronaves que vayan a despegar o aterrizar en el aeropuerto y sólo podrá ser penetrada con autorización de la Torre de Control, dicha zona comprenden un radio de 5 MN con centro en CJS dentro del territorio nacional.

b) Se establecen las rutas visuales de salida y llegada VFR descritos en la Carta Visual para efectos de sobrevolar en el aeropuerto de El Paso, Tex. (KELP) y del aeropuerto de Santa Teresa, NM. (K5T6) hacia el interior del territorio nacional y viceversa, así mismo las rutas VFR que deberán utilizarse para integrarse a los circuitos de transito para aterrizar en el aeropuerto de CD. Juarez, Chih. (MMCS).

c) Las aeronaves que utilicen el corredor VFR deberán hacerlo a una altitud no mayor de 6500 FT, dicho corredor se extiende perpendicular a la pista 03-21, con referencia en el VOR CJS en los radiales 120 y 300 con 3 MN de longitud.

3. Procedimientos de vuelo VFR.

Las aeronaves VFR planearán su vuelo dentro del area Terminal de CD. Juárez, tanto para salir o llegar al aeropuerto, utilizando las rutas VFR mostradas en la carta y respetando las altitudes especificadas para cada sector.

3.1 Llegadas.

a) Las aeronaves en vuelo VFR deberán notificar su posición en la frecuencia de la Torre de Control para que el controlador le asigne la ruta para sobrevolar hacia ELP o en su defecto aterrizar en CJS.

3.2 Salidas.

a) El controlador instruirá a las aeronaves en vuelo VFR la ruta a seguir después de su despegue.

b) Las aeronaves en vuelo VFR mantendrán radiocomunicación con la Torre de Control CD Juárez hasta recibir autorización de esta para abandonar la frecuencia.

4. Rutas VFR de llegada / salida

SALIDAS

IDENTIFICADOR	RUTA	DESTINO
CHAMIZAL	JUAREZ-CHAMIZAL-ANAPRA	SANTA TERESA, N.M.
PUENTE ZARAGOZA	JUAREZ-PUENTE ZARAGOZA-VALLE DE JUAREZ	DURANGO
CRUCERO	JUAREZ-CRUCERO	HERMOSILLO, SON.
SAMALAYUCA	JUAREZ-ADUANA-SAMALAYUCA	CHIHUAHUA

LLEGADAS

IDENTIFICADOR	RUTA	DESTINO
CHAMIZAL	ANAPRA-CHAMIZAL-JUAREZ	SANTA TERESA, N.M.
PUENTE ZARAGOZA	VALLE DE JUAREZ-PUENTE ZARAGOZA -JUAREZ	DURANGO
CRUCERO	CRUCERO –JUAREZ	HERMOSILLO
SAMALAYUCA	SAMALAYUCA-ADUANA-JUAREZ	CHIHUAHUA

SCT-DGAC-SENEAM MAY-07-2009 02/09 (370)

Fig. 8 Restriction location government request for the Internacional Abraham Gonzalez Airport (Secretaría de Transporte 2016)

process of ranking discrete candidate alternatives and finding the best compromise solution based on the decision maker's subjective assessments of multiple evaluative criteria [17]. Ting Yu Chen [7] indicated the MCDA problems becoming increasingly complicated, exact assessments of the choices based on evaluative criteria may be difficult to measure or quantify along the MCDA cycle, see Fig. 11

Table 1 Evaluation smart airports

Aspects evaluations	Smart Airports			
	Changi (Singapur)	Incheon (Corea del Sur)	Hamad (Doha)	Carrasco (Uruguay)
Scanning systems (delivery at home)	x		x	
Luggage processing by radiofrequency	x	x	x	x
Auto service boots	x	x	x	x
Smart PathTM de SITA	x			x
Customer service robots	x			
Advanced systems for parking information	x	x	x	x
Interterminal transportation			x	
Bird dispersion acoustic system	x	x	x	
Wall retention for out-of-control landings or takes off	x	x	x	x
Instrument-based landing system	x	x	x	x
Portatile system for dangerous cargo	x	x	x	x
Ionized molecule-based device for detection of explosives and narcotics	x	x	x	x
T-ray technology for inspecting clothes	x	x	x	x
Retractile tunnels for boarding and onboarding	x			
Noise-mitigation walls combined with exhaust gases deflectors	x	x	x	x
Aircraft retrieval systems				
Security points	x	x	x	x

Source Own elaboration

The Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS) is a MCDA tool. The TOPSIS Model is considered low criteria but is complete ranking with close score, according with Hwang and Yoon the Analysis Multicriterial Model have different level to evaluated and utility. It was primarily established by Hwang and Hwang and Yoon [17] for ranking based on resemblance to perfect solution, with advancements done by Yoon in 1987, and Hwang, Lai and Liu in 1993 (2016). TOPSIS is a prevalent method suitable for taking a multiple criteria decision for rank ordering by comparison. It is a technique for rank ordering based on closeness to

Fig. 9 Polygon International Hamad Airport ("Google Earth," n.d.)

Fig. 10 International Hamad Airport ("Google Earth," n.d.)

perfect outcomes. The ultimate option is the one that is nearest to the perfect positive outcome and extreme from the negative perfect outcome [34].

This study uses the TOPSIS method. A positive ideal solution maximizes the benefit criteria or attributes and minimizes the cost criteria or attributes, whereas a negative ideal solution maximizes the cost criteria or attributes and minimizes the benefit criteria or attributes. The TOPSIS method expresses in a succession of six steps as follows:

Step 1: Calculate the normalized decision matrix.

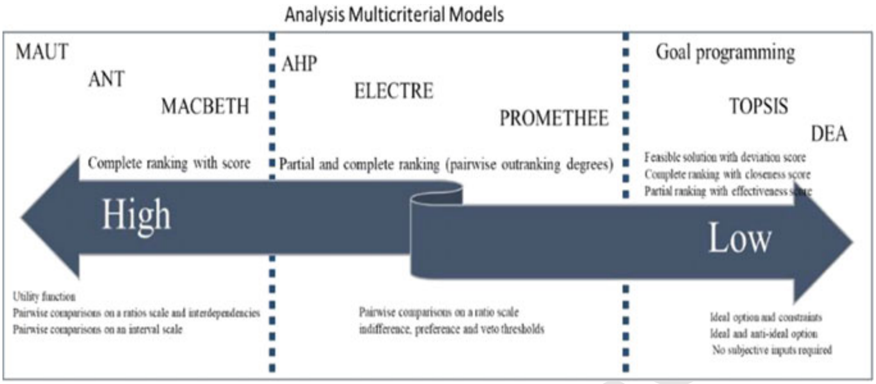


Fig. 11 Multiple-criteria decision-making (MCDM) [7]

The normalized value *rij* is calculated as follows:

$$r_{ij} = x_{ij}\sqrt{\sum_{i=1}^{m} x_{ij}^{2}}\; i = 1, 2, \ldots, m \; and \; j = 1, 2, \ldots, n. \qquad (1)$$

Step 2: Calculate the weighted normalized decision matrix. The weighted normalized value *vij* is calculated as follows:

$$Vij = rijXWj \quad i = 1, 2, \ldots, m \; and \; j = 1, 2, \ldots, n. \qquad (2)$$

where W_j is the weight of the j^{th} criterion or attribute and $\sum_{j=1}^{n} Wj = 1$

Step 3: Determine the ideal (A^*) and negative ideal (A^-) solutions.

$$A^* = \left\{\left(\max_i v_{ij} | j \in C_b\right), \left(\min_i v_{ij} | j \in C_c\right)\right\} = \left\{v_j^* | j = 1, 2, \ldots, m\right\} \qquad (3)$$

$$A^- = \left\{\left(\min_i v_{ij} | j \in C_b\right), \left(\max_j v_{ij} | j \in C_c\right)\right\} = \left\{v_j^- | j = 1, 2, \ldots, m\right\} \qquad (4)$$

Step 4: Calculate the separation measures using the m-dimensional Euclidean distance.

The separation measures of each alternative from the positive ideal solution and the negative ideal solution, respectively, are as follows:

$$S_i^* = \sqrt{\sum_{j=1}^{m}\left(v_{ij} - v_j^*\right)^2, j = 1, 2, \ldots, m} \qquad (5)$$

$$S_i^- = \sqrt{\sum_{j=1}^{m} \left(v_{ij} - v_j^-\right)^2}, j = 1, 2, \ldots, m \quad (6)$$

Step 5: Calculate the relative closeness to the ideal solution. The relative closeness of the alternative A_i with respect to (A^*) is defined as follows:

$$RC_i^* = \frac{S_i^-}{S_i^* + S_i^-}, i = 1, 2, \ldots, m \quad (7)$$

Step 6: Rank the preference order.

The studies carried out using the two methods of MCDA using AHP and TOPSIS in the analysis of green spaces is increase. The review of the literature allows visualizing how the methods of MCDA are used comparatively to determine the best decisions through AHP and TOPSIS, finding that there is no research where they are used for the decision of Green spaces and urban parks location [8, 17, 18, 24–26].

8 Criterial Evaluation Areas

Furthermore, we included Beta-values, or compliance (or suitability or fitness) value judgments, with the following arbitrary Lickert scale:

The Beta-values, or compliance (or suitability or fitness) value judgments, based on the following arbitrary licker scale:

(a) Worst (no compliance)
(b) Very (low compliance
(c) Undesirable compliance
(d) Slightly undesirable compliance
(e) Neutral compliance
(f) Slightly desirable compliance
(g) Desirable compliance
(h) Very desirable compliance
(i) Best possible compliance.

Federal office, such as *Federación Mexicana de Pilotos y Propietarios de Aeronaves* (FEMPPA), *Organización de Aviación Civil Internacional* (OACI) and *Secretaría de Comunicaciones y Transporte* (SCT), dictate the normative airport restrictions for both Mexico as well as for the US-Mexico border region (see Table 2).

Table 2 Evaluations items

ID	Items	Level
FEMPPA1	The VFR flight above the maximum latitude(s) established for each sector within a 15 nautical mile radius of the MMCS airport is prohibited	9
FEMPPA2	VFR flight is not permitted within the N-restricted areas between radial 360° and radial 060° to the border line, and S between radial 180° and radial 240° up to 15 MN unless you are authorized by the Airfield Control (Control Tower)	9
OACI1	Uses of noise-sensitive terrain should be restricted; most buildings are not allowed	9
OACI2	When planning land use, at least two zones should be established with regard to aircraft noise in the vicinity of airports: A (high) and B (moderate)	9
OACI3	Parallel tracks must be built at least 1534 m between center lines	8
SCT1	The airport must have technical and infrastructure characteristics adapted to the needs of its users	9
SCT2	The airport must be complemented by a transport infrastructure that communicates it with the territory where it is located so that an efficient multimodal transport structure is achieved	9
SCT3	The airport must be self-sufficient, self-regulate its growth and not represent an economic burden on society	7
SCT4	Temperature, pressure, air humidity, wind rate, in the field should be taken into account	9
SCT5	The location must have a record of the quantity and distribution of rainfall and evaporation of the place	9
SCT6	Physical characteristics of the soil its use, its type of permeability and surface storage capacity	9
SCT7	You should not interrupt locally in the hydrological cycle	9
SCT8	Presence of other airports and availability of airspaces	9
SCT9	Surrounding obstructions (the surrounding area of the airport must be restricted and protected from any future building)	9
SCT10	Nearby access roads	9
SCT11	Terrain size (land availability for possible expansion)	7
SCT12	The identification and measurement of pollutants generated by the airport at this location are required for the location	7

8.1 Proposed Location Zones

Four locations were identified for the location of the new airport in Juarez. All of the are out of the actual urban spectrum and comply with the normative requirements and with the minimum area of 27 km^2 (see Figs. 12 and 13).

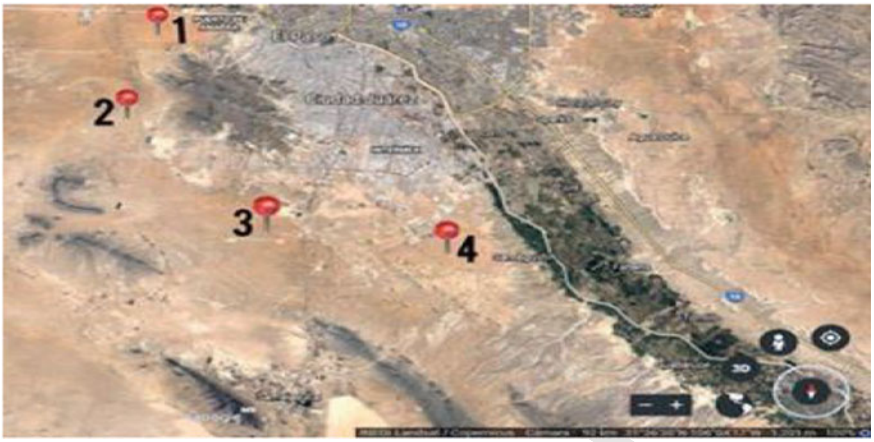


Fig. 12 Location areas

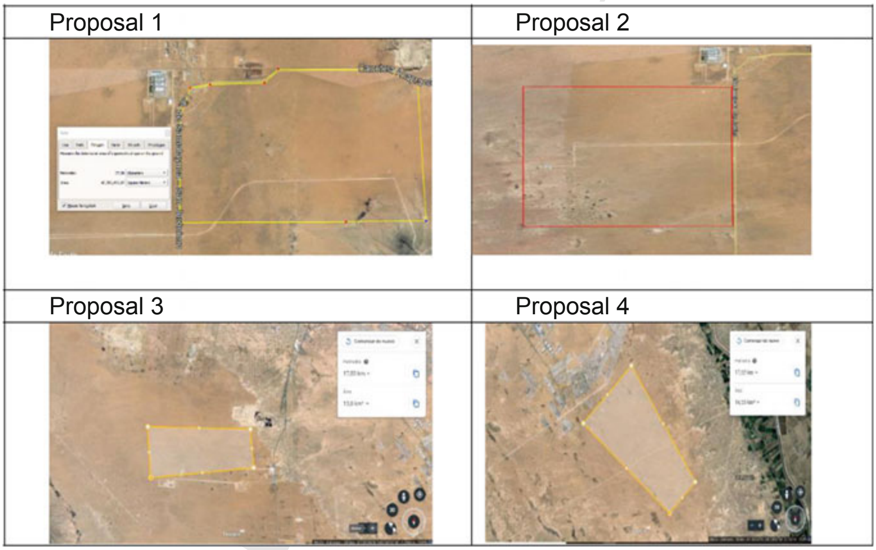


Fig. 13 Four proposition areas

9 Results

The results presented according to the TOPSIS method. The criteria used to determine the values are as follows: (1) Worst (no compliance), (2) Very (low compliance, (3) Undesirable compliance, (4) Slightly undesirable compliance, (5) Neutral compliance, (6) Slightly desirable compliance, (7) Desirable compliance, (8) Very desirable compliance, (9) Best possible compliance.

The four locations proposal were evaluated under the criteria previously defined. The initial results are shown in Table 3.

TOPSIS Evaluation according with four steps, Tables 4, 5, 6, and 7 show the results.

The algorithm proved that the best location for the new airport is proposal 2, see Fig. 14.

This polygon encompasses 30 km, the state highway towards Santa Teresa border cross would be the main Access to this location. There are no building developments in the surroundings. The normative requirements can be easily met. Moreover, the location has the potential to increase initial airport capacity.

10 Conclusions

TOPSIS allowed to identify the best location for a new airport in Juarez, Mexico. The proposed location meets all federal and international regulations. These regulations served as the criteria for the locations evaluation. A new airport in Juarez will cope with an increased demand and will enhance the competitive profile of the region.

The study revealed that locating a new airport faces a great deal of challenges, ranging from regulations, availability of adequate empty land to environmental restrictions. Be able to identify a location in the nearby of the urban realm in a smart city brings positive conditions for a sustainable economic growth.

This work is in line with the recommendations of Cheng-Lung Wu, Andy Lee [25], who state that it is better to propose mid-size airports to alleviate the operations of the large scale airports. This would allow less delays, providing better customer service for passengers, cargo and private users.

Table 3 Proposal evaluations

	FEMPP	FEMPP	OACI1	OACI2	OACI3	SCT1	SCT2	SCT3	SCT4	SCT5	SCT6	SCT7	SCT8	SCT9	SCT10	SCT11	SCT12
	9	1	5	8	8	7	9	7	7	7	8	4	9	3	7	2	9
	9	9	9	8	9	7	9	7	7	9	8	9	9	9	7	9	9
	9	9	9	8	9	7	1	3	6	9	8	9	3	1	3	9	9
	9	9	7	8	8	5	1	3	5	6	8	8	9	9	1	3	6

Source Own

Table 4 Step 1 Calculate Normalized Matrix

WEIGHTAGE	0.062	0.062	0.062	0.062	0.048	0.062	0.062	0.048	0.062	0.062	0.062	0.062	0.062	0.062	0.062	0.048	0.048
ZONE	FEMPPA1	FEMPPA2	OACI1	OACI2	OACI3	SCT1	SCT2	SCT3	SCT4	SCT5	SCT6	SCT7	SCT8	SCT9	SCT10	SCT11	SCT12
PROPOSAL1	9	1	5	8	8	7	9	7	7	7	8	4	9	3	7	2	9
PROPOSAL2	9	9	9	8	9	7	9	7	7	9	8	9	9	9	7	9	9
PROPOSAL3	9	9	9	8	9	7	1	3	6	9	8	9	3	1	3	9	9
PROPOSAL4	9	9	7	8	8	5	1	3	5	6	8	8	9	9	1	3	6

Table 5 Step 2 Calculate the weighted normalized decision matrix

ZONE	FEMPPA1	FEMPPA2	OACI1	OACI2	OACI3	SCT1	SCT2	SCT3	SCT4	SCT5	SCT6	SCT7	SCT8	SCT9	SCT10	SCT11	SCT12
PROPOSAL1	0.027	0.00 3	0.015	0.024	0.024	0.021	0.027	0.021	0.021	0.021	0.024	0.012	0.027	0.009	0.021	0.006	0.027
Proposal 2	0.027	0.02 7	0.027	0.024	0.027	0.021	0.027	0.021	0.021	0.027	0.024	0.027	0.027	0.027	0.021	0.027	0.027
Proposal 3	0.027	0.02 7	0.027	0.024	0.027	0.021	0.003	0.009	0.018	0.027	0.024	0.027	0.009	0.003	0.009	0.027	0.027
Proposal 4	0.027	0.02 7	0.021	0.024	0.024	0.015	0.003	0.009	0.015	0.018	0.024	0.024	0.027	0.027	0.003	0.009	0.018

Table 6 Step 3 Calculate the ideal best and ideal worst value

ZONE	FEMPPA1	FEMPPA2	OACI1	OACI2	OACI3	SCT1	SCT2	SCT3	SCT4	SCT5	SCT6	SCT7	SCT8	SCT9	SCT10	SCT11	SCT12
Proposal1	0.001	0.000	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.000	0.001	0.000	0.001	0.000	0.001
Proposal2	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.005	0.001	0.001	0.001	0.001	0.001	0.001
Proposal3	0.001	0.001	0.001	0.001	0.001	0.001	0.0002	0.0004	0.001	0.001	0.001	0.001	0.0006	0.0002	0.0006	0.001	0.001
Proposal4	0.001	0.001	0.001	0.001	0.001	0.001	0.0002	0.0004	0.001	0.001	0.001	0.001	0.001	0.001	0.0002	0.0004	0.0009
Step 4 Calculate the separation measures using the m-dimensional Euclidean distance																	
V+	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
V-	0.001	0.000	0.001	0.001	0.001	0.001	0.0002	0.0004	0.001	0.001	0.001	0.0008	0.0006	0.0002	0.0002	0.0003	0.0009

Table 7 Final results. Step 6 Calculate the relative closeness to the ideal solution, Step 7 Calculate the Rank

ZONE	Si+	Si-	Pi	Rank
Proposal 1	0.002531	0.002450	0.49189	3
Proposal 2	0	0.003665	1	1
Proposal 3	0.002641	0.002408	0.476862	4
Proposal 4	0.002	0.002599	0.518525	2

Fig. 14 Proposal 2, Santa Teresa area

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Chapter 9

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