PLANNING TO MITIGATE HURRICANE DAMAGE AND TO INSURE THE CONTINUED GROWTH OF CANCUN AND ITS REGION

ISOCARP CANCUN URBAN TASK FORCE TEAM

Figure 1: Aerial view over Punta Cancún

ABOUT THE URBAN TASK FORCE

The Urban Task Force (UTF) is an ISOCARP initiative to provide expert and unbiased advice on pressing planning issues. The Cancun UTF was organized in response to the damage inflicted on the region by Hurricane Wilma. The intent of the project was to provide local authorities with a set of ideas designed to enable Cancun to be better prepared for future hurricanes. An additional task was to propose alternative urban models for Cancun.

BACKGROUND

For much of the 20th century, Cancun was an almost unpopulated and undeveloped island just off the coast of the Yucatan Peninsula. In the early 1970s, the government of Mexico decided to develop a tourist resort on Cancun. A causeway was built to link Cancun to the mainland, together with an international airport and an entire city for workers, with housing, schools, and medical facilities on the mainland. As a result the entire development, both on the island and on the main land, assumed the name Cancun.

Despite initial skepticism that forced the Mexican government to finance the first eight hotels, Cancun soon attracted investors from all over the world. Cancun's population is approximately 500,000 inhabitants. Most 'Cancunenses' are from Yucatan and other Mexican states. A growing number of residents are from the rest of America and Europe.

HURRICANE WILMA AND THE DAMAGE IT CAUSED[1]

Wilma was the third Category 5 hurricane of the 2005 season. At its peak, it was the most intense tropical cyclone ever recorded in the Atlantic basin and the tenth most intense globally.

On 21 October, Hurricane Wilma's eye passed over the island of Cozumel. Then, around midnight on 22 October, it entered the mainland south of Cancun, with winds near 140 mph. Once ashore, the eye slowly drifted northward, with the centre passing just to the west of Cancun. Overland, it quickly lost some of its power, dropping first to a category 3 and finally to a category 2, still a large and powerful hurricane. Although Wilma's intensity weakened, the storm had been undergoing a cycle of eyewall replacement prior to making landfall and had formed a double eyewall structure. This unusual structure subjected the region to four eyewall passes rather than the normal two and led to a doubling of the area affected by the hurricane winds[2]. Wilma passed northward and out of Mexico early on 23 October.

Figure 2: Satellite image of Hurricane Wilma.
Source: http://dave.isom.us/wp-content/uploads/2012/01/Hurricane_Wilma_200510212015.jpg

In addition to at least three deaths and numerous persons reported missing, the insured damage to Cancun was estimated to be between $5 and $8 billion (USD). It was estimated that 95% of the tourism infrastructure was seriously damaged. A number of the beautiful beaches of Cancun were washed away. Many houses were devastated, many commercial buildings sustained damage, and many jobs were lost.

There are three forces that caused the damage to the Mayan Peninsula: wind, waves, and flooding.

Wind

Wind damage to buildings can be caused by debris or from structural failure induced by the wind itself. There was an enormous amount of glass broken during Wilma. Such damage can lead to water damage and even structural failure as the hurricane force wind enters and causes a cascade of interior door and even wall failures.

Roofs and signs are especially prone to wind-induced failure. Roofs tear off and signs and various outdoor standards bend and break. Wind damage is responsible for most electrical service failures during a storm.

Windblown branches, wood, and landscape materials also can become dangerous projectiles during hurricanes; a coconut is reported to have penetrated a window and then an interior wall of a house near Puerto Morelos, as if shot from a cannon. Landscape materials can also be blown around by the wind. In fact, landscape damage is such a reliable predictor of storm intensity that it is one of the metrics used to categorize hurricanes on the Saffir-Simpson scale.

Waves

There are three types of wave damage: storm surge, overwash, and beach transport.

Storm surge is water pushed by the force of the storm. There are five processes that act on storm surge, of which two, pressure and wind, are the most influential. The extremely low pressure found in Wilma's centre pulled water higher near the centre of the storm so, as the center of the storm approached the coastline, the water and waves in the ocean became higher. In addition, the friction of the waves piled the water up. Wind direction also pushes waves higher, an effect termed 'wind set-up', so that waves are higher

Figure 3: Beach erosion and wave damage. Source: Authors.

downwind and lower at upwind locations.

The slope of the seabed near the shore greatly influences the amount of damage on the shore from waves. If the seabed approach to the shore is deep, there is less friction and the waves do not build up. The seabed along the Yucatan Peninsula is shallow, characterised by a gentle rise approaching the shore. As a result surge builds into large powerful waves, with the potential for great damage to structures near the shore. Mitigating this situation are offshore reefs, which allow waves to break, losing much of their power. Off the island at Cancun, there are no reefs; the waves build and roll in unabated. But south of Cancun, the offshore reefs protect shore properties.

Overwash is the term for wave-driven seawater that flows over low areas along the coast and floods interior areas. Overwash was not a major problem from Wilma, as the mainland is located on limestone bedrock that gently slopes upward from the sea. There was some localised overwash, which mostly affected mangrove vegetation.

Beach transport consists of the erosion and deposition of sand along the shoreline caused by waves. It is influenced by the wind direction, and in the case of Wilma, the highest winds occurred from the east southeast, which resulted in the scouring of sand along the northern reaches of the coastline. This scouring effect was especially evident along the island of Cancun, and sand deposition was greatest at southerly locations along the coast. In Puerto Morelos, several small piers were buried in sand. Besides causing the obvious damage to swimming beaches, erosion exposed foundations in some locations.

Flooding

Rainfall from Wilma ranged from 9 to 14 inches. As the soil is thin and the underlying geology consists of fractured, but only moderately porous, limestone, water drained slowly in many locations. In urban areas with large amounts of impervious surfaces, natural drainage was further challenged by the higher amounts of run-off. Flooding was a major problem.

Figure 4: (top) Damaged caused by wind and flooding. Source: Authors

Figure 5 (bottom): Wave and wind damage. Source: Authors

PLANNING CONSIDERATIONS TO MITIGATE FUTURE HURRICANE DAMAGE

Wind

First, it is important to note that the concrete block and reinforced concrete construction methods universally employed in urban centers such as the Cancun region are far less susceptible to wind damage than wooden frame structures. Photos and buildings examined by the UTF did not display any evidence of major direct wind-induced structural failures. There appeared to be a small number of progressive failures, where the roofs failed, and then some, or all, of the structure failed. Such financial loss can be avoided by including building code requirements for improved tie-downs, especially at edges. Despite the lack of structural failures, it is a good idea to require large buildings, especially those in an urban environment, to undergo wind tunnel testing of both the building and the building's neighborhood environment and to insist that structural engineers perform load calculations on the building envelope and rooftop equipment. In rural areas, however, it was reported that traditional wood and thatched dwellings sustained serious damage.

However, damage to glass was a major problem resulting from Wilma. Engineers have extensively studied the this kind of damage, and several studies confirm that small missiles, such as roofing gravel and other missiles have sufficient strength to shatter even thick hotel windows when propelled by hurricane-force winds[3]. While wind-borne debris may have been a major cause of broken glass in the downtown, it appears likely that glass damage to oceanfront structures might have been the result of wind-induced changes in pressure along the outer shell of buildings, perhaps as a result of gusting. If this is to be prevented, methods to shield the glass on new and existing buildings need to be developed and implemented. The only reliable protection is to cover windows with other materials, such as wood sheets. Other types of wind damage from Wilma need to be collected, and the newer building codes now in effect in Florida should be scrutinized for ideas to be incorporated in the local building codes. It also is important, once specific mitigation techniques have been established, to communicate these ideas to the local design professionals and builders.

Waves

Bathymetry along the coastline, completed in the mid-1990s, can be used to model surge using programs such as SLOSH (Sea, Lake and Overland Surges) using the Composite approach which can simulate several thousand hypothetical hurricanes under differing storm conditions. Areas identified with higher surge damage probabilities might be deemed less suitable for development. Existing buildings in areas prone to surge damage should be informed of the hazard, so the owners can implement mitigation efforts (such as the establishment of energy reflective seawalls).

Beach transport can be mitigated in highly developed areas, such as the hotel on the barrier island, through the constructions of groins. However, the effectiveness of groins to mitigate beach transport during a hurricane is doubtful. There also is evidence that the construction of vertical seawalls exacerbates beach erosion. Beach erosion and sand transport during hurricanes can only be mitigated by implementation of set-back limits and the restoration of natural dunes and their associated vegetation. Whenever that is not possible, the construction of energy-dissipating types of sea walls can be used, but set-back limits are still advisable. More detailed engineering studies should be made of this issue; some consideration should be given to removing the existing vertical seawalls if possible, and construction of new vertical seawalls along the beachfront areas of the region should be prohibited.

Other Damage Mitigation Considerations

Natural Features

The natural topography of the region also contributes to the extent and duration of, and damage resulting from, flooding. A new map produced as part of the UTF displays a series of three dunes as well as existing and fossilized mangrove swamps. Farthest to the right is today's narrow coastal dune band, and next to it in light green lie today's existing mangrove swamps. Two elevated ridgelines made of ancient dunes are located to the east of these swamps. They are shown in darker shades of yellow. Behind each of these ancient dune systems are low-lying areas, the fossilized remains of

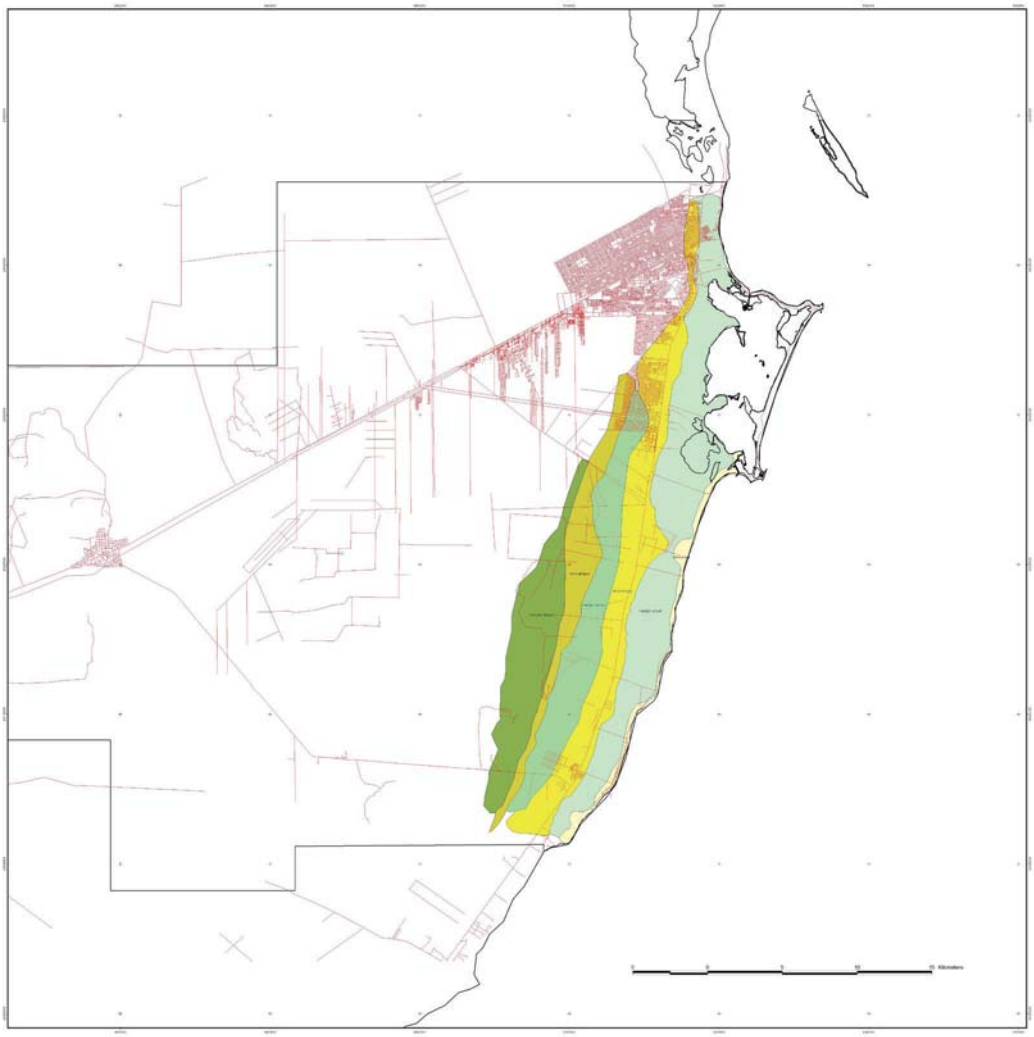

Figure 6: Ancient dunes: the long yellow bands following the coast as former shore line dunes. Source: Authors' design

ancient mangrove swamps. These areas are shown in shades of darker green. All the fossil strandline and mangrove units were formed during Pleistocene Inter-glaciations, when the sea level was equal to, or higher than, the modern level.

Flood water falling behind the fossil dunes is collected and held in the lower ancient mangrove areas. To drain, flood water must slowly percolate though the fossilized sand dunes, a process that can take several days or more. Therefore, the ancient mangrove areas act as a reservoir for flood waters.

Every effort must be made to preserve the existing natural outfalls for flood water from mangrove swamps. Extensive construction in low-lying areas, the locations of ancient mangrove swamps, should be avoided. Development parallel to the coast should be focused on the dune areas, and to preserve future development options, the continuation of quarrying of these areas needs to be carefully considered. Similarly, areas excavated by the quarrying now represent areas prone to surge-induced flooding, and any construction in these areas should recognize this fact.

Another way to reduce damage is to use decorative planting materials, which are less susceptible to wind damage, or to producing wind-borne debris and projectiles. The use of plants native to the shoreline and region is highly recommended.

Sea Level Rise

The planning team secured information and actual measurement data about sea level change in the region from a variety of sources. However, much of the actual data was collected over a period of time, which makes interpretation unreliable. As a result, it was thought prudent to rely on a global coastal average of 3.7 mm/yr obtained by Holgate and Woodworth 2004 (GRL 31, L07305) as the best estimate for the peninsula. If this rate continues, some sources project "a sea level rise of 0.09 to 0.88 m for 1990 to 2100, with a central value of 0.48 m". Developments along the beachfront coastal areas need to take sea level rise and its possible contribution to hurricane damage into serious consideration.

Further study

It is also recommended that the pre-Wilma and post-Wilma aerials collected by IMPLAN during the course of the UTF be used to accurately assess and document beach transport as well as document areas where over wash occurred. Such analysis can assist in documenting areas more or less suitable for development, especially along the coast to the south of Cancun.

SCENARIO PLANNING FOR CANCUN'S FUTURE

Three main areas can be identified in Cancun's urban form. The first area consists of a narrow strip of 22 km extending North-South along the axis of Boulevard Kukulkan, between the Nichupté Lagoon and the Caribbean Sea. This linear development, aptly called the Hotel Zone, concentrates tourism-related development with a multitude of resorts, hotels, and support businesses, as well as historical ruins.

The second area is known as Pueblo de Apoyo (literally, Support Town), and is located north of the Kukulcan strip. Its distinctive pentagonal shape was planned by Enrique Landa. This area is otherwise known as Centro (downtown) and concentrates a number of civil amenities such as the city hall. Its character is mainly residential.

The third area, Zona de las Regiones, located to the north of the Centro, is an attempt to cope with Cancun's considerable growth. The urban fabric of this area consists of a large orthogonal carpet, dedicated to residential use, with single family housing the dominant typology. Its capacity is for a remarkable half a million people. However, its roads are narrow, and open areas and civic amenities scarce.

Scenario planning is a group process that encourages knowledge exchange and the development of a mutual deeper understanding of important issues central to the future. The goal is to craft a number of diverging stories by extrapolating uncertain and heavily influencing driving forces. The team adopted this methodology with the aim of provoking a thorough reflection on the challenges and opportunities facing Cancun.

It is relevant to mention that the tourism industry in Cancun will be an enduring element in city planning. Therefore, it is to be noted that the tourism supply and demand economics for tourism dictate specific planning requirements.

Informed by a series of presentations with lo-

cal experts in regional and municipal planning, GIS and meteorology, and a number of dialogues with representatives of the private sector, the team elaborated the following three scenarios.

Scenario A: "Ciudad Turismo"

This scenario assumes that the region's tourism infrastructure, residential neighbourhoods, and commercial districts will continue to develop much as they have done in the past 35 years.

The economic base of this scenario focuses on mass tourism. In this setting, the competitive factor for Cancun can be described as "sun and sand at an attractive price". Cancun's competitors are those destinations that can offer comparable climate conditions at comparable prices. The target consumers of this scenario are concerned with price, a group that generally chooses all-inclusive packages for their holidays. Hence, the main actors in this model are the tourism industry integrators, international tour operators, and hotel chains, such as Barceló, Melia, and Starwood.

In tourism industry models based on the quantity of visitors, the role of the host territory can be described as a provider of natural resources and workforce for a fee. In most such cases, resource consumption (i.e. land, water, energy, waste) is very high, and the economic margin for locals rather low. The workforce's required skills can be considered as low. The model's labour force comprises mainly low wage service industry workers, who have reduced opportunities for cultural development and little access to broader skills.

In this scenario, the role of institutional policy making can be considered marginal. The main actor in the scenario is the private sector, specifically travel industry integrators who control key elements in the value chain (visitor's transport from and to their origin, accommodation, leisure, and food and drink consumption), and commoditise local resources and labour.

Future development is assumed to preserve the current lineal growth pattern and other tendencies previously established. The actual Zona Hotelera will increase its density. The Pueblo de Apoyo, where the support workforce resides, is expected to grow, although to a lesser degree, based on the existing grid pattern extending in a northwest direction. This scenario has a strong parallel with the coast development of Waikiki, Hawaii, dominated by large-scale tourism developers.

Further expansion of the Hotel Zone along the coastline would increase the pressure on infrastructure and urban services, such as the provision of energy and waste management. Emission will also increase, as well as land and water consumption. A larger service sector will result in increased stress to the workforce residential areas outside the city.

It is expected that the density increase of the Zona Hotelera will lead to higher pressures on traffic and very likely a congested situation at the connecting intersection nearby the city centre.

This suggests that a broad and comprehensive traffic strategy needs to be prepared, considering public transport as a vital element.

In this regard, it was made known to the team that the local government is already considering a multi-million dollar bridge across the Nichupte lagoon. Whist Scenario A is the only one that would create conditions which might support this investment, the UTF team recommends reconsidering the bridge project, as perhaps increasing intersection options and improving the circulation pattern at both ends of the Hotel Zone could render the bridge unnecessary.

In contrast, the area existing between the airport and the city centre is to be considered as an independent project that can be implemented in parallel or at a later stage. It is believed that this development evidences little synergy with the scenario of mass tourism.

Scenario B: "Ciudad Central"

This scenario sees Cancun develop as a leading commercial and service centre serving its surrounding region and a larger influence zone in Yucatan and the Caribbean. The tourism industry will be retained, but the main source of employment would be in service-related jobs.

The economic base consists of a combination of the currently existing tourism industry, which would be retained to some extent, with the addition of a cluster of services focusing on the tourism industry reaching the Yucatan peninsula and the near Caribbean region. Services provided to the region can include financial services, telecommunications, education, health, transportation, logistics and distribution, and light manufacturing.

Figure 7: First sketch of concepts.
Source: Authors' design

The scenario's competitive factor can be described as "employment in paradise", as the capacity to attract skilled human resources to operate the model is vital. The target consumers are the professionals in addition to a less relevant visitor figure. The model's main actors are the public sector, which is responsible for providing the enabling policy and the required infrastructure, and the corporations, which are required to address a location commitment to create a services critical mass.

Cancun's resource consumption, as a regional centre providing services to support the regional tourism industry, can be described as medium as the model calls for a compact, higher-density urban development. Margins for service-focused cities tend to be high if they are capable of aggregating significant value for their surrounding region. Education and cultural development are crucial in this scenario, as the economic model requires high workforce skills, with special mention to information and communications technology.

The role of institutional policy making is critical. Without the vision and initial impulse from the public sector it is unlikely that the private sector can independently undertake such transformation, as it has neither enough human resources to implement such complex, comprehensive vision nor the financial mechanisms to avoid short-term obligations.

The model will require a remarkable transformation in the accommodation stock, from hotel rooms to condominiums to provide housing for professionals moving in. In addition, hospitals, schools, and other support facilities need to be upgraded or built from scratch. As much as the investment in infrastructure such as roads and airports is critical, so is a high expenditure in education and cultural activities to both attract and prepare professionals.

To fulfil the growth perspective foreseen in this scenario, urban development will need to be carefully planned, including a series of catalytic projects. Specifically, these comprise the site of the new civic centre in Malecon and the creation of three major corridors in addition to the Hotel Zone:

1. Via Lopez Portillo Corridor: A mixed-use district with an emphasis on small commercial/service developments that serve both local residents and the building industry in the Hotel Zone;
2. Libramiento Merida -Playa del Carmen Corridor: An industrial district intended to serve the import-export activities of the region with relevant trade/logistics components and infrastructure;
3. Cancun-Puerto Morelos Corridor: A regional district that would contain a myriad of corporate headquarters and professional offices, major health facilities, universities, and specialised services. The international airport becomes an important node for commerce as well as tourism, and the two ports are to be developed as potential doors to the Caribbean. Somewhat like San Diego, California, this balanced economic scenario necessitates a new vision for future demographics and investment.

Keeping its focus on the tourism industry, this scenario contemplates a switch in target market from mass tourism to a qualitative-based profile with fewer visits. In this setting, Cancun's competitive factor is its capacity to offer a distinctive tourist experience, adding cultural, educational, and health-related activities to those pull factors expected to be found in a sun and sea destination. The target segment consists of tourists looking for environmental quality, historical and cultural heritage, unique design and construction, and unparalleled service.

To make this model possible, close cooperation between sectors is required.

Institutional instruments must be put in place to ensure quality in new development and standards of service, and to financially support the transformation of the built stock from mass-oriented to increase its competitiveness in terms of quality. The dynamism of the local entrepreneur is vital, as the model is based on a number of local private sector ventures rather than relying on large tourism industry multinationals. The concordance with environmental lobbies in development policy is also indispensable, as the model needs the highest environmental standards to be competitive.

Future urban development is structured in three distinctive axes: between the airport and the city centre, along the extension of the highway going westwards, and a bypass between the two main highways, connecting the airport and creating a compact, triangular urban lay out.

These new city strips induce an increase in urban density within the existing city grid. The distinctive urban areas express a variety of programmatic clusters that represent a diversification of economic activity. In general terms, the Western Corridor acts as a small scale yet regional production and service area; the Southern Corridor as a more extensive industrial zone specialised in transport and value added logistics, taking advantage of the proximity of a relatively well equipped airport. The East Corridor will feature a cluster of universities, research, technology services, and government institutions. The model banks on the quality of landscape and climate in attracting highly educated human recourses from all over the world.

The scenario assumes a diversification of economical activities in the city itself, an efficient infrastructure network that is largely based on connectivity and a strengthening of social networks between management, knowledge, technology, and production. It is proposed that the existing bus service be complemented by a light rail system.

Scenario C: "Ciudad de Comunidades"

The "City of Communities" model would place emphasis on preserving the environmental quality of the region and the redevelopment of a number of communities within the region, such as Puerto Juarez and Puerto Morelos, which have grown organically around small ports to the north and south on the Cancun city proper.

Tourism would continue to be a primary economic driver, but its territorial footprint will show a dispersed arrangement which peaks, marking these communities as well as other attractors such as the cenotes (immense, deep, open wells) located to the southwest of Cancun.

With some similarity to the smaller-scale development of Oregon or New England coastlines, this model would decentralise the tourism economy. It would also facilitate opportunities for more diverse tourism experiences and support ecotourism development at the cenotes and coastal villages

In many ways, this scenario is the opposite of Scenario A: tourism is scattered around in a much bigger area along the Mexican Riviera. Small communities of high-quality tourist compounds are embedded in the natural beauty of the landscape. For the demanding tourists, it provides a sense of privacy, almost a thematic approach, which might as well be one of the unique selling points of the region. At the same time, the relative separation of the contained settlements makes it possible to diversify the tourism opportunities. The sprawl of the communities can be seen as an archipelago of different experiences.

To reduce daily commuting, each village is to be accompanied by housing facilities for local inhabitants that work in the tourist industry. The small scale in the mix of locals and tourists could even be one of the attractions of the vacation (authentic informality). The sprawl of small communities makes it possible for the ecological green zones function to as a whole; the urban settlements are just 'plug-ins'. Normally, such lay outs cause negative effects on the environment because of increased mobility. To prevent this, the communities should have an autarchic (self-sufficient) character: Cancun as the city of villages.

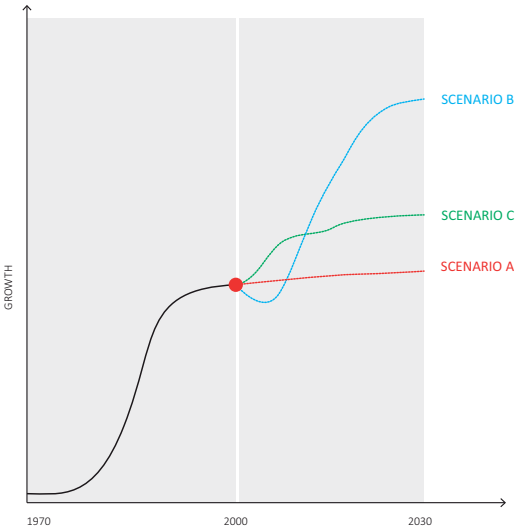

Figure 8: Urban forms - growth options.
Source: Authors' design

ENVIRONMENTAL IMPACT MATRIX

EFFECT ON —>	ENVIRONMENTAL VARIABLES				FACTORS OF THE LIFE QUALITY			
	LAGOON	MANGROVES	FOREST	REEF / BEACH	WATER RESOURCES	NOISE	AIR QUALITY	URBAN GREENERY
SCENARIO A								
Hotel zone								
Urban shape								
Other settlements								
Mobility								
Airport								
Urban utilities								
SCENARIO B								
Hotel zone								
Urban shape								
Other settlements								
Mobility								
Airport								
Urban utilities								
SCENARIO C								
Hotel zone								
Urban shape								
Other settlements								
Mobility								
Airport								
Urban utilities								

EFFECTS: ADVERSE LESS ADVERSE NEUTRAL FAVOURABLE

Figure 9: Environmental Impact Matrix.
Source: Authors' design

HURRICANE IMPACT MATRIX

POTENTAL DAMAGE	WIND	FLOODING	STORM SURGE
SCENARIO A			
Hotel zone			
Urban shape			
Other settlements			
Mobility			
Airport			
Urban utilities			
SCENARIO B			
Hotel zone			
Urban shape			
Other settlements			
Mobility			
Airport			
Urban utilities			
SCENARIO C			
Hotel zone			
Urban shape			
Other settlements			
Mobility			
Airport			
Urban utilities			

Figure 10: Hurricane impact Chart.
Source: Authors' design

ENVIRONMENTAL ASSESSMENT

The following evaluations have been prepared to allow stakeholders in the Cancun region to compare the impacts of the alternative development scenarios on the environmental and their relative resistance to the destructive forces of hurricanes. The accuracy of assessment is limited by the general nature of the assumptions and information used, so the analysis operates only with qualitative estimates which are meaningful solely for comparison purposes.

The analysis has been presented in the form of matrices. For each alternative, the following plan components have been assessed: hotel zone, urban shape (city of Cancun), development of the other settlements within Benito Juarez municipality, mobility (understood as flows of people and goods as well as means of their transportation), airport, and public utilities (excluding transportation).

The environmental impact matrix compares both environmental and quality-of-life issues. The environmental features assessed are: Nichupté Lagoon; mangrove areas along the coast (south of Cancun); forest systems; and finally, reef/beaches. The quality-of-life issues examined include water resources; noise level; air quality; and urban greenery /landscaping. The overall matrix shows the impact of each component within each scenario on each of the environmental and quality-of-life variables. The classic environmental impact matrix analyses separately its magnitude and importance, but due to the general form of scenarios, this impact estimation is limited to a four-grade scale of effects: adverse; less adverse; neutral; and favourable.

The matrix estimating the potential hurricane impact uses three variables to address the principal detrimental factors of the hurricane: high-speed wind; rain flooding; and, storm surge. The impact strength is estimated within a three-grade scale: from the least to the most serious potential damage (or from the most to the least resistant item).

Scenarios and their environmental impact

Although the overall impact of all scenarios (measured by the number of filled matrix cells for each of them) can be considered as similar, it should be pointed out that its differing plan elements are affected differently in each scenario.

Scenario A shows the greatest number of adverse environmental effects. Further and intensive development of the hotel zone around the lagoon, and the possibility of creating a new bridge across it, threaten the fragile ecosystem. It will also exploit most intensively the beach on Cancun's Zona Hotelera. The transport of tourists, if still by buses and taxis, will adversely affect the acoustic and air quality. Both hotel and municipal growth will increase the demand for water supply and public utilities. A second landing strip for the airport will be needed, and its construction will result in loss of forest and increased noise, which will have a negative effect on fauna in the surrounding zone. Growth of mobility between the city, airport, and Riviera Maya as well as within the sprawling area of the city itself, will produce great volumes of air pollution and a high level of noise. Lower emphasis on the development of the other settlements within the municipality will have less adverse environmental impact.

In Scenario B the development impact lessens on the lagoon (it is assumed to receive a nature conservation area status) and beach but increases on the forest as the city will need to grow, despite the higher densities. The territorial expansion can threaten the aquifer zone, which supplies Cancun's drinking water. The problem of worsening the life quality within the city will be similar to scenario A.

In Scenario C, the environmental impact of development is generally less strong than in the other scenarios (in the Hotel Zone even the favourable effects can be expected), but it affects a much greater area. The pattern of dispersed tourism will affect above all the natural areas south of Cancun - the mangroves, forest, reef, and beaches although probably not so badly as in Scenario A. The necessary mobility increase will still have strong effect on the quality of life.

Factors related to quality of life (especially the levels of noise and air quality) are most strongly threatened by the developmental forces within all scenarios. The adverse effects accumulate also on the lagoon and the forest in the Scenario

Figure 11: People enjoying the beach at Cancun. Source: Authors

A, the forest in Scenarios A and B and all environmental variables in Scenario C.

An analysis of the hurricane impact matrix shows that the biggest potential damage should be expected from Scenario A closely followed by Scenario C due to the concentration of growth adjacent to the ocean. Scenario B represents the highest flooding alternative due to an increase in the built area and the potential for greater damage to utilities.

CONCLUSION

It is likely that the scenario that best matches the future of Cancun results from a combination of the three scenarios presented in this report.

Therefore, many of the issues discussed in each scenario would have to be addressed and planned. A successful urban planning strategy in a complex urban fabric such as this requires a strong determination to improve existing conditions by creating strong relations with the context, through a clear sense of location, position, and orientation.

This establishes a coherent urban environment that not only unlocks private sector development possibilities but most importantly redefines the regional center structure with the creation of a coherent public place that enhances the activity of its residents and users.

The Ciudad Turismo Scenario is believed to be the most likely if the government does not support a revision of the current development approach. The Urban Task Force estimates that Cancun will recover from Wilma and follow a continued moderate growth pattern with this scenario.

The Ciudad de Communidades would have an improved growth pattern with a more distributed socio-economic base, and the Ciudad Central scenario would have the highest potential by cap-

Figure 12: The team of the Urban Task Force. [4]
Source: Authors

turing regional and international commerce complementary with an expanding tourism industry.

Population projections for 2030 based on these scenarios range from 1,500,000 to 2,000,000, but the density would vary considerably, with the "mass tourism" model showing the highest density and the "ciudad de comunidades" model the lowest.

In the end, Implan's challenge will be to create a master plan for the municipality that considers the same factors forming the basis for the UTF program: promote economic opportunities, social equity, and environmental quality.

Cancun/the Mexican Riviera is an extraordinary place that has the potential to be one of the most memorable tourism experiences, a vital Caribbean trade centre, and an environmental heritage for the people of the Yucatan, Mexico, and the world. ■

Endnotes

1 We acknowledge the assistance of the following individuals and institutions which provided invaluable information about hurricane Wilma: Dr. Chis Pyke, US EPA, Global Change Research Program; Lindy Dinaers, Hazard, NOAA Coastal Services, Remote Sensing Service Center; Dr. Jim Titus, US EPA, Sea Level Rise; Alan E. Strong, NOAA; Dr. Bruce Richmond, USGS; Christopher Junkins, Meteorologist, National Hurricane Center, Tropical Prediction Center; Wayne P. Szameitat, Sales Manager, Optech Incorporated; Dr. Edward Olsen, NASA, Jet Propulsion Laboratory; Dr. Bjorn H. Lambrigtsen, NASA, Jet Propulsion Laboratory.

2 National HurricaneCenter release 11 PM EDT SAT OCT 22 2005
The center of Wilma has moved off of the northeastern coast of the Yucatan Peninsula....
The plane also reported the remains of an inner eyewall... and an outer eyewall with a diameter varying between 60-80 n mi. Wilma is currently trying to finish an eyewall replacement cycle that began almost 48 hours ago....

3 See: http://www.wbdg.org/design/env_wind.php

4 ISOCARP Team Members: Pablo Vaggione, Spain – Team Leader; Ismael Fernandez, Mexico - VP UTF; Alvaro Arellano, Mexico; Krystyna Mieszkowska, Poland; Jim Reilly, USA; Ric Stephens, USA; Hein Struben, Netherlands; Gijs Wolfs, Netherland. IMPLAN Team Members: Eduardo Ortiz Jasso, Director; Margret Bongers; Rocio Garza Leonard; Luis Ernasto Perez Fernandez; Isaac Rincon Garcia; Gerardo Garcis Beltran; Angel Lorento Viruel. A special thanks to Dr. Paul Blanchon, Universidad Nacional, Instituto de Ciencias del Mar y Limnolgis, Reef Systems Unit.