



New Orleans Hurricane Evacuation Plan

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Abstract

Hurricanes are natural disasters with the potential to cause damage to property and lead to the loss of lives. The New Orleans government requires a preparedness plan that would outline the measures to be taken by the government in the event of a hurricane. The plan is especially important given that the city is vulnerable to such calamity and the levees plans are no longer effective. New Orleans is situated in a floodplain which makes it vulnerable to floods when a tropical cyclone hits the region. The levees further make the place more threatened because they have disrupted the deposit of silt from the River Mississippi making the place sink further in the era of rising sea level. It is evident from hurricane Katrina that government officials need to be conversant with disaster plans for successful evacuation. However, key limitations to the success of this measure include the lack of adequate public transport and the fact that some members of the community ignore the warnings. The Earth Systems Engineering and Management (ESEM) principles of continuous learning, resiliency, long-term investment and systems and artifacts are essential for building practical infrastructures that can withstand strong hurricanes. It is recommended that the New Orleans government engage public officials in disaster planning, ensure there is enough public transport for evacuating the citizens and create an effective plan for resilience.

1. Introduction

The coastal cities and towns in the United States have in the recent past been experiencing large tropical cyclones that have led to massive damages to property as well as loss of life.

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Hurricanes have caused significant social and economic disruptions in places such as New Orleans which is vulnerable to such climatic catastrophes. The city of New Orleans is built on a floodplain which makes it subjected to floods that are resulting from hurricanes, especially in areas that are below sea level (Colten, 2006). The existing levees that were built after the hurricane in 1915 are no longer effective as their proper maintenance has been neglected for over 100 years and hurricanes are increasingly becoming stronger with time due to global warming and the rising sea level (Colten, 2006). Hurricane Katrina brutally exposed the vulnerability of New Orleans if considering socioeconomic and transportation challenges in disaster preparedness. The New Orleans government needs a preparedness plan that would involve explicit community evacuation procedures and takes into consideration sociocultural issues that may affect emergency planning measures such as evacuation. The need for such a well-developed disaster initiative will help in ensuring that hundreds or even thousands of lives are saved in New Orleans. The report provides key recommendations that can help in creating a practical and effective evacuation plan for all residents regardless of their socioeconomic status.

2. Methods and Tools: Preparation and Warning

New Orleans is at high risk of experiencing the consequences of hurricanes since it is predominantly located below the sea level. A significant section of the city has been built on a floodplain which increases the vulnerability of flooding in the region. The area has experienced cases of flooding in the past, with the most significant being the one caused by hurricane Katrina in 2005 (Colten, 2006). Engineering practices that were employed in the past to reduce the risk of flooding from rivers and precipitation are proving ineffective. The building of the levees to help contain and mitigate flooding in the region has, however, presented new problems for the city, making it even more vulnerable to flooding (Figure 1). Natural silt deposit from the Mississippi River has been unable to replenish the delta which has made the region to continue sinking (Colten, 2006). The development of the area and the construction of large buildings have further aggravated the situation, and the area is now even more threatened given that the Earth has been experiencing a rise in sea level because of global warming.

The levees that were built in New Orleans were not constructed to withstand strong hurricanes, which was evidenced by the disaster caused by hurricane Katrina. The condition of the levees has also been deteriorating over the years due to their centennial age as well as a lack of proper maintenance (Campanella, 2008). Additionally, most of the levees in New Orleans were built in the 1950s and 1960s by the Army Corps Engineers and had not been receiving enough funding from the government to help in their maintenance for over half a century. The levees that surround New Orleans and its adjacent areas have made it a large bowl and the water that falls collects in low areas and must be pumped out to the nearby river, lakes, and other water bodies. All these manmade features have significantly increased the risk of flooding during a hurricane.

cyclone would be severe. The mayor did not take the warning with the level of urgency that it required and stated that he would issue a voluntary evacuation notice later (Brinkley, 2006). It is, therefore, important that government officials are well conversant with the disaster plan prepared by the relevant agencies and work towards conveying the urgency of a disaster warning to the populace (Landy, 2007). Creating urgency is necessary to achieve the desired goal of evacuating high-risk areas. A mandatory evacuation notice is the best option to protect the population from the devastating effects of a hurricane. A voluntary evacuation notice does not suffice as people usually interpret the situation as not being serious enough to warrant them to leave their homes and businesses.

3. Hurricane Preparedness

A plan is an important first step to hurricane preparedness. One should not wait until the storm develops to make their plan. The plan should include where one will go, how they will get there and what they will bring along during the hurricane period or survival kit and what they should do or not do during and after the storm. Before the storm, one must identify a suitable area where they will go in case the storm starts, and notify their family, relatives, and friends of their suitable evacuation plan. File their personal evacuation plan with the OISS, and lastly have a disaster kit with the checklist confirmed accordingly. During the storm, one should stay informed through their local radio station, UNO website, and emergency alert system. After the storm, they should monitor the UNO website and update on the state of the storm and identify the procedure of leaving their evacuation area and returning to their normalcy.

4. Intensity and Death Toll from Previous Hurricanes

Hurricane Katrina is the third strongest hurricane reported in the United States. Katrina led to massive property damage and loss of human lives. The winds reached a speed of almost 175 mph, and the storm surge was up to 20-ft high (Brunkard, Namulanda, & Ratard, 2008). While the approach of Katrina to the shore was slow and steady, the storm suddenly became dangerous and inevitable with increasing wind speed. The death toll from Hurricane Katrina was 1,836 with 49% of the death toll being among the elderly population, persons aged 75 years and above. Drowning represented 40% of the total deaths, an indication that the individuals did not evacuate on time before the water levels rose. Injuries and trauma led to 35% of the deaths while the remaining 11% died because of heart failure. Fifty-three percent of the deaths were men, among whom 51% were black and 42% were white people (Brunkard, Namulanda, & Ratard, 2008). The data is an indication of the vulnerability of certain individuals during a catastrophic event. As has been mentioned above, the most affected population cohort was the elderly, which signifies that there needs to be an evacuation plan that caters to the needs of this cohort.

					Cardiovascular	Evaluation		Vehicle				Power			
Rank	Name	Year	D	I	Card	CaEy	Evac	VEv	Yeh	VeTr	Tree	Co	Elec	Fire	Fall
1	Katrina	2005	520	565	318	27	46	0	12	2	4	9	3	0	5
2	Rita	2005	7	101	0	0	37	46	4	0	0	9	2	0	1
3	Andrew	1992	23	90	3	1	5	1	12	0	4	4	5	2	6
4	Sandy	2012	73	82	2	1	0	0	15	2	6	15	2	3	10
5	Camille	1969	288	55	30	0	0	0	9	0	0	0	4	0	0
6	Frances	2004	6	49	3	0	1	2	18	5	3	2	4	1	6
7	Ike	2008	20	44	1	0	0	3	0	0	5	9	7	2	1
8	Isabel	2003	16	36	2	0	0	0	4	6	4	8	3	1	4
9	Charley	2004	10	29	3	0	1	0	5	1	1	2	2	1	4
10	Hugo	1989	17	27	7	0	0	0	0	0	2	0	4	13	0
All 59		1963-2012	1803	1418	430	38	98	63	163	38	39	69	68	45	49

Figure 3: The Death and Causality Caused by Tropical Storms
 Source: (Brunkard, Namaland, & Ratard, 2008)

A few weeks later after hurricane Katrina hurricane, Rita came with an even stronger impact. The city of New Orleans had not yet fully recovered from Katrina and had to deal with another storm. The death toll directly caused by Rita was 7 deaths and 101 indirect deaths. Forty-six of the indirect deaths were caused by vehicle accidents during the evacuation; thirty-seven were because of evacuation without vehicle accidents (Rappaport & Blanchard, 2016). Some of the people died in traffic while evacuating from the region when their bus caught fire. The bus that was in flames was carrying the senior citizens from the elderly care facility. It is evident that in both hurricane incidents, the most affected individuals were exactly the people from this population category, and this calls attention to the needs of all vulnerable people such as those in hospitals, long-term care facilities, and the elderly. It is also important that the emergency management agencies also consider persons from low socioeconomic backgrounds. Most people from this cohort do not have the necessary means of transport to go out of the city during an evacuation and may not be able to afford to pay for commercial services, which also leaves them in risk of losing lives.

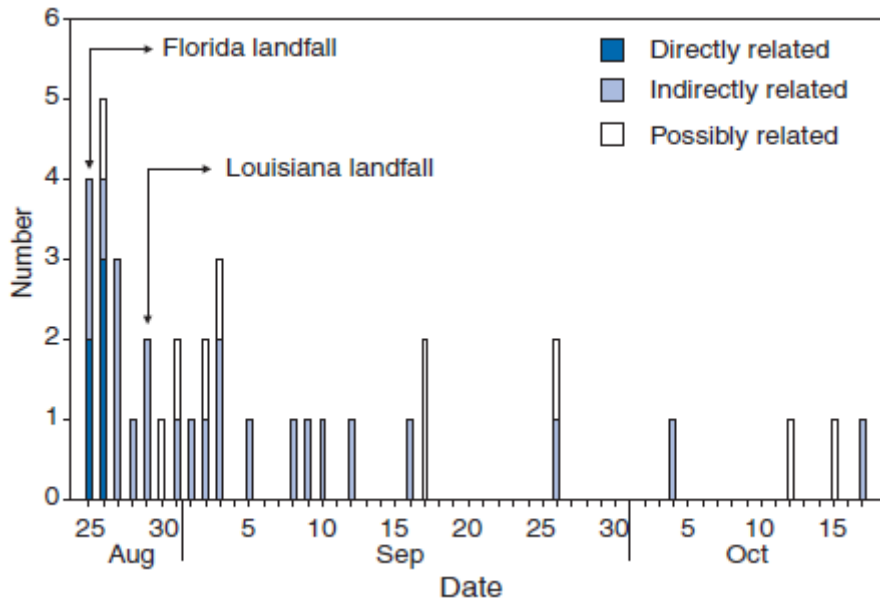


Figure 4: Deaths Related to hurricane Katrina
 Source: (Centers for Disease Control and Prevention, 2006)



Figure 5: An Elderly Woman being saved after getting trapped in Flood Water
 Source: <https://edition.cnn.com/2013/08/23/us/hurricane-katrina-statistics-fast-facts/index.html>

5. Current Evacuation Plans

An evacuation plan is the most immediate remedy to prevent the loss of lives in the event of a catastrophic condition. New Orleans's evacuation plan was put to the test after hurricanes Katrina and Rita and failed on both occasions. During Katrina, the government was not well prepared to evacuate the population. The warnings of a hurricane were not met with the urgency that it deserved and, therefore, the evacuation was postponed to the last hours before the hurricane struck the area. The government had organized public transit buses to pick people up in ten locations but required that they pay for commercial services which left low-income populations behind (Litman, 2006). The number of buses was also not enough to effectively evacuate all the people in danger. The New Orleans government exhibited further

failure during hurricane Rita where it heeded to the warning and had no effective evacuation plan for the public. High-occupancy-vehicle lanes and inbound lanes on highways went unused as the officials waited until the last minute to open them. The result was that a significant percentage of New Orleans residents were stuck in traffic in their personal vehicles and could not move due to congestion (Litman, 2006). It is evident that the evacuation plans by the New Orleans government are not effective for saving the residents during hazardous events. The existing plans lack flexibility and resilience that would help the high-risk areas to mitigate and avert the loss of lives.



Figure 6: Evacuation Plans during Katrina

Source: <https://theconversation.com/should-i-stay-or-should-i-go-timing-affects-hurricane-evacuation-decisions-40141>

5.1. New Orleans City Evacuation Timeline

The city evacuation timeline plan operates within the 72 hours or more where the evacuees are expected to be out of town within the first 30 hours before a tropical storm hits the coast. The plan is designed to move about 10% of the city resident which is approximated at around 35,000 to 40,000 people. The timeline will operate within 3 main phases where phase one (50 hours before the storm) will be carried out in evacuating areas outside of any levee protection system. Phase two (40 hours before the storm) in areas from the north of intra-coastal canal and south/west of the interstate and Mississippi river and phase three (30 hours before the storm) evacuation of areas north/east of the Mississippi River and south of Interstate 12. The evacuation plan will go as indicated in figure 7.

6. Limitations

The effectiveness of disaster preparedness plans is questioned in cases when, despite the warning issued by the city, federal, and state government, some members of the population choose to stay behind. This puts their lives in danger, and the government may not be able to do anything leading to more deaths. The lack of sufficient transportation systems within the city to allow for effective evacuation within 48 hours is also a significant limitation to disaster preparedness (Litman, 2006). During hurricane Katrina, the state government was initially unable to plan for the correct number of public buses that were needed for the effective

evacuation of the public. The city also failed to effectively prepare for evacuation during hurricane Rita an indication that the preparedness plans by the government are not flexible to effectively adjust to any uncertainties presented by the disaster.

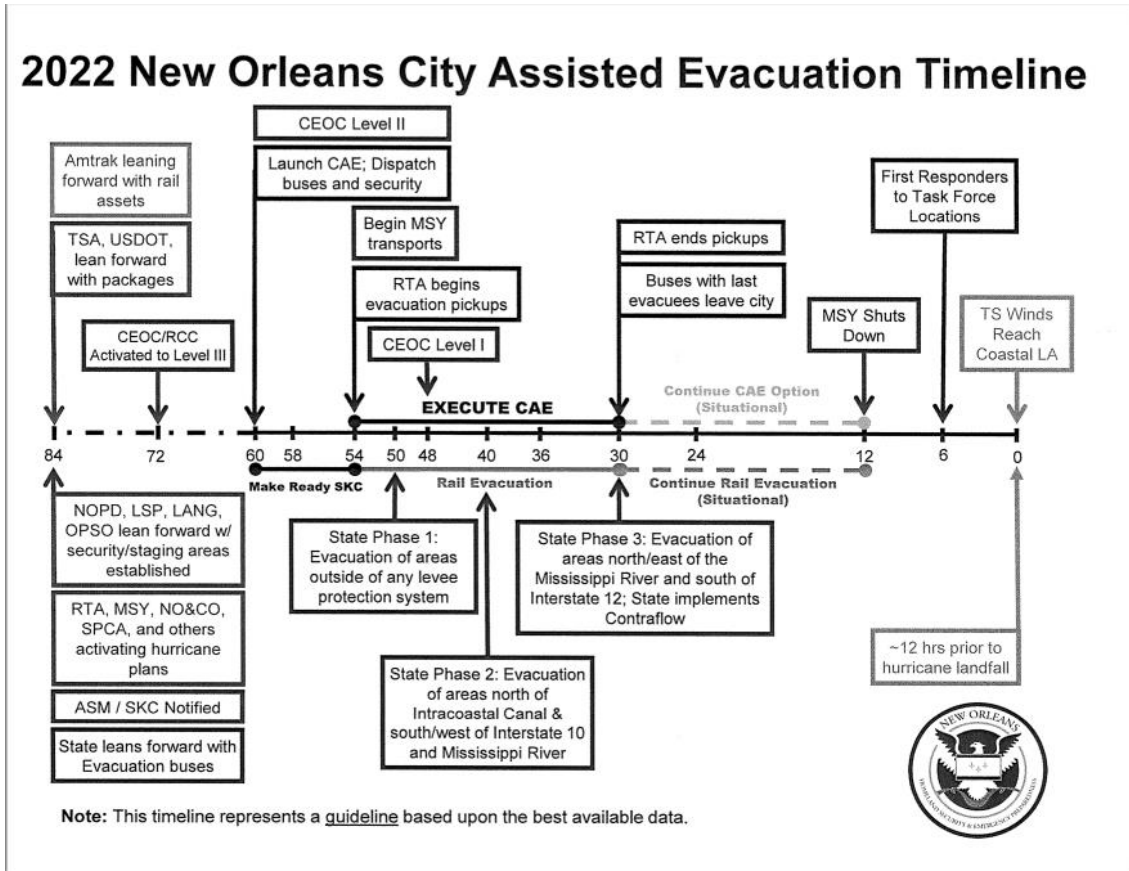


Figure 7: New Orleans City Evacuation Timeline
 Source: (Berlin & Parker, 2022)

7. Results

7.1. Management Strategy/Guiding ESEM Principles

Earth Systems Engineering and Management (ESEM) supports conscious choices as opposed to depending on the chance to evolve in an unpredictable direction. The earth has become highly complex, and an integrated system that increasingly challenges society to develop tools that enhance reasonable responses is necessary, and this means that engineers can no longer depend on traditional skills alone (Allendy, 2007). ESEM should be applied in hurricane preparedness to ensure there is a limit to the extent of property damage, and loss of life, as well as for the provision of security and safety measures. The principles of continuous learning to promote sustainability, resilience in system design, long-term investment systems, and technology artifacts are relevant to hurricane management.

Continuous learning is an important principle in the understanding of the complex socio-ecological systems that characterize the modern earth system. According to Allenby (2007), complex systems learn all the time, but the learning has, however, been referred to as ‘adapting’ or ‘evolving.’ Feedback loops and evaluation metrics are important in the learning process. New Orleans should, therefore, learn from the mistake and the failures during hurricane Katrina and Rita to effectively establish more sustainable solutions for similar

disasters in future. Sustainability relates to the construction of sustainable infrastructure that will help in mitigating the risks posed by hurricanes. There is a need for adequate levees that will be able to protect New Orleans against strong hurricanes, and that will be sustainable and last for a long period of time. Sustainable development may also be applied in building solutions that can help in designing buildings that can withstand strong hurricanes and, therefore, this will reduce property damage. The government can also participate by implementing policies that require all buildings to comply and be hurricane-proof, especially those that will be built below sea level (Skinner, 2016). Continuous learning should also be applied in evacuation planning where the city learns from previous failures and continuously updates its evacuation protocols.

According to Allenby (2014), technology artifacts even those that are deemed as simple should not be considered standalone but rather as entities that have a larger impact. The theory behind the notion is that each technology innovation has ripple effects that extend beyond its intended utility. Therefore, there is a need to understand the ripple effects of technologies to allow for effective management of its trajectories. Technology plays a vital role in the coordination of evacuation plans as well as communication during disasters. Technology convergence is a crucial guideline as it will help in accelerating the development of information technology and communication systems that will meet the immediate utility (Allenby, 2014). During a disaster, communication lines are usually down making it hard for the rescuers to get to the people in need. However, engineering can help solve this problem using technology and sustainable infrastructure to design and build a communication system that can be used even during disasters to help the public and rescuers keep in touch and ease the evacuation process. The immediate utility may be to communicate with people, but the technology may also be used to schedule evacuations and control traffic along congested highways.

The principle of long-term investment aims at ensuring that there are adequate resources over time to support the project as well as associated sciences, research, and development. The failure of the New Orleans levees has been because the maintenance of the same was not done as required. The main reason for the poor condition of the levees was the lack of the necessary funds needed as the funds allocated for the same had been previously slashed by the government (Allenby, 2014). It is vital that the city, state, and federal governments work to ensure that there is enough funding to support the levees systems that are meant to protect the region against any form of flooding. The funding system must be sustainable to ensure that each budget year the relevant authorities receive the resources needed for upgrading and maintaining the levees system. It is also important that disaster preparedness funds are always available to ensure that the New Orleans government will be able to coordinate evacuation plans effectively and will have the necessary resources to provide necessities such as food and water for the people in transit stuck in traffic.

Along with continuous learning, long-term investment, and systems and artifacts the principle of 'resilient not simply redundant' is also relevant. The evacuation plan must have built-in redundancy to ensure that when the primary system fails, there is a backup that can take over and successfully accomplish the set goals and objectives. Therefore, it is vital that engineers build infrastructure that is resilient and that can be able to address any uncertainties that may arise. Vulnerabilities in the evacuation plan are design spaces for resilience. The current systems should, therefore, be assessed for any vulnerability first to ensure that the officials can build resilience to cover the same. For example, the government should ensure that there is free transportation for the socioeconomically vulnerable members of society.

8. Discussion, Recommendations/Conclusion

8.1. Recommendations

Hurricane Katrina became a huge disaster because of poor management and planning failure by the City of New Orleans officials. There clearly lacked the appropriate action plan and, therefore, the city officials were using the strategies that had been used in previous hurricane events and were unaware of the severity of Katrina. It was also evident that the city officials did not fathom the extent of potential damage and the need for urgency in the situation hence because of underestimating the flood, great and massive destruction happened within the city. It is recommended that the national government engage city officials while making a disaster plan to ensure that they are all conversant with what needs to be done in such a situation, since in such a case of disaster within the city if the city officials were well conversant with such a disaster, then we would be talking of a totally different scenario since they would be able to manage the disaster, accordingly, hence reducing its severity. Therefore, the top officials of the national government should not lock themselves in the boardroom and decide on the action plan without engaging the people that will need to implement the plans on the ground who are the city officials. It is important that the officials who will be involved first-hand in the evacuation process be well prepared and contribute towards the plan preparation as they are better conversant with the needs of the people on the ground. The evacuation process should also be a collaborative process where the officials engage other key community members such as heads of homeowner's associations to effectively coordinate the evacuation plan at the regional level that way increasing the rate of management of the disaster within the city. Coordination with community leaders will help make the entire process easier by increasing the pickup points for people. City officials should also learn how to develop a scalable capacity that will allow the government to respond to whatever nature will present effectively. Based on the analysis of disaster preparedness of the city, it is evident that city officials have designed inflexible plans and seem to anticipate a disaster that will fit their response which was clearly not the case in the Katrina incident. This approach renders the current plans futile as they cannot handle any uncertainty of what was not planned for by the city and this is not advisable while preparing for a disaster. Training of city officials in disaster preparedness is a necessity to help build the necessary capacity for effective disaster management within the city.

It is also highly recommended that the Louisiana state government create a transportation evacuation plan for all its residents. During hurricane Katrina, the most affected persons in the city were individuals who lacked personal transportation. The individuals were unable to evacuate and depended on public means within the city and since there was a disaster that led to panic within the city, the transportation system did not function accordingly leading to most folks within the city being trapped (Brunkard et al., 2008). However, there were ten pickup points within the city for individuals without the means of transport, and they were required to pay for commercial services which significantly impacted the low-income earners who did not have money hence such practices should be abolished during times of disaster. The establishment of the pick-up point also significantly disadvantaged the elderly population that could not be able to access the locations. The result is that most of the people who died because of Hurricane Katrina were the elderly a majority being those above the age of 75 years who represent 49% of the death toll (Brunkard et al., 2008). It is, therefore, vital for the state government to arrange for transportation for the people who lack reliable personal transport, and this includes having drivers designated to work during emergencies but with the required training to ensure they save lives and not lose them. The evacuation should be

done within the first 48 hours before the disaster strikes to ensure that the drivers are not also put at risk evacuating individuals during a category 5 hurricane. Trains also present a practical solution to evacuation as they are faster and will not experience any traffic. It is also recommended that the city officials encourage people with personal cars to take the buses or carpool as this will reduce traffic by reducing the number of automobiles on the road and will also increase the number of lives being saved.

The Louisiana state government should plan for resilience to accommodate unexpected events and variables without failure. Resilience includes diversity, flexibility, and efficiency. The city should ensure that it uses other means such as rail to help in the evacuation of residents as opposed to solely depending on road transport since this will be like putting all their eggs in one basket which in such cases can be a disaster in waiting. The rail system should also be used to evacuate the residents within the first 48 hours before the calamity strikes since most of them run on electric power which can be affected once the disaster strikes (Berlin & Parker, 2022). The advantages of using rail are that it will not encounter any traffic contestation and is a faster means but also in case of a power surge since most of them depend on electricity then they will be grounded. The city should also consider the use of helicopters if there are still people stranded and the storm and there is little time left before the storm hits. However, the use of helicopters may not be necessary if the government has an effective evacuation plan that will be able to evacuate all individuals within the 48 hours allocated for evacuation (Berlin & Parker, 2022). The use of helicopters should only be left as a last resort as they are more expensive and have a limited capacity for the people that can be evacuated. Nonetheless, the government should always have helicopters on standby that can be useful to avoid last-minute confusion if roads cannot be used due to a rise in flood water. The evacuation plan should also be flexible, and the city officials should be able to accommodate and help the people who are unable to access personal transportation. The designated public buses should also be able to pick up residents from various locations besides the pickup points highlighted as not all residents may be able to arrive at these stations (Berlin & Parker, 2022). The city can achieve this by coordinating with community leaders to identify the vulnerable populations and effectively planning the most suitable pickup location.

The cost of evacuation will depend on the number of people being evacuated. According to Mazumdar and Vásquez (2015), the average cost for voluntary evacuating a household is \$194 and the cost for mandatory evacuation is \$300. It is estimated that it will cost the city one million dollars per mile during compulsory evacuation. The table below provides a statistical breakdown of costs.

Table 1: Estimated Evacuation Cost for New Orleans City

Direct Cost per household (Voluntary evacuation)	Estimated Evacuees	Total Cost for New Orleans (Voluntary evacuation)
\$194	393,292	\$76,298,648
Direct Cost per household (Mandatory Evacuation)		Total Cost for New Orleans (Mandatory Evacuation)
\$300	393,292	\$117,987,600



Figure 7: The Use of Helicopters during Evacuation

Source: <https://edition.cnn.com/2013/08/23/us/hurricane-katrina-statistics-fast-facts/index.html>

9. Conclusions

There is a need for effective disaster plans that include a workable evacuation plan for New Orleans in case of a hurricane. The city is vulnerable, and the levees in place cannot withstand strong hurricanes. The levees have further increased the susceptibility of the place to floods because they have created a basin that further collects water in the lower sections when there is flooding. The levees have also disrupted the deposition of silt at the Mississippi Delta which has made the region sink further below sea level. All these factors are an indication that the New Orleans government needs to be always alerted to ensure that it can effectively evacuate the residents if there is a hurricane warning. The government has disaster warning procedures, but the responses in the past have been inadequate as government officials were not well conversant with the disaster plans. The key limitations to proper evacuation are the lack of enough public transport and the stubbornness of some people to heed the issued warnings. The ESEM guiding principles of continuous learning, resiliency, long-term investment, and systems and artifacts are important in designing good infrastructure and communication lines that can withstand hurricanes and that are flexible enough to handle uncertainties. It is highly recommended that government officials be conversant with disaster plans, have adequate transport, and plan for resilience.

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خطة إخلاء إعصار نيو أورلينز

الأعاصير هي كوارث طبيعية يمكن أن تسبب أضراراً للممتلكات وتؤدي إلى خسائر في الأرواح. تتطلب حكومة نيو أورلينز خطة استعداد تحدد التدابير التي ستتخذها الحكومة في حالة حدوث إعصار. الخطة مهمة بشكل خاص بالنظر إلى أن المدينة معرضة لمثل هذه الكارثة وأن خطط السدود لم تعد فعالة. تقع نيو أورلينز في السهول الفيضية مما يجعلها عرضة للفيضانات عندما يضرب إعصار استوائي المنطقة. تجعل السدود المكان أكثر تهديداً لأنها عطلت ترسب الطين من نهر المسيسيبي مما جعل المكان يغرق أكثر بالنسبة لارتفاع مستوى سطح البحر. من الواضح من إعصار كاترينا أن المسؤولين الحكوميين بحاجة إلى أن يكونوا على دراية بخطط الكوارث من أجل الإخلاء الناجح. ومع ذلك، فإن القيود الرئيسية لنجاح هذا الإجراء تشمل عدم وجود وسائل النقل العام الكافية وحقيقة أن بعض أفراد المجتمع يتجاهلون التحذيرات. تعد مبادئ هندسة وإدارة أنظمة الأرض للتعليم المستمر والمرونة والاستثمار طويل الأجل والأنظمة والتحف ضرورية لبناء البنى التحتية التي يمكنها تحمل الأعاصير القوية. من المستحسن أن تشارك حكومة نيو أورلينز المسؤولين العموميين في التخطيط للكوارث، ضمان وجود وسائل نقل عام كافية لإجلاء المواطنين ووضع خطة فعالة للمرونة