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PROPOSING AN EMPIRICAL APPROACH TO RISK MANAGEMENT FOCUSING ON DAMAGE-REDUCTION*

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RESUMO

Proposta de abordagem empírica à gestão de riscos focada na redução de danos. Habitamos uma terra onde as catástrofes e as manifestações de risco são mais regra do que exceção, pelo que os danos se repetem com muita frequências e deixam os residentes nas comunidades vulneráveis surpreendidos com o poder da Natureza. O modelo típico de gestão de emergência não tem a componente crítica de mitigação do risco, pois considera as pessoas como vítimas, em vez de recursos, uma vez que se concentra na resposta quando deveria concentrar-se na mudança dos resultados associados ao evento perigoso.
Palavras-chave: desastre; evento perigoso; vulnerável; gestão de emergências; mitigação.

RESUMEN

Propuesta de aproximación empírica a la gestión de riesgos con enfoque en la reducción de daños. Habitamos un planeta donde los desastres y situaciones de peligro son más la norma que la excepción, donde el daño se repite con frecuencia y los residentes de las comunidades vulnerables son sorprendidos por el poder de la naturaleza. El modelo típico para la gestión de emergencias carece del componente crítico de la mitigación de riesgos, y considera a las personas como víctimas en lugar de recursos, mientras que se centra en la respuesta en vez de cambiar los resultados del evento de riesgo.
Palabras clave: desastres, situación de peligro, vulnerables, la gestión de emergencias, la mitigación.

RÉSUMÉ

Proposant une approche empirique de RISQUE de gestion axée sur de réduction des dommages. Nous habitons une planète où les catastrophes et les événements des dangers sont plus la norme que l'exception, les dommages sont souvent répétées et les résidents des communautés vulnérables sont surpris par la puissance de la nature. Le modèle typique de la gestion des urgences n'a pas l'élément essentiel de l'atténuation des risques, et considère les personnes comme des victimes plutôt que des ressources, tout en se concentrant sur la réponse au lieu de changer les résultats de l'événement dangereux.
Mots clés: catastrophes; événement dangereux; vulnérables; gestion des urgences; atténuation.

SUMMARY:

We inhabit an Earth where disasters and hazard events are more the norm than the exception, damage is often repeated and residents of vulnerable communities are surprised at the power of Nature. The typical model for emergency management lacks the critical component of hazard mitigation, and considers people as victims instead of resources, while focusing on response instead of changing outcomes from hazards event.
Key Words: *disasters; hazard event; vulnerable; emergency management; mitigation.*

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BACKGROUND

Observation, simplification and knowledge acquired through experience offer a solid foundation, but more often than not remain unused or are underutilized as tools, for the practice of risk management.

Empirical knowledge, which is gained from observing the impacts of natural hazards on vulnerable communities, shows there are key elements that contribute to our understanding of risk management. These key elements of knowledge include those listed below:

- We inhabit a hazardous world
- A framework is a good starting point
- Nature gives signals
- Humankind in conflict with Nature
- The surprise factor
- Damage is often repeated
- It helps to define terms
- Vulnerability not well understood
- There are impact modifiers
- All disasters are local
- Disasters are opportunities for learning
- Empirical knowledge is an effective tool
- Technology is a practical tool
- Mitigation is the best option we have
- Risk management is about CHANGING OUTCOMES
- We need to change behavior
- The public is a resource
- Success depends on knowledge not luck
- It is all about the HUMAN IMPACT

1. We live in a hazardous world:

Datasets maintained by the International Federation of Red Cross and Red Crescent Societies reveal that in an average span of ten years natural hazards may cause worldwide damage measured as follows (fig. 1):

Population affected:	1,800 to 2,600 million
People killed:	700,000 to 1,000,000
Cost of damage:	US$ 700,000 million (2009)

Fig. 1: In an average span of ten years the impact of natural hazards cause vast damage worldwide.

This is without a doubt quite a steep price to pay for our vulnerability, especially when it is realized this cost would be substantially higher when other damage factors are also included, such as: (a) value of services not provided because of degradation or loss of government function, (b) economic losses from businesses shutting down, (c) the human costs associated with displacement of population, (d) indirect and consequential damages including physical and mental health problems, and (e) the social cost of adverse human effects such as spousal abuse, family disruption, alcoholism, substance abuse, post-stress syndrome and others that often become evident in the aftermath of a disaster.

Data collected and maintained by Munich RE, a large international reinsurance firm, show (fig 2) there is an ascending trend for great natural catastrophes that goes back sixty years.

The same Munich RE dataset shows (fig. 3) that the distribution of great natural catastrophes is worldwide, which confirms the fact that we inhabit a hazardous Earth.

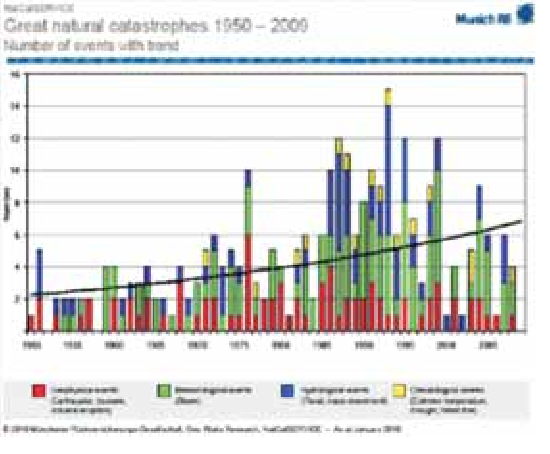

Fig. 2

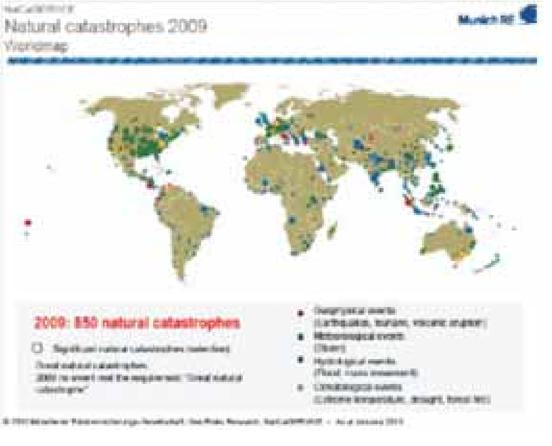

Fig. 3

The true magnitude of our vulnerability is evident when we add damage caused by the impact of anthropogenic hazards such as death and injury, health problems, displacement of population, contamination of the biosphere, damage to ecosystems, damage to the built environment and destruction of infrastructure.

2. A Framework for risk: a starting point:

We inhabit a hazardous Earth where the byproducts of natural and anthropogenic processes carry the capabilities for causing potential damage at global, regional, national and local scales. The interaction of human activity with hazards results in the vulnerability of humankind, creating the risk of loss of life, structural, economic, political and social damage as well as incalculable human suffering. The interaction of human activity with hazards and resulting damage is illustrated by the diagram below (fig. 4):

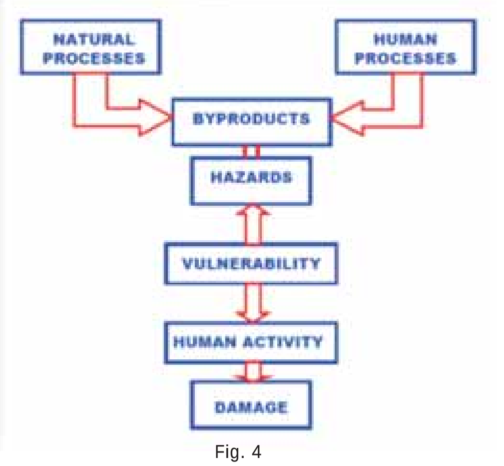

Fig. 4

3. Signals from Nature are there for us:

Over the years I have learned that Nature gives us signals from the numerous natural processes that are in progress. We fail to read these signals or, even worse, we choose not to pay attention to these signals at our own risk. Often the results of this lack of attention to the signals of Nature are disasters and catastrophes, involving death, injury, structural and economic damages, and plenty of human suffering. We can read the signals of Nature by observing the topography, geology, geomorphology, hydrology, climate, and ecosystems of a place, learning from these what Nature is doing and also acquiring knowledge about what may happen as human activity interacts with those ongoing processes.

Examples of signals from Nature include *Volcanoes:* what do we see when we look at volcanoes? Do we just see a topographic feature, a mountain which happens to be a volcano? Or do we see a volcano as evidence of an ongoing natural process, such as *plate tectonics*?

Ricardo A. Alvarez

Fig. 5: Picture of volcano San Cristobal. One of several active volcanoes along a mountain chain paralleling the Pacific coastline in Nicaragua, which is also part of the so-called Pacific 'Rim of Fire'.

The features near the summit of this volcano are clear signals of where ground temperature, chemistry and volcanic activity prevent vegetation from taking hold. Other features below the summit coming down the sides of the mountain show the effects of years of volcanic activity, and erosion caused by wind and water. In this respect it is important to 'read' these features as paths for future flows of water or lava.

Ricardo A. Alvarez

Fig. 6: Volcano Ometepe one of two volcanoes on the island of the same name in Lake Nicaragua, Nicaragua. The topography of the slopes of this volcano show where lava and water have flowed down the sides of the mountain over the course of hundred and even thousands of years. If we were to dig into the soil and take core samples, we would find deep layers of volcanic soil containing the lavas and ashes from past eruptions.

The most important signal perhaps, when looking at the volcano in fig. 6, in this picture is the interaction of human activity evidenced here by the houses and boats with the hazard that is the volcano. In fact tens of thousands of people live on two towns and several small villages around volcano Ometepe, and there are also numerous farms, cattle ranches and agriculture fields throughout the island in the shadow on two large volcanoes. The marks of past eruptions on the flanks of this volcano, the lava fields descending from the summit and reaching in some cases all the way to the waters of the lake where the dark sand beaches, bear testimony to their fiery origins.

The rich volcanic soils on this island are highly fertile and as such prime locations for agriculture, one of the oldest of human activities associated with civilization. The result is what is seen on these photographs, which is also evidence that despite the signals given by Nature humankind often elects to ignore them when presented with alternatives that may be viewed as representing higher priorities or better choices.

In evaluating the situation that exists, it becomes clear that these centers of human activity are at risk from the impact of future hazards, which may include volcanic eruptions and the seismic movements and/or lava flows associated with them, or flash flood and mudslides that may be triggered by extreme rain events. The potential for damage from recurring hazard events is indeed present and documented by way of these pictures.

The question to ask is: when we see a volcano near a city or other evidence of human activity, do we see the volcano as landscape or a beautiful backdrop to the city, or do we see the real signal, which is the potential for damage, death and human suffering from future eruptions?

Ricardo A. Alvarez

Fig. 7: Volcano Cosiguina on the península of the same name in extreme northwestern Nicaragua. This volcano experienced a violent explosive eruption in 1835, which blew the top 700 meters totally off the mountain and poured so much ashes and gases into the atmosphere that the year that followed was known as the "year of the smoke".

Volcano Cosiguina one of a couple dozen volcanoes that parallel the Pacific coastline of Nicaragua is easily visible by air travelers that flight the Central American route in and out of Managua, capital of Nicaragua. In viewing the remains of what once was a much taller mountain, and imagining what the catastrophic explosive eruption of 1835 might have been like, it is fair to then ask if the potential for such destructive force is one of the signals we get when we see a volcano. I would argue that in displaying such an example of the destructive potential of volcanism Mother Nature is sending us a clear signal that other volcanoes may also be capable of suffering equally explosive and catastrophic eruptions.

And so it goes with Nature. The topography and geologic features of a place, such as stratigraphic layers on display on a mountain side, dry river beds, flood plains and other features are all evidence of natural processes at work. They are all natural features sending us signals that are quite useful when assessing the vulnerability of a given location.

When trying to 'read' or interpret the signals of Nature it is often helpful to have other knowledge such as the geographic location, or geologic or climatic history of a place, or the existence of other local factors that may contribute to the generation of specific conditions leading to hazard events and damage; this approach is valuable when conducting an assessment of potential consequences from the impact of a hazard signaled by Nature.

An example of this type of assessment would be the combining of lack of precipitation, drought and high temperatures with knowledge that dry vegetation exists in an area presenting a high probability of wild fires should high winds and or lightning also occur over the same location.

The various examples given above relate to signals from Nature about historic or currently ongoing processes, which by themselves or when combined with additional knowledge about local conditions are helpful in assessing the vulnerability of a place and the reasons for specific signals that exist, or the likelihood that specific hazard events may take place.

These examples also show the benefits and importance of reading the signals Nature provides, as well as the need for integrating these natural signals into the process of vulnerability assessment.

Regarding this type of natural signal it is important to identify it for what it is, understand the underlying natural process and what it means in terms of risk and vulnerability, and potential for damage from future hazard events.

Perhaps more relevant to the interests of Portugal is an island located in the Atlantic whose profile is recognizable from the picture, fig. 8, which follows:

Fig. 8: Topographic map of Madeira. Viewing the marked features of this island, what signals is Nature sending us?

Madeira is a volcanic island in the Atlantic Ocean to the southwest of mainland Portugal off the coast of Africa. The picture (fig. 8) shows the topography of the island where ancient volcanic cones and lava flows are still discernable.

With the concept of reading signals from Nature, which has been described, and concentrating on the eastern portion of the island where most of the population centers are located let us interpret what the physical features of the terrain, as illustrated by a topographic map (fig. 9) and a satellite view (fig. 10), tell us about the byproducts of natural processes that have shaped the island and what they mean for existing population centers now and in the future.

USGS

Fig. 9: Topography of eastern Madeira**.**

Fig. 10: Lines highlight main water flow.

Beyond the clear signs of past seismic and volcanic activity in the island, the topography as highlighted by color lines (fig. 10) show where the conduits for water flow, and potential flash flood or mudslides, are.

When that visual information is combined with location of population centers such as Funchal on the coastal regions of eastern Madeira, the signal that emerges is the high level of risk in the event that extreme precipitation resulting from the interaction of weather systems with the topography of the island may trigger flash floods and/or mudslides.

Given the continuously increasing moisture content in the atmosphere it appears, based on empirical data, that extreme precipitation events where the amount of rain over a certain period of time mat exceed the drainage capacity of natural and man-made flow structures (i.e.: natural rivers, or man-made canals and other engineered water management works) leading to flooding events, are becoming more common and are also contributing to the increased vulnerability and risk of given locations. The main signal given by these natural features of the island of Madeira relates to the high risk of flooding faced by coastal communities in Madeira.

Such high risk became evident earlier in 2010 when extreme rain events in Madeira triggered flash floods (see fig. 16) and mudslides that impacted Funchal and other coastal communities, causing death, injury, and both structural and property damage, which led to the declaration of a state of emergency by local civil defense authorities on the island.

USGS

Fig. 11: Extreme rainfall over the region caused flash floods in Madeira, mainly in coastal cities. Signals from Nature made this outcome predictable in the event of extreme rain events.

4. Humankind is in conflict with nature:

We inhabit a hazardous Earth where the byproducts of natural processes carry the capabilities for causing potential damage at global, regional, national and local scales. The interaction of human activity with natural hazards results in the vulnerability of humankind, which places it at risk of suffering loss of life, structural, economic, political and social damage as well as incalculable human suffering.

This has led to an accelerating cycle of conflict and crisis. Humans are in conflict with nature, and must as a result continuously confront various degrees of crisis situations at a number of locations worldwide. The fact that humankind has emerged as a force capable of generating positive feedback to affect, modify, natural systems, may exacerbate this cycle of conflict and crisis.

5. There is a surprise factor;

In 1998 major hurricane Georges crossed over the Dominican Republic, Haiti and Cuba and then the Florida Keys. Interviews conducted afterwards in the Florida Keys revealed that less that 27% had obeyed the mandatory evacuation order, but more than 50% expressed surprise at the amount of water that had flooded the islands driven by the surge caused by the hurricane. Considering that the highest elevation on the islands is approximately 1.8 meters above mean sea level and the surge from hurricane Georges had been forecast at 3 meters plus wave action on top of it, how could anyone have been surprised?

This example is neither rare nor the exception, in fact I have heard the comment of having been surprised quite often in the aftermath of many hazard events ranging from hurricanes and floods to earthquakes and wild fires. Why do we keep being surprised by the power of Nature?

6. Damage from hazards is often repetitive:

Something else I have learned over the years is that you see the same type and amount of damage happening again and again at the same location over the years, as new impacts occur. **Why do we see damage being repeated?**

7. It helps to define terms:

In order to communicate effectively about risk it is essential to define key terms to be used. It is only through this process that we will all understand each other. In arriving at these definitions two criteria are important: (a) using the root of the word as a foundation for a definition, for example: *vulnerability* from the Latin, *vulnus* = wound, *vulnerare* = to wound, immediately gives one a vision of something painful and damaging; (b) simplifying and shortening each definition as much as possible, the fewer words used in defining a term the easiest it will be to understand and remember.

A basic vocabulary on the topic of risk consists of the following six terms: **HAZARD, VULNERABILITY, DAMAGE, MITIGATION, HAZARD EVENT, RISK** (fig.s 12, 13, 14, 15, 16 and 17).

Fig. 12

Fig. 13

In addition to defining these terms it is beneficial to dissect and explore each key term in depth to gain a better understanding and really appreciate what it means, and how each of these concepts plays an important role in the field of risk management.

For example, when we define hazard as a source of damage do we really understand what is meant by damage? This question is partially answered by defining the term 'damage', but from the perspective of risk management it is also important to understand damage can be direct, indirect or consequential. Relative to this it is also important to understand the meaning of 'causality' and the process of 'cause and effect' that it embodies. In summary, the definition of key terms contributes to establishing a common language to promote an effective dialog and exchange of knowledge and ideas relative to the practice of risk management.

Fig. 17

Fig. 14

Fig. 15

Fig. 16

Fig. 17

8. We need to understand the characteristics of vulnerability:

In addition to defining vulnerability it is essential to know and understand that it has three main characteristics, which are graphically depicted below, see fig.s 18, 19 and 20:

Vulnerability is interactive: This means that the capacity of a hazard as a source of potential damage and actions taken by the vulnerable community as a receptor of damage actually affect each other. So in reality vulnerability is a two-way street where the eventual level of damage from the impact of a hazard is affected by the interaction of the hazard's damage components and the community's defenses (fig. 18).

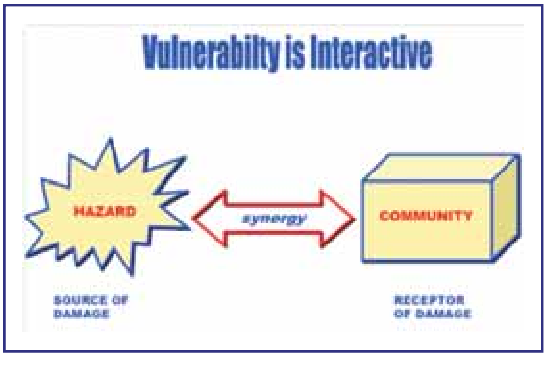

Fig. 18: vulnerability if a two-way street where the impact of a hazard will be shaped by its damage components as well as by the actions and defenses of the affected community.

Vulnerability is dynamic: which basically means the vulnerability of a community will change over time in response to changes in the community itself and/ or cycles of variability in the natural processes that generate hazards affecting the community.

For example: an increase in population in a given community will lead to more housing development, construction of commercial buildings, added infrastructure. More urbanization, which in turn means there will be more people, structures and things of value at risk (fig. 19).

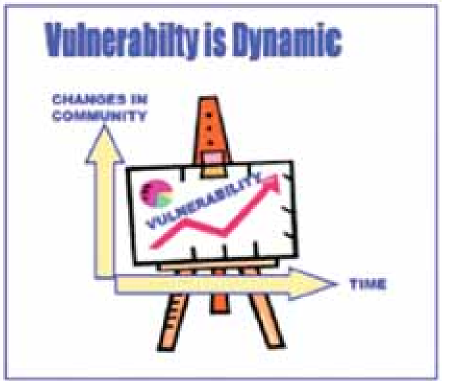

Fig. 19: the relative vulnerability of a community changes over time in response to a number of factors.

Similarly, demographic changes where the make-up of the population of a community changes over time or the construction of new protective structures will also lead to changes in vulnerability.

From a practical standpoint what this means is that the vulnerability of a place or site needs to be reassessed periodically to gauge how it may have changed over time. In large urban communities undergoing rapid growth it is recommended vulnerability be reassessed every 2 to 3 years on a community-wide basis, but yearly on a site-specific basis especially when a new construction project is about to be designed.

Vulnerability is shared: vulnerability is a shared concern for all residents in a vulnerable community, meaning that even if the impact of a hazard varies from one district to another, all residents will be affected to some degree (fig. 20).

Another way of looking at this is that in a vulnerable community whatever action or lack thereof by any members of such community affects all residents in said community. No one really has the luxury of saying "it doesn't affect me, so why should I care?"

For architects, engineers, urban planners, community developers and risk managers knowing and understanding these characteristics of vulnerability equips them with tools for a planning and design process that will effectively address the vulnerability of a project site.

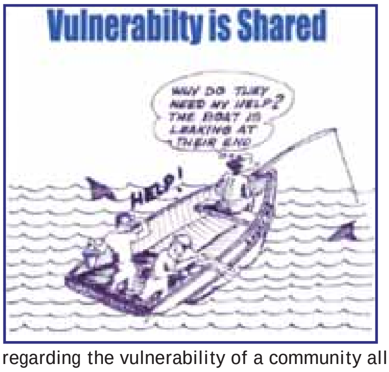

Fig. 20: regarding the vulnerability of a community all residents are in it together.

9. There are impact modifiers:

There are natural and human features that exist locally, which may have the capacity for modifying the impact of a hazard on a community or site-specific basis.

For example the geology of a place, the type of soil upon which buildings are built, affect the way seismic waves propagate as well as the acceleration of gravity which in turn modify the impact on buildings, hence the potential for damage during earthquakes;

Also the topography of a site and the near shore bathymetry will modify the behavior of storm surge and wave height during hurricanes; consequently these factors modify the impact and potential for damage on buildings in coastal locations.

It is important then, to identify impact modifiers during a process of vulnerability assessment for a given location.

10. All disasters are local:

Beyond the spatial or temporal characteristics of the impact of a hazard, what really matters most to an individual are the effects upon the local community, the home and family, places of work etc. In this sense all disasters are local.

11. Disasters are opportunities for learning:

Often in the aftermath of a hazard event or a disaster in the rush to respond and assist those in need, we forget that the damage we see presents invaluable opportunities to identify causes of damage, to learn what worked well and what did not, to evaluate the effectiveness of emergency plans and preparedness measures adopted before the impact. Beyond the clear need to respond and recover from the impact of a hazard and a resulting disaster, these events must be viewed as opportunities to learn lessons that can be applied to improve and enhance existing plans.

12. Empirical knowledge is an effective tool:

Also on the topic of opportunities for learning it is important to emphasize that the knowledge we acquire through direct observation, empirical knowledge, in the aftermath of a hazard event is one of the most effective tools to learn valuable practical lessons about the impacts of hazards and the practice of risk management. In this regard the acquisition of post event empirical knowledge should be incorporated as a critical component of risk management and emergency plans.

13. Embrace technology as practical tool:

Technological advances such as improvements in remote sensing instrumentation and analytical software, computer simulation and animation, GIS and enhanced mapping technologies, and many others can significantly contribute to the practice of risk management. Technology should be embraced to the degree that it can enhance our ability to practice emergency management to reduce the potential for damage to vulnerable communities, in doing so however technology must be considered as a tool we use not as 'the solution'.

14. The best alternative is mitigation:

On a worldwide basis it is still common to explain the practice of emergency management as being supported by three key elements, three pillars, which are (fig. 21): **PREPAREDNESS, RESPONSE and RECOVERY.** In analyzing such three-component model for emergency management there are critical questions that must be asked. For example: Why do we need to plan and prepare before a hazard event? Why must we initiate response activities as early as feasibly possible after the impact of a hazard? Why do we need to move from response activities to actual repair of damage and reconstruction as part of recovery efforts after a hazard event?

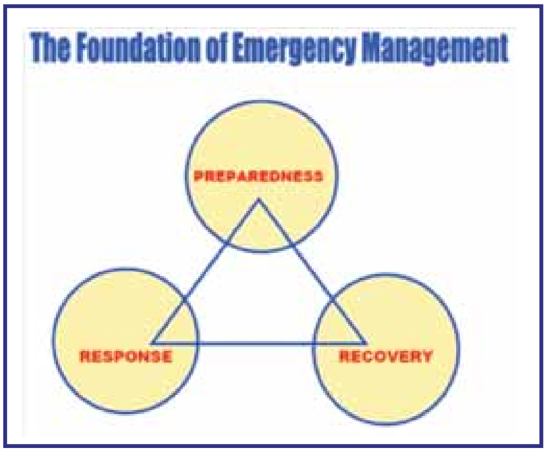

Fig. 21: Current model is missing a critical element.

The answer to these three questions is the same. We plan and prepare in order to minimize damage, protect life and property, from the impact of a hazard. We carry out response activities to assist those in need and to reduce the potential for loss of life, further injury and to reduce the potential for additional damage. Recovery initiatives are undertaken to make the impacted community whole again as a way of reducing long lasting damages.

If the main reason we practice emergency management, and we carryout activities under the three generally accepted components of emergency management, is to reduce damage then this model of emergency management leaves out what is undoubtedly a critically important component of the practice; it leaves out MITIGATION, which has been defined as being about DAMAGE REDUCTION. Mitigation, damage reduction, is central and critically essential to the practice of emergency management, consequently a four-component model must be adopted, one where mitigation becomes the core of the practice (fig. 22).

Fig. 22: A new model focusing on damage reduction (Mitigation)

Fig. 23: Panoramic view of Cancun' hotel strip, beach and lagoon from the air.

Fig. 24: View of Cancun hotel strip's southern point from the air.

15. A Case Study:

The use of empirical knowledge and the need for mitigation are best described by way of a case study, an example of a real event and a real place. Let us look at Cancun, Mexico an area that is highly vulnerable to tropical cyclones that I first visited in 1979, and where I have conducted vulnerability assessments and hazard mitigation studies, as well as research into the performance of buildings under hurricane impacts over the past 22 years.

Cancun was originally a barrier island off the coast of Quintana Roo state in Mexico's Yucatan peninsula, which in 1974 was connected to the mainland at its southern and northern ends by way on land bridges, during a project designed to open Mexico to international tourism by way of the Caribbean. The result was the creation of a hotel and tourism strip along the original coastline and on both land bridges, and a lagoon separating these from the mainland (fig.s 23, 24).

The character of the built environment is as important as the natural features of the place (fig. 25). Design criteria, types of construction, height and location of buildings and supporting infrasctruture are all key elements to consider in the assessment of vulnerability.

Fig. 25: Typical hotel architecture in Cancun. Retention walls are commonly used to protect landscaping and exterior recreational infrastructure for hotels sited as close to the waterline as possible. Reinforced concrete construction in prevalent and several hotels incorporate spectacular design features such as the skylight above a central open space as shown on the photo on the right.

Fig. 26: other views of the built environment that is typical of the hotel resort area in Cancun. The views on the left of this figure show several hotels built on the water side of the dune of the original island and the use of retention walls to allow for landscaping and even sand to be maintained on the waterfront of these buildings. The pictures on the right show buildings on the northern man-made land bridge linking the original Cancun Island to the mainland, which has no dune allowing for buildings to be built even closer to the waterline and at lower elevations (as low as only 1.5 to 2 m above mean sea level) with respect to mean sea level.

Fig. 27: two views of one luxury hotel in Cancun showing the main lobby and reception area and the pool, terrace and outdoor beach-side recreational areas. The ground floor of this particular hotel and outdoor terrace areas are elevated 3.5 m to 4 m above mean sea level, which is higher that many of the other hotels.

These photographs, fig.s 25, 26 and 27, are typical of those used to document the initial visual inspection during the first phase of an assessment of vulnerability of a location. These pictures begin to document certain site-specific conditions that will be useful for characterizing the impact on future hurricanes and for estimating the potential for damage from such impacts. Such graphic documentation becomes highly relevant within the context of Cancun's vulnerability to tropical cyclones.

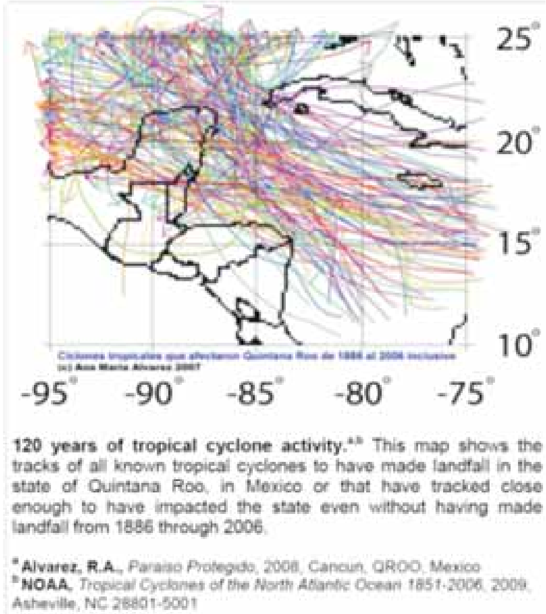

Fig. 28: a picture is worth 1000 words; the map in this figure clearly tells the story of Cancun's high vulnerability to tropical cyclones. This map shows 183 tracks of tropical cyclones that affected the state of Quintana Roo during the 1886 to 2006 period.

Cancun was hit by category 5 hurricane Gilbert in 1988, when it has approximately 9,000 hotel rooms. The area was hit again, this time by a high category 4 hurricane Wilma in 2005 (fig. 29), when it had grown to more than 30,000 hotel rooms and its tourism infrastructure had expanded for several miles along the coastal region to the south in what is now own as the 'Maya Riviera'. In between such major impacts Cancun and neighboring areas have been hit several times by hurricanes throughout the years.

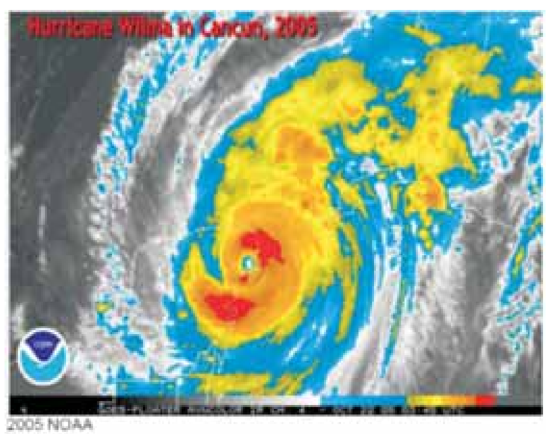

Fig. 29: satellite view of category 4 Hurricane Wilma making landfall in the Cancun environs in the early morning hours of October 22, 2005.

In late October 2005 tropical storm Wilma formed in the western Caribbean and quickly strengthened to major hurricane force, reaching and intensity of category 5 just prior to impacting the island of Cozumel to the southeast of Cancun. The storm was a strong category 4 hurricane when it made a second landfall just south of Cancun, generating a storm surge of 4.5 meters on the eastern side of Cancun, where the major hotel strip is, and dumping over 1350 mm of rain as it meandered over the region for more than 48 hours before exiting over the northern tip of the Yucatan and aiming for South Florida where it caused widespread damage a few days later. The impact of a major hurricane such as Wilma on major urban area such as Cancun presented an opportunity for acquiring invaluable empirical data on the causes of damage to the built environment, and the performance of various types of buildings and building components under the impact of hurricane damage components, as well as the role of impact modifiers that may have been present at the time.

This hazard event also offered a great opportunity for visualizing the interaction of specific buildings with damage components of known magnitudes, and for linking the same to actual damage as recorded in the aftermath of the impact.

The value of this kind of knowledge gathering and visualization in the context of an actual hazard event is that it is real, and it is something that can not be replicated experimentally or analytically given the number of variables at play simultaneously. Empirical knowledge gained from these types of exercises provide an invaluable foundation for characterizing the impact of hurricanes, meaning their various damage components, on specific types of buildings and locations.

16. It is about damage components interacting with the built-environment:

The process of vulnerability assessment, especially the visual assessment, requires visualizing specific buildings interacting with damage components of specific hazards. In the case of hurricanes in general terms the main damage components are wind and water. What happens when a building interacts with the winds of a hurricane or with the water of a storm surge generated by a tropical cyclone? In this respect it is understood that visualizing such interaction is a kind of observation that provides important empirical knowledge, which is helpful in evaluating the potential for damage from the impact of a hurricane on specific buildings.

Going back to the example of Cancun, Mexico and its vulnerability to tropical cyclones, before viewing actual evidence of the damage caused by the impact of hurricane Wilma it would be helpful to review the various effects of wind interacting with buildings. Toward that end following are simplified examples of such effects (fig.s 30, 31 and 32):

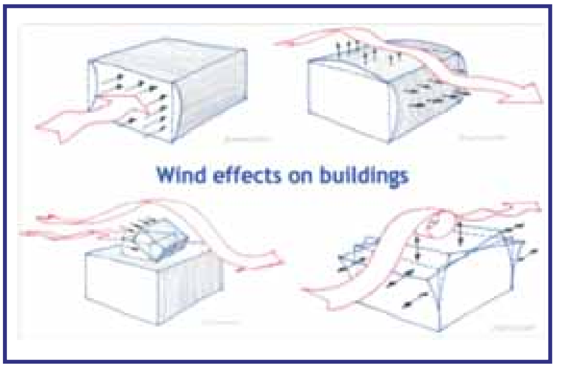

Fig. 30: Shown in this figure clockwise from top left are the following effects of wind as it interacts with a building: (a) Positive wind-velocity pressure; (b) Negative (suction) wind-velocity pressure; (c) Buffeting, and (d) Leveling-off also known as 'clean-off' effect.

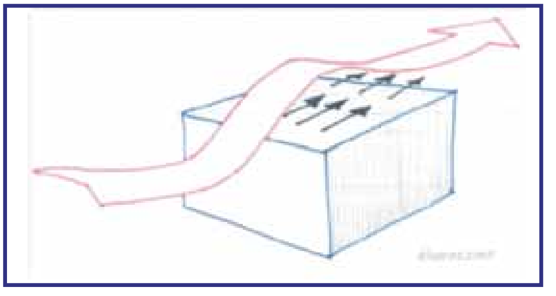

Fig. 31: The schematic on this figure depicts the effect of Drag as the building interacts with hurricane winds.

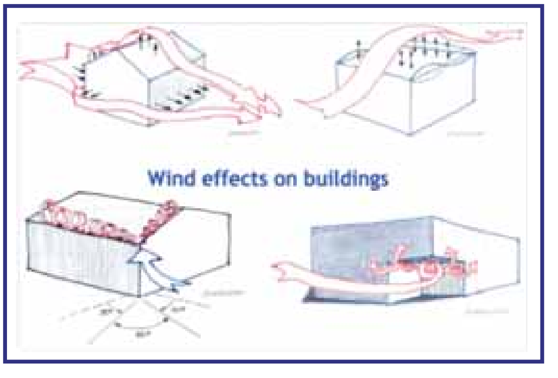

Fig. 32: Clockwise from top left we see: (a) Several wind effects happening simultaneously; (b) Vibration; (c) Wind-cupping, and (d) Vortices, generated when the wind hits the corner of a building r at a certain angle of attack.

The same approach used in above figures (fig.s 30, 31 and 32) is used to depict building interaction with water, the other main damage component in tropical cyclones.

With the benefit of this 'primer' on visualization of building-wind interaction let us examine evidence of some of the damage caused by hurricane Wilma as it hit Cancun in 2005 (fig.s 33, 34 and 35).

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Fig. 33: In this figure Clockwise from top left: (a) Loss of beach from the impact of storm surge, and some structural failure on exterior infrastructure; (b) Total beach erosion; (c) Failure of a reinforced concrete retention wall, the dark line about 1.5 m up the wall is where the upper level of the sand used to be marking the tremendous amount of erosion that took place; and (d) Beach erosion and damage to external infrastructure.

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Fig. 34: Other examples of damage; top right shows wind damage to the interior and contents; bottom right shows storm surge damage to interior and contents; top left, total structural failure of reinforced concrete building due to undermining of foundations by storm surge; top center shows impact of floating debris on a building; bottom left shows damage to a skylight atop a high rise hotel building.

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Fig. 35: Other examples of damage to buildings and infrastructure from the impact of wind and water during hurricanes. The photo on the right shows damage to external infrastructure as the storm surge overtopped the retention wall and undermined it from behind; the photo on the bottom left shows roofing tiles, which had been attached by mortar and wire ties, which were uplifted and torn off roofs by negative wind-velocity pressure applying an uplift force to the roof of buildings. These tiles at one point became 'flying debris' propelled by hurricane winds.

In viewing this damage caused in recent years by the impact of a hurricane especially in view of similar damage caused by other recent impacts to the same area, meaning this is a case of repetitive damage, it is revealing when it is compared to another vulnerable coastal community some 120 kilometers to the south, the ancient 800 year old cultural and scientific center of the Maya in Tulum, to notice the difference in the sitting of structures with respect to the water line used by Maya planners and by their modern counterparts in Cancun and other areas.

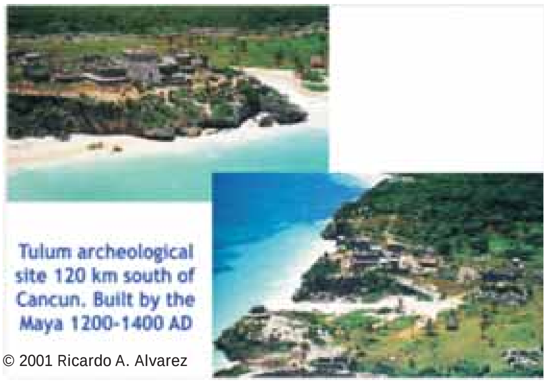

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Fig. 36: two aerial views of the Tulum archeological site 120 kilometers to the south of Cancun, in the state of Quintana Roo, Mexico. Several religious and scientific buildings constructed by the Maya some 800 years ago still stand today despite having suffered numerous hits from hurricanes over the years. When observing these buildings, whether in person or in these photographs, it is important to try and visualize them interacting with damage components of tropical cyclones meaning wind and water.

In comparing Cancun and Tulum a fair question to ask is if modern buildings along the beach on the hotel strip in Cancun will remain standing and in structurally sound conditions over the next 100, 200, 500, even 800 years? One could also ask what did Maya builders and planners do 800 years ago and even earlier when they selected this site and then built their buildings, which has allowed these structures to still be standing several centuries later? How many hurricanes have hit this site over the past 800 to 1000 years no one really knows, but the existing statistical record suggests approximately 100 tropical cyclones could have impacted this site over that period of time.

A current kind of vulnerability assessment could be undertaken for the Tulum site by analyzing the physical features of this geographic location such as topography, geology, beach geomorphology, bathymetry, underwater configuration and other natural features that are present, which may act as impact modifiers when it comes to tropical cyclones. In doing this it is important to note two features that are quite different today than they were 800-1000 years ago are mean sea level and the width of the sandy beach. A rough speculative estimate of these two features is that the sandy beach was perhaps 100-120 meters wider than it is today while mean sea level was perhaps one meter lower than today. Two other geomorphologic features that still exist today are: (a) a barrier reef currently located about one kilometer offshore from the present day beach, which protects the current beach and marks a transition from shallow water to deeper water and a more pronounced slope of the continental platform, and (b) a transition from the sandy beach to an inland rocky ridge elevated from 10 to 15 meters above the beach and gently sloping higher as the terrain moves inland.

From these features it could be deducted that what Maya planners had that long time ago was a relatively protected stretch of coast with a wide natural sandy beach, shallow waters offshore for about one kilometer, and a rocky coastal ridge marking the transition to higher ground inland.

How did the Maya take advantage of these local features in the planning and building of the main buildings in Tulum? An analysis of the archeological site reveals that the Maya were aware of the signals of Nature with respect to the impact of wind and storm surge during hurricanes, and they took them into account while also taking advantage of the natural features of the site in locating and building their religious, cultural and scientific buildings on the site. Evidence of this approach to the development of Tulum is the fact that all of the stone buildings that have been found were built atop the rocky coastal ridge at heights of 12 meters and higher above what is the present mean sea level putting them well beyond the highest levels of storm surge and wave impact during hurricanes (fig. 37).

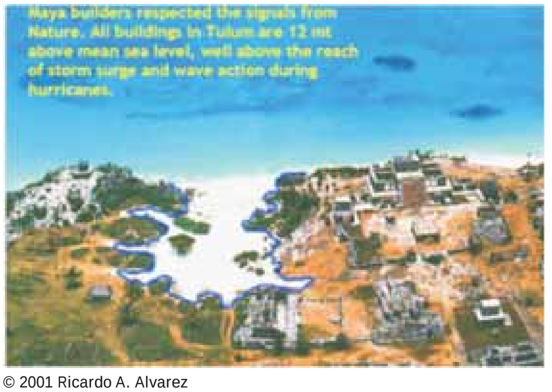

Fig. 37: aerial view of the Tulum complex showing some of the main building on the site and also delineating the typical extent of surge penetration and the fact that all buildings were built well above that hazard.

Relative to this, recent tropical cyclone impacts elsewhere in coastal regions in Quintana Roo have shown present day Maya continue to respect the signals from Nature and by and large continue to build accordingly (fig. 38).

Fig. 38: In 2007 category 5 Hurricane Dean made landfall in Quintana Roo to the east and just north of the Bay of Chetumal. The town of Bacalar and surrounding areas on the western shores of Chetumal Bay were hit by storm surge and sustained hurricane winds of 240 kph. Evident after the impact was how well some building performed under such damage components. An example of such good performance is shown in this picture: a house built with heavy masonry walls, well protected exterior door and windows, a heavy timber roof structure and light roof covering that while impermeable to water is porous to wind. This combination of design and construction features performed quite well under the impact of such a major hurricane. This is a present day example of Maya architecture and construction.

A question that emerges from above examples is: why is it that modern architects, planners and builders with more technology and supposedly better tools, methods and materials of construction have seen so much damage to their buildings and infrastructure from the impact of hurricanes, when hundreds of years ago Maya builders and planners were able to design and built for the same hazards in similar vulnerable communities buildings that remain standing to this day? Clearly the Maya provide us with examples of best practices in design and construction for vulnerable regions.

17. Other factors to take into account:

Accumulated empirical knowledge leads to the understanding that there are several other key factors, which must be taken into account and incorporated into the current practice of emergency management if we want to bring about positive and effective change; change could be instrumental in reducing the high price we universally pay for our vulnerability to natural hazards.

Given the potential criticality of such factors of change it is important that we define and review them. These factors include those described below:

a) *It is about changing outcomes*; it would appear that emergency managers as well as scientists, researchers and professionals in many fields, all of us who contribute to the practice of emergency management often concentrate so much on the ‘how’ that we lose sight of the ‘why’ or the ‘what for’.

Specific models, methods and practices in the field of emergency management all have a common purpose, which is to change the outcome of the impact of a hazard. The clearest example of a change in outcome is to have the impact of a hazard without having a disaster.

Experiencing a hazard event without having a disaster is possible when emergency management practices are designed and implemented with a clear focus on damage reduction.

*b) We need to change behavior***:** A change in outcome requires a change in behavior. This means a continuous, effective, long-lasting wholesale change in behavior among those who reside in a vulnerable community, region or country.

The most significant behavioral changes are those that would transform a community's 'business-as-usual' outlook toward its vulnerability to a true 'culture of mitigation', where all residents understand the shared nature of vulnerability and take actions that can prove effective in reducing the potential for damage from the impacts of recurring hazards.

Such culture of mitigation is based on behavior that focuses on damage reduction. This also requires all sectors of society to adopt this culture of mitigation, from professionals in many fields, to emergency management practitioners, policy makers, educators and the general public, all need to understand their actions, behavior, focusing on damage reduction can effectively change the outcome of a hazard event.

c) In risk management the public is a resource: current models of emergency management including planning a community's response to a hazard event generally look at population almost abstractly in terms of potential number of victims, dead and injured, as if residents of a vulnerable community are passive bystanders waiting for the impact of a hazard they are powerless to modify.

This clearly needs to change, residents of vulnerable communities must be considered a resource; these are individuals who can be empowered to take charge of the potential outcome of a hazard event, and proactively contribute to their own protection and that of their community.

The general public must be educated and provided with knowledge that can be used as practical tools to reduce the potential for damage from a hazard event. This change is a critical component of behavioral change and a major contributor to the change in outcomes that is needed.

d) *In risk management success depends on knowledge not luck:* the historical record offers plenty of contrasting examples of how humankind has approached its vulnerability at different times and places throughout history.

There are examples of communities that feared nature and saw hazard events as 'Acts-of-God' or as Divine punishment, making prayer and sacrifices their main lines of defense against the impacts of hazards. On the other hand there are numerous example where architecture and construction were used to reduce the potential for damage from various hazards, such as elevated buildings in regions where flooding was a major hazard, or the thick-walled buildings with screened windows and central courtyards and fountains build in many Mediterranean and dessert settings to ward off extreme heat and sunlight, or the steep-roofed buildings in countries where snow precipitation is a major concern.

Over the years humankind has emerged from that pessimistic approach that blamed God for disasters, to one where it is possible for humankind to take action in its own defense against the impact of hazards. Curiously the terms "act of God" or "force majeure" still survive in some sectors, such as insurance and law, as a way to avoid responsibility for some outcomes.

It is clear however that in the field of emergency management, with proper respect for the power of Nature, there is no substitute for sound knowledge, understanding and effective execution when it comes to influencing the outcome of a hazard event. Put differently luck and other esoteric factors have nothing to do with the practice of emergency management, but the effective application of sound practical knowledge does.

e) It is all about the human impact: returning to the issue of the "why" it is critically important for emergency managers to realize the main objective of the practice is to reduce the human impact. Along these lines practitioners must understand that the main reason we harden buildings and protect infrastructure is not the value of the building or its contents, but the protection of human life and the continuity of human activity that is sheltered by a building or supported by infrastructure.

In this regard it is true that physical and structural damages are the most obvious and easily seen in the aftermath of a hazard event, but it is the dead, and the injured, and the long-lasting adverse health and social consequences for residents of the affected community, and the human suffering, which truly represent the worst damage. This is why minimizing the human impact, reducing damage, must be central to the practice of emergency management.

f) *We must simplify:* what to do with all these elements of knowledge that have been described before? Careful review of the various concepts introduced here will show that these, in effect, describe the components for a simple yet effective model for the practice of emergency management. From this it follows that by incorporating these elements of knowledge into the practice of emergency management we simplify.

In this day and age when there appears to be a tendency for adding more layers of bureaucracy and regulatory constraints, and more complex methodologies, into the practice of risk management, there are examples of where this approach has failed even though on paper at least it appeared to work. One such example is the case of hurricane Katrina impacting several Gulf states in the United States, and the catastrophic disaster that resulted, which happened just after a new bureaucratic and more complex government structure for emergency management and national response plan had been adopted replacing a model that had worked well during prior events.

Complexity of approach does not equal effectiveness of result. A simpler model that integrates essential critical elements and focuses of damage reduction will foster improved execution, and effective results.

GAPS, FLAWS AND WEAKNESSES

First hand observations or the review of written reports provide important knowledge about the practice of risk management around the world.

While there are examples of excellent performance and best practices in the management of emergencies and disasters, there still remain numerous gaps and voids and weaknesses that must be closed or strengthened in order to better protect our vulnerable communities.

Weaknesses in the practice of risk management include those listed below:

1. *Emphasis on response*: there appears to be an emphasis on response, which makes most models reactive rather than anticipatory or proactive. While an effective initial response to a hazard event can be instrumental in reducing consequential damages it basically has no bearing in the reduction of direct damage from the impact of a hazard.

2. *No dedicated budget:* in most countries there is no dedicated budget for key components of emergency management. Usually there is a budget for the planning and day to day administration of a civil defense infrastructure, which in case of hazard event counts on the military, first responders such as fire and police departments, the Red Cross and voluntary efforts to tackle the initial response. However this common model provides virtually no dedicated resources to longer term response in case of a disaster, nor does it address resources that may be needed for the recovery effort. As a result of this, many countries are forced to draw resources from other public programs and as a result adversely affect development, or to rely heavily if not exclusively on foreign aid to repair the damage and rebuild.

3. *Scientific research in a vacuum:* another flaw is a research effort that focuses on basic scientific issues that may be relevant to the practice of emergency management, but unfortunately is not linked to applications that can be converted to tools for practitioners. Or important research efforts that are conducted for academic advancement of individuals, but are not shared with other sectors that could benefit from it.

4. *Engineering community largely absent:* although there are engineers who participate in and support emergency management practices, the reality is that the engineering profession in general remains absent from this field. This is unfortunate because this profession has so much to offer especially with respect to structural design and major civil works for the protection of building and vulnerable communities.

5. *Architectural community largely absent:* the same issue of lack of active participation applies to the architectural profession. A common view held by architects in some countries is that their responsibility is to meet the requirements of pertinent building codes and standards, while this position is correct from a legal point of view the fact remains that codes and standards only reflect the minimum requirement for building design and construction, which is not the same as designing hazard-resistant buildings and infrastructure.

6. *Characteristics of vulnerability not well understood:* the dynamic, interactive and shared character of vulnerability are often ignored or at best not well understood by many sectors involved in the practice or emergency management; moreover there appear to be some confusion among some sectors between vulnerability and risk or disaster. Such confusion has an adverse effect on the practice of emergency management.

7. *Knowledge gaps regarding natural hazards:* there is a generalized lack of knowledge with respect to specific natural hazards, their damage components, and how they may cause damage on vulnerable communities. Such knowledge gaps may translate into ineffective emergency management, and poorly

informed decisions relative to damage reduction alternatives.

8. *Some hazards go unrecognized:* the use of vulnerability assessment as a tool of emergency management has not yet been adopted in many places, as a consequence of this hazard assessments may be lacking and some hazards may go unrecognized. An example of this is the exacerbation of storm surge and coastal flooding, which may gradually grow worse over time exacerbated, by sea level rise and global warming. A result of this is the large number of coastal communities that are not taking measures to reduce the potential for damage from such an unrecognized hazard.

9. *Causality of damage not well understood:* there are knowledge gaps regarding the specific damage components of a given hazard, and how these are capable of causing direct damage, which in turn may lead to indirect and consequential damages. There is also little understanding of the role of impact modifiers that play a role in the type and amount of damage caused by a hazard. As a result, most sectors, including emergency management practitioners, have a poor understanding of cause and effect when it comes to damage.

10. *Intensity scales fail to convey impact:* there are scales used to identify the intensity or magnitude of a hazard. The Modified Mercalli scale and the Richter scale for earthquakes, the Safir-Simpson scale for hurricanes and the Fujita scale for tornadoes are examples of such scales. The problem with such scales however is that by offering a numerical index of intensity or magnitude they do little to actually convey what the impact may be in terms of actual damage, while they also lend themselves to subjective interpretation. For example a category 4 hurricane may appear as a big problem for one individual, and nothing to worry about to another depending on their personal experiences with previous hazards.

11. *Erroneous perception of responsibility:* a widespread problem results from the misconception among many sectors, both within the general public and professional sectors, when it comes to hazards and emergency management that this is the responsibility of a department of Emergency Management or the Civil Defense, or some other government agency, therefore there is not much they may need to do in this regard.

12. *The blame game avoids responsibility:* often in the aftermath of a disaster various sectors blame each other or some other third party for failures in execution or for the level of damage suffered by the community, this often leads to a huge blame-game where an effort is made by some to shift responsibility to others, thus avoiding responsibility themselves.

13. *Backward looking plans:* past hazard events and historical conditions are often used by planners to device emergency plans. Also most if not all buildings are designed on the basis of design criteria derived from historical observations and data of hazards that may affect them. While empirical knowledge derived from past events is a valuable foundation for planning, relying solely on this leaves out potential future impacts that may be beyond current capabilities.

14. *No effective plans for extreme events:* hazards' assessments conducted while evaluating the vulnerability of a community help identify specific hazards that may affect it, as well as the range of intensities or magnitudes, the probability of impact, and the temporal and spatial characteristics of various impacts. While this knowledge is used in designing and implementing emergency management plans, it has been found that in most cases such plans make no effective provisions to deal with extreme events, such as a category 5 hurricane or a magnitude 8.5+ MM earthquake, or the eventual impact of an asteroid on Earth. The rationale for this appears to be that the annual probability of occurrence for such an extreme event is statistically so low that it doesn't pay to really plan or design for it; so the extreme hazard gets listed in the hazard assessment and is assigned a very low probability of actually happening. The problem with this approach is that when it does take place, even when you have previous warning, it is too late to do much about it.

15. *Signals from Nature ignored:* as has been discussed here, Nature continuously provides numerous signals relative to the vulnerability or potential for damage at a given place, but as it turns out most of these signals are often and generally ignored. One result of this is the continuously increasing population and value at risk in most vulnerable communities.

16. *Opportunities for mitigation ignored:* perhaps the worst gap in the practice of emergency management is almost total absence of mitigation measures in the design and construction of buildings and infrastructure; also the missed opportunities for incorporating mitigation measures during the repair or restoration of building and facilities damaged by a hazard event. This means that opportunities for damage reduction are being customarily ignored.

So, here we have a number of critical elements of knowledge gained through observation on the one hand,

and knowledge of a number of weaknesses in the practice of emergency management also acquired empirically. What can we do with this knowledge? I wrote a book about this topic, but on a more practical note I propose such knowledge needs to be incorporated into a new and simplified model for risk assessment, something that can truly become a widely-used effective and practical tool to minimize the human impact and reduce the potential for damage to vulnerable communities everywhere.

PROPOPOSING A SIMPLIFIED MODEL FOR RISK MANAGEMENT

At its core the purpose of this simplified model is to attack existing weaknesses and gaps in current practice by using the critical elements of knowledge acquired through observation of actual events.

This model uses *empirical knowledge* as its foundation, and will be continuously updated and enhanced based on observations; meaning observations in the full range of the definition of that term, which involves *physical observations* of the consequences of actual hazards events in the field or by using remote sensing technology, also *virtual observations* of hazard events acting on specific communities through *computer aided visualization* or *simulations* based on *computer animation*.

The model will also make use of observations and data collection while *interacting with hazards*, through the use of especially designed hazard-resistant autonomous data acquisition equipment deployed in the path of or in areas expected to be directly affected by a natural hazards.

The emphasis of this model will be on the *characterization of impacts* by specific natural hazards on a community and even site-specific basis. Such characterization of impact will take into account all contributing factors including the design criteria and construction methods, as well as natural and artificial *impact modifiers* that may affect the outcome of the resulting hazard event. This characterization of impact will be used to identify the existing capabilities of the built environment and supporting infrastructure in the community under study, and that in turn will be used to identify and assess the effectiveness of various *hazard mitigation* alternatives that reduce the potential for damage from recurring events. The characterization of impacts will also take into account projected future impacts from hazards that may be exacerbated by natural processes including global climate change and its damage components such as sea level rise, global warming and others.

This model proposes viewing people in the community under study as potential *survivors* rather than potential *victims*, who must be educated and empowered to become active contributors in the protection of their community. In this sense people are a *resource* to be considered in emergency plans.

This proposal will also embrace *scientific research* that can be converted to actual *applications* to meet the objectives of the simplified model. Such applied research will tackle the full range of components and needs of the proposed model, from data acquisition, to characterization of impact, to the design and implementation of actual solutions.

The clearly stated objectives of this model will be: (a) to *change the outcome* of potential hazards events that have been identified through the practice of *vulnerability assessment*; (b) to *modify behavior* at all levels and in all sectors within the vulnerable community, including emergency management practitioners, building design and construction professionals, policy-makers, and the public-at-large; (c) to achieve significant *damage reduction* through the design and implementation of solutions designed on the basis of criteria derived from the characterization of impact.

The main focus of proposed simplified model will be on *hazard mitigation*, meaning the full range of cost-effective technologically and structurally sound measures, designed to reduce the potential for damage and minimize the human impact from recurring hazard events that may affect a given vulnerable community.

All emergency plans and other design and planning efforts based on the use of this simplified model will be forward looking, in the sense that while using historical empirical knowledge as a foundation they will also incorporate projected changes in the behavior of natural processes, results from future applied research, lessons learned from future hazards events, and above all the dynamic, interactive and shared characteristics of vulnerability.

AN IDEA FOR FUTURE ACTION

The formula to achieve an effective and practical version of such proposed model calls for EDUCATION, EDUCATION and more EDUCATION.

All sectors and all levels of society must be educated in the key concepts and components of this simplified plan. Elementary and secondary schools must educate children while also engaging their parents, so that young students may develop an interest in these concepts that may provide the incentive to continue on these fields of study at the university level, and eventually become the future scientists, engineers, planners and emergency management practitioners in charge of reducing the potential for future damage to their vulnerable communities.

Universities can play an essential and critical role in this education enterprise by incorporating relevant content in the curricula of various disciplines, so that hazard mitigation and damage reduction become accepted objectives in the everyday practice of many professions. This effort at the university level also includes the education of future educators who will become the teachers of future generations at the elementary and secondary school levels as well as in higher education.

Universities can also contribute by supporting applied research efforts focusing on the search for solutions to the many problems posed by future hazard events.

Also part of such education effort will be the congresses, conferences and workshops sponsored by various professional and academic associations dedicated to the topics of risks, prevention and security.

The time to take action toward these educational initiatives and the implementation of the proposed simplified method focusing on damage reduction in now!

BIBLIOGRAPHY

Alvarez, Ricardo (2010) – *Characterization of Impact: A Tool for Designing for Disasters.* 2010 Annual Convention American Institute of Architects [AIA], Washington DC, USA

Alvarez, Ricardo (2009) – "There is a Link Between Climate Change and Hurricanes" – *Natural Hazards Observer.* Volume XXXIII, Number 5, May 2009, pp 20-21.

Schmidt, Gavin; WOLFE, Joshua (2009) - *Climate Change*. W.W. Norton & Company, Inc., New York

Asce – American Society of Civil Engineers (2008) – *Minimum Design Loads for Buildings and Other Structures.* ASCE, Washington DC, USA

Alvarez, Ricardo et al (2006) – *El Impacto del Huracán Wilma en Cancún: Informe Preliminar de la Visita del 30 de Noviembre al 6 de Diciembre de 2005.* Chetumal, Quintana Roo, Mexico.

Alvarez, Ricardo & WILLIAMS, Allan T. (2003) – *Submarine Landslide and Tsunamis.* Pp 303-313 Yalciner, A.C., Pelinovsky, E., Okal, E., Synolakis, E., (Editors) Kluwer Academic Publishers, The Netherlands.

Alvarez, Ricardo et al (2001) – *The Storms of 1998.* Special Publication 38 – Natural Hazards Research and Applications Center, Institute of Behavioral Science. University of Colorado, Boulder, CO, USA

Geschwind, Carl-Henry (2001) – *California Earthquakes: Science, Risk and the Politics of Hazard Mitigation.* The Johns Hopkins University Press. Baltimore, London.

Alvarez, Ricardo (1999) – *Tropical Cyclone.* Hydrometeorological Hazards – Natural Disaster Management pp 34-36. Ingleton, Jon (editor). Tudor Rose Ltd., Leicester, England.

Elsner, James B., KARA, A. Bidol (1999) – *Hurricanes of the North Atlantic: Climate and Society.* Oxford University Press, Inc.

Alvarez, Ricardo (1998) – *The Need for Action to Confront Potential Consequences of Global Climate Change on a Regional Basis.* White Paper. Climate Change and Extreme Events Workshop. National Assessment of Climate Change Impact on the United States. The U.S. Global Climate Change Research Program. Florida International University, Miami.

Florida Department of Community Affairs (1998) – *The Local Mitigation Strategy: Cities & Counties Working Together to Build Disaster-Resistant Communities.* Florida DCA, Tallahassee, FL

Yeats, Robert, Sieh, Kerry, Allen, Clarence (1997) – *The Geology of Earthquakes.* Oxford University Press, Oxford, New York.

Fema (1997) – *Multi-Hazard Identification and Risk Assessment: The Cornerstone of the National Mitigation Strategy.* Federal Emergency Management Agency [FEMA} Washington DC, USA