HEMISPHERIC ACTION PLAN FOR VULNERABILITY REDUCTION IN THE EDUCATION SECTOR TO SOCIO-NATURAL DISASTERS
Physical Infrastructure Area

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Pending Issues for the Vulnerability Reduction of the Education's Physical Infrastructure

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1.0 Introduction

Natural hazards, like natural resources, are part of the offering of our natural systems; they can also be considered negative resources. In every sense, natural hazards are an element of the "environmental problems" currently capturing so much public attention. They alter natural ecosystems and intensify the impact of those ecosystems and degradation, reflecting the damage caused by mankind to the environment and can affect large groups of people. Examples of events include: hurricanes, earthquakes, tsunamis, landslides, floods, droughts, cyclones, volcanic eruptions and fires.

Disasters are classified as events that overwhelm the response capabilities and disposable resources of the institutions or the people affected. A disaster can affect a population at the local, provincial or national level. Disasters of different magnitudes require different levels of attention and different mechanisms of response. One effective response is when a plan is adopted prior to an event, caution measures exist and there are pre-established mitigation strategies. It is important to point out that there is not a country, sector or institution, including our schools, that is immune to disasters.

The consideration of the vulnerability of educational infrastructure to natural disaster should include the prevention of threats that hinder the continuity of services offered. Only recently, damage to educational infrastructure caused by natural events has been recognized in terms of the loss of hours in the classroom which consequently diminishes the quality of education. For example, even small floods affect school operation by hindering school based activities. Furthermore, as centers used as shelters in case of emergency, it is essential that strategies be developed to ensure that the buildings are quickly restored to their normal function after a disaster occurs. Cost-benefit analyses should also be carried out in order to demonstrate the efficiency of these building before the natural disaster.

Over 90% of the current inventory of educational infrastructure is vulnerable to natural hazards. The cause of this high percentage is due to the lack of knowledge about natural hazards existing in the area where the infrastructure was built; the use of inadequate school design, construction and modification practices; and the high level of deterioration that is found in some buildings due to lack of preventative maintenance. Many times, although the authorities are conscious of the risk level, budgetary restriction usually determine that available funds are used for repairs or additions to school infrastructure and do not consider the building's vulnerability to natural hazards. Most lending and technical cooperation institutions do not consider the vulnerability of school buildings to natural hazards such as earthquakes, floods, hurricanes, etc. as an

objective of their projects. Nor is protection considered, during or after a disaster, for the student population, equipment or goods and services that are found within the school buildings.

2.0 Objective

The physical infrastructure component looks to prepare directed actions which incorporate security from natural disasters in evaluation requirements, project design, and construction standards and norms for school buildings.

This component includes management and retrofitting strategies for school buildings that look at the planning process, design, execution of work, repair, construction, reconstruction and maintenance.

3.0 Methodology

Precautions should be taken to protect school buildings from natural disasters within design and execution of vulnerability reduction programs which encompass: policies, the planning processes, investment projects, and preparedness. In order to develop such a program, the programs should use, as a reference, the regional history of the natural hazards, natural hazard vulnerability analysis and structural and non-structural mitigation programs.

3.1 Policy

The education sector should have policies in place that reference natural hazards, with qualitative and quantitative goals, in the form of agreements, standards, resolutions or laws, issued by public organizations or other institutions within the sector. This gives the endorsement necessary to incorporate vulnerability reduction measures in the planning, construction, and management of educational infrastructure. Such programs must include:

- Setting goals and objectives for vulnerability reduction in the sector, with the inclusion of all relevant organizations.
- Defining acceptable levels of vulnerability of school facilities to natural hazards.
- Coordinating with the various agencies responsible for the maintenance of school infrastructure so they can carry out specific actions to reduce vulnerability.

3.2 Processes

- It is necessary to incorporate vulnerability reduction criteria that take into account design, construction, repairs, and maintenance. There is a need for planning in the education sector on the basis of assessment and analysis of vulnerability variables. To achieve this objective, it is necessary to:

- Develop the planning capacity of the sector.

- Train technical staff in charge of maintenance, as well as the educational community, on natural hazard information management.

- Support the sector in creating and/or up dating information systems on school infrastructure, including information about natural hazards.

- Ensure that these information systems serve as decision making tools for reducing vulnerability.

- Make sure that the identification of natural hazards, vulnerability and risk assessment, and the identification of mitigation measures are all included in the planning process.

3.3 Projects

Mitigation projects must be developed based on vulnerability assessments, and their implementation must be part of all building, reconstruction, rehabilitation, repair and maintenance activities. In order to achieve this goal, it will be necessary to:

- Revise and update codes, standards, and regulations of school building design and construction in accordance with identified natural hazards.

- Design educational infrastructure projects that include structural mitigation measures based on vulnerability reduction criteria.

- Secure financing for mitigation efforts, including repairs, the building of extensions and the relocation of existing buildings in accordance with vulnerability reduction criteria.

- Develop supervision and monitoring mechanisms for all stages of school facility construction, reconstruction, and maintenance in those areas

subject to natural hazards, in order to meet acceptable standards of risk mitigation.

3.4 Emergency Preparedness

Preparedness programs should be developed to respond to emergencies, within a global plan that identifies natural hazards for each building. It will be necessary to:

- Identify those school facilities most at risk to natural hazards.

- Support emergency and disaster preparedness programs, based on the diffusion of information about natural hazards among the educational community.

4.0 Considerations for Implementing Programs

Educational infrastructure is the responsibility of all institutions who interact in the education sector in the following programs: planning, project design, budgeting, maintenance, repairs, construction, and financing. The organizations involved in the application of said programs are as follows:

- Ministries of Education.
- Agencies in charge of school facility construction and maintenance.
- Local and national NGOs.
- Regional and international aid and technical cooperation agencies.

Usually planning activities, and design projects are developed by the ministry of education. The majority of projects are carried out by official organizations responsible for public works. Communities, in some cases, also build and repair their schools with their own resources or with external help, by local, national, regional or international NGOs or private companies.

In order to develop all of these activities, the agencies should establish policies where acceptable risk levels of school buildings are defined by vulnerability or natural hazard problems and then applied in their respective region. The actions that these agencies or institutions should follow are:

- Quantify the educational infrastructure, expressed in terms of quantity, type, location, construction date, performance and natural hazard setting.

- Determine the priorities of the educational physical plan according to the types of natural hazards, building characteristics, physical conditions and education levels.

- Coordinate the application of vulnerability reduction criteria with the agencies responsible for construction, expansion, repair, and maintenance of the school infrastructure.

5.0 Sub-areas

Activities have been proposed achieve the objectives of the Hemispheric Plan and reduce the vulnerability of school buildings to natural disasters. These activities are distributed in the following six sub-areas:

1. Programming and planning.
2. Codes, standards and regulations.
3. Construction systems:
    a) For seismic zones.
    b) For hurricane, flood and landslide zones.
4. Project design.
5. Inspection and implementation.
6. Evaluation, reinforcement and maintenance.

The implementation of these activities is not possible without the establishment of policies in the education sector that consider the vulnerability of the school infrastructure and will not be complete if emergency preparedness programs are not developed for school building.

5.1 Programming and Planning

Natural hazard identification, with regards to location, frequency and severity, should be considered in the physical infrastructure planning phase. In this planning phase, information systems should be used as a basic tool in making decisions concerning school buildings. The information system, in addition to the infrastructure identification data (location, characteristic and physical building conditions, the school registry and educational level) should include information concerning the prominent natural hazards in the area and the history of natural hazards that have affected the area where the school is located. With the processing of this information, it is possible to establish the vulnerability of each building to natural hazards.

The analysis of school vulnerability to natural hazards is based on the relationship between the possible hazards and the school's location. This

analysis should be done rigorously, building by building, in order to incorporate the information that show natural hazard information about school infrastructure. The analysis should be made from two points of views: information submitted by specialized agencies and information gathered directly by means of surveying school buildings. This information should used to develop matrixes with information about responsible organizations and the vulnerabilities of school buildings to natural hazards. These matrixes will help paint a clearer picture of the existing situations in the education sector.

In this form, it is possible to detect and characterize specific vulnerabilities for each type of school building. This phase should be culminate with the preparation of an investment plan where structural mitigation measures are considered as part of activities to be developed in school building maintenance, repair, expansion, relocation, or new construction projects.

Considering the importance of existing buildings compared with those still being built, yet still recognizing the need for new infrastructure, the sector, supported by loan institutions, should determine what type of existing school buildings have priority from a vulnerability reduction stand point. For the existing buildings, this signifies that detailed vulnerability inventories should be prepared according to the type of building, location, educational level and construction date. This should also relate to natural hazard type, location, intensity and frequency. For new structures, this signifies developing and utilizing construction systems that satisfy minimum risk levels in identifying natural hazards.

In order to define priority areas in the reduction of vulnerability of educational infrastructure, one should consider maintenance and functionality of the existing buildings, in addition to the location with respect to urban centers, surrounding rural areas and concentration of poor areas.

Considering the challenges that educational systems face, it is necessary to prioritize the investment in physical educational infrastructure. Priorities should be focused on guaranteeing safety (the lives and health of the education community) and functionality of the school locale in terms of short, medium and long term program duration and comfort, short, medium and long term program changes.

It necessary to develop or use an information system that quantifies the deficiencies in existing construction, that includes prevention and mitigation criteria for natural hazards, social demands and new requirements for the implementation of educational policies.

The authorities need to be motivated to make decisions concerning the use of available resources. In the same way, concentrate efforts and encourage the participation of other agencies and institutions.

5.2 Codes, standards and regulations

The available information concerning natural hazards is constantly increasing. The study of the causes, processes and effects on the population, economy, and in particular infrastructure advances daily. Because of this, we have the ability to propose mitigation measures that respond to the natural hazards that we have identified. These mitigation measures should mention development and the application of specific codes, standards and regulations for school buildings responding to acceptable risk levels for educational use.

In actuality, there are a large percentage of educational centers with a high vulnerability to the natural and man-made hazards, due to difficulty in incorporating the risk reduction concept to the design process, project evaluation and construction that existed at the moment of design. Furthermore, the lack of prevention and maintenance programs, renovation and structured reinforcement in existing school buildings, has resulted in the deterioration of educational infrastructure and has increased the risk to student populations. This absence of prevention and mitigation, in new as well as existing infrastructure, places us at greater risk.

Even if the norm applied in most countries other important vulnerability reduction factors are not considered, such as:

- Identification of hazardous areas (site evaluation).
- Architectural types.
- Percentage of usable land.
- Architectural elements designed for safety.

Countries should devise an effective legal standard, in order to make a diagnosis, with respect to the potential or limitations, of reducing vulnerability of school buildings and promote actions that will lead to risk minimization. The standards should consider the following aspects:

Structural Aspects:

- Integration of the charges with respect to existing hazards in each location.

- Adequate reinforcement of the structures.

- Avoid the use of elevated structures without minimum security conditions.

- Retrofitting structures for protection against winds, rain, etc.

- Establish different structural protection levels in accordance with the hazards and use of the school building.

Architectural Aspects:

- Retrofit architectural topologies to the existing natural hazards.

- Retrofit ground occupation indexes and evacuation prevention.

Location Aspects:

- Avoid construction of educational centers in:

    1. Hillside and unstable ravine zones.
    2. Geographical fault zones.
    3. Areas of high environmental contamination.
    4. Flood zones.
    5. Zones with liquefaction problem.
    6. Zones near flammable materials deposits.
    7. High tension line zones.

Safety Aspects:

- To provide emergency staircases, as escape routes.

- Retrofit the accessibility of the location.

- Retrofit basic services (water, light, drainage, etc.)

Recommendations for:

- Revise, evaluate and diagnose the existing physical infrastructure.

- Repair or renovate infrastructure at risk.

- Move school buildings located in maximum risk areas.

- Produce multi-hazard maps.
- Produce infrastructure risk maps.
- Do not build school buildings without environmental qualifications on construction site.

5.3. Construction Systems

In the planning phase of construction systems in seismic, hurricane, flood and landslide areas, technical information should be developed according to established policy. This information should include maps, details, specifications and the number of works necessary to assure that school buildings are within the acceptable risk levels.

There are many different types of schools to consider. Schools can vary from a simple single room where many different activities at different levels exist to a set of buildings that hold a complex variety of staff and administrative activities which are connected by open and closed areas. Construction systems for school buildings should take into account the different possibilities that are determined by student population, educational levels and size of the available area. Major consideration should be given to schools with a large student population. The standardization of construction systems is a common procedure followed by the countries of the Caribbean and Latin America. These practices take into account only the general information about natural hazards, without considering specific details about risks and their global affect. For this reason, it is necessary to develop activities that adapt the construction systems to the most relevant menaces that have been detected in the region: seismic, hurricane, flood and landslide zones.

5.3.1 Construction Systems for Seismic Zones

The design of the construction systems in seismic zones requires an understanding of preventable forces, and taking into account all previous earthquakes in the zone. Two types of data are needed to evaluate the risk that earthquakes present: the potential severity of the earthquakes and their probability of occurrence within a specific time period. When this information does not exist, a partial evaluation of available information can be made.

The principal seismic threats are earthquakes, fault rupture, and propensity of liquefaction. Once earthquake tendencies in a certain region are recognized, it is important to prepare maps to trace the parameters of high risk zones. In some countries in Latin America and the Caribbean, certain maps have done this

already, but in general, they are not specific enough for use by engineers, or government consultants assigned to develop specific tasks. Some national and regional projects have started to incorporate recent scientific and advances in seismic hazard and risk mapping are producing work of much higher quality.

The science of earthquake engineering, has devised building techniques and materials that resist all but the strongest shaking. Building codes should consider and apply these techniques. School building retrofitting can have important benefits in addition to saving lives.

In order to evaluate the risk presented by earthquakes, a review and awareness of the physical and functional vulnerability of the education sector should be developed. It is therefore important to encourage detailed studies on risk management in order to obtain a complete evaluation.

It is also necessary to revise and update the seismic micro-zoning projects, which give planners useful data to determine the feasibility of building new schools and revising the existing schools.

In order to develop the construction systems for seismic zones, the following issues should be taken into account:

- Compile a registry of all the past faults and seismic activity patterns.
- Study the national, regional and local plate tectonics and it interrelations.
- Study soil characterization.
- Include seismic resistant design parameters.
- Implement reinforcement and structural mitigation measures.
- Revise architectural concepts of:
  Spatial configurations
  Open first floors
  Strong rafters/ weak columns
  Short columns and others

5.3. 2 Construction Systems for Hurricane, Flood and Landslide Zones

Lack of understanding of hazards has resulted in the vulnerability of structural and non-structural elements of buildings. Many existing schools have not been designed appropriately and are located in zones vulnerable to hurricanes, floods

and landslides. Hurricanes can produce damages simply from wind and or by the combination of wind and water.

A hurricane is defined as a large tropical depression, with winds that surpass 119 km/hr (a tropical storm has wind between 63 to 119 km/hr). Hurricanes cause extensive damages by its powerful winds, precipitation and cyclonic waves. The winds that reach 162 km/hr cause the least amount of damages. For example, they can break windows. When they surpass this velocity, they can cause structural damages. The stronger rains can cause the rivers to flood; making it dangerous for all structures, and also can provoke landslides.

In order to evaluate risks, one should first determine if the area of study is within the hurricane belt. If it is, then a registry of past storms should be studied. Once these risks have been defined and quantified, the planners, architects and engineers should design the appropriate mitigation mechanisms. Some examples of mitigation measures are to avoid development in areas that are affected by cyclones or floods and apply these standards of construction design in order to endure hurricanes.

Floods are generally categorized according to statistical frequency. Development practices can unconsciously increase the threat of a flood, increasing the amount of water that must be carried off or decreasing the area available for absorption. The study of locating where a school building should be built should establish the water course characteristics and its predisposition to floods.

Landslides are generated by the soil saturation which diminishes its ability to absorb rain. The danger of landslides is frequently ignored when in reality, we should focus on the relationship of landslides to torrential rains and seismic activities as a catalyst. A secondary effect of earthquakes and volcanic activity should be considered but only abundant rains can produce the same effect.

In order to develop construction systems for hurricane, flood and landslide zones, the following aspects should be considered:

- Compile a historic registry of all storms, floods and landslides in the past.
- Study national, regional, and local atmospheric situations and their interrelation.
- Study wind characteristics.
- Include of up to date hurricane resistant design parameters.

- Implement structural reinforcement and mitigation measures.

- Revise architectural concepts of:
  Roof configuration
  Open first floors
  Windows and eaves

5.4 Project Design

The project prototypes in indiscriminating form, without considering the physical characteristics of the land used, lack of standard and technical specifications applied for vulnerability reduction and inadequate training programs for technical personnel in design. The prototype designs are used in different regions of the country without taking into account the specific variable in each location and the necessary soil and topography studies, essential for defining infrastructure of each project. In the case of school buildings, it is important to know the soil in order to determine the soil-structure interrelation and thus the necessary retrofit components.

In order to look for a solution, projects should be developed which respond to physical and specific land conditions where the future school will be built in order to secure acceptable risk levels for each vulnerability problem and to demand technical design specifications. This strategy requires constant personnel training and the tools that promote the modernization of educational infrastructure offices in order to overcome the lack of technical development in design and in the management of school infrastructure projects.

5.5 Inspection and Work Implementation

In the implementation phase, it is necessary to supervise work in such a manner that technical indications are fulfilled and that necessary modifications are carried out. The fundamental problems are that standard application and construction procedures have not been made correctly, making evident the lack of professional ethics at the implementation and supervisory levels. In addition, projects carried out by the educational community and other public and private organizations, with rare exception, are implemented without control or monitoring form planning institutions or public works departments.

A training strategy for technical personnel responsible for supervision, inspection and implementation is necessary. Furthermore, sufficient human resources

should be provided to ensure that supervision and control is provided during the retrofitting of infrastructure. Legislation should be created addressing vulnerability reduction in the educational sector. The legislation should include the role of the local groups and community organizations in recognizing and evaluating school building vulnerability. In the operational phase the local government organizations and civic groups (NGO's, professional high schools and others), should be included to ensure their participation and support.

5.6. Evaluation, Repair and Maintenance

It is necessary to inspect and repair existing school buildings in every country in accordance with the natural hazards identified, which in general renders more attention to project improvement of new schools, while those already in existence constantly deteriorate. The number of all school buildings in most countries greatly outnumbers newly constructed ones. Similarly, the vulnerable schools in each country greatly outnumber the ones well suited for the hazards they face. Moreover, in most countries schools exist originally designed for other uses or purposes. In most cases, this increases the degree of the buildings vulnerability to natural hazards.

Vulnerability studies should be conducted that take into account all of the important school building components in order to proceed in its immediate readapting, but constantly increasing methodology tools duly validating and standardizing, that guide vulnerability evaluation of educational centers to natural disasters and preventative and corrective actions with the normal reinforcement and maintenance programs. Unfortunately this duty is often seen as a function of the central government organizations, not the municipalities and civic groups.

To resolve this problem, a strategy that motivates systematic and permanent training is required, in the construction and educational community, to minimize the damages to materials and human life. This strategy should contemplate the following:

- Implement policies of locales in order to guarantee the physical security of students and to commit resources to new school building construction.

- Institutionalize corrective and preventive maintenance programs. Suggest the creation of technical and methodical instruments (guides, manuals, etc.) for the evaluation of the vulnerability of school infrastructure.

- Incorporate vulnerability reduction measures in reinforcement and maintenance programs, with the purpose of guaranteeing security to the users and to prolong the use of the school buildings.

- Manuals for the inspection and evaluation of school building's vulnerability should be at two levels: 1) basic- to be applied to local education communities and 2) specialized- for application by school infrastructure and technical professional.

- Technical guides should consider construction methods and details as well as maintenance and reinforcement of school infrastructure.

- Implement training programs at two levels: 1) basic- for local education communities and 2) specialized- for professional personnel from the educational technical community.

- Evaluate school building vulnerability as a first step in the planning organizational stage to ensure the protection of school buildings.

- Incorporate the evaluation of the vulnerability of physical construction aspects, at the organizational level and preparation of the users.

- Support participation of local organizations (municipals, NGOs, professional high schools), in school vulnerability evaluation.

- Establish relationships on the local level in order to reinforce school vulnerability issues so that mitigation activities are supported and sustainable.