SAFER SCHOOLS

Developing Guidelines on School Safety and Resilient School Building Codes

DIAGNOSIS & RECOMMENDATIONS

Executive Summary

Republic of Mozambique
Ministry of Education and Human Development

Republic of Mozambique
Ministry of Public Works, Housing and Water Resources

National Institute of Disaster Management

UN-HABITAT FOR A BETTER URBAN FUTURE

EDUARDO MONDLANE UNIVERSITY
Faculty of Architecture and Physical Planning

THE WORLD BANK

GFDRR

Title
Executive Summary of Diagnosis and Recommendations

Scope
Safer Schools Project in Mozambique “Developing Guidelines in School Safety and Resilient School Building Codes in Mozambique”

Promoted
Ministry of Education and Human Development
Ministry of Public Works, Housing and Water Resources
Ministry of Statal Administration and Civil Service – National Institute of Disaster Management

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Autors
Faculty of Architecture and Physical Planning – Eduardo Mondlane University
Each year UEM-FAPF graduate 30 architects and urban planner in Mozambique. Has 30 teachers and is a center of excellence for the country. The Faculty has a Development and Habitat Studies Center (CEDH) which is a research and services institutions of UEM-FAPF created in 1992, whose objectives are, among others (1) contribute to the development of direct resources or indirectly related with the improvement of habitat conditions in the cities of Mozambique, (2) conduct and promote research projects in urban planning, housing, architecture and the environment, (3) provide technical assistance for studies, research projects and urban environments, housing, environment and within the municipal or local government.
United Nations Human Settlements Programme
UN-Habitat is mandated by the United Nations General Assembly to promote socially and environmentally sustainable human settlements and adequate shelter for all. In Mozambique, the UN-Habitat is since 2002 and supports the country in search of architectural solutions, participatory physical planning and community participation appropriate to reduce disaster risks. The program is implemented through advocacy standards, information analysis, and demonstration support at national, provincial, district, urban, community and technical assistance.

1st Edition
Maputo, January 2015

Acronyms and Abbreviations

AEMC	Mozambican Association of Consulting Companies
ARA – Sul	Regional Water Administration – South Zone
BM	World Bank
CEDH	Center for Studies and Habitat Development
CLGC	Local Committee for Disaster Management
CRED	Centre for Research on the Epidemiology of Disasters
CRM	Republic of Mozambique Constitutions
CTG/GTC	Consultive Technical Group
CTGC	Technical Council for Disaster Management
DINAPOT	National Directory of Territorial Planning
DIPLAC	Directory of Planning and Cooperation
DIPLAC-CEE	DIPLAC – School Equipments and Constructions
DNA	National Directory of Water
DNG	National Directory of Geology
EFA-FTI	Education For All – Fast Track Iniciative
EP1	1st grade of Primary School;
EP2	2nd grade of Primary School
EPC	Complete Primary School
ESG	General Secundary School
FASE	Fund to Support Education Sector
FEWS NET	Famine Early Warning Systems Network
FID	Fond d'Investissment pour le Developpement, Madagascar
FME	Mozambican Federation of Contractors
GFDRR	Global Found for Disaster Risk Reduction
GIMMS	Global Inventory Monitoring and Modeling Studies
INAM	National Institute of Meteorology
INDE	National Institute of Education Development
INE	National Institute of Statistic
INGC	National Institute of Disaster Management
INNOQ	National Institute of Narmalization and Quality
IPCC	Intergovernamental Panel on Climate Change
KfW	Grupo bancário do Governo Alemão.
LEM	Engineering Laboratory of Mozambique
MAEFP	Ministry of State Administration and Civil Service

MINEDH	Ministry of Education and Human Development
MCT	Ministry of Science and Technology
MOPHRH	Ministry of Public Works, Housing and Water Resources
NASA	National Aeronautical and Space Administration
NOAA	National Oceanic and Atmospheric Administration
NDVI	Normalized Difference Vegetation Index
OCHA	Office for the Coordination of Humanitarian Affairs
ONG	Non Governmental Organization
PCA	Accelerate Construction Programme of Schools Infrastructure
POEMA	Planning, Budgeting, Implementation/Execution, Monitoring and Evaluation
RRD/DRR	Disaster Risk Reduction
SDEJT	District Service of Education, Youth and Technology
SDPI	District Service of Planning and Infrastructure
SISTAFE	Financial Administration System of the State
SNE	National System of Education
UCEE	Unit Construction of School Equipment
UGEA	Managing Execution Units Procurement
UFSA	Funcional Unit for Supervision of Procurement
UEM	Eduardo Mondlane University
UEM-FAPF	Eduardo Mondlane University – Faculty of Architecture and Physical Planning
UEM-FD	Faculty of Law - UEM
UEM-FENG	Faculty of Engineering - UEM
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention of Climate Change
UN-Habitat	United Nations Human Settlements Programme
UNICEF	United Nations Children's Fund
UNISDR	United Nations International Strategy for Disaster Reduction
UNOSAT	Operational Satellite Applications Programme
UPCEE	Provincial Unit Construction of School Equipment

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Introductory Note

The diagnosis and recommendations developed under the Safer Schools Project were one of the results of a comprehensive process of evidence collection, draft recommendations generated by analysis and general technical guidelines that appear on the document divided into four sections.

In the introductory section (Section I), describes the participatory methodology applied by the Technical Team of the Safer Schools Project to collect data and generate consensus on the evidence and the analyzed facts as well as the components of the Project.

In Section II, it explores the relationship between the profile of natural hazards of Mozambique and the school network exposure in the country and proposes a prioritization of threats, based on the level of the impact recorded in recent decades. Through existing documents and georeferenced school network map (2007), the study calculates the percentage of exposure of school buildings to 4 prioritized natural hazards and illustrates in depth the recurring effects of the impact of hazards in schools nationwide. This section also analyzes the general context that regulates the construction in the country, demonstrating the legal and normative maladjustment and co-factors which, although not directly technical, might influence the quality of works and safety of the school environment in several areas. This section is the essential part of the diagnosis and analysis, and proofs the findings and recommendations presented in the following section.

In Section III, a set of findings achieved through in-depth process analysis, diagnosis, consultation and consensus building is presented. Is also patent a set of recommendations that could be implemented in the short, medium and long term. It was decided to present as "phased" recommendations recognizing the great complexity of the current build system and the need to progressively resolve obstacles and therefore offer a more realistic and effective way to achieve Safer Schools.

In Section IV, finally, it presents the best practices identified in the country. The general guidelines of a technical nature to build safer schools are also presented which must be accompanied by more specific rules to be proposed under the proper draft of Safer Schools.

Each chapter concludes with a note "Important!" That allows drawing attention to some key issues for understanding the process conducted to carry out the study. Such notes also list the recommendations generated by the analysis, summarized in the short, medium and long term in Section III.

SECTION I

INTRODUTION

It's necessary to find and maintain a balance between the need to rapidly expand the school network coverage in Mozambique - aiming to clog up the existing deficit and satisfy the population growth - and the resistance of school buildings toward a prevailing natural hazards profile, with the main concern of preserving the physical, psychological and social Child safety.

The Safer Schools Project - "General Principles and Guidelines for Safer Schools and Safer Schools Building Regulations in Mozambique" (Developing Guidelines on School Safety and Resilient School Building Codes) - is an initiative supported by the World Bank - Global Services Risk Reduction disasters (Global Facility for Disaster Reduction and Recovery - GFDRR) and led by the Ministry of Education and Human Development (MINEDH) in coordination with the Ministry of Public Works, Housing and Water Resources (MOPHRH) and the Ministry of State Administration and Civil Service (MAEFP) through National Institute of Disaster Management (INGC) who in 2011, mobilized the technical partnership in response to disasters that affected more than 1,000 classrooms in of Maputo, Gaza and Zambezia Provinces, during the end 2011 and early 2012. The project has the technical assistance of the Faculty of Architecture and Physical Planning of the University Eduardo Mondlane (UEM-FAPF) and the United Nations Human Settlements Programme (UN-Habitat) and aims to provide guidance on the safety of schools in Mozambique based on the reality of the country and promote construction methods for resistant schools.

Identified Institutions (MINEDH, MOPHRH, MAEFP and INGC) constituted important actors in the implementation of the project with responsibility in the matter of school construction and security in Mozambique through a consultative and inclusive process at all stages and products.

The project, initiated in July 2012, has the following expected results:

a) Generate consensus on the need to build safer schools among the various actors in the school building process in the country;

b) Analyze the school constructive reality in Mozambique in order to detect areas for improvement and promising experiences through diagnosis that is one of the bases for the development of guidelines and rules for safer schools constructions;

c) Produce consensus on the broad guidelines, technical measures and the standardization process to be conducted in the short, medium and long term to build resistant schools to natural hazards such as cyclones, floods, droughts and earthquakes.

d) General Guidelines for the resilient schools construction based on the diagnosis and recommendations in all areas related to school construction (Institutional and Administrative, Regulatory and Legal, Technical and Practice);

e) Technical measures and principles for safer Schools Construction, including technical annexes based on the zoning of hazards, to serve as a basis for national standards the development.

f) School Risk assessment as a basis for the application of resilient measures.

The Safer Schools Project was based on the collection of relevant information for a better understanding of the problem through interviews with institutions that participate directly or indirectly in school construction process in Mozambique, reading and analysis of documents (legal rules, technical standards, reports, etc.) and field surveys. In addition to the CTG regular meetings were conducted with the Executive Group, composed by the National Directors of relevant areas, particularly DIPLAC-CEE, DNE and INGC.

Figure 1 – 1st Consultive Technical Group with Directors of INGC, DPLAC and DNE

Different Governmental and non-governmental institutions concerned with school building matters took part of the process, not only CTG but also the whole range of bilateral and thematic meetings (Table 1).

Ministries	National Institutes	Private Sector	Organizations of Civil Society, and International Organizations
Ministério da Educação e Desenvolvimento Humano (MINEDH) Ministério das Obras Públicas, Habitação e Recursos Hídricos (MOPHRH) Ministério da Administração Estatal e Função Pública (MAEFP) - Instituto Nacional de Gestão de Calamidades (INGC) Ministério da Economia e Finanças	Instituto Nacional de Meteorologia (INAM) Instituto Nacional de Normalização e Qualidade (INNOQ) Direcção Nacional de Geologia (DNG) Direcção Nacional de Águas (DNA) Direcção Nacional de Materiais de Construção (DNMC) Direcção Nacional de Edifícios (DNE)	Consultores (Representados pela Associação das Empresas Moçambicana de Consultoria – AEMC) Empreiteiros (Representados pela Federação Moçambicana de Empreiteiros - FME)	ONGs e Doadores (World Vision, Save the Children, Conselho Cristão de Moçambique, FASE, DFID, Plan Internacional) Ordem dos Engenheiros de Moçambique Agências das Nações Unidas (UNICEF, UNDP) UEM (Faculdades de Engenharia, Direito, Ciências-Física, Geologia) FASE

Table 1 – Institutions Mobilized during Safer Schools

The results of diagnosis and establishment of consensus have been validated through three seminars that led to the validation of the results / products achieved by the Safer Schools and institutional accountability of the recommendations.

Figure 2 – Photo family of 3rd WorkShop

Methodologically for the diagnosis and production of guidelines for the safer schools construction in Mozambique, aimed to:

1. Analyze the legal, regulatory, institutional, construction practices and techniques and the role of the main actors in the construction of school buildings;

2. Analyze the constraints and strengths that exist in the school buildings process;

3. Based on the above analysis, make recommendations as a basis for the preparation of general Guidelines and Standards or Safer Schools Construction Codes in Mozambique. **Establish an evidence base through data gathering and analysis.**

In order to achieve the objectives and results the following research method has been adopted:

- **Preparation of research tools -** Integration of recommendations from the Seminar I, specifically in relation to the diagnosis of the Terms of Reference and composition of the Technical Advisory Group; preparation of questionnaires, document review records (reports, technical standards, rules, etc.), scheduling interviews and bilateral meetings, forms for synthesis and systematization of interviews, and analysis and recommendations sketching up.
- **Data collection -** primary and secondary sources were searched:

Primary Sources:

- ✓ Bilateral Interviews with over 30 key partners in the construction of schools in Mozambique as well as governmental institutions and non-governmental organizations, academia, civil society organizations;
- ✓ Focus on Groups Driving on school construction processes
- ✓ Field survey in 636 classrooms in 7 provinces (Maputo, Inhambane, Sofala, Gaza, Zambezia, Nampula, Manica) and 4 threats/hazards (floods, earthquakes, cyclones, droughts).

Secondary Sources:

- ✓ Research of technical documents of school construction in Mozambique as technical reports, legal and technical standards, international building codes, international experiences for similar safer schools Project;
- ✓ National and international laws research;
- ✓ Global reports for Research on resilient construction, threats mapping, risk management, damage assessment during the emergency, etc.

- **Systematization and Analysis of Information -** based on the gathered information, a process to analyze the data was previously initiated and such analysis led to the further presented results.

During the conduct of the study in addition to the various meetings at different levels, international experiences show was also helpful to the process with the intuited to strengthen proposals and recommendations that were aligned with the experience and knowledge globally and adapted to the reality of the country. Precisely, this process of adaptation is a major challenge, considering two limiting factors, namely **(i) the complexity of school construction system in the country and (ii) lack of adequate scientific data with regard to some natural hazards or difficulty of access to data, if any, to make probabilistic and deterministic calculations.**

Important!

Front limiting the above, the Technical Team, in consultation and discussion of the Technical Advisory Group, proposed first draft and adopt interim measures for four natural hazards the country through simple legal instruments (Diploma Ministerial Decree) and based on an approach based on probabilistic calculation with existing data to cyclones and High Wind, earthquakes, flooding and drought. Also intends to diversify the action in the short, medium and long term, as suggested in the recommendations in the last section of the document.

SECTION II

THE NEEDS ON SCHOOL SAFETY IN MOZAMBIQUE

Historical Analysis of School Construction in Mozambique

The war intensification and the desestabilization of the country resulted in the destruction of most of the schools infrastructures, mainly during the 80´s. As a result, the EP1 reduced to 3441 in beginning of 90’s, corresponding to a 40% reduction in school infrastructure compared to the 80´s. Equally, the admission gross rate in EP1decreased to 54% in 1994. With “*Acordo Geral de Paz*”, in 1992, and the progressive stabilization of the political scenario and economic of the country, a new era begins where the number of constructed schools and the matriculated students progressively increases every year. Its important to recall a very new attention toward EP2 school construction and General Secondary Schools: **in short period of 10 years, the EP2 schools increased from 232 to 1304- an increase of 462%- and the General Secondary schools increased more than 3 times- from 59 to 189 schools.**

I. In table 2, you can see the evolution of the number of primary and secondary schools from 1975 until 2012, as well as the change in the total number of students, who jumped from 709,000 in 1975 to 6.2 million in 2012. The figures are presented according to a division into four different stages of school construction, namely:

   I. The of post-independence phase, characterized by a very pronounced increase in the number of schools;

II. II. The phase of intensified destabilization of War, between 1983-1992, marked by the destruction of about 60% of existing EP1 schools with a total of 1,414,222 students affected Regarding EP2 schools, from 1983 until 1989, the year which recorded in the latest updated data about war post damage assessment in the education, about 18% of closed and destroyed schools and 13.266 affected students.

   III. The stability phase after the Peace Accords, when the number of schools started to increase over the years; and finally

III. IV. The latest phase characterized by the establishment of Accelerated Construction Program - which changed the goals and building practices of primary schools - and a general increase in the number of EP1 schools as well as Secondary Education.

Evolution of the number of schools and students, 1975-2012

Period	Year	Number of Schools*					Total of Students** (in thousands)
		EP1	EP2	ESG1	ESG2	Total of Schools	
Phase 1: After independency	**1975**	5235	26	7	5	**5273**	709,3
	1980	5730	99	19	3	**5851**	1492,5
Phase 2: Intesification of the desistabilization war	**1985**	4616	156	41	5	**4818**	1453,7
	1990	3441	169	39	5	**3654**	1400,6
Phase 3: Stability after Acordo Geral de Paz	**1995**	4167	232	49	10	**4458**	1602,7
	2000	7072	522	93	20	**7707**	2690,3
Phase 4: Acelerated Construction Programme	**2005**	8713	1304	154	35	**10206**	4303,7
	2008	9662	2210	287	76	**12235**	5575,2
	2010	10458	2991	376	119	**13944**	6130,8
	2012	11164	4068	446	156	**15834**	6216,7

* Dy shift. It's not about the school buildings but schools that teach such education level.
** Includes students of technical education. The years 1975-2000 include students in higher education; However, they only represent 0.1-0.5% of the total.

Source: 1975 - 2000 - MINEDH 1994a, 1994b, 1997, 2000, MEC 2005 2008. MESCT 2003 (Withdrawn from Brouweretal, 2010); Period 2005-2012 - data provided by the Statistics Department of DIPLAC

Table 2 – Evolution of number of Schools and Students, 1975 - 2012

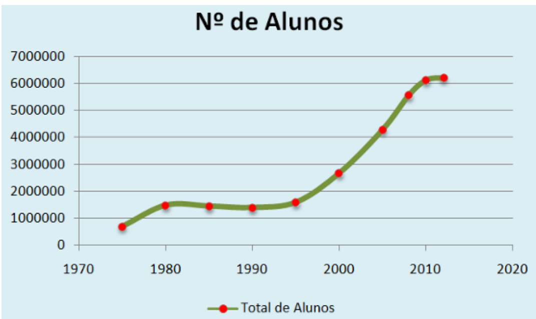


Chart 1 –Evolution of Number of Students, 1975 - 2012

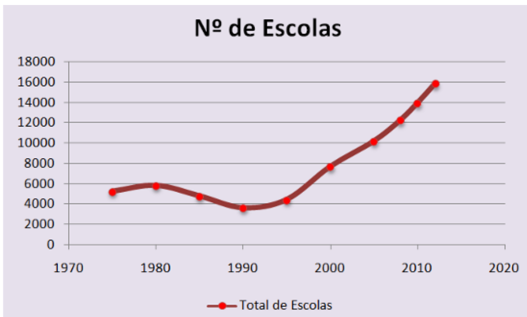
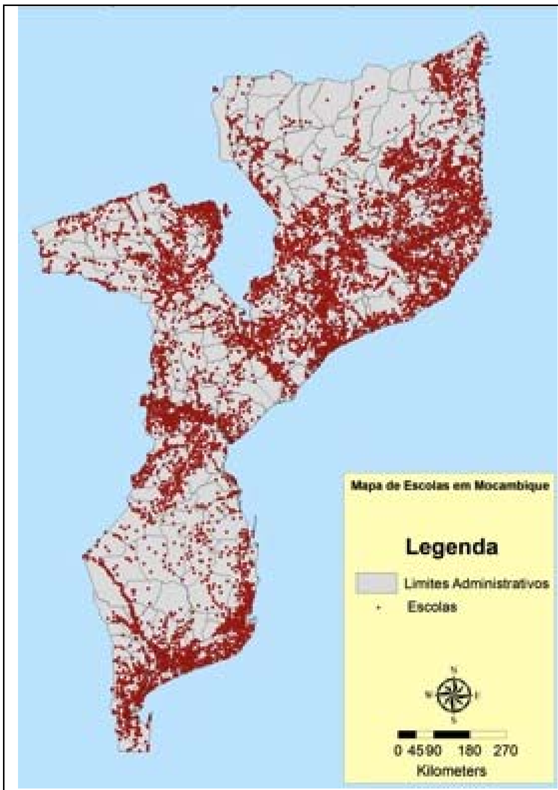


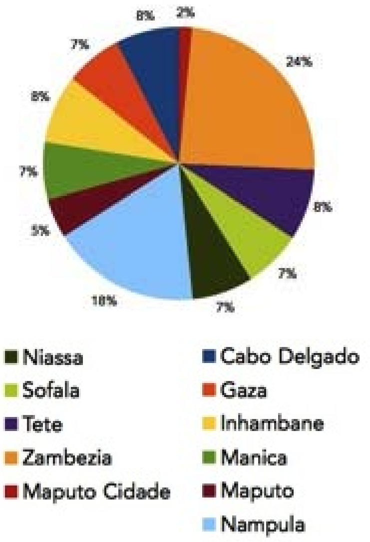
Chart 2 – Evolution of Number of Schools, 1975 - 2012

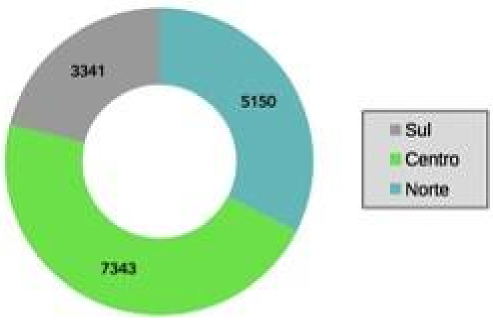
The current geographical distribution of school buildings (Box 1)widely reflects the distribution of population by different regions in Mozambique: the most populous provinces - Nampula and Zambezia - which concentrates almost half of the total number of schools in the country, about 42% of school network. The remaining provinces of Mozambique, in turn, own figures ranging between 750 and 1300 schools - or 5-8% of the total - (with the exception of Maputo City, which has 247 schools).

Box 1 – View of the Geographical distribution Schools in 2012, Mozambique



Província	Número de Escolas	População (em milhões)
Cabo Delgado	1201	1,83
Gaza	1070	1,36
Inhambane	1286	1,45
Manica	1084	1,8
Maputo	738	1,57
Nampula	2799	4,76
Niassa	1150	1,53
Sofala	1094	1,95
Tete	1340	2,32
Zambezia	3825	4,56
Maputo Cidade	247	1,21
Total	**15834**	**24,34**





From 63551 existent classrooms in 2013[1] about 44% are of poor construction, i.e. classrooms "maticadas", *pau a pique* and others local materials. Most of these classrooms are frequented by the EP students, half being located in the provinces of Nampula and Zambezia.

[1] Data from statistical survey "03 of March" of 2013, from the Directorate Planning and Cooperation of MINEDH

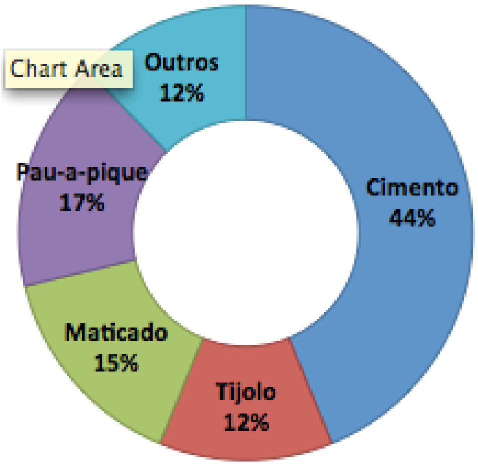


Chart 3 – Number of Classrooms in Mozambique by construction material typology in 2013

Understanding relation between Hazard and School Construction

It is estimated that 25% of Mozambique's population lives in areas exposed to recurring hazards. The 2 types of hazards in Mozambique are:

- Climate and Geological: ex. Floods, cyclones, droughts and earthquakes, respectively;
- Anthropogenic: the anthropogenic disasters can be generated by man or technical failures.

Thus, a high number of hazards can potentially affect the school buildings, its surroundings or its users.

a number of georeferenced data of the school network was analyzed crossing this information with maps of natural hazards in order to generate school network exposure maps to the four hazards that most affect the country, including floods, cyclones, earthquakes and droughts. This exposure mapping when crossed with the historical record of the impact and the sensitivities based on a sample of 830 classrooms in 7 provinces, will allow the estimative approximation of the risk of schools areas affected more often affected by hazards.

For the mapping of the Mozambican school network, the geo-referenced data from the World Bank database (2007) was used combined with not georeferenced data from MINEDH (2012). Mozambique has a population of 16,764 schools, of which 9,400 are georeferenced through the World Bank database (2007). The remaining 7364 are not georeferenced and present information at the District level.

The methodology for mapping the school network exposure to natural hazards is summarized by the following diagram:

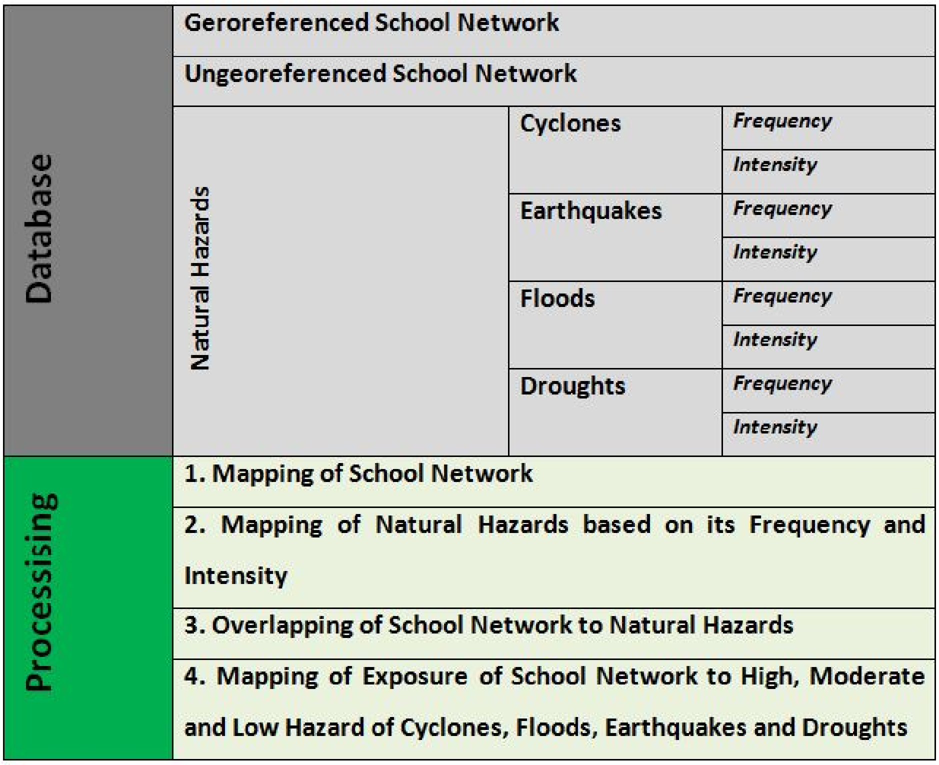
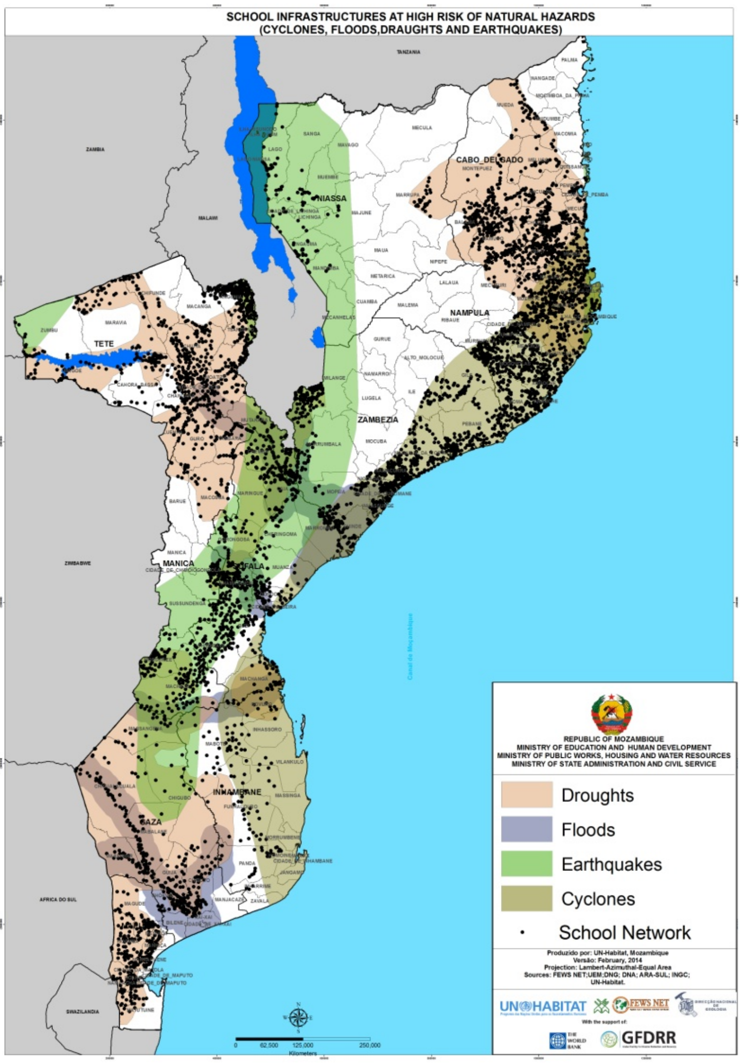


Figure 3 – Methodological Scheme for School Exposure to Natural Hazards

As a result, 4 exposure maps of the school network for each hazard were produced and the following was found:

- Cyclones: 4968 (27%) of the schools are located in areas of high-level cyclonic hazard, 5533 (33%) in moderate hazard areas and 6263 (41%) in areas where the level of hazard is low;
- Earthquakes: 3017 (18%) schools are in high-level seismic hazard areas as 8047 (48%) at the level of areas of moderate seismic hazard and finally 5700 (34%) in low seismic hazard areas;
- Floods: about 1341 (8%) Schools are located in high-level flood hazard areas in the country, while 5364 (32%) are in moderate hazard areas and finally, 10058 (60%) are from areas the hazard is low;
- Dry: about 3185 (19%) schools are located in high hazard areas, 10729 (64%) in moderate hazard areas and 2850 (17%) in low hazard areas.
- In summary, the team found that 72% of schools are in high-risk areas of one or more natural hazards (cyclones, earthquakes, droughts and floods).



Map 1 – School Exposure to Natural Hazards (Cyclones, Floods, Droughts and Earthquakes)

Important!

However, a limitation for the construction of Safe Schools in Mozambique remains access to reliable and specific data on the Natural Threats in Mozambique in areas under-district, in particular wind and floods, to calculate load in structures of school buildings and, based on this, zoning and categorization of specific areas by threat. Studies could be carried out together with universities in the future to bridge the gap.

Four natural hazards should be prioritized in the adoption of basic principles of construction as well as specific rules adopted quickly.

To understand the threats in school buildings we chose to analyze the potential sensitivity of buildings of the school network in Mozambique in order to find constructive weaknesses that influence the resistance of buildings affected by the natural phenomena above mentioned. Three types of technical information sources was chosen: (i) analysis of architecture and documentation projects; (ii) techniques interviews; (iii) Field surveys and results of "guidelines" and UN-Habitat manuals prepared for Mozambique between 2005 and 2012.

Therefore, were carried out field surveys of 830 classrooms in 7 provinces and for 4 hazards (floods, earthquakes, cyclones, droughts). The survey form was structured into 5 parts, namely: (i) General Information; (ii) Preparation and Disaster Response; (iii) Funding Sources; (iv) Impact on School Infrastructure; (v) Perception of the reaction towards hazards by the members of the school community (principals, teachers, students, parents and guardians, district secretaries, block heads, community leaders).

In this survey analysis, rooms of existing classes in the country were studied, grouped into three types depending on the particular type of material used to build: Conventional Materials; Traditional Material or Mixed Material.

The study looked at all areas of the school building system in Mozambique within which there are risk factors that must be mitigated in order to introduce in an effective and efficient way, tough measures in school construction.

Briefly, there was a consensual way during the study that the safety of children in schools in Mozambique, depends on a set of operative factors in a coherent and harmonized manner, as shown in the pyramid below:

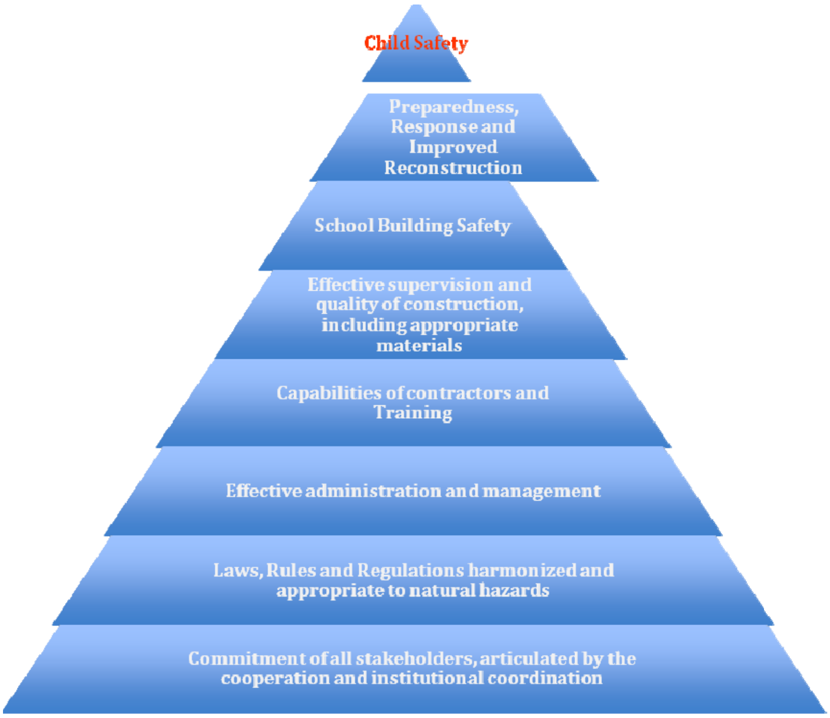


Figure 4 – Diagram on Operative Factors for Safety of Children

In the following paragraphs are the summaries of the weaknesses and recurring failures and strengths analysis observed in school infrastructure both in conventional and unconventional (non conventional) material, caused by Cyclones, Floods and Earthquakes.

Drought is a threat that does not cause damage to the school building but compromises the safety of children in areas with its occurrence and the evaluation done on the school buildings regarding this threat were rainwater system checked out for schools to collect and store rainfall water.

Recurrent failures toward cyclones

Summary of the recurrent failures in case of Conventional Classrooms Material toward cyclones

In areas exposed to cyclones and strong winds, the building must comply with (i) site selection and appropriate ground (ii) deep foundations and walls sufficiently heavy or with clamping (iii) transfer the loads directly to the ground by pillars and walls bearing (iv) resistant connections between components foundation-wall-covering, (v) a heavy or sturdy cover enough to prevent the wind loads in different directions. In summary, the following findings were raised in conventional buildings;

A. **Architectural drawing not adapted to wind zones:** (i) projection of roof to the balcony/veranda area with an excessive prolongation without sufficient reinforcements;

B. **Location and orientation:** classrooms orientation not in accordance neither with the prevailing winds or historic winds of past cyclones. Choice of wind highly exposed locations in case of cyclone (Seaside), raised areas directly receiving the wind without protection, and not protected by topography open land or afforestation;

C. **Defective junctions between the elements of the roof**: (i) wall-trusses (ii) trusses-purlin (iii) purlin-roof.

D. **Lack of dimensioning within trusses elements and appropriate junction between them.**

E. **Lack of appropriate dimensioning of the purlins and excessive spacing between them.**

F. **Quality of the roof material**: rippled rood sheet and IBR roof type represent an inadequate thickness (0.3mm) to withstand a wind force/load (minimum recommended reference is 0.6 mm).

G. **Lack of protection in door and window openings** to avoid the wind entrance and defend the building from the internal extra-pression as well as the wind dragged out objects.

H. **Gable solution**: although structural failures evidences caused by the wind force in walls and pillar in masonry schools does not exist, in school with 2 waters coverage the masonry gable without reinforcement is still a potential danger to human life, when used sand-cement made blocks or even other massive elements like top coverage in "fire-guards". This detail must be reviewed.

I. **Electric equipments,** in urban areas or most populous where night class exist its recommended that the technical guides are elaborated with matters related to installation and maintenance of electric equipment that may potentially lead to accidents in a cyclone scenario.

Figure 5 – Schools destroyed partially by Strong Winds

Recurrent failures in Non-conventional material classrooms in a cyclone event: plant- derived mixed material classrooms (*pau a pique*, reeds, poles, adobe and bricks, dry grass cover or between Macúti among others depending on the geographic area of the country).

A. **Inexistent available architectural project-type at local level** (SDPIs SDJETs), nonetheless some exceptions. The sketches are most of the times defined by the local communities. In most cases they are not adapted for strong wind situations, except the 4 waters coverage.

B. **Bad location and orientation:** similar to the conventional classrooms case, the orientation of the school buildings is not in accordance with the most prevailing winds neither the historical ones of the past events. The choice of places highly exposed to wind strength in case of cyclones (sea shore), elevated areas without protection that directly receive the wind strength and open land non topographically protected or under deforestation and unconventional buildings built under the houses.

C. **Groundwork bad dimensioning:** lack of groundwork dimensioning in the massive material school buildings (adobe, raw brick). In plant materials school buildings the groundwork preparation and protection of the stakes in the ground is most of the time inadequate, especially in sandy soils that do not resist to traction force.

D. **Bad dimensioning of Walls foundations and wall clamping:** these failures contribute to the wall sloping and the crumbling of the plant deficient lacking of diagonals and horizontals, it's also necessary that the completion of the walls is appropriate with the purpose of delay the floods and strong winds effects over the structure.

E. **Walls in Adobe structure or row brick offer less resistance to torrents caused by cyclones.** Since the row adobe is drenched in water, the wall does not offer resistance to wind and falls down.

F. **Lack of dimensioning and non appropriate concrete pillar applications in mixed classrooms:** fact that leads to the classrooms walls tumble, caused by the mist of materials such as wood blocks and posts making them highly vulnerable to wind lateral loads.

G. **Defective hawsers between the joint elements (i) trusses - wall; (ii) purlins-roof**

H. **Lack of dimensioning of roof structure elements (trusses) and inadequate hawsers between them.**

I. **Lack of appropriate dimensioning of purlins or stakes in the roof structure and excessive spacing between them.**

J. **Poor quality of roofing material in mixed classrooms:** the corrugated sheets and IBR type layers present an inadequate thickness (0.3 mm) to withstand the wind (recommended minimum reference is 0.6 mm);

K. **Roof with plant material:** insufficient material, thus offering little resistance to the wind and the rain, poor moorings, insufficient slope, and little maintenance or periodic replacement of the material.

Recurrent failures to floods

Summary of the recurrent failures in case of Conventional Classrooms Material toward Floods

If the school infrastructure cannot be located in a high and safe area as are the resettlement neighborhoods in areas exposed to flood, the school building should note especially: (i) selection of the fittest or elevated location within the danger zone ; (ii) deep foundations and enough heavy walls or crashes to support the lateral load of the force of the water; (iii) transfer loads directly to the ground via bearing walls or pillars; (iv) power connections between the components foundation wall covering; (v) a roof capable of withstanding increased overhead in case of emergency and (vi) Preparation of raised areas within the space. In summary the following findings were raised in conventional buildings:

A. **Arquictectural designs type non adapted to flood zones:** in primary schools there are not construction models adapted to flood zones or that indicate mitigation solutions such as protection dykes, first floor schools, drainage systems or elevated basis of obligatory character.

B. **Localization:** Choice of places exposed to flood strength such as the proximity to the river beds, where evacuation routes are not defined.

C. **The necessity of revision of moorings between the elements in the coverage zone:** (i) wall-trusses (ii) trusses-purlins (iii) purlins-roof;

D. **Lack of scaling trusses elements and appropriate mooring including case load in excess of the coverage;**

E. **Lack of appropriate sizing of the purlins and excessive spacing between them;**

F. **Quality of covering material:** corrugated roofing type and IBR have an inadequate thickness (0.3 mm) to withstand overload in case is used as a refuge-emergence location;

G. **Lack of protection spans (doors and windows)** to prevent entry of water and vandalism in urban areas in times of emergency;

H. **Electrical installations,** both in flood zones as cyclone in particular in urban or densely populated areas where there are night classes, we recommend the development of technical guidelines on issues related to installation and maintenance of electrical installations that are likely to cause accidents one full of scenery;

I. **Drawings of latrines, drains and septic tanks should be reviewed and adapted to full zones:** once crossed the dangerous phase and leaking water, the flooded infrastructure need cleaning and disinfection. Sanitation systems adapted to flood situation can help to restore a timely way the sanitation systems and prevent disease outbreaks

Figure 6 – Damage caused by earthquakes in classrooms

Summary of the recurrent failures in case of Non Conventional Classrooms Material toward Floods

A. **Architectural Project-type adapted to flood zones not available at local level (SDPIs or SDJET):** for primary schools don't exist models adapted (eg elevated platform) to floods zone or that indicate mitigation solutions that can be applied by communities;

B. **Localization:** choose of the places exposed to the floods as proximity of river beds and slopes, most of the schools are not defined evacuation routes. Many structures are built under trees which increase the construction vulnerability.

C. **The needs to strengthen and stabilize pau-a-pique walls** throught horizontal and vertical braces and improve the depth of foundations. Appropriate wall finish in order to delay the effect or water on the structure.

D. **The necessity of revision of moorings between the elements in the coverage zone**: (i) wall-trusses (ii) trusses-purlins (iii) purlins-roof;

E. **Lack of scaling trusses elements and appropriate mooring between them if there are overloads above the roof;**

F. **Lack of appropriate sizing of the purlins and excessive spacing between them;**

G. **Quality of covering material:** corrugated roofing type and IBR have an inadequate thickness (0.3 mm) to withstand overload in case is used as a refuge-emergence location;

H. **Lack of protection on doo rand windows.** There is not a priority compared to other needs, lifting and stabilizing structure to protect doors and windows may delay the effect of water on the interior classrooms.

Figure 7 – Classroom in built mixed material affected (left side) and level of inundation in Chókwè District.

Recurrent Failures to Earthquakes

Summary of observations in areas prone to earthquake in Conventional Materials Classrooms

A. **The conventional Project-type of EP are not clearly adapted for earthquake zones;**

B. **Localization:** should prevent the potential dangers in the choice of land for construction of schools in areas prone to earthquakes, especially avoid steep areas, and should apply solutions taking into account the different types of soils.

C. **Fundation:** the foundations of conventional type can be improved and technically specified, to incorporate armed solid solleret in the foundations to improve the connection between pillars and resistance level of the foundation**.**

D. **Walls/Structure:** the conventional material type with a single floor use a structural confined masonry pillar system every 4 meters and reinforced concrete beams. This diaphragm possessed sufficient rigidity to resist earthquake with epicenter in Machaze (2006 7-7.5º Ricthter), yet the design and calculation of structures should be reviewed and evaluated taking into account potential of greater intensity earthquake scenarios.

E. **Gable Solution:** in schools with two waters roof the ribs without masonry gable is a potential danger to human life, and this construction element must be reviewed.

F. **Moorings in the region between the roof elements / bearing structure:** tie between the structure / wall and the rib can be enhanced by incorporation of specific technical details, to prevent movement of the cover in case of earthquakes

G. **Roof:** the majority of schools use slight roof sheet metal that is well executed and tied between its components and the wall, has had a good seismic performance.

H. **Openings:** when it is not reinforced there is evidence of vertical cracks in the area of the corners. May be proposed specific reinforcements for these areas in the project.

I. **Furniture:** inside the classroom don't have shelves on walls or other elements that can cause injury by fallen object in an earthquake. This can change in the future, with the incorporation of libraries or laboratory, it is recommended to include some guidelines in this regard in the catalog.

J. **In urban areas in necessary check the facing wall and existent around buildings which can affect students and damage school buildings.**

Summary of recurrent failures in case of Earthquake in Unconventional Materials Classrooms – Schools of brick masonry without reinforcements

A. **Shape:** the shape shows how the room is regular and simple, the ratio between the width and length (eg Ratio 1: 6.), subjected to large building horizontally twisting forces that might collapse the structure.

B. **Fundation**: lack of scaling foundation elements for effective transmission of horizontal loads.

C. **Structural Wall Damaged**: monolithic walls in brick masonry produced locally without reinforcements. Their existence of damaged walls with diagonal cracks, showing the inability of the structure to resist horizontal loads of the earthquake.

D. **Mixed Classrooms of Blocks and Stakes**: Discontinuities materials on walls constitute a great danger.

E. **Bad moorings between elements in the union between the truss-wall.**

F. **Masonry gable unreinforced highly vulnerable to fall down** for the cases observed in the field.

G. **Lack dimensioning of structure elements of the roof.**

Figure 8 – Classrooms damaged by earthquake

Important!

The evidence raised through the exposure of mapping work generates three important considerations:

a) First, each time schools are constructed in the above mentioned areas, increases the degree of disaster risk and therefore the potential impact with loss of human and / or material and economic resources lives;

b) Second, there is currently a large number of potentially exposed to natural hazards schools of different nature. It should therefore be thought of gradual way, to a retrofitting process or in the worst case, to an improved reconstruction after disasters.

c) Finally, it is estimated, in fact, that the next 30 years most of the population growth will occur in coastal areas, and therefore probably exposed to strong winds, storms and cyclones. Assuming that there is always a relationship between population density and the distribution of the school network, it is expected therefore the increase in the school network exposure to natural hazards, leading therefore to increase schools in areas at risk of natural disasters.

Against the impact of natural hazards on schools, it is urgent remedial action to reduce the risks on schools to build, from the more immediate construction campaigns.

It is important to recognize that the extent to which there is a lack of schools in conventional materials are built to bridge the deficit, a considerable number of infrastructure spontaneously by communities, sometimes through community fund-raising systems. Support, although limited technical guidance, will be useful in the construction of small infrastructure in place or mixed material. It is also necessary to recognize that a single type plan for conventional schools, cannot answer the diversity of climate and natural phenomena in the country.

All interviewed stakeholders agree that recurring failures of various natural hazards in school buildings in Mozambique, and the direct causes of weaknesses, but also the points of strength. Stakeholders, national and local, have agreed on a set of immediate measures that can be taken to mitigate the impact of these durable form threats. Among them, readability of projects for local builders, who are not always able to interpret technical specifications correctly.

A safer school, that is, to resist requests above normal as a result of a more rational design, will cost in the long run less than a school that has to be rebuilt whenever happen a severe natural event. Thus, building Safe Schools is not only a must for children and young people - the most vulnerable populations and capital for developing countries - but also an economic benefit. More precisely, the economic benefits projected in 500 rooms with measures designed into the original project are $ 1,535,000 Every 500 rooms. Whereas between late 2011 and early 2012, 1100 classrooms were destroyed, the benefit is considerable.

Reduce Disaster Risk in the school environment in a comprehensive way is the only way to build Resilient Schools, and safe in strictly infrastructural sense. That is, not only through a better constructive design of buildings but promoting integrated actions to reduce the day-day and civic awareness, based on the pillars above.

SECTION III

CONCLUSIVE FINDINGS AND RECOMMENDATIONS

"Safer Schools can minimize the interruption of activities related to education and also provide children spaces for learning and a healthy development.

Safer Schools can be centers for community activities and constitute crucial social infrastructure in the fight against poverty, illiteracy and a world free of diseases.

Safer Schools can be community centers to coordinate response and recovery efforts after a natural disaster occurrence.

Safer Schools can serve as emergency centers to not only protect the population using the school (teachers, students, etc.), but the whole community to which the school serves.

The construction of a safe school is on average only 8% more expensive than a conventional building. "

Finally, one of the important results achieved so far by the Safer Schools Project up until the conclusion of the present study has been the increasing awareness of the stakeholders and the establishment of consensus around six general findings that resulted from the organization of the National Seminars, meetings of the Technical Consultative Group, several formal consultations and field surveys.

Specific findings and consensus

First finding. There is an increasing exposure of the public school network to several types of hazards (Floods, Cyclones, Droughts, Earthquakes) resulting from the rapid expansion of the network, particularly in the last decade (~16,000 school network, assessment of 3 March 2014). The exposure will be further increased in the process of building new classrooms over the next years (The figure presented informally is between 30,000 and 40,000 among new classrooms and the ones replacing local material classrooms). More specifically:

- 73% of schools are exposed to high and medium recurrence of Droughts phenomena

- 67% of schools are exposed to high and medium recurrence of Cyclones
- 39% of schools are built in areas exposed to high and medium recurrence of Floods
- 72% of schools are exposed to high and medium probability of recurrence of Earthquakes of different intensities

The exposure could increase as a result of the changing climate (further reaching strong-winds and cyclones, floods and/or droughts). Studies in Mozambique seem to suggest this as a reality. However, no hard-data is currently available.

Second finding. The three typologies of classrooms (Conventional, Mixed, and Local Materials) diffused in Mozambique –and directly constructed with public works by the Ministry of Education and its partners– present a high sensitivity to adverse natural phenomena. Schools are therefore extremely vulnerable to the hazards, i.e. because of a poorly adapted and non hazard-sensitive technical design, inconsistent use of the materials, poor execution, inconsistent and non disaster-sensitive implantation and orientation of the buildings. Vulnerable infrastructural points for each typology of classrooms have being identified as a result of field assessment in approximately 1000 classrooms in the most disaster-prone provinces. This included schools already affected by a disaster as well as prone to disasters (likely to be partially or totally destroyed), and more resistant existing buildings. These typical infrastructural vulnerabilities result in damages with recurring patterns. The sample of school assessed in all districts is sufficiently representative to establish a credible risk assessment on future potential impact.

Third finding. Given the above recurring technical features sampled in (7) seven provinces, and recurring patterns of technical weaknesses, the risk of future impact in the schools of Mozambique is extremely high. In simple terms, every year a given number of schools will be partially or totally destroyed by strong-winds and floods of varying intensity as all typologies studied present the same technical, technological and constructive features. For instance, the project calculates that 6433 schools will be affected up to 80% of their structure against strong-winds in the coastal areas (Ref. Zoning): the roof, roof structure, gable roof and openings will be partially or totally destroyed.

Fourth finding. The technical failings and vulnerabilities are easy to address from a technical stand-point, and using technologies available in the Country, as Primary Schools in Mozambique are simple low buildings. Therefore:

1. Slight changes in the design, with potentially no additional costs, will mitigate the effect of the natural phenomena over the buildings.
2. A generalized better execution of works will further reduce the effect of these hazards, as many recurring mistakes observed in the execution of the works are clearly the cause

of the infrastructural failures. As this depends from the capacities of the constructors and the contract management, effort should be put in training constructors throughout the country in the execution of these simple works, simplifying to a maximum extent the project and the technical solutions through user-friendly materials; and finally to strengthening the mechanisms of oversight and contract management.

3. Basic additional technical solutions (measures) should be introduced to enhance the capacity of these buildings to withstand the varying intensities/magnitude of the recurring hazards, as studied by the project (Ref. to Hazard maps and Zoning maps)

Fifth finding. The current lack of a foreseeable and consistent maintenance policies or practices will represent degradation factor overtime, likely to increase the abovementioned risks. In other terms, the sensitivity of a number of schools will increase to hazards of even lower intensity as a result of deteriorating infrastructure. Therefore, a policy and practice of maintenance is as important as the improved construction of new schools. On the one hand, a policy of preventive maintenance should be immediately integrated in the yearly campaigns. On the other hand, almost always the affected schools are reconstructed with the same techniques –and sometimes very same materials. Finally, the schools that are at risk of destruction (as per risk assessment) should be the object of a programme of retrofitting. Realistically, though, the cost of a nation-wide retrofitting programme of the entire exposed network might be prohibitive. The constant maintenance is even more of essence, thus to mitigate the portion of risk related to infrastructure degradation. Seizing the recurrent disaster impacts as an opportunity to build back better is also a viable alternative: whenever a vulnerable school is affected, the building should be rebuilt applying the improved measures, as it is in use in Madagascar (60% damage = *ex-novo* reconstruction; 40% damage = improved partial reconstruction)

Sixth finding. The technical failings in the school buildings are directly and indirectly related to factors of normative, pragmatic, economic and of governance nature. The project encountered an extremely complex interplay of these issues that will not be sorted only by introducing improved technical measures. The problem of School vulnerability will be therefore sorted overtime if solutions are progressively applied in the short, medium and long-term. The first and most urgent need is to mitigate the impact of natural disasters in new schools, while laying the foundations for a lasting reduction of risks. Solutions must include a more robust interministerial/sectorial cooperation and synergies at national and decentralized level; a progressive revision of the building regulations, in order to develop and adopt a Building Code while adopting immediately applicable technical normalized standards; the progressive capacity-building of constructors, contractors and technicians; the progressive reinforcement of the oversight and contract management.

<u>Seventh finding.</u> Improving the technical, institutional, legal and supervision instruments alone will make little difference without improving capacities of the ones that execute the works in the field. The (lack of) capacities of Provincial, District and Local Contractors/Constructors has been singled-out by all informants as one single factor that causes poor execution and therefore increases the vulnerability of the buildings. A partnership amongst technical institutes, academic, public institutions and private sectors should be initiated through dissemination, qualification and training at all levels. The technical building capacities should be strengthened in the following target groups: (1) local small and medium builders for both technical as well as administrative capacity, (2) communities and local committees for technical capacity for self-construction, (3) NGOs, national and international technicians, (4) Experts and Technicians from the INGC, MOPHRH and MINEDH, and (5) engineers and technicians of private construction companies; (6) Faculties of Architecture and Civil Engineering

<u>Eight finding.</u> The supervision (commonly referred to as *Oversight*) of works is deficient as a result of logistic challenges, technical capacities available in the Districts, and contract administration. There is a large consensus and many of the Private Consulting Firms and Professional Associations indicate this as the most important contributing factor. **This essential aspect of the quality control should be strongly enhanced and a shift promoted towards the idea of contract management,** in which the institution or individual responsible for the oversight of the works would be responsible to train the contractors.

<u>Ninth finding.</u> There is today a stronger political, institutional and technical will in the Country for sorting the issue of School vulnerability. This will has generated overtime and was consolidated between 2011 and 2013 at the highest level. The Safer Schools Project itself, promoted by INGC, led by the MINEDH in cooperation with the MOPHRH and a number of other relevant national institutions, should be considered an indicator of this will. The interest in actively participating in the process of adopting measures to make Safer Schools in Mozambique was also demonstrated by the Private Sector.

<u>Tenth finding.</u> Although the primacy of conventional technologies and materials in public construction is legitimate and recognized, still 45% of classrooms in the Country are built with local or mixed material. In some provinces (Zambezia) the % is much higher. To the current pace of construction, the total replacement of mixed and local materials buildings with conventional buildings will take more than a decade. Meanwhile, every year, local material schools constructed by the Community with great effort and resources are destroyed. **Therefore, while the so–called 'precarious' buildings are replaced with conventional buildings, support should be given to communities for the construction of more resistant schools in local resistant material.** This does not need the Ministry of Education to engage in a community school project. More realistically, user-friendly construction manuals for non-engineered community schools should be developed and distributed widely in exposed communities of the Country. This could be done through the District Services of Public Works and Housing; through the Local Committees for Disaster Management and other services. Set of information, brochures, blueprints and plans for improved community construction could be disseminated. Video tutorials for step-by-step construction could be shared.

Eleventh finding. **Field surveys in disaster-affected schools, accumulated construction experience of the technical team in Mozambique, as well as global data, converge on that the costs involved in including resistant technical solutions to the original schools design is on average between 5% and 15% more expensive, while savings – both on direct and indirect costs – are enormous**.

Twelfth finding. **The low base of hazard data in the Country is an important challenge for the dimensioning of Cyclone Resistant and Earthquake Resistant buildings; the models for floods are also not sufficiently precise to consistently orient the site selection and the areas suitable for building. There is an urgent need to open specific lines of research in this crucial area of work.** Although Climate Change is extremely important, and donors have dedicated lines of action for it, resources should be found and channeled to develop scientifically reliable data on the current hazards. This should include a country-wide programme for measuring winds, a serious in-depth seismic assessment as well as micro-zoning of floods at least. The Team had to elaborate Maps for Zoning (the basis for structural calculation) working on the data available. The team had to extrapolate, along with the University, the necessary data for Cyclones from historic data. An operational evidence-based wind-map was produced. For earthquakes, information was cross-checked with studies in the region, and probabilistic methods applied. However, the map can be used for general purpose for simple buildings, but should be emended against a serious in-depth seismic and geologic study in the country. The flood information was derived from digital elevation models, and the existing models. The map is a good instrument for planning. However, for site-selection purposes, micro-assessments at Provincial and District level should be conducted in flood prone areas and disseminated in the District Services of Public Works and Housing. The maps for droughts were derived from existing vegetation models and other sources, and can be used as orientation for water harvesting provisions.
A list of recommendations was adopted, including the responsible institution and focal points at WS3 for monitoring and follow-up[2]. As this report is written, the Institutions are taking the platform forward.

[2] See report of Lessons Learned in Safer School Project.

Recomendações de Curto Prazo (~1 ano)

1. Mapping Hazards in Mozambique to create detailed maps of hazards, impacts and risks to schools and other public infrastructures, in a short-term in macro regions, but a medium and long term might be adapted to district and local levels. The Safer Schools Project is responsible for creating the School risk maps in the country, following this study.
2. Based on the above maps, categorize the existing hazards in Mozambique
3. Introduce a building techniques interim campaign 2013/2014, towards cyclones and strong winds in the construction of 1,000 classrooms through a demonstration of lessons developed by the Safer Schools Project, and monitoring / evaluation (NdR: The measures have been designed by the technical team to implement the safer schools project and adopted by MINEDH)
4. Train the SDPI, municipalities, DPECs, DOPH, and SDEJT, to guide the process of locating new schools based on district risk maps to be gradually developed.
5. Develop and adopt mandatory standards for conventional schools, to be collected in a catalog - including graphical information simplified to a broad understanding - to be quickly taken through effective legal instruments (for example, with Ministerial Diploma)
6. Elaborate adapted models in relation to the hazard zones and building material typology, including manuals and field guides (to be performed the Safer Schools project, UN-Habitat DIPECHO IV in partnership with MINEDH and MOPHRH).
7. Elaboration of project-type and simplified norms of non conventional material schools (communitarian schools), to support communities in the local or mist classroom more resistant construction and systematization of examples of communitarian schools that incorporate technical building measures of reinforcing and vulnerability reduction (to be performed the Safer Schools project, UN-Habitat DIPECHO IV in partnership with MINEDH and MOPHRH).
8. Create team of trainers on behalf of a partnership MOPHRH/MINEDH, defining the intervention levels, target group, for institutional staff building capacity intervening in the school building process at all levels (national, province and district), including the private sector.
9. Examine thoroughly the possibility of conferring mandate and training of the natural disaster management local committees and schools directories to amend and reinforce the schools before the cyclones and rainy seasons, and support the communities in the communitarian safer schools construction (INGC, MINEDH, and MOPHRH).
10. To launch a formulation and Public Polices approval process regarding Safer Schools in

Mozambique embracing the 4 pillars of vulnerability reduction towards natural phenomenon.

11. Promote and disseminate the use of POEMA in the general school building process.
12. Create an interministery team work on Schools construction, dedicating special attention to Disaster Risk reduction.
13. Adopt improved reconstruction measures (Building Back Better) whenever a school is affected by a natural event through a contingence budget inclusion.
14. Categorize schools by education level and type (MINEDH) including school construction manuals.
15. Support and follow up the activities began by MINEDH, with the support of UNICEF and other partners, in order to include DRR practices in the school curricula.

Medium Term Recommendations (1 to 3 years)

16. Establish an intersectorial/ministerial work platform, and harmonization of design, fiscalization, training and sensitization practices for safer schools leaded by MOPHRH, with the participation of at least MINEDH and MISAU.
17. Validate and legalize the recommendations about resistant school construction towards cyclones and strong winds, safer schools in case of floods and rainfall water profit best practices produced by the Safer Schools Project (1: Norms Catalogue; 2: Interim Measures; 3: Guidelines; 4 Hazard Maps and Country Zoning)
18. Produce sensitization DRR materials in Education to be distributed at National scale.
19. Continue with the identification o the national legislation aspects about construction that need to be adjusted to the country reality and promote the progressive adaptation of Codes based on international experiences.
20. Simplify progressively the graphic representation of the school's projects in order to facilitate it's interpretation by the local level constructor technicians.
21.
22. To adopt improved reconstruction measures (Building Back Better) whenever a school is affected by a natural event through a contingence budget inclusion.
23. To launch a national campaign of risks survey in each school building (16.000) based on checklist Guidance on Safer Schools and other instruments to set the vulnerability level and establish risk indices.

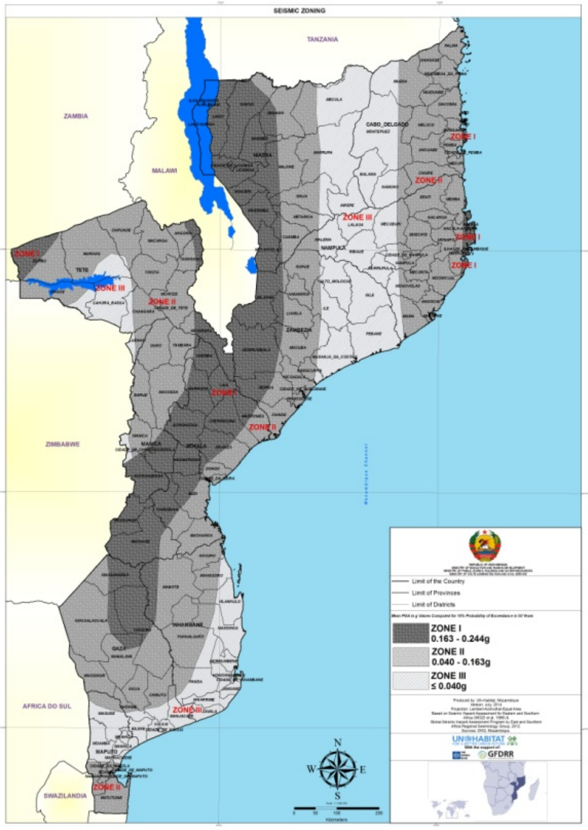
24. To carry out maintenance and retrofitting actions with the purpose of reducing the vulnerability of the existing school buildings.
25. To recognize the national professional organizations (Ordem and MOPHRH) in the accreditation of technicians and the civil construction companies.
26. To elaborate and approve consultant's categorization and qualification instruments for the elaboration of projects and State works fiscalization according to its complexity and hazard exposure.
27. To revise the minimum guarantee term of the works according to its localization and exposure, in order to include at least one natural hazards cycle, to test the works.
28. To produce and disseminate a support Guide to the preparation of contest documents to the school work.
29. Produzir e disseminar em todas as escolas do ensino básico de materiais de sensibilização sobre RRD na Educação a serem distribuídos à escala nacional, desenvolvidos de forma lúdica e simples, mas rigorosos no conteúdo.
30. To produce and disseminate DRR sensitization materials in Education in every basic education schools, to be distributed at national scale, in a simple and entrained manner, nevertheless rigorous in the content.

Recomendações de Longo Prazo (de 3 a 5 anos)

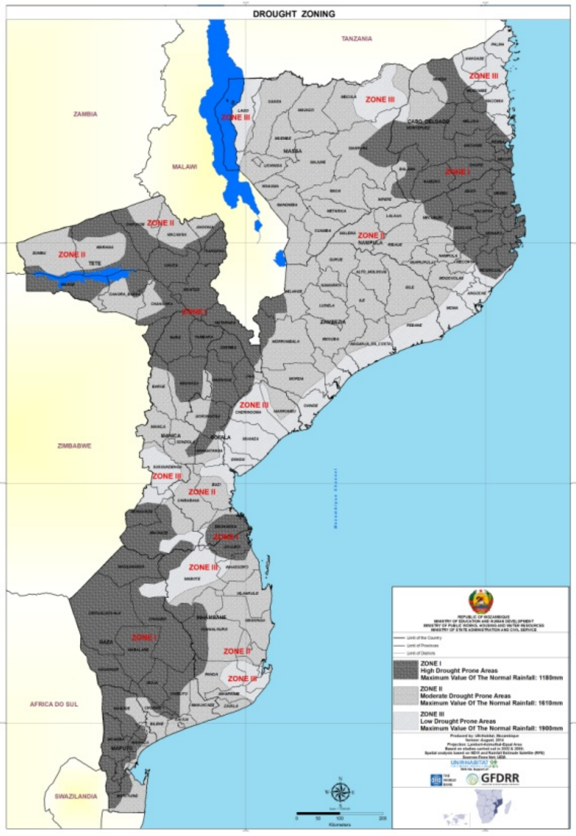
31. To conclude the elaboration process of Public Polices on Safer Schools in Mozambique, embracing the 3 vulnerability reduction pillars towards natural phenomenon.
32. To codify the construction through new construction through new Building Codes, with a particular attention at risks.
33. To continue a preventive classrooms maintenance.
34. To introduce DRR subjects and modules in the Superior Education Institutes and Medium Technique curriculum, in particular to the engineering and architecture areas.
35. To elaborate and approve the consultant’s qualification and categorization instruments for the elaboration and fiscalization of State works according to its complexity and exposition towards natural hazards.
36. Orientar iniciativas para construção de escolas de outros intervenientes que não seja o Estado.
37. To guide the school construction initiatives from another intervenient apart from the state.

In conclusion, it is worth outlining two urgent activities to be carried out in the short term, with a long-term impact:

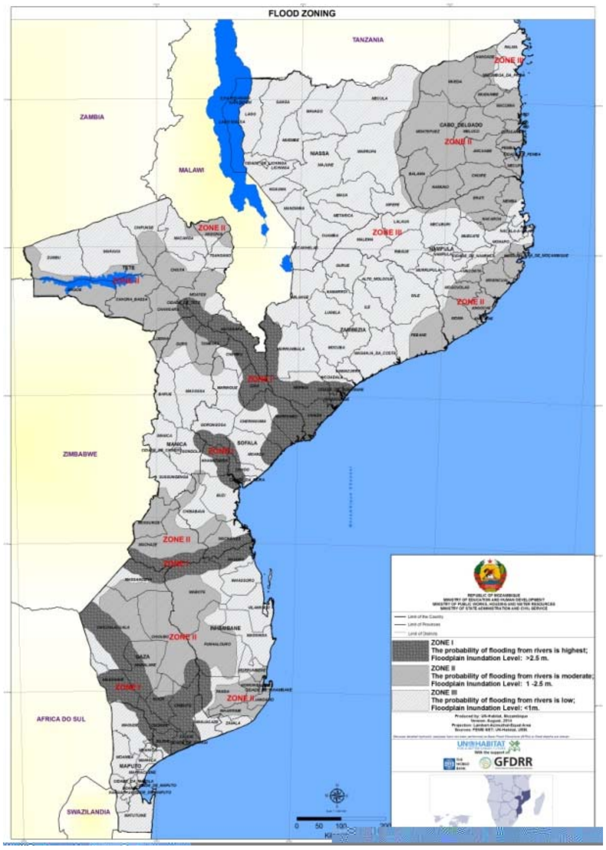
1. First, improve the categorization and zoning of threats in the country, by level of intensity and frequency. Therefore, it takes more details as possible, not least for the front structural calculations to earthquakes as seismic acceleration and extreme and normal winds in case of cyclones. At present, the project Safe Schools is in the process of categorizing and zoning the country for the four mentioned threats (cyclones, floods, earthquakes and droughts), along with the different technical partners of the project implementation, so that such maps can be used to guide the construction in locations exposed to threats or retrofitting process, for example:

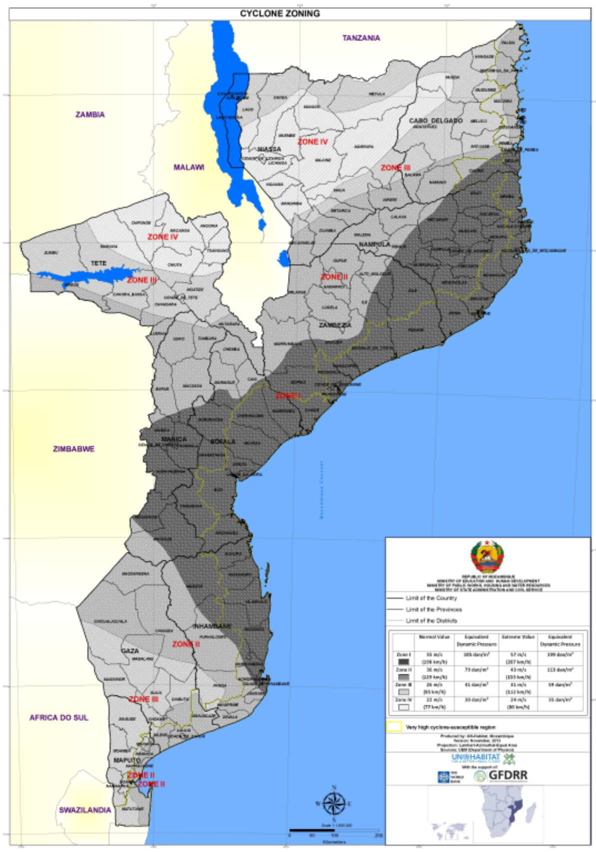


Map 2 – Earthquake Zoning Map



Map 3 – Drought Zoning Map

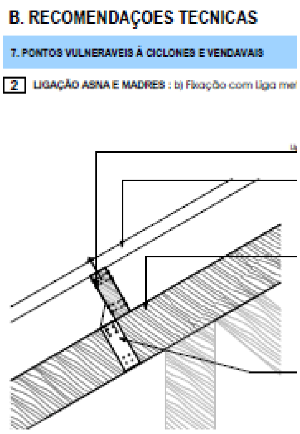


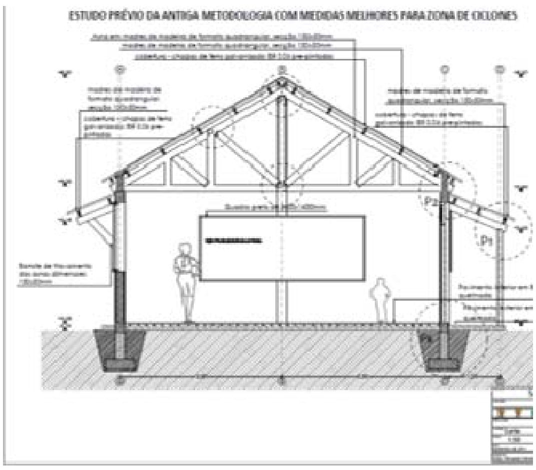


Map 4 – Floods Zoning Map

Map 5 – Cyclone Zoning Map

Associated with the above maps, develop a set of rules and technical measures to be urgently implemented in the construction of new schools and, if possible, in the strengthening of existing schools or in case of impact. The Safer Schools project developed a set of anticyclone rules that will be applied in the 2014 construction season such as the ones illustrated in the images below. These measures should now be extended to four hazards and, if possible, made binding by means of decrees or ministerial orders, for example:





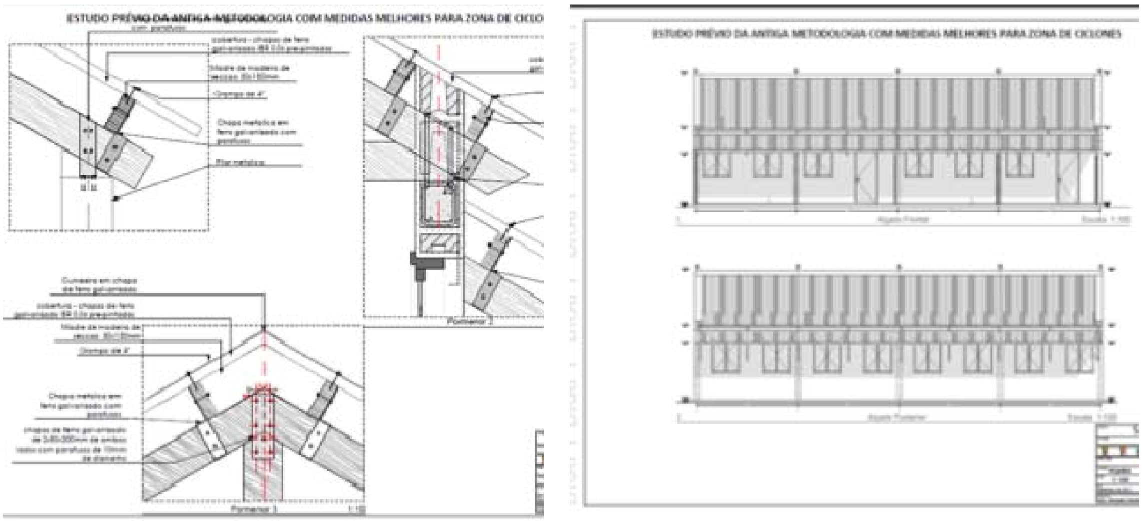


Figure 9 – examples of technical measures prepared within Safer Schools Project to built school more resistant to cyclones and strong winds

SECTION IV

GUIDELINES FOR SAFER SCHOOLS IN MOZAMBIQUE

The exposition of nearly 72% of schools to risk of results in a high impact probability and destruction of school buildings in Mozambique.

Therefore, it requires a high attention in the proper construction of school buildings. This should be based on knowledge and mapping of hazards for each region and their possible impact; in the school adequate location and its proper implementation; in the anti-cyclonic anti-seismic and flood resistant dimensioning or provisions for rainy water collection (in the case of drought), depending on the exposure.

Finally, it should be base in the cooperation of every State and Society sectors to reduce in a lasting manner the disaster risks in these critical infrastructures within all School environment.

Despite the recurrent schools destruction scenario by natural hazards, it was found during the assessment the existence of promising experiences of school buildings in the adaptation context that can be used as study baselines. Bellow, some of the experiences that seek to respond to adaptation aspects face to natural hazards as following:

- To incorporate the adequate security factors to avoid a likely catastrophic scenario:
- To apply security Coefficients- redundant structure:
- To integrate costs analysis- measures benefits to not disturb the construction rhythm in the country;

  The possibility of acting in a large scale by the simple execution capacity. Such fact must be taken into account in the measures adoptions for Mozambique in an immediate manner, considering the local technicians capacity.

Figure 10 – EP1 Esperança Berta Sove (Chibabava District) built above a platarform

Figure 11 – School done with Old Methodology Design e rebuilt with measures for estrong winds

Figure 12 – School with metalic structure roof (EPC 25 de Junho – Caia District)

Figure 13 – School resistant to strong winds in Chinde District, Zambezia Province. Structure reinforced with "diagonais"

Figure 14 – Connections reinforced with local materials

Figure 15 – Elevated School of Maniquenique in Chibuto District, Gaza Province

The Guide for Safer School defines four main principles:

a) Ensure the safety of children and school users;

b) Minimize disruption of activities related to education;

c) To serve as community centers to coordinate response and recovery efforts after the occurrence of a natural disaster;

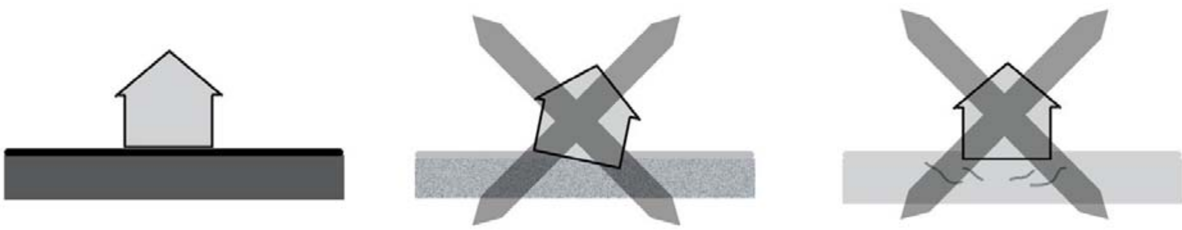
d) To serve as emergency centers to not only protect the population using the school (teachers, students, etc.), but the whole community to which the school serves.

Among others, the methodology of "Child Friendly School", developed by UNICEF, provides some basic principles. First, regardless of exposure to natural hazards, the principles of good ventilation and good lighting should be privileged. Often, however, certain principles can contrast with the anti-cyclonic design, as in the case of school orientation that favors the reduction of heat due to sunlight, but sometimes in contrast to the prevailing winds in an area.

General Guidelines for Building Safer Schools

I. Find the school away from land susceptible to landslides induced by earthquakes and rains

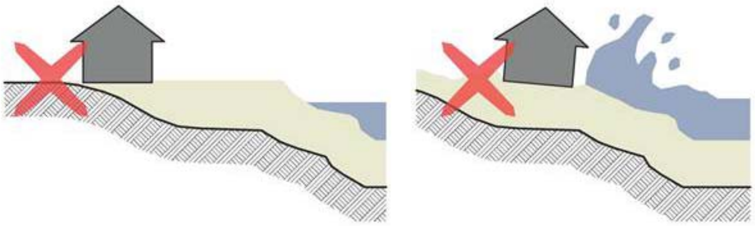
II. Choose land located in areas with firm subsoil. Sub-poor soils are susceptible to liquefaction of the soil, which is a phenomenon that occurs when solid soil pressure assume a molten state thereby causing the movement on the ground, but may damage foundations and even cause collapse of the foundation and the construction of the building.



III. Deploy buildings away from trees or set of trees. Natural locks winds as trees can reduce the exposure of buildings to the winds, but however, great care must be taken because these (natural locks) may be a risk to buildings, in case of falling they damage the buildings, hence it is recommended that buildings are located away from trees and / or set of trees.

IV. Keep away from each other constructions. The buildings should be located apart from each other to avoid that when one of them falls, thereby destroying each other.

V. In areas prone to tsunami, select the location in elevation above the maximum wave height potential. In areas prone to tsunamis is advisable that the school will be located on a hillside above the maximum of the wave height potential.



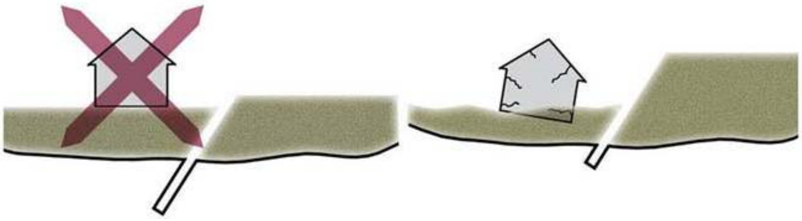
VI. Identify potential evacuation routes and access routes for emergency services. It is extremely important to be identified near the school the site, safe means and without obstruction, so those in cases of emergency serve as a route of access and evacuation.

VII. Consider the proximity of structures in surrounding areas that can serve as shelter for displaced persons in case of emergency.

Earthquake

I. <u>Considerations on Localization of the Buildings:</u>

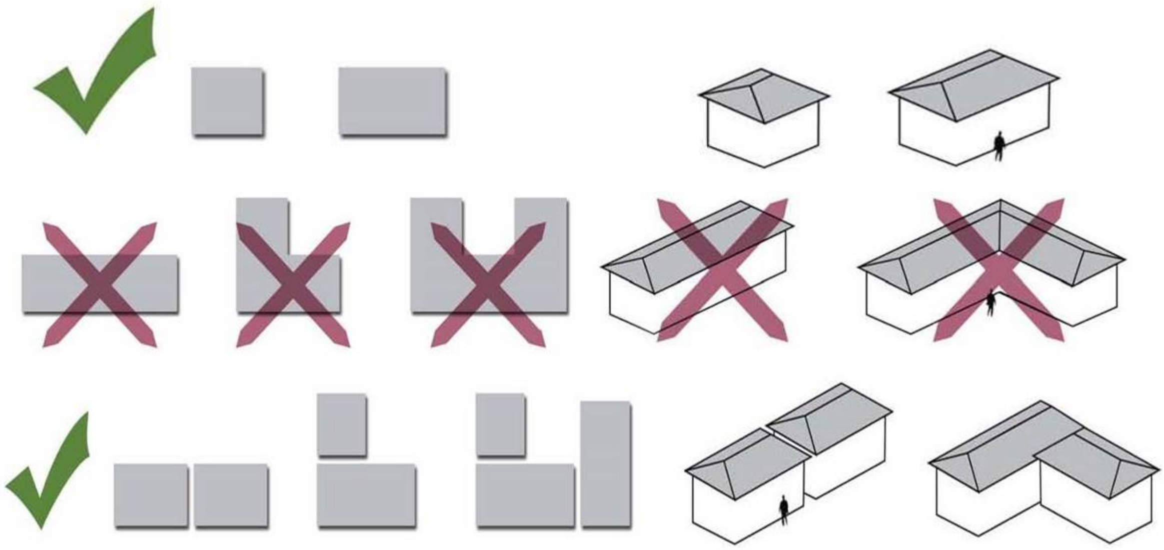
a) Locate the school as much far as possible from geological faults of known earthquakes.



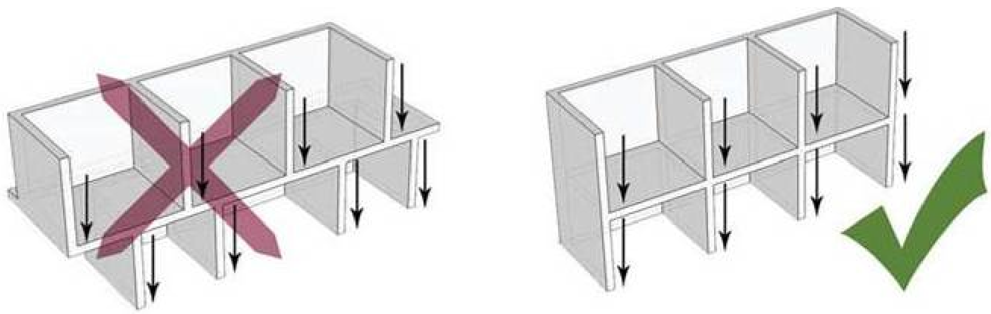
b) Choose the place where the soil water level is very low from the foundation level.

II. <u>Considerations on the Project (design) and the construction:</u>

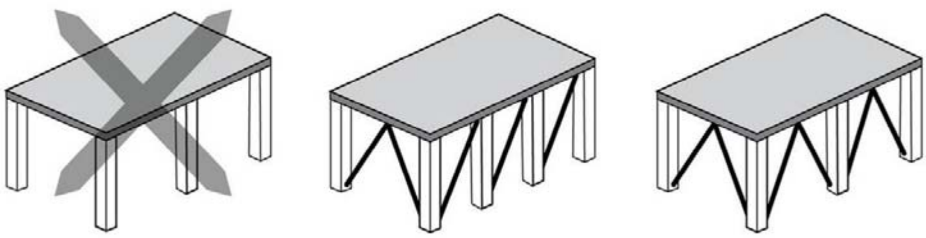
a) Project the building in a symmetric manner and uniformly dispose the spacing over the building plane.



b) Construction project must be vertically regular in relation to the lateral stiffness and weight distribution.



c) Make sure that all the structural elements are well connected.



d) Project and construct to withstand to electric discharges from every direction.

III. <u>Construction of walls and lateral closings:</u>

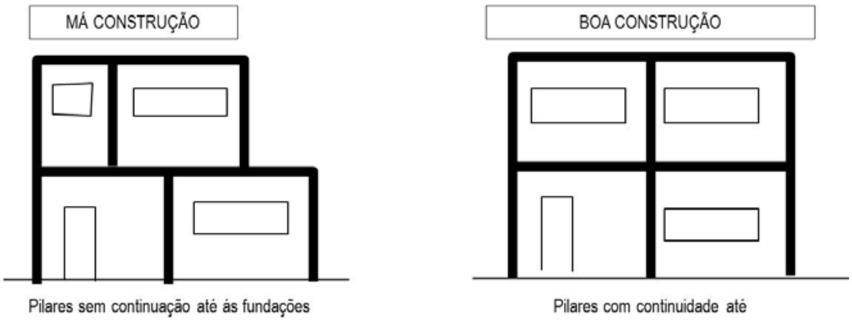
a) To make sure the load over the diaphragm is well transferred to ensure that the load on diaphragm is correctly transferred to the supporting walls, it must be rigid and act like the only element that must be firmly grounded to the walls..

b) Minimize the opennings in the wall construction.

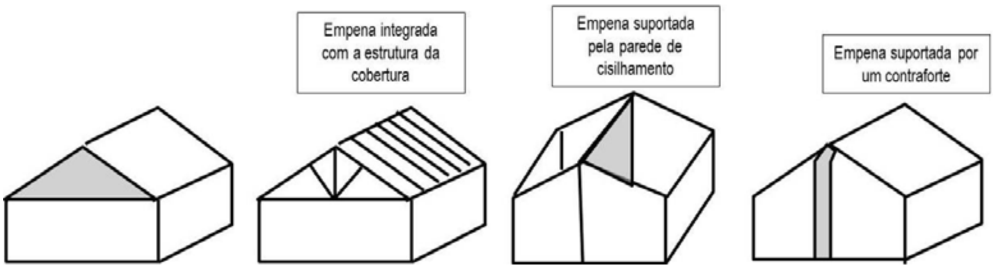
IV. <u>Construction of the Structure:</u>

a) To allow the the expansion between the structural columns and the swelling walls.

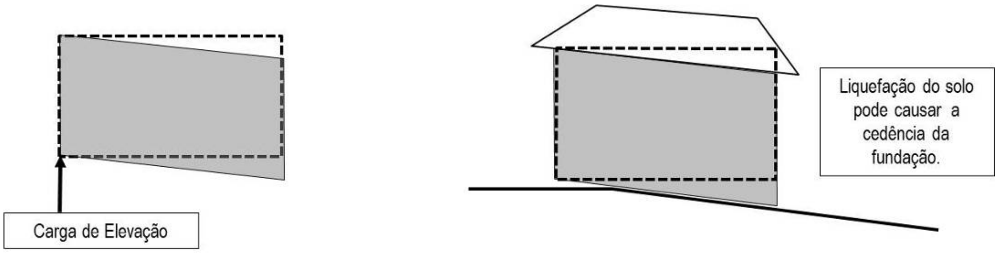
b) To project all the elements to transfer load directly to the ground.



c) Gables must be fixed up to its total height.



d) To project to resist to elevation discharges.



V. <u>Precautions for Non tructural components:</u>

a) To steadily annex the external construction elements to the non structural elements.

b) To hold the non structural internal elements of the building into the structural elements

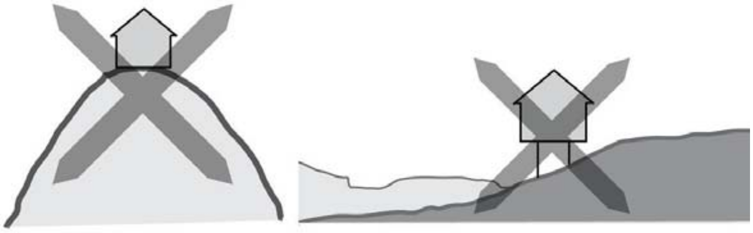
c) Secure furniture and other equipment that can cause damages, injury or loss.

d) Design the stairs so that will withstand to earthquake loads

Cyclones

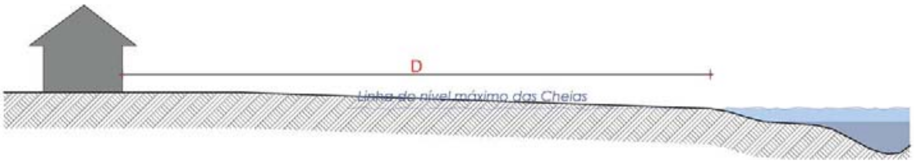
I. Consideration about the place and modifications

a) To not locate the building in areas potentially exposed to the event.

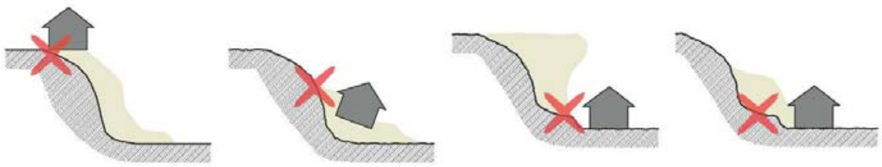


b) Reduce the proximity of the potentially dangerous structures and potentially harmful residues

c) To select the place with high elevation rather than places with high inundation levels from previous storms.

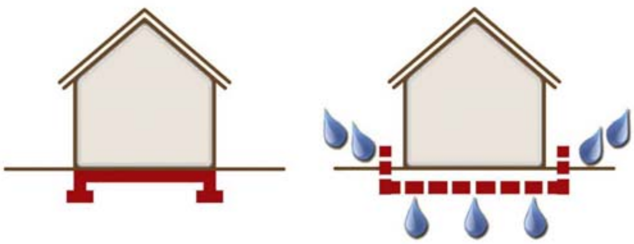


d) To consider the selection criteria of the place towards another identified dangers, such as landslides and earthquakes.

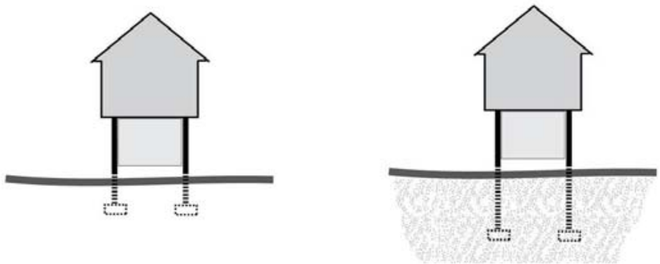


II. Design and Construction

a) To implement a strong anchorage due and waterproof so that the building can withstand to the elevation load.



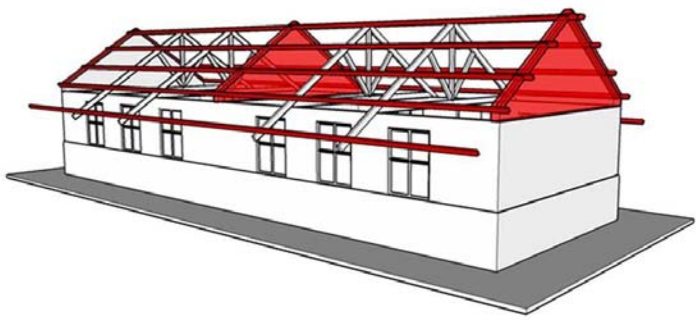
b) To implement the foundation in a adequate foundation, to withstand erosion from potential storms.



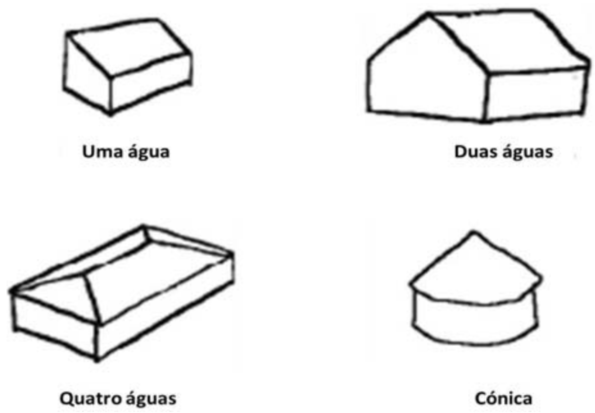
c) Make sure that the structural elements are well connected and steadily anchored to the foundation.

d) To project all the elements in order to transfer the loads directly to the ground.

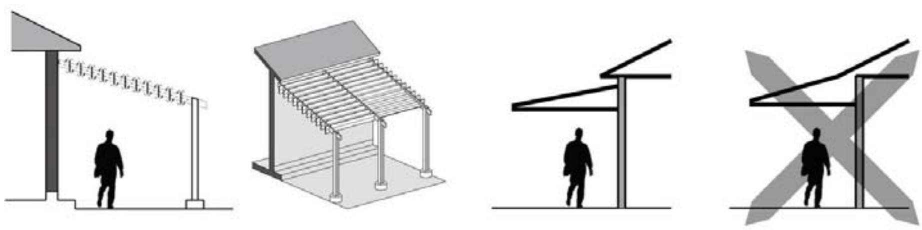
e) To reinforce the junctions where the roof structure finds walls and where the different roof surfaces meet.



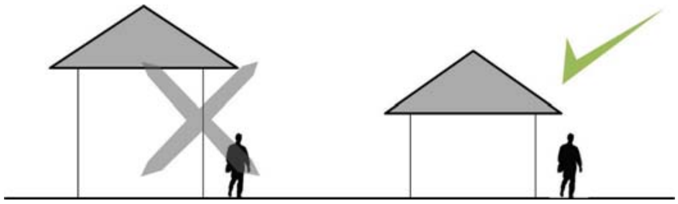
f) To implement wind resistant shape and roof structure.



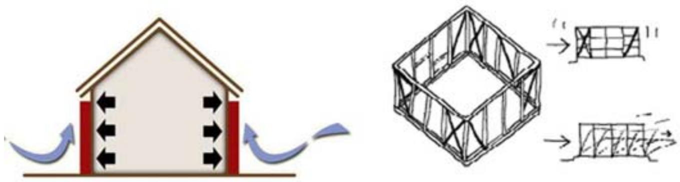
g) To avoid large *beiras* of the roof.



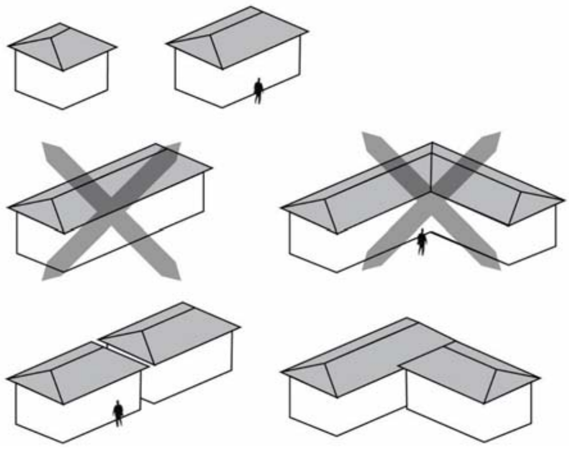
h) Minimize the total height of the building.



i) To reinforce the corners, edges of every side of building, mainly the surfaces with higher contact with the wind.

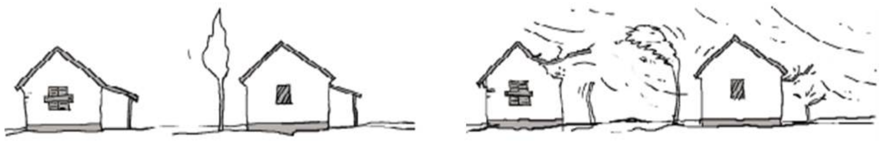


j) To minimize the external surface roughness.



k) To minimize the openings in the wall construction.

l) Verandas and other transitional spaces should not have their roof structures as main roof 's extensions but yes structurally independents.

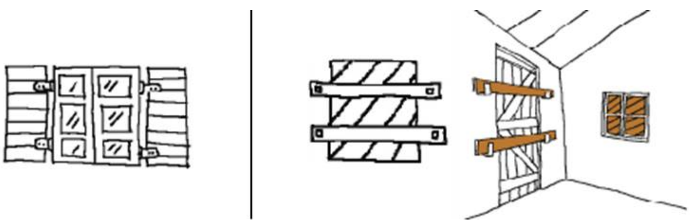


III. <u>Precautions for Non Structural components of other Instalations</u>

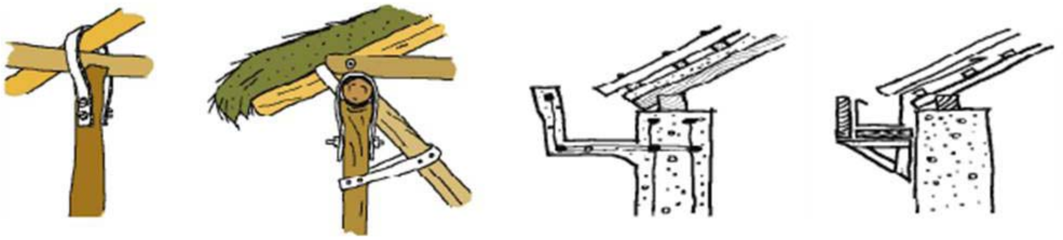
a) To Guarantee that the building warping is well stuck to the structure

b) The building warping must be designed in a such a way that can withstand wind debris damages.

c) To design doors and windows to withstand wind loads.



d) Hoops, supporters and/or internal components annexion



e) Tie to the ground any exterior equipment auxiliary structures that may be damaged our cause damages.

Floods

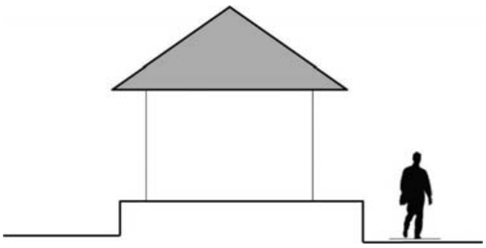
I. <u>Considerations on localization and modification</u>

a) To select the elevation place above the expected inundation level.

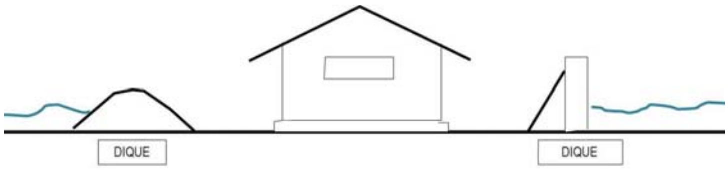
b) To evaluate the drainage systems and select the place with better drainage potentiality.

c) Select the place with natural erosion obstructions such as trees and land cover.

d) To add land to fill and raise the place above the expected inundation level.



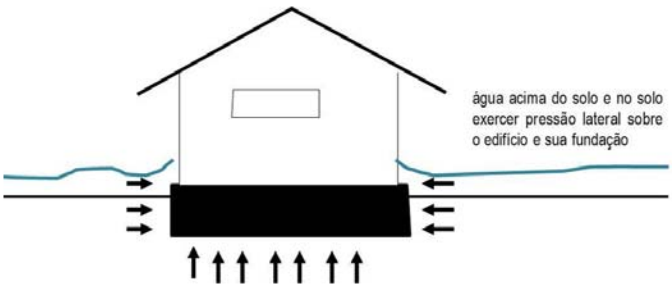
e) To create barriers full of clay or concrete in the place or inundation source.



II. <u>Design and Construction</u>

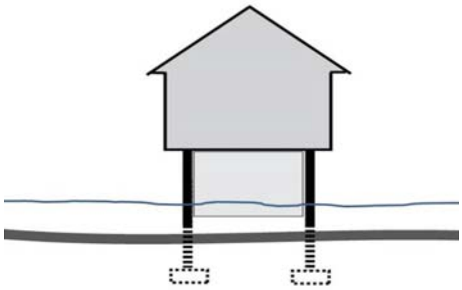
a) To guarantee that all the construction elements are steadily tangled and anchored to the foundation.

b) To design and construct or reshape the construction with components to withstand lateral loads.



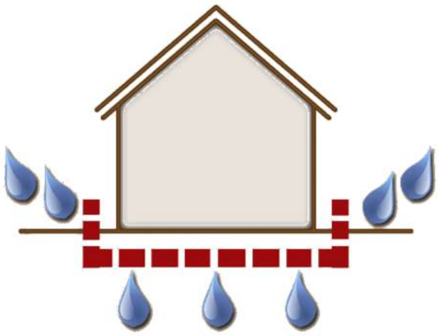
c) If the expected inundation level reaches the building foundation, the foundation must be filled up or designed with openings in the base to equilibrate the internal and external water pressure.

d) To project and construct shearing walls, pillars or fill with land to elevate the building.



e) To create a water proof building.

f) Maximize the use of water proof construction materials (turn the building humidity proof)



g) Construct buildings that rapidly drain water.

III. Precautions for Non Structural Components and other installations

h) Install electronic systems, mechanical and hydraulic, and any other valuable equipment above the expected inundation level.

i) Make sure that sanitary school installations are located above the expected inundation level and prop *ajusante* bellow the school installations.

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