Politecnico di Torino
Master's degree programme in
ARCHITECTURE FOR SUSTAINABILITY

Master's degree thesis in

Social and Technological Innovation Through Design, in Contexts of Economic, Environmental and Political Scarcity:

A Design Tool for Risk Reduction in Learning Facilities:
Earthquake and Tropical Storm Prone Areas

Supervisor:
Prof. Francesca De Filippi

Co-supervisors:
Valeria Federighi
Roberto Pennacchio

External Collaborator:
Michele Di Marco(EAHR)

Students:

Andrea Matevska
Jana Tosheva

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A debt of gratitude is also oved to Michele Di Marco, currently coordinator of the World Health Organization Technical Science for Health Network (Téchne) who during our thesis was a a co-founder of Emergency Architecture and Human Rights, and supported and supervised all the research and development of the design tools and the thesis itself.
Last but not least, we would like to thank our parents, without them none of this would be indeed possible.

Abstract

This research thesis seeks to provide a tool that could be affectively used when building educational structures in vulnerable areas affected by multiple hazards around the globe. The first chapter introduces the reader to the topic of natural hazards, their impact and the key terminology with a deeper outlook on the deadliest global hazards in the past 20 years – earthquakes and storms. The following chapter was done in a collaboration with our colleagues, Juan Benavides and Erika Cerra, in which a tool was developed in order to assist NGOs (Non-governmental organisations) or CBOs (Community-based organizations) in choosing the most adequate building components with respect to the specific site characteristics, climate and hazard/s affecting the area where a school is needed, maximizing the participation and use of the community's capacity. The hazards developed by the authors in the matrix tool are earthquakes, floods, cyclones and diseases. Finally, in the third chapter, the tool is applied in one of the most multi hazard prone and vulnerable countries – Haiti. This thesis was done as a collaboration between Jana Tosheva and Andrea Matevska.

Preface

This thesis was developed in large as a collaboration between four postgraduate students (Benavides Juan, Cerra Erika, Matevska Andrea and Tosheva Jana) as a matter of both individual and group work. The development of this thesis is thanks to EAHR (Emergency Architecture and Human Rights), a non-profit organisation based in Copenhagen, Denmark. The team of EAHR provide consultancy around the world, as well as creating educating frameworks, conducting research and hosting a range of workshops on architecture in humanitarian emergencies in universities around the world.

"EAHR believe that Architecture is a Human Right."

Methodology

The primary aim of this thesis was to examine the nature of schools in hazard prone areas and to explore hazards and the factors which impacted upon the construction performance as well as interaction with the communities.

While we entered the research context with a clear framework for investigation based on a global level, the research was not focused on testing of any hypothesis or theory in terms of efficiency of different guidelines for hazard resilient buildings which were used as a starting point for the development of our tool – The matrix.

The initial purpose of this tool was to reveal and describe the possible solutions for a hazard safe classroom, in order to gain greater understanding for the site characteristics, local materials as well as building techniques which can be used by the communities.

Chapter 1

Natural Hazards

This chapter encompasses the various natural hazards that have had great impact in forming today's environment and society. In order to understand the gravity and people affected by each hazard we take a look at the global observation of hazard driven disasters over the last 20 years.

1.1 Natural Hazards
1.1.2 Defining the problem of natural hazards

Before going into detail on explaining the various natural hazards that have affected the environment and society since the beginnings of time, it would be best to define some key vocabulary regarding their classification and societal impact. Firstly, the term hazard is defined by the UNDRR as a process, phenomenon or human activity that may cause loss of life, injury or other health impacts, property damage, social and economic disruption or environmental degradation. A natural hazard does not include the human activity aspect of the definition, phenomena like war, pollution, and chemical contamination. In the literature available there are many different, though generally similar, classifications of natural hazard classification, depending on the source. One such classification is defined by the *Sendai Framework for Disaster Risk Reduction 2015-2030* where natural hazards are classified as:

- **Biological hazards:** These hazards are of organic or vector-conveyed origin, such as bacteria, parasites, viruses and venomous or disease causing agents carried by plants, wildlife and insects

- **Environmental hazards:** More accurately defined as risk and hazard drivers, rather than hazards, they may lead to disaster as a result of environmental degradation and air, water and/or soil pollution

- **Geological or geophysical:** Processes within the internal earth composition are the origin of these hazards. Very often, combined with hydrometeorological events they can trigger land, rockslides and debris or mud flows

- **Hydrometeorological:** These hazards can be of atmospheric, hydrological or oceanographic origin and may also be a factor in other hazards such as landslides when combined with geological hazards, or epidemics when combined with biological ones

- **Climatological:** In the case of an unusual fluctuation of a given climate factor, for example lack of precipitation or extreme heat or cold waves are a hazard that may cause a disaster

When a hazard strikes in a particular place during a particular time period it manifests as a hazardous event. Depending on the severity of the event, interacting with a combination of other risk factors (e.g. exposure, vulnerability) , a hazardous event may lead to a disaster, thus causing human, economic, material and/or environmental impacts and losses. Disasters happen when the hazardous event leads to a significant disruption in the daily life of a community, or more broadly, society. Even though the knowledge on this complex issue is increasing, so are the losses from catastrophes caused by natural hazards. Natural hazards may and often do cause disasters and their impact does not solely depend on the hazard intensity, since a major factor is defined by the vulnerability and coping capacity of the both people and society as a whole affected. The classification of the hazards is not an

exact science since some hazards, such as landslides, appear in two categories in table 1. This is due to the fact that most landslides are a product of both geological and hydrometeorological hazards. Such is the case with tsunamis as well, because although being caused by under-water earthquakes, they manifest as a water-related disaster.

Table 1: Hazard classification (EM-DAT) and expanded by thesis authors

Hazard	**Disaster**
Biological	*Epidemic, Insect infestation*
Environmental	*Soil degradation, Sea level rise, Deforestation*
Geological	*Earthquake, Landslide, Volcanic activity*
Hydrometeorological	*Flood, Storm, Landslide, Extreme temperature*
Climatological	*Drought, Wildfire, Extreme temperature*

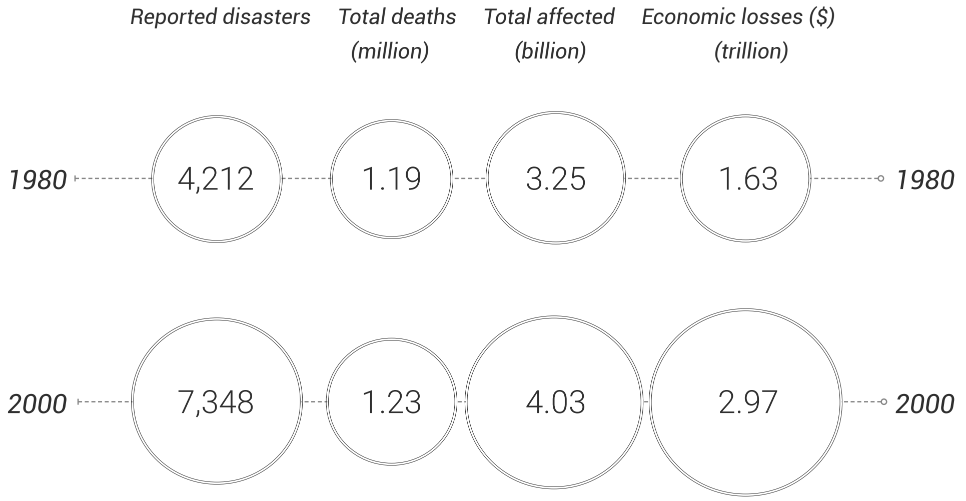
In most areas the exposure to a single hazard is not isolated. In many localizations multiple hazards can occur simultaneously or cumulatively, with interrelationships between the ones that impact a specific location during the same timeframe. In this research, the main focus are areas that are subjected to multi-hazard. Multi-hazards comprehension has some challenges like fragmentation of literature in the field (a variety of terms are used to define hazard interrelationships like multi, cascade, compound, interaction), gaps in the approaches taken by different institutions (e.g., single hazards archived without considering interrelationships with other related hazards) and the complexity of multi-hazard events combined with the different approaches experts can take in understanding them. The impact of a disaster varies and is determined by factors that can be of different nature:

- **Physical factors:** poor design and construction of buildings and unregulated, unplanned land use, rapid urbanisation
- **Social factors:** poverty, inequality, marginalisation, social exclusion and discrimination by gender, social status, disability and age (children or elderly)
- **Economic factors:** vulnerable livelihoods, the uncertainty of the informal sector that accounts for the majority of jobs in developing countries, dependence on single industries, globalisation of supply chains
- **Environmental factors:** overconsumption of natural resources, climate change

These conditions all increase or decrease the susceptibility of an individual, a community or an asset to the impacts of hazards, thus describing their vulnerability. Individuals, communities and assets can all be vulnerable to the impact of hazards, albeit in different ways. The coping capacity represents the people or community's capability to manage disasters. In order to cope, a community needs to possess constant awareness, enough resources and good management, not only in emergency times, but in normal conditions as well. Through a combination of strengths (social relationships, leadership and proper management) and resources (infrastructure, institutions, human knowledge) available a community has the relative capacity to reduce disaster risks and build up resilience. The hazard impact possibility, together with the probable consequences on the community and assets describes the risk factor. The level of risk is shaped by the increasing level of vulnerability and hazard exposure and the decrease of coping capacity.

1.1.3 A global observation

Hazards only become disasters when human lives are lost, and livelihoods damaged or destroyed. Increases in the global population, particularly in areas of high hazard risk raises the level of the risk of disasters as more people are exposed to the potential harms of hazards. (CRED, UNDRR, EM-DAT. 2020)



<Figure 1.

Disaster impacts between 1980-1999 and 2000-2019

The human cost of disasters: an overview of the last 20 years (2000-2019). CRED, EM-DAT, UNDRR.

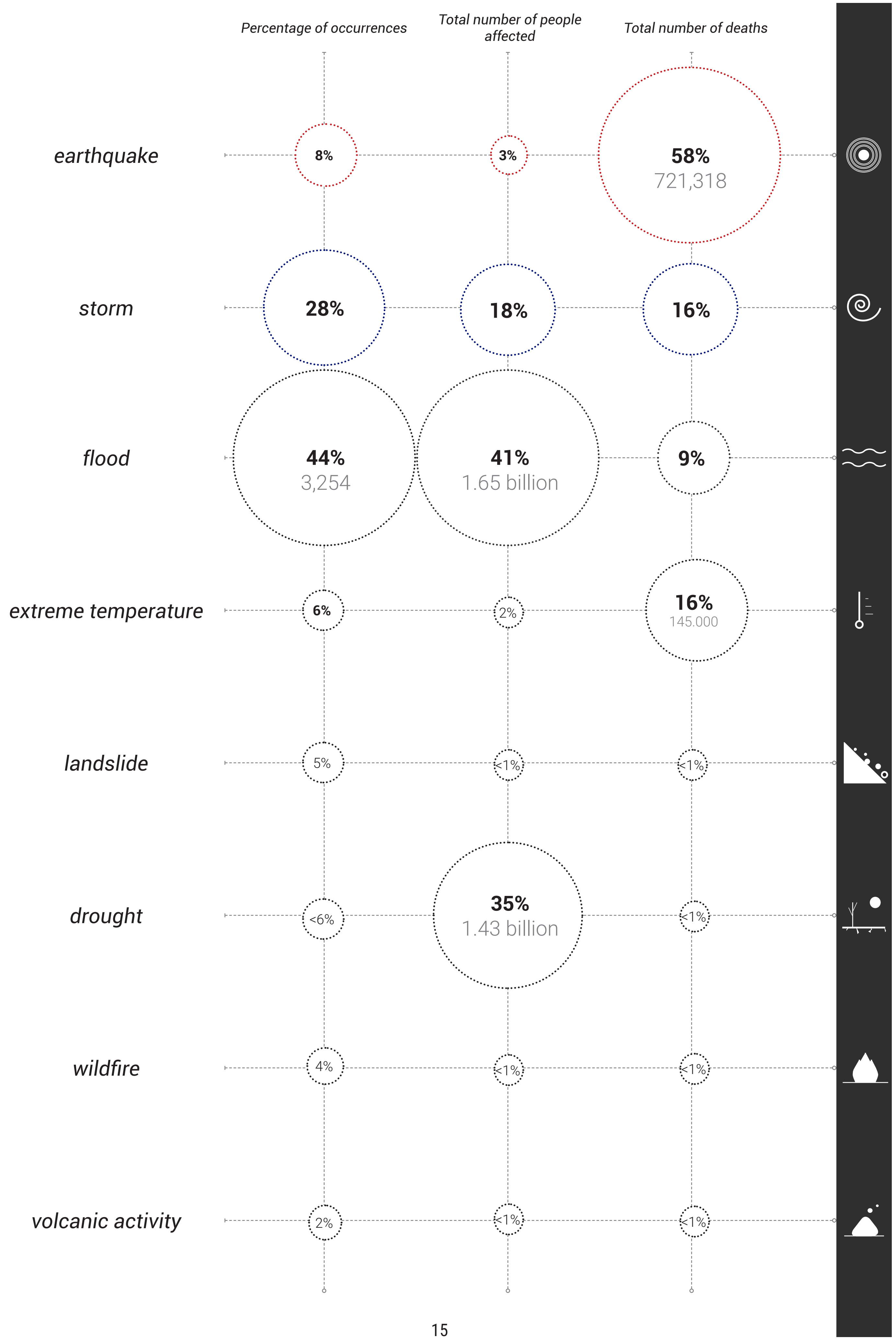
Illustrated above in Figure 1 are the recorded disasters caused by natural hazards (Biological hazards are excluded) in the span between 2000-2019 which claimed an average of 60.000 human lives annually along with the total affected population and economic losses. In comparison with the previous years (1980-1999) a sharp increase is evident which can be, in part, explained with the better recording and reporting nowadays. However, a major role in the increase is played by climate change, since the increase is mostly in climate-related disasters. In contrast with the decrease of mortality, the affected population (including injuries and livelihood disruptions) and associated economic damage are growing.

Floods account for almost half of the disasters that occurred in the last 20 years. They are the most common hazardous event, with 163 events per year, on average. Their impact is biggest in Asia, with 1.5 million affected around the continent, however Africa and South America experience a large share of flooding events as well. Flood impacts are one of the hazards that are most affordable to manage, by building mechanisms of prevention like dams and drainage systems. Asia is also the most affected continent regarding **storms**, the second deadliest hazard in the 2000-2019 period. Due to climate change, many areas globally are expected to experience an increase of flooding and storm events. The population that needs to be protected is expected to increase as well, given the general increase in population in disaster-prone areas. **Earthquakes**, unlike the hydrometeorological hazards that are relatively seasonal, have a more uneven impact. They represent only 8% by occurrence, but 58% of the total number of deaths caused by hazard impact.

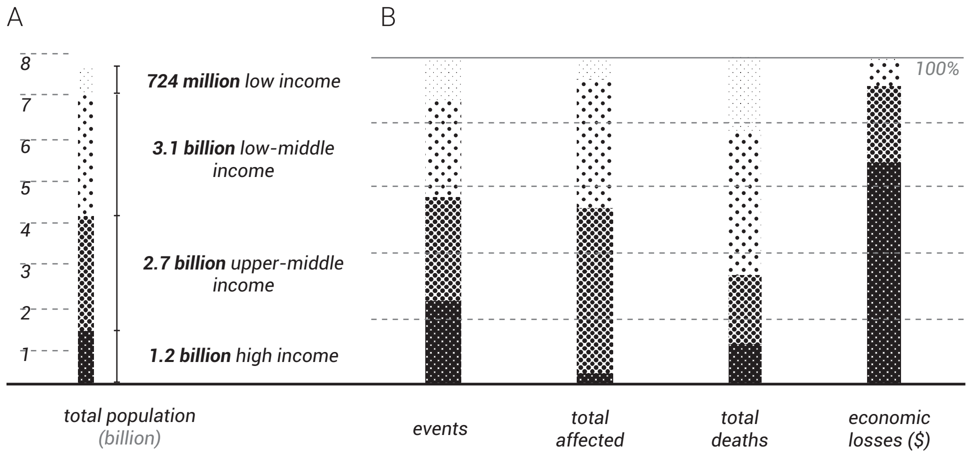
Figure 2>

Occurence, people affected and deaths from natural hazards between 2000-2019

The human cost of disasters: an overview of the last 20 years (2000-2019). CRED, EM-DAT, UNDRR.



Earthquakes cause huge damages to infrastructure, which underlines the importance of updated building codes in zones where there is the possibility of a seismic event, based on fault lines vicinity and historical data. On the other hand, **droughts** directly accounts for 2% of global deaths since the significant indirect impacts caused by droughts are poorly documented. Displacement, malnutrition and disease may all be outcomes of droughts. Africa is most affected by this hazard, some of which can last years and significantly affect agricultural and livestock based livelihoods, water shortages and epidemic outbreaks.
When grouping together nations by income level, there is a notable distinction in impacts from hazardous events. The disaster events distribution is evenly distributed across different income groups, in contrast to the distribution of deaths, affected people and economic damage which varies across different income groups. Lower-middle and upper-middle income countries make up the majority of countries worldwide, so the fact that majority of events, deaths and affected people happens in these areas is coherent. Low-income countries suffer the highest death toll per disaster, but report limited economic damages. High-income countries, rather, suffer from larger economic losses, but less people are affected. Reduced exposure, better infrastructure and DRR (Disaster Risk Resilience) are one of the main factors of the improved protection the population of higher income level countries benefits from.



<Figure 3A
Global population distribution by income group (millions)

>Figure 3B
Proportion of various impact types on countries by income group

A **mega-disaster** is a hazardous events that kills over 100.000 people. They can impact the overall statistics, such as the high death toll of earthquakes, as seen in Figure 2. In the past twenty years, three mega disasters occurred: the Indian Ocean Tsunami in 2004 (caused by a 9.2 magnitude earthquake in the Indian Ocean), the Nargis cyclone that hit Myanmar in 2008 and the 2010 Haiti earthquake.

earthquake & tsunami	Indian Ocean	*2004*	**224,408**
earthquake	Haiti	*2010*	**222,570**
storm	Myanmar	*2008*	**138,366**
earthquake	*China*	*2008*	**87,476**
earthquake	*Pakistan*	*2005*	**73,338**
heatwave	*Europe*	*2003*	**72,210**
heatwave	*Russia*	*2010*	**55,736**

<Figure 4
Ten deadliest disasters 2000-2019

The hazard of
Earthquakes

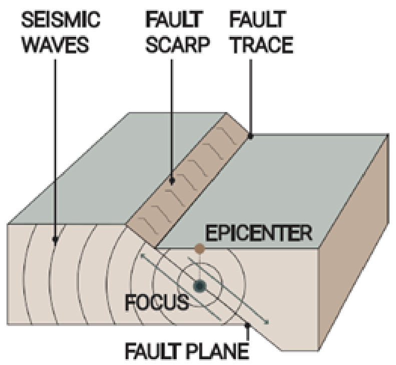
The following pages explain the earthquakes as a hazard, why they occur, their consequences on the population with general considerations on building resilience along with a global observation of the current situation on their occurence.

Image 1:
TENT CITY - A bird's-eye view reveals a colorful tent city sprouting among the ruins of Port-au-Prince as Haitians sought shelter in the wake of a deadly January 2010 earthquake. Truly epic disasters, the so-called "great quakes" which level cities or spawn giant tsunamis, happen about once every five years on average.
PHOTOGRAPH BY UNITED NATIONS

Image 2
HAITIAN NEIGHBORHOD - A Port-au-Prince neighbourhood lies ruined and reeling on January 16, 2010, just four days after one of the more devastating quakes in recent memory rocked the island nation of Haiti.
PHOTOGRAPH BY JOE RAEDLE, GETTY IMAGES

1.2 Seismic hazard and causes

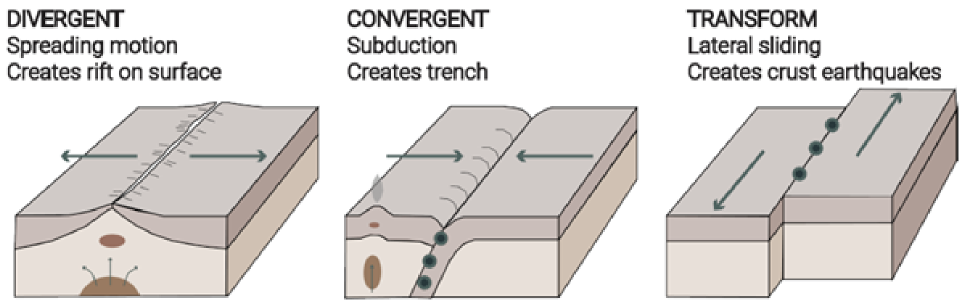
Earthquakes may be one of the most prevalent natural phenomena and for many people living in earthquake-prone areas they cause fear and danger, given their unpredictable nature. Earthquake impacts are potential disasters which often destroy infrastructure and cause displacement, loss of livelihood and, in worst case scenarios, loss of life within the impacted community Earthquakes happen due to forces in the Earth's interior affecting the Earth's surface, causing it to rupture. When the energy from these forces, stored deep within the rocks, is all of a sudden released (e.g. shear movements along the faults in Earth's crust) an earthquake, or sometimes referred to as a seismic event, occurs. The area where this rupture happens is called the focus of the earthquake. The epicentre, which is more commonly used as a location of the earthquake's origin, is the point in the surface located above the focus.



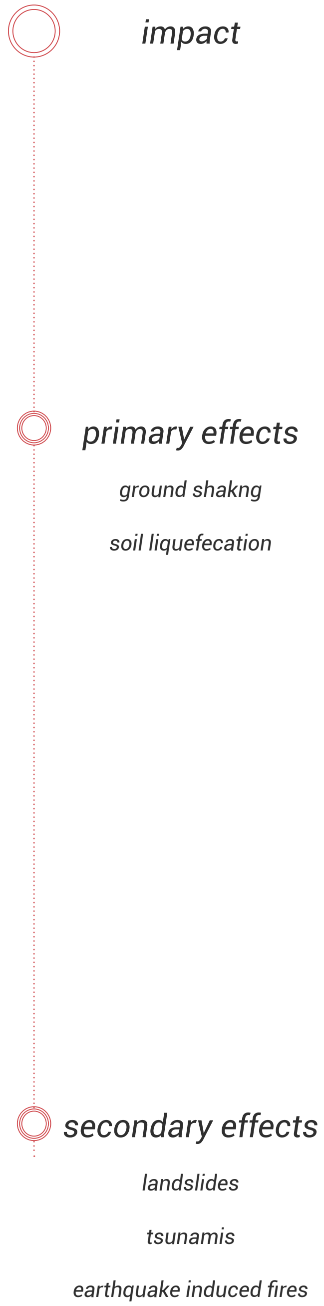
MERCALLI SCALE INTENSITY [LINEAR]	RICHTER SCALE MAGNITUDE [LOGARITHMIC]
I	1-2
II	2-3
III	3-4
IV	4
V	4-5
VI	5-6
VII	6
VIII	6-7
IX	7
X	7-8
XI	8
XII	8+

<Figure 5
Formation of earthquakes and severity measurement scales.

At the edges of the tectonic plates that compose the crust of the Earth there are major fault lines that are all potential seismic hazard event areas. When these plates move they release energy expressed as seismic waves. This movement motion is an ongoing process that has shaped the Earth as a planet. When the plates push towards each other, or converge the result is the creation of mountains. Where plates pull away from each other, or diverge, the continents rift and oceans form. A transform fault is what happens at the area where two tectonic plates slide beside each other.



<Figure 6
Different types of plate tectonics



The Mercalli scale bases its measurement on the observed effects of the earthquake [humans/objects/surface] and describes its intensity, in contrast with the Richter scale which measures the seismic waves, or the energy released, causing the earthquake and describes its magnitude. Intensity varies depending on where it is observed with respect to the epicentre of the earthquake, where as the magnitude is a single value that instrumentally measures the seismic waves' amplitude released at the focus, or hypocentre, of the earthquake.

1.2.1 Earthquake effects

Most of the harm and damage is done by the ground movement of the seismic impact itself. Nonetheless, combined with other factors, the initial impact damage can be magnified depending on the soil properties causing it to liquefy, settle and lateral ground displacements. Furthermore, the initial ground motion can be enhanced in areas where there is the conditions for landslides, tsunamis or fires to form. When planning a project to mitigate the seismic hazard, these secondary effects need to be considered.

Primary effects

The ground movement that seismic waves produce lead to simultaneous lateral and vertical ground motions which can be intense enough to translate force and shake buildings. This is the primary effect that the seismic waves cause. If the shaking is severe enough it can cause deforming, cracking, bending, and ultimately lead to collapse. Since the impact occurs at ground level, the foundations are most vulnerable and by displacing it, stresses are formed throughout the building. Shifting of foundations consequences depend on the shape, weight and material of the building. After the initial deformation, gravity forces may play a role in the increase of damage.
If the soil is loose and moist, it loses its stabilizing properties and the ground motion can transform it into an almost fluid mass. This kind of fragile soil is common in areas near water bodies such as lakes, rivers and coastlines. The settlements and displacements caused can vary in size, but can easily cause harm, even full collapse, of structures.

Secondary effects

When an unstable soil located on a hill is shaken by an earthquake or liquefied, landslides (or downward land movement) may occur and cause damage to infrastructure and buildings built along the hill and/or on the foothills. When an earthquake happens in the ocean, the seismic waves translate into actual water waves, causing tsunamis to form. While moving towards the coast, as the ocean water gets shallower, the size of the wave grows in height and may cause severe damage. Fires are a common secondary effect of earthquakes largely due to the difficulty to manage them in times of emergency. The earthquake impact and damage may cause both a fire, but also chaos on the roads and cut off water supply.

1.2.3. General concepts of earthquake resilient buildings

"The term non engineered building is defined as buildings which are spontaneously and informally constructed in the traditional manner without intervention by qualified architects and engineers in their design, but may follow a set of recommendations derived from observed behaviour of such buildings during past earthquakes and trained engineering judgement." (Arya, 2014)

Many typical methods of construction lack some fundamental resistance to earthquake shaking, Through adequate knowledge of a few general rules of thumb when constructing in earthquake-prone areas it is possible to at least minimize the collapse of buildings, if not prevent damage. Certain general principles are defined by the non engineered buildings guidelines:

A. Structures should be tough and ductile, maximizing the ability to deflect and deform

B. Bracing elements and shear walls must be distributed evenly both in horizontal and vertical direction

C. The structure should behave monolithically during the ground shaking, thus all elements should be tied together, transferring forces across strong connections (e.g. between wall-roof)

D. Soft and weak soils should not be built on or specially strengthened if there is the possibility of a seismic hazard

E. Strong building – foundation – earth connections

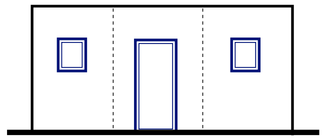
F. The materials used need to be of good quality in order to preserve the strength property

G. Provide rain, sun and insect protection to maximize the strength of the material over time

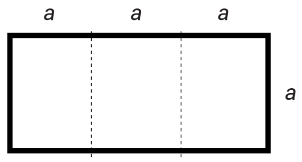
H. If using masonry, which is a brittle construction technique, reinforcement must be used to increase compressive strength

The most desired properties a material can have to be earthquake - resistant are ductility, deformability and robustness.

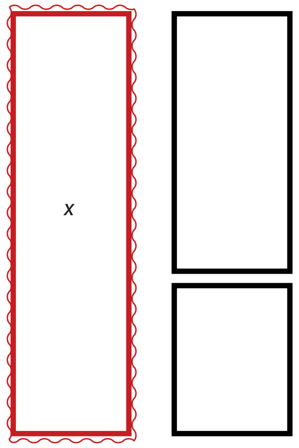
Regarding the building plan a few key principles that should be respected are:



<- **Symmetry:** both for the building as a whole and the placement and sizing of openings



<- **Regularity:** it is best to restrict projections and the length of a rectangular shape to maximum 1/3 of its width



<- **Separate blocks:** to obtain the two concepts mentioned above, it is better to separate a narrow rectangle into separate blocks

<- **Separate buildings for different functions:** decreases cost while being hazard resilient

<- **Simplicity:** avoid ornamentation, since seismically projections are poten tially dangerous, if needed it needs to be reinforced with steel

Types of "non engineered buildings", and their seismic properties:

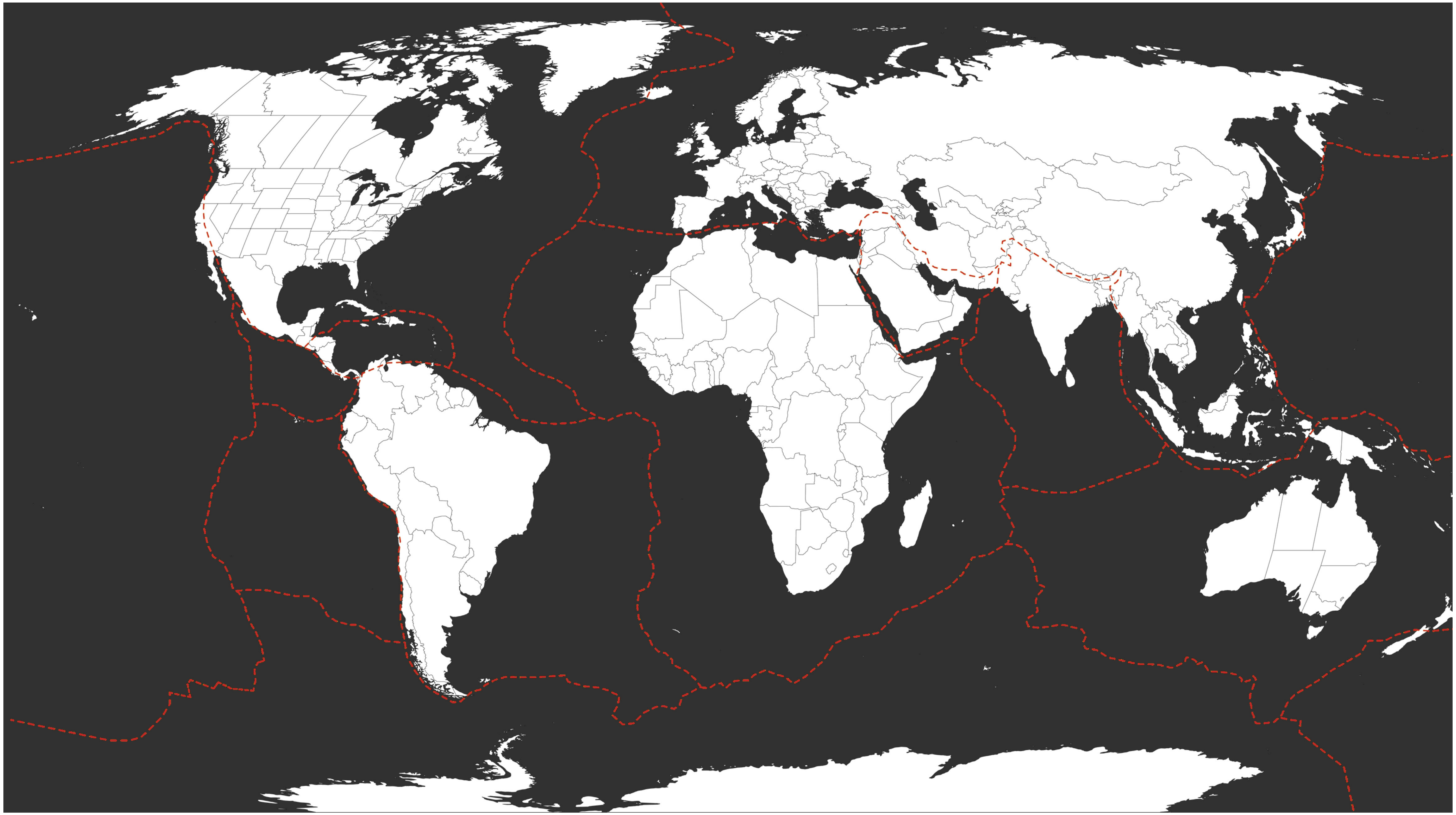
- **Masonry Buildings:** Seismic deficiency of masonry buildings is the cre ation of tensile and shear stresses within the walls. Should be reinforced

- **Stone buildings:** Without the seismic improvements and proper reinforce ment can be particularly dangerous in earthquake-prone areas

- **Wooden Buildings:** Wood has a high strength per unit weight making it optimal for seismic zones. Due to lack of availability, better to be used combined with other worse performing, but widely available, materials (e.g. brick, stone)

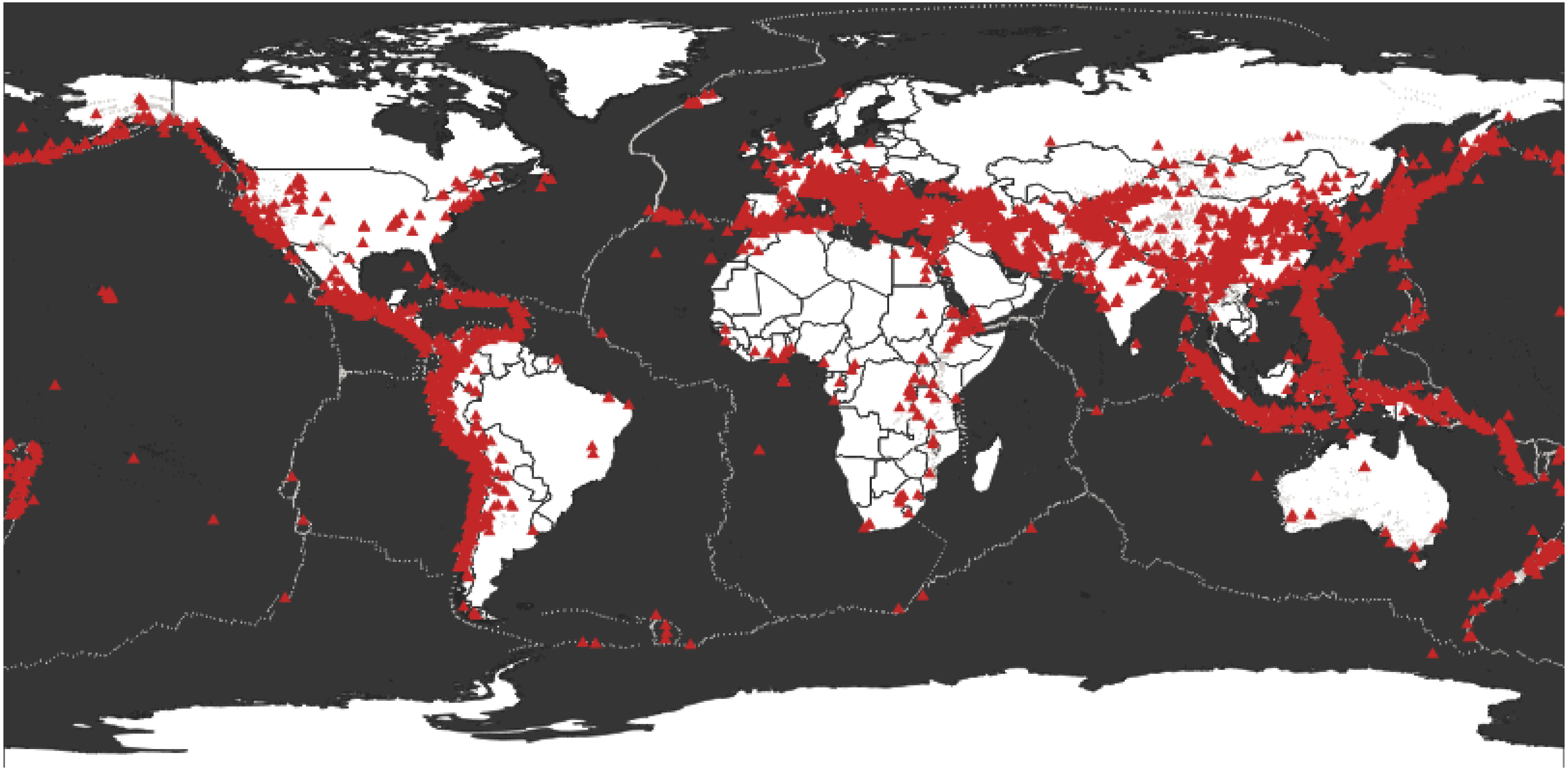
- **Earthen Buildings:** Advantages are the costs, heat insulation and low ener gy consumption, but if not stabilized has poor seismic performance

- **Non Engineered Reinforced Concrete Buildings:** due to lack of knowl edge, deficiencies in mixing and curing as well as lack of consideration given for the effect of seismic lateral loads, they often are very fragile when ground motion occurs



1.2.4A A global observation - *Earth's tectonic plates*

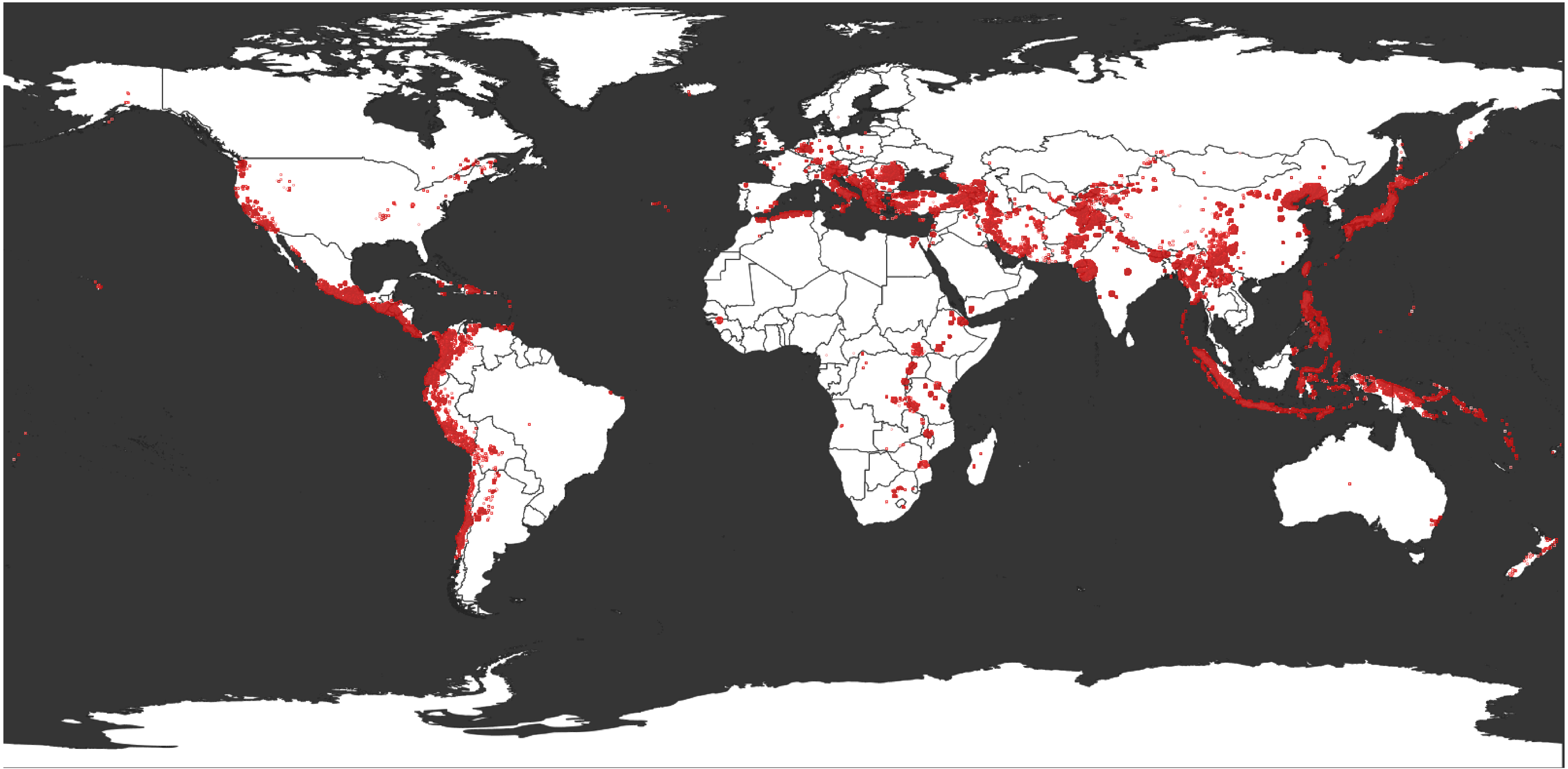
Source: World Bank Open Data



1.2.4B A global observation - *Earth's fault lines; events with over 6 magnitude since 1970*

Source: GIS processing Shakemap Atlas from USGS, compilation and global hazard and redrawn by authors

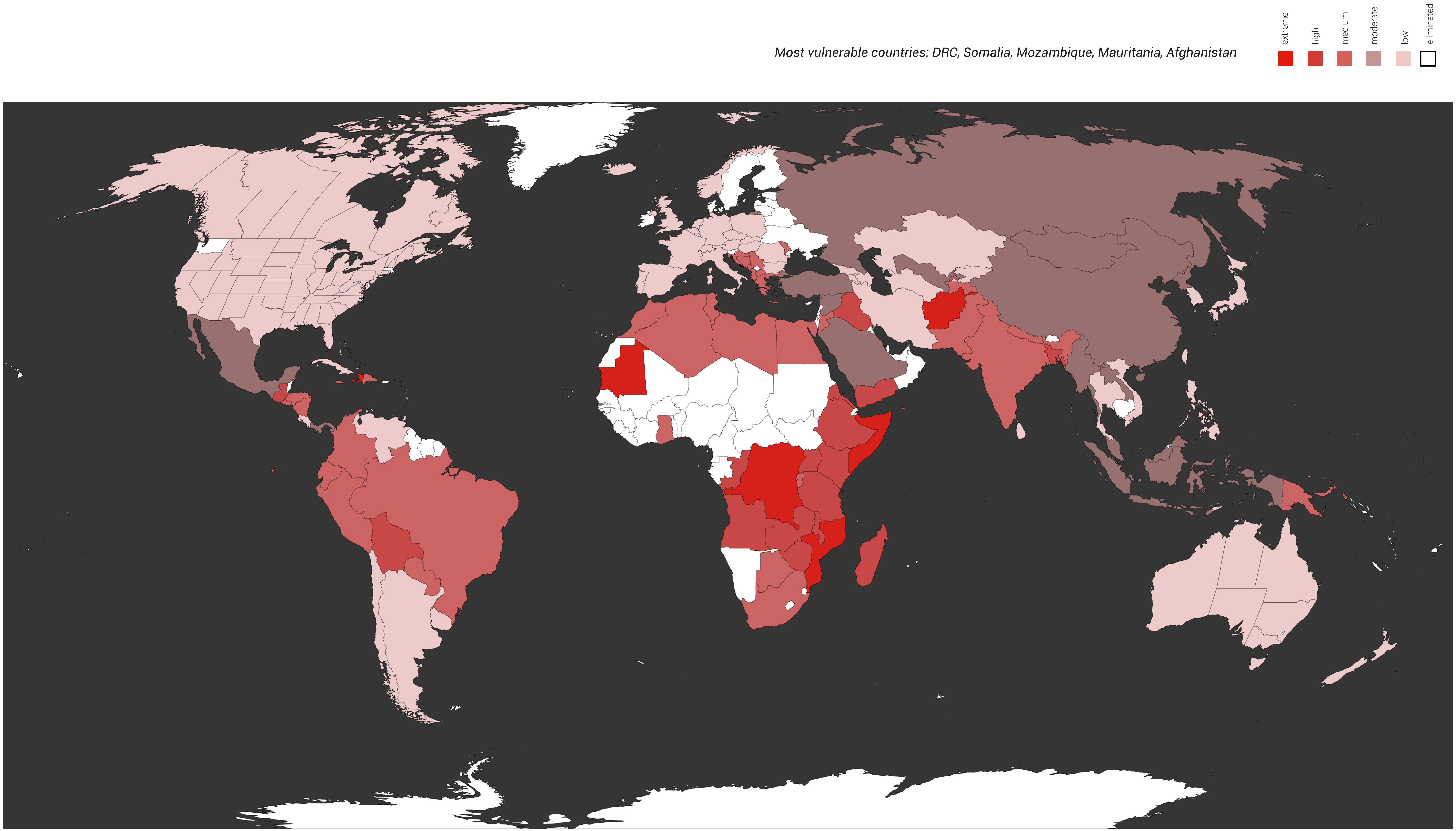
A fault trace occurs at the intersection of a geological fault with the Earth's surface, leaving a crack-like disturbance along the fault and jutted rocks as a consequence. Most earthquakes occur along, or near, these fault lines.



1.2.4C A global observation - *Physical exposure to seismic activity*

Source: GIS processing Shakemap Atlas from USGS, compilation and global hazard and redrawn by author

Most vulnerable countries: DRC, Somalia, Mozambique, Mauritania, Afghanistan

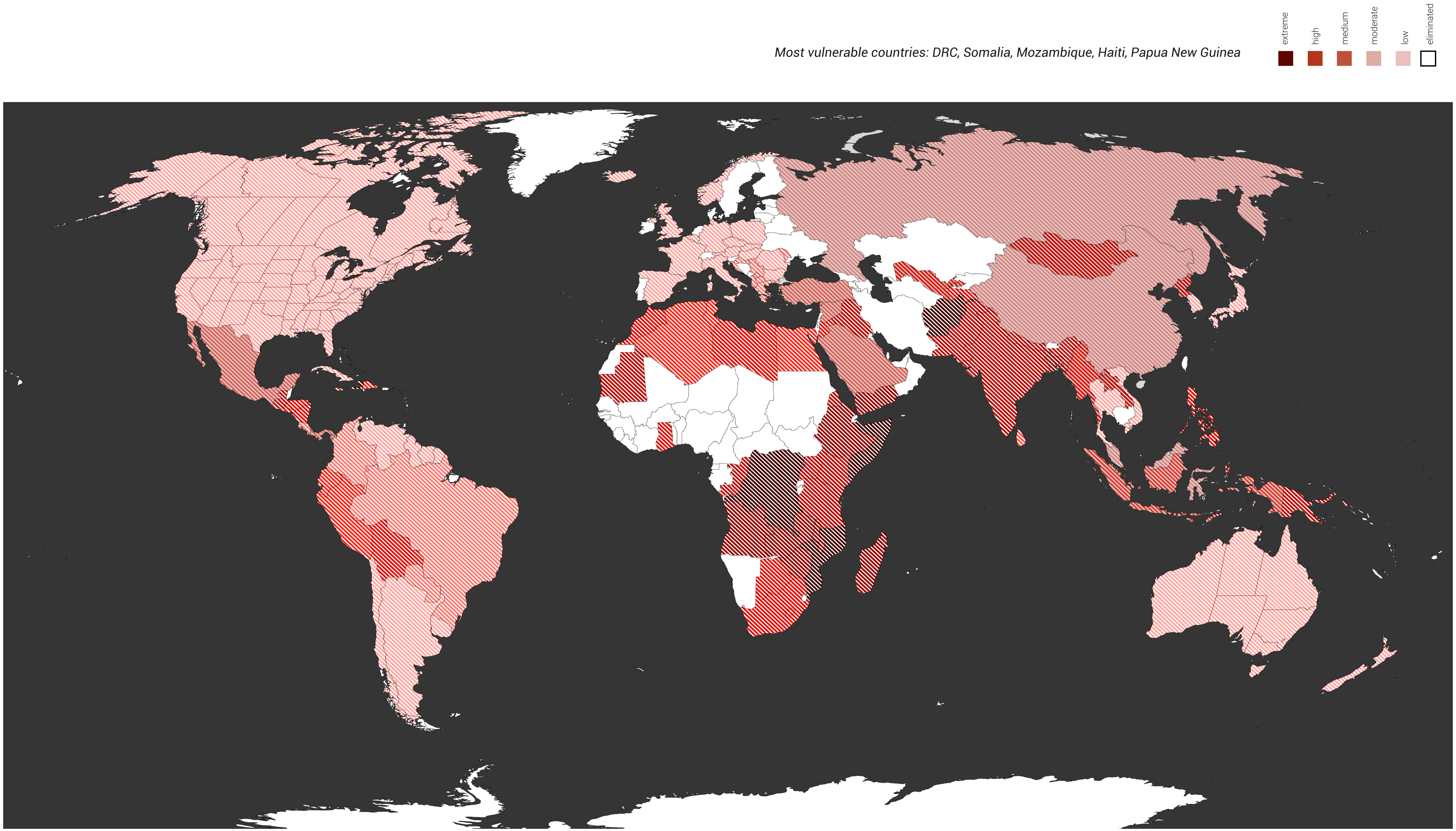


1.2.4E A global observation - *Global earthquake social vulnerability*

Source: C Burton, M. Toquica (September 2020). Global Earthquake Model (GEM) Social Vulnerability Map (version 2020.1) and redrawn by author

The social vulnerability index helps to explain why some countries will experience adverse impacts from earthquakes. Factors that increase social vulnerability are young and elderly population, homelessnes, under-educated percentage, population density, slum populations etc

Most vulnerable countries: DRC, Somalia, Mozambique, Haiti, Papua New Guinea

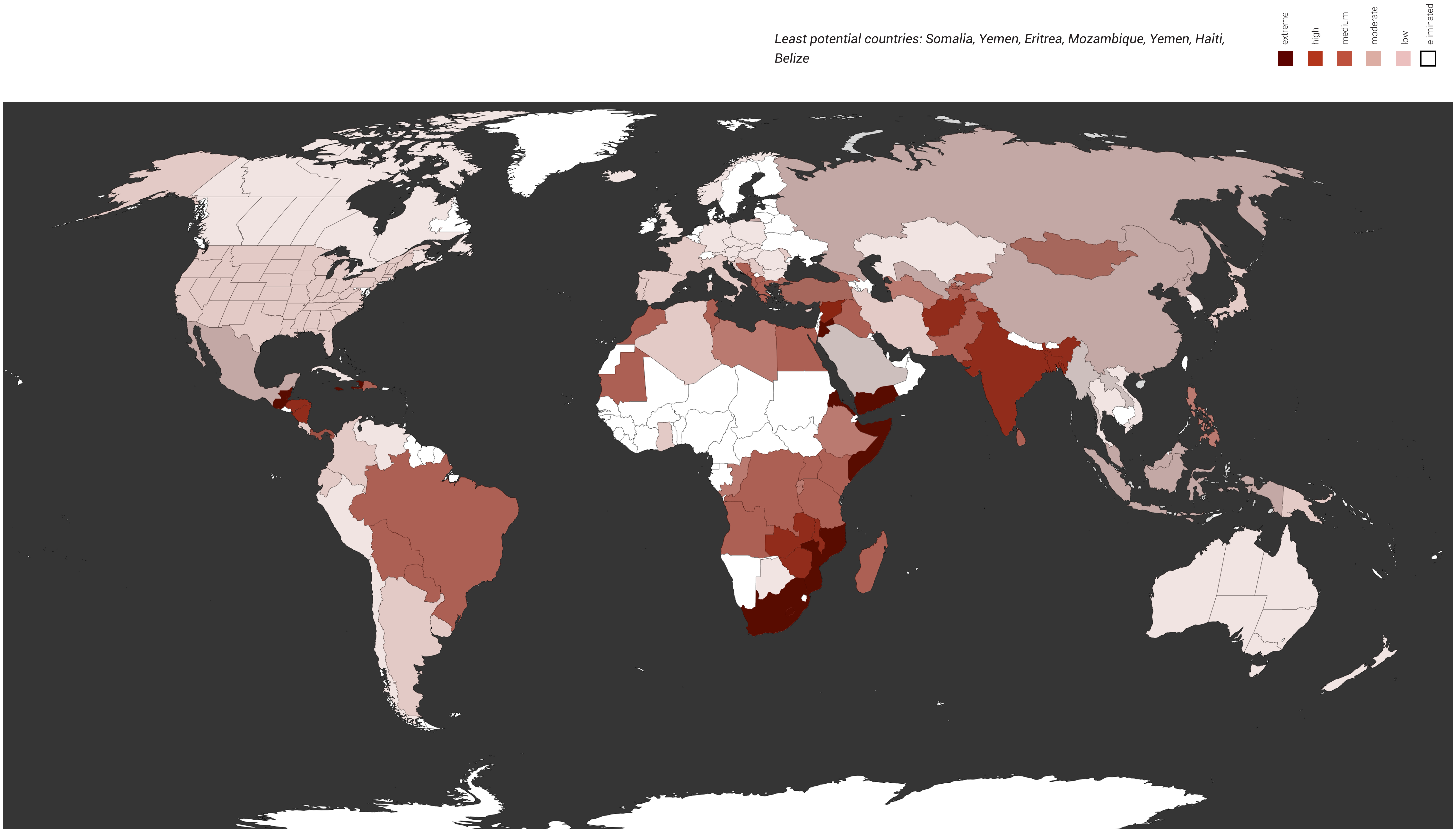


1.2.4F A global observation - *Global earthquake economic vulnerability*

Source: C Burton, M. Toquica (September 2020). Global Earthquake Model (GEM) Economic Vulnerability Map (version 2020.1) and redrawn by author

The potential for economic losses from earthquakes due to a country's macroeconomic exposure is measured. Relevant indicators include the density of exposed economic assets, reliance on imports/exports, government debt, purchasing power, income inequality, and unemployement.

Least potential countries: Somalia, Yemen, Eritrea, Mozambique, Yemen, Haiti, Belize



1.2.4G A global observation - *Global recovery (reconstruction) potential*

Source: C Burton, M. Toquica (September 2020). Global Earthquake Model (GEM) Recovery Reconstruction Potential Map (version 2020.1) and redrawn by author

The global recovery potential is measured as an ability of communities within a country to absorb impacts and cope with a damaging earthquake event.

The hazard of

Tropical Storms

The following pages explain the tropical cyclones as a hazard whose effect is noticable on a global level, defining its characteristics, where and why does it occur as well as its frequency and categorization, and which are the main factors that are gulity of its development.

Image above credit:
UN Photo/Sophia Paris
Devastation Caused by Tropical Storm Jeanne to Inhabitants of Haiti.
2004

Image below credit:
UN Photo/Logan Abassi
Hurricane Matthew makes landfall in Haiti.
2016

1.3 Tropical storms

There are various and very distinctive names for this hazard – storms , all of them relying on where it takes place. Hurricane is the name with which this climate phenomenon is defined with in the Atlantic and Northeast Pacific, while the term typhoon is used when these storms take place on the territory of the Northwest Pacific. Cyclones- describes the equal climate occasion on the territory of the Indian Ocean and South Pacific. All of these various terms also use distinctive scales to categorize their strength relying again on the places wherein they occur. Even though all of these scales are primarily based on wind speeds, the line among them is drawn in a different way in distinctive areas which makes it very hard to compare them. To make it more clear cyclones begin at 63km/h in the Fiji coast whilst hurricanes will most effectively be described as such only from 119km/h upwards in the Haitian Coast, this means that for the highest classification of their scales which is category 5, a cyclone has to attain 280km/h whereas a hurricane 252km/h.

1.3.1 The hazard – Tropical Cyclones and causes

Tropical Cyclones are considered the revolving, arranged structures of clouds and thunderstorms, that develop over the territory of the subtropical and tropical waters and they have a closed low degree flow. This hazard endangers approximately 2 billion humans internationally every single year. Generally, about 80-90 tropical cyclones construct yearly, from which approximately one third makes landfall, which makes this hazard one of the most often climate extremes.

Causes and Effects

What causes the tropical cyclones or so called storms that have various names around the world? Numerous situations, conditions need to happen in order for a storm, tropical cyclone to form. Firstly a huge role plays the sea temperature which needs to reach at least 26.5°C in depth all the way down to 50 meters under the sea level, Furthermore, there must be a widespread distinction in air temperature at specific altitudes meaning the atmosphere is unstable and allows convection. On the other hand in order to shape a strong storm , the wind shear should be low so that the energy is not scattered over a large area, which will not allow the storm to form. This means that the reason why tropical cyclones are very rare in the Southern Atlantic

Ocean is actually because of the high wind shear. Another reason why tropical storms occur is because there is high humidity in the lower to middle levels of troposphere meaning the lowest layer is the one where most weather related hazards occur. So we come to a conclusion that in order for tropical cyclones to form , they need at leaest some disturbance near to the surface.

1.3.2. Storm Characteristics

The main characteristics of the tropical storms, which frequently occur when a tropical cyclone happens and are also worldwide known are heavy rainfalls and destructive winds which can cause in most cases flooding. A lesser acknowledged phenomenon caused by tropical s torms is the storm surge, and even though it happens more rarely it can be the most life threatening component.

Destructive winds

The most powerful winds are close to the eye, but their damaging is extending for hundreds of kilometers from the center. Around the center in the eyewall, we may notice wind from 90-360km/h . Even though the eye itself is capable of having calm winds and clear skies, right afterwards winds from different sides occur and they are- catastrophic.

Heavy rainfall

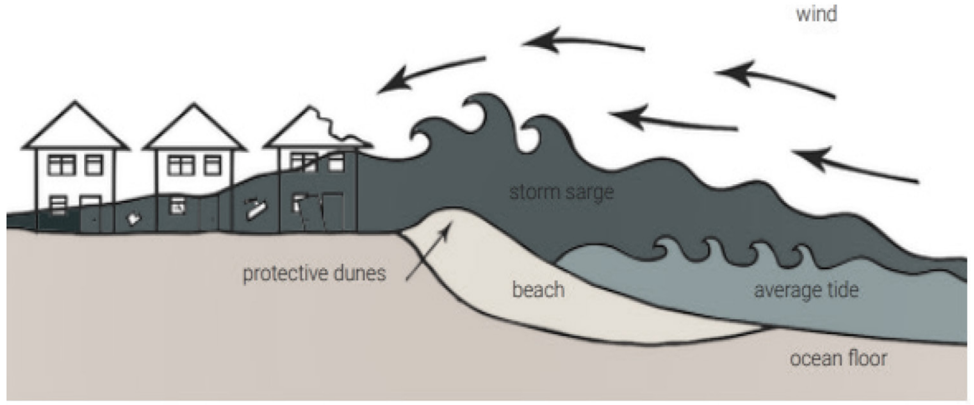
This characteristic can be noticed over large-scaled areas where storms, tropical cyclones occur and it creates intense affect on the land by inflicting floods and landslides.

Storm surge

Storm surge is produced as a union of the low atmospheric pressure and the water on the coast driven by the very strong winds which are all part of the tropical cyclones. In other words it is the growth of the sea level due to winds and atmospheric stress adjustments related to tropical storms. The biggest surge commonly extends among 30 and 60 kilometers from the eye of the tropical cyclone or the crossing point of the center. Depending on the angle at which the cyclone crosses the coast and the topography of the seafloor, its influence also converts.

Figure 7>

The formation of storm surges



1.3.3 The phenomenon of El Nino & La Nina

These worldwide known climate phenomenon's, due to cyclical shift, take place withinside the sea surface temperature of the Pacific Ocean. Even though they are targeting a small territory near the Equator, they have a huge impact on temperature and rainfall and of course the weather all over the globe. Usually in there Equatorian area the sea level temperatures are 'normal' meaning they are particularly cold in the eastern part of the Ocean, while on the Western they are particularly hot, but every 3-7 years this normal pattern is being disrupted by one of these phases – El Nino meaning the warm phase and La Nina meaning the cold phase , which usually lasy 9-12 months even though in some uncommon occasions they could last over a couple of years.

EL NIÑO

This weather phenomenon, as it was already said, it is considered to be the warming phase of the sea water in the territory of the Equator in the Pacific Ocean. To make it more clear how this phase works, we firstly need to be aware that during normal, ordinary climate patterns at this exact location, the trade winds deliver hot/heated water from the tropical areas onto the cooler areas of the ocean. (in the equadorian territory). What happens during the El Nino phase is that those winds, that carry the hot water from east to west , weaken in strength and the exchange stops,but this does not stop here, the winds reverse and they deliver the heated water back to east warm region which makes the tropical water even more heated, in this way the sea water temperature at the surface can growth through 15 degrees C for monts or maybe even years.

LA NIÑA

The alternative of El Nino is the phenomenon called La Nina which also characterizes with a change of the so called normal climate east-west wind patterns. The difference here is that La Nina is the opposite of El Nino signifying that if the El Nino is the heating phase, this one is the cooling, so the trade winds actually fortify and the heated water and rainstorms are driven all the way to the western equatorial Pacific , meaning the surface water is cooler.

1.3.4. Exposure

Western North Pacific Ocean

The biggest basin of all of the basins in the world is the one named western north pacific. This basin is not only the largest of them all but also it is the most active one in terms of frequency of tropical cyclones but also their intensity. As a matter of fact every 12 months we can acknowledge approximately 30 tropical cyclones from which around 9 would be in a higher category i.e. category 3/4 or 5 and 21 of them would meet the criteria for the lowest of them all, category 1. The principal season in which these hazard occur in this area is from July to October but that does not mean that it cannot be seen throughout the rest of the year. The tropical cyclones formed in this basin mostly affect the Asian Countries with a high population such as Philippines, China, Korea, Vietnam, Taiwan etc.

Central and Eastern Pacific Ocean

After the western north pacific basin, the second one, in terms of being the most active basins in the world is the CEP- central an eastern north pacific. In a period of 12 months the most common number of tropical cyclones occurring is around 19 , from which around 5 can belong to a higher category as category 4 or 5 while the rest of them mostly belong to the lowest category, category 1. Even though much of the information on which are the factors that regulate this basin are unknown, we can say in the last few years the interest for this basin is growing, especially since four out of 5 seasons (considering the last years) have passed 75% of the gathered cyclone energy over the length of the years 1975-2017. The cyclones from this basin mostly impact the territory of the southwest US, Mexico, Hawaiian Islands etc.

North Atlantic Ocean

The third most active basin in the world in terms of tropical cyclones and their intensity is the North Atlantic (NA) one. This basin yearly has the average of around 12 named storms (category 1), 6 hurricanes (category 2/3) and 3 major hurricanes (category 4/5). The phenomenon of El Nino performs a considerable role in the tropical cyclone activities in this basin such as landfalling etc. The hurricanes in this basin mostly affect the areas of Central America, the Caribbean etc.

North Indian Ocean

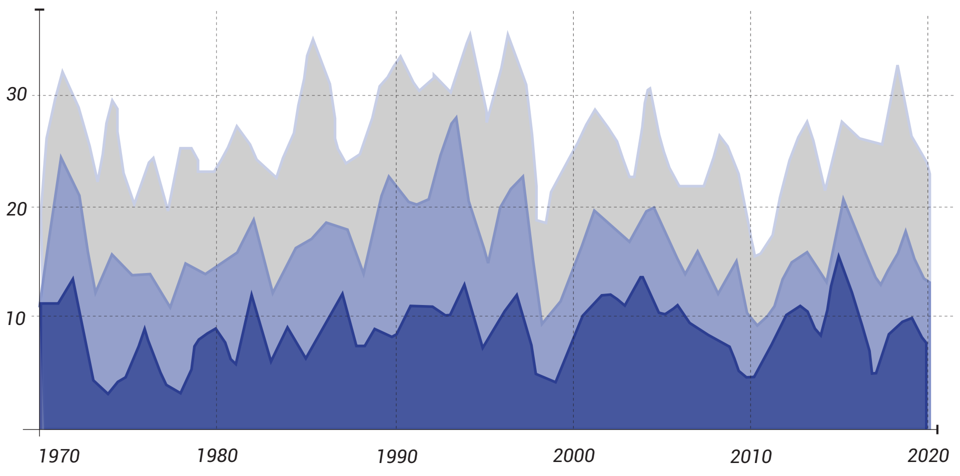
The average of 4.3 tropical cyclones on a yearly level, shows us that the North Indian ocean is not a very active basin in the world in terms of tropical cyclones and their intensity, compared to the rest of the basins, but, even though the cyclones are rare still they are causing a huge damage to the southern Asian countries such as Pakistan, Bangladesh, India etc. The threat they are causing is huge to their livelihoods and because of the great density in population it's not only the insufficient infrastructure that is damaged but there are lives that are claimed mostly in high numbers. Still the knowledge for this basin and the tropical cyclones that occur in the coastal territories are inadequate .

Southern Hemisphere

This basin gains a huge impact from the phenomenon of El Nino in terms to its variability whereas around one third of the common tropical cyclones that occur on the global level, form in this basin which is called the South Pacific Ocean, Southern Hemisphere. The tropical cyclones from this basin mostly impact the territory and population of the island nations in the South Pacific Ocean in addition to the Australia's northern states .

Storm counts

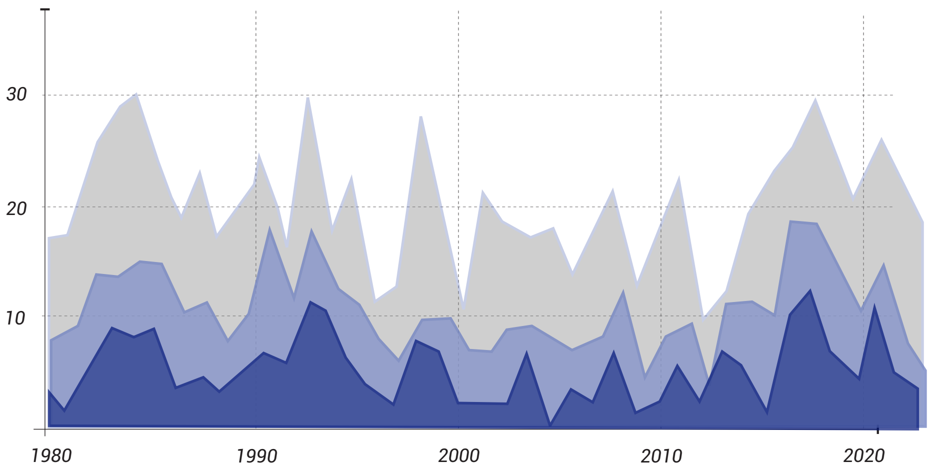
I. Western North Pacific Ocean



Storm counts in the Western Pacific 1970 - 2020

- Named storms
- Typhoons
- Major typhoons

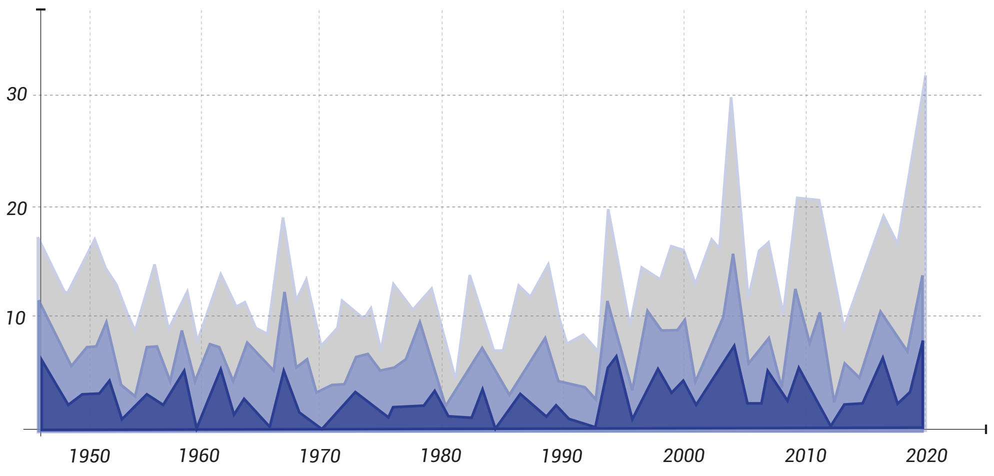
II. Central and East Pacific Ocean



Storm counts in the Eastern Pacific 1980 - 2020

- Named storms
- Hurricanes
- Major hurricanes

III. North Atlantic Ocean



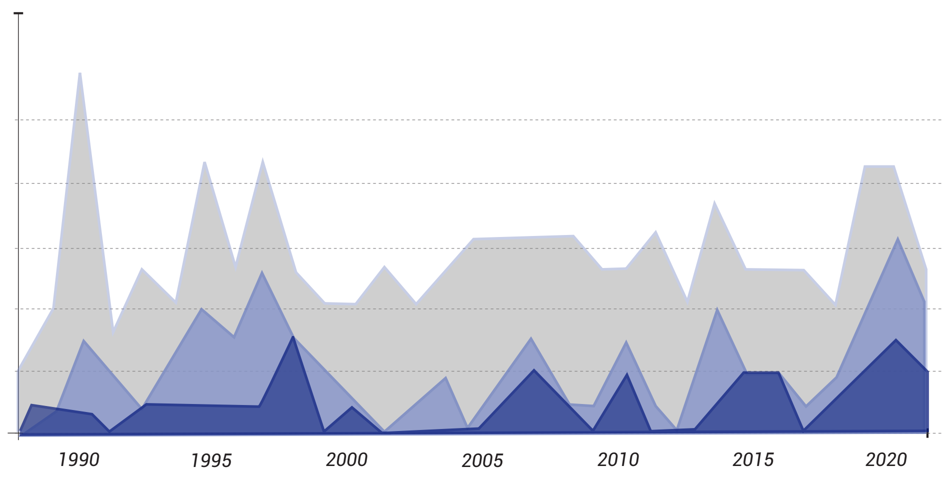
Storm counts in the North Atlantic 1960 - 2020

- Named storms
- Storms
- Major storms

IV. North Indian Ocean

Storm counts in the North Indian 1969 - 2020

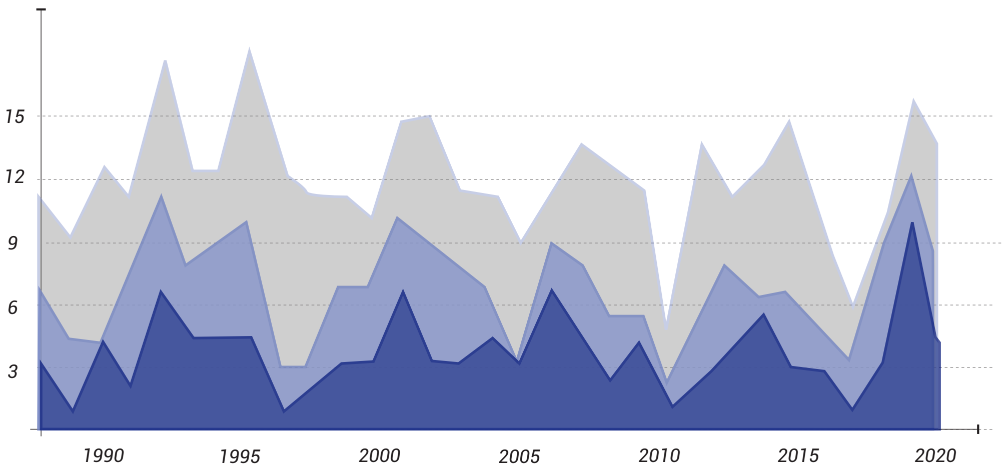
- Named storms
- Storms
- Major storms



V. South Indian Ocean

Storm counts in the South Indian 1990 - 2020

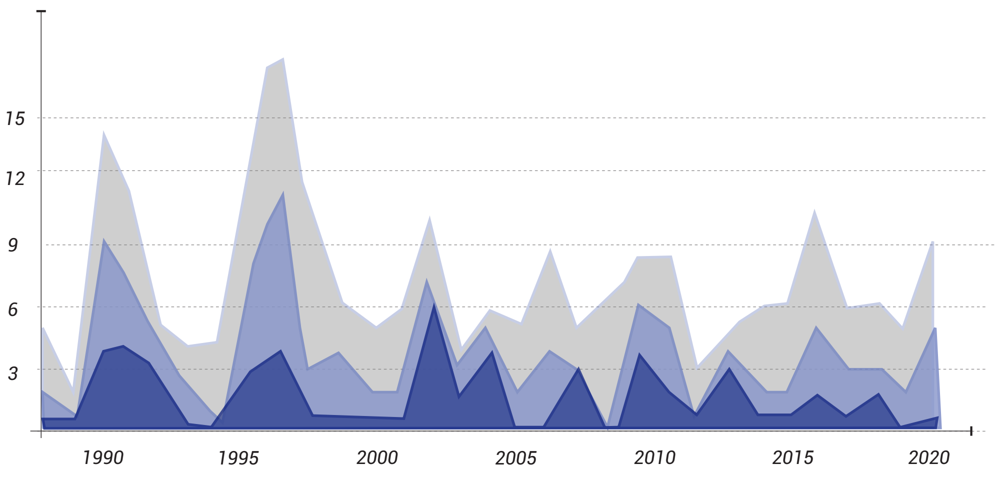
- Named storms
- Cyclones
- Major cyclones

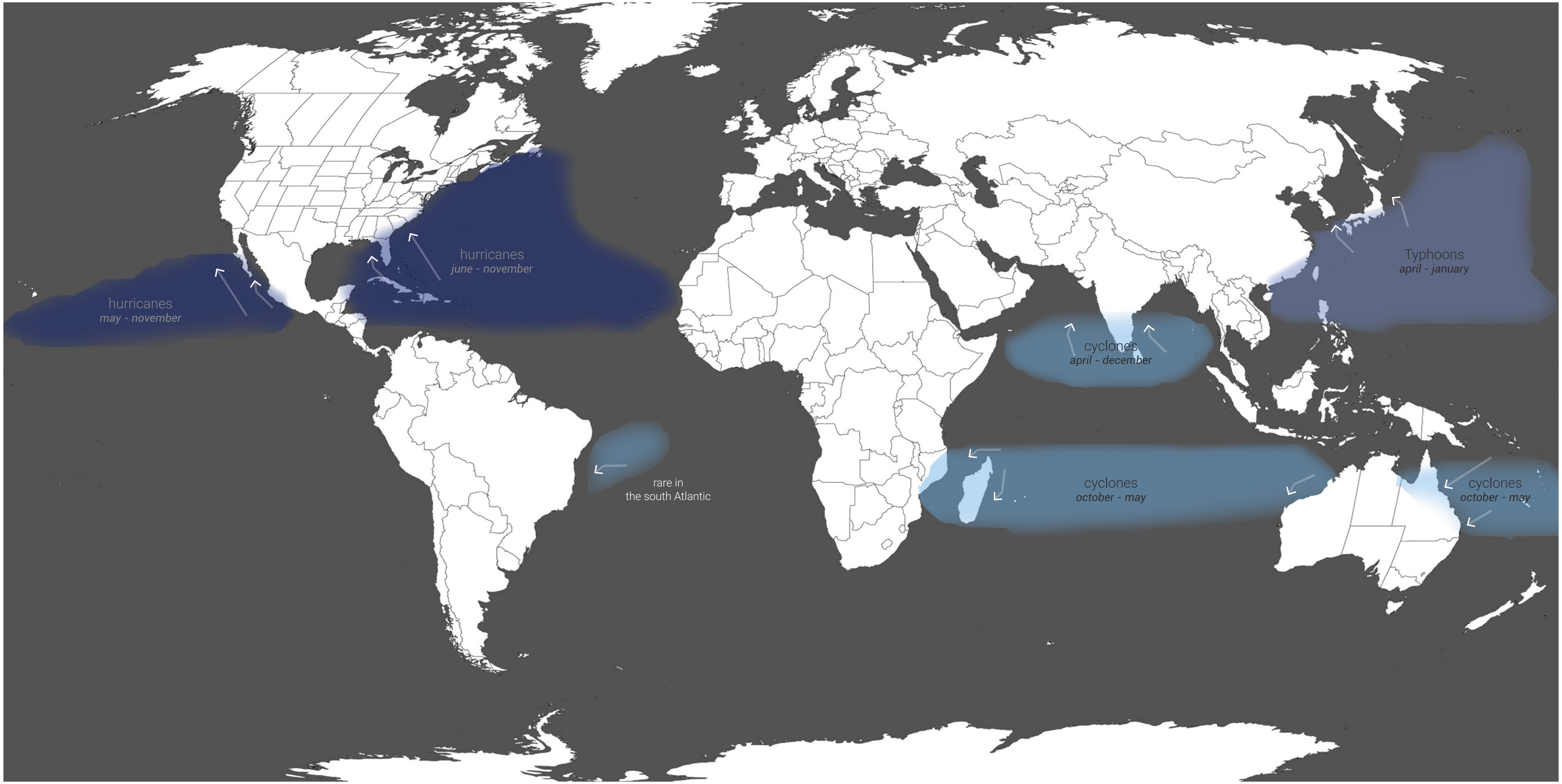


VI. South West Pacific

Storm counts in the South West Pacific 1990 - 2020

- Named storms
- Cyclones
- Major cyclones

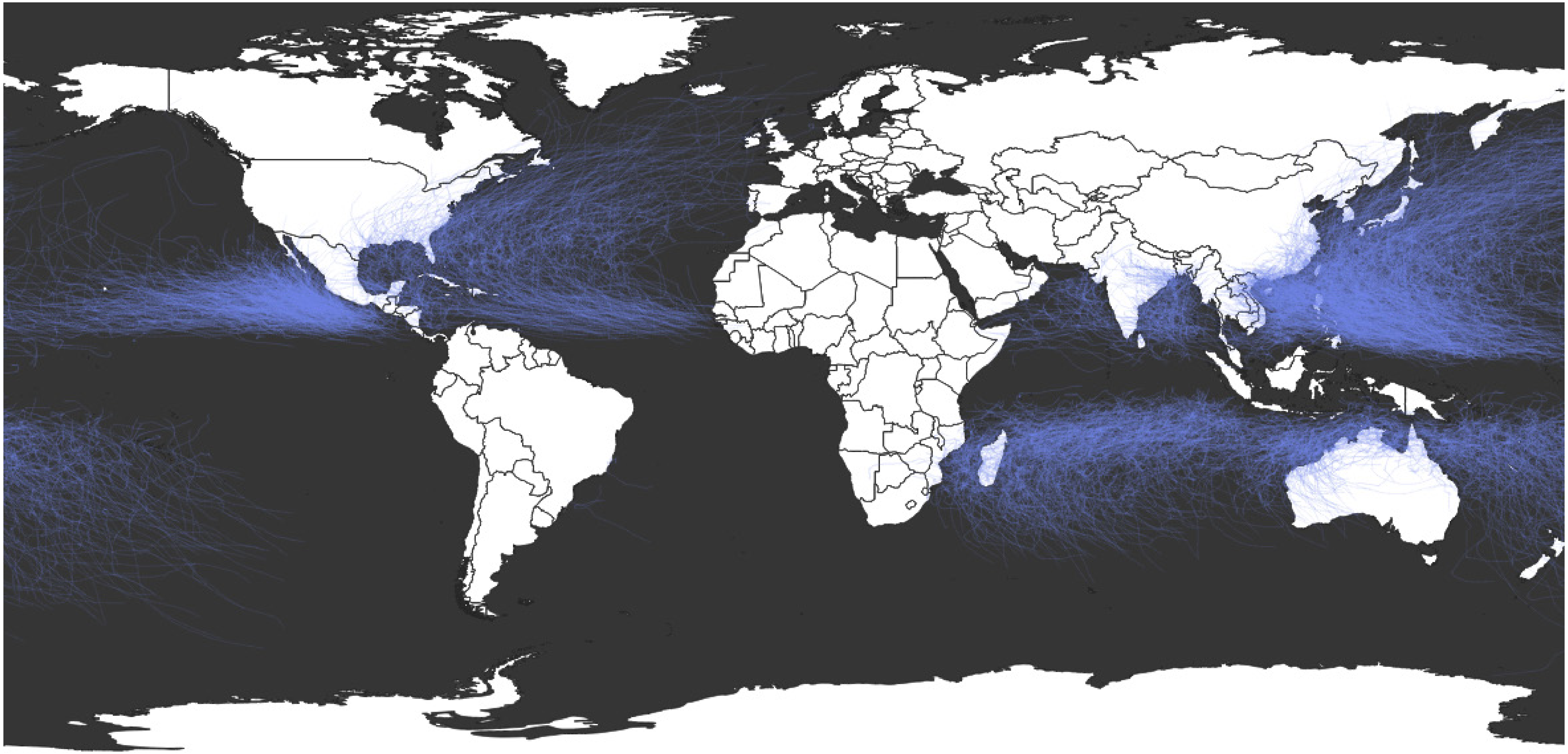




1.3.5A A global observation - *Tropical storms and their nomenclature*

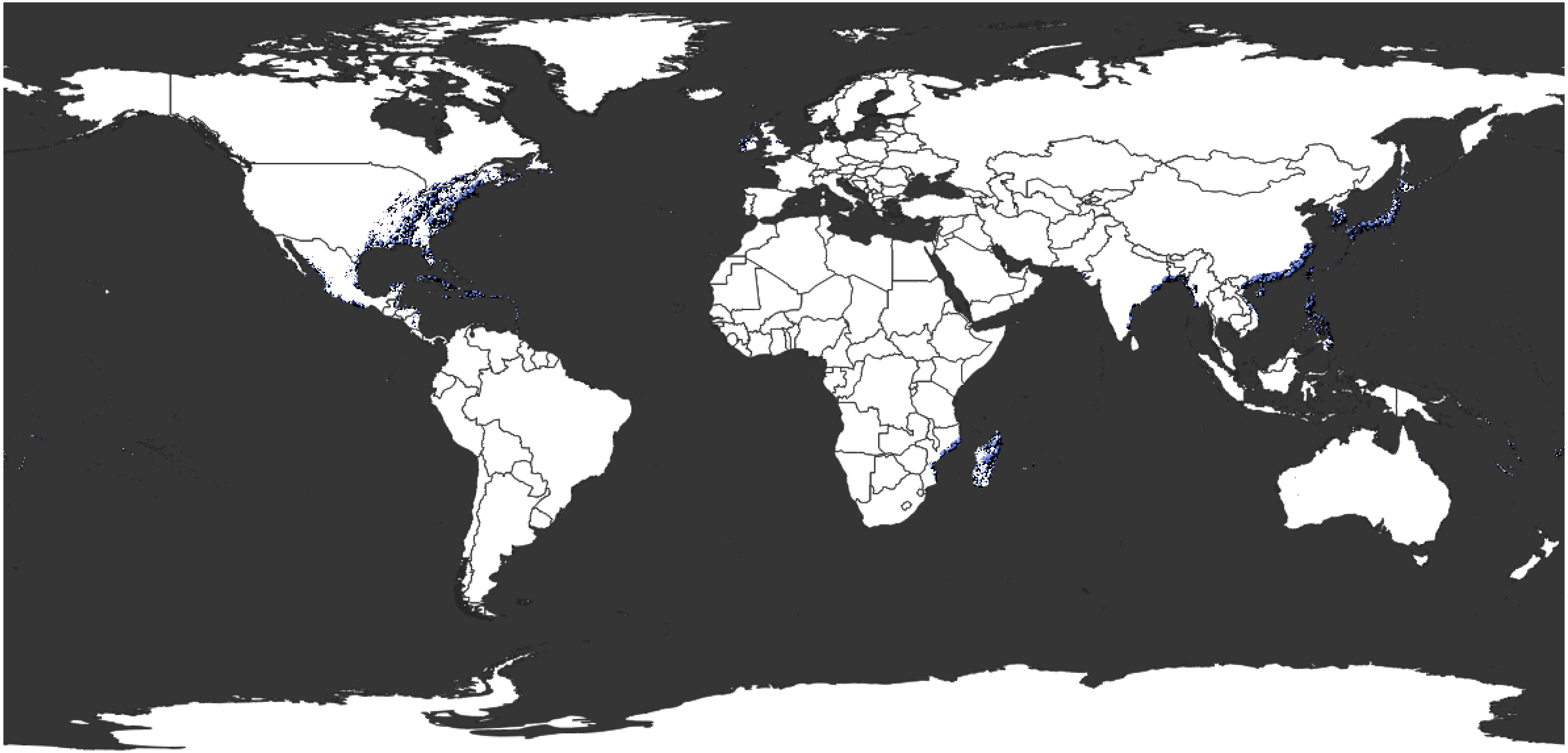
Source: Multiple sources, a combination redrawn by authors

Hurricane is the name with which this climate phenomenon is defined with in the Atlantic and Northeast Pacific, while the term typhoon is used when these storms take place on the territory of the Northwest Pacific. Cyclones- describes the equal climate occasion on the territory of the Indian Ocean and South Pacific.

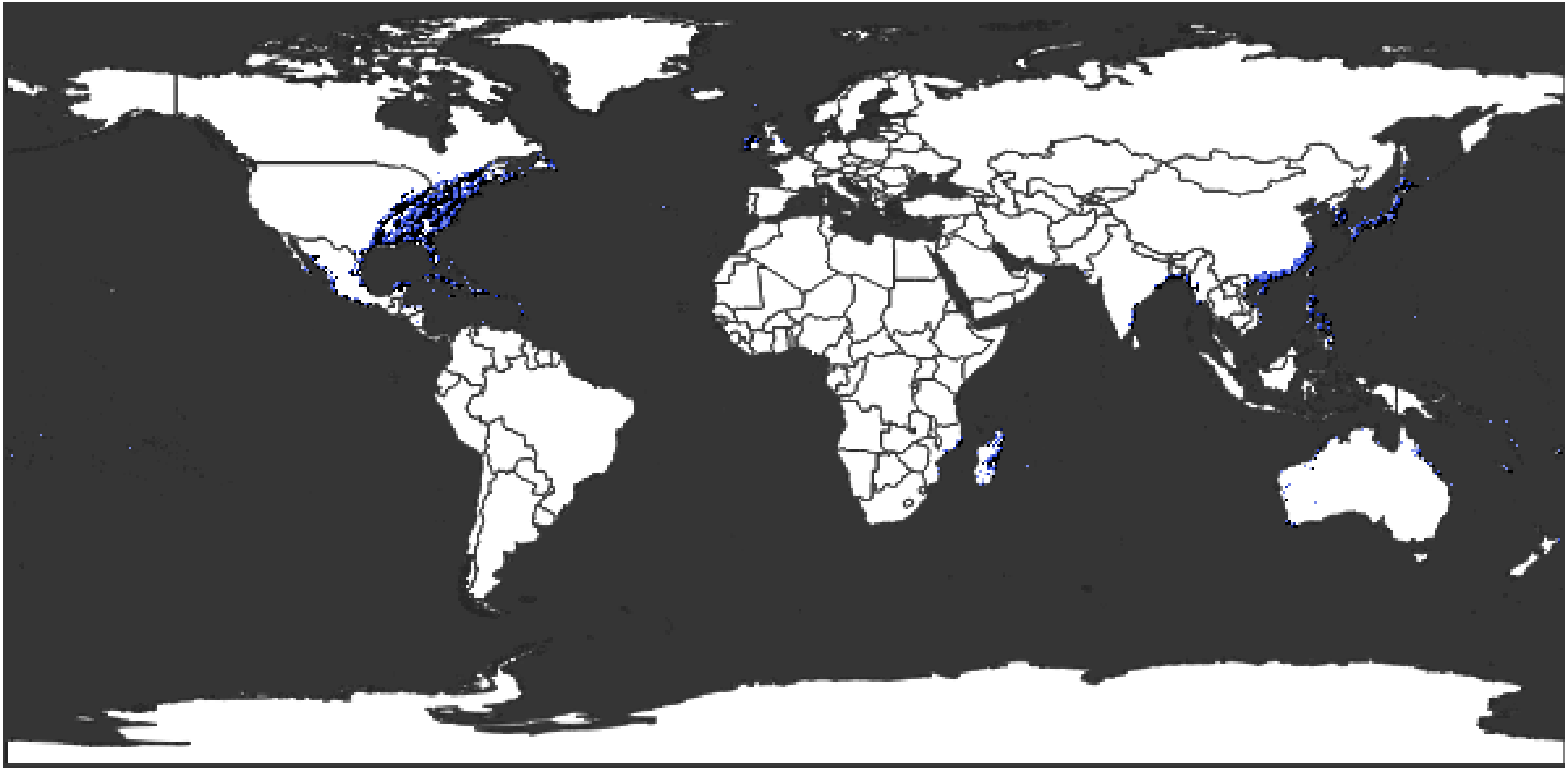


1.3.5B A global observation - *Cyclone paths, 1980 - 2020*
Source: GIS processing map from Global Risk Data Platform and redrawn by authors

A line trace of every cyclone that has occured at the Earth's surface, since 1980, leaving a minimal disturbance.

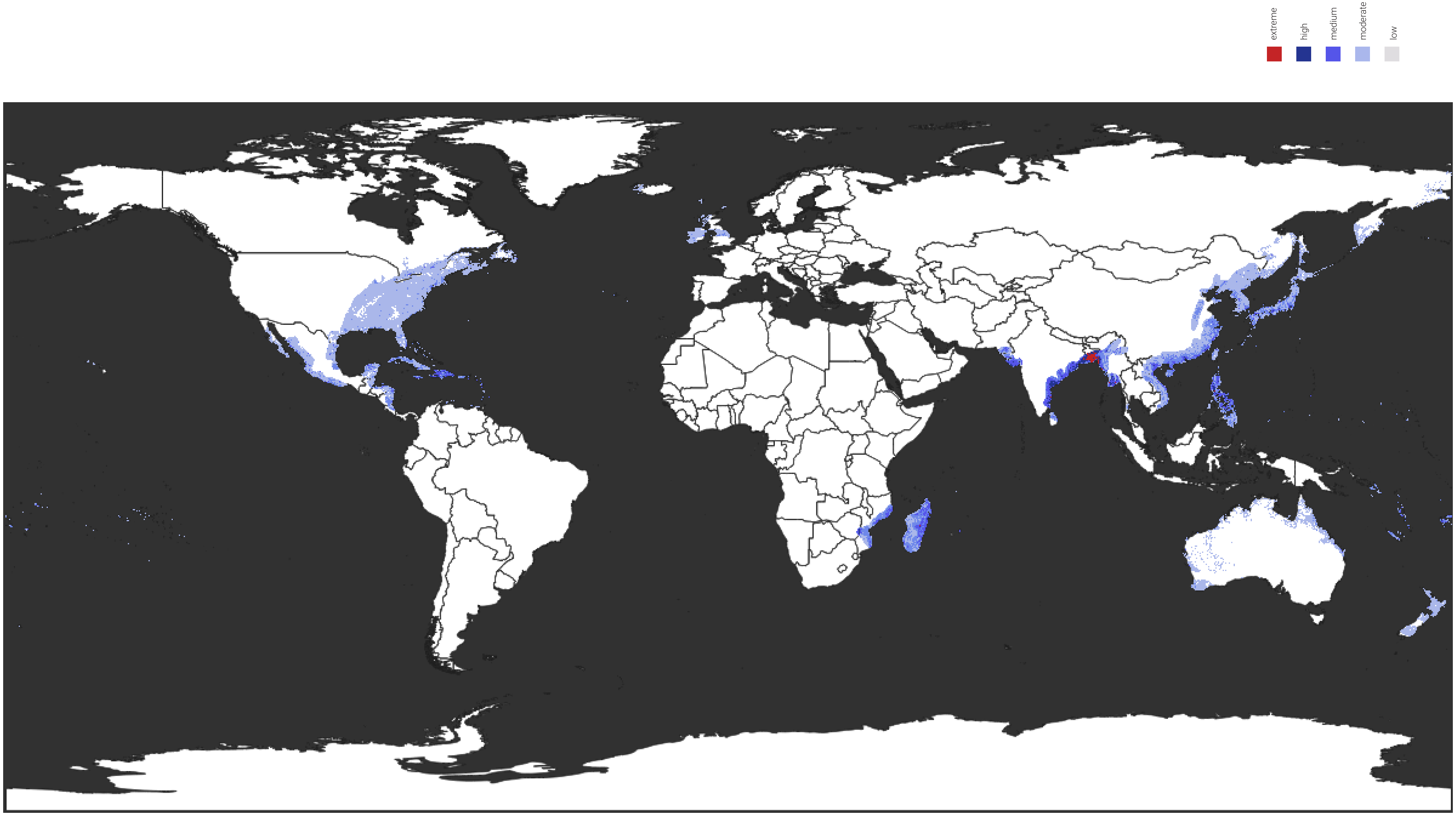


1.3.5C A global observation - *Physical exposure to category 5 tropical cyclones, 1975 - 2020*
Source: GIS processing map from Global Risk Data Platform and redrawn by authors



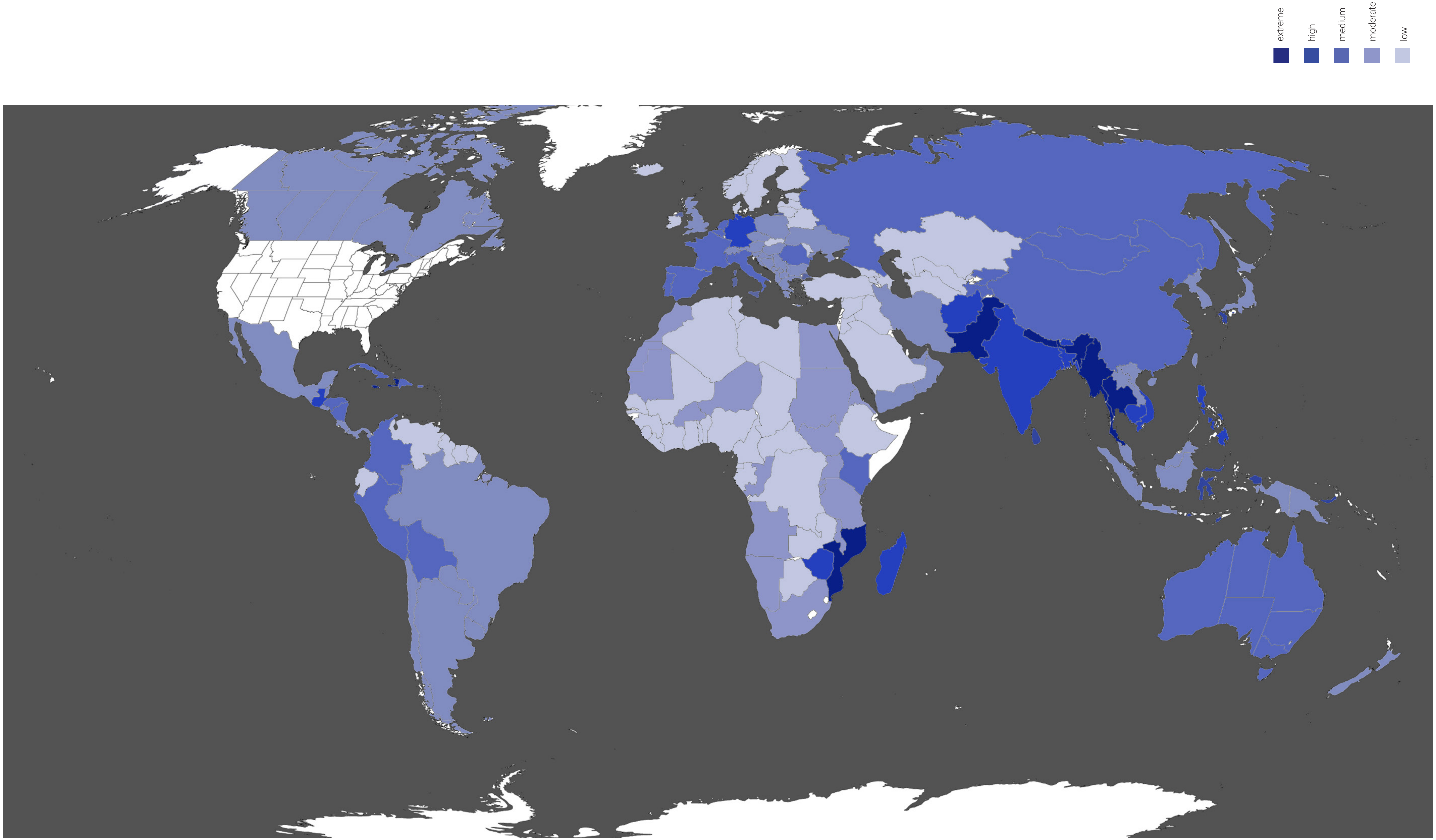
1.3.5D A global observation - *Economic exposure to category 5 tropical cyclones, 1975 - 2020*
Source: GIS processing map from Global Risk Data Platform and redrawn by authors

The potential for economic losses from cyclones due to a country's macroeconomic exposure is measured. Relevant indicators include the density of exposed economic assets, reliance on imports/exports, government debt, purchasing power, income inequality, and unemployement.



1.3.5E A global observation - *Global estimated risk index for the tropical cyclone hazard*
Source: GIS processing map from Global Risk Data Platform and redrawn by authors

The global estimated risk index helps to explain which countries will experience impacts from cyclones.



1.3.5F A global observation - *Countries most affected by extreme weather events, 2000-2019*
Source: Germanwatch Global Climate Risk Index 2021 and redrawn by authors

Most affected countries: Puerto Rico, Myanmar, Haiti, Philippines, Mozambique, The Bahamas, Bangladesh, Thailand

1.4 Building safe and resilient schools

Children's right to education are universal and apply regardless of the emergency situation (e.g. hazard impact, conflict) present at any given time. Education is key in a child's early development and by getting educated it can learn the proper skills needed in order to obtain coping skills and capacities. Once children are able to read, they are able to read emergency warnings and medical instructions, exercising their basic rights to life and health (e.g. how to access healthcare or protect yourself from AIDS).

The extent to which a school is safe will depend on its location, construction, and operation. Four factors contribute to reducing risk:

- hazards

- site location

- physical planning

- quality of buildings

(GFDRR)

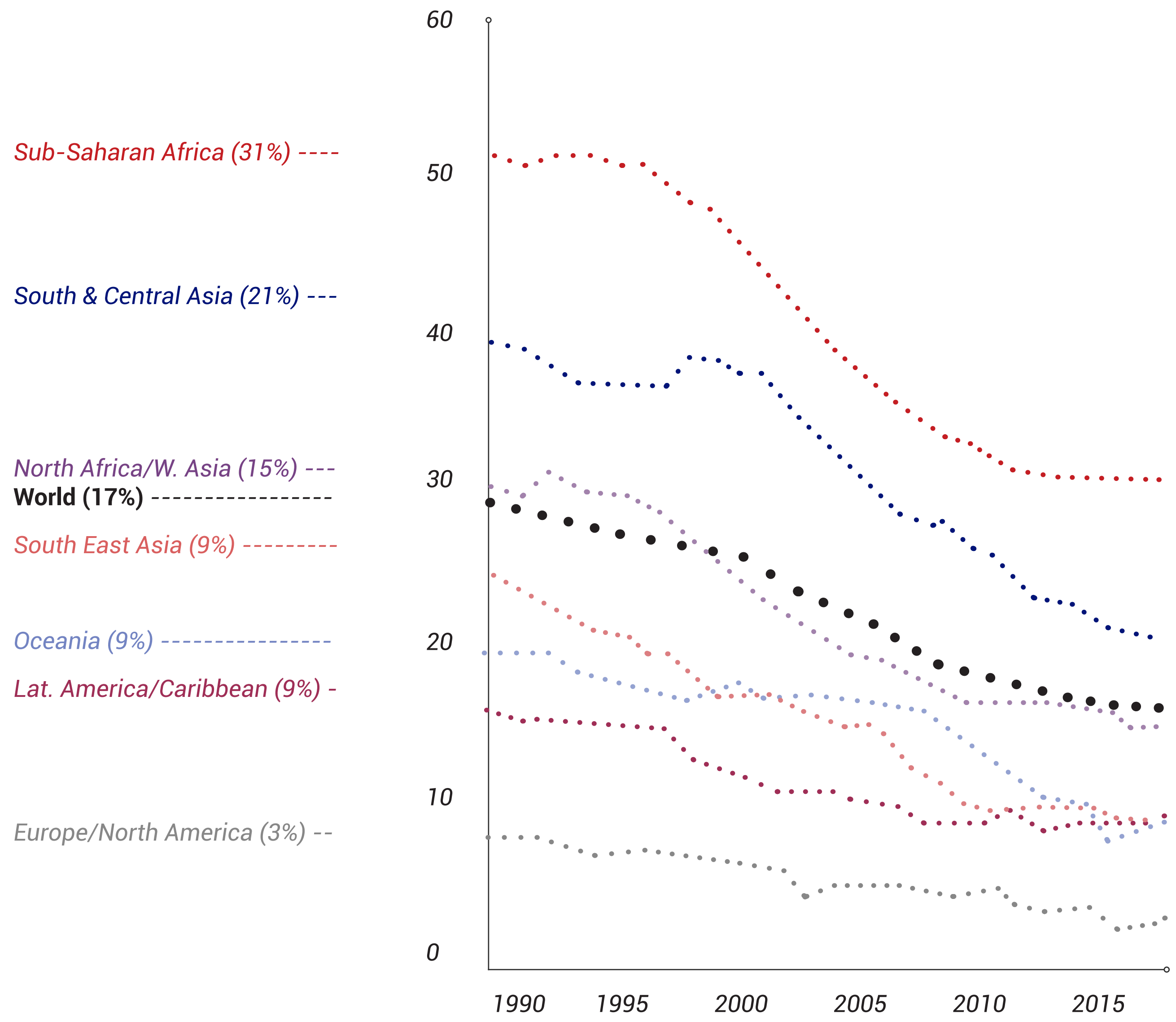
Access to education is a responsability of national or local governments. In emergency situations, if the national authority is not meeting this obligation, this responsability is delegated to NGOs, CBOs, UN and simillar international,national, and/or regional organizations. The availability of education, especially in emergencies, provides safe learning spots where youth in need of assistance can be sustained and aknowledged. For much of the youth in poor countries schools represent the gateway to indispensable support that goes beyond education, such as acess to water, sanitary services and food. The cognitive shock that hazard impacts or conflict situations cause can be mitigated by the security, support and sense of routine a safe learning environment provides.

Safe schools need to be capable of sucessfully enduring hazardous events without catastrophic structural failure and human fatalities. While it is acceptable for the building to sustain cracks, failiure should be confined and the people inside able to exit the building unharmed.

A school is a key player in increasing a community's resilience.Quality education spaces double as a shelter from external crisis and exploitation. In an emergency situation, the continuum of school attendance is imperative and accelerates the rate of recovery. Educational structures often double as refugee, logistics and resource senter in the post-disaster recovery process.
A community-based approach to building safe and resilient schools support the disaster risk reduction of the localized area. Decrease in the vulnerability of schools is tightly correlated with the engagement the community itself has with the planning and construction, whether it is a direct involvment or in the form of communication and engagement with the community.

Figure 8>
Out-of school rate of primary and secondary school-age children, adolescents and youth by region (1990-2018)

A quarter of a billion children, adolescents and youth are not in school.



Source: Global Education Monitoring Report (2020) and modifyed by thesis authors

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Chapter 2

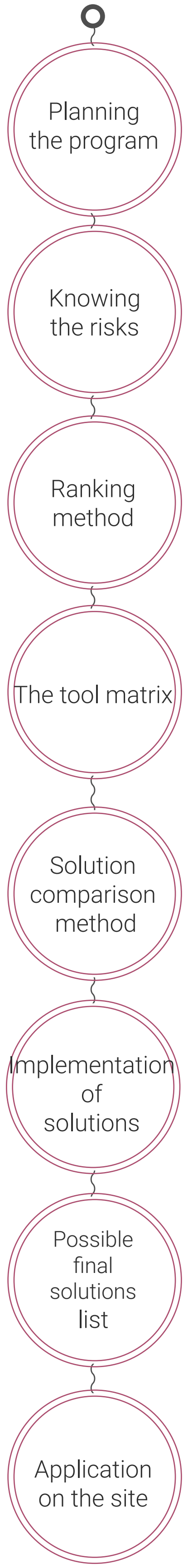
From Investigation to Action

**The following chapter is a result from a team effort consisting: Andrea Matevska, Jana Tosheva, Erika Cerra and Juan Pablo Benavides and it will be noticed in all of our theses.*

This chapter selects the possible existing, reformulated, and new tools and methodologies to be adopted in a structured way to collect, analyze and systematize information on the dangers and vulnerabilities to such dangers of a given community. This information is used to diagnose and classify natural or man-made multi-hazards present within the community, from which to develop a new analysis tool, called "The Tool Matrix", which allows us to develop action matrices. for the individual Hazards studied and for the problems inherent to the educational system.

The developed matrices are subsequently compared and expanded through the identification of the needs and capabilities of the community involved in the process, in order to derive the best action solution to be adopted within the project. The chapter emphasizes the importance of the community in the choice of actions, and identifies which tools may not be participatory in the event that there is no possibility of involving the community (see the case study).

The purpose of the new tools and methodologies is therefore to facilitate the reading and identification of action solutions in relation to the problems, needs and abilities of the place of study, with the aim of creating a resilient and resistant to climatic and social problems.



2.1 Planning the Program

2.1.1.How to start

2.1.1.1.The CCDRR and VCA: What are they?

In order to evaluate the many risks and vulnerabilities of a community there exist various processes of investigation and instruments, the most used ones being developed by Plan International (PI) and International Federation of Red Cross and Red Crescent Societies (IFRCI). The former has developed the Child Centered Disaster Risk Reduction (CCDRR) which takes "An approach that fosters the agency of children and youth, in groups and as individuals, to work towards making their lives safer and their communities more resillient to disasters" (Plan International, 2018) (1); while the one developed by the IFRC is the Vulnerability and Capacity Assessment (VCA).

VCA uses a series of participatory techniques to collect and analyze information that allows you to have a better understanding of what problems and vulnerabilities are present in a community, and to identify which risk should be prioritized. They build sustainable solutions that the community can develop and implement by leveraging their capabilities. With this tool, people and local communities become the core, active participants in the development initiative, so that people are more fully involved in identifying risks and designing programs and actions to prepare for disasters (2).

1) Plan International (2018) Child-Centered Multi-Risk Assessments: A Field Guide and Toolkit, United Kingdom: Plan International.

2) IFRCI (2006), What is VCA? An introduction to vulnerability and capacity assessment, 2006.

2.1.1.2. The Need of the Community Involvement

There is mounting evidence that most top-down disaster risk management and response programs fail to meet the specific local needs of vulnerable communities, ignoring the potential of local resources and capabilities and, in some cases may even increase people's vulnerability. Consequently, greater emphasis needs to be placed on community-based programs to ensure that there is a greater likelihood of the project being successful and lasting longer (3).

As reported above, both analytical tools adopted a participatory process with the community involved. Participation means that anyone involved in the process has a voice and the right to be included in the decisions that are made for a more inclusive process, which can better meet local needs. Community members, women and men, but especially children and young people should be involved to contribute and facilitate, the collection and analysis of information, to make sustainable and resilient decisions on how to deal with problems, derived from natural or human causes, specific to the context, without which there would be no possibility of understanding its local constraints (4).

Furthermore, the evaluation of the project process and outcome is essential to help the educational project work better. This can be planned for pre-established times during the activities, to take place in the middle of the project or after specific phases. The participatory evaluation exercise to examine the impact and results of the project takes place accompanied by the team, external evaluators and community members.

3) United Nations Human Settlements Programme (2018), Pro-Poor Climate Action in Informal Settelements 2018
The following paragraph intends to describe, in the form of subparagraphs, the steps to be implemented for the identification and selection of the participants in the analysis process (Team and community), summarizing the reasons why community involvement is essential in the analysis and definition of actions to be taken in the project.
For the development we use two great tools that will help define the steps to follow.

(4) INEE (2010), Minimum standard for education: preparedness, response, recovery 2010.

2.1.1.3. Identification, Selection and Planning the Participants

Step 1 - Identify and consult Key Stakeholders: The community must be involved at the start of planning and throughout the evaluation, to ensure that the proposal is accepted by wide range of stakeholders, based on existing resources, skills and activities. It is therefore important to identify who are the interested parties in the evaluation process, to do this we are supported by some questions that can be asked:

- Who makes the decisions of the community?
- Who has influence on others?
- Who knows which interventions and activities have already been activated?
- Who should you ask for consent or approval?
- Who conducts the assessment?

Step 2 - Clarify the Reason of the Evaluation: To identify who will be the parties involved in the project analysis and evaluation process, it is necessary to clarify the reasons why the analysis tools are used and, depending on this, for whom this analysis process is carried out.It therefore becomes necessary to know the community, at least superficially, even before undertaking the research and choosing the analysis tools (Tools).Existing data sources are useful for familiarizing yourself with the community you will be working with (Government documents, Newspaper and magazine articles, National risk maps, Reports, etc), these help to understand the cultural and historical context inwhich the research will take place , including the physical characteristics of the place of study.

Step 3 - Selection Evaluation Team: it is important to determine who will be the people responsible for collecting and analyzing information for subsequent evaluation. Easy, safe and participatory analysis and evaluation requires training and building a team that is able to communicate effectively with participants and has excellent values across transversal skills, as well as knowing techniques in relevant fields such as DRR, community development and child protection. They can be people within the community or other external professionals. A solid team is composed of a minimum of 3 people (preferably 4 or 5), it does not have to be very numerous as it could hinder the creation of relationships and trust with the participants, in addition, a balanced team includes different ages and genders *1.

The roles of the team are specified within the Child Center multi-risk assessment:
- Leader Facilitator: Responsible for conducting participatory analysis activities and the creation of dialogue and discussion that promote inclusion and the active sharing of perspectives, opinions and learning.
- Co-Facilitator/Note Taker: Responsible for documenting discussions through careful note-taking, and the collection and archiving of all the outputs of the analysis activities.

Some Team's Skills *1:

- Ability to listen and facilitate discussion;
- Understanding of social diversity, with the ability to ensure a sensitive facilitation and analysis of vulnerability;
- Language skills;
- The ability to work with children and encourage their participation;

"Mortality rates for women tend to be higher in certain types of disaster. Women and girls may be less well nourished and may have worse access to health care than men and boys." 5

(5) IFRC (2007), VCA toolbox with reference sheets, 2007

Some key questions 6:
- Are there man-woman, boy-girl gender separations?
- can pregnant or married girls participate in the process?
- can community members arrive safely at the assessment site?
- can the activities be followed by everyone, considering the day and time?

(6) Plan International (2010), Child Centred DRR Toolkit, 2010. https://resourcecentre.savethechildren.net/pdf/5146.pdf/

- Observer/Assistant: Assists Leader Facilitators and Co-Facilitators / Note Takers by organizing attendees, observing analytics activities and providing constructive feedback to improve participation, facilitation and documentation.
- Assessment Coordinator: It conducts the entire analysis through the effective management and supervision of time, people, resources and processes.

Step 4 - Select partecipants and Location: The word inclusion literally indicates the act of including children, young people and adults within a group, which follows the analysis process, in a meaningful and non-discriminatory way. For an efficient analysis and evaluation it is important that individuals and groups of a society, especially children and young people, take part in the process to enjoy their rights

During the analysis and evaluation process it is important not to generalize the experiences, especially those of women and children, but that the specific risks, vulnerabilities and capacities of the different member groups of the community are identified. Participants chosen must reflect a diversity of experiences in the community, therefore participants should be men, women, girls and boys of different ages and other representatives of vulnerable subgroups who do not have easy access to educational infrastructure (marginalized such as young mothers, households with breadwinners , separated and unaccompanied minors, etc.).

Both in disasters and in ordinary and daily life, the experiences of men and women can differ. It is necessary to be aware that in some societies attitudes about gender issues can be at odds with the participation tools promoted. Consequently, it can be difficult to allow women and girls to participate fully in the process and / or gathering of information that reflects the different risk experiences of men and women, and therefore, can influence the wayinformation is collected, analyzed. and used to decide the activities to be carried out. Therefore, this process will have to be handled delicately (5).

The planning of groups and the workplace for the process of gathering information and using the tools implies awareness of gender and age differences (6):

- Gender: To effectively identify specific problems, it is recommended to work with separate sex groups. As anticipated before, working with mixed groups may not be culturally appropriate, in some contexts, and therefore, groups of different sexes could be a positive requirement for the analysis.
- Ages: It is recommended to work with age-separated groups such as children (8 to 12 years), teenagers (13 to 17 years), young people (18 to 24 years) and adults. This is useful to ensure that the analysis is as representative as possible of the needs for each individual requirement.

Finally, it may be necessary to schedule sessions at different times of the day for women and men or for different ages in order not to compromise the analysis and evaluation process.

2.2 Knowing the Risks

2.2.1. Basic Concepts

Natural hazards do not discriminate, but it is clear that societies in the poorest segments are often the most vulnerable to the impact of disasters, due to the place and conditions in which people live and work and their slow ability to recover from a disaster. People exposed to risk differ based on their class, gender, ethnic identity, age and other factors.(7) Indeed, economic and political factors often determine people's level of vulnerability and the strength of their ability to resist, cope and recover. Vulnerability is greatest where poverty and / or inadequate social protection make people less able to resist risks (8).

2.2.2.Key Terms

Defining the key terms allows you to discuss the topics with the participants and they will be in a better position to recognize the areas that need the development of projects, to better meet the needs of the community.

• Hazard: any natural phenomenon or situation, in a certain period of time and geographic area, which has the potential to adversely affect human life, property to the point of causing a disaster such as disruption or damage to infrastructure and services, to people's health, their properties and their environment. The methods of forecasting hazards (namely their probability and frequency of occurrence) vary widely according to the type of hazard; (9)

• Vulnerability: they are a combination of interrelated and dynamic factors, such as physical, social, economic, environmental and institutional factors that influence the susceptibility of individuals, families, communities and society to possible risks and dangers. One way to understand vulnerabilities is to group or classify them into the following six categories: human vulnerability, physical vulnerability (e.g. poor people who have few physical resources, basic services, materials, and others, are more vulnerable to disasters and have a harder time surviving. and recovering from a disaster), economic vulnerability, social vulnerability (people who have been socially or economically marginalized are vulnerable to suffering from disasters, while people who belong to well-organized groups in which there is a high mutual commitment suffer less when a disaster occurs), natural environmental vulnerability (the uncontrolled use of natural resources) and institutional vulnerability (people who have little faith in their ability to make change or little trust in the national institution and feel defeated by events they cannot control are more affected by disasters than those they have or a sense of their ability to bring about the changes they desire).(9)

(7) ADPC (2004), Community-Based Disaster Risk Management, field practitioners' handbook, 2004,p.14.

(8) IFRC(2008), VCA training guide, Classroom training and learning-by-doing, 2008

(9) IFRC, EVCA Resources, Key concepts: determinants of risk. Available from: https://www.ifrcvca.org/resources

Some Key questions:
- "Vulnerable to what specific hazard or what specific shock?"(8)
- "Why are some people more vulnerable to disasters in some places and countries than in others?" (2)

• Capacity: they are the combination of the resources, attributes and strengths of individuals, families, communities or societies to manage and strengthen resistance to the possible impact of a hazard.9 The capabilities of people in chronically disaster-prone countries that face multiple risks (such as drought, locust infestation and / or civil unrest) weaken over time, thereby reducing their ability to mitigate the effects of the next crisis. The capacities can be analyzed and assessed using the same classification used for vulnerabilities, but considering the available capital (human, economic, social, physical, natural, institutional).9 Recognizing the capabilities of the affected population is essential to design and implement responses to disasters that impact development.

• Explosure: it is the dangerous geographic location in which the individual, family, community, society, services, means of subsistence or other elements are subject to the potential risk of loss.(9)

• Disaster: The serious disruption of the functioning of society, causing widespread human, material or environmental loss, which exceeds the ability of affected communities to cope with it using their own resources.(9) Disasters occur when the negative effects of hazards are not well managed.

$$\text{disaster} = \frac{\text{hazard x exposure x vulnerability}}{\text{capacity}}$$

• Risk: The unexpected loss (in terms of human life, means of subsistence, property and / or economic activity) due to the impact of a given hazard on a given element at risk in a given period of time. The concept of Risk is a function of the correlated concepts of Hazard, Vulnerability and Capacity. The relation of these elements is illustrated by a formula used by the International Federation and Cross (IFRC) to assess the potential impact of a Hazard on a community. The risk is greater, the greater the Hazards and the vulnerabilities of a community, in Function of their Capacity.(8)

$$\text{risk} = \frac{\text{hazard + vulnerability}}{\text{capacity}}$$

• Disaster preparedness: The readiness of communities and institutions to foresee and, where possible, prevent disasters, reduce their impact, as well as respond to and cope with their consequences.(8)

• Disaster prevention: Actions aimed at avoiding the possibility of risk; activities to avoid the negative impact of dangers and means to minimize the related environmental, technological and biological disasters.(8)

• Disaster mitigation: Structural and non-structural measures taken to limit the negative impact of natural hazards, environmental degradation and technological risks.(8)

2.2.2. Hazard explosure - Vulnerability - Capacity Identification

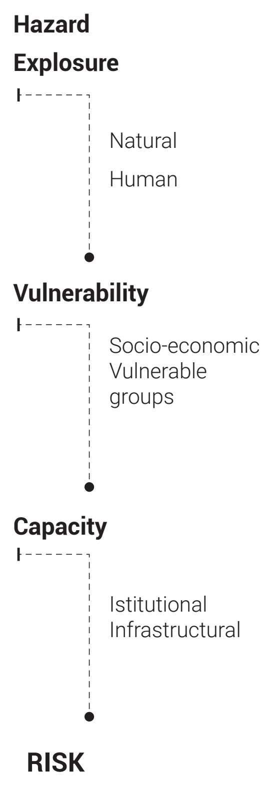
2.2.2.1. Description

This section provides the description of the different search tools (Contents and reworked by the CCDRR and VCA tools), involved in the analysis process, defining when (in the form of sub-paragraphs) and with which criteria to use the tools and what to do with the information collected. These will further help to understand who is involved in the different forms of investigation, how to work with the community and what to consider within the Tools. At this stage it is important that the team lead the development of the analysis tools and therefore have a basic understanding of how to conduct research.The aim is to analyze society and the environment, defining the main dangers for children, adolescents, adults and what are their vulnerabilities and risk exposures that limit their access to the educational system (also, according to their gender , age and ability). And finally to know which risk preparation skills the community possesses and applies.

2.2.2.2. The Research Tools

Tool 1 - Direct Observation (Community Not Involved)

This first Tool helps to collect and review existing data and written sources. It allows you to get a general picture of the community and the possible problems that arise within. Therefore, it is also indispensable in the phase of identifying the people, beloning to the community, who are involved in the process (Step 4 - Select partecipants and Location). These documents, data and sources from which information is gathered should not be limited to documents within the community, but should also include all external sources of information that could be useful (e.g. risk maps or information on climate change , etc.).



10) Jim Good and Chales Dufresne, Disaster Management Community Baseline Data, A checklist for assessing community disaster vulnerabilities and capacities for response to disaster events, InterWorks, 21 April 2001.

The sources are often in the form of written material, therefore, the ability to read and understand (often complex) documents is a requirement that must be considered during the formation of the Team. The community selected previously will be involved after having carried out this primitive analysis, to communicate the research carried out to them and to collect any additional documents derived from possible discussions with the community.

A useful aid for research is the information checklist, devised by Jim Good and Chales Dufresne of InterWorks: "Disaster Management Community Baseline Data"(10). This list comes to our support both in this research phase and during the development of the subsequent

Tools. Here the list is not complete, but adapted to our purpose :

1. Location of Community:
• Rural;
• Sub-urban (within 5 km of urban services);
• Urban;
• Other.
2. Physical description of community:
• Location is mountainous;
• Includes floodplain or flash flooding hazard;
• Coastal;
• Elevation above sea level;
• Ease and ability to access this community during floods,
landslide, post-hurricane damege.
3. Climatic conditions (including extreme events and
changes in climate)
4. Demographics of the community
• Distribution of the population (age, work, gender):
• Daily routine (school-aged children in school, adult present
with children at home, working in fields, etc.);
• Average family size (under same roof);
• Community interaction.
5. Human vulnerability to disasters:
• What people are most at risk during disasters (ages, gender,
occupation)?;
• In what specific way are they vulnerable?.
6. Health and nutritional conditions:
• Malnutrition rate for children under 5;
• Infant mortality rate;
• Most common illness;
• Sanitation (availability functionality and type);
• What basic service exist?;
• Distance people have to travel to schools and health centres.

7. Physical vulnerability of the community:
• Grade:
- Building are built on level ground (0 - 2% grade);
- Buildings are built on low slope (3 - 5% grade);
- Building are built on medium slope (5 - 10% grade);
- Building are built on high slope (>10%);
• Situation of community on or near streams that do or may
flood:
- River banks, not elevated structures;
- River banks, but with elevated structures;
- Flood plain;
- High ground;
• Important physical structures, buildings and infrastructure
most vulnerable to disaster:
- List types and the kinds of disasters they are
vulnerable to.
8. Housing and Infrastructure
• Type of housing and other infrastructure;
• Construction materials, design and proximity of buildings;
• Vulnerability of buildings and materials;
• Green spaces and playgrounds. 9. Water
• Water source for community;
• Water source vulnerable to flooding;
• Quality of the drinking water source.
10. Local capacities for disaster mitigation and
response
• Physical/material resource and capacities;
• Technical skills/human resource in the
community;
• Social/organization capacities in the community.

Table 1) Checklist developed by Jim Good and Charles Dufresne 10 with changes made by the author of the thesis

Tool 2 - Focus Group (Community Involved)

It is an interview tool for selected groups of individuals, led by a facilitator, expressing a deeper perspective on how community members experience problems, generating discussions on specific topics and gaining insight into how specific groups are thinking and coping a particular issue. It is a tool that can also be used in other subsequent phases.(5)
The selected participants come from similar backgrounds, who through their interests, activities or profession are involved in the issues. In addition, they must feel comfortable talking about the issue to be addressed, taking into account age, sex, race and economic context. At the end of the discussion, it is necessary to summarize the key points and make sure that the participants agree on the selection and invite them to make further comments.

Tool 3 - Mapping (Community Involved)

Mapping is a tool that consists of physically drawing a map (together with community members) to provide a broad overview of a particular area of interest by displaying in visual form the resources, services, vulnerabilities and risks and facilitating the discussion on the community issues.
The maps can be used to track the position of schools, water sources, shelters and places of risk (such as areas subject to floods or areas at risk to health), and indicate which of the groups are vulnerable.(5)
The participants involved (men, women and children of different ages) must be familiar with the area and must be open and willing to share their experiences and knowledge

The mapping can be done in groups of up to six people or individually, to then compare the maps later.1Very often maps drawn by groups of women illustrate priorities, resources and problems different from those drawn by groups of men; therefore, it may be necessary to have gender groups (women and men) to draw separate maps for later comparison.

This tool contains 3 types of maps, each of them identifying a different purpose (5):

• Hazard/Risk Map: Useful to indicate the areas and vulnerable people subject to dangers or risks and, which and when they pose a threat to the community;

• Spatial Map: Useful for having an overview of the main characteristics of the study area. These characteristics could include social environments (church, sports fields, commercial areas and main areas of concentration for children, adolescents, adults), physical environments (characteristics of public and private buildings, rivers, drainage, etc.) or neighboring communities (what is neighboring community, if this has an influence on the community involved in the analysis process);

• Capacity Resource Map: Useful for identifying local qualities, resources and capabilities.

Area photographs may be too detailed limiting the reading and accurate representation of the community; therefore, a graphical representation developed by hand by each participant is often more useful.

After making the maps we proceed with the collection of data to note which places are Safe or Unsafe, what are the potential risks and vulnerabilities, which part of society is involved and how the community can influence change through their qualities, resources and capabilities (Table 2).

Table 2) Developed by Plan International 6 and reformulated
by the author of the thesis.

Location	Safe	Un-Safe	Which Hazard	Which Vulnerabilites	Who Affects	Capacities
Home						
School						
Others: -Playground -Market -Workplace ..						

Tool 4 - Seasonal Calendary (Community Involved / Community Not Involved)

A seasonal calendar allows the community to view which risks, trends, events and changes occur during the period of a year and when. It is used to explore and classify hazards and seasonal changes and models related to natural or man-made hazards, such as weather models, hurricanes, floods, drought and conflict hazards, social and economic conditions 5.The calendar is represented by a graph containing on the vertical axis the list of significant events, activities and climatic phenomena, while, on the horizontal axis, the months of the year and the impact that these events have on the community and on the environment (Table 3). On the side page a random example (X =Heavy / x = high / x= low). analysis can help the community to rethink its lifestyle habits based on its vulnerability. The tool is also useful for understanding what individuals do during these times and their coping strategies.

Events/Type of Risk	Months											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dic
Cyclone												
Earthquake												
Flood												
Disease												
Drought Period												
Harvest Period												

Table 3) Developed by IFRC, VCA, Toolbox, p.98 5 and modified by the author of the thesis

Some key questions:
- How do events affect the economic situation of the community ?;
- What is the relationship between climatic events and diseases ?;
- What impact do the events identified on the lives of girls and boys of different ages ?;
- What are the relationships between the different categories identified ?;
- Which community members are most affected or influenced more significantly than others?

Tool 5 - Annual Calendary (Community Involved / Community Not Involved)

The annual calendar is a tool that collects information facilitating the understanding and identification of events that have occurred in the past that have affected the growth and development of the community (link between past and present in terms of health problems or dangers and vulnerabilities). This will give us a first help in understanding the frequency of one or more dangers that will take priority of action over other dangers. It also allows you to gain an understanding of trends, of the community over time, and how they may continue to change in the future.When choosing the participants (adults and young people) who will be involved in the discussion, it is important to identify the people who are able to provide information on the historical picture, one way to do this is according to age and time spent in the community, this it allows to identify a starting year and, moreover, to let new generations know how the community has evolved and the efforts made by previous generations.(5)
The calendar is represented by a graph (Table 4) containing on the vertical axis the topics for which you want to collect information (such as: food insecurity, hazards, land distribution or conflicts, etc.), with the related years in which the events occurred, while, on the horizontal axis, the impact they had on the community and the environment in terms of effects and losses.

(Table 4) Developed by the Plan International 6 and reformulated by the author

Year	Type of Hazard	Impact	Source of Info
	Cyclone		
	Earthquake		
	Flood		
	Disease		

In several countries around the world, children are often forced to work or engage in illegal activities to generate greater livelihoods within families, limiting their ability to attend school.

Tool 6 - Livelihoods and Capacities analysis (Community Involved)

Livelihoods can be defined as essential activities in which people use the resources they have available to support their lives. Often, for most people, this means the amount of capital in cash (tangible means of subsistence), but it does not only include this factor but any basic needs of a person, such as skills and education (food, water, shelter, cloathing, etc.), to ensure the basic necessities of life. It is the presence of the means of subsistence or the non-presence that determines the basic state of each person and therefore on his or her vulnerability.(5)
These also affect the adequate protection from specific risks and are influenced by the perception of the risk deriving from known dangers. For example, people who regularly experience flooding will surely have livelihood strategies that take these risks into account.

It is a powerful analysis tool to identify the influence that possible known risks (previously identified and selected) have on assets and resources that are crucial for the livelihoods of each family (community or individual). These assets can be divided into five vulnerability categories (5)(Table 5):

• Natural: Land, water supply, forest resources, fish resources, wild plants, etc.;
• Infrastructural: Homes, public buildings (example: schools), roads (example to reach schools), transport, electricity, sewers, water taps, wells, etc.;
• Financial: Savings, access to credit, debts, etc.;
• Human: Education, training, qualifications, skills, etc.;
• Social: Participation in the community, links in other villages or cities, links with a religious education, political party, etc..

(Table 5) Developed by the IFRC, VCA, Toolbox, p.118 5

Type of Hazard	Vulnerability Categories				
	Natural	Infrastructural	Financial	Human	Social
Cyclone					
Earthquake					
Flood					
Disease					
Drought Period					

Some key questions:
- What goods or resources are available within individual families?
- When a disaster occurs, what are the possible damages to assets and resources?
- What strategies for the protection of livelihoods are being applied or can be improved?
- What are the capabilities within the community to build safely

After having identified the categories of vulnerable vulnerabilities for each hazard, we move on to the development of a table that identifies the elements at risk, the impact of each Hazard on the element at risk and with which characteristics at risk elements contribute to the vulnerabilities (Table 6).

Table 6) Developed by the author of the thesis

Type of Hazard	Vulnerability Categories	Component at risk	Impact of Hazard to element at risk	Characteristics
Storms				
Earthquakes				
Floods				

By identifying the vulnerable areas of the community, of individual families or individuals, they identify what capacities they have to protect themselves from possible risks. The analysis of coping strategies focuses on what people do when they are hit by a danger (eg storms). These strategies are what the community (or the individual or family) relies on to maintain their livelihoods during and after a disaster.

Table 7) Developed by the author of the thesis

Type of Hazard	Component at risk	Capacities	Resource Used
Storms			
Earthquakes			
Floods			

2.2.3. Method 1 - The Ranking
(Community Involved / Community Not Involved)

2.2.3.1. Description

In this phase the community (or the project team) selects and prioritizes the problems and dangers among all those identified in the process. The identification of the most urgent, critical or most often cited problems by community members (who took part in the process) can be achieved through a classification process (Ranking Method) 5. In our case, the exercise will be limited to the identification and classification of the hazards and Hazards studied, such as Floods, Eathquakes, Cyclon and Storm, to proceed with the development of the Tool Matrices.

Some key questions:
- How does each problem affect the community? And why?
- What types of vulnerabilities exist in relation to each problem?.

2.2.3.2. Ranking Method

This method is useful for sorting and ranking a group of similar items that need to be compared (what are the main natural hazards that threaten the community? What they think is most important?) for the identification of multi-Hazards. The assessment takes place according to established criteria such as frequency (Which hazard occur most offen?) during a year or month, whether it occurs seasonally or only once in life and the effects in terms of lives and economics.

Table 8) Developed by the author of the thesis

Type of Hazard	Effect/ Loss	Rank
Storms		
Earthquakes		
Floods		

Once the priority Hazards have been established, the community re-examines the previously analyzed data to identify the impacts, in terms of vulnerability, that these have on the environment and society; and to reflect on the existing and desired capabilities needed to address or minimise the problem/risk identified.

2.3. The Action Plan

Here we intend to give an explanation on the development of the actions to be implemented after the analyses carried out with or without the community. The first part contains the development of matrices for different identified Hazards; while in the second part there is the application of a methodology that helps us to compare the solutions proposed, for each category group, from each hazard matrix. These want to be new tools and methologies to be applied continuously with the programs that have been supported (CCDRR and VCA)

2.3.1. Tool 7 - The Matrix
(Community Involved / Community Not Involved)

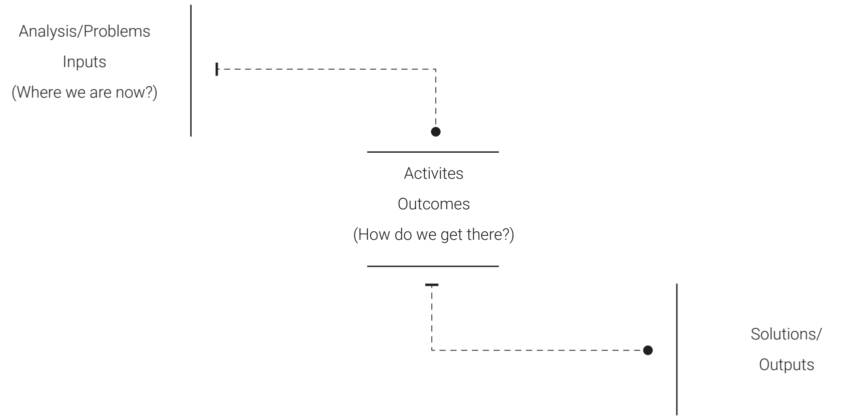
2.3.1.1.Description

The Tool defines the methodology for the development of matrices intended as a first strategic approach to the project, which will support the identification of possible resilient andresistant solutions to the problems identified in the risk analysis, to be used within the project and moreover, it can be understood as a tool for gathering the skills of the community in relation to a specific problem and need.

The matrices proposed in the following pages are non-exhaustive tools, knowledge of the problem and of the possible solutions that can be used in different global contexts and therefore on a large scale, therefore they require external support, such as general or local manuals and above all through direct cooperation actions with the community. local (therefore with the development of the process described above) for the collection of useful information, such as local cultural needs and solutions (economic, material, technological, volumetric, social solutions) in order to obtain the least impact on society and the environment.

2.3.1.2. The Steps for Development

To develop the matrices we use the analysis extrapolated in the process (through the use of tools) from which the problems and vulnerabilities (INputs) for each identified hazards are obtained. From the same analysis we collect useful information to identify the Needs / Activities (OUTcomes) to be carried out (How do we get there?).
Lastly, we identify the capabilities, as well as the best Solution/s (OUTputs) to be used for each extrapolated problem and need.



We therefore develop a table (Table 9) that contains the vulnerabilities (problems) identified for each Hazard (found through the Ranking Method) and the causes of these vulnerabilities, the needs and capabilities identified for each vulnerability, and finally the likely actions to transform vulnerabilities in capacity (Suggested Solutions). Capacities come to our support when the community itself identifies them, and moreover, they will be able to understand how to take actions based on the skills they already possess.

Type of Hazard	Vulnerability Factor	Causes	Capacities Identification	Needs Identification	Needs Identification
Storms	Vulnerability 1.1	Cause 1.1.1 Cause 1.1.2	Capacity a Capacity b	Needs a Needs b	Solution a Solution b
Earthquakes	Vulnerability 1.2	Cause 1.1.1 Cause 1.1.2	Capacity a Capacity b	Needs a Needs b	Solution a Solution b
Floods	Vulnerability 2.1				

(Table 9) Developed by IFRC, VCA training guide Classroom training and learning-by-doing, p.78 8 modified and reformulated by the author of the thesis

(11) Sphere Association. The Sphere Handbook: Humanitarian Charter and Minimum Standards in Humanitarian Response, fourth edition, Geneva, Switzerland, 2018.

(12) UNESCO, UNICEF(2014), Towards A Learning Culture of Safety and Resilience Technical Guidance for Integrating Disaster Risk Reduction in the School Curriculum, 2014.

The Needs / Activities are directly linked to the analyzes carried out and therefore require a knowledge of the place and the community that requires them.
In our specific case, the possibility of having a direct confrontation with the community is reduced, if not zero, with this we search for possible OUTcomes strategies from the information obtained and from the available programs that define design standards.
The matrix as a strategic approach seeks to respond to natural disasters associated with climatic conditions. For this reason, the needs that guide the design process derive from different plans, which are set out below.

1) Humanitarian Needs:

On the humanitarian level, we consider three manuals:
Humanitaria Character and Minimum Humanitarian Standards in Humanitar ian Response (Sphere, 2018), which provide practical, albeit rather general, guidance for planning, managing or implementing an adequate humanitarian response. The characteristics of the Shelter therefore reflect the importance of fulfilling physiological and safety needs in the first place, as well as laying the foundations for satisfying the needs of belonging, esteem and self-fulfillment. Therefore, some guidelines relating to the following areas are made explicit: liveability, privacy, safety, adequacy of spaces and materials, natural light and ventilation, thermal comfort, accessibility to health services (11);
L'INEE Minimum Standards for Education (The Inter-Agency Network for Education in Emergencies, 2010) provides key actions and guidance notes. The manual aims to improve the quality of educational preparation, response and recovery, increase access to safe and relevant learning opportunities and ensure accountability in the provision of these services. Therefore, some guidelines relating to the following areas are explained: Equal Access, Protection and well-being (4);
Towards A Learning Culture of Safety and Resilience Technical Guidance for Integrating Disaster Risk Reduction in the School Curriculum (United Nations Educational, Scientific and Cultural Organization, 2014) this technical guide recognizes the importance of adopting a holistic education framework for risk and resilience. In addition to considering natural hazards, this framework examines the man-made risks that the education sector faces, such as violent conflict. While not dealing with this topic in detail, the guide supports the integration of conflict risk reduction and DRR (Disaster Risk Reduction) in education.(12)

These guidelines were useful for identifying the Safe Criteria / needs to be adopted in the education sector, considering the socio-cultural context, natural hazards and violent conflicts, such as: Equal Access (in and around the school) considering an inclusive environment (in terms of location, gender, lenguage, race, religion and learning environment), flexible and accessible; Quality of education in terms of protection and well-being and appropriate facilities and services. (4)
The needs described above must necessarily be accompanied by the needs deriving from the condition of the pre and post disaster, whatever the surrounding conditions, two concepts remain valid: the need to control the temporal variable and the economic variable.

2)Needs in the climate context:

A further area that needs deepening is the climatic context in which the project is located, since the set of meteorological characteristics of a place substantially influences the needs of the individual who lives there and consequently the requirements that dwelling must meet. The needs adopted are limited to maximizing or minimizing ventilation and solar radiation and protection from rain and humidity. These suggest the best action to take in the climatic context in which we are.

3)Needs of the risk scenario:

In order to deal with natural disasters, such as floods in my case, risk prevention and mitigation measures play a fundamental role, which make it possible to reduce the vulnerability of people and potential material damage through planning and design tools, applicable to different intervention scales.Disaster Risk Reduction tools can include strategies regarding location, materials and construction techniques as well as design precautions. For the development of the actions / needs are listed the possible and already existing buildings resilient to floods high or not. Suggesting the best type according to the site where you are and the alluvial characteristics.

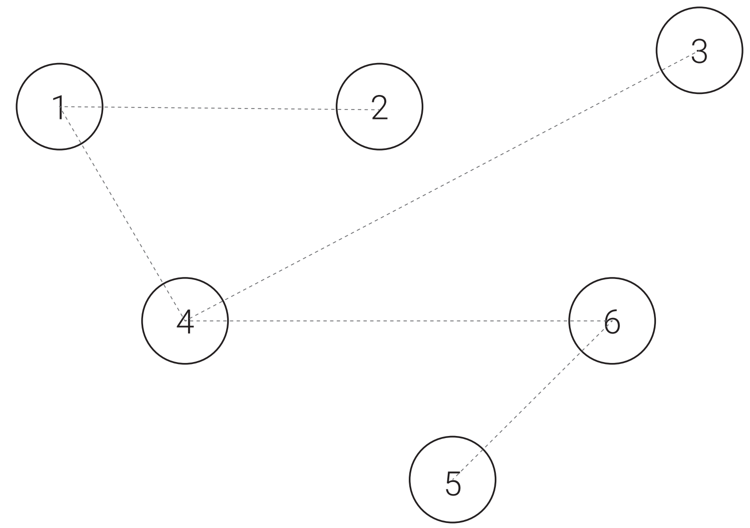
4)Compatibility and material durability Needs:

After carrying out an analysis on the availability of materials, economics and local construction techniques, it is important to identify which of the available materials are compatible with each other. The performance of the foundations, walls and roofing are dictated by the compatibility and durability of the materials and components. Various incompatibilities, as well as poor durability of the materials affect the overall duration of the building and minimize the benefit of the initial invested capital.

n the last phase, various usable solutions are defined which should not be understood as unique or irrevocable solutions but vice versa as strategic, cognitive and expandable tools from guides, manuals or the capacities of the community involved, for the subsequent development of the project.

2.3.1.3. What is a Matrix? Graphic Translation

Generally, the matrix can be understood as an agglomeration of elements that constitute the point of origin of a shape or space. To create the matrices and be able to simplify the collection and union of information, we use a structure known in mathematics as Grafo, whose application lies in a wide range of areas. This mathematical structure is supportive for its excellent schematization ability. What is a **Grafo**?: Basically, a graph is a set of elements, called Nodes connected to each other, through the use of lines called Arches.



For a simpler reading, the Graphs are then inserted into a particular device, such as the Adjacency Matrix, which identifies the final structure of the Matrix tool. This is defined in mathematics as a square binary matrix having as rows and columns the “names” of the nodes of the graph.The matrix will be filled in proximity of the connection point between two or more nodes, in case the graph itself has a connection between the same nodes.

	1	2	3	4	5	6
1	0	1	0	1	0	0
2	1	0	0	0	0	0
3	0	0	0	1	0	0
4	1	0	1	0	0	1
5	0	0	0	0	0	1
6	0	0	0	1	1	0

Another tool that ease reading of graphs and the Asking the development of lists of Solutions to adopt (explained of the next paragraph) is the Adiacence list to which it comes associated with every summit of Graph a list listing
all the vertices with which the same is connected;

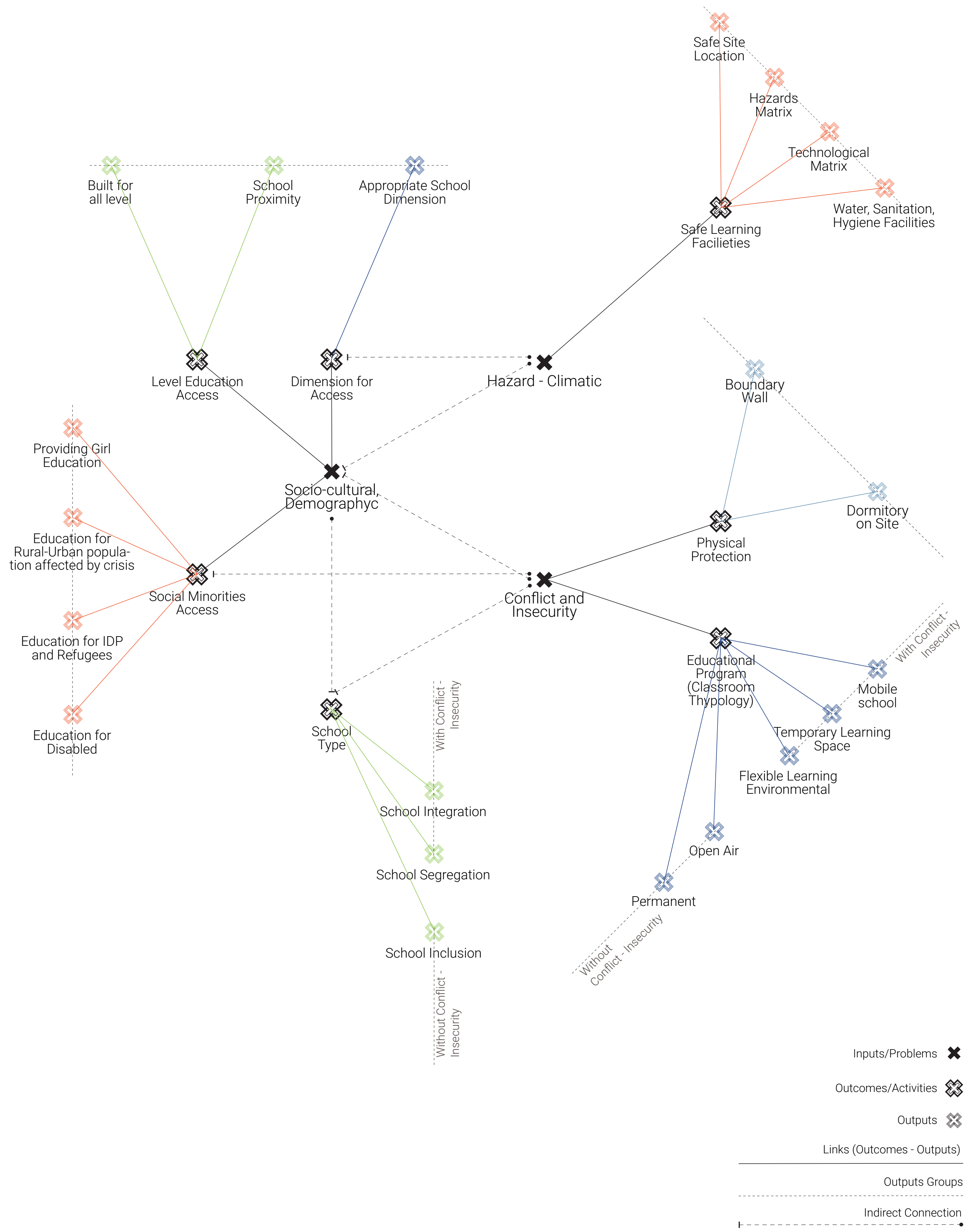
1 ⊢----• 2 ⊢----• 4
2 ⊢----• 1
3 ⊢----• 4
4 ⊢----• 1 ⊢----• 3 ⊢----• 6
5 ⊢----• 6
6 ⊢----• 4 ⊢----• 5

The Tool MATRIX

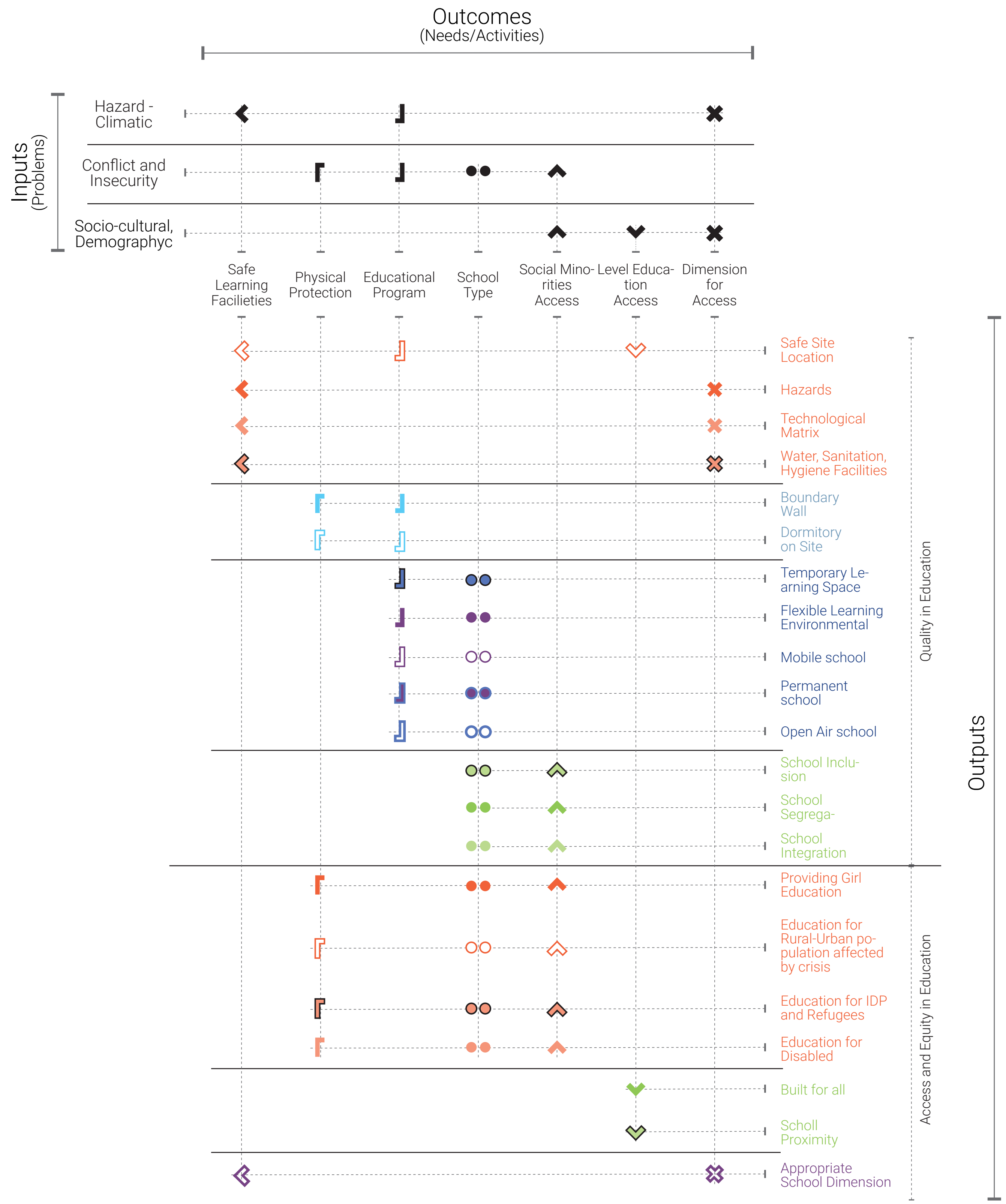
+ The other matrices

* *Flood Matrix*
* *Disease Matrix*

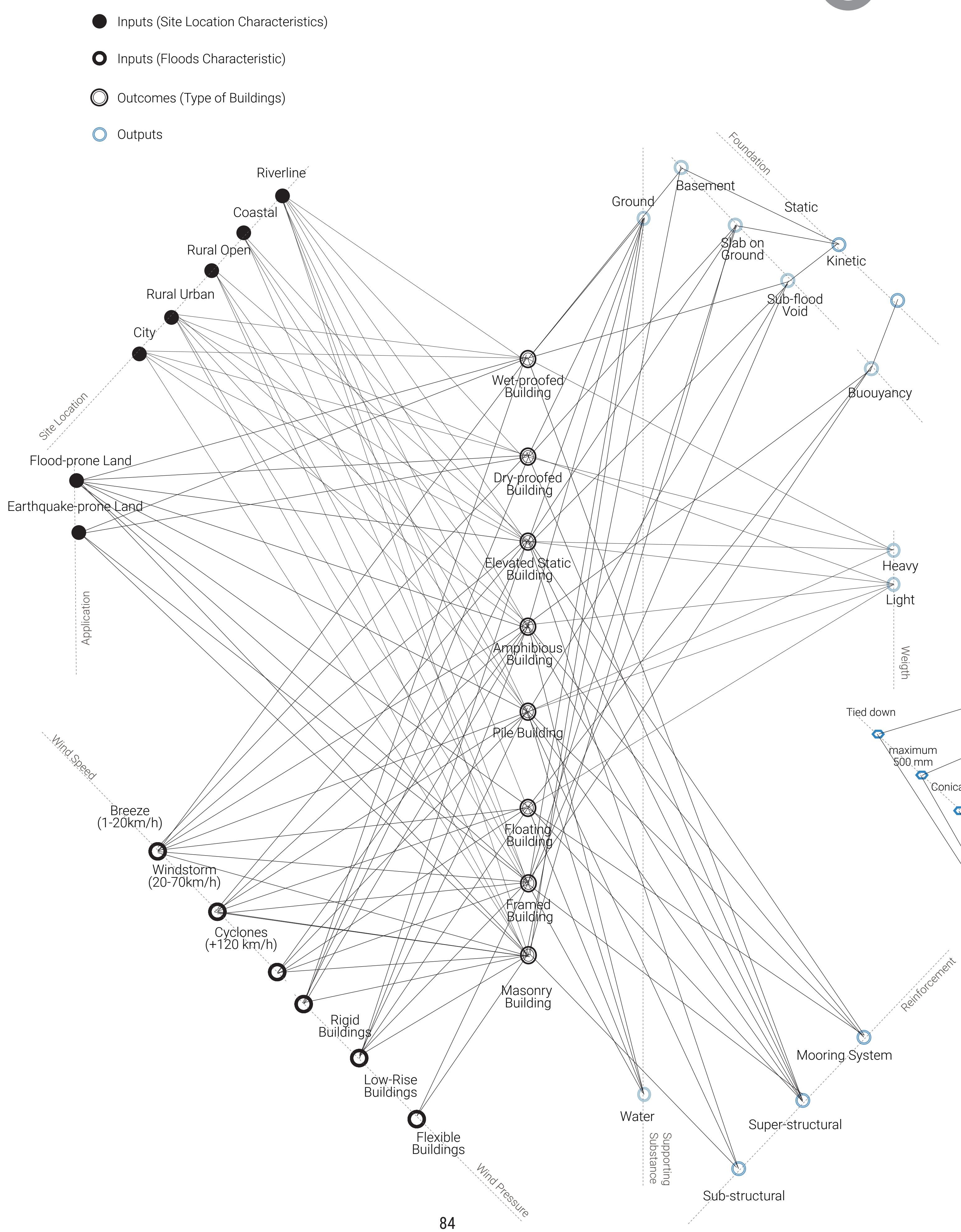
Education Grafo



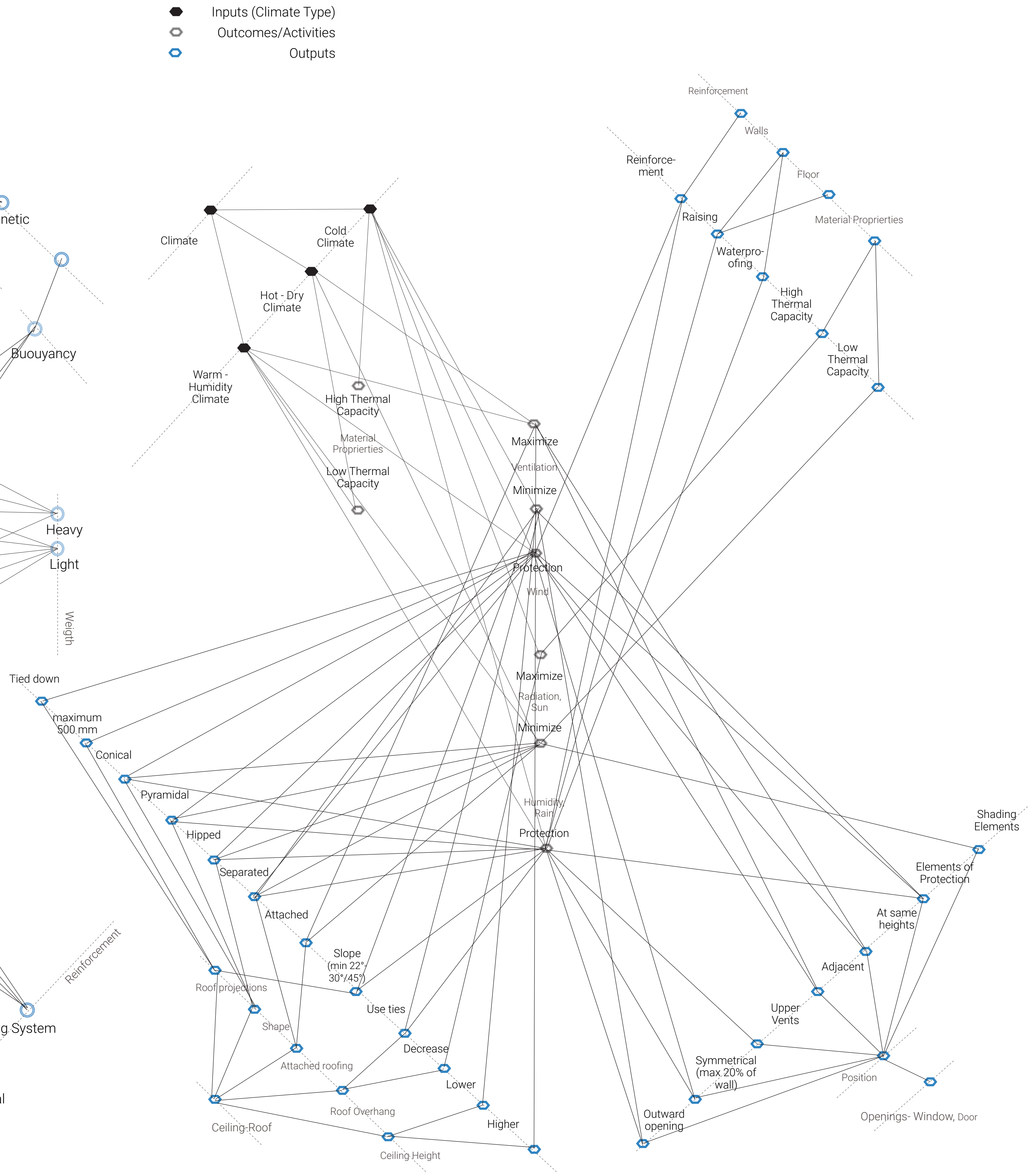
Edeucation Matrix



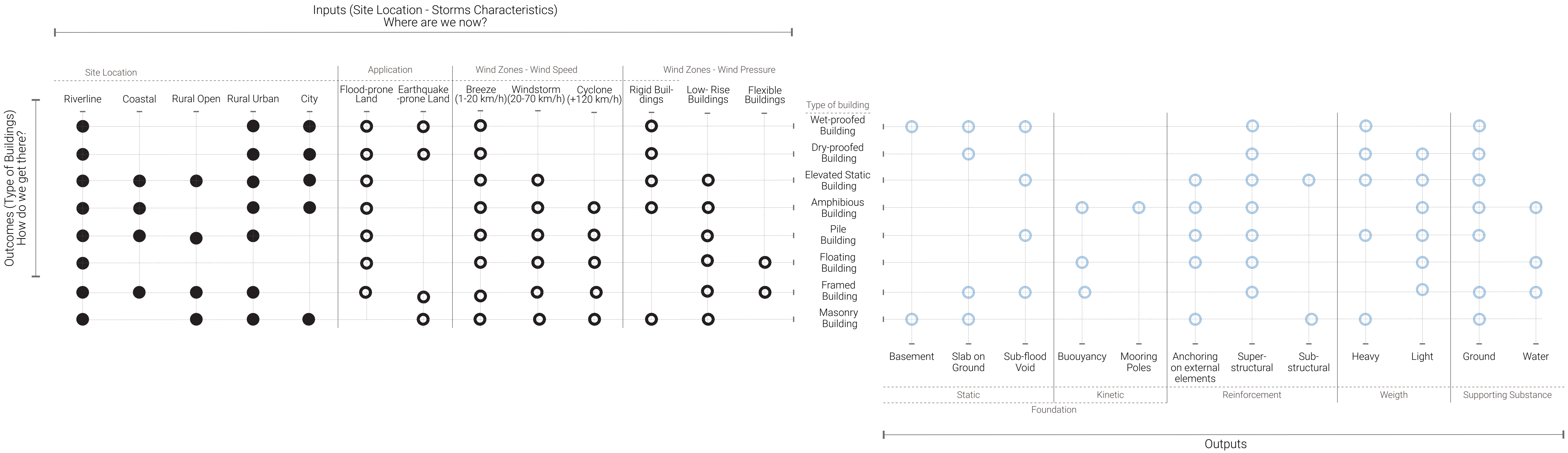
Storm Characteristics Grafo

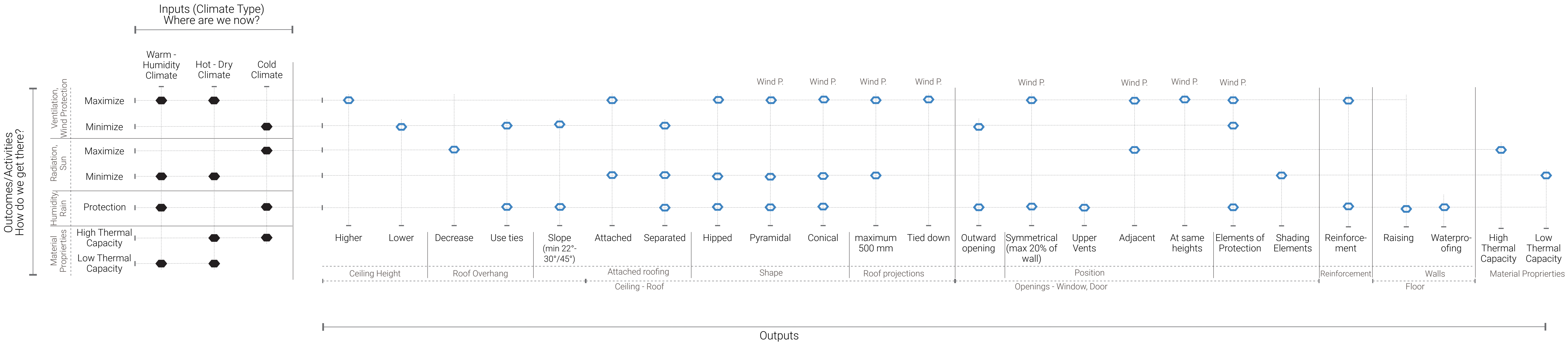


Technological Grafo



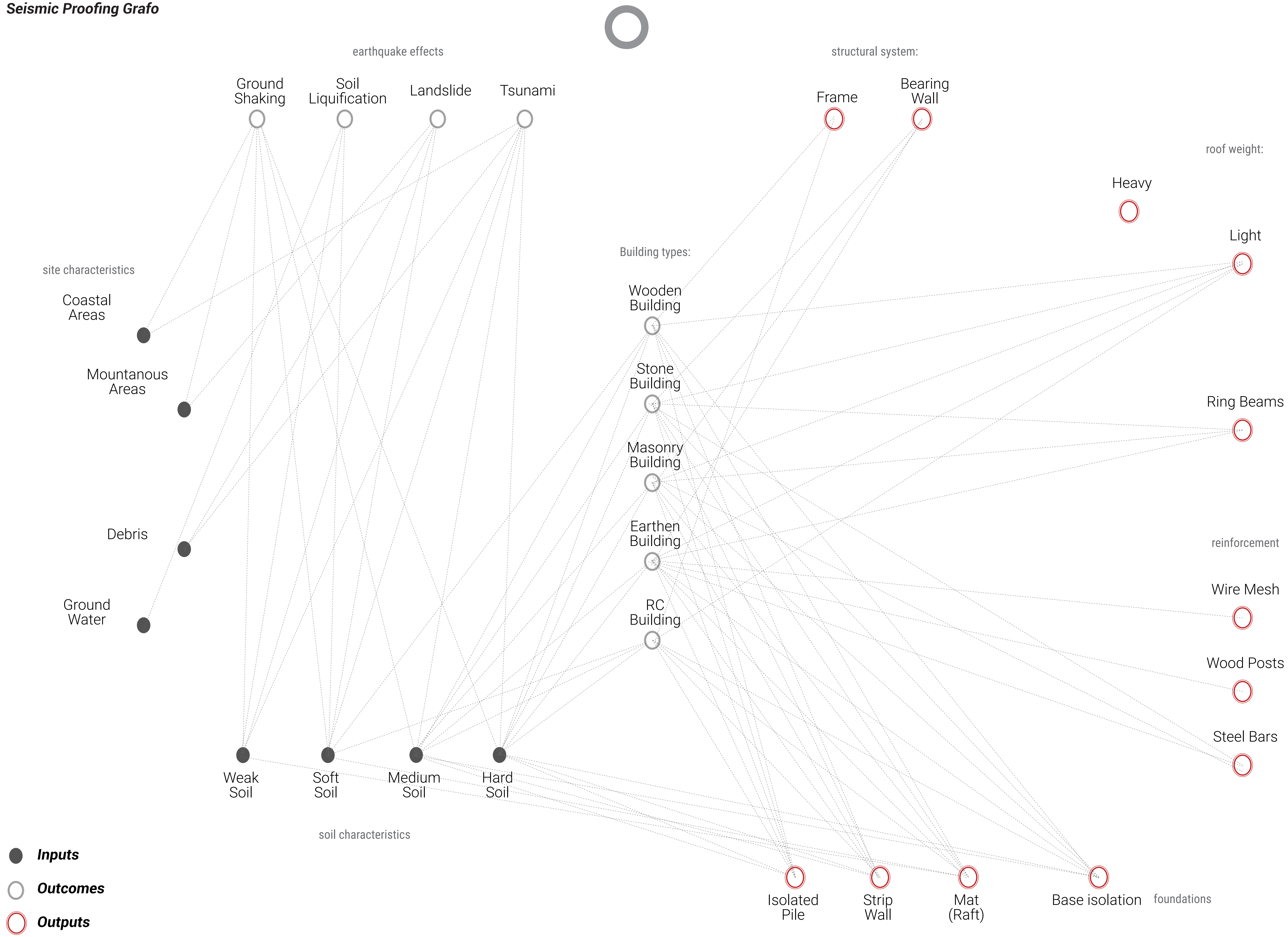
Storm Proofing Matrix

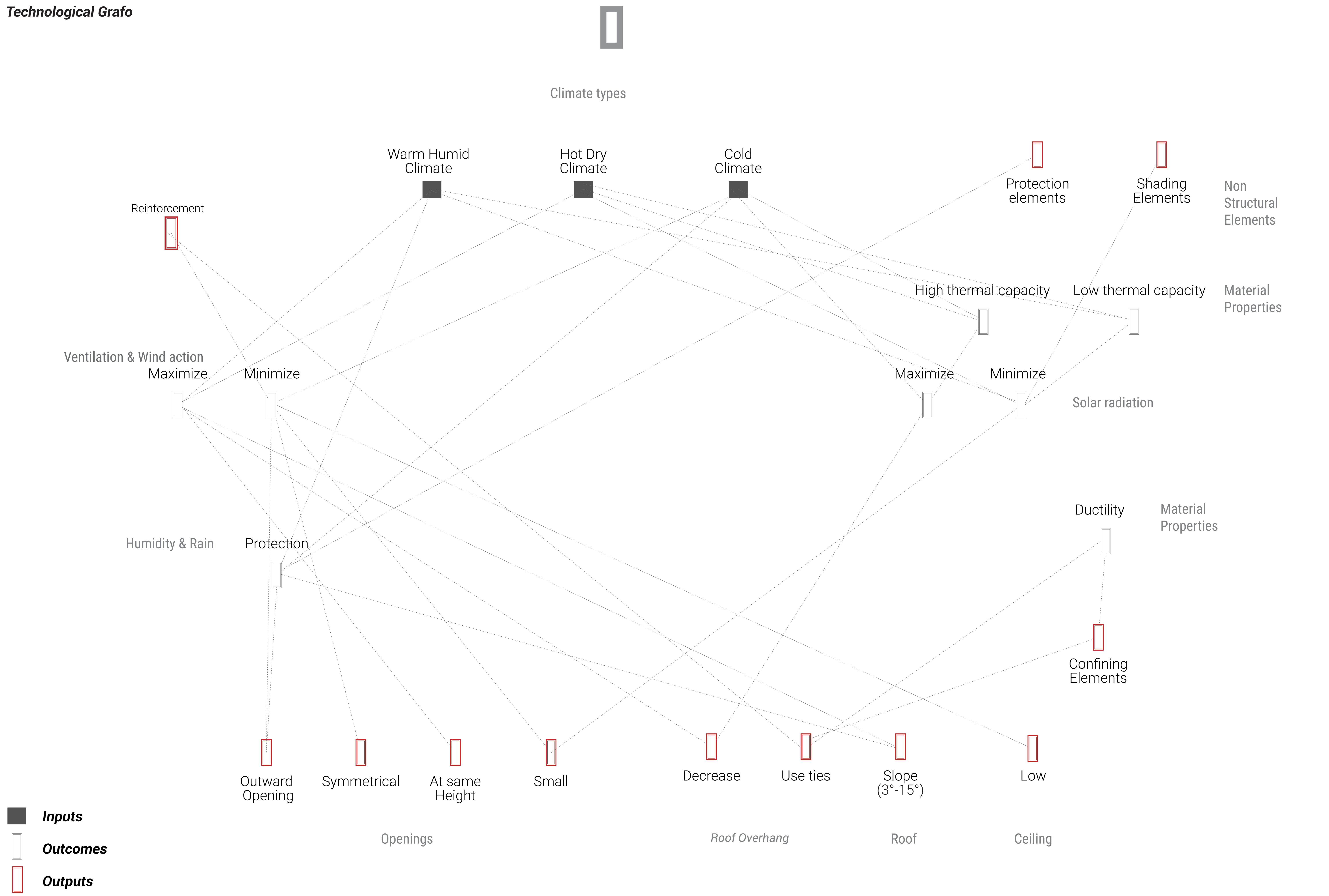




Technological Matrix

Seismic Proofing Grafo




Climate types
Warm Humid Climate
Hot Dry Climate
Cold Climate
Protection elements
Shading Elements
Non Structural Elements
Reinforcement
High thermal capacity
Low thermal capacity
Material Properties
Ventilation & Wind action
Maximize
Minimize
Maximize
Minimize
Solar radiation
Ductility
Material Properties
Humidity & Rain
Protection
Confining Elements
Outward Opening
Symmetrical
At same Height
Small
Decrease
Use ties
Slope (3°-15°)
Low
Openings
Roof Overhang
Roof
Ceiling
Inputs
Outcomes
Outputs

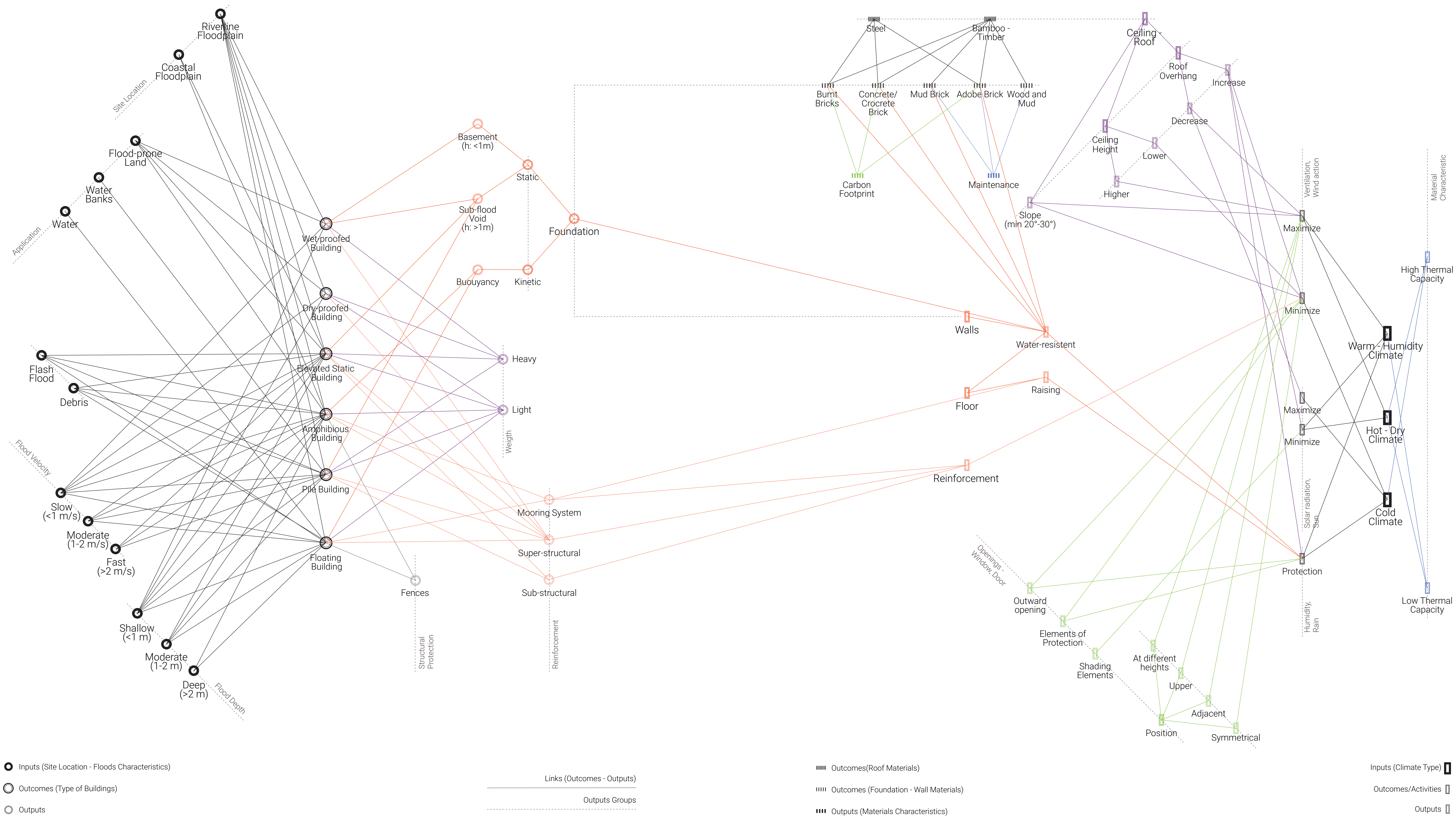

Outcomes
Outcomes
Types of non-engineered buildings
Outcomes
Earthquake effects
Inputs (Location)
geography
soil profiles
Coastal area
Mountanous Area
Weak
Soft
Medium
Hard
Debris
Ground Water
Wooden Building
Stone Building
Masonry Building
Earthen Building
RC Building
Ground Shaking
Soil Liquification
Landslide
Tsunami
Frame
Bearing Wall
Heavy
Light
Strip Wall
Isolated Pile
Mat (Raft)
Base Isolation
Ring Bands
Steel bars
Cane/Bamboo Posts
Wire Mesh
Structural System
Roof Weight
Static
Kinetic
Foundation
Horizontal
Vertical
Reinforcement
Outputs
Outcomes/Activities
How do we get there?
Material Proprierties
Ventilation, Wind Action
Solar Radiation, Sun
Humidity, Rain
Ductility
Inputs (Climate Type)
Warm - Humid Climate
Hot - Dry Climate
Cold Climate
High Thermal Capacity
Low Thermal Capacity
Maximize
Minimize
Maximize
Minimize
Protection
Optimization
Ceiling - Roof
Ceiling Height
Roof Overhang
Low
Decrease
Use ties
Slope (3°-15°)
Openings
Position
Size
Outward opening
Symmetrical
At same heights
Small
Reinforcement
Confining elements
Non-Structural
Elements of Pro-tection
Shading Elements
Material Properties
High Thermal Capacity
Low Thermal Capacity
Outputs

Flood Proofing + Technological Grafo

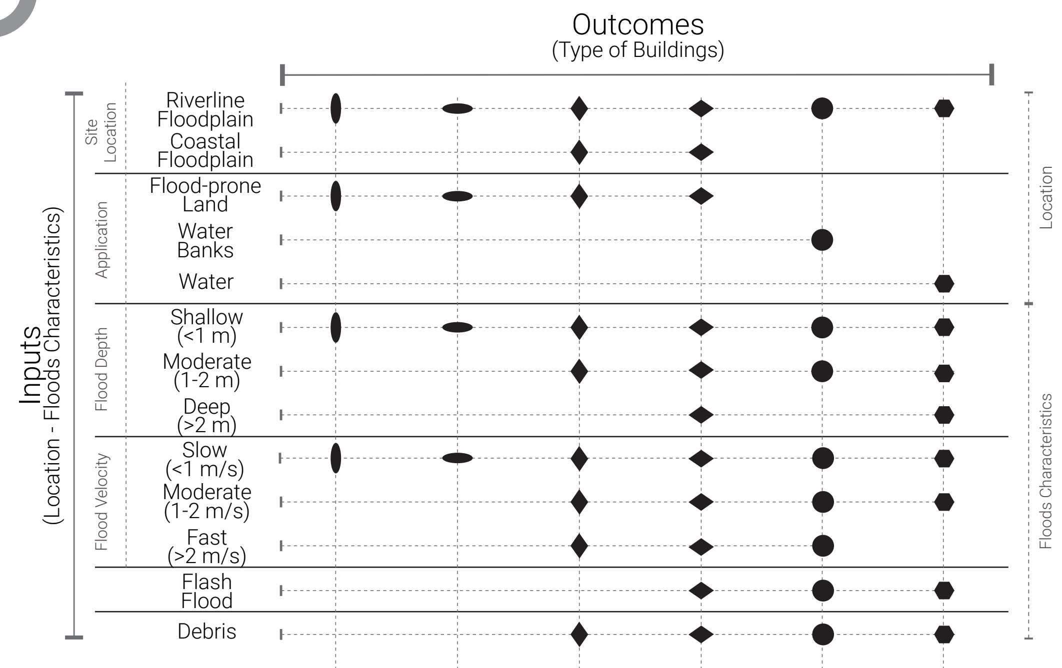
Flood Proofing (Resilient Solutions)

Materials Compatibility

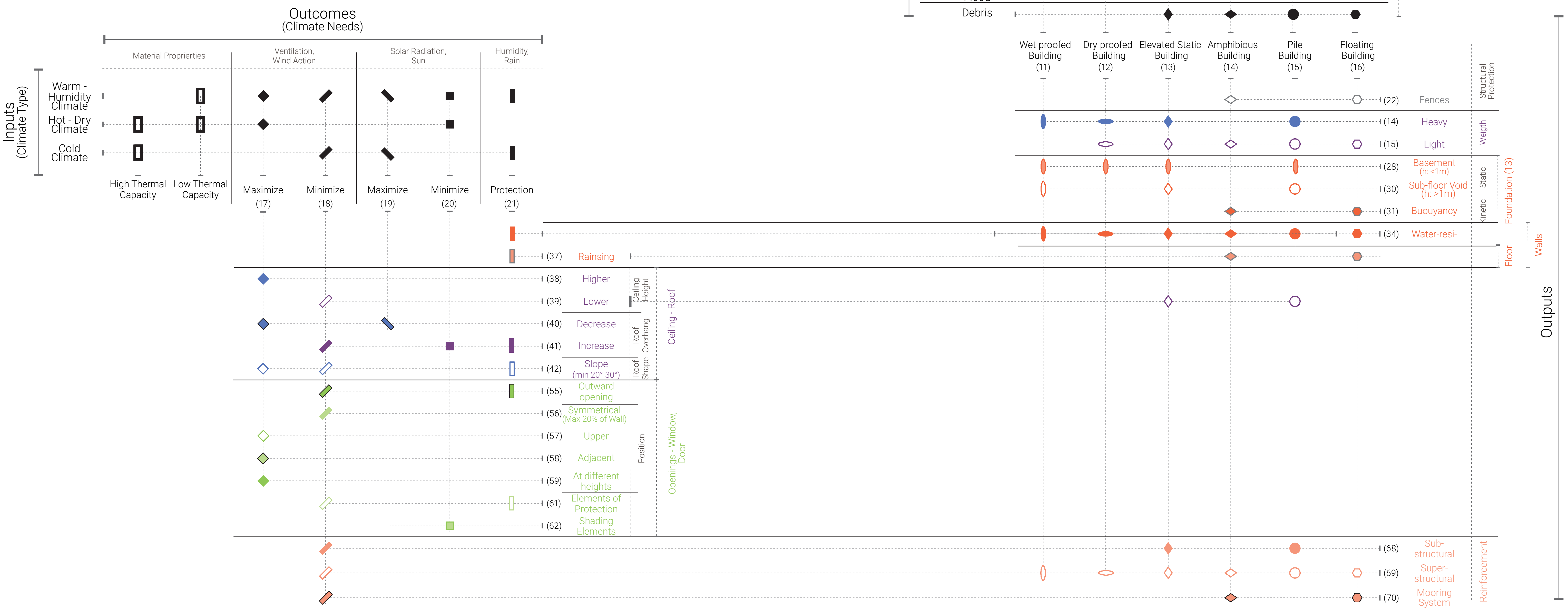
Technological Solutions



Flood - proofing Matrix



Flood matrix



Technological Solutions

Flood Proofing (Resilient Solutions) ([1])

	Site Location		WASH				Ventilation	
	Location: tropical zones	Location: Waterbody	Open defecation	Accesibility to higiene	Accesibility to drinkable water	Waste management	Lack of ventilaiton	Crowded spaces
Water borne diseases	○	○	○	○	○	○		
Air borne diseases				○			○	○
Vector borne diseases	○	○	○			○		

	Physical protection form vectors				Lifting the building			Toilets		Hand washing facilities			Water supply systems		Materials		Ventilation		Social distancing	
	Screening doors	Screening Eaves	Screening Windows	Screening Nets	Foundation: Slab on fill	Two store buildings	Foundation piles	Disaster-Resilient toilet	Waste management	Location close to the toilet	Materials	Accessibility to everyone	Ground water catch-ment system	Rain water catchment system	Roof: Iron sheet/corru-gated tin	Wall:Fired brick/ cement	Mechanical ventilation	Natural ventilation	Desk - chair spacing	Open and adaptable spaces
Water borne diseases					●	●	●	●	●	●	●	●	●	●						
Air borne diseases											●	●					●	●	●	●
Vector borne diseases	●	●	●	●	●	●	●		●						●	●				

2.4. Matrix Solution Comparison Methodology

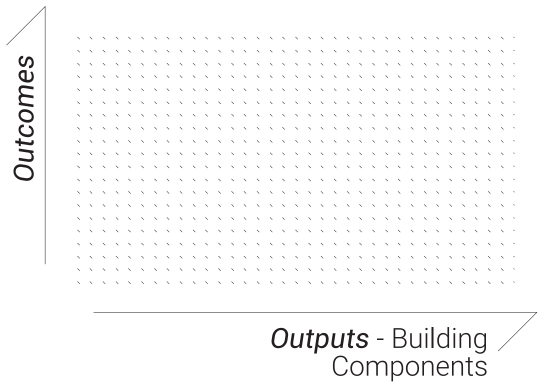
2.4.1. Description

The methodology that will be described below has the purpose of comparing the different solutions of the individual Hazards Matrix previously identified and classified by priority through the Ranking Method, therefore only in the case of Multi-Hazards.
For the graphic development we use only the OUTcomes and OUTputs (of each developed matrix), the latter divided into categories of groups (macro-groups) equally present in each Hazard Matrix.The final purpose is, therefore, to obtain a first list of solutions compared (1st Solution List), to then be able to move on to the next step which will be to implement the primitive list, considering the capabilities of the community, only in the case in which this will be involved.

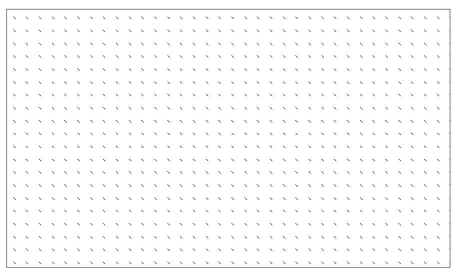
2.4.2. Graphic translation

The methods of synthesis and spatialization of the possible actions / solutions to be adopted are described below, experimenting with forms of representation in a graphic survey, which is an attempt to answer the questions of the analyzes posed previously.

_The axis



_The 2d space (action plan)



The axis
The plan is defined by the two axes correspon -ding to Outcomes and Outputs of each developed matrix;

The 2d space
It represents each Matrix broken down into macro-groups in such a way as to facilitate the overlap and identification of the solutions that can be adopted

The 4d space
The Ranking Method
allows the comparison between the solutions (Outputs) of each macro-group and therefore the choice of the best solution, from which to derive the 1st Solution List.

Legend (Outcomes - Outputs)

Outcomes (simbols)

- [1] Safe Learning Facilieties
- [2] Physical Protection
- [3] Educational Program
- [4] School Type
- [5] Social Minorities Access
- [6] Level Education Access
- [7] Dimension for Access

Outputs (colors)

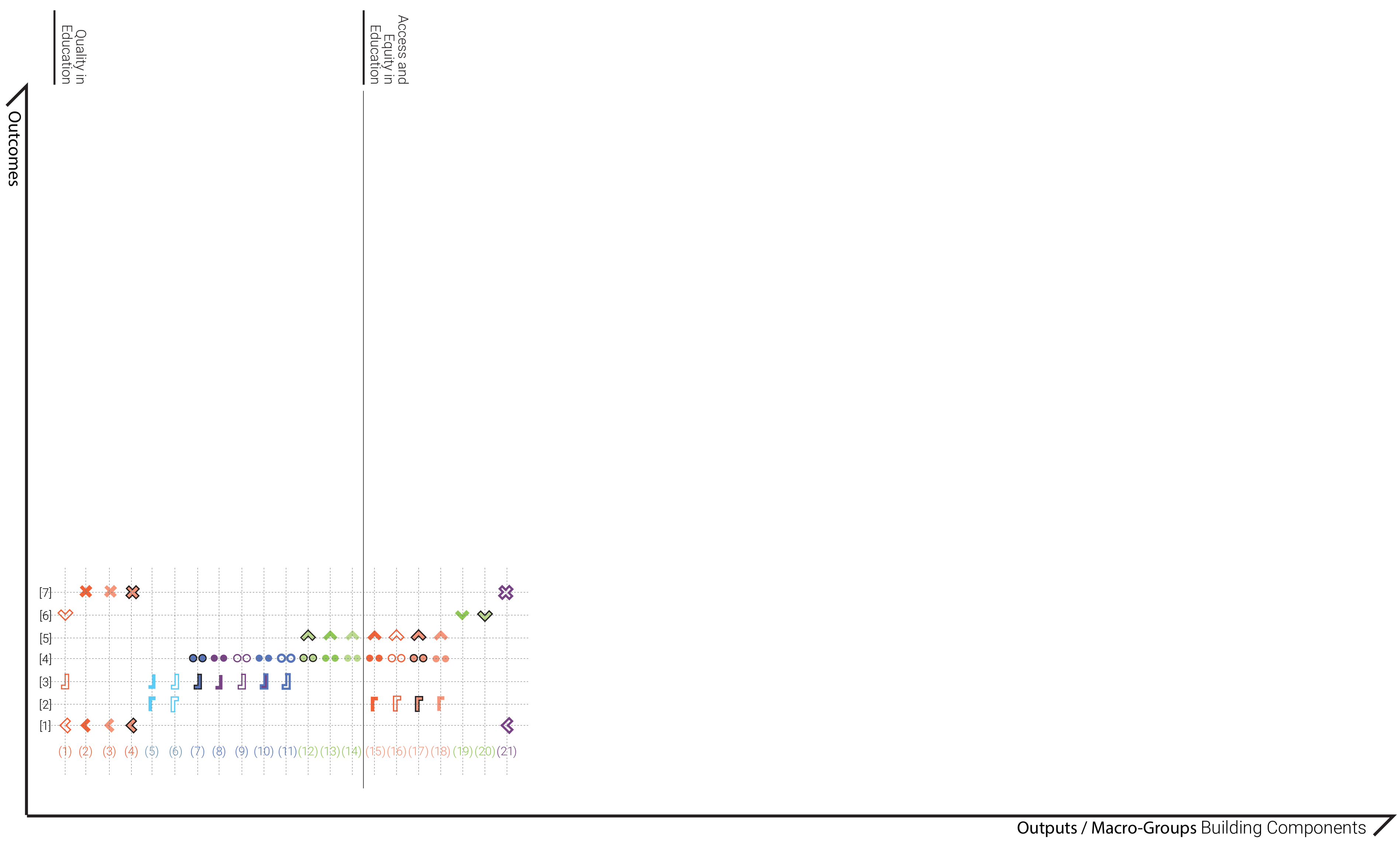
Quality in Education

- (1) Safe Site Location
- (2) Hazards Matrix
- (3) Technological Matrix
- (4) Water, Sanitation, Hygiene Facilities
- (5) Boundary Wall
- (6) Dormitory on site
- (7) Temporary Learning Space
- (8) Flexible Learning Envirnmenal
- (9) Mobile School
- (10) Permanent School
- (11) Open Air School
- (12) School Inclusion
- (13) School Segregation
- (14) School Integration

Access and Equity in Education

- (15) Providing Girl Education
- (16) Education for Rural-Urban
- (17) Education for IDP and Refugees
- (18) Education for Disabled
- (19) Built for all level
- (19) School Proximity
- (21) Appropriate School Dimension

Educational Resilience - Resistance



Legend (Outcomes - Outputs)

Outcomes (simbols)

Type of Disease
- [1] Vector Borne Disease
- [2] Air Borne Disease
- [3] Water Borne Disease

Eathquake Effect
- [4] Tsunami
- [5] Landslide
- [6] Soil liquification
- [7] Ground motion

Type of Building
- [8] Earthen Building
- [9] Stone Building
- [10] Masonry Building
- [11] Wet-proofed Building
- [12] Dry-proofed Building
- [13] Elevated Static Building
- [14] Amphibious Building
- [15] Pile Building
- [16] Floating Building

Ventilation, Wind
- [17] Maximize
- [18] Minimize

Solar Radiation, Sun
- [19] Maximize
- [20] Minimize

Humidity, Rain
- [21] Protection

Foundation/Wall Materials
- [22] Burnt Brick
- [23] Concrete/ Concrete Brick
- [24] Mud Brick
- [25] Adobe Brick
- [26] Wood and Mud

Roof Materials
- [27] Stell (Iron sheet)
- [28] Timber (Wood)
- [29] Bamboo

Outputs (colors)

Social Distancing
- (1) Desk-Chair spacing
- (2) Open and adapted space

Toilets
- (3) Disaster-resilient toilet
- (4) Waste management

Hand Washing Facilities
- (5) Location close to the toilet
- (6) Materials
- (7) Accessibility to everyone

Water Supply
- (8) Ground catch-ment System
- (9) Rain Water catchment system

Structural System
- (10) Frame
- (11) Bearing wall

Weigth
- (12) Heavy
- (13) Light

Structural protection
- (14) Screening Doors
- (15) Screening Eaves
- (16) Screening windows
- (17) Screening Nets
- (18) Boundary wall
- (19) Set-back
- (20) Fences

Foundation

Static
- (21) Two store building
- (22) Pile Foundation
- (23) Strip wall
- (24) Mat
- (25) Base isolation
- (26) Basement (h <1m)
- (27) Sub-floor void (h: >1m)

Kinetic
- (28) Buouyancy

Material Characteristics
- (29) Water-resistance
- (30) Carbon footprint
- (31) Maintenance

Floor
- (32) Raising

Roof

Ceiling Height
- (33) Higher
- (34) Lower

Roof Overhang
- (35) Decrease
- (36) Increase
- (37) max 500 mm
- (38) Use ties

Roof Shape
- (39) Slope (min 20°-30°)
- (40) Slope (22-30°/45°)
- (41) Hipped
- (42) Pyramidal
- (43) Conical

Roof Weigth
- (44) Light
- (45) Heavy

Openings

Type of ventilation
- (46) Mechanical ventilation
- (47) Natural Ven-tilation

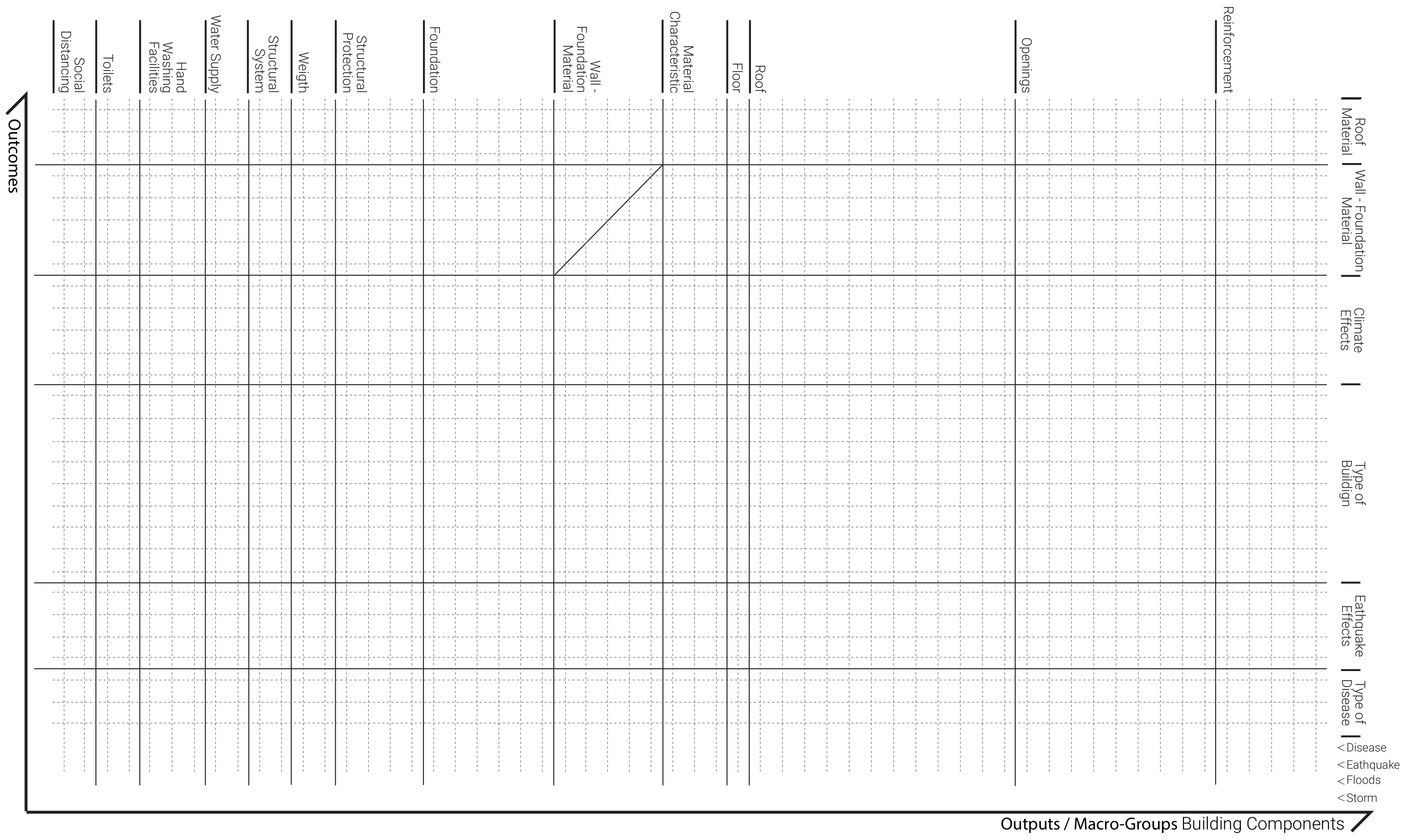
Position
- (48) Outward opening
- (49) Symmetrical (Max 20% of wall)
- (50) At same heights
- (51) Upper
- (52) Adjacent
- (53) At different heights
- (54) Elements of Protection
- (55) Shading Elements

Reinforcement

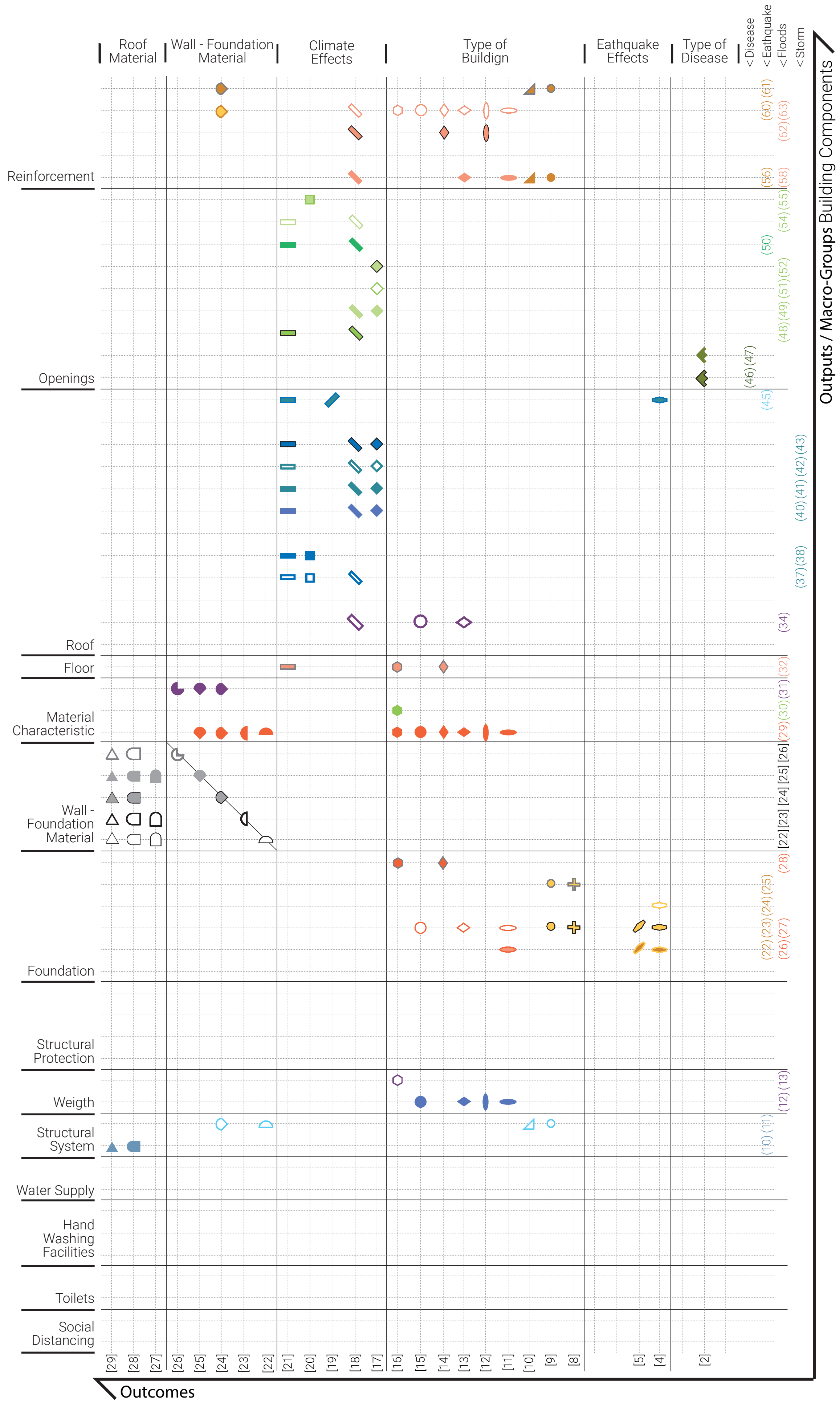
Horizontal
- (56) Ring beams
- (57) Collar bands
- (58) Mooring system

Vertical
- (59) Wire mesh
- (60) Wood post
- (61) Steel bar
- (62) Super-structural
- (63) Sub-structural

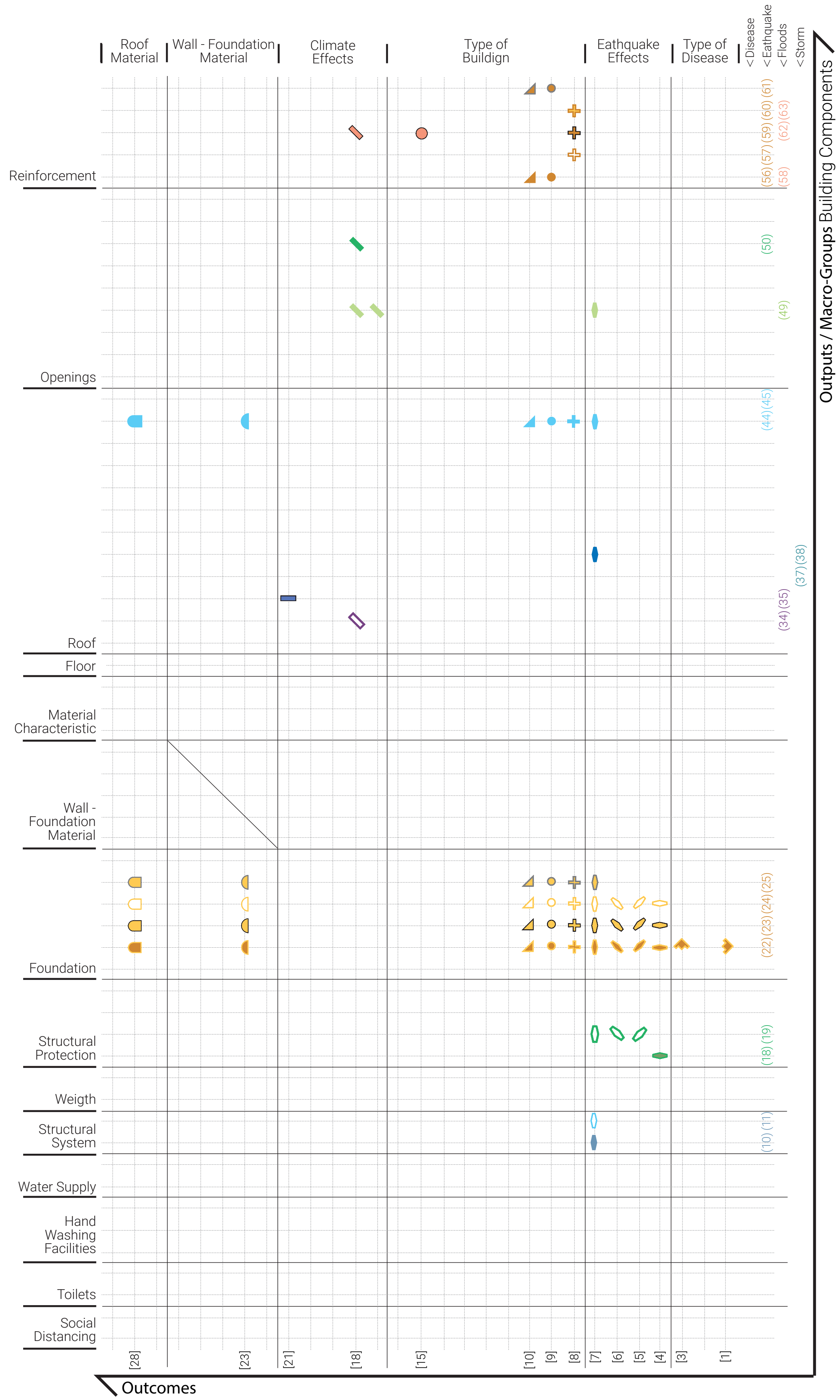
Axis and 2d Space

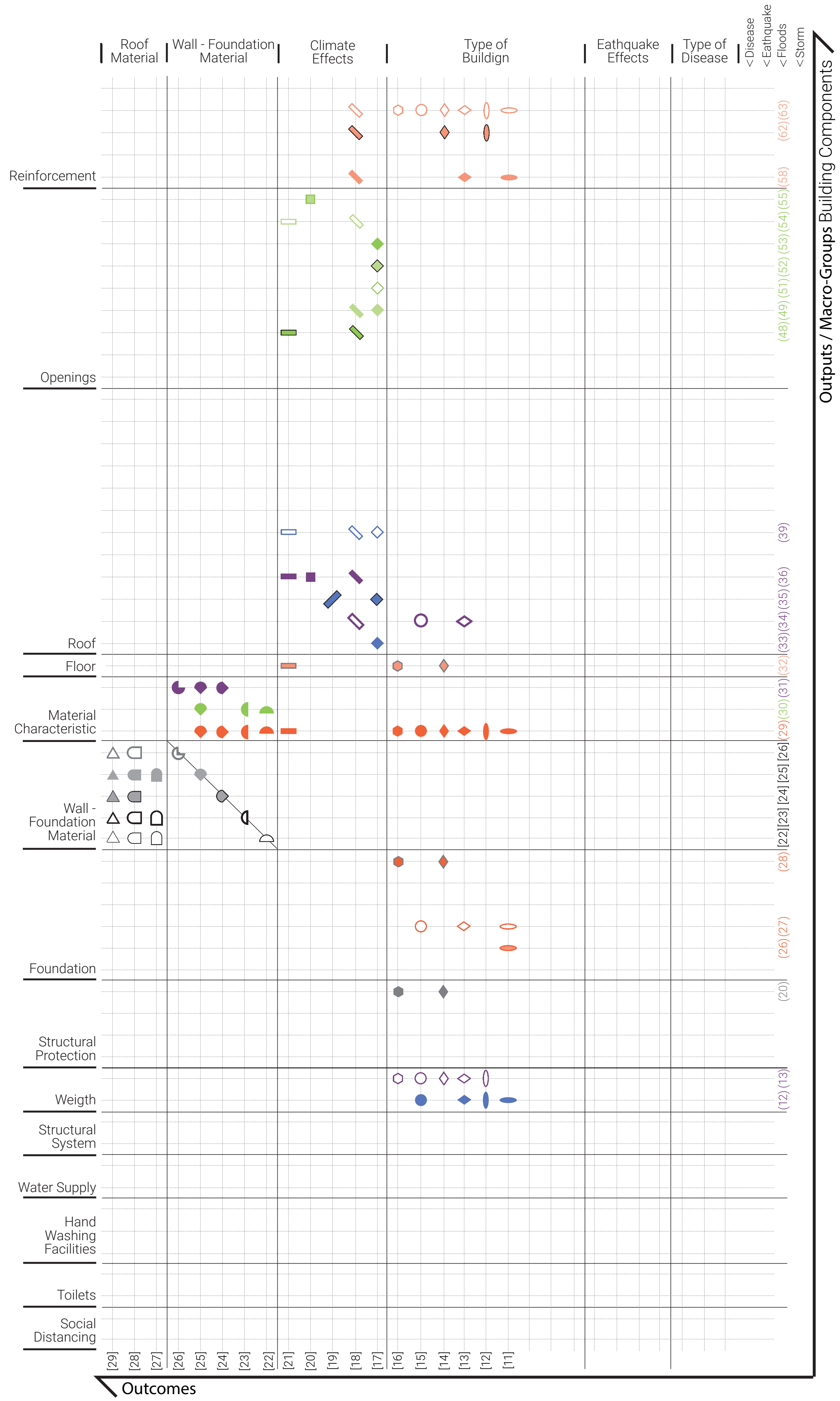


Storm Matrix



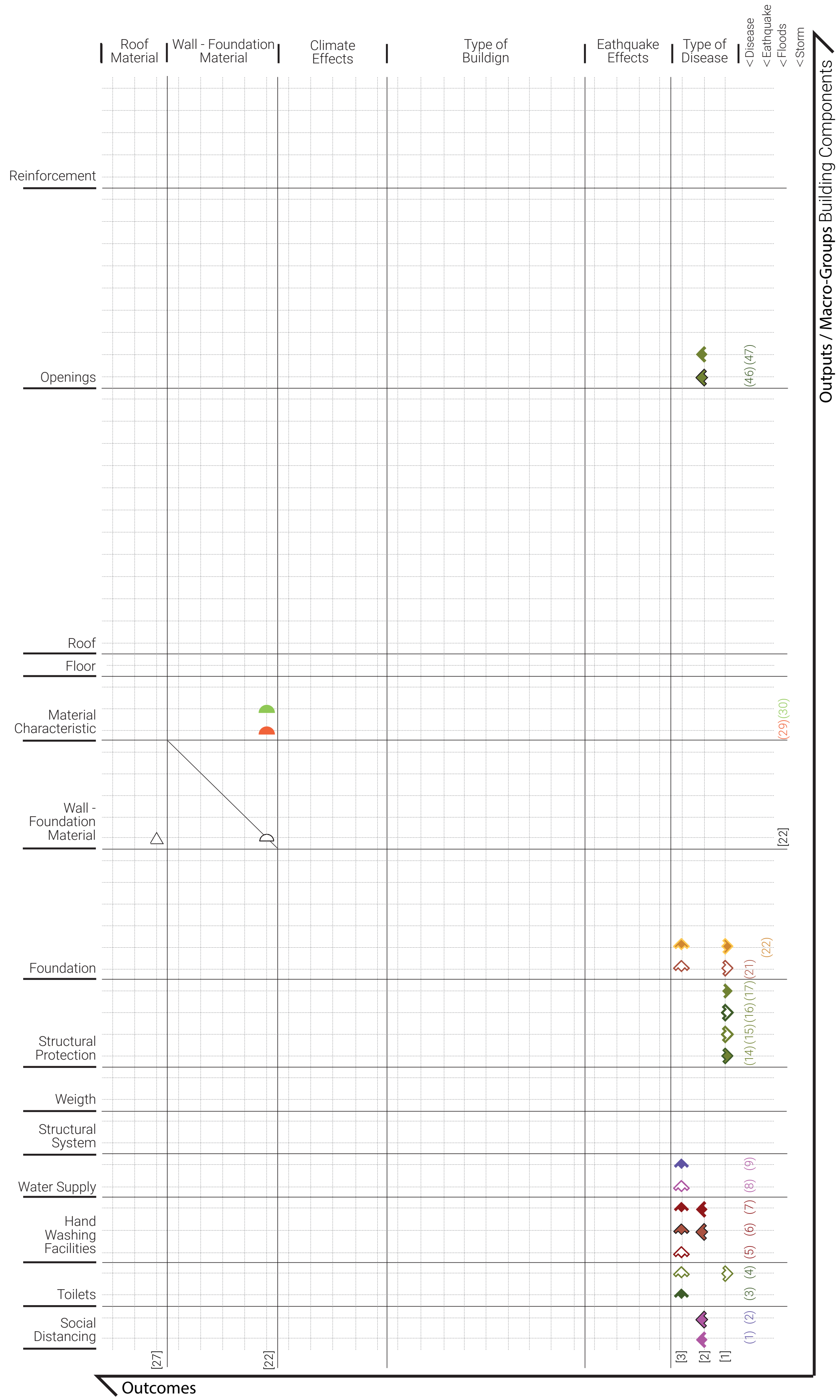
Eathquake Matrix





Floods Matrix

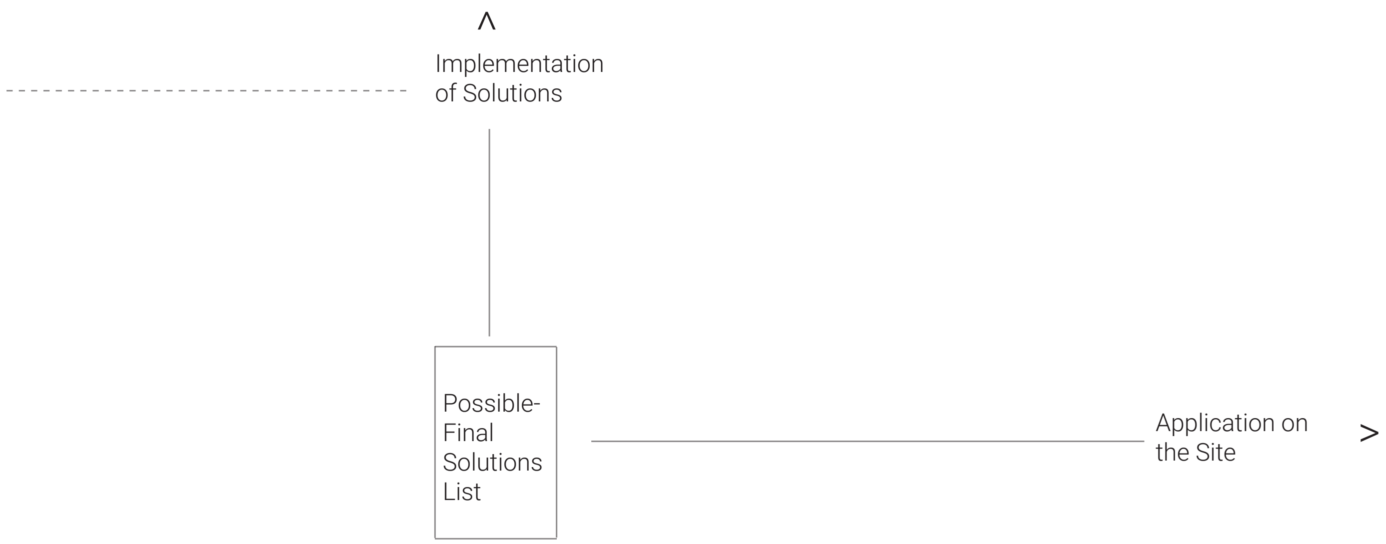
Disease Matrix



2.4.3. Implementation of the Solutions (Community Involved)

The next step of the process consists in evaluating in detail how realistic each solution obtained from the Comparison of Matrices is and what is needed to implement it (time, money, materials, people involved, construction skills). Then, we implement the solutions obtained from Compared Solutions considering the capabilities identified in the community (identified with Tool 6 - Livelihoods and capacities analysis), building with them The Final Solutions List.

Some key questions:
- Can the identified actions be implemented by those at risk?
- If the solutions identified are beyond the capabilities of the community or individuals at risk, could they influence the success of the project in the medium or long term?



IFRCI (2007), How to do a VCA, A practical step-bystep guide for Red Cross Red Crescent staff and volunteers, 2007.

2.4.4. Ensure that the project will be done (Community Involved)

Determine the realistic solutions, participants will have to determine how they will acquire what they need and whether the actions require specific skills, available within the community or outside, and where they can be found.

(Table 10) Taken from IFRCI, How to do a VCA, A practical step-by-step guide for Red Cross Red Crescent staff and volunteers, pag.7113 modified by the author of the thesis.

Actions/Solutions	Requires financing	Can we find the resources ourselves?How?	Technical support

Whatever the proposed project is, it is necessary to develop and agree on a clear, easy-to-understand action plan that is precise all the steps to be followed, the necessary resources and who is responsible for ensuring that the actions are carried out.

Some key questions 13:
- Can the project be started immediately?
- How much and what resources does the development of the project require?
- Can existing local resources be used? if so, how can they be used?
- Does the project development require external technical support?
- the start of these actions can help you mobilize others resources; Or do you need external resources?

Actions/Solutions	Resources Needed	Who will ensure it is done?	Timeline

(Table 11) Taken from IFRCI, How to do a VCA, A practical step-by-step guide for Red Cross Red Crescent staff and volunteers, pag.72 (13).

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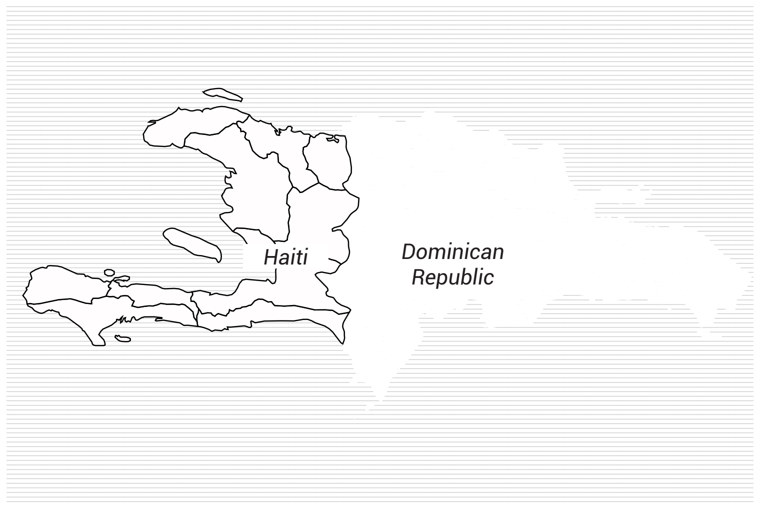
Chapter 3

The Case Study

This chapter is an example of the way of implementing the tool in a vulnerable community. The community chosen for this case study is a rural community called Carrefour Cadet, a fraction of the Petit-Trou-De-Nippes town. Located in the vicinity of fault lines, with seasonal tropical storms occurence and shallow flooding from the nearby river together with occasional cholera outbreaks, given that 90% of the population does not have access to latrines. Due to the isolation, lack of funds and poor governance in Haiti the community is extremely vulnerable to the impact of these hazards, with the only community center/shelter preforming poorly when disasters strike.



3.1. Country profile: *Haiti*

3.1.1. General overview

Haiti is a country in the Caribbean Sea that occupies the western third of the island of Hispaniola. Haiti's population is almost entirely descended from African slaves who through revolution created the second country in the Americas, after the United States, free from colonial rule. Over the centuries Haiti has had a fair share economic, political, and social difficulties along with exposure to various different natural hazards caused serious poverty and lack of capacities in the country.

Area:	*27,065 sq km*
Population: (2021 est.)	*11,198,000*
Capital:	*Port-au-Prince*
Languages:	*Haitian Creole, French (both official)*
Religions:	*Christianity, Vodou*
Currency:	*Gourde*
GDP per capita:	*1,703 USD*
Poverty rate:*	*59%*

*From World Bank Open Data

Haiti's topography make up is mostly mountainous. Between the mountain ranges there are fertile plains that attract the population, making them overpopulated. The majority of the country is densely populated, most evident in the cities, but not neglegable in rural areas as well. Haiti's population is growing, however both rates of birth and infant mortality are high. A large percentage, at about 35% is under 15 years old. Life expectancy is among the lowest in the world. Many haitians live in absolute poverty with lack of employement opportunities.
Haiti has a developing economy mostly based on agriculture and is the poorest country in the Western Hemisphere. The natural resources on the land have been exploited ever since colonial rule, causing farmers to migrate to cities in search of income.
Due to the prevalence of infectious diseases (e.g. cholera, aids) and malnutrition Haiti death rate is high. This is worsened by the lack of running water, sanitation and health care personnel, which became apparent after the catastrophic 2010 earthquake.

components

hazard and exposure
- natural — *earthquake, tsunami, tropical cyclone, environmental degradation, drought, epidemic*
- human — *conflict, violence, asylym seekers*

vulnerability
- socio-economic — *poverty, development, inequality, dependency*
- vulnerable groups — *uprooted people, other vulnerable groups*

lack of coping capacity
- institutional — *governance, DRR implementation, social protection, security, violence containment*
- infrastructure — *communication, physical connectivity, access to health care, access to education*

Components of risk covered by the LAC-INFORM index, 2020
https://sara.humanitarianresponse.info/inform-lac

Highest ranking Latin American and Caribbean countries according to the INFORM risk

	Haiti	*Guatemala*	*Honduras*
hazard and exposure	**8.5**	8.2	8.1
natural	**8.0**	8.3	8.4
human	**8.1**	7.9	8.0
vulnerability	**8.4**	8.6	8.0
socio-economic	**9.2**	8.5	8.1
vulnerable groups	**7.4**	8.6	7.9
lack of coping capacity	**9.0**	7.6	7.9
institutional	**8.4**	7.7	8.4
infrastructure	**9.4**	7.5	7.2
INFORM risk	**8.5**	8.2	8.1

Ranking in comparison to the other Caribbean countries

Country	*Risk (0-10)*
Antigua and Barbuda	3.3
Bahamas	4.2
Barbados	2.7
Cuba	4.4
Dominica	5.0
Dominican Republic	5.7
Grenada	3.2
Haiti	**8.5**
Jamaica	5.7
Saint Kitts and Nevis	2.8
Saint Lucia	4.0
Saint Vincent and Grenadines	3.8
Trinidad and Tobago	4.8

Underlying factors of the exposure to natural hazards category in the LAC countries with the hihghest scores
(from 0-10 with 10 being the highest risk)

Country	*Natural Hazards*	*Earthquake & Tsunami*	*Flood*	*Tropical Cyclone*	*Environmental Degradation*	*Epidemic*
Haiti	**8.1**	**8.9**	**5.1**	**8.7**	**8.4**	**8.4**
Honduras	8.0	9.1	6.7	5.5	9.5	7.4
Guatemala	7.9	9.4	6.0	5.8	9.3	7.1
Mexico	7.9	8.6	8.1	8.9	7.0	5.9
Nicaragua	7.7	9.4	7.2	4.6	8.4	7.3
Colombia	7.4	9.5	8.3	5.6	4.5	7.0
Dominican Republic	7.4	8.9	5.6	8.7	4.6	7.2
Ecuador	7.3	9.8	9.2	0.0	5.6	6.2
El Salvador	7.3	9.6	3.4	4.6	8.7	6.9

3.1.2. Natural hazards exposure

Haiti's geographic location exposes it to numerous natural phenomena: earthquakes, landslides, tsunamis, submersions, floods, cyclones, drought. Haiti is also exposed to the phenomena of mainly man-made origin, soil erosion and desertification. More than 96 percent of its population is at risk of two or more hazards and it ranks as one of the countries with the highest exposure to multiple natural hazards, according to the World Bank's Natural Disaster Hotspot study. With the growing urbanization in the absence of effective consideration of these threats it is very likely that natural hazards will increase strongly, both in number and intensity, in decades to come.

Based on the analysis of historical data, annual losses and damages associated with hydrometeorological events are estimated at an amount equivalent to 1.95 percent of the GDP ***(GFDRR).***Haiti's geographic location in the path of Atlantic hurricanes, along with the topography of its western region from which all major river systems flow to the coast, makes the country particularly vulnerable to hydrometeorological disasters, especially between June and December. When it rains, the steep, often barren hills that surround them flush rainwater toward the urban areas. Widespread deforestation in the upper reaches of these valleys, coupled with lacking drainage infrastructure, creates an environment conducive to flooding. Haiti also has the highest vulnerability rating in terms of cyclones (tropical depressions, storms and hurricanes) among the region's small island states. In the past fifteen years 16 cyclones and 15 tropical storms had a trajectory on Haitian coast and inlands. Cyclones in this area of the caribbean usually have a trajectory oriented from south-east to north-west. The south part of the country is more exposed to these phenomena since it faces the main direction of wave propagation and does not have any surrounding islands protecting it. The effects of cyclones include wind damage, flooding,landslides, torrential debris flows, and coastal surges. In addition to the hydrometeorological hazards, Haiti is also located in a seismically active zone, intersected by several major tectonic faults.

Additionally, the Island of Hispaniola, where Haiti is located marks the border between the North American tectonic plate and the Caribbean tectonic plate. These two large plates converge towards each other at a speed of around 2 cm / year. This movement causes deformations along the rupture zones (faults) causing strong magnitude earthquakes (e.g. 7.0 magnitude earthquake in 2010 killed 220.000). Other secondary hazards impacting Haiti include landslides, debris flows, soil liquefaction and tsunamis.

Furthermore, Haiti suffers from severe environmental degradation, as evidenced by only 2% forest coverage and the overall degradation of the country's land. To satisfy local food, energy and other income-generating demands, most of the forests have been converted to agricultural plots, or the trees were simply cut down for charcoal production, for heating and cooking.

Figure 1>

Number of people affected by natural hazards 1985 -2020

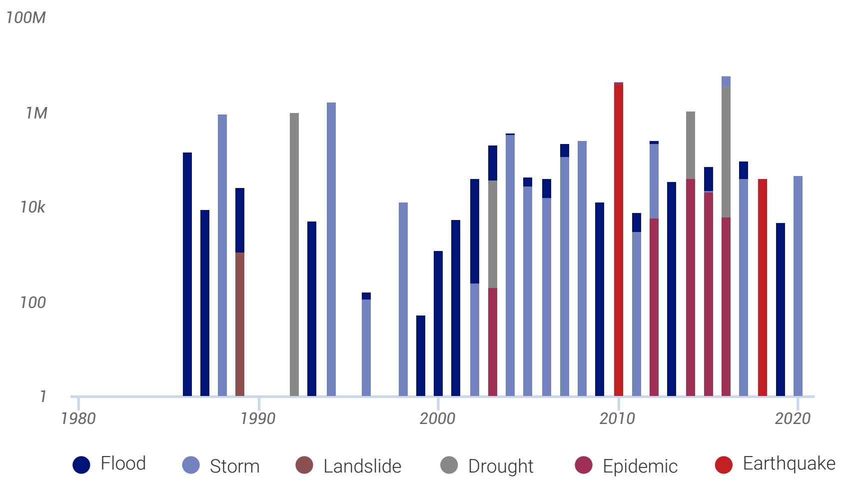
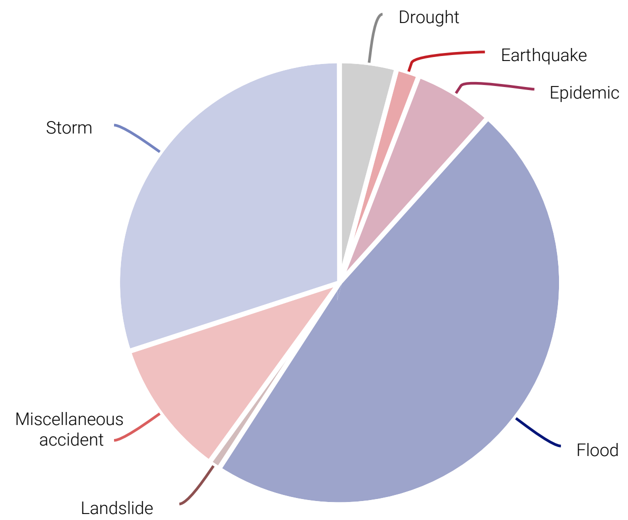


Figure 2>

Average annual hazard occurence 2018 -2020



https://climateknowledgeportal.worldbank.org/country/haiti/vulnerability

Hazards	*No. of Events*	*%*	*Fatalities*	*%*	*Affected*	*%*
Hydrometerological	97	69.3	19,262	7.5	5,363,876	45.6
Droughts	20	14.3	-	-	2,668,000	22.7
Earthquakes and tsunamis	13	9.3	235,952	92.2	3,721,730	31.6
Landslides and debris flow	10	7.1	635	0.3	10,509	0.1
Total	140	100	255,849	100	11,764,115	100

SOURCE: Disaster Risk Management in Latin America and the Caribbean Region: GFDRR Country Notes

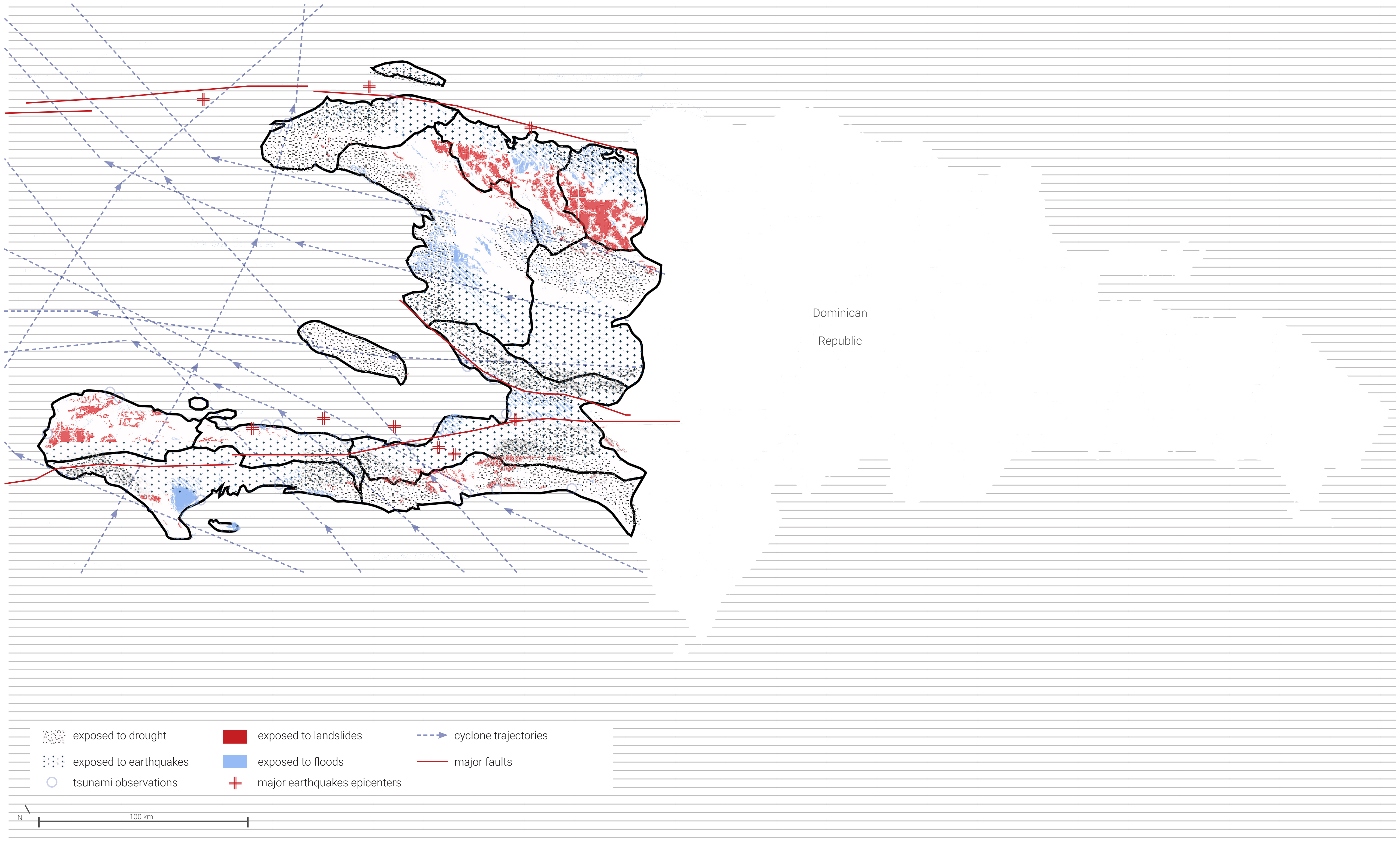
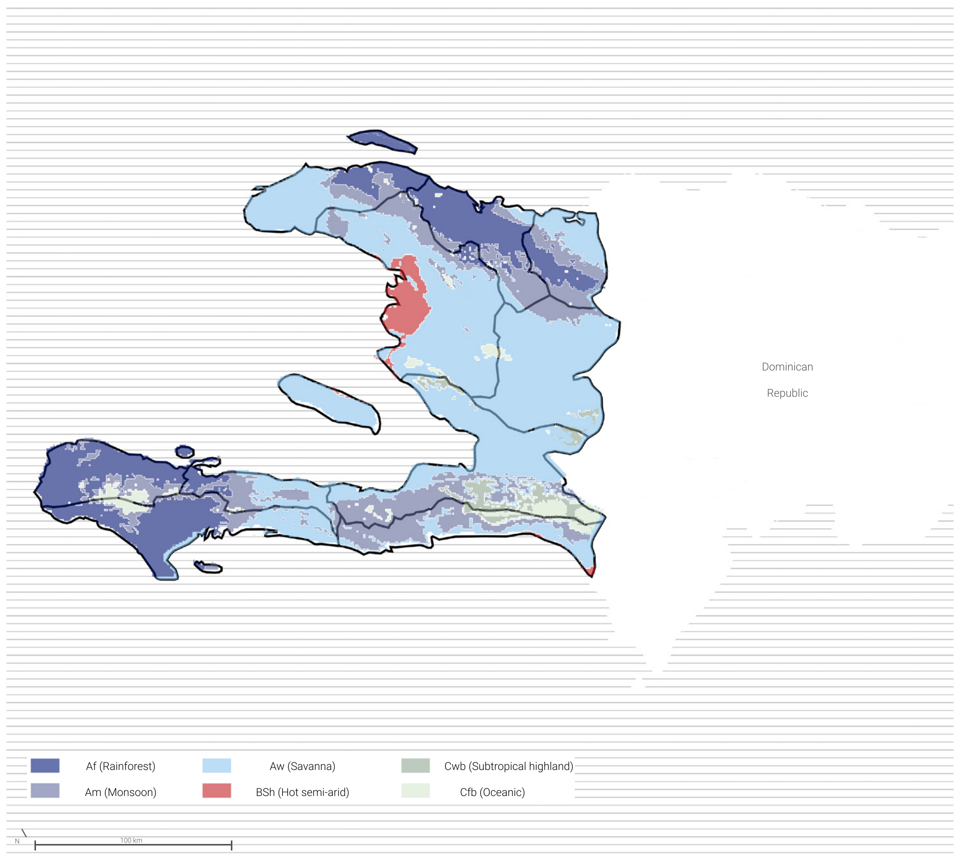


Figure 3: Mapping the multiple hazards - *Earthquakes, Cyclones, Landslides, Floods, Droughts*

Source: Atlas des menaces naturelles en Haïti, CIAT, GFDRR, Comité Interministériel d'Aménagement du Territoire and modifyed by author

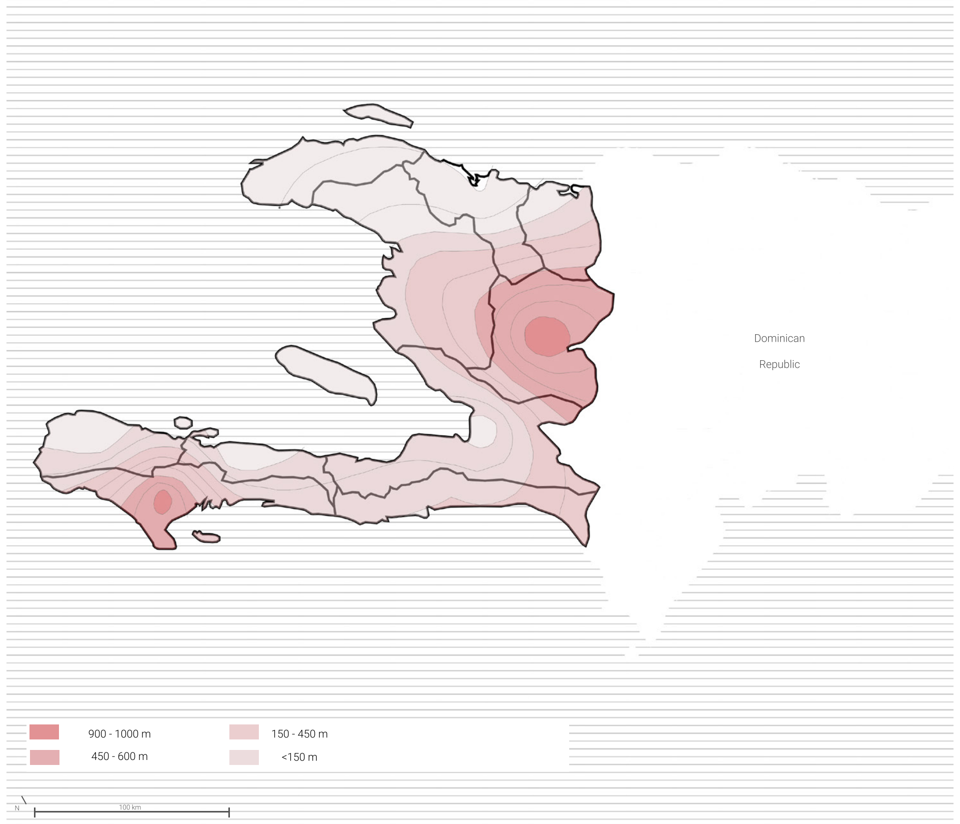
3.1.3 Geography



<Figure 3

Climate types in Haiti in accordance with the Köppen climate classification.

From the figure it is evident that the prevailing climate is the Tropical Savanna, with dry summers and winters. The dry season can be severe, with drought conditions often occuring. The second most prevailing climate is the Tropical Rainforest, forest with small temperature changes and rain that falls throughout the year, followed by the monsoon climate which is an intermediate of the previously mentioned climate types with monthly mean temperatures above 18 °C throughout the year.



<Figure 4

The elevation of Haiti

Haiti is the most mountainous country in the Carribean, with the two major mountain ranges: Massif du Nord in the north and Massif de la Selle south west part.

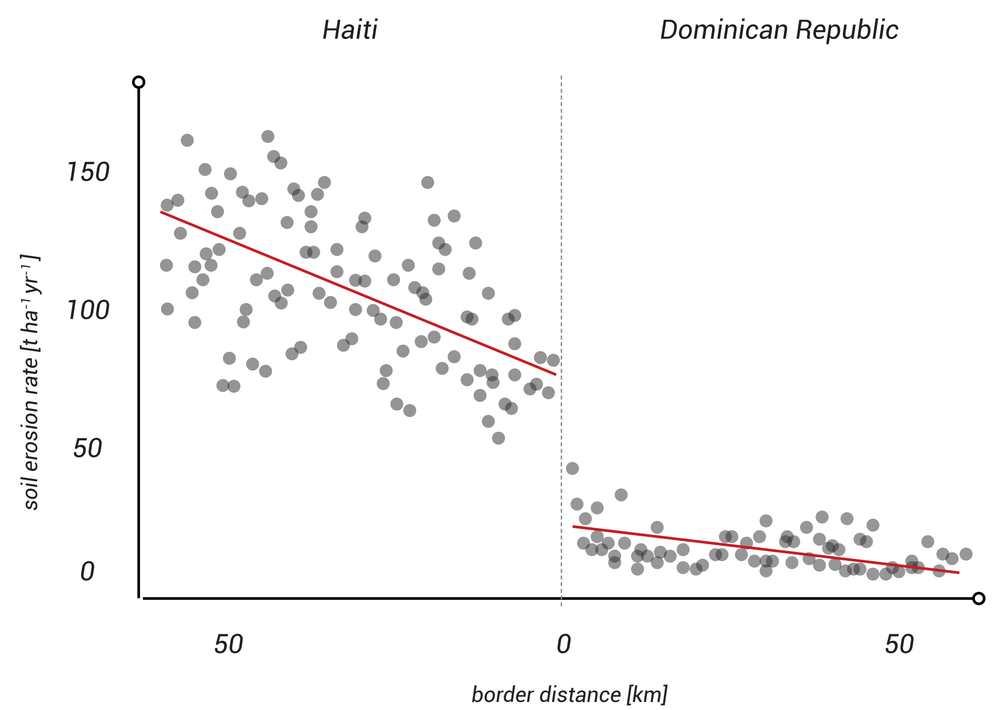
3.1.4 Environmental degradation

^Figure 5
An aerial photograph of the Haiti - Dominican Republic border, showing the large scale deforestation on the Haitian side
https://www.unep.org/ru/node/873

Figure 5>
The soil erotion rate of

The environmental degragation to the haitian land is most evident when comparing the soil erosion rate on both sides of the Haiti - Dominican Republic border. As the rural population grows food crops, mostly coffee, are planted instead of trees, on the steep mountainsides resulting in the worst case of soil erosion in the Western Hemisphere.

DOI: 10.1038/s41893-019-0438-4



3.1.5 The social aspect

Haiti has the youngest population in the Caribbean; with about 70% of Haitiand being under 30 years of age. While young people represent an important asset for any country, they need opportunities in order to prosper. Haiti's demographic reality impacts significantly the development in the country. Countries with very young and youthful age structures are the most likely to face outbreaks of civil conflict and be governed by authoritarians. While the relationship between age structure and instability is not one of simple cause and effect, demographics do play an important role in mitigating or aggravate country's development. Haiti's very young age structure is deeply tied to the country's economic recovery and security.

A country is classified as a "fragile state" when the government cannot or will not deliver core functions to the majority of its people, especially its poor. (Vallings, 2005)

Since the country's creation, Haiti has had a history of political instability, conflict, repression and violence. Post colonialism two distinct populations arose in Haiti: a small french-speaking urban elite the vast majority of black, Creole-speaking people.The assassination of President Jovenel Moise on 7 July 2021 has caused an increase in the political instability and gang territorial control along with lootings, threatening the safety of the inhabitants.

of women aged 15-49
Experienced physical violence since the age of 15

of women aged 15-49
Have been sexually abused at some point in their life

1.5 million
PEOPLE AFFECTED BY CONFLICT

18,000
IDPS (internally displaced persons)

High risk
OF GENDER-BASED VIOLENCE
2021

<Figure 6

Gender-based violence and conflict impact in Haiti 2021

3.1.6 Socio-economic vulnerability

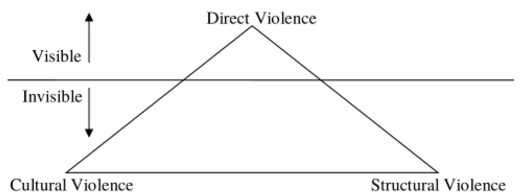
Hazards in Haiti have larger consequences not only because of the country's geological, geographical, and developmental challenges—but also because of institutional weaknesses. Both urban and rural populations in coastal areas are particularly vulnerable to weather and other natural events. Urbanization patterns and the dense urban settlements (most significant in the capital - Port - au - Prince) account for a shareof the monetary losses due to the damage to housing and infrastructure and loss of life. Rural areas, on the other hand, hold a larger share of the costs in terms of losses in agricultural produce, which have an impact on food security nation - wide and livelihoods. With a majority of the Haitian population living on less than US$2 a day, half of which living on less than US$1 a day, extreme poverty represents a significant social vulnerability.

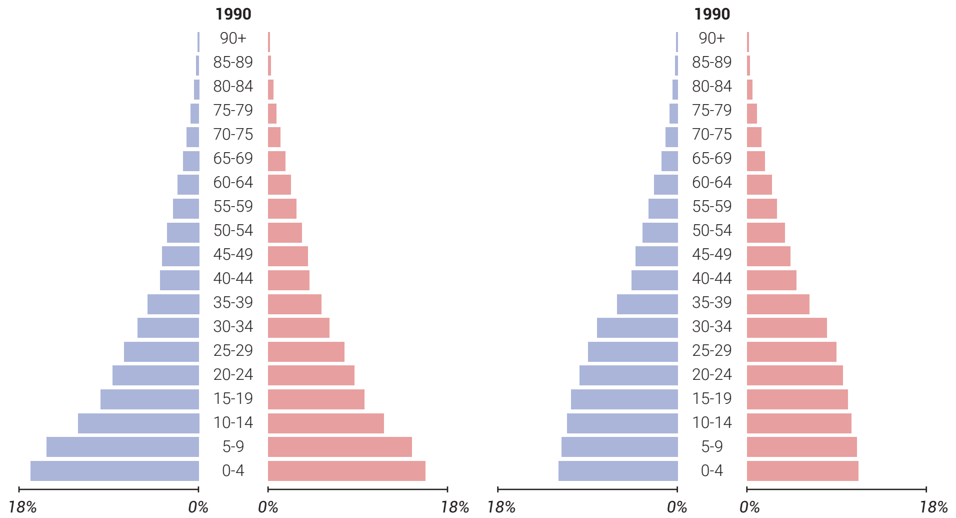
"Structural violence is the way by which social arrangements are constructed to put specific members of a population in harm's way. Social inequalities are at the heart of structural violence, where the prevailing societal framework imposes invisible barriers that perpetuate the suffering of certain groups of people."

Haiti is impacted by structural violence, a form of dysfunction where social structures prevent certain groups of people from having access to basic human rights, like education and healthcare.This has resulted from its colonial history, and from decades of political instability and social unrest. Additionally, Haitians are financially impoverished and within Haiti, there exist social inequalities. Educational standards within the nation are low and Haiti continuosly ranks low in various measurements of health outcomes.Such health outcomes include life expectancy, mortality rates, and disease levels. While there has been some international assistance, there are insufficient supportive infrastructures in place within the country to provide resources and opportunities for Haitians who are trying to attain a higher quality of life. Causes that have resulted in higher levels of structural violence within Haiti include political instability and corruption, as well as the impact of post-colonialism, which has established a caste-based class system within Haiti. All of these issues are contributing to the lack of coping capacity of the Haitians as a whole to recover after and mitigate the impact of a natural disaster.

Figure 7>

The 'iceberg' of structural violence that affects Haitians





<Figure 8

Population pyramid
1990 - 2015

While young people represent an important asset for any country, they need opportunities in order to prosper. Haiti's demographic reality has and will have a profound impact on development in the country.

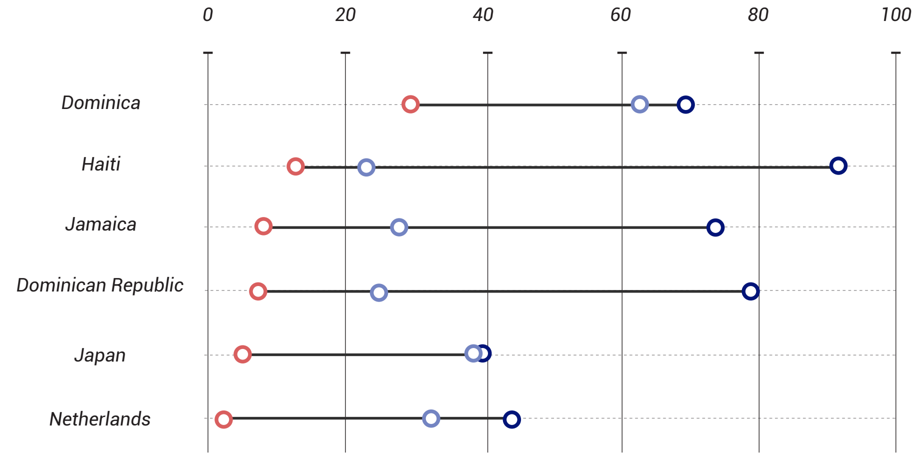
Poverty and hunger	*%*
Proportion of people living in poverty (<2 USD a day)	76%
Proportion of people living in extreme poverty (<1 USD a day)	56%
Unemployment rate	44.9%
Food insecure households	45.2%
Underweight children	22.2%
Child mortality	
Child mortality rate	48.6 / 1000
Youth mortality rate	86 / 1000
Children vaccinated against measles	57.7%
Maternal health	
Maternal mortality rate	630 / 100.000
Childbirth assisted by skilled personnel	26.1%
Rate of use of contraceprives	24.8%
Diseases	
Prevalence of HIV/AIDS	2.2%
Prevalence of Malaria	4.9%
Environmental sustainability	
Forest coverage	<2%

Figure 9>

Susceptibility to disasters for selected countries

Although not the most exposed, Haiti lacks the coping capabilities needed to deal with a natural or social hazard.

World risk report, 2021



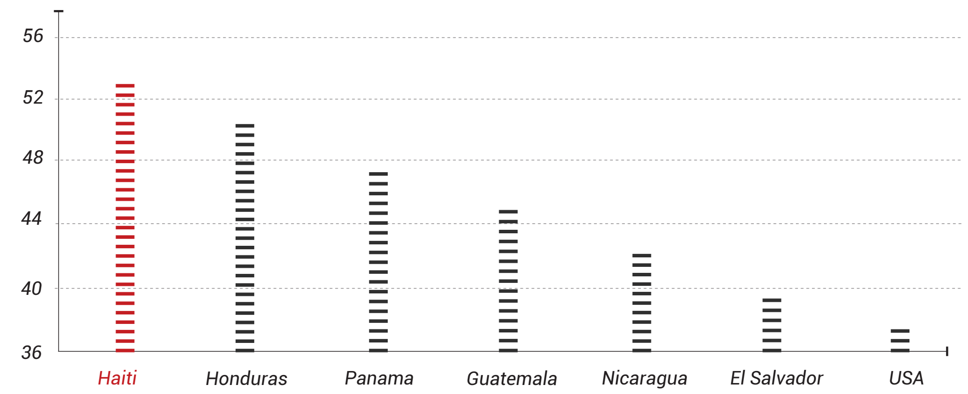
3.1.7 Vulnerable groups

People living in public institutions, such as orphanages, hospitals, and penitentiary centres, may be especially affected by Haiti's political and economic instability, especially in accesibility to WASH infrastructure and food. Other vulnerable groups include subsistence farmers as well as the urban poor, who may face increased humanitarian needs resulting from their precarious livelihoods' situations. Women and children may be especially vulnerable to the effects of the complex crisis. Despite some recent improvements, inequality in Haiti remains high. Although we are seeing improvements in education and life expectancy, income inequality has continued to widen. According to various cross-country datasets, Haiti remains among the most unequal countries in the world as measured by the Gini coefficient. This is related to a concentration of resources in the hands of a small but powerful group of elites, many of whom have dominated entire sectors of the Haitian economy since the Duvalier era, when they were granted monopoly rights in key industries and exclusive import licenses for major consumables (Singh et al, 2015). The persistence of such high levels of inequality is due in part to the weakness or absence of channels of resource redistribution, such as targeted transfers and a social safety net.

Figure 10>

Haiti ranking according to the Gini Coefficient
2012

Standardized World Income Inequality Database (SWIID)



3.1.8 Infrastructure

Lack of access to sanitation

Deficient sanitation systems, poor nutrition, and inadequate health services have pushed Haiti to the bottom of the World Bank's rankings of health indicators. According to the United Nations World Food Programme, 80% of Haiti's population lives below the poverty line. Consequently, malnutrition is a significant problem. Half the population can be categorized as "food insecure," and half of all Haitian children are undersized as a result of malnutrition. Less than half the population has access to clean drinking water, a rate that compares poorly even with other less-developed nations. Haiti's healthy life expectancy at birth is only 54 years. The World Health Organization (WHO) estimates that only 43% of the target population receives the recommended vaccines.
Haiti's low income, unemployment, poverty and lack of potable water lead to negative health effects, particularly among children.

Lack of access to Water

The water and sanitation situation in Haiti is among the most critical in the Western hemisphere. According to the UNICEF 2012 Joint Monitoring Program report, 85% of urban residents and 51% of rural residents have access to improved water services. Access to sanitation is extremely low, 24% of urban residents and 10% of rural residents have access to an improved sanitation facility. This is why Haiti is considered a water-stressed country.
Unimproved drinking water sources include unprotected dug wells, unprotected springs, surface water (river, dam, lake, pond, stream, canal, irrigation channels), bottled water etc.
Improved water sources ' include sources that are protected from outside contamination, particularly faecal matter.

Lack of access to Education

Education levels in Haiti are low. The country has shortages in educational supplies and qualified teachers, and its rural population remains under - educated. The 2010 Haiti earthquake has amplyfied the already constraining factors on Haiti's educational system. The biggest problem is the fact that 80% of schools are private, thus unavailable for the majority of Haitians making a huge gap of the quality of education. School fees and tuitions are required at both private and public schools, making them unattainable for the 5.5 haitians who live on under 1USD a day. Iliterate Haitians have a disadvantage regarding opportunities. Challenges arise both on the demand and supply side of Haiti's educational system. Firstly, regarding the supply, there is insufficient infrastructure for children to enroll in school. On the demand side, however, the pricing (80 USD yearly on average in tuition fees) excluding books, uniforms and transportation, places basic education unattainable for many.

Figure 11>

Access to sanitation

Percentage of population	2020	2015
using at least basic sanitation services	37.1	32.5
using improved sanitation facilities	65.6	58.9
using limited sanitation services	28.5	26.4
using improved latrines and other improved facilities	48.5	46.0
using sanitation facilities connected to septic tanks	16.5	12.1
using sanitation facilities connected to sewer networks	0.6	0.7
practising open defecation	18.1	21.5
using unimproved sanitation facilites	16.3	19.6

Figure 12>

Access to water

Percentage of population	**2020**	**2015**
Using at least basic drinking water services	66.7	64.6
Using improved drinking water sources available when needed	63.9	61.5
Using improved drinking water sources	76.5	73.8
Using limited drinking water services	9.8	9.2
Using non-piped improved drinking water sources	57.4	48.0
Using piped drinking water sources	19.1	25.8
Using improved drinking water sources located on premises	7.8	11.2
Using surface water	0.0	0.7
Using unimproved drinking water sources	23.5	25.5

Figure 13>

Access to education

Attendance (%)	Sex	2017
Adolescents not in education, employment or training	Female	13.1
Adolescents not in education, employment or training	Male	6.2
Adolescents in the labour force who are unemployed	Female	10.0
Adolescents in the labour force who are unemployed	Male	7.3
Attendance rate for children of primary school age	Female	85.2
Attendance rate for children of primary school age	Male	83.4
Attendance rate for children of primary school age	Total	84.2
Attendance rate for youth of secondary school age	Female	23.1
Attendance rate for youth of secondary school age	Male	19.2
Attendance rate for youth of secondary school age	Total	21.2
Completion rate for children of primary school age	Female	58.4
Completion rate for children of primary school age	Male	48.7
Completion rate for children of primary school age	Total	53.6
Completion rate for youth of secondary education	Female	16.5
Completion rate for youth of secondary education	Male	17.1
Completion rate for youth of secondary education	Total	16.8

3.1.9 Construction materials and techniques

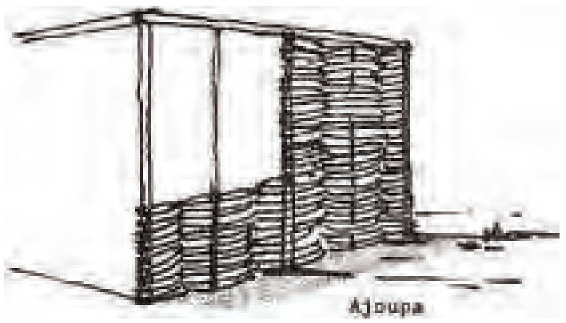
Availability of materials

Supply can be problematic in some remote areas of Haiti, accessible only on foot, for example. The quality of the materials available is also a problem.
Most traditional houses have a wooden structure. The wood used is the *bwa plé* (colubrina arborescens). It's a very hard wood, of high density, naturally resistant to termite and fungal attack. Haiti's deforestation made this wood rare and expensive. The supply of quality wood is therefore insufficient and local populations are forced to use wood with poor characteristics. This wood must now be purchased and its use does not guarantee a quality of production, especially when the manufacturer does not take special precautions to overcome this problem (treatment of the wood, base, etc.). In addition, the low availability of local wood and the high price of imported wood make the houses more expensive than before, except when recycling existing materials. The lack of quality wood and the lack of a short-term alternative to using wood from reforestation projects leads to populations to move towards new technical solutions based on poorly mastered industrial materials. Setting implemented does not respect good standards and rules and results in the production of relatively expensive and insecure informal housing. The sheets found on the market are of very variable qualities. Those of better quality have a lifespan of several decades, which has built their good reputation. But the cheapest, often the only ones accessible to residents modest, are too thin and deteriorate very quickly (rust, tearing during strong winds) especially in coastal areas.
The aggregates used for the manufacture of concrete are often too fine and are not properly washed, which interferes with the proper setting of the cement. Sea sand is used as the raw material, which greatly reduces the quality of the concrete (size and shape of the grains not always suitable and too high a chloride level which speeds up the corrosion of steels).

Building typologies common in rural housing

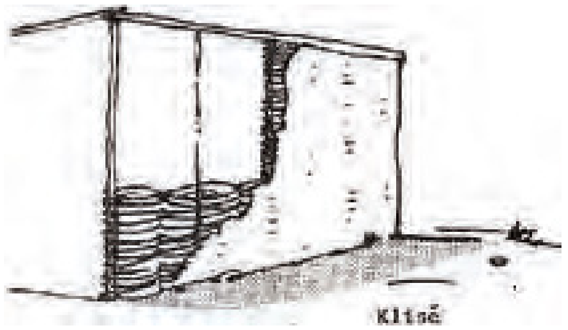
KAY AJOUPA
wattle or reed house

Wood pole frame with woven cane or sticks as walling. Lived in by the poorest Haitians.



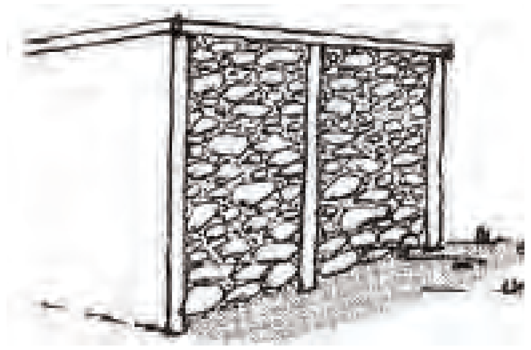
KAY KLISE
wattle and daub house

Wood pole frame with woven cane or sticks and mud render as walling.



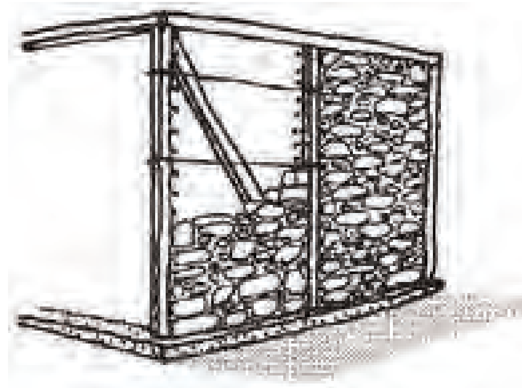
KAY MUR
stone nog

Small stones are cemented between a wooden frame. This is the most popular type of housing found in the south of Haiti.



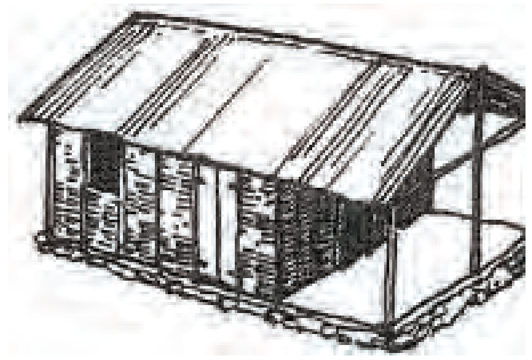
KAY MELANGE
spanish wall

Similar to Kay Mur, but stones are smaller and a board is used as a guide during construction. Illustrated here with a suggested improvement of cross bracing.



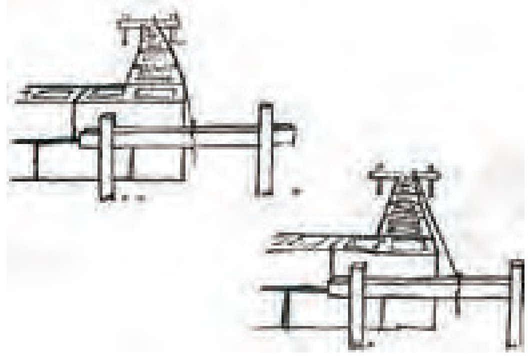
KAY AN PLANCH
wood house

Wooden houses made of locally available timber or wood salvaged from urban construction sites. Deforestation had made wood scarce, palm wood is often used.



KAY AN BLOC
block house

Houses made of cement block. These suffered from poor quality blocks and mortar as well as poor quality construction.



3.1.10 Local material most commonly used in the South of Haiti

Construction materials are widely available in the cities. Even if some particular material, such as hurricane straps or sawn lumber, were not immediately available the shops stated that it is possible to order additional materials from Port au Prince if the demand is sufficient. The concrete block quality is generally low. Blocks were typically manufactured manually, but some vibrated blocks were observed in Les Cayes. The sand used for construction was poor quality. Sands were sourced from either from the sea or from the river with a lot of fine sediments
There are several material types identified for common construction of housing and schools.

Sand: Generally unwashed river sand. In the towns or cities close to the shores it is not rare to see beach sand used.

Gravel: Round river gravel extracted from riverbeds, generally without any angular parts.

Concrete Masonry Units, CMU: Typically 15cmx20cmx40cm in dimension. The majority of blocks are manually made, with the exception of some producers in the bigger urban areas. The quality of the blocks is generally low due to use of poor quality material: unwashed sand, insufficient use of cement in the mix, and the addition of clay in the mix. The low quality could also be due to a lack of training and knowledge of good manufacturing practices such as: insufficient curing, curing under the sun, and insufficient vibration.

Lime: Lime mixed with clay, mud and sand is used as a mortar or as plaster to protect masonry from the environment.

Wood: The wood used for housing is generally round natural timber with irregular section. The wood is typically not treated and can be protected from the environment with lime or cement plaster. The wood often deteriorates due to insects, typically termites. Homeowners and carpenters typically use the most resistant wood they find in the area. The names vary depending on the location. In the South the wood used is typically, bois de Campêche, bois d'Acacia or bwaple.

Rocks: Rocks generally comes from the soil around the construction sites or found during excavations. The stone use is typically limestone or basaltic stone or tuff depending on the geological layer of the location. Some quarries exist too. Rocks are generally 10-25cm diameter unworked.

Timber: For schools, sawn lumber is used typically for the roof trusses. It is imported Southern Pine 2x4 or 2x6 elements.

Mortar and concrete: Round gravel and unwashed sand is used in the concrete or mortar mix. Mud, lime and mud are also used in some villages. There is also a lack of training in the placement of the concrete and problems with concrete cover, segregation etc.

Steel reinforcing: In reinforced concrete frame elements, the rebar for longitudinal reinforcing is usually 6 mm diameter ribbed bars, and for transverse reinforcing, like stirrups and ties, it is usually 13 mm diameter smooth bars.

3.1.9 School construction types

For schools, there are two main types of construction systems in the southern part of Haiti:

Concrete frames, typically with masonry infill
mostly in urban areas

The most common type of structure for schools in cities is reinforced concrete frames with infill walls. These are typically two or three story buildings. The floor system is usually a reinforced concrete slab or blocks and ribbed beams. The roof systems are typically either metal or wood trusses covered with metal sheets.

Figure 14>

Urban areas schools built with concrete frames and masonry infill

Unreinforced block masonry
mostly in rural areas
In villages, the schools most often are made of unreinforced block masonry with partial confining elements. The roofs are mainly gable roofs with wood trusses or rafters only. The quality of the connections varies between the schools, but generally the roof is made with sawn lumber and plywood gusset connections are used.

Figure 15>

Rural areas schools interior built in unreinforced block masonry

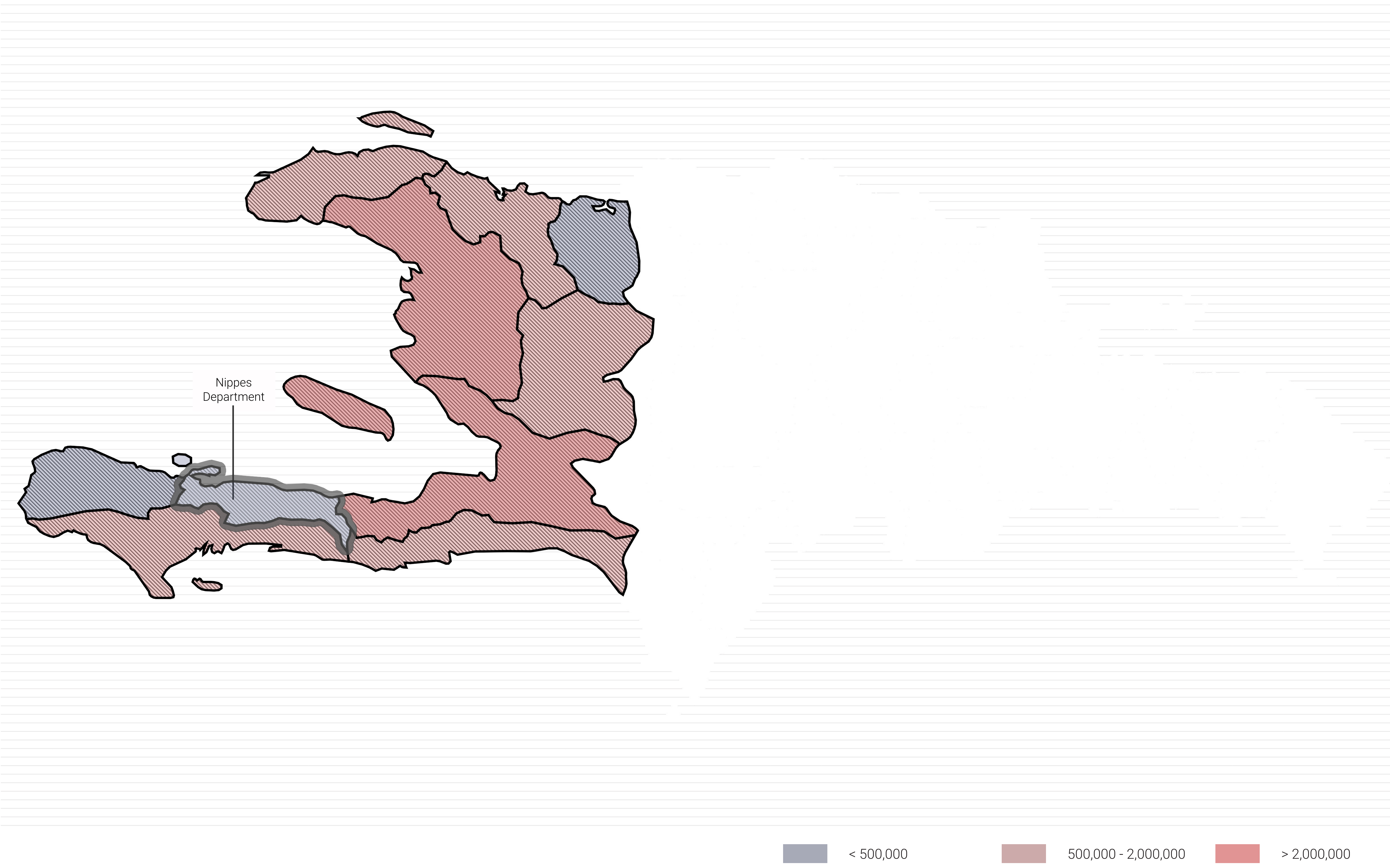


Figure 16: Population density by department

Source: Atlas des menaces naturelles en Haïti, CIAT, GFDRR, Comité Interministériel d'Aménagement du Territoire and modifyed by author

Department	*Cyclone*	*Flood*	*Drought*	*Landslide*	*Soil Erosion Desertification*	*Tsunami*	*Earthquake*
Artibonite	Intense if coastal floods are combined with exposed wind and cyclonic swell	All watercourses can cause flooding	Intense in the low plains and North part of the department	localized	intense on the reliefs	possible, linked to the seismic activity of the faults up north	Seismic threat is not so high
Centre	exposed (wind)	Intense at the level of major rivers	Intense on the upper plateau	localized, potentially intense in relief zones	intense on the reliefs	-	Seismic threat is not so high
Grand - Anse	exposed (wind, cyclonic swell, coastal floods)	All watercourses can cause flooding	sometimes exposed to intense droughts	exposed to instable slopes of the la Hotte mountains	intense on the reliefs	possible, linked to the activity seismic system northern faults or Enriquillo-Plantain Garde fault	Seismic threat very high, lies especially near the Frags of Enriquillo Plantain Garden fault
Nippes	**exposed (wind, cyclonic swell, coastal floods)**	**All watercourses can cause flooding**	**sometimes exposed to intense droughts**	**exposed to instable slopes of the la Hotte mountains**	**intense on the reliefs**	**possible, linked to the activity seismic system northern faults or Enriquillo-Plantain Garde fault**	**Seismic threat very high, lies especially near the Frags of Enriquillo Plantain Garden fault**
Nord	Intense if coastal floods are combined with exposed wind and cyclonic swell	Intense in the North plain	sometimes exposed to intense droughts	exposed to instable slopes of the Nord mountains	intense on the reliefs	very exposed in the Cap-Haitian region in Reason for proximity Fault systems Northern and North Hispaniola	Seismic threat very high, lies especially near northern faults as well as the Hispaniola Fault
Nord - Est	Intense if coastal floods are combined with exposed wind and cyclonic swell	Intense in the North plain	Intense in the northern plain	exposed to instable slopes of the Nord mountains	intense on the reliefs	very exposed in the Cap-Haitian region in Reason for proximity Fault systems Northern and North Hispaniola	Seismic threat very high, lies especially near northern faults as well as the Hispaniola Fault
Nord - Ouest	exposed (wind, cyclonic swell, coastal floods)	Intense near major rivers and in the plains near the coast	Very intense, zone with a very low annual average rainfall (<500 mm) year, droughts appear often	localized, potentially intense in relief zones	intense on the reliefs	very exposed in the Cap-Haitian region in Reason for proximity Fault systems Northern and North Hispaniola	Seismic threat very high, lies especially near northern faults as well as the Hispaniola Fault
Sud	Intense if coastal floods are combined with exposed wind and cyclonic swell	Very intense in the Alluvial Plain of Cayes	exposed littoral zone	exposed to instable slopes of the la Hotte mountains	intense on the reliefs	possible, linked to the activity seismic system northern faults or Enriquillo-Plantain Garde fault	Seismic threat very high, lies especially near the Frags of Enriquillo Plantain Garden fault
Sud - Est	exposed (wind)	All watercourses can cause flooding	Coastal area exposed	exposed to instable slopes of the la Selle mountains	intense on the reliefs	possible, linked to the activity seismic system northern faults or Enriquillo-Plantain Garde fault	Seismic threat very high, lies especially near the Frags of Enriquillo Plantain Garden fault
Ouest	Intense if coastal floods are combined with exposed wind and cyclonic swell	Intense in the plain of Cul-de-sac	exposed, in particular, Matheux	exposed to instable slopes of the Matheux mountains	intense on the reliefs	possible, linked to the activity seismic system northern faults or Enriquillo-Plantain Garde fault	Seismic threat very high, lies especially near the Frags of Enriquillo Plantain Garden fault

Figure 17: Common hazards and their impact by department

SOURCE: Atlas des menaces naturelles en Haïti, CIAT, GFDRR, Comité Interministériel d'Aménagement du Territoire.

3.1.11 School buildings built after the 2010 Earthquake

Organisations involved: CRAterre, PADED, DIGICEL

Following the 2010 earthquake, the Ministry of Education (MENFP) has validated 3 construction systems to meet the huge reconstruction needs damaged schools in rural areas in reinforced concrete, in confined masonry, or in wood frame with stone masonry infill.
For remote and difficult to access areas, the timber frame construction has been assessed as being the most suitable and economical solution, a structure that is both resistant and at a moderable cost . The construction metod is inspired by the local construction technique: timber frame and stone masonry infill. The construction was led by a CRAterrre architects and engineers. The TCLA construction system has been adapted to the guidelines of the Haitian School Engineering Department taking into account the major risks in the area (earthquake and cyclone) but leaving more responsibilities to local actors.

<Figure 18

Pre-school in Grand Boulage, in the rural area of Croix-des-Bouquet using the timber frame with stone masonry infill construction method. Front side 2013-14

<Figure 19

Pre-school in Grand Boulage, in the rural area of Croix-des-Bouquet using the timber frame with stone masonry infill construction method. Back side 2013-14

Figure 20>

Grand- Goâve, the school of the Little Sisters of Ste Thérèse (PSST) 2017

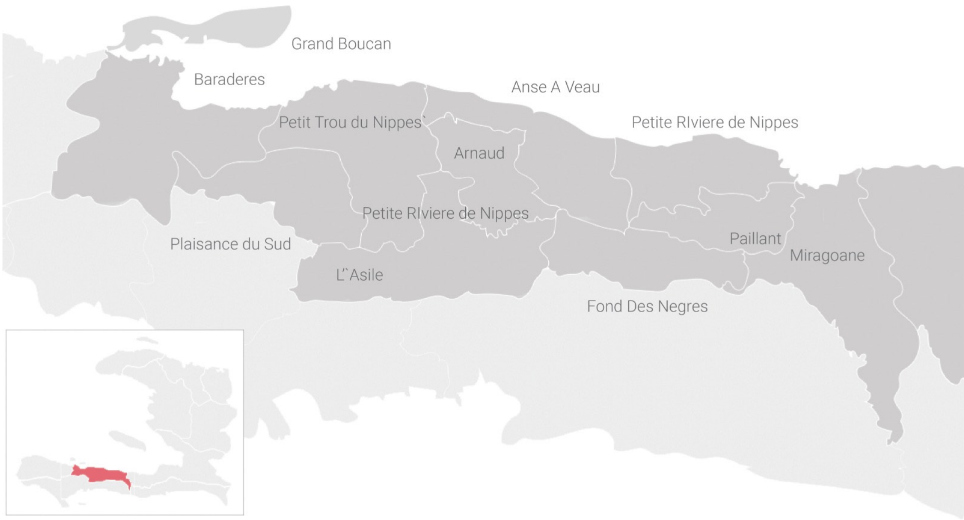
Figure 21>

Ecole Nationale de Grande Rivière Jolie in Anse-à-Veau, DIGICEL 2014

3.2. Department profile: *Nippes*

3.2.1 General Outlook

This department whose territory covers 1,267 km2, is positioned alongside the northern coast of Haiti's southern peninsula. Nippes was part of the department Grande'Anse until 2003 when it separated as its own department in the territory east from it(meaning Grand'Anse) and west from Port-au- Prince, Haiti's Capital. The department has a population of around 343,000 and even though it is separated in 11 communes, approximately 89,5% of the people live in the rural areas. The capital of Nippes is a city called Miragoâne.

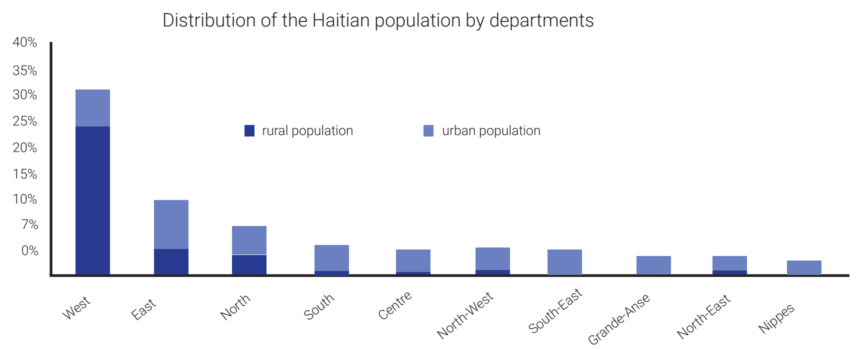


<Figure 22

A map of the Department of Nippes and it's 11 communes

Area:	1,268 km2 (490 sq. mi) (4.6% of the country)
Population (2015):	342,525 (3% of the population)
Population rank:	10th - The least populated department
Density :	270 people per sq. km (699 per square mile)

Average household size (nationally) : 4.4
Age distribution (nationally) : 36.1% under 15
Under-five mortality rate : 78/1,000 live births
Malnutrition prevalence (severe wasting): 0.9%
People in bottom two quintiles (40%) of socio-economic well-being: 64%



<Figure 23

Rural / Urban population for each department of Haiti

It is evident that Nippes has the vast majority of rural population along with the Sud-Est and Grand-Anse

3.2.2 Landscape

The relief in the department of Nippes is consisting valleys, plains and mountains, but due to the numerous watersheds its geographical position makes it susceptible to cyclones and depressions.Even though Nippes has 3 cruical massive watersheds identified at the country level (Corali catching areas – Grand Riviere de Nippes, Petite Riviere de Nippes, Anse a Veau) there are lots of micro – watersheds that sometimes extend to two or more departments. The department is likewise characterized with a rather dense hydrografic network, to make it more clear, it has 386 water points a Pond called the Miragoane Pond (which extends over 24m2) and lots of rivers, from which the 3 main are the Grande Riviere des Nippes, the River Bossard and the Baraderes River.

3.2.3 Movement

Most of the departments area is familiar for having roads that are almost impossible to tour on, meaning even though there are a few covered roads, most of them are dirty and ingrained with rocks. Some of this region's parts are only accessible by boat, leaving the Route National 2 the only accessible connection of the eastern part – between Miragoane and Fond-des-Negres , and the rest of the southern peninsula, as well as the metropolitian area of Port-au- Prince.

3.2.4 Hazard Profile

The department of Nippes, as already mentioned, is prone to natural disasters and experiences them on a regular compared to the rest of the country, mostly due to its little by none disaster risk reduction techniques. Compared with the rest of Haiti's areas, the exposure and vulnerability to storms, floods, earthquakes and droughts in Nippes and the southern peninsula is noticeably higher. The number of rivers is also noticeably high, from which 84 rovers are specially vulnerable to flooding. Hurricane seasons also bring the risk of flooding and landslides. Particulary susceptible to floods are the communes Baradères, Petitie Rivière des Nippes and Miragoâne, while the Plaisance du Sud commune has a very high risk of landslides, meaning,approximately 8,380 people live in very high risk flood zones.

3.2.5 Economy

Like most of the communes in the southern peninsula , agriculture, petty trade and fishing are the most crucial activities from which more than 60% of the people benefit in this department, making it one of the poorest in the whole of Haiti. Even though men dominate the rural, agricultural sector, with more than 70%, and women work mostly at home in some small business , still only 3% of the population has a full time salaried job.

In other words, their main source and potential lies in the agricultural sector in most of this departments communes,but it still lacks environmental management in terms of fishing and farming techniques, agricultural growth as well as education and limited sanitation.

Informal economy: more than 35% of the population of Nippes works an informal job, whereas their profit is much less than a half of the formal economy sectors. Remittances: A large part, nearly two thirds, of the fully supplies by domestic transfers, are remittances from abroad, which play a huge role in the poverty reduction part in the department of Nippes.

3.2.6. Fundamentals

3.2.6.1.Conveyance and power

Infrastructure is extraordinary restricted withinside the southern peninsula of Haiti, meaning that most of it is focused in the capital city, including the only international airport of the country as well as its main port. Most earthquakes reconstruction initiatives have centered on short-time period interventions, as opposed ti improving core infrastructure. In Nippes there are no airports, but the department consists 9 helipads, four in Grand- Boucan, three in Miragoane, one in Anse- Au- Veau and one in Fonds des Negres.

There are no national roads passing in this department, and the only departmental road is the one connecting Miragoane and Petit- Trou-de-Nippes. As already mentioned, coastal parts past Petit-trou-de-Nippes are accessible only by sea. Heavy rains, storms and floods play a very high role in stress placing on existing roads.

Miragoane as the capital of Nippes, has one of Haiti's biggest ports, while rest of the coastal cities in this department own a few simple ports that aren't able to cope with heavy volumes.
The urban areas of this region are electrified , around 75% of them, while from the rural areas the percentage is very low- around 15%. Considering the fact that most of the people in Nippes live in the rural areas, we may conclude that the houses are poorly connected.

3.2.6.2. News & Communication

In the whole Haitian Country , around 70% of the population already has access to a mobile phone and within the years it is growing more and more. Their dominant service provider Is Digicel, and internet is available mostly in the urban areas. However, telecommunications in the department of Nippes Is more limited than most of the other departments. The varieties of traditional media is the maximum broadly accessed shape of media in Nippes, such as TV and Radio, which mosto people listen to it at least once per week, mainly men.

Form of media	Nippes (male)	(female)
Newspaper once a week	14.3%	12.1%
Television once a week	18.1%	15.2%
Radio once a week	80.7%	62.5%
All once a week	5.3%	2.3%
No form of media	18.8%	34.4%

sources: MSPP 2012

3.2.6.2.Food Security

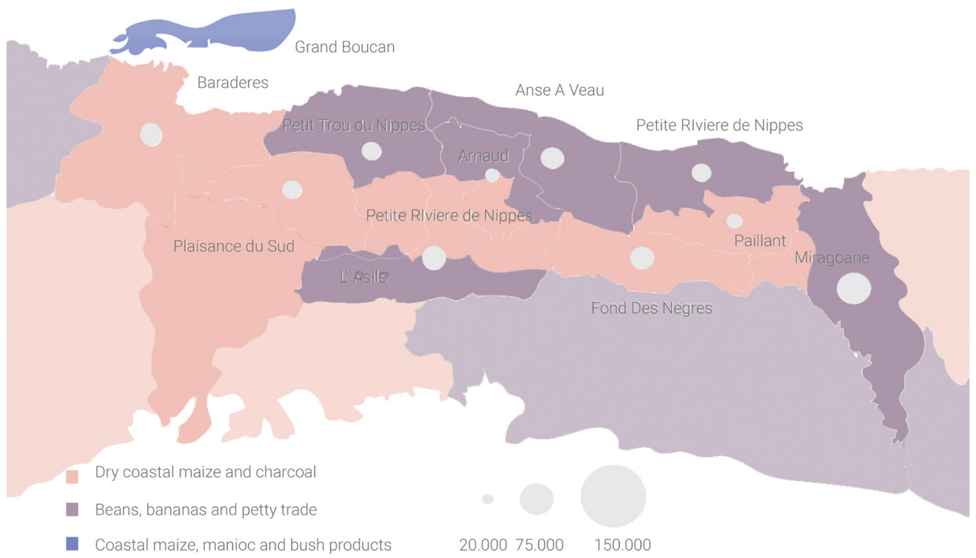
Miragoane is a commune which is considered as the most important trading center, having the best food availability along with the department of Petite Riviere des Nippes and Fonds des Negres. Nippes on the other hand is physically remoted from rest regions by poor infrastructure and rough terrain , which means high import costs but also impacting food access and availability.Food security stress in Nippes can be noticed in August and in September and it is anticipated to enhance with the passing of El Nino phenomenon, besides withinside the coastal areas.

Food security	Nippes	National Average
Percentage of families often missing meals	19.4%	23.2%
Severely food insecure	2%	2%
Moderate food insecure	30%	28%
Marginally food insecure	35%	38%

source: WFP o8/2016. MSPP 2012 Based on an August survey by WFP of Nippes

3.2.6.3. Livelihoods

As we already mentioned, agriculture, farming, but also charcoal and timber manufacturing are the base of the economic system in this area. But the fundamental reasons behind the poverty of it lies in the high vulnerability to multiple hazards, birth and migratory movement, reduced land access etc. Livelihoods range by regions in Nippes, the first larges and most sizable livelihoods is the one with banana and beans cultivation in addition to petty trade. The second is the charcoal area and the dry coastal maize. In order to recompense, the poorest people vary their interests. They are at a noticeable risk of the marketing fee increase, since they purchase most of their meals from markets as they produce very little on their own. Whereas the middle- earnings families alternate larger trade between livestock and agricultural products etc.

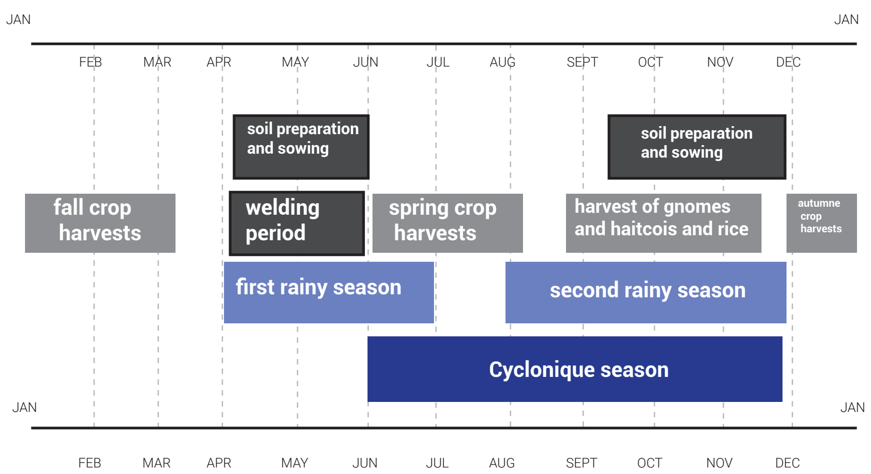


<Figure 24

Different livelihood zones in the Nippes department

In the Petit Trou de Nippes area beans, bananas and petty trade are the biggest contributors

3.2.6.4. Seasonal Calendary



<Figure 25

The Seasonal Calandary and cyclones effects on crops

The secondary sowing season for beans is from July to August and the secondary growing season is in September, meaning hurricanes will impact these seasons severely. Vegetation coverage was considered between average and healthy in June (FAO 05/07/2016)

3.2.6.4. Health

34 Hospitals may be observed withinside the branch of Nippes . The inpatient capacity of these hospitals is 135 people (primarly based totally on matress availability) – a ratio of 3.8 beds per 100,000 inhabitants, below the national average of 6.7. In 2019, there were 240 medical staff members in Nippes: 67 doctors, 95 nurses, 76 auxiliary nurses, and two midwives, for a ratio of 6.8 medical staff members per 100,000 inhabitants, below the national average of 10.47

Communes	**Type**	**Total**			
		CSL	CAL	Hospital	
Anse a Veau	2	0	0	1	3
Arnauld	1	0	0	0	1
Asille	3	0	0	1	4
Pond-des-Negres	2	0	0	1	3
Grand Boucan	1	0	0	0	1
Miragone	6	0	0	1	7
Paillant	3	0	1	0	4
Petit Trou de Nippes	0	0	1	0	1
Petite Riviere de Nippes	1	1	1	0	3
Plaisance	1	0	1	0	2
Total	20	1	4	4	29
%	68.97%	3.45%	13.79%	13.79%	100%

CAL = Clinic with bed; CAL = Clinic without bed

3.2.6.5. Wash

In the department of Nippes even though 60% of families can frequently get their right entry of water, there isn't any waste treatment.(13) In the previous times MINUSTAH has needed to offer potable water to personal and public establishments consisting of hospitals, schools,and police stations because of the excessive degree of water shortage in Nippes.While no cholera cases have been officially diagnosed in Haiti since February 2021, this does not mean that the vibrio cholerae bacterium (the bacterium that causes cholera) is absent in the ground.Even though 60% have access to a water point, more than 70% of Nippes population do not have access to clean water, soap and hygiene poroducts. During previous humanitarian emergencies, WASH has been one of the priorities because of the lack of water connection networks in the regions.

3.2.6.6. Shelters

In Haiti, most of the housing, both rural and urban, includes two -room houses constructed from mud walls and floors. The floor in 55% of the cases is made of cement, 3.5% use mud and 5% use sand.The openings are panel less and covered with wooden shutters. The roofs are frequently thatched with grass or palm leaves however can also be fabricated from plastic or corrugated metal. Professionally constructed homes suffer from lax enforcement of zoning and safety rules. In Nippes, there were 130 emergency shelters with a capacity for 26,000 people.

3.2.6.7.Education

This department's education indicators are mostly all, under the country's average. 83.2% of men and 80.3% of women are literate in Nippes.

Education	Nippes	National Average
Primary school attendance	80.5%	77.2%
Secondary school attendance	18.7%	25%
Women with no education	16%	14.8%
Men with no education	11.8%	13%
Literacy (women)	70.3%	73.6%
Literacy (men)	73.1%	78.7%

sources: WFP o8/2016. MSPP 2012
Education indicators Nippes vs National, 2012

3.2.6.8.Protection

Compared to the rest of Haiti;s physical and gender violence, the rates in Nippes are far better, even though on a global level it is still concerning. Gangs that are present in the Capital of Nippes (Miragoane) have attacked human beings looking to transit to different regions of the the department

Protection	Nippes	National Average
Gender Based Violence Prevalence (1)	27.4%	28.2%
Sexual Violence Prevalce (2)	10.8%	18.1%
Child Labour Rates (3)	80.8%	65.3%
Violence against children (4)	84%	86%

sources: MSPP 2012
(1) Percantage of women who have experienced physical violence at least once since the age of 15
(2) Percentage of women who have experienced sexual violence at least once since the age of 15
(3) Children aged between 5 and 11 who have work for one hour per month on economical activity or 28 hours per month on domestic
(4) Percentage of [arents who use violent disciplinary against children from 2 to 11 years old

Considering hazard protection, it is certain that people should not return to partially or fully destroyed homes to search for refuge or retrieve personal belongings. Numerous human beings died after the 2010 event (earthquake and cylone) mostly due to two factors, firstly they have been injured and could not be found and secondly due to return to their damaged homes which collapsed all over them.The number of missing people in Nippes is presently unknown, mostly because of the big variety of homes that are destroyed and damaged.

3.3. City profile: Petit Trou de Nippes

3.3.1 General overlook

This commune is located in the Nippes department of Haiti, more specific in the Arrondissement of Anse-A- Veau. It's population counts 29,990 inhabitants.

3.3.2.Landscape

Petit Trou de Nippes's is located between the borders of the cities called: Arnaud (on East), the city of L'asile (on the southeast) , Plaisance(on the west), Baraderes (on the west) and Anse-a- Veau (on the northeast) and it's area takes around 153.19km2 from the area of Nippes. The town has 3 communal sections, the city center and the firstand second communes.

3.3.3.Demography

Its inhabitants are called Trou-Nippois.

Year	Population	+/-
1890	6.000	
1998	41.147	+586%
2003	36.143	-12%
2009	27.273	-25%
2015	29.990	+10%

3.3.4.Seed Banks

The huge amount of loss from these hazard In Petit Trou de Nippes' s, results mostly with loss of crops and seed replanting. That means that now farmers need to travel long distance and buy seeds ,while not having money from selling due to the hazard hits. Local agricultural associations, together with the leaders of the community, requested for aid in beginning a Bank Agrikol or a seed bank. This is basically a seed shop to assist the farmers with the primary replanting after the hurricane.

3.3.5.Economy

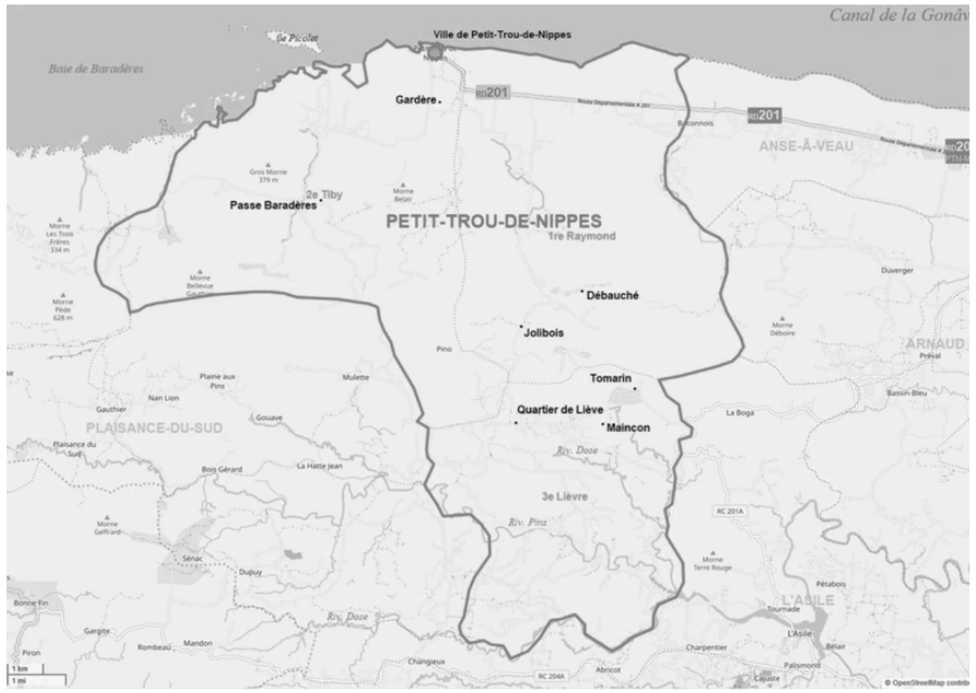
The city of Petit Trou de Nippes has a small local economy mostly based on the fishing port, growing coffee, cotton and sugar lane, or in other words, only ten food supply centers have been counted whit inside this city This commune also produces red and yellow ocher to make pottery and clay. Another thing that has been counted in the municipality is a pharmacy and of course the seed bank that was mentioned above. The seed bank is being led by the locals ,making them responsible for their own project and it's their own decision on how to invest, on what to invest, if they have profit and should stay open and many many other possibilities. This project is not only about mobilizing the community but its also a response to the hazard itself.

3.3.6. Neighborhoods

PTN	Nippes		29.990
VPT	Ville de Trou de Nippes	Urban	1.189
	Quartier de Grand Ravine	Urban	2.614
	Quartier de Lieve	Urban	1.368
RAY	1ere Section Raymond	Rural section	7.661
TBY	2eme Section Tiby	Rural section	7.606
LIV	3eme Section Lievre (ou Vigny)	Rural	13.687

Figure 26>

The commune of Petit Trou De Nippes within the Nippes reion



3.3.7 Fundamentals

3.3.7.1. Movement

Petit Trou de Nippes is a small city to be found at the coast of the azure Caribbean sea. It is a great holiday spot not only because it has natural environment for people who like taking walks but also its waters are domestic to dolphins, making it a pleasant and interesting sight for tourists, in addition to lovely sunsets and sunrises an crystalline waters with a sugar-white sand.

On the other hand, to reach on to this extraordinary beauty, one must take a minimum 5 hour journey from Haiti's capital , Port-au- Prince, mostly because of the roads conditions, dirt, water etc. This small city is situated at the end of Route Departmentale 21.

3.3.7.2.Education

The municipality of Petit Trou de Nippes in collaboration with the Ministry of National Education of Youth and Sports, in its territory has 3 kindergarden, a few primary schools, around 6 secondary schools and two technical and vocational schools.

3.3.7.3.Health

In this commune there are only 3 health facilities, with a combined medical stuff of 2 dentists, 5 nurses, laboratory technician and 4 doctors. None of them are not in collaboration with the Ministry of Public Health since they don't take part in the municipality.

3.3.7.4.Utilities

Petit Trou de Nippes has 4 rivers, 7 sources and numerous public fountains, there also are seven pumps, regarding the water sources. On the other hand, regarding the electricity, the area Gardere and the towns center are electrified through an electric powered motor.

3.4 The site: Community Carrefour Cadet of the commune of Petit Trou de Nippes

3.4.1. Introduction

From everything that was mentioned before, we come to a conclusion that Nippes is one of the most if not the most vulnerable region considering climate and hazard occurrences. As we already discussed, the territory of Nippes Is prone to multiple hazards and the floodable river areas makes the vulnerability of the communes increase even more. Carrefour Cadet is a community located in the city of Petit Trou de Nippes, more specific at the borderline of the 1st communal section and the city center, whose territory faces huge problems in terms to natural hazards.

There are many awareness-raising activities on how to deal with this types of situations given by the Haitian Red Cross, but in spite to all of that the Carrefour Cadet situation is becoming more and more difficult, mostly because of the climate change and escalation-strengthening of the hazards like cyclones, floods and in the last years especially earthquakes.

It may be stated that:

1. We do not have control over nature, so hazard will continue to occur this community, even though we are fighting a battle against climate change the awareness is not at all helpful
2. Humans who actually live on this territory will continue to stay right where they are due to the fact they don't have any different land to pass to.
3. In the last years there had been more people and there will be more people in this community due to birth and migratory movements

VCA Analysis

*This part consists the VCA analysis of the commune Carefour Cadet of Petit Trou de Nippes and all of its developed tools such as : seasonal calendary, direct observations,vulnerability factors etc. *Done by the teams of Osnol Marcel & Mondesir Vital in colaboration with the Canadian Red Cross and Haitian Red Cross

*translated, updated and modyfied accordingly to the needs of the thesis authors

4.4.2. TOOL: Historical Calendary

Year	Events
1963	Cyclone Flora flooded the community of Carrefour Cadet/PiedMorne, destroyed the majority of homes and devastated almost every garden. Cyclone Flora also killed a good number of cattle in the community and also caused loss oflife.
1964	Cleo flooded the community and caused loss of life, destroyed homes, caused excess livestock losses and ravaged the community's planta tions.
1966	Ines flooded the area and destroyed homes, ravaged plantations, caused loss of life and forced the majority of residents to climb into the mountains to avoid falling victim to the passage of water.
1980	On August5,Cyclone Alen flooded the area and destroyed homes, rav aged plantations and caused loss of life.
1986	The departure of Jn Claude Duvaliercaused unrest at the community level which caused the death of many supporters of the regime, the destruction and burning of houses and plantations and also forced many others to flee by little to be killed.
1990	Cyclone Gilbert flooded the area and destroyed homes, ravaged plan-ta tions, caused loss of life.
1992	The Lycée National de Petit Trou de Nippes was founded.
1996	A public administration has been in operation in the community (DGI).
1998	The community suffered a drought for a period of 6 months which caused the destruction of its Natural Resources such as: Garden, Coco nut etc ..). It also caused the death of the community's live-stock and caused the community's inhabitants to starve.
2000	We moved one of the community markets that was in Pied-Morne(SE RADOT Market)which forced the inhabitants to move very far to either sell their products or buy products they need. This displace-ment has had a strong impact on the community's economy.
2001	The community was hit by a big flood in which the water level was 2me ters. During that same year Gosen's Mission Vision was im-plement-ed in the community (Church, School).
2003	In November, the community suffered a very large flood that de-stroyed 80% of the community's gardens. Following this big flood the inhabi tants of the community were victims of severe itch-ing.
2004	The community has been the victim of an epidemic of malaria and also influenza. In the same year, Cyclone Jeanne also flooded the area and destroyed its homes, ravaged its plantations, caused loss of life.

i. Effects of natural disasters (cyclones, floods, earthquakes):

a. Cyclones:
Due to the preconditions of vulnerability in which the population of Carrefour Cadet/Pied Morne are victims, the effects and impacts of cyclones are considerably increasing compared to previous years.

b. Floods:
The effects of floods are always enormous when they hit the community of Carrefour Cadet. These effects are especially huge because of the presence of the Osso River which always tends to flow into the community during almost all cyclones and also whenever there is a heavy rain shower.

c. Earthquake:
Earthquakes generally do not have too much impact on the Carrefour Cadet/Pied Morne community. And also since earthquakes are not frequent in this community we really can not make an analysis if their impacts have evolved or not during their passage.

d. Agriculture:
As far as agriculture is concerned, the profitability of the land has decreased while the population is increasing.

ii. Environmental resources (forests, land for crops, available spaces and land occupation, cultivated areas versus open spaces):

a. Population:
While the population of Carrefour Cade is increasing considerably, there is a very significant decrease in natural resources. So this aggravates the conditions of vulnerability of the people of the community of Carrefour Cadet since for a considerable number of inhabitants there are not enough resources available for survival.

b. Community:
The community of Carrefour Cadet has no forests and the majority of the trees are used to produce coal.

c. Land:
The land by the river of Carrefour Cadet cannot be used for cultivation. Some houses in this community are built by the river.

i. Diseases and related social problems:

a. Diseases are increasing considerably in the community of Carrefour Cadet/Pied Morne, among which can be mentioned:

- Diseases related to poor water quality
- Typhoid
- Diseases related to increased or decreased blood pressure
- Diseases related to increasing age
- Diseases caused by poor feeding conditions

i. Demographic evolution, housing and social conditions, sanitation and hygiene:

a. Demographic evolution:
The population of Carrefour Cadet/ Pied Morne is growing considerably day by day.

b. Housing and social conditions:
At Carrefour Cadet the houses are placed at a reasonable distance. They are usually made of clay and wood. There is not too much tension in the community the few tensions that exist are most often for causes of land conflicts.

c. Sanitation and Hygiene:
As far as hygiene principles are concerned, many people in the community are not well imbued with them. Added to that They don't really have latrines to defecate so they do their business anywhere. This situation increases the vulnerability of people who do not have a health service that can help them in case of certain diseases.

d. In general, the spaces that houses have are not enough for people. And the few houses in the community that have reasonable spaces are those whose owners have at least much more reasonable socio-economic conditions.

2005	The community was the victim of a very disturbing mosquito prolifer ation following the flood of November 2003. Community leaders had to seek outside assistance to solve this problem.
2006	In November, the community suffered a very big flood people were forced to leavetheir homes since the water had returned to their homes more than a meteraway. Thissituation has led to the destrution of thegardens and also to the loss in large numbers of its livestock. And also the water took away the majority of the property of the members of the community.
2007	The community has lost these lemon trees, mazonbels and coconut trees in surplus. This has had a very strong impact on its economy.
2008	Cyclones Gustave and Anna flooded the community and ravaged the majority of its gardens, destroyed its homes and roads and then killed many of its livestock. In that same year, a large tornado hit the commu nity and destroyed many of its homes, not to mention the devastation it caused to the plantations.
2009	In November the community suffered a flood that destroyed the majori ty of its plantations and killed most of its livestock.
2010	The earthquake affected many families in the community and dam aged many homes. On February 27 of this year, the community was hit by a big flood that ravaged the plantations and caused the loss of a large number of livestock. On December 10 of that same year, the community was again hit by a big flood that caused much more damage than the one it suffered on February 27 of that year. And finally, in the same year the community was hit by cholera, which claimed many victims and terrorized people to the point of leaving their homes and fleeing to the surrounding communities or to Port-au-Prince.
2011	The community was hit by an outbreak of measles and Sarampion
2012	The community was hit by a long period of drought that caused the destruction of the majority of its plantations.
2016	Hurricane Matthew hits Haiti with catastrophic flooding of up to 40 inches and storm surge of up to 10 feet. At least 580 people were killed and more than 35,000 left homeless by the storm.
2020	Hurricane Laura was a deadly and destructive Category 4 hurricane that was tied with the 1856 Last Island hurricane and it killed 31 people in Haiti and four in the Dominican Republic.
2021	A magnitude 7.2 earthquake struck Southwestern Haiti. It's epicenter was about 10 km from Petit-Trou-de-Nippes, approximately 150 km west of Port-au-Prince, the capital. The quake left behind significant damage. Tsunami warnings were immediately issued as several small tsunami waves struck surrounding areas. An estimated 2,207 people have been confirmed dead, while 344 remain missing, and over 12,000 left injured. It is the strongest earthquake to strike Haiti since 1842.

4.4.3. TOOL : Increased Risk Calendar

Year	Effects of Natural Disasters	Land Use and Environmental	Diseases and social problems	Density and Habitat, Relations Demography and Social Resources
1963	Weak	Rational	Few	Less Dense
1970	Slight increase	Decreases slightly	Increases slightly	Increases slightly
1980	Increases slightly	Decreases slightly	Increases slightly	Increases slightly
1990	Increases significantly	Decreases significantly	Increases significantly	Increases significantly
2000	Increases significantly	Decreases significantly	Increases significantly	Increases significantly
2010	Increases very significantly	Decreases very significantly	Increases very significantly	Increases very significantly
2021	Increases very considerably	Decreases very considerably	Decreases very significantly	Increases very considerably

- *This table describes the increased damage caused by cyclones due to the worsening of the community. It should also be noted that the risks are becoming more evident by the day because of the Osso River that threatens to invade the community.*
- *On the other hand, the increase in population makes the value of cultivated land low compared to the past. Fishing is also not exempt from this situation.*

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4.4.4. TOOL : .Seasonal Calendar

EVENTS		FEB		APR	MAY	JUN	JUL	AUG		OCT	NOV	DEC
Cyclone/Hurricane						X	X	X	X	X	X	
Flooding						X					X	
High food prices					X	X	X				X	
Sowing period			X	X	X	X	X					
Harvest period	X							X	X			X
Famine period						X						
Period of receipt of money from the diaspora												X
Period of diarrhoea diseases					X	X						
Water-related/ Cholera				X	X						X	X
Malaria cases					X	X					X	X
Case of Typhoid					X							
Drought Period	X	X	X			X						
Fishing							X	X	X	X	X	X
Decrease local product	X							X	X			

4.4.4.1. Hazard Ranking Method

Type of Hazard	Effect/ Loss	Rank
Cyclone	10	1
Earthquake	8	2
Floods	6	3
Diseases	3	4

Effect Loss scale 1-10; Rank scale 1-5 where 10/5 is the highest

4.4.5. TOOL : Direct Observations

4.4.5.1.Population & community

- *The population is divided into 40% young people and children, 35% adults and 25% veillard. 60% of the population are women and 40% are men.*
- *60% of the children in the community are of school age and 80% of the adults in the community live with children. The work that is most common in the community is agriculture, livestock and masonry.*
- *More than 60% of the families in the community are very large, about 10% contain heads of families who are still children and 30% of the families are not numerous.*

4.4.5.2.Conflicts

- *The conflicts that are most frequent in the community are often related either to the problem of animals sometimes destroying the gardens of others or between people in the community who have different opinions. But the community is still organizing itself to manage these conflicts amicably*
- *Families are united and when for certain causes it is children who are heads of household, the community organizes itself to help these children according to the resources available.*

4.4.5.3.Housing and material use

- *60% of the houses in the community are built of metal sheets and wood, 15% of houses are built in blocks, 10% in concrete and 15% in straw. Not all latrines in the community are well used and well guarded. The materials used most often during constructions are: rock, wood, metal roof. The materials that are not used too often are: blocks, lime, cement . And what is used very rarely is: Clay. And the abandoned materials are: bricks. The distance between the houses is about 80 - 200 meters.*

4.4.5.4.Road Infrastructure

- *The roads are dirty and inaccessible in case of rain, the community does not have a reasonable vegetation cover. The community has no spaces where members can really recreate themselves sometimes. Young people play football in the street where there is the traffic of motorcycles and cars or trucks.*

4.4.5.5.Water Circulation

- *The community doesn't really have a channel to allow proper water circulation. There is a part of the community that is channeled but the canals are clogged with debris and mud. The water that people use to drink and cook their food comes from the source and is not often treated before it is used. The community has no electricity , but it is available in the community at every popular festival. For telephone services Digicel and Natcom work very well.*

4.4.5.6.Transportation

- *There are no basic services in the community, the distance traveled to school is between 1 hour to 2 hours of time and 2 to 3 hours of time to go to a health center when going out in remote places in the area. The animals found on the street are domestic and farm animals.There are no institutions in the community except a church and a DGI office.*
- *The means of transport used in the community are: Taptap, bicycle, motorcycle, Horse, Motorcycle Taxi, travel trucks and sailing boat*

4.4.5.7 Trees

- *There are not many trees in the community but there are still some coconut trees*

4.4.5.8 Sanitation

- *90% of the houses in the community do not have latrines and the 10% of houses in which there are latrines they are misused*

4.4.5.9. Religion

- *The religions practiced are: Christianity, Catholicism and Vodou*

4.4.6. TOOL : Mapping of the community

This map shows where the community's resources are located to deal with threats and to reduce the effects of natural disasters. On this map we can see the sites of refuge, the useful infrastructures (church, roads, offices of humanitarian agencies etc.).

4.4.6. TOOL : Vulnerability factors and opportunities

4.4.6.1. Vulnerability factors (Weak points) :

1. *People live too close and downstream of the river;*
2. *People do not have knowledge of what to do in the face of natural disasters;*
3. *No early warning system*
4. *No invention team in case of disaster*
5. *People don't have latrines so they do their business on the floor;*
6. *Deforestation of the upstream part of the community;*
7. *Not all children in the community are in school;*
8. *There is a lot of unemployment in the community;*
9. *There are not really any temporary shelters in the community as the only building considered shelters is floodable.*

4.4.6.2. Opportunities (Strenghts of community) :

1. *The community has water as natural resources in case of irrigation actity and also that could be used during certain construction activities.*
2. *The community has basic materials in case of activity of Gabionnage or masonry dam.*
3. *The community also has sand as its resources.*
4. *At Carrefour Cadet there are people experienced in masonry and also civil engineering.*
5. *At Carrefour Cadet there are people experienced in natural medicines.*
6. *At Carrefour Cadet there is a space available authorized to safely store materials and materials in case of certain construction activities.*
7. *The Carrefour Cadet community has Red Cross volunteers trained in Mi cro-Project Formulation and Management.*
8. *The Carrefour Cadet Community has Red Cross volunteers trained as com munity rescuers.*
9. *The Carrefour Cadet Community has animals (Mulet, Horse... etc) available capable of transporting materials or work materials to inaccessible places and also motorcycle taxis.*
10. *At Carrefour Cadet there are trucks capable of transporting materials in case of certain construction activities.*
11. *The DGI office of the municipality is located in Carrefour Cadet and also the Digicel office which most often serves as shelters in case the BAC is flooded.*
12. *At Carrefour Cadet there are trained Matrons able to help women in case of childbirth.*
13. *At Carrefour Cadet there are Churches and Shops capable of serving the residents of the community.*
14. *The community has teachers capable of training the people of the community.*

4.4.7. TOOL : Vulnerability aspects and influence

ex. Things we can change (aspect)

- *How we can change them (influence)*

4.4.7.1. The problem of latrines

- *Building latrines in the community*
- *Educate people in the community on how to use latrines well*
- *Provide training sessions to people in the community so that they can know how to protect themselves from diseases related to the mis use of latrines such as cholera.*

4.4.7.2. Flooding

- *Cleaning the Gabionnage or masonry dam activity in the riverbed*
- *Clean up drainage channels or outlets to allow proper water runoff.*
- *Conduct awareness sessions with people to change their behaviour with regard to the flood phenomenon and prevent them from becoming a victim of it.*

4.4.7.3. The Problem of Agriculture

- *Properly equip farmers in the community and also provide them with training sessions.*
- *Make irrigation canals by capturing water from the Osso River in order to water the arable land.*

4.4.7.4.The Electricity Problem

- *Installation of a wind turbine system to produce energy capable of sup plying the community or installation of a hydroelectric power plant in the Osso River.*

4.4.7.5. Road infrastructure problems

- *Arrange roads that are repairable in the community and build roads in inaccessible areas of the community.*

4.4.7.6.Leisure-related problems

- *Build a public square with football, basketball, volleyball fields in the community.*
- *Build a museum in the community, a library and a movie theater.*

4.4.7.7. Health problems

- *Build a health structure in the community.*
- *Equip the structure with adequate equipment*
- *Recruit trained staff to provide service to the community.*
- *Equip the structure with an ambulance service to transport cases that exceed the skills of the service staff of the structure.*

4.4.7.8. Diseases

4.4.7.8.1.Malaria

- *Distribute mosquito nets.*
- *Fill the pools with water to avoid the creation of mosquitoes.*
- *Do cleanings in the area to avoid the proliferation of mosquitoes in the waste.*

4.4.7.8.2.Cholera

- *Encourage the population to consume drinking water.*
- *Consume food that is only well cooked.*
- *Do some cleaning in the environment.*

4.4.7.8.3.Drought

- *Install pumps in the community to water the land.*
- *Plant in adequate seasons.*

4.4.7.8.4.Swine fever disease

- *Conduct vaccination campaigns in the community.*
- *encourage people to drink clean water*

4.4.7.9.Erosion

- *Plant a lot of trees in the community.*
- *Make living ramps at the level of the dreary of the community*

4.4.7.10.Roads

- *Put some grease in the roads until they are not yet built.*
  The problems of Latrines
- *Digging holes in the community for people who don't have latrines until they can have them*

4.4.8. Organizations that are in the community

#	Organiza-tion	Respon-si-	Phone Number	Field of activity	Result Impor-	Work Outcome
1	HRC/CRC	Charles Jean Renel	3109-0489	GD/RRC Campaign against cholera, Sante Communautaire Formation at the community level, latrinization.	4.5	4.6
2	OFAPTN	Moselline Yolene	3836-0264	Street cleaning/ Socio-Cultural Activities	3.11	3.72
3	Fondep	Mario Coty	3715-7274	Supports to OCB/ Community Radio	2.6	3.28
4	Cadec/ ProdeP	Joseph Daniel	3805-4683	Training and support to OCB/ donation community store.	3.78	2.28
5	MOPEP	Henry Priffin	3839-2252	Installation of irrigation system, Donation of mill Com, loans	2.56	3.11
6	ODSIM	Romain Nicolas	3843-9622	Pipe/ Filling of Mats	1.88	2.22
7	OJCDP	Kerasaint Leriche	3387-4010	Reforestation and Street Clean-ing/Awareness-raising and Pre-paredness/ Activities against Natural Disasters	1.89	1.94
8	ODEPTN	Jose Roosevelt	3199-0901	Pipe repair at the community level	2.11	1.5

- *This step consists on the one hand the identifying of the important organizations existing in the locality, the groups of people and associations, and on the other hand, the type of relations that exist between these groups/associations and organizations and the community (the importance of these institutions and organizations).*

- *This step gives the result of the ratings assigned to each organisation working int he Community. Scores ranging from 1 to 5 are ratings given to each of these organizations based on their importance in the Carrefour Cadet community.*

WHERE TO BEGIN?

THE COMMUNITY OF PETIT-TROU-DE-NIPPES IS AFFECTED BY STORMS, EARTHQUAKES, FLOODS AND DESEASES.

STORMS #1

EARTHQUAKES #2

FLOODS #3

DISEASES #4

"We are mostly affected by ..."

Now we know which solutions to prioritize

INPUTS

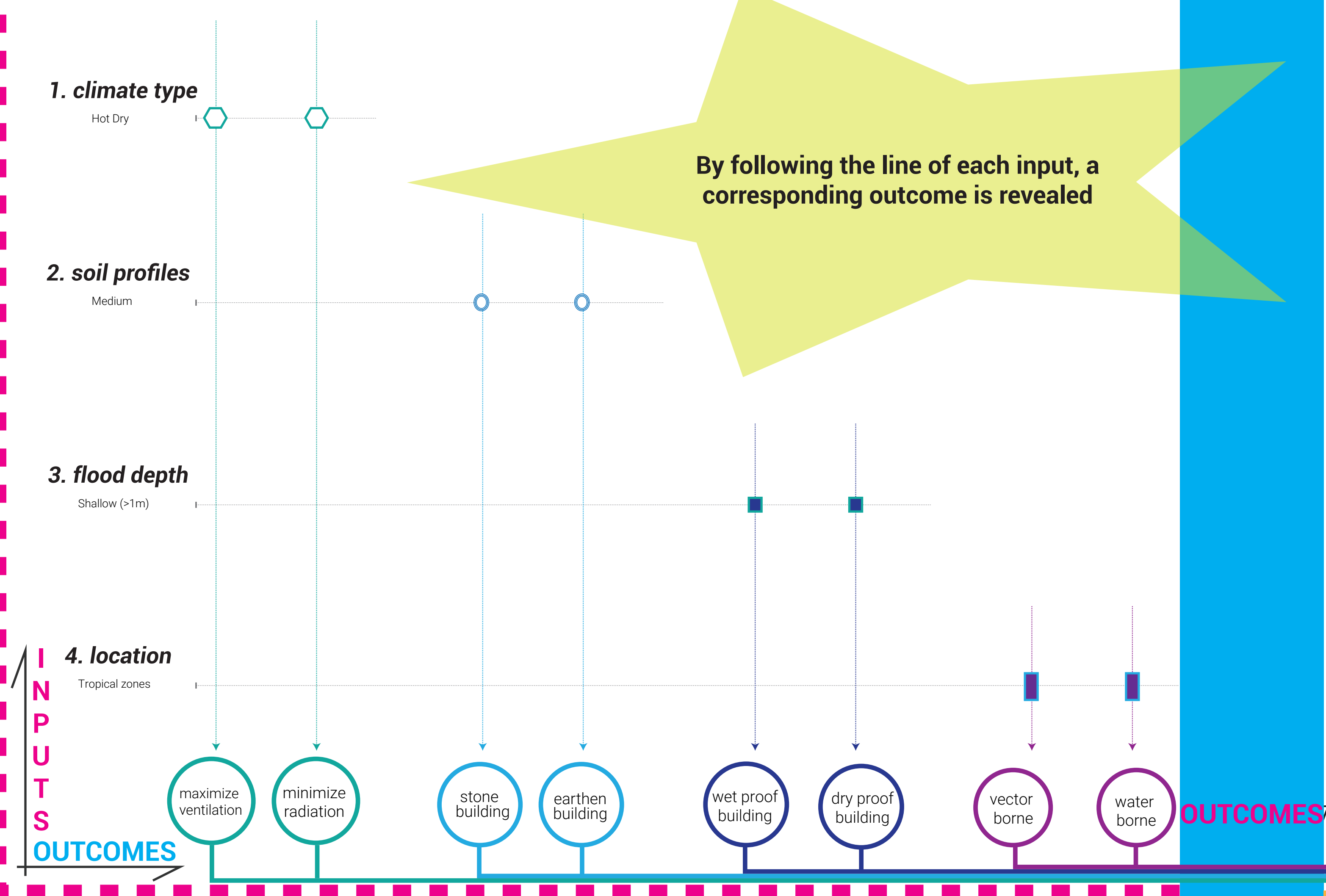
1. Storm matrix

2. Earthquake matrix

4. Flood matrix

4. Disease matrix

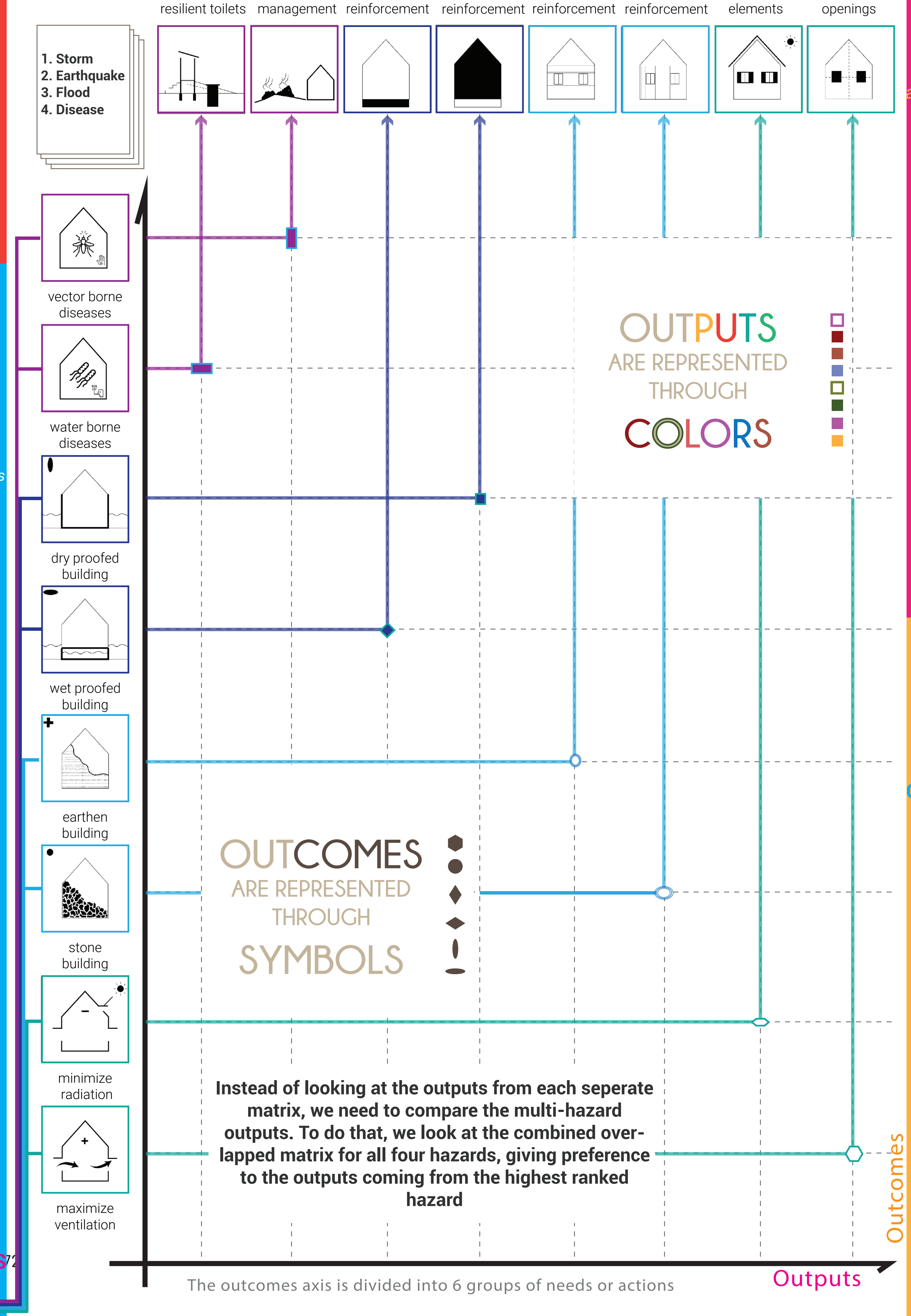
The INPUTS are defined for each hazard 2D matrix separately. They represent previously defined site characteristics of the area of application. An example are these two inputs from each hazard matrix that further reveal eight outcomes:



1 RANKING METHOD

2 INPUTS *site characteristics*

The outputs axis is divided into 14 macro-groups with various architectonical features that can be adopted as possible solutions.

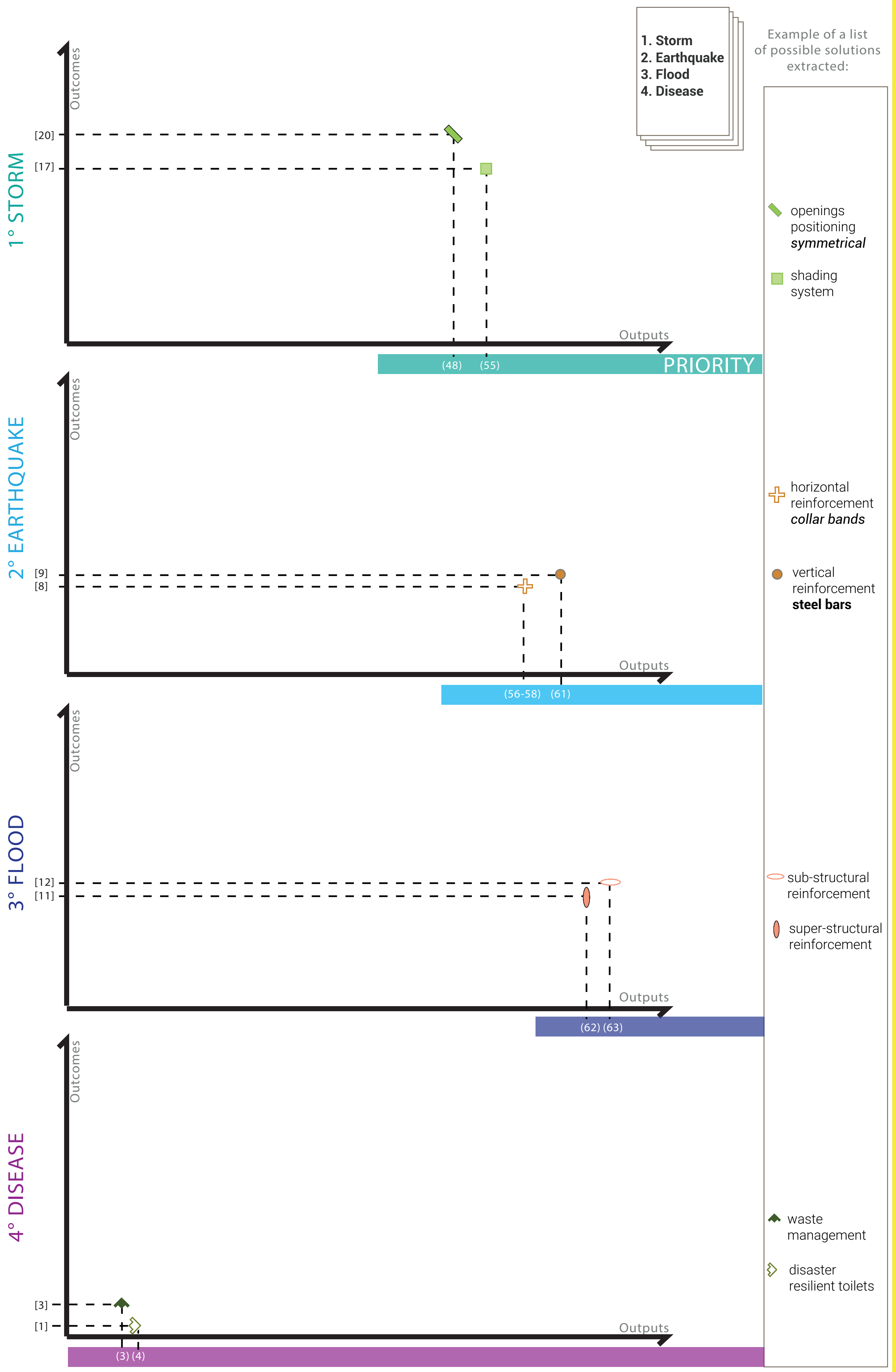


Instead of looking at the outputs from each seperate matrix, we need to compare the multi-hazard outputs. To do that, we look at the combined over-lapped matrix for all four hazards, giving preference to the outputs coming from the highest ranked hazard

The outcomes axis is divided into 6 groups of needs or actions

4 OUTPUTS *architectonic features* *possible solutions*

3 OUTCOMES *needs actions*



5 FINDING THE OUTPUTS IN THE CO-MATRIX

The final list of possible solutions

hazard co-matrix possible solutions
+
knowledge of community capacities
+
education matrix possible solutions

FINALLY, REPEAT THE PROCESS FOR THE EDUCATION MATRIX AND ADD THE OUTPUTS TO THE FINAL POSSIBLE LIST OF SOLUTIONS

The education matrix is separate and does not overlap with the rest of the hazard matrices

COMMUNICATE THE SOLUTIONS FOUND AND LEARN ABOUT THEIR CAPACITIES
(monetary, technical knowledge, localy available materials)

FOR MAKING THE FINAL LIST OF POSSIBLE SOLUTIONS, COMMUNITY INVOLVEMENT IN SOME WAY IS CRUTIAL

7 final list of possible solutions

education matrix

6 community involvement

Legend (Outcomes - Outputs)

Outcomes (simbols)

Type of Disease
- [1] Vector Borne Disease
- [2] Air Borne Disease
- [3] Water Borne Disease

Eathquake Effect
- [4] Tsunami
- [5] Landslide
- [6] Soil liquification
- [7] Ground motion

Type of Building
- [8] Earthen Building
- [9] Stone Building
- [10] Masonry Building
- [11] Wet-proofed Building
- [12] Dry-proofed Building
- [13] Elevated Static Building
- [14] Amphibious Building
- [15] Pile Building
- [16] Floating Building

Ventilation, Wind
- [17] Maximize
- [18] Minimize

Solar Radiation, Sun
- [19] Maximize
- [20] Minimize

Humidity, Rain
- [21] Protection

Foundation/Wall Materials
- [22] Burnt Brick
- [23] Concrete/ Concrete Brick
- [24] Mud Brick
- [25] Adobe Brick
- [26] Wood and Mud

Roof Materials
- [27] Stell (Iron sheet)
- [28] Timber (Wood)
- [29] Bamboo

Outputs (colors)

Social Distancing
- (1) Desk-Chair spacing
- (2) Open and adapted space

Toilets
- (3) Disaster-resilient toilet
- (4) Waste management

Hand Washing Facilities
- (5) Location close to the toilet
- (6) Materials
- (7) Accessibility to everyone

Water Supply
- (8) Ground catch-ment System
- (9) Rain Water catchment system

Structural System
- (10) Frame
- (11) Bearing wall

Weigth
- (12) Heavy
- (13) Ligth

Structural protection
- (14) Screening Doors
- (15) Screening Eaves
- (16) Screening windows
- (17) Screening Nets
- (18) Boundary wall
- (19) Set-back
- (20) Fences

Foundation

Static
- (21) Two store building
- (22) Pile Foundation
- (23) Strip wall
- (24) Mat
- (25) Base isolation
- (26) Basement (h <1m)
- (27) Sub-floor void (h: >1m)

Kinetic
- (28) Buouyancy

Material Characteristics
- (29) Water-resistance
- (30) Carbon footprint
- (31) Maintenance

Floor
- (32) Raising

Roof

Ceiling Height
- (33) Higher
- (34) Lower

Roof Overhang
- (35) Decrease
- (36) Increase
- (37) max 500 mm
- (38) Use ties

Roof Shape
- (39) Slope (min 20°-30°)
- (40) Slope (22-30°/45°)
- (41) Hipped
- (42) Pyramidal
- (43) Conical

Roof Weigth
- (44) Light
- (45) Heavy

Openings

Type of ventilation
- (46) Mechanical ventilation
- (47) Natural Ven-tilation

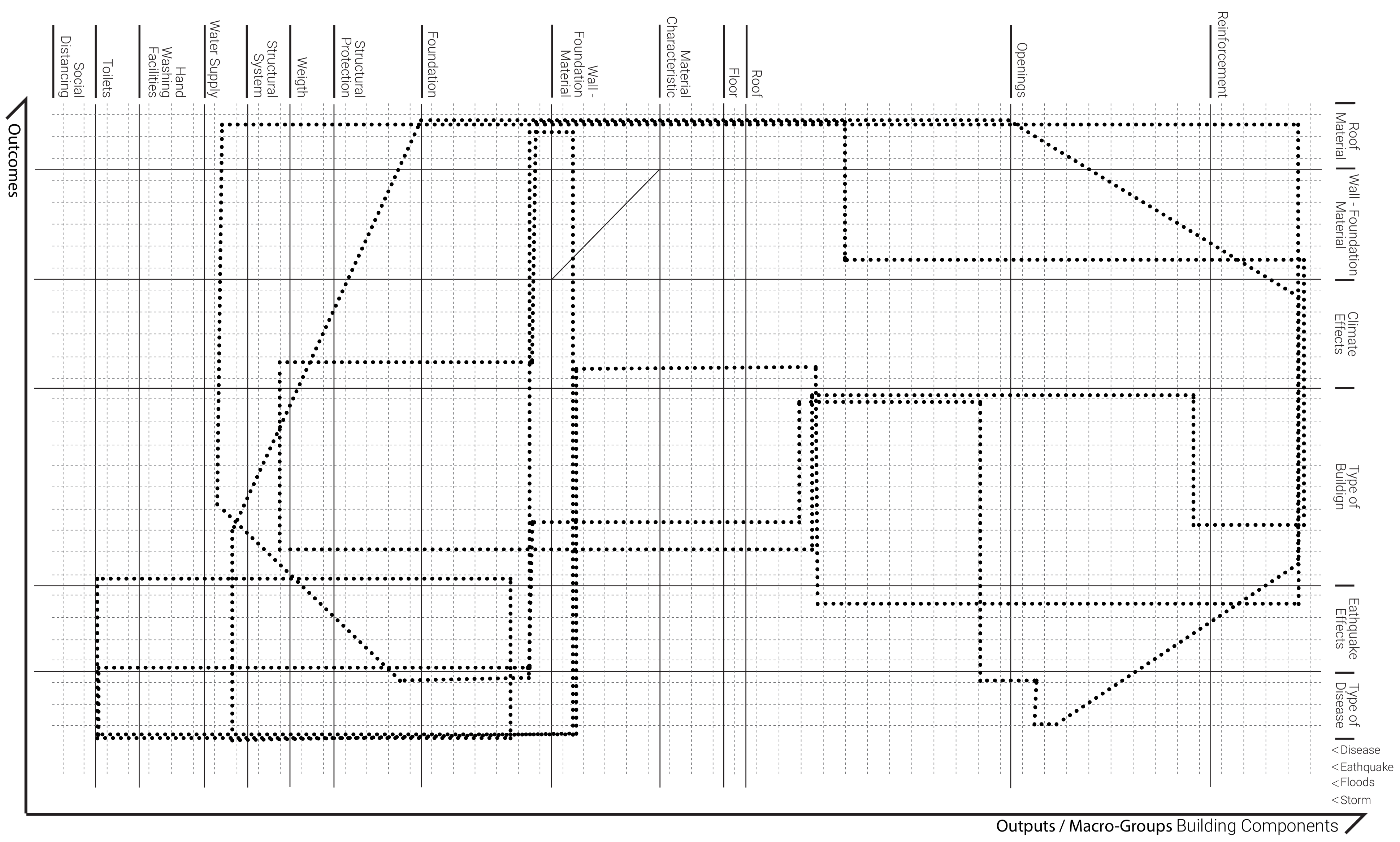
Position
- (48) Outward opening
- (49) Symmetrical (Max 20% of wall)
- (50) At same heights
- (51) Upper
- (52) Adjacent
- (53) At different heights
- (54) Elements of Protection
- (55) Shading Elements

Reinforcement

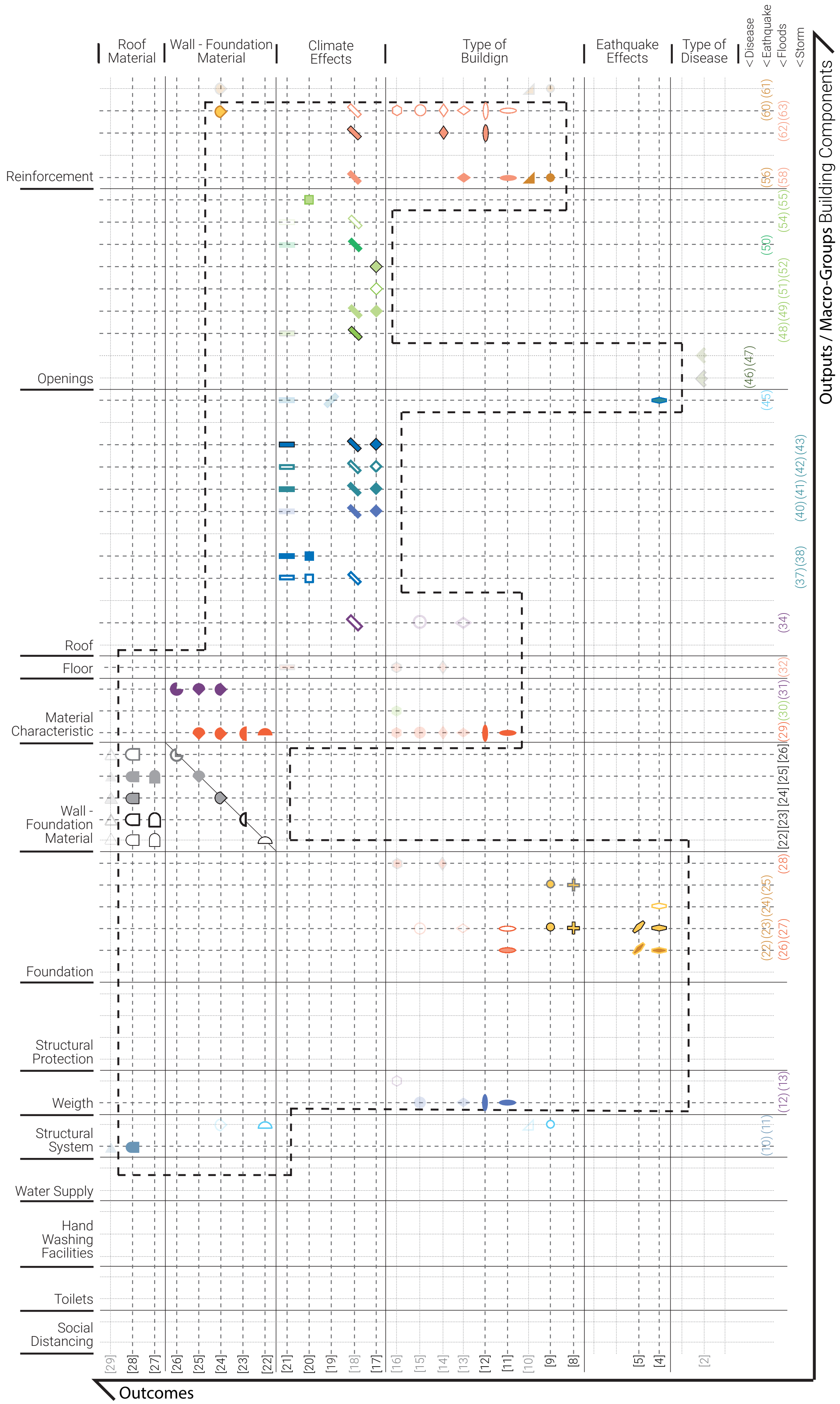
Horizontal
- (56) Ring beams
- (57) Collar bands
- (58) Mooring system

Vertical
- (59) Wire mesh
- (60) Wood post
- (61) Steel bar
- (62) Super-structural
- (63) Sub-structural

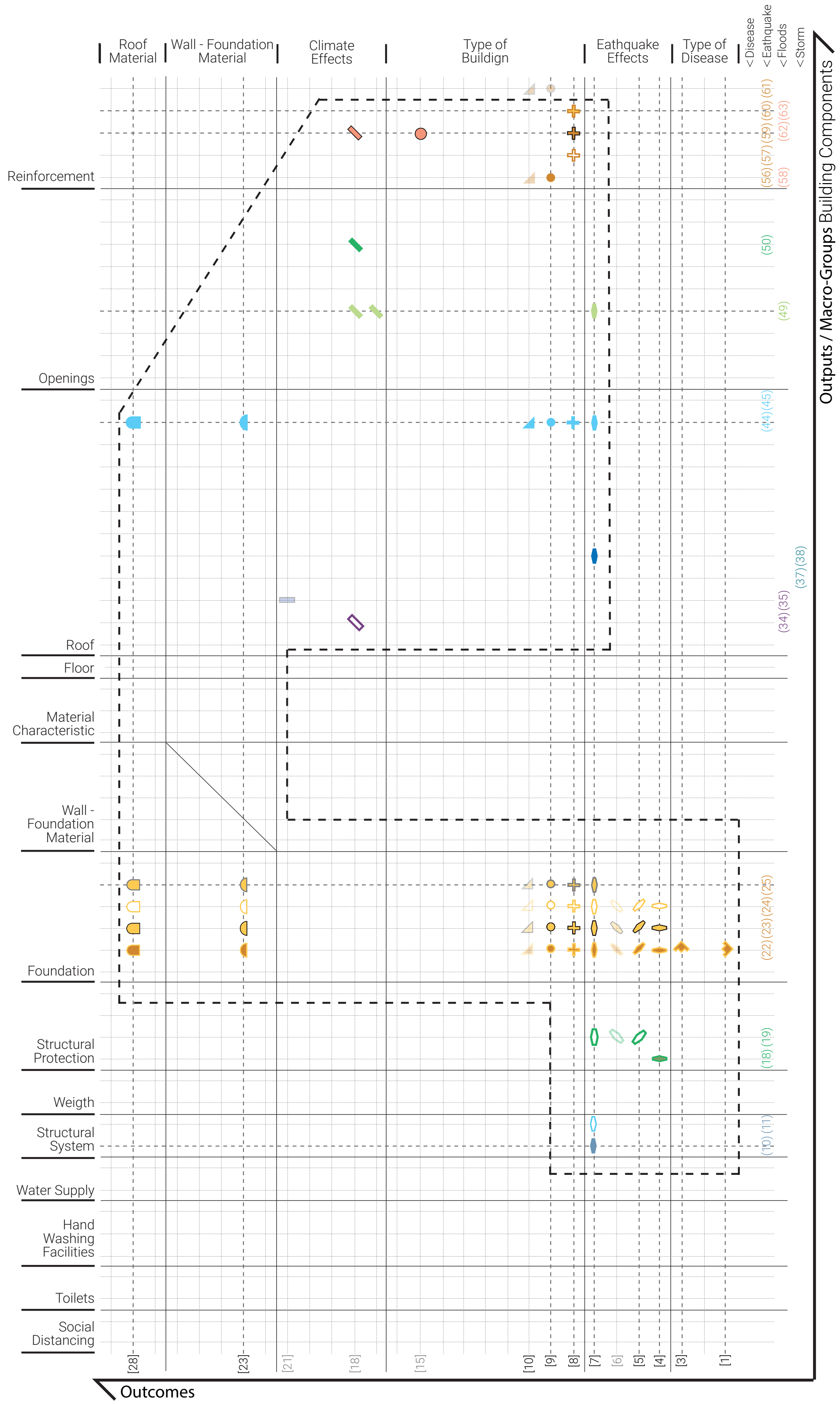
Axis and 2d Space



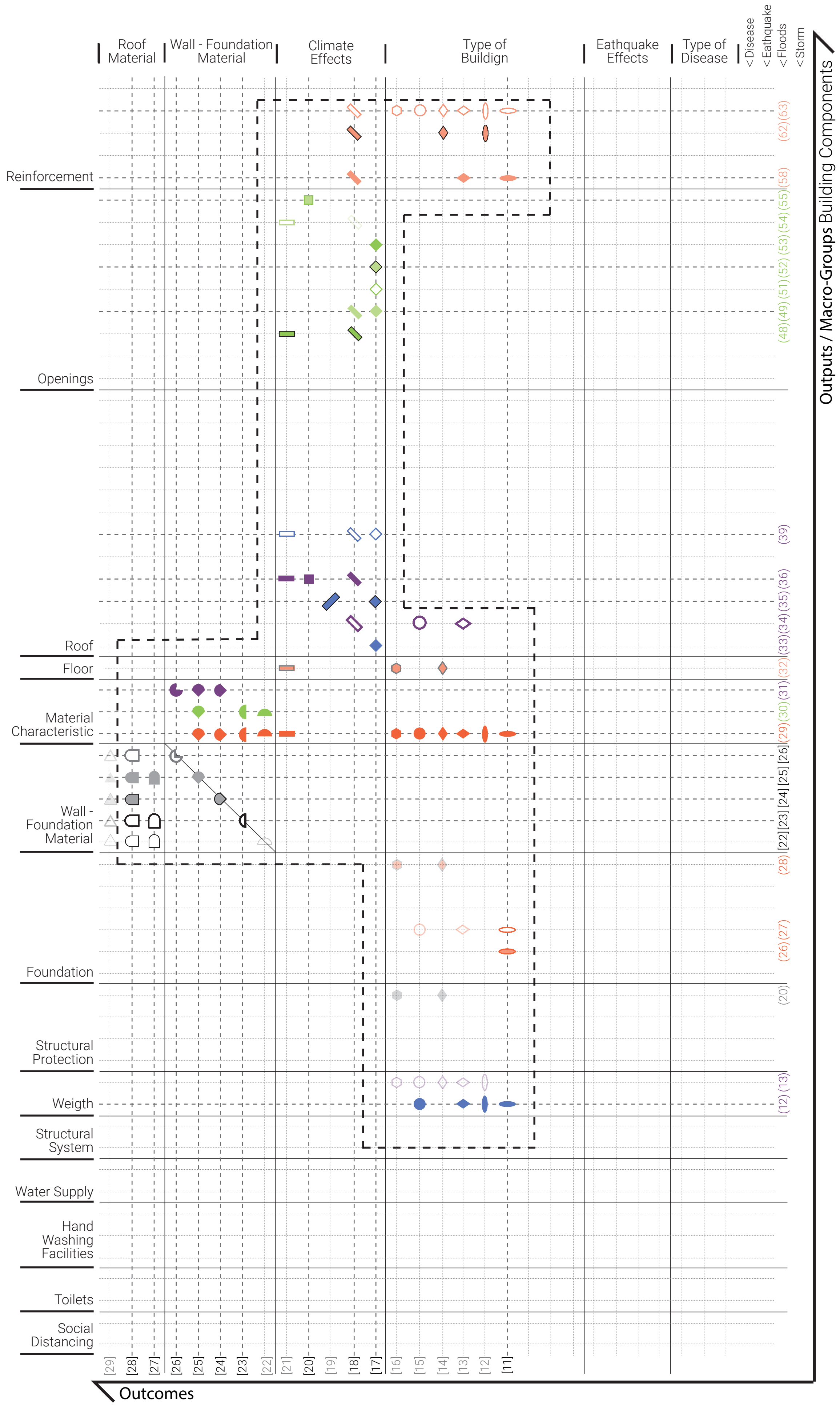
Storm Matrix



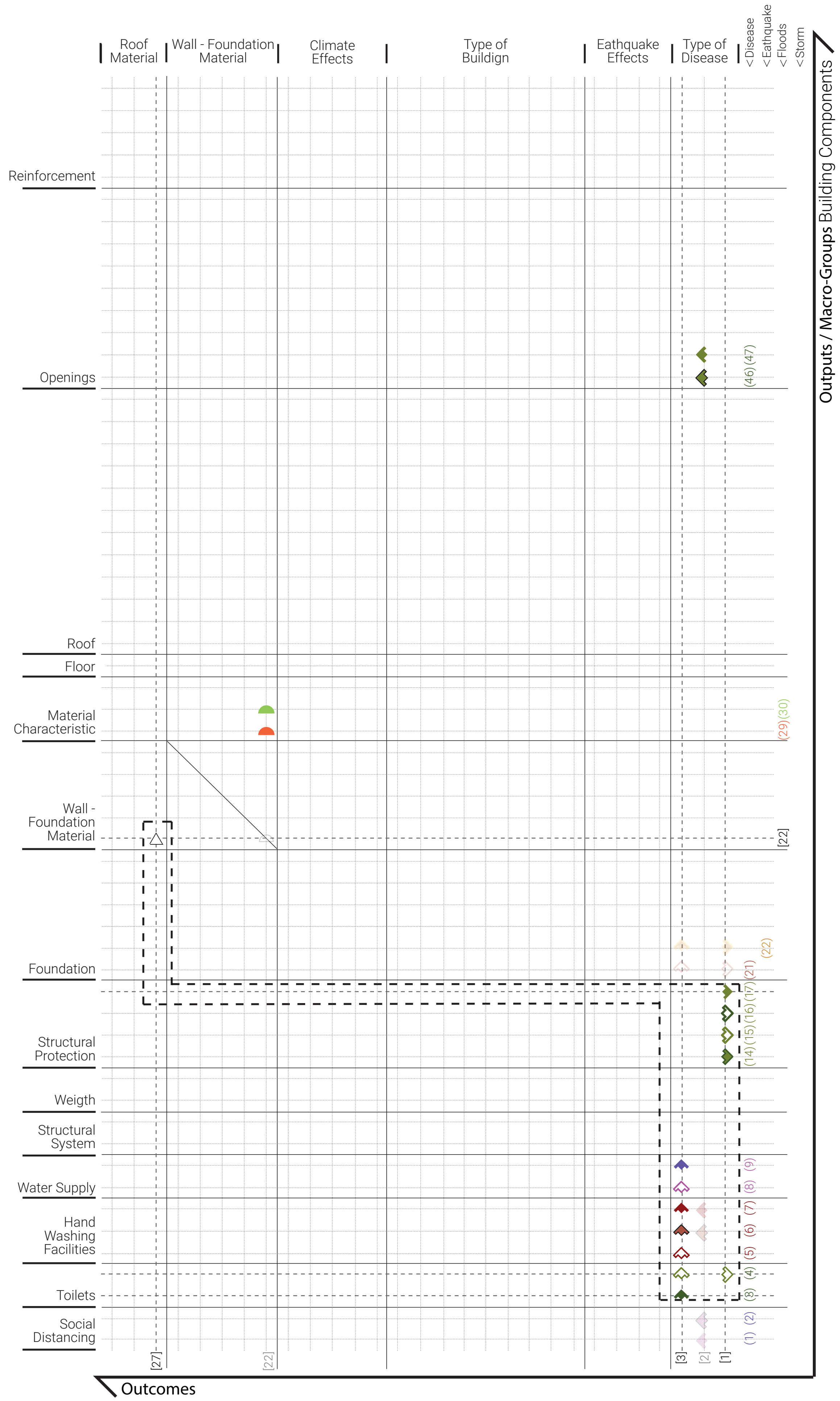
Eathquake Matrix



Floods Matrix



Disease Matrix



Legend (Outcomes - Outputs)

Outcomes (simbols)

- [1] Safe Learning Facilieties
- [2] Physical Protection
- [3] Educational Program
- [4] School Type
- [5] Social Minorities Access
- [6] Level Education Access
- [7] Dimension for Access

Outputs (colors)

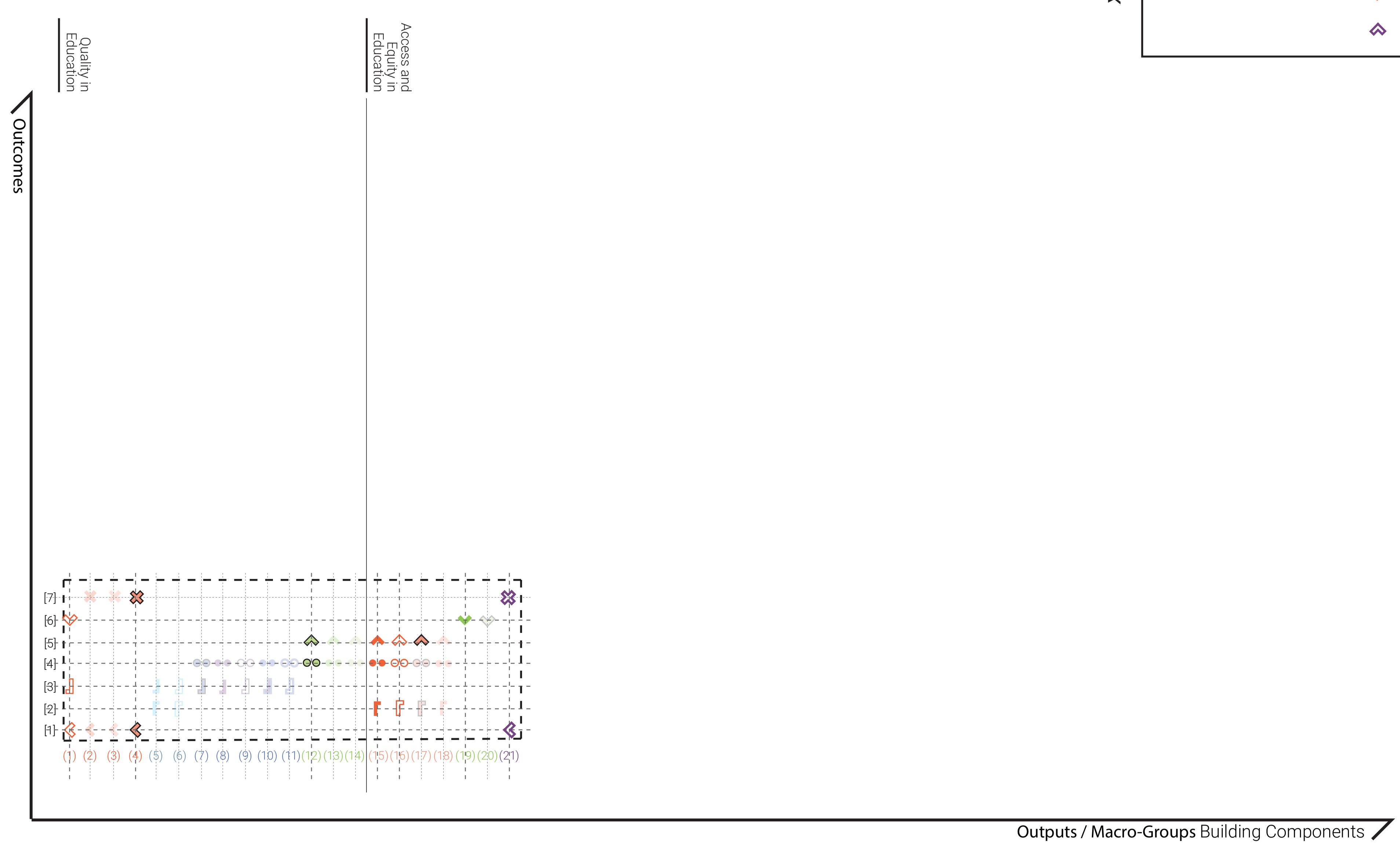
Quality in Education

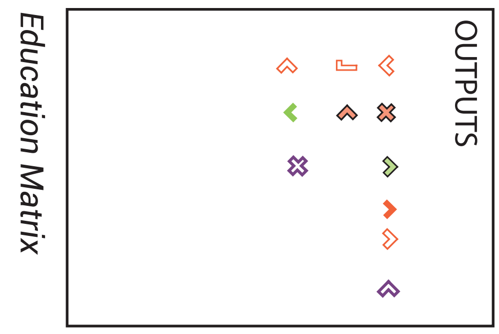
- (1) Safe Site Location
- (2) Hazards Matrix
- (3) Technological Matrix
- (4) Water, Sanitation, Hygiene Facilities
- (5) Boundary Wall
- (6) Dormitory on site
- (7) Temporary Learning Space
- (8) Flexible Learning Envirnmenal
- (9) Mobile School
- (10) Permanent School
- (11) Open Air School
- (12) School Inclusion
- (13) School Segregation
- (14) School Integration

Access and Equity in Education

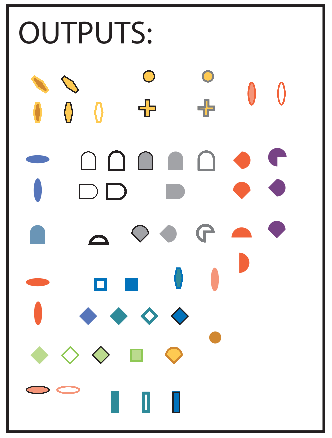
- (15) Providing Girl Education
- (16) Education for Rural-Urban
- (17) Education for IDP and Refugees
- (18) Education for Disabled
- (19) Built for all level
- (19) School Proximity
- (21) Appropriate School Dimension

Educational Resilience - Resistance

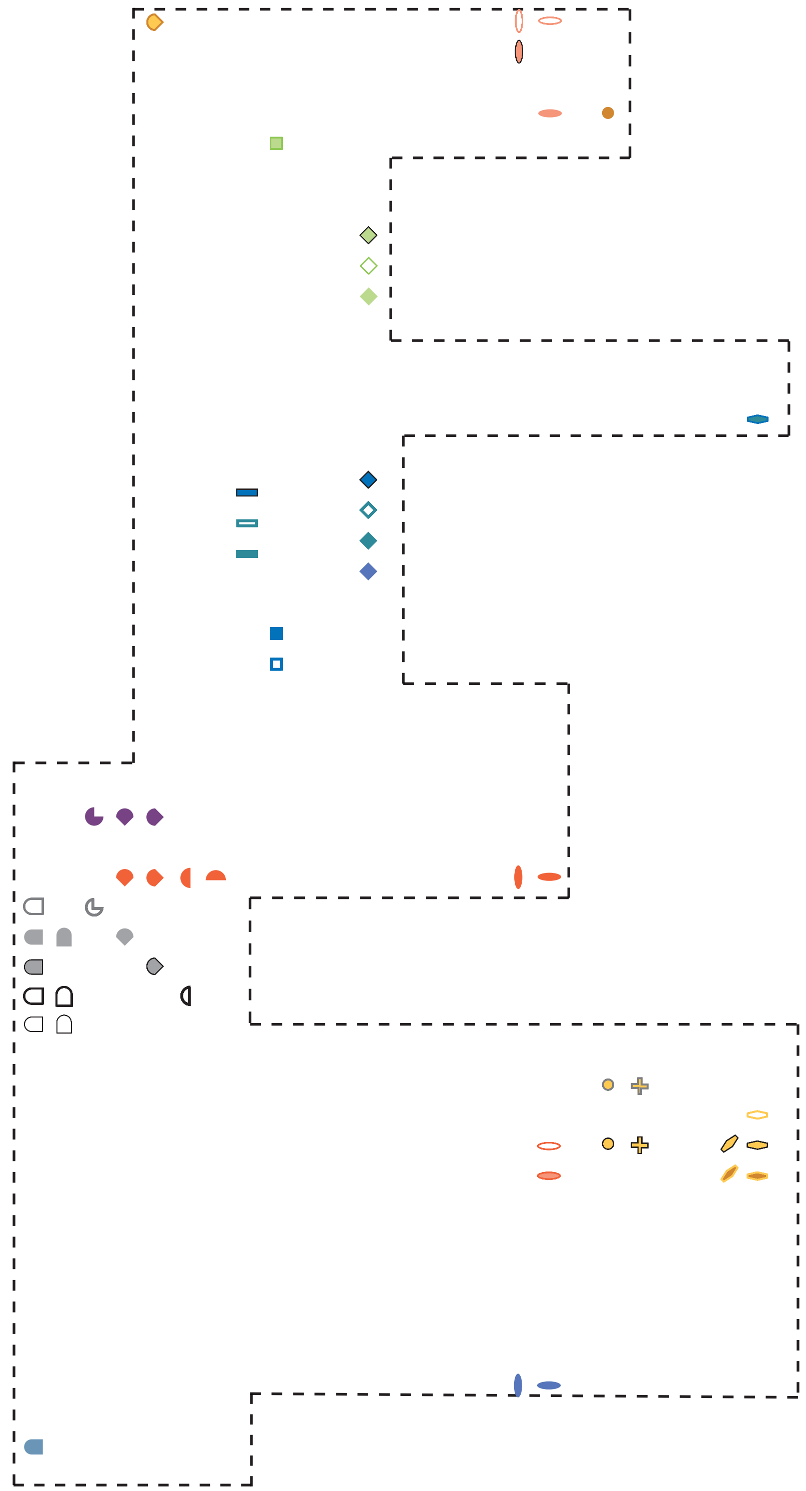


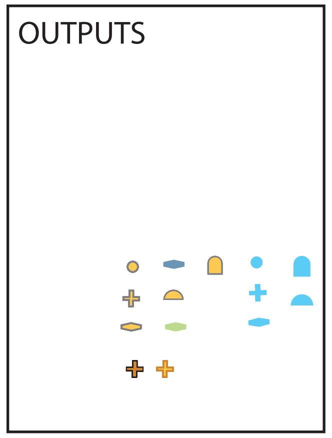


Education Matrix

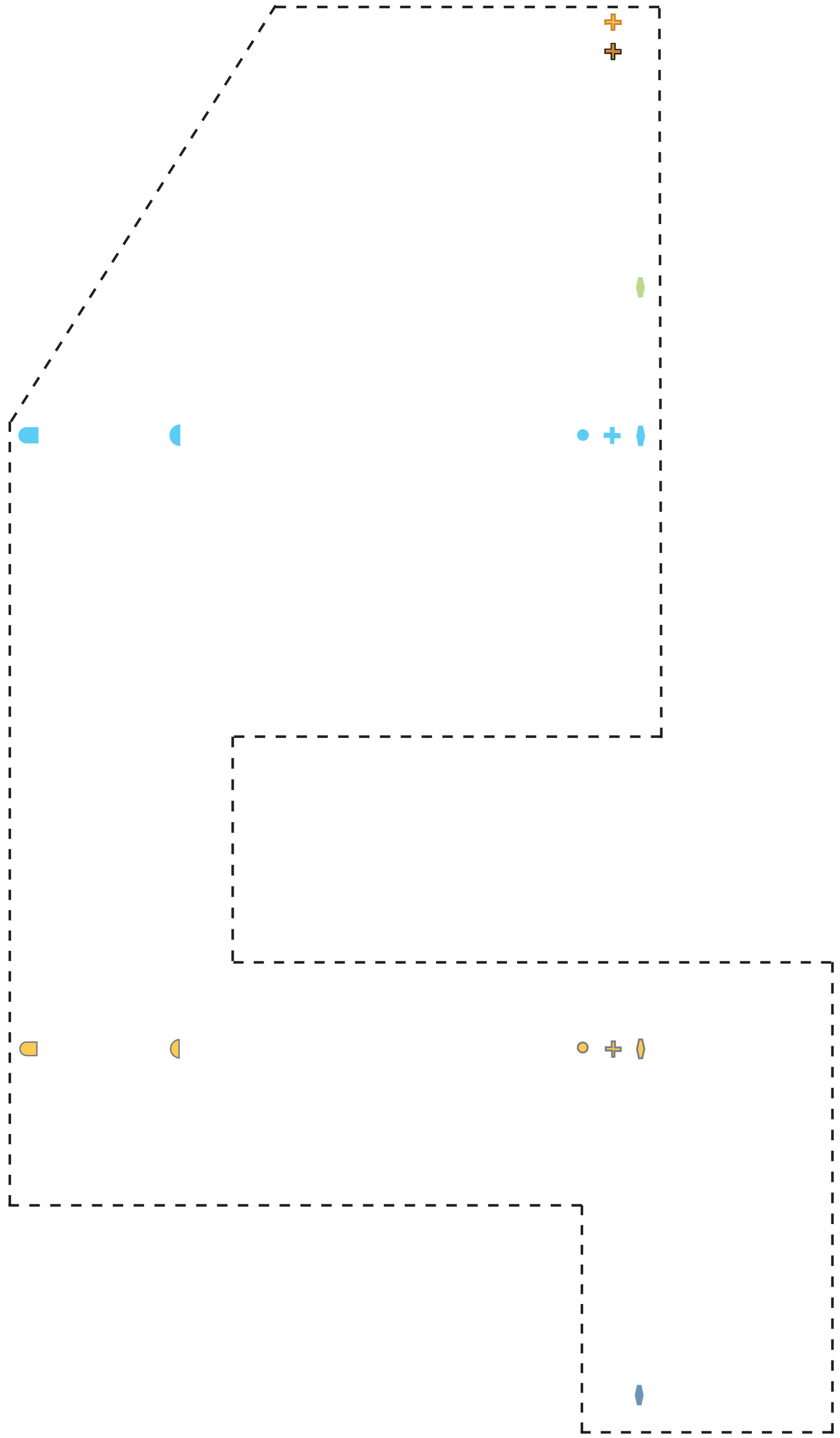


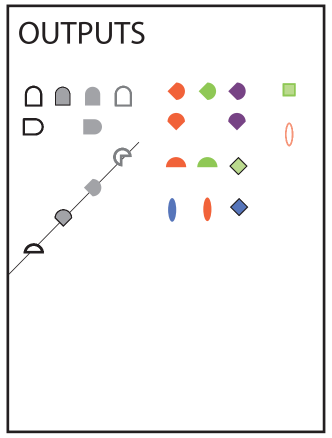
Storm Matrix



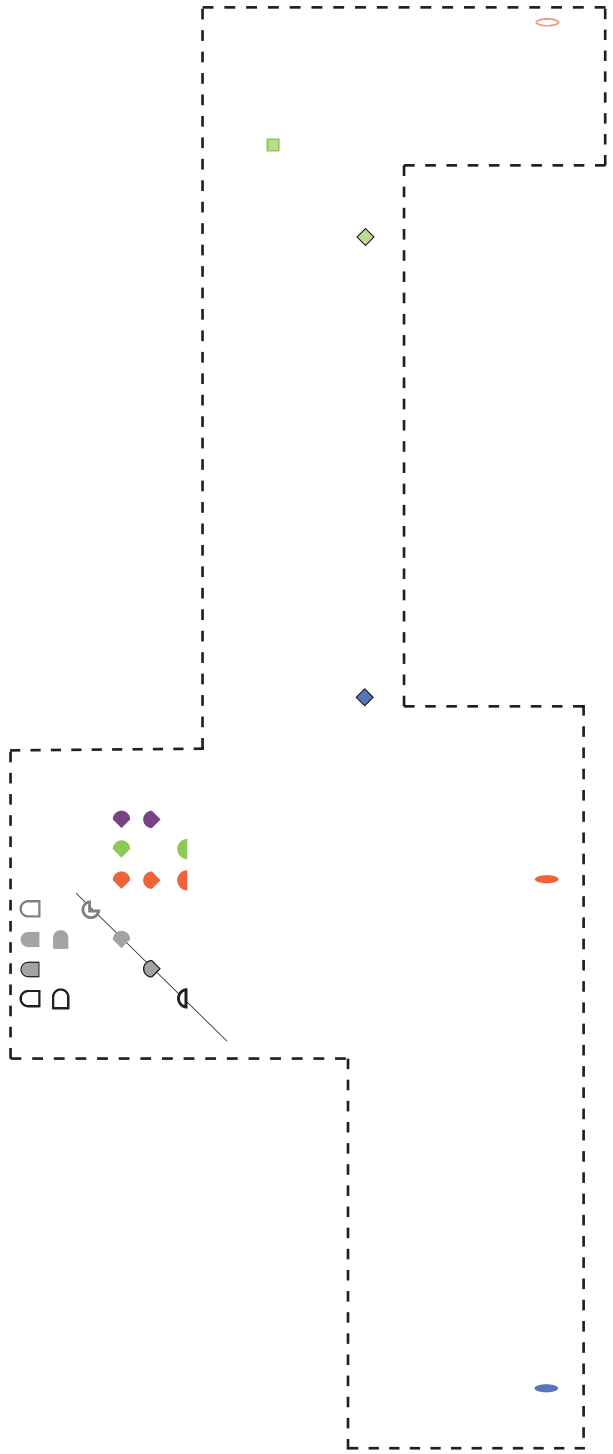


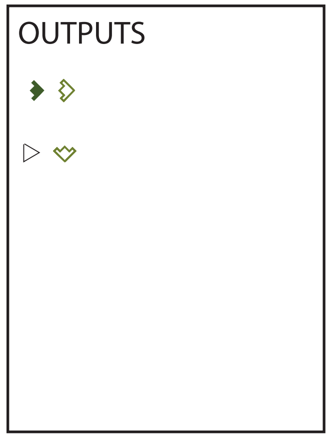
Earthquake Matrix



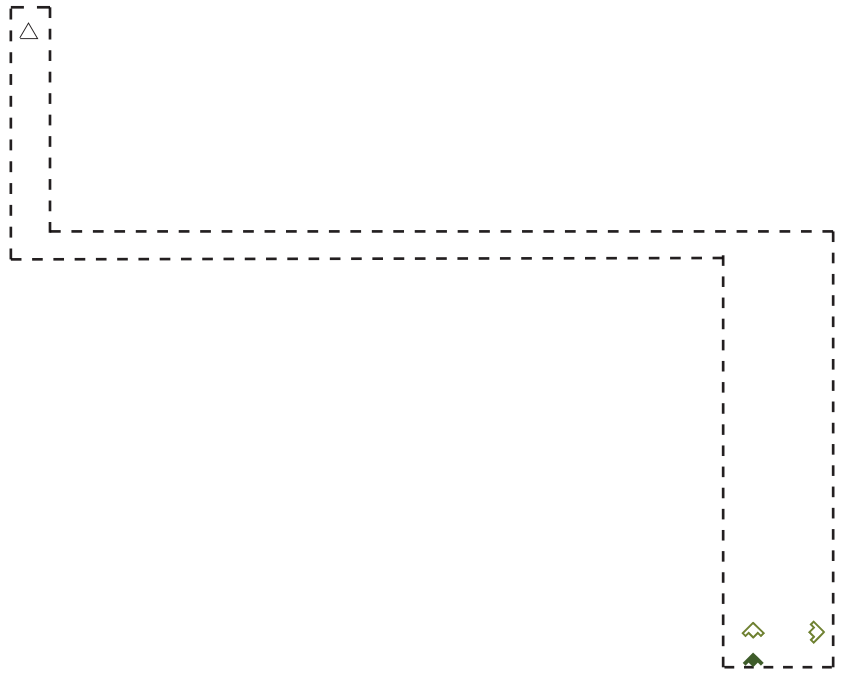


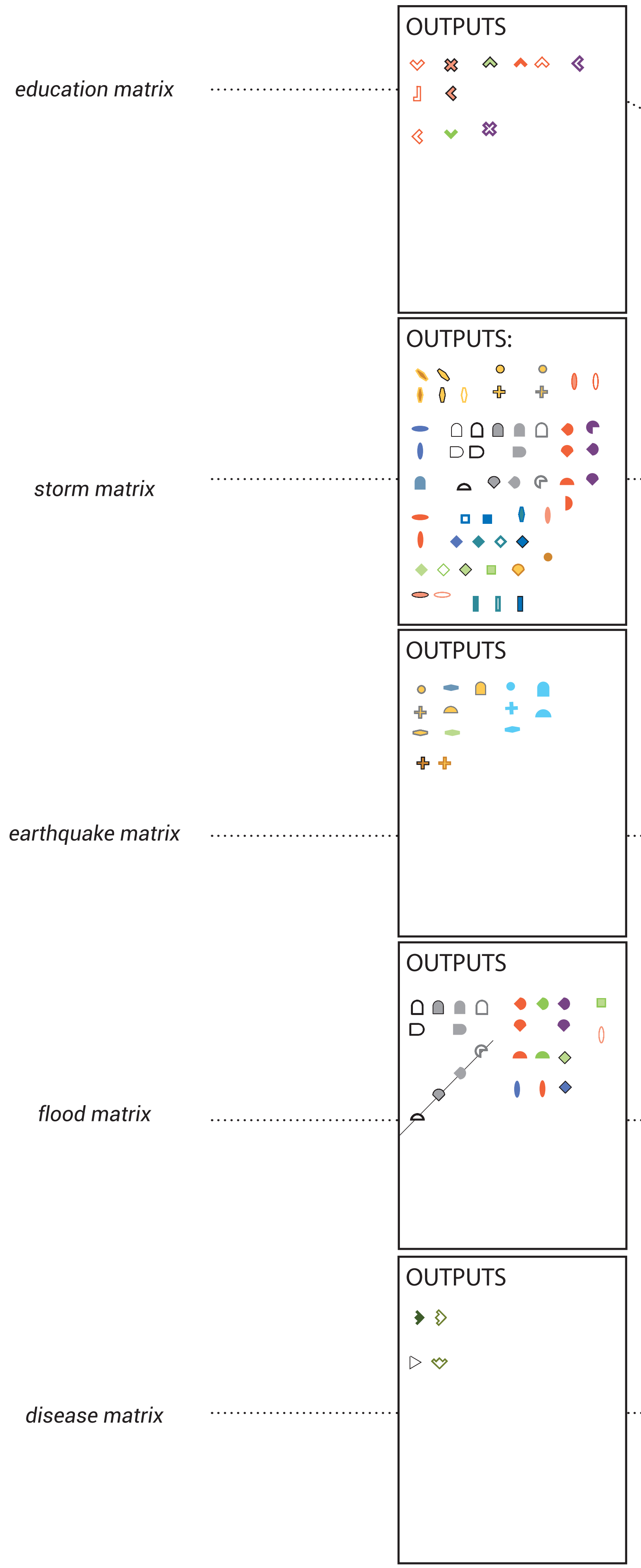
Flood Matrix





Disease Matrix





4.5. The List of Actions

(Implementation)

Solutions obtained from the comparison of matrices and what is needed to implement it (time, money, materials, people involved)

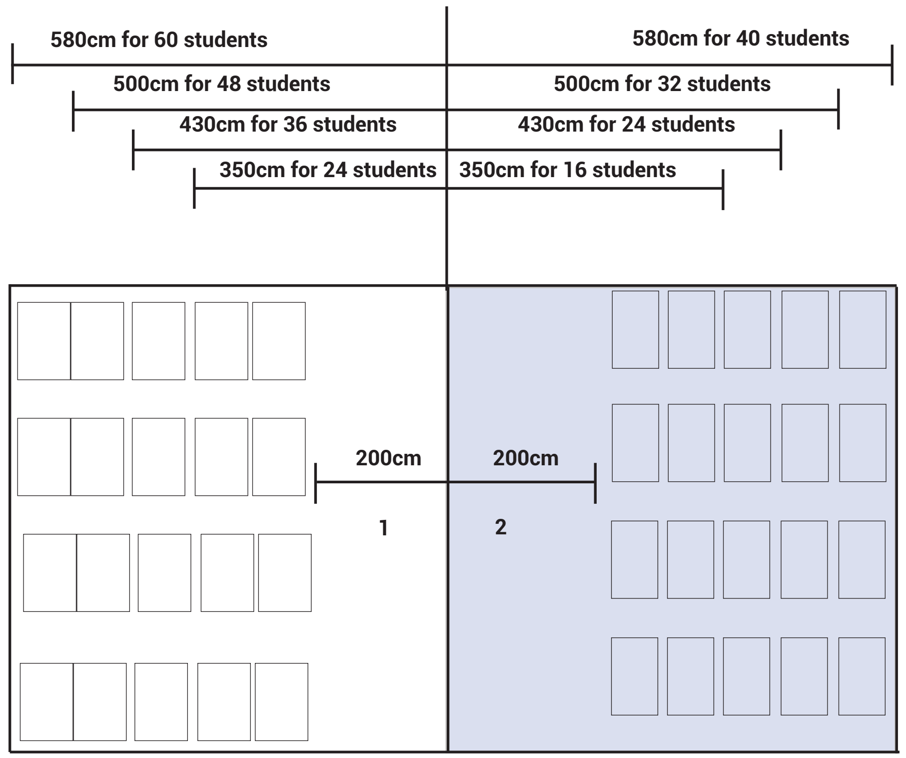
- ***a. Building shape***
  symmetrical , preferably square/ rectangle
  -easy to build, less people/time
- ***b.Foundation***
  strip wall, base isolation, floor rasing, **stone**/concrete
  -local material/exsistent people with knowledge
- ***c.Wall Material***
  stone, reinforced concrete, stabilized adobe, **stabilized mud**, **wood** /wet -proofed walls
  -wet -proofing local material?
- ***d.Reinforcement***
  ring beams, collar bands, **wood post**, steel bar, **wire mesh**
  -wood as a local material that saves time/money and people involved, very flexible and well performing in case of seismic / high winds
- ***e.Structural system***
  bearing wall, **frame**
  -better flexibility in case of seismic/ high winds
- ***f.Supporting substance***
  Ground, water
  -site location
- ***g.Openings***
  at the same height, same size, middle position, symmetrical, lintel at same height for doors and windows,wall openings under roof
  -all of the above for seismic/high wind pressure protection, maximize ventilation in normal conditions due to climate
- ***h.Shading elements/nets***
  minimize solar radiation, sliding, **fixed from inside**, **wood**, aluminum,**screening doors and windows, nets**
  -wood as local material, minimize radiation due to climate, protect from vector born diseases
- ***i.Roof***
  light construction with very good connections, slope 15-30 degrees, attached, tied down, pyramidical, **hipped, wood**/aluminum sheets, **no overhang, detached verandas**
  -local material,best solutions for seismic/ wind protection
- ***j.Sanitation***
  outside structure with waste menagments, latrines, disaster resilient toilets
  -fullfiling the basic sanitation needs
- ***k.hand washing facilities***
  location close to toilet, accessible to everyone
  -fulfilling the basic needs
- ***l.Watter supply***
  water treatment, rain harvesting, cleaning up water channels
  -waterborn disease protection, basic needs

A FINAL LIST OF POSSILE SOLUTIONS:

MATRIX TYPE	OUTCOMES	OUTPUTS	MACRO-GROUPS
MATRIX OF EDUCATION	(1)	(1) (4)	Quality in Education
	(3)	(1)	
	(5)	(12)	Access and Equity in Education
		(15) (16)	
	(6)	(19)	
	(7)	(21)	
HAZARDS MATRIX (Storms, Earthquakes, Floods, Diseases)	(1)	(4)	Toilets
	(3)	(3) (4)	
	(9)	(12)	Weight
	(9)	(10)	Structural system
	(1)	(14) (16) (17)	
	(9)	(25)	Foundation
	(27)	(25)	Materials
	(28)	(26)	
	(23)	(28)	
	(23)	(29) (31)	Materials Characteristics
	(28)	(29) (31)	
	(25)	(29) (30) (31)	
	(9)	(32)	Floor
	(27)	(34)	Roof
	(17)	(35) (37) (38)	
	(19)	(39) (41)	
	(21)	(45)	
	(17)	(49) (50) (52)	Openings
	(20)	(55)	
	(21)	(54) (48)	
	(9)	(56) (60) (63)	Reinforcement

The internal distribution

Figure 27:
Area per place for various sized classes



Room	Room Size	Student/per class	Area per student
A	~35m2 (ex. 5x7)	60/40	~0.5m2/~0.8m2
B	~30m2 (ex. 5x6)	48/32	~0.6m2/~0.9m2
C	~25m2 (ex. 5x5)	36/24	~0.7m2/~1m2
D	~20m2 (ex. 5x4)	24/16	~0.8m2/~1.3m2

1. Based on a bench of 115cm long to seat 3 students per bench

2.Based on bench of 100 cm long to seat 2 students per bench

Figure 28:
Classroom furniture arrangements

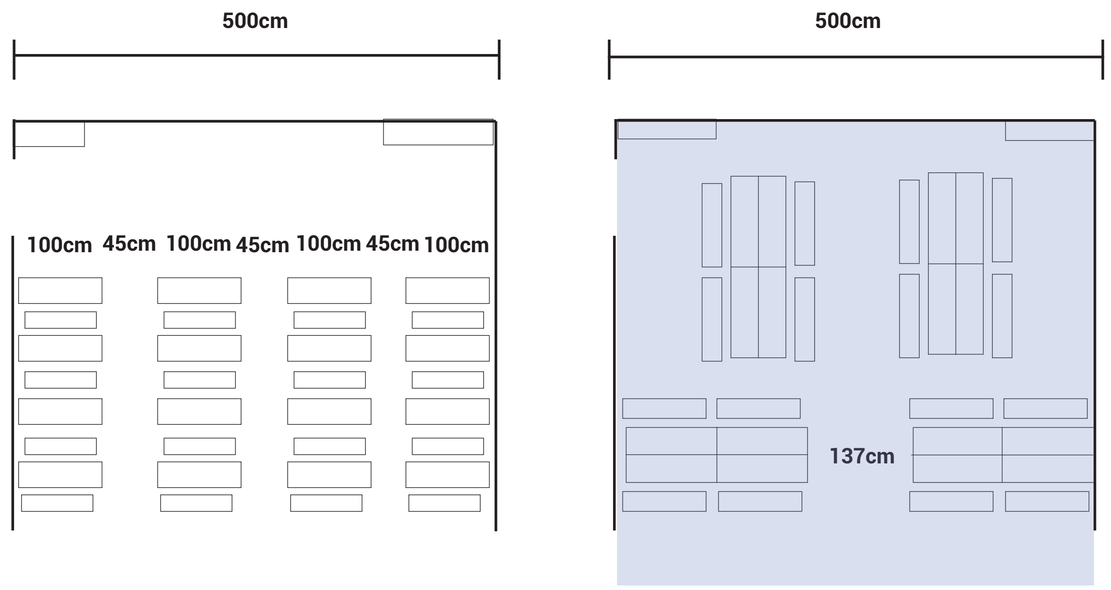


Figure 29:
Seating area

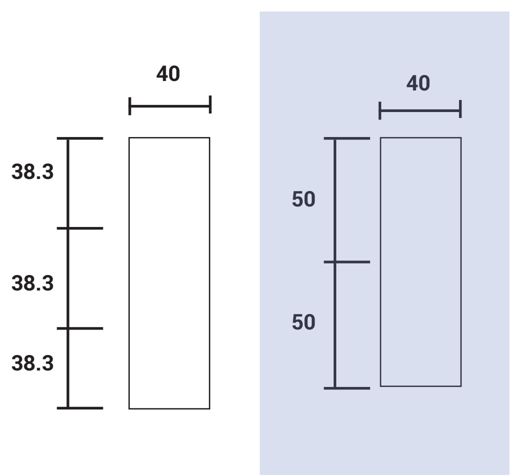
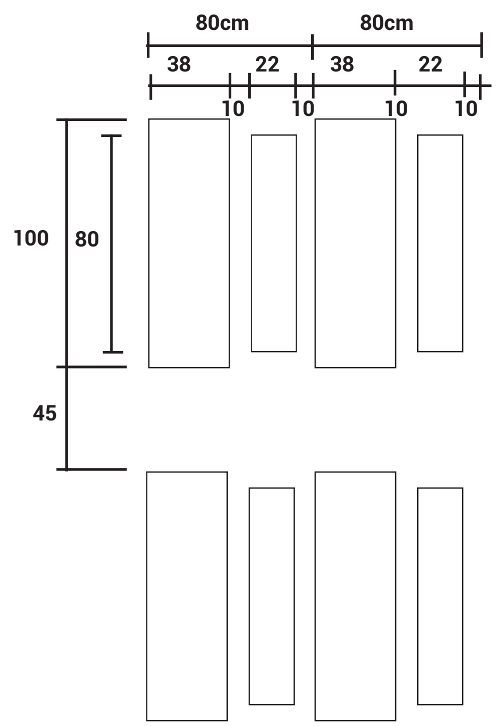
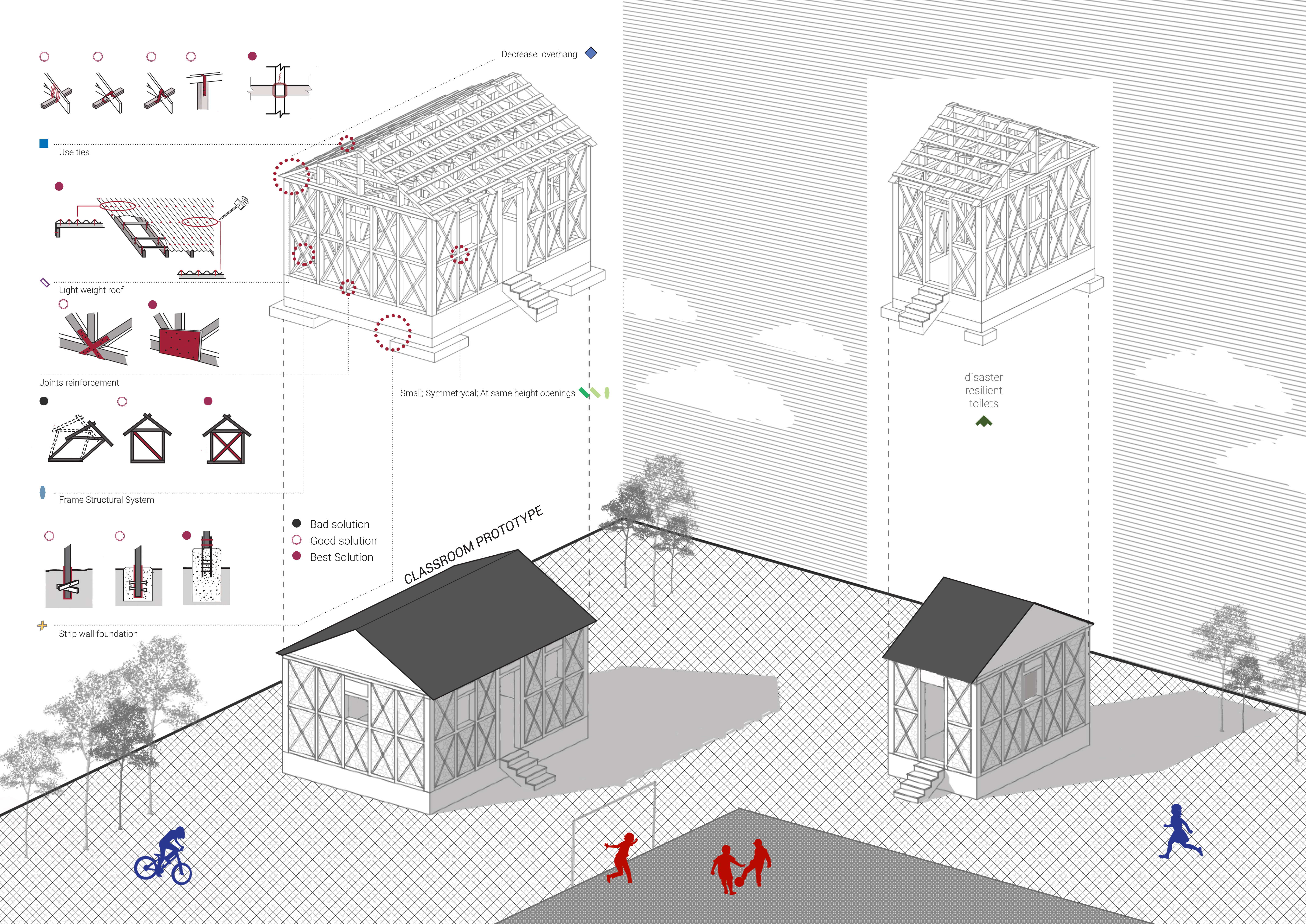


Figure 30:
Spacing of benches and tables





Decrease overhang
Use ties
Light weight roof
Joints reinforcement
Frame Structural System
Strip wall foundation
Small; Symmetrycal; At same height openings
Bad solution
Good solution
Best Solution
CLASSROOM PROTOTYPE
disaster
resilient
toilets

Conclusion

The issue of natural hazards impacting communities across the globe is a complex one. One thing is certain – earthquakes, cyclones, floods and disease epidemics always have and will continue to be potential disaster drivers worldwide. Another certainty, at least for the time being, is the global disparity in coping capacities. Improper governance, wealth disparity and lack of access to education and healthcare are a harsh reality in many poverty-stricken communities, making the population substantially vulnerable to the already gruesome impact of hazards.

For much of the youth in low income countries schools represent the gateway to indispensable support that goes beyond education, such as access to water, sanitary services and food.

The analysis and decisions made before designing the structure are just as fundamental in the durability and longevity of the final building. A proper understanding of the area is crucial in optimizing the building design, thus a community participation in all phases of the project cycle is recommended. Given that community itself knows best the needs and risks are, a certain degree of community participation is favourable. Community participation should be done without generalizations and with caution to participants' diversity, before applying the research tools and methods of communication.

The final tool developed in this research is an attempt to simplify and alleviate the decision-making process when building educational structures in hazard-prone areas. It is simple enough to be used by non-professionals in the field, summarizing the vast amounts of literature available in a separate matrix for each hazard driven by three aspects: the inputs – problems and vulnerabilities, the outcomes - the needs or activities to be carried out, finally reaching the outputs – capabilities and solutions for the specific situation. In the case of multiple hazards, after ranking the hazards' occurrence, an overlap of the different solutions is done taking into account the hazard ranking. This overlap provides a list of possible solutions, which based on the information provided by the community, a final solution list is obtained.

The matrix tool serves as a prototype which can further be developed, by encompassing a larger variety of hazards (e.g. droughts, extreme temperatures) or building typologies (e.g. residential, healthcare).

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Annex

Inputs:
(Education Matrix)

The impacts on education systems can be multiple, so it is important to identify the risks and understand how they can affect education systems. Disasters and conflicts have similar impacts on the education system, destroying or damaging infrastructure and threatening, in the long term, the physical and psychological insecurity of students and educational staff.

Hazard-Climatic

This issue defines the possible natural hazards and extreme climatic conditions that could be a source of risk and school leaving, from which to provide safe learning structures. Such dangers could be: floods, storms, earthquake, disease, extreme temperatures.

Conflict and Insecurity

It defines man-made dangers that could endanger children and the school environment, such as conflicts, violence and insecurities (for example: food insecurity). These often cause school dropouts.

Socio-cultural, Demographic

Identify the vulnerability factors, within the context, such as poverty, literacy, health situation (e.g. mortality, malnutrition, disease), inhomogeneity and marginalization of the population (example: multilingual, religion, cultural context, man-woman division), growth disproportionate population and migration.

Outcomes:
(Education Matrix)

Safe Learning Facilities

Good and safe design is essential to protect students from natural hazards. Good design could save on the potential costs of rebuilding or repairing school infrastructure and teaching materials and, in the long term, contribute to social cohesion and social security.

Physical Protection

In situations of conflict or insecurity, priority should be given to the physical protection of children and educational staff, to ensure their protection, identifying a safe place easily accessible and in which to take refuge from any conflict situations.

Educational Program

To ensure school attendance in the event of natural or man-made hazards, it is necessary to identify the educational program among the different forms of education spaces. For example, in the event of a natural disaster, schools are often used as shelters and restrict access to the educational service, it is therefore necessary to provide temporary facilities.

School Type

Understanding the context in which you go to act is essential to design classrooms that are safe and accessible, to avoid those unpleasant events dictated by gender, racial or religious discrimination.

Social Minorities Access

Access to education should be guaranteed to minorities who, due to the socio-cultural context, are unable to.

Level Education Access

Educational infrastructure should be easily accessible, close to urban or rural communities, and there should be educational infra - structure for all ages.

Dimension for Access

The size of the entire infrastructure should be adapted to the number of students applying for education and to make the school structure safe from possible dangers, such as diseases.

Outputs:
(Education Matrix)

Quality in Education

Safe Site Location

Defines the safe and good location of the educational infrastructure, with respect to potential natural disasters or possible areas of conflict and insecurity that could make the building inaccessible in the medium to long term.

Hazards Matrix

It suggests the single or superimposed use of the hazards matrix, in the event that the area is subject to potential natural disasters

Technological Matrix

It suggests the use of the technological matrix, in relation to the climate, to ensure comfort performance within the school environment

Water, Sanitation, Hygiene Facilities

The school infrastructure, to ensure wellbeing and safety, must include hygiene services and drinking and non-drinking water systems. This, too, to prevent possible water-borne disease.

Boundary wall

In order to protect children and young people from possible insecurities, conflicts or natural events (such as floods, landslides, etc.) it is necessary to provide perimeter walls that limit the access of people or things.

Dormitory on site
In the event that the educational infrastructure is too far from major population centers or is located in conflict zones that could limit safe access to the infrastructure, it is important to provide dormitories for teachers and pupils, inside or adjacent to the educational facility.

Temporary Learning space
The temporary educational structures are mostly informal structures, made with materials readily available locally, which do not require specific work force and are not resistant to possible climatic actions. These are carried out in the event that there is no possibility of accessing the main ones due to disasters or conflicts; or they can be temporary during the time necessary for the realization of a formal structure.

Flexible Learning space
The educational environment can be flexible to allow access, at different times or days, to those people who are subject to insecurities and social discrimination (by gender, language, origin, age, etc.); Furthermore, often to maintain a subsistence income, students leave schools to devote themselves to work, therefore, to avoid this possible problem, specific times and days can be foreseen.

Mobile school
Defines a school built with light materials and not anchored to the ground, to ensure that it can be easily moved to safer and more accessible areas.

Permanent school
Unlike the movable one, they are often formal infrastructures; therefore, financed and built by the state or region with conventional materials and construction techniques and possibly resistant and resilient to possible natural disasters, so that the infrastructure remains for the medium to long term.

Open Air school
Defines a school environment in which lessons take place in the open, in the event that, as for the temporary ones, there is no possibility of accessing educational facilities, due to natural disasters or conflicts. In addition, open-air education can also be part of the school program, alternating outdoor lessons and classroom lessons.

Access and Equity in Education
To reduce the risk that education may contribute to the aggravation of social problems, existing inequalities need to be identified and addressed by proposing flexible social inclusion programs for:
Girls
Urban-rural population affected by crisis ;
Internal Displaced People and refugees ;
Disabled.

Building for all levels
It is important to ensure school continuity and therefore allow children of different ages to access and move to different educational levels.

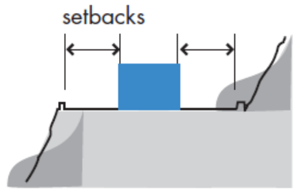
School proximity
Education systems should be easily accessible or close to built-up areas, in order to maintain school attendance.

Appropriate school Dimension
Children and teenagers should be placed in classrooms that are not overcrowded, but made with appropriate dimensions to ensure an accessible, safe and healthy school environment. The school size must also be appropriate to allow for easy evacuation in the event of a disaster.

Inputs:
(Seismic-proofing)

Coastal areas
Coastlines are dynamic. Beaches erode and migrate, and bluffs collapse as part of the natural process in the coastal zone. Earthquakes can ac celerate this process and additionally potential vulnerability to tsunamis, if located in an open water area. Site plans must address the dynamic nature of the beach-ocean interface, providing setbacks adequate to accommodate inevitable change. Set back structures beyond the code or zoning minimums to provide an extra margin of safety.

Mountanous areas
Mountanous slopes liable to slide during an earthquake should be avoided and only stable slopes should be chosen to locate a building. Change of elevation and sloping around the site, along with other factors like soil type and seismic risk could trigger landslides and debris flows. To mitigate, set back struc-tures from both the toe of an upslope and from the lip of a down slope.



Debris
In debris flows, large rock fragments are transported at high speeds in a dense mixture of soil and water, which produce large impact forces when impacting infra-structure. It is therefore critical to protect infrastructure from such events, if there is a possibility of its occurence.

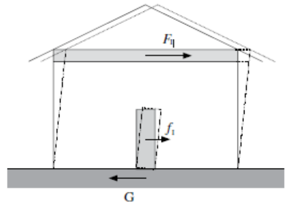
Ground water
Ground water presence allows for the liquification of soils. The site performance can be improved through barrier constructions against the infiltration of water so the groundwater level on a given site is lowered.

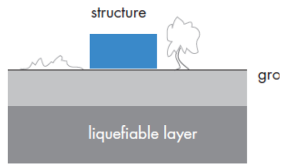
Soil profiles

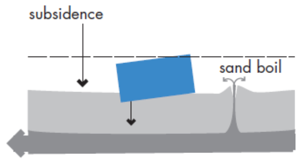
Soil profile	Description	Vs	Ns	Na	notes
Hard soil	Rock, deposits of very dense sand, gravel or very stiff clay	>400	>50	50	
Medium soil	Deposits of dense or medium-dense sand, gravel or stiff clay	400~200	50-15	20	
Soft soil	Deposits of loose cohesionless soil or soft-to-firm cohesive soil	<200	<15	5	*should be compacted before building*
Weak soil	Very soft soil liable to large differential settlement or liquefecation during earthquake	-	-	-	*not suitable for building on*

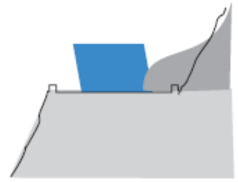
Vs - Shear Wave Velocity (m/s)
Ns - Standard penedtration test blow count
Na - Allowable bearing capacity (1 t/m² 10 kN/m²)

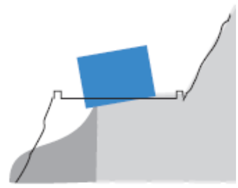
Further information on the standardpene-tration test blow count: Engineering Geology Field Manual - Volume II - 2nd Ed. - Chapter 22

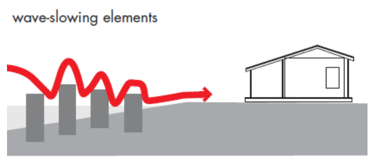







upslope landslide


downslope landslide



Outcomes:
(Seismic-proofing)

Ground shaking
As the earth vibrates, all buildings on the ground surface respond to that vibration in varying degrees. Due to this vibration, the base of the building moves and inertia forces are created throughout the mass of the building and its contents. It is these reversible forces that cause the building to move and sustain damage or collapse.

Soil liquefecation
Very loose sands and sensitive clays are liable to lose their original structure and undergo compaction during an earthquake, which can lead to damage of the building. If these soils are saturated with groundwater they apt to lose theis shear resistance and liquefy, therefore a site with a soil of sufficient bearing capacity and adequate drainage is needed in order to protect the footing.
Non engineered buildings guidelines, Arya, 2014, pg

FEMA 454 / December 2006 RISK MANAGEMENT SERIES, Designing for Earthquakes A MANUAL FOR ARCHITECTS PROVIDING PROTECTION TO PEOPLE AND BUILDINGS, chapter 2, page 14-16

Landslides:
During an earthquake, a series of seismic waves shakes the ground in all directions, so that under the critical conditions of water saturation, slope, and soil type, even relatively low levels of ground acceleration can cause a landslide. Upslope landslides and debris flows can inundate a site with debris, damaging utilities, cutting off access and trigger mud flows, where as downslopes slides can undermine the building foundations, render it structurally unsafe, as well as cut off access and utilities.

FEMA 454 / December 2006 RISK MANAGEMENT SERIES, Designing for Earthquakes A MANUAL FOR ARCHITECTS PROVIDING PROTECTION TO PEOPLE AND BUILDINGS, chapter 3, page 23

Tsunami
Tsunamis are seismic wave movements in the ocean that travel athigh speed and may result in large coastal waves of 10 meter height or more.. Sites near large bodies of water at elevations 15 meters or less above the water surface are susceptible. In addition to dependence on local conditions, quantifcation of the risk from tsunamis is diffcult because not every earthquake generates such a wave.
FEMA P-424,Design Guide for Improving School Safety in Earthquakes, Floods, and High Winds, December 2010, pg 4-4

Stone buildings
Without the seismic improvements and proper reinforce ment can be particularly dangerous in earthquake-prone areas. In terms of structural propertie for earth-quake resistance, the stone walls compressive strength even while using clay mud as mortar can support three storeys but its tensile strength is near to zero. Shear strength will only be due to frictional resistance.

Wooden Buildings
Wood has a high strength per unit weight making it optimal for seismic zones. Due to lack of availability, better to be used combined with other worse performing, but widely available, materials (e.g. brick, stone).

Earthen Buildings
Advantages are the costs, heat insulation and low energy consumption, but if not stabilized has poor seismic performance.

Non Engineered Reinforced Concrete Buildings
Due to lack of knowledge, deficiencies in mixing and curing as well as lack of consideration given for the effect of seismic lateral loads, they often are very fragile when ground motion occurs.

Outputs:
(Seismic-proofing)

Structural System
Frame
A structural system in which vertical forces associated with the structure's weight and that of its supported contents are carried by beams and columns while lateral forces associated with wind or earthquake loading are carried by either diagonal braces or vertical walls that do not support significant portions of the structure's weight.

Bearing wall
A structural system in which vertical structural walls serve the dual purpose of providing vertical support for a significant portion of the structure's weight as well as resistance to lateral forces.

Static foundation - the most vulnerable aspect of the structure
Pile Foundation
A type of foundation in which a vertical or nearly vertical element (the pile) is embedded directly into the ground to transfer the weight of a structure into the ground either through friction between the sides of the pile and the surrounding soil or end bearing of the pile against stiff soils and rock beneath it. Should be avoided in soft and weak soils.

Strip wall
Strip foundations consist of a continuous strip of concrete formed centrally under loadbearing walls. The continuous strip acts as support for which walls are built and is to a width to spread the load evenly of the building on the ground underneath it, supporting it.

Mat
A form of foundation in which a monolithic reinforced concrete slab underlying a large portion of a structure or the entire structure is used to transfer the structure's weight to the underlying soil.

Kinetic foundation
To avoid the seismic forces on the entirety of the building, an alternative option is isolation of the structure from the ground motions which actually impose the forces on the structure - **base isolation**. For simple buildings, this can be achieved by placing a flexible connection between the structure and its foundation, however it is difficult to achieve on a long term solution without expensive and high-technology equipement.

Roof weight
Heavy
mass above 20 kg/m²
Heavy roofs cause large inertia forces on top of walls and may lead to complete collapse in severe earthquakes All tile claddings must be adequately fixed to the structure below to prevent them being displaced if the roof framing distorts under lateral loads or if high vertical seismic accelerations occur.
Example: concrete and clay tiles, slate or stone

Light
mass under 20 kg/m²
A structure with lightweight roof claddings has less earthquake load on it than one with heavy roof claddings. The lower mass generates smaller inertial forces when the structure is exposed to lateral seismic loads. Lightweight roof claddings also require less roof bracing to resist gravity and seismic loads.
Example: steel aluminum or copper sheet

Horizontal reinforcement

Horizontal reinforcing of walls is required for increasing horizontal bending strength against plate action for out of plane inertia load and for tying perpendicular walls together. Horizontal reinforcement is especially needed in brittle walls, such as masonry, especially at the lintel, plinth, roof levels.
Example: **collar bands**

Vertical reinforcement

Vertical reinforcement is needed at the seismically critical sections of the wall, in particular the corners and wall openings. The amount of reinforcement depends on the seismic zone, number of storeys, soil type, among other factors.
Example: **steel bars, bamboo or cane posts, wire mesh**

Inputs:

(Storm-proofing)

Location and Site Characteristics
These inputs take in consideration the terrain categories in terms of site location as well as their site roughness.

Riverline
Riverline defines a site close to the rivers, which is exposed to the water as well as the winds from it.

Coastal
Coastal areas are called the areas exposed to the wind from the sea (near the coast) or on high exposed hills, in general sites vulnerable to the sea wind.

Rural open
Rural open are the areas that have an open country adjacent or different paddy fields.

Rural urban
Rural urban are the sheltered areas suburbs and locations near heavy treed areas.

City
Cities define the heavy density areas.

Application
Flood prone land
Application on an area subjected to frequent flooding (close to river, sea or a high precipitation and it is flooded once every 100 years).

Earthquake prone land
Application on an area prone to " frequent earthquakes/ underground movements- it had earthquake once every 100 years.

Wind zones - Wind speed
The wind moves over the ground at a certain speed normally referred to in m/sec, km/h or miles/h. Due to different geographical features cyclonic storms occur with predictable frequency in different locations. By reviewing meteorological data of a country subjected to cyclones it is possible to define the zones which will get the strongest winds (storms/cyclones), strong winds (windstorms) and less strong winds (breeze). For most of the countries the wind zones are labelled with different wind codes.

Breeze – *lightest category of wind (1-20 km/h)*

Windstorm - *stronger category of wind (20-70 km/h)*

Storm - *the strongest category of winds (+120km/h)*

Wind Zones – Wind Pressure
Wind speed is converted into pressure that is exerted on the surfaces normal to the wind. Winds create both positive and negative pressures on buildings. The windward planes which are tending to be pushed towards the inside of the building are considered to be positive external pressures. Those pressures which are caused by the airfoil effects of wind blowing around the walls or over the roofs create an external vacuum or a negative external pressure – suction, which causes the various building planes to be pushed outward.

Rigid Buildings, Low Rise Buildings, Flexible Buildings

Outcomes:

(Storm-proofing)

Type of building
Wet-Proofed
Construction type on dry land, away from floodplains, consisting of a base formed by an air chamber useful to allow flood water to enter its interior, with the aim of preventing damage to possible water pressure and reducing the buoyancy effect. This structural typology is suitable for sites that count as cyclone prone areas, since floods are mostly their results.

Dry- Proofed
Construction type on dry land, away from floodplains . Unlike the wet-proofed structure, this type does not require drilling of the base; therefore, it requires a structure much more resistant to the depth, speed of floods and winds and the impact of debris. In addition, it is important to consider a good closing of doors and windows to not allow infiltration of water, dirt and debris inside.

Elevated Static
Construction type with an elevated ground floor(2-3m), supported by a high perforated structure that allows water from cyclones and floods to move below it without any damage to the building.

Amphibious
Construction type that is able to float at a sudden increase of water due to floods and cyclones. It's low weight allows it vertical movements and the structure is hooked to mooring elements. Outside fences are recommended to avoid debris under it.

Pile
Construction type located partially or totally inside shallow water mostly in the coastal areas, where water levels are predictable. It is supported by perforated structure and the piles rise the building 2-4 m.

Floating
Construction type located totally inside water that floats but also stays in one place because of the mooring system as well as its light construction.

Framed
Construction type made out of different materials in which weight is carried by a skeleton or framework, as opposed to being supported by walls.

Masonry
Construction type made from individual units of different materials, which are often laid in and bound together by mortar; the term masonry can also refer to the units themselves.

Outputs:

(Storm-proofing)

Foundation
The foundations are essential in the design of the building, as they ensure the stability and resilience of the building during a storm. The foundations must be designed based on the maximum level of flooding of a given area and therefore can be divided into static foundations, which allow the building to be raised to no more than 4 meters; and in kinetic foundation that allow an elevation of over 4 meters.

Static
Basement
Allows the minimum elevation of the building of about 1 meter. This technology can be applied to any type of static building;

Sub-Floor void
Allows an elevation of 4 meters from the treading ground, leaving the space below the building open, in order to allow the free flow of water during floods caused by storms

Slab on Ground
Allows the buildings to stay in a good condition in case of very strong winds.

Kinetic
Buouyancy
In the case of a flooding as a result of strong winds and rains the building can rise as the water rises and, therefore, reach variable heights even over 4 meters. This typology is used and required for amphibious buildings and floating buildings.

Reinforcement
Any structural type that comes in touch with storms should include structural reinforcement systems, to prevent the strong winds and hydrodynamic actions or even the transport of debris by winds and water, causing the structural failure of the building. There fore it is necessary to foresee **substructural,** or **superstructural reinforcement systems** and/or sufficiently rigid and robust **mooring systems(when needed)** to limit the movement of the structure to external forces such as wind, currents or other.

Weight
Heavy building
Buildings made with heavy and stable materials that do not allow the building to rise to be blown away or float in the event of a storms

Light building
Buildings made of lightweight materials that allow lifting and floating in the event of a flood as a cause of cyclone but have a good mooring system that keeps them in once place

Supporting substance
Ground
Construction which are on soil not prone to flood where construction does not need elevation and cyclones do not include heavy rainfall.

Water
Construction which are either partially or totally standing on water, such as pile buildings, floating buildings etc.

Inputs:

(Technological)

Climate type

Warm-Humid climate

Known also as "Humidity Subtropical Climate". These climates are normally found on the southeast side of all continents. It is characterized by high temperatures and rainfall distributed throughout the year. During the summer, the regions that have this climate are under the influence of the flow of humid and maritime air. Generally, the temperatures are very high. Summer is generally wetter than winter, with much of the precipitation due to the activity of thunderstorms (tropical cyclones also increase the precipitation of the hot season). Winter is usually very mild.

Hot-Dry climate

This climate is characterized by several days of very warm temperatures compared to the average (the average monthly outdoor temperature is above 7 ° C throughout the year) and in which annual rainfall is generally less than 50cm . The regions are very dry as rainfall is very scarce and moisture evaporates quickly from the air. Heat waves and periods of heat can have an important impact on human health, structures and natural ecosystems.

Cold climate

It is a climate that is generally present in the innermost areas of the continents. It has rigid winters and short summers, typically hot and humid with thunderstorms. Rainfall occurs in all seasons, but more frequently in summer. This type of climate is found in Europe, East Asia and North America.

Outcomes:

(Technological)

Climate Needs

Material Properties

It is important to consider materials with different properties depending on climatic conditions. They can be materials with high thermal capacity (for example compact brick materials, such as stones or concrete) suitable for hot or cold climates, as they are able to slow the flow inwards and / or store heat; o materials with low thermal capacity (such as wood) suitable for both dry-hot climates and hot-humid climates.

Ventilation - *Wind Action*

It is important to consider ventilation or wind action in the design, as factors of comfort and prevention from the spread of diseases or, in extreme cases, as factors of probable damage or destruction of the building.

- ***Maximization***: Suitable for warm-humidity and hot-dry climate. To maximize ventilation, first of all, it is necessary to provide for the good orientation of the building with respect to the prevailing cold winds, reducing the entry of hot winds. Maximizing ventilation prevents the formation of internal mold or disease, especially in warm-humid climates.

- ***Minimization:*** The areas subject to warm-humidity climates that are often hit by cyclones, even if these require the maximization of ventilation, it is necessary to provide systems that reduce the possible detachment of the structural elements, due to wind pressure (example: reduction of the roof overhang for avoid its lifting). In addition, cold climates require minimization of ventilation, to keep the heat inside the building.

Solar Radiation-Sun

- ***Maximization:*** In cold climates it is necessary to maximize the entry of the sun. A floating building located entirely in a reservoir can float and stay in place thanks to its low weight, the presence of floats and various mooring systems (or stop poles or anchors, etc.). Inside the building, therefore there is no need solar radiation protection systems. In addition, even warm-humidity climates may require solar radiation to be maximized
- ***Minimization:*** Minimizing solar radiation in areas with hot-dry climates. Also in areas with a warm-humidity climate often subject to tropical cyclones, these may not provide protection from solar radiation (example: shading systems), as they could cause damage to the structure due to strong winds.

Humidity-Rain protection

Warm-humidity and cold climates are often subject to heavy rain or snowstorms; therefore, any raised floors or elements of protection from rain, capillary rising water from the ground and the shape and slope of the roofing system to drain the water or, possibly, to avoid the accumulation of snow, should be considered.

Outputs:

(Technological)

Ceiling

Ceiling Height:

In relation to the climate, the height of the ceiling influences the internal comfort of the structure. In fact, buildings with a high ceiling improve and help internal ventilation and retain less internal heat, vice versa, buildings with a low ceiling minimize ventilation to the building, retaining heat inside. These features are important. In addition, buildings such as elevated static and pile building must maintain ceiling heights that are not too high to avoid being too exposed to the actions of the wind. To achieve compactness of the structure in seismic zones the ceiling height should be kept at a minimum.

Roof Overhang:

It is essential to define how far the roof must protrude beyond the edge of the wall, as, depending on the climate, the overhang can be advantageous or disadvantageous.

- Decrease: the overhang must be reduced if the area is subject to strong winds or earthquake shaking that could damage the roof structure by lifting it; or it should be reduced to allow solar radiation to enter the structure. In seismic zones, the overhang should be kept to a minimum to keep the structure compact. If needed, for shading or rain protection purposes, a structurally independent cannopy is advised.
- Increase: vice versa, the projection must be increased in the event that you want to minimize the ventilation inside the building or the entry of solar radiation. In addition, the overhang of the roof is necessary to protect the perimeter walls of the building from rain.

Roof Shape
The shape of the roof, and there - fore the number and the slope of the pitches, are an architectural feature to be taken into consideration during the design, as they influence the resistance to winds and rains.. The optimal slope to allow the water to flow easily off the roof is from a minimum of 20 ° to a maximum of 30 °. In seismic zones, the optimal roof slope is lower, between 3-15°.

Openings
Outward Opening
The opening of the windows must be external to prevent the entry of wind and flood water due to their strong pressure.

Openings Position:
The direction and location of the openings helps to minimize or maximize ventilation.

Symmetrical: symmetrical openings prevent wind pressure, as they allow the rapid entry and exit of the wind. It is also the optimal placement in earthquake zones for structural regularity

Upper:
the openings at the top help to maximize ventilation by creating the chimney effect.

Adjacent
Allow cross ventilation inside the building, however they are suboptimal in earthquakes since the large opening area does not conform with the structural regularity required.

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The openings at the top help to maximize ventilation by creating the chimney effect.

Adjacent
Allow cross ventilation inside the building, however they are suboptimal in earthquakes since the large opening area does not conform with the structural regularity required

Small
In areas subject to earthquakes the openings should be as small as possible, not to conflict with the structural integrity of the structure as a whole

At different heights
As for the adjacent openings, the position of the openings at different heights also allows cross ventilation, maximizing ventilation.

Element of Protection
The protection elements of the openings can be bags filled with heavy elements (such as stones, etc.) or wooden bars, which perform the function of protection from the possible entry of wind and flood water due to their strong pressure.

Shading Element
If the minimization of solar radiation is foreseen, it is important to consider shading systems. Such systems can be weak points of the structure in case there are strong winds.

Confining Elements
Can help achieve the structure's ductability property by horizontal and vertical ties that provide the necessary tensile strength to protect from disintegration in the case of earthquakes, especially for masonry walls

Floor
Raising:
To avoid the infiltration of moisture and alluvial water from the floor, it is necessary to provide for the lifting of the floor, especially for those building types that have direct contact with water, such as floating buildings and amphibious building

Reinforcement
Any structural type should include six structural reinforcement systems, to prevent the strong hydrodynamic actions or the transport of debris by alluvial water, causing the structural failure of the building. Therefore it is necessary to foresee sub-structural, super-structural reinforcement systems and sufficiently rigid and robust mooring systems for kinetic structures (such as amphibious and floating building) to limit the movement of the structure to external forces such as wind, currents or other.

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