A DESIGN TOOL FOR RISK REDUCTION IN LEARNING FACILITIES

FLOOD

PRONE AREAS

A DESIGN TOOL FOR RISK REDUCATION IN LEARNING FACILITIES: Flood prone areas

POLYTECHNIC OF TURIN
MSc degree program in
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Master Thesis

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Abstract

In a global context full of political, economic and climatic contrasts, the research frames the problems deriving from the observation of these macro-issues, underlining the needs of places with connotations far from an idea of stability and accessibility, in economic and cultural terms and accessibility to primary resources. Within these realities characterized by precarious infrastructures, it can be seen how the population, in a state of physical poverty and socially segregated, is extremely vulnerable to climatic conditions, making it difficult to return to post-disaster normality. This translates into migratory flows and the removal of the younger sections of the population from accessing educational services, in a context in which access to culture is already difficult.

From the observation of the global background arises the desire to develop architectural solutions, which respond to the needs of educational services and climatic problems, such as floods, storms, earthquake and disease, while respecting the architectural and social culture and the economic capacities of the context in which attention is placed. Following this, the research focuses on flood issues affecting vulnerable communities and especially the education system and, how solutions based on vernacular architectural systems can mitigate disastrous events, making society and especially children resilient, from possible flood impacts.

The purpose of the thesis is to provide new tools, methodologies and aspects to which the project activity should pay attention, expanding those participatory and organizational tools already implemented by Red Cross and Plan International that aim at assessing risks, vulnerabilities and capacities of a given community. These new tools help to define, through the use of methodologies, possible architectural solutions, applicable to global contexts, resilient to conflict situations, floods, storms, earthquake and disease, emphasizing, therefore, the value of the support of the participatory process for the application and extension of solutions that adapt and are accessible by the community on which attention is placed.

The theoretical development has a design application in Mozambique, context of multiple social and alluvial problems, the latter due to the tropical climate, which generates heavy rains and cyclones. The design application therefore aims at the architectural development of educational services in a rural area of the Zambezia region, in Mozambique, considered particularly prone to such problems.

Notes for the reader

The thesis proposes a project development based on collaboration with three other undergraduates: Andrea Matevska, Jana Tosheva, Juan Pablo Benavides.
The entire collaboration focuses on natural disasters and aims to provide tools to marginalise the effects on the population, proposing architectural principles for the construction of resilient schools.

Specifically, four types of hazards (flood, storm, earthquake, disease) were studied, divided among the team members, through which each one developed the correlated tool-matrix, with the ultimate aim of creating common practices and structures for project development. My paper places greater attention on flood problems and on social problems that have an impact on the educational system.

For this reason the thesis was developed in 3 main sectors, each corresponding to the different phases faced during the research.

I. GLOBAL OBSERVATION.
A first section allows you to place the research within a theoretical context, setting clear concepts that focus on understanding some phenomena that generate challenges and risk situations in societies, placing an effect on the abandonment of schools, on the effects floods and the architectural ones to pay attention to.

II. FROM INVESTIGATION TO ACTION.
In this section a more in-depth study is carried out on the reasons that drive us to involve communities for project development, which aims at identifying the architectural problems that create communities vulnerable to certain dangers, from which they are derived the needs and possible architectural solutions resilient to the individual hazards treated (by each member of the team), with the ultimate aim of developed tools and methodologies as a useful support for the design process.

III. MOZAMBIQUE: A FRAGILE LAND.
Finally, the last one, focuses on Mozambique, the main state affected by flood events, in which an initial theoretical research is carried out on the various problems, vulnerability and abilities,useful for understanding which problems to pay attention to in implementing the tools and methodologies (illustrated in the previous section) that support the planning and decision making process.

The research and development of the design tools was supported and supervised by professors Francesca De Filippi, Valeria Federighi, Roberto Pennacchio and Michele Di Marco, architect in the humanitarian sector and expert in disaster risk reduction, with the support of the Danish studio "Emergency Architecture and Human Right" (EAHR), a non-profit organization founded in 2015 an European Leader that combines architecture with sociology, structuring participatory approaches to empower vulnerable groups and generally increase the resilience of communities involved in situations of humanitarian crises.

I.

A Global Observation

I.I Interconnected Events

To identify the root causes that lead to the occurrence of a disastrous event, it is necessary to observe, at the base of the existing structures, the dynamics and actions of the structured model that influences both personally and socially, such as infrastructures, policies and behavioural models, attitudes and moral or cultural beliefs. The root causes, even if apparently disconnected, are common and shared, although they reveal themselves in different ways.

1.1.1. The Anthropic Actions

Uncontrolled anthropogenic actions are defined as the main causes of climatic and environmental alterations, such as the increase in GHG emissions dictated by urbanization, deforestation and the pollution of the soil, water and air (Graph 1). These anthropogenic operations alter the frequency or intensity of risks and increase exposure and vulnerability to certain hazards. Through the increase in the global average temperature, with the probability that it will reach 1.5 ° C between 2030 and 2052 (IPCC Special Report on Global Warming) 1, resulting in ocean warming and drought periods, man-made gas emissions contribute and will contribute to disastrous events in the future(Graph 2).

(1) Intergovernmental Panel on Climate Change. (2018). *Global Warming of 1.5°C* 2018.

Climate change is a phenomenon that amplifies risks and threats, which attacks human health and the ecosystem. The continuous increase in gas emissions into the air has a negative effect on social environments, on the availability of clean water and air and therefore on environmental safety, also influenced by thermal shocks. As emissions increase, atmospheric events are amplified, such as rising, warming and acidification of expanses of water and the spread of infectious diseases linked to more extreme weather conditions which amplify the risks especially for the poorest and most vulnerable communities 2.

(2) UN Office for Disaster Risk Reduction. (2019). *Global Assessment Report on Disaster Risk Reduction* 2019, pp. 133-144.

Furthermore, one of the deepest and most common causes is insufficient disaster risk management before and, post-disaster occurrence, related to risk governance issues (including funding resources)where environmental and protection costs are underestimated, prioritising economic development, indirectly exacerbating perception, exposure and vulnerability to risks and disasters 3.
Therefore, when an event occurs, even if in different contexts, the insufficient protection and resilience measures, to minimize the impact, mean that the events have disastrous consequences.

(3) UNU-EHS (2021). *Interconnected Disaster Risks* 2021, pp. 80-83.

Urbanization

Urbanization and uncontrolled population growth are one of the main causes of climate change, making it more difficult to effectively manage the risk of disasters, especially in areas where extreme disasters are more common (Graph 5).

It is estimated that within 30 years, two-thirds of the world's population growth will occur in cities and slums 4. Much of this rapid urbanization occurs in regions where capacities and resources are limited, such as Africa, Asia and Latin America. Due to limited resources and underdevelopment, these areas are also those that show the least amount of CO2 produced per individual. These demographic trends coincide with poor progress, accompanied by gender inequalities in terms of access to education, job opportunities (especially for women) and the lack of national policies 2.

(4) United Nations Human Settlements Programme (2020). *Climate Change Vulnerability and Risk – A Guide for Community Assessments, Action Planning and Implementation* 2020, p. viii.

Urban areas are increasingly at risk of being threatened and affected by the increase in the average global temperature, the spread of desertification and drought, the increase in rainfall and floods, the rise in sea level, cyclones and storms increasingly frequent and more strong. Poverty and migration are also urban phenomena, in cash exposure to shocks and risks. Exposure to possible risks causes population movements, aggravating the danger of informal settlements, consisting of a large number of "urban poor", located in areas where conditions are unsuitable and highly dangerous, where the impact of climatic actions is more acute.

Climatic events are described as dangers mediated by the human system exposed and affected by the dangerous. Therefore disasters are measured in human terms as lives lost, people affected and economic losses.

Currently, around 18% of the world's population lives in informal settlements 2.
However, in low-income countries, while many people live in urban settlements, they lack

essential services, including water, sanitation and durable housing. (Graph 3).
The "urban poor" are increasingly vulnerable to climatic actions, due to three substantial factors: the location, which often occurs in fragile places such as floodplains, coastal areas or slopes subject to landslides and residing in structures vulnerable to natural hazards; socio-economic characteristics, such as literacy and poverty that influence defence capabilities in dealing with climate impacts; and the absence of significant services and infrastructures for the management and reduction of risks deriving from climatic and social factors.
Often, the lack of building codes and standards further increase the risks deriving from inadequate living conditions, inadequate nutrition, poverty and poor sanitation, amplified during events such as floods or droughts 3.

As every climate disaster causes loss of property, human lives and business interruptions, the "urban poor" are trapped in a cycle of poverty and vulnerability, perhaps they are more limited by environmental factors and their ability to cope and adapt to future risks.

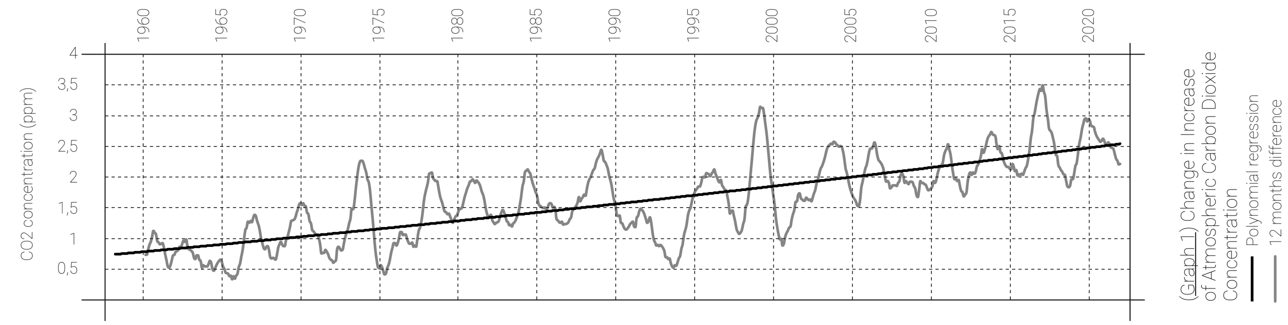
Deforestation

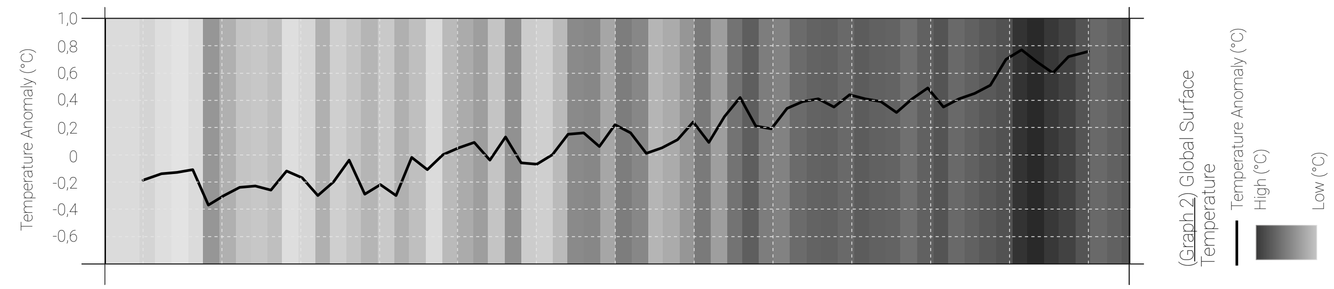
Anthropogenic factors, such as agricultural expansion, the unstoppable growth of the world population that implies new settlements caused by human migration, urbanization and industrialization, linked to social, political and economic changes, contribute to the fragmentation and destruction of forest areas (Graph 4).
It is evident that the conversion of forest land to other land uses is the cause of the fragmentation of forest territories 5.
The decrease in forest soil and its fragmentation affect ecological functions, contributing to the reduction of carbon sequestration, the control of erosion and the loss of biodiversity. It is leading to a significant reduction in the resilience of local communities.

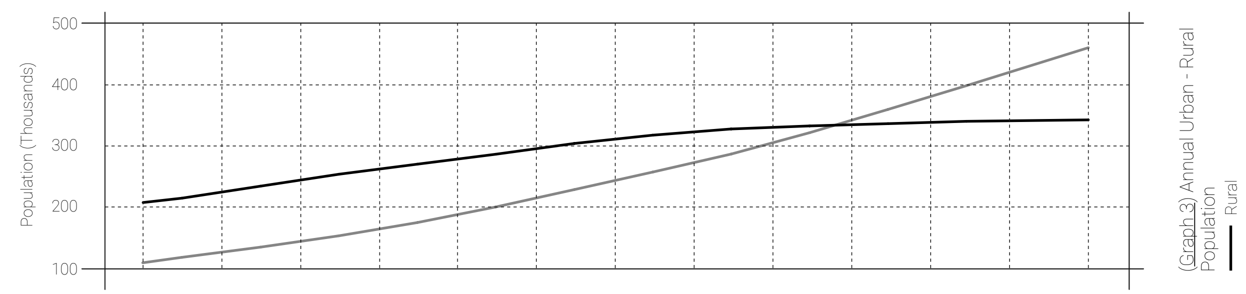
Agriculture represents the largest use of land (more than a third of the earth's surface) and is a contributor to climate change, due to the excessive use of pesticides that lead to high levels of soil erosion and pollution of surface waters, with risks on human health and wildlife.
The industrialization of urban areas and the growing demand of the population has implied the industrialization of agricultural practice for the supply of raw materials, contributing up to a third of global emissions and deforestation 2.
Soil degradation, dictated by the consequent mutation of precipitation patterns and global temperatures, exacerbates the effects of drought and the effects of natural hazards such as flash floods and storms, limiting the ability to sustain human well-being and the ability to adapt to build resilience. This can exacerbate water stress, especially in areas often at risk of drought and where groundwater is running out, affecting the agricultural system (over 2 billion people suffer from water stress) 6.

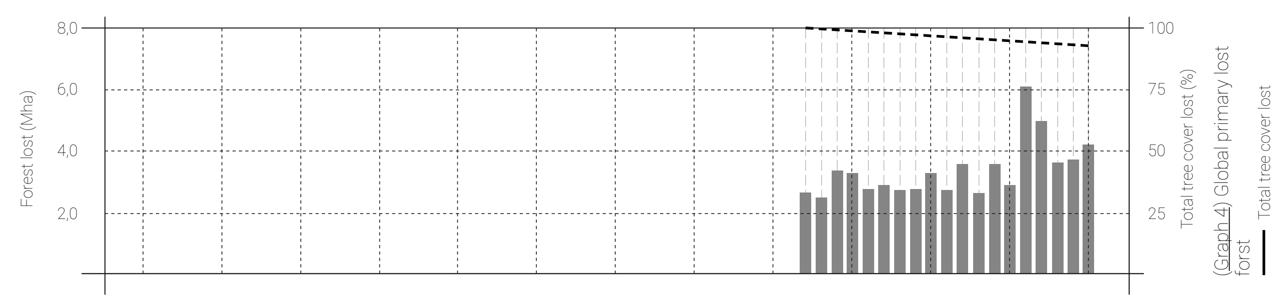
(5) FAO and UNEP (2020). *The State of the World's Forests* 2020. Forests, biodiversity and people, p. 26.

(6) World Meteorological organization (2021), *State of Global Climate* 2021, WMO Provisional report, p. 42.

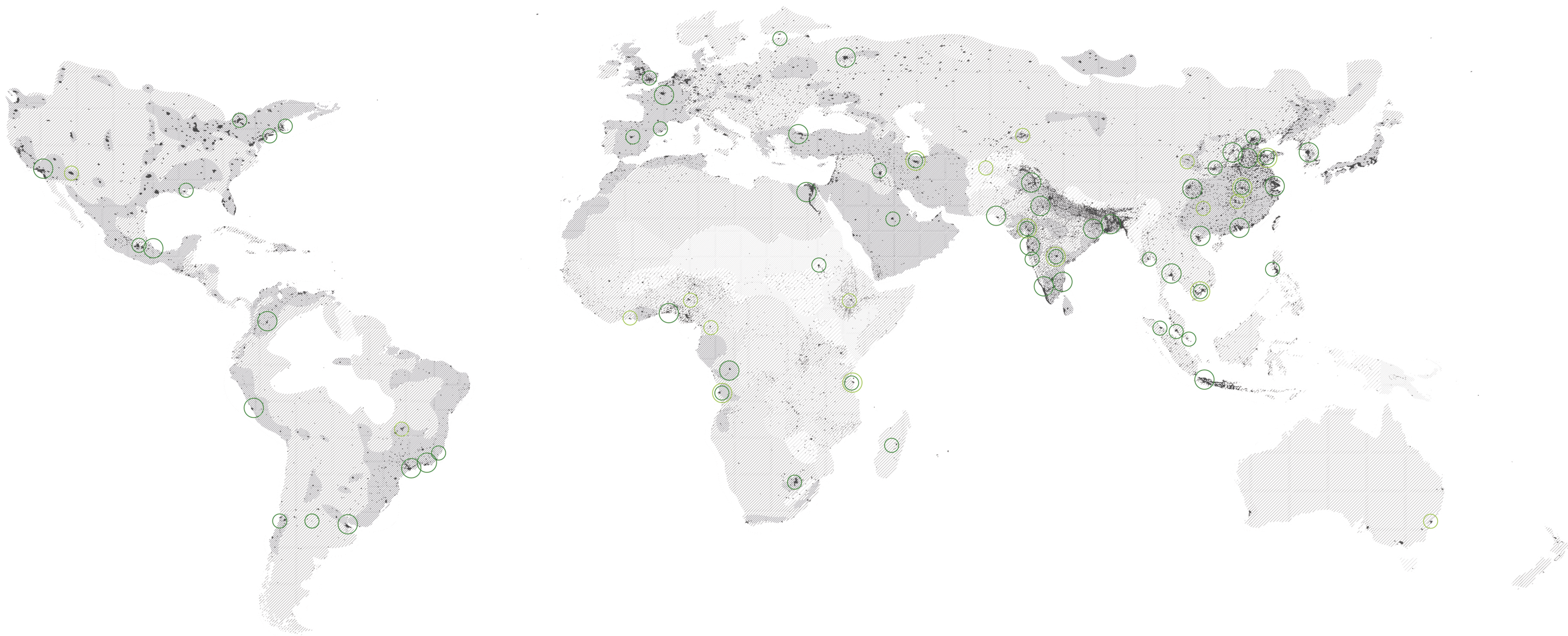








Urban - Rural Population



% Population (2030)

80-100 60-80 40-60 20-40 0-20

Current Population Distribution

City population Growth (2018-2030)

> 10 million

> 5 million

2018

2030

Sources: UN- Department of Economic and Social Affairs; European Commission/Global Human Settlement Layer (GHSL)

1.1.2. The Correlated Extreme Events

Disastrous events, in addition to sharing root causes, can be dependent or independent of each other. For example, the consequences of climate change, on a global scale, which have more acute impacts during extreme weather events such as rain, drought, storms (including tropical storms and cyclones), can lead to or aggravate other events such as floods, landslides, diseases and conflicts, with greater impact on society such as loss of livelihoods, reduced food or water security; and on the environment such as the loss of biodiversity.

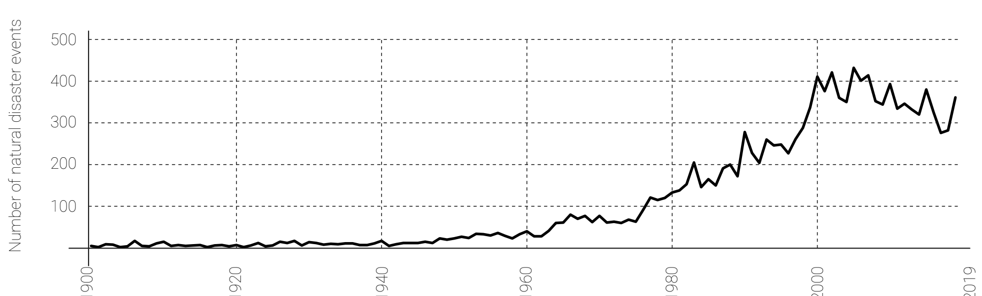
In 2020, the incidence and intensity of global natural disasters were lower than in the last 30 years (less than 4%). According to the Global Assessment Disaster report, the number of deaths was 73% less, the affected population was 50% less and 29% more in economic losses [7]. At the regional level, Asia has had the highest frequency of natural disasters in 2020, followed by Africa.

Worldwide, 389 major natural disasters occurred in 2020 hitting 123 countries and regions [8]. Graph 6 shows the trend in the number of natural disasters from 1990 to 2020, peaking in 2005 (432 events) causing millions of people affected and in need of immediate assistance. The intensity of the event and the level of resilience and preparedness of the country or of the individual are related to the negative impacts that natural disasters can have on people. Disasters can occur at various intensities: they can occur frequently or they can be catastrophic events at low frequency. Among these disasters, inundations and floods have been most frequent since 1990, accounting for 42% of 90.924 natural disasters from 1990 to 2019, followed by storms (cyclones, hurricanes and tornadoes, etc.) and earthquake, respectively in second and third place [9].
The graph opposite shows the number of deaths for each type of disaster, represented by the size of the bubble (Graph 7). It is evident that the devastating effects in terms of deaths are attributed to floods, storms, droughts, and earthquakes. Considering the rapid global growth, however, the decrease in deaths from almost all disasters, with the exception of earthquakes.

(7) Disaster Reduction and Emergency Management, Ministry of Emergency Management - Ministry of Education, National Disaster Reduction Center of China, Ministry of Emergency Management, International Federation of Red Cross and Red Crescent Societies (October 2021), *Global Natural Disaster Assessment Report* 2020, pp. 5-6.

(8) CRED & UNDRR. 2020: *The Non-COVID Year in Disasters*. Brussels: CRED; 2021.

(9) Institute for Economics & Peace. Ecological Threat Register 2020: *Understanding Ecological Threats, Resilience and Peace*, Sydney, September 2020. p. 49



< (Graph 6) Number of recorded natural disaster events, All natural disasters, 1900 to 2019 Source: EMDAT (2020): OFDA/CRED International Disaster Database, UCLouvain-Brussels-Belgium.

(Graph 7) Deaths from natural disasters by type (1960-2020) Source: Our Wold Data on EM-DAT, CRED/UCLouvain-Brussels-Belgium.

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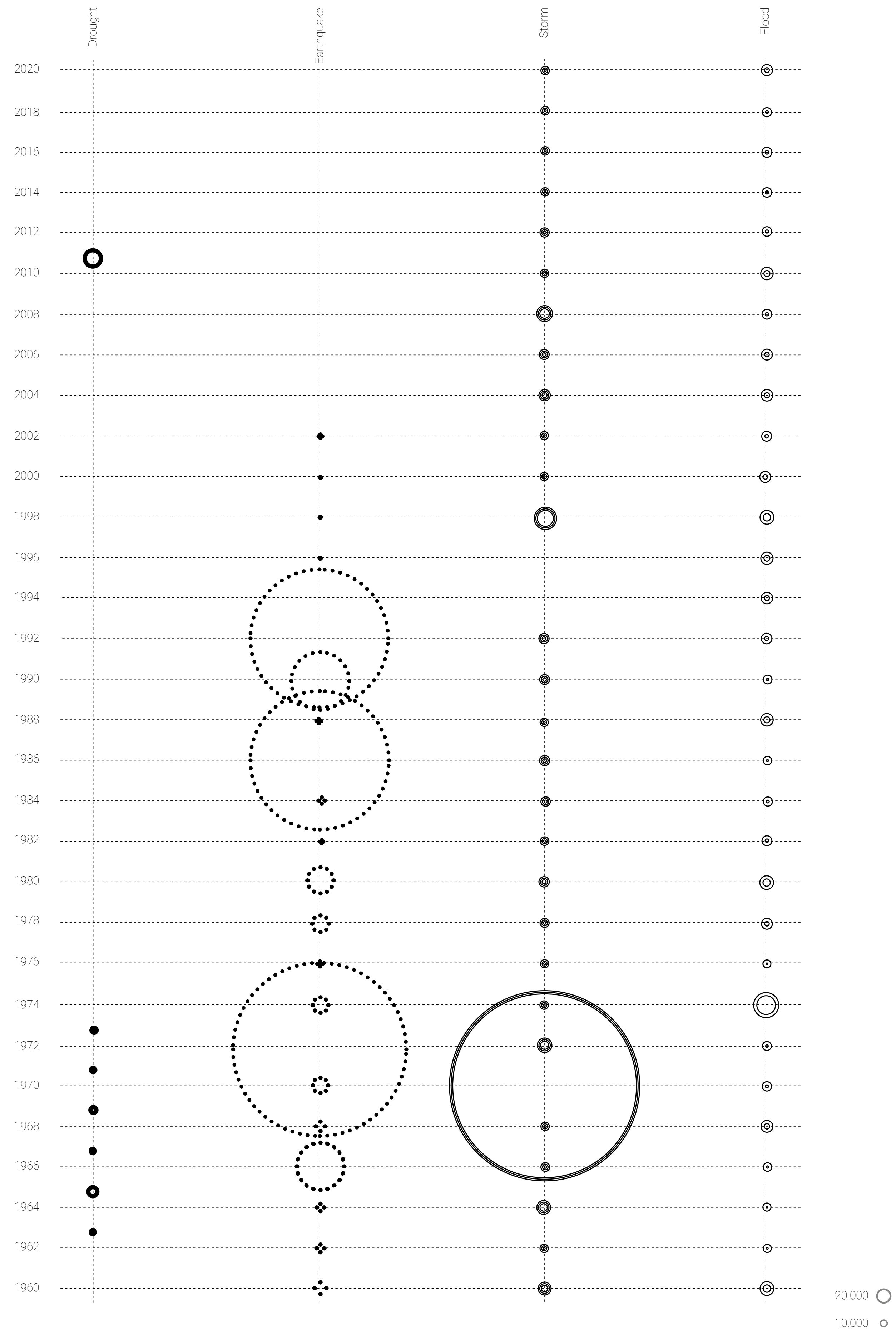
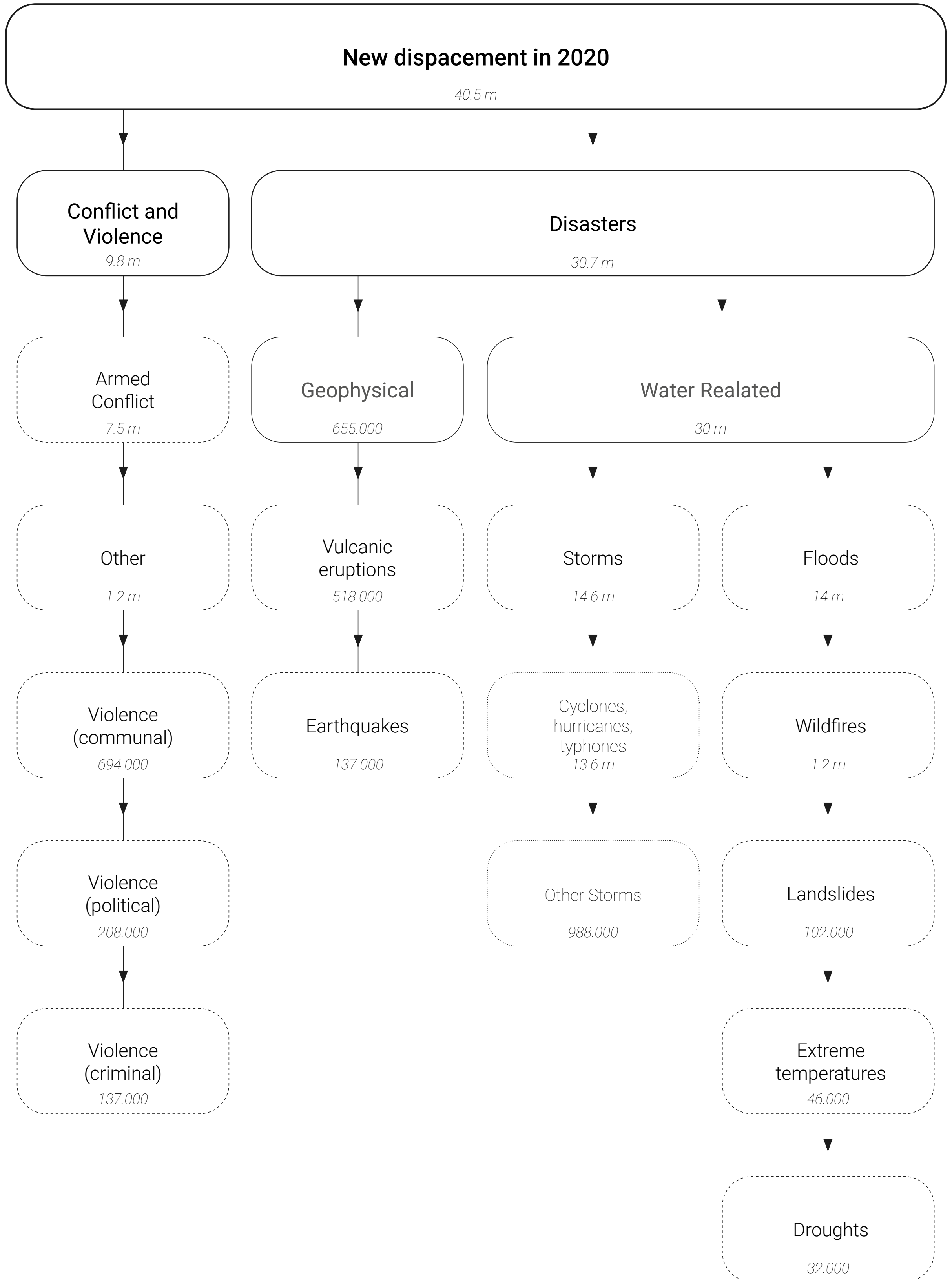




(Graph 8) New displacement in 2020: breakdown by conflict and disasters
Source: Interna Dispacement Monotoring Centre, Internal Dispacement in a changing climate, GRID 2021, p. 11-12

Displaced People

Trends in water-related disasters are aggravating in developing countries, such as Africa and South Asia, which are distinguished by their high population growth, urbanization and poverty and where access to basic services such as education, sanitation, water services and electricity, remain inadequate. About 98% of natural disasters are related to water, affecting 30 million people a year 10 (Graph 8). However, the number of people affected, displaced and who have lost their lives due to flood impacts, droughts and conflicts is far greater than that caused by inadequate sanitation and lack of drinking water (40.5 million people).

(10) Interna Dispacement Monotoring Centre (2021), *Internal Dispacement in a changing climate*, GRID 2021, pp 11-18, 80-98.

In 2020, 92% of new displacements due to natural disasters occurred in the regions most vulnerable to the impacts of climate events 10.
As climate change and the over-exploitation of natural resources worsen, instability and conflicts often arise, which in turn increase the number of displaced people.
Migration mechanisms are used to cope with possible natural or man-made disasters and shocks (such as conflicts and violence). However, if it happens suddenly and unplanned, such as displacement, it can exacerbate the fragility of the destination, which is often characterized by informal settlements.
The prolonged displacement of the population affected by natural disasters is generically due to the inability of the affected regions. An example is sea level rise and sudden storms that cause erosion and flooding along coastal areas, making them uninhabitable.

It is important to recognize that the impact of displacements on residents of informal settlements is not heterogeneous. Age, disability, health and gender are major determinants of vulnerability to a specific climate impact, conflict or violence. Children, the elderly and people with disabilities tend to be the most susceptible to prolonged periods of drought and floods. In general it is women who are most vulnerable, especially if cultural norms are relevant. While people suffering from chronic illnesses can easily be attacked by parasite-borne diseases that arise during and after prolonged periods of rain and floods 11.
At the same time, factors related to levels of income and security of livelihoods, and the level of education that influence the ability of individuals to manage the impacts of climate change, differ in communities.

(11) UN-HABITAT (2018), *Pro-Poor Climate Action in Informal Settelements* 2018, p. 11.

Education in Emergency

In particular, it is the education sector that is notably vulnerable to the effects of natural disasters and conflicts, reducing their accessibility, quality and equity.
It is a key area to ensure the protection of children and young people, especially for those living in areas at risk.
Schools should be a pleasant place for study and socialization. However, around 127 million children and young people of school age do not attend school in the regions most affected by the climate crisis 10, as educational facilities often become inaccessible or called to be used as emergency shelters, or as families affected by climatic events are forced to move to a safe place away from educational centres.
Due to the disasters, families with a lower income are forced to face enormous financial, housing and emotional constraints, which often lead to the abandonment of school students to enter the world of work.
The abandonment of schools is also due to the poor quality of education, the low number of teachers and the inadequacy of school size compared to the number of children applying for education.
These and other challenges very often coincide with the interruption of education.
With no safe places to learn, children and young people are at risk of child labour child marriage, exploitation and military recruitment.
These situations are further aggravated by the lack of funding, in fact in 2019, only 2.6% of the sector received humanitarian funding 10.
However, the need for education is most in demand in places where rebuilding conflict-affected societies is essential to maintain stability and boost economic development.

(12) The Inter-Agency Network for Education in Emergencies (2010), *Minimum Standards for Education: Preparedness, Response, Recovery* 2010, p.120.

Schools are suitable places for forming lasting collective values and suitable places for training in a culture of prevention and resilience to disasters. Some examples may be information on how to protect yourself from sexual abuse, avoid infections from communicable diseases (such as HIV) and how to access health care and food 12.
Therefore, they should be secured places, as school buildings can save lives, are a valuable national and local investment and, they should be secured to ensure school continuity during or after periods of emergency.

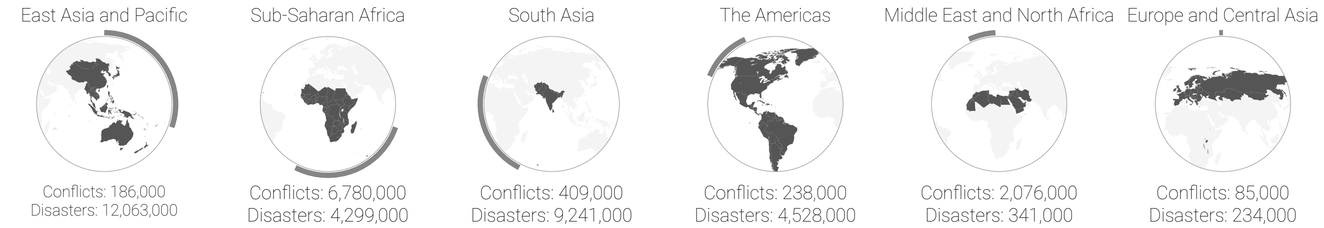
"By providing education in emergencies it'll be easier for a country to get back on track, because its children and young people are educated.".
(Sigbjorn Ljung, *education in emergencies specialist at Plan International*)

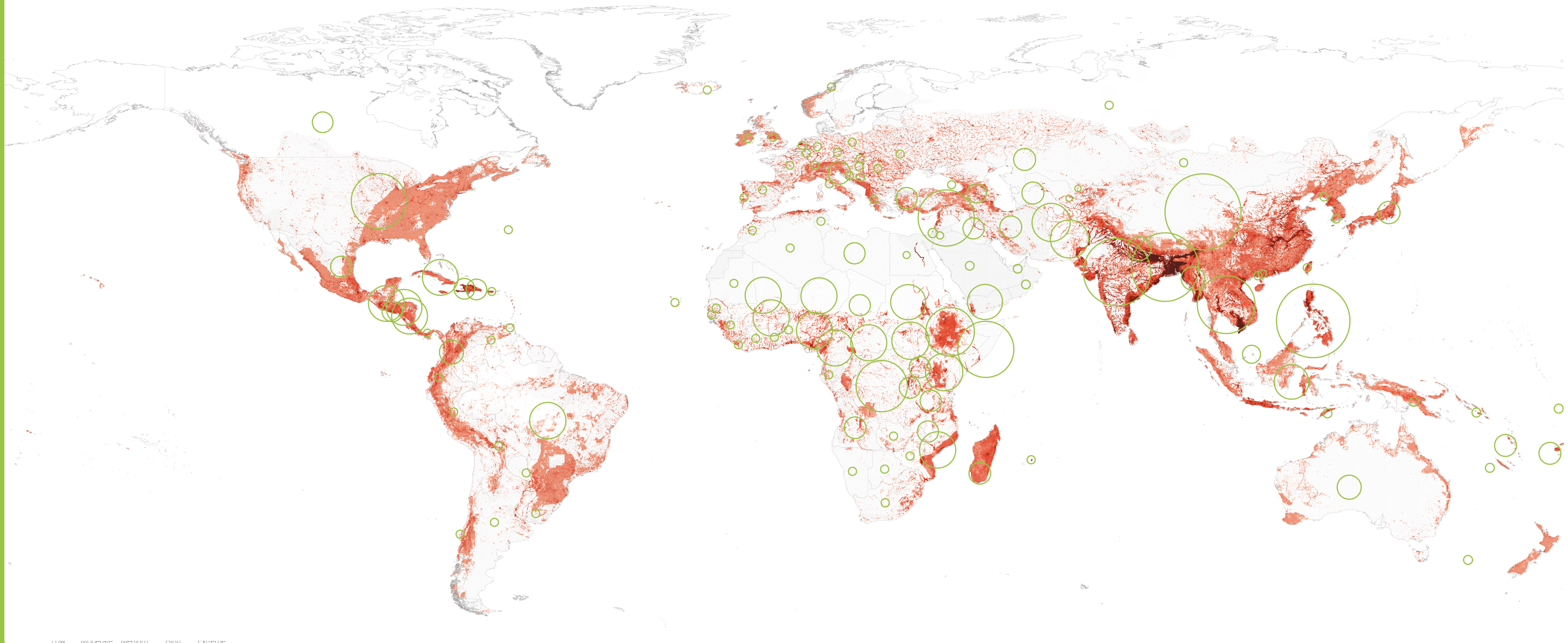
Displaced people by Conflict-Disasters and Children out of School (2020)

Country	Under 15	Conflict	Disaster	Total Dispacement	Poverty rate (%)	Children out of school (Primary)
China	249.901.204	-	5.074.000	5.074.000	0,6	-
Philippines	32.921.093	111.000	4.449.000	4.560.000	16,7	406.435
Bangladesh	44.061.889	230	4.443.000	4.443.230	24,3	-
India	361.017.585	3.900	3.856.000	3.859.900	21,9	6.545.825
Dem. Rep. Congo	41.014.814	2.209.000	279.000	2.488.000	63,9	-
Ethiopia	45.890.745	664.000	1.692.000	2.356.000	23,5	2.187.570
Syria	538.577	1.822.000	25.000	1.847.000	-	-
United States	60.531.991	-	1.714.000	1.714.000	-	224.977
Somalia	7.334.706	293.000	1.037.000	1.330.000	-	-
Viet Nam	22.576.747	-	1.267.000	1.267.000	6,7	-
Honduras	3.029.639	-	937.000	937.000	48	342.726
Pakistan	76.913.746	390	829.000	829.390	21,9	-
South Sudan	4.626.119	271.000	443.000	714.000	-	-
Indonesia	70.941.104	4.600	705.000	709.600	9,4	-
Cuba	1.803.279	-	639.000	639.000	-	7.158
Mozambique	**13.772.016**	**592.000**	**25.000**	**617.000**	**53**	**196.208**
Nigeria	89.645.181	515.000	20.000	535.000	40,1	-
Sudan	17.451.732	79.000	454.000	533.000	-	-
Afghanistan	16.280.845	404.000	46.000	450.000	49,4	-
Mali	9.519.370	136.000	276.000	412.000	41,9	-
Cameroon	11.166.234	123.000	279.000	402.000	37,5	346.513
Yemen	11.582.089	143.000	223.000	366.000	48,6	-
Brazil	44.019.351	-	358.000	358.000	-	80.305
Guatemala	5.620.978	-	339.000	339.000	59,3	495.246
Kenya	20.750.132	3.900	335.000	338.900	36,1	-
Central Africa Rep.	2.102.963	318.000	15.000	333.000	-	-
Burkina Faso	9.274.847	277.000	7.400	284.400	41,4	1.605.496
Nicaragua	1.954.287	-	232.000	232.000	24,9	-
Japan	15.664.768	-	186.000	186.000	-	-
Colombia	11.287.640	106.000	64.000	170.000	42,5	35.080
Niger	7.636.431	79.000	71.000	150.000	40,8	723.879
Chad	12.023.910	79.000	71.000	150.000	42,3	1.647.273
El Salvador	1.724.719	114.000	17.000	131.000	26,2	109.486
Myanmar	13.866.659	70.000	50.000	120.000	-	-
Mexico	33.310.119	9.700	101.000	110.700	43,9	106.131
Azerbajan	2.373.427	84.000	-	84.000	6	126.809
Vanuatu	117.977	-	80.000	80.000	15,9	3.556
Uzbekistan	9.858.846	-	70.000	70.000	14,1	38.738
Iraq	15.169.413	67.000	1.200	68.200	18,9	-
Cambodia	5.170.334	-	66.000	66.000	17,7	412.981
Tanzania	26.016.895	-	57.000	57.000	26,4	3.525.377
Iran	2.078.380	-	52.000	52.000	-	-
Burundi	5.380.807	310	51.000	51.310	64,9	140.973
Australia	4.955.653	-	51.000	51.000	-	15.542
Nepal	8.394.231	-	48.000	48.000	28,6	103.384
Croatia	588.526	-	42.000	42.000	23,3	-
Turkey	20.192.508	-	41.000	41.000	39,8	259.524
Uganda	21.048.125	79	40.000	40.079	20,3	-
Libya	1.909.172	39.000	-	39.000	-	-
Fiji	260.070	-	37.000	37.000	29,9	-
Kazakhstan	5.465.826	-	32.000	32.000	4,3	157.910
Dominican Republic	2.976.593	-	31.000	31.000	21	93.374
Malawi	8.224.361	-	29.000	29.000	51,5	-
Canada	5.995.422	-	26.000	26.000	-	6.652
Angola	15.248.424	-	25.000	25.000	32,3	-
Malaysia	7.589.218	-	24.000	24.000	8,4	41.336
Madagascar	11.093.725	-	23.000	23.000	70,7	80.511
Haiti	3.702.847	7900	13.000	20.900	58,5	-

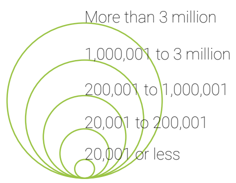
Sources:
Population ages 0-14, total. Source: The Wold Bank, World Development Indicators;
New displacements in 2020 (conflict and violence), New displacements in 2020 (disasters). Source: IDMC, Internal Dispacement in a changing climate, GRID 2021, pp. 148-150;
Poverty. Source: The Wold Bank, World Development Indicators;
Children out of school, primary. Source: The Wold Bank, World Development Indicators.

Global Dispacement by Conflicts-Disasters (2020)





Displaced people by Conflicts and Disasters



Sources: UNEP/GRID-Europe;
IDMC, Internal Dispacement in a changing climate, GRID 2020, New displacements by conflict and disasters in 2020.

I.II Floods and Impacts in Education

1.2.1. Understanding Floods

Floods are natural phenomena, which occur when there is an "high-water stage in which water overflows its natural or artificial banks onto normally dry land, such as a river inundating its floodplain" (Encyclopaedia Britannica, 2022).
As already mentioned in the previous section, floods are the natural hazards that occur most frequently and have the greatest impact on rural and urban settlements. Conflicts between urbanization, land use practices and climate-related vulnerabilities contribute to the worsening and occurrence of floods in various forms.
In order to mitigate and manage flood disasters, it is important to understand the risks before they occur. Therefore a compression of the possible types and causes of floods is necessary. Typically, a combination of extreme weather, hydrological conditions (e.g. precipitation or tropical storm) and human activities lead to the occurrence of floods. Based on these combinations, the floods are generally: River floods (or fluvial), pluvial floods (or overland), coastal floods. Furthermore, on the basis of their speed of onset, floods are divided into: flash flood, semi-permanent flooding. 13

- *River floods (fluvial)*: a river flood occurs when the surface water level of a river, lake or stream exceeds capacity and overflows onto the surrounding banks and land due to excessive rainfall (hurricanes, monsoons, topic depressions, etc.) or human factors such as the presence of dams, embankments or debris 13. Other factors include soil saturation due to past rainfall or flood events, which often lead to flooding beyond the floodplain. River flooding tends to be slow and prolonged in the flatter areas; while in hilly or mountainous areas, they can occur in a few minutes and be drained quickly from the soil 14;

- ***Pluvial floods (overland):*** occurs when events such as extreme precipitation or snow melting create a flood that flows on the ground (as it is not absorbed) and is therefore independent of a body of water 14.These floods can occur both on urban and rural areas, although in urban areas, we find the presence of this event more due to the lack of soil permeability. Furthermore, this flood typology often occurs when the urban drainage system is overwhelmed 13;

- ***Coastal floods***: is characterized by the flooding of land along the coast by the ocean or sea. The common causes of the unexpected increase in water are wind storms or tsunamis (caused by seismic activities). Wind storms occur when strong winds cause sea level rise, causing devastating floods (usually they last a short time, from 4 to 8 hours) 13;

- ***Flash floods:*** they are floods triggered by torrential rains that fall over a short period of time or they can be caused by a landslide, a block of ice or a sudden release of water from slopes that are no longer able to absorb water (slopes with recent fires forests are a known source of rain floods) 13. These can occur in any urban area, even in elevated areas that lie above coastal and river floodplains. Flash floods depend on the intensity and duration of the precipitation, the surface conditions and therefore the slope of the basin and topography. Flash floods are very dangerous and destructive and are directly related to the speed characteristics of a flood and the transport of debris that is often swept away by the flow 14;

- ***Semi-permanent flooding:*** this alluvial type occurs when some urban settlements, especially if not planned ("informal" settlements), are built on land below sea level or where the aquifers are close to the surface. These lands are often flooded for long periods 13.

(13) The Wold Bank, Abhas K Jha, Robin Bloch, Jessica Lamond (2012), *Cities and Flooding: A Guide to Integrated Flood Risk Management for the 21st Century and A Summary for Policy Makers*, pp. 55-64, 254-276

(14) Zurich, *Three common types of flood explained*, 2020.

(Figure 1) Young Boys are trying to reach the affected areas of her villages with some Rescue Materials during the devastating Flood of Bengal , 2017. Photographer: Avishek Das

(Figure 2) A businessman is carrying his cloth materials from his store to a safer place which is completely under water and make huge loss for him. Photo was taken at Howrah District on 28 July 2017 as the villages waterlogged due to excess water release by DVC. Photographer: Avishek Das

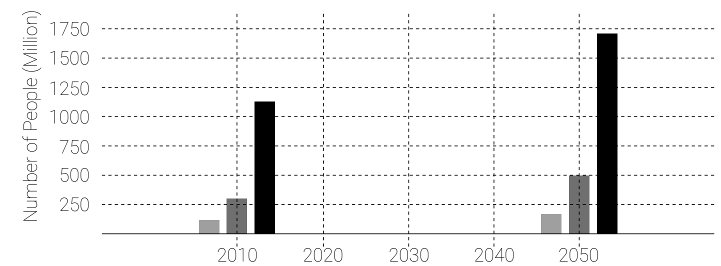
1.2.2. Benefits and Disadvantages of Floods

Benefits

While floods pose a threat to communities (especially developing ones), they have always been an important part of the natural regeneration process, providing various benefits to those living in flood-prone areas and making them an economic advantage (Graph 9). Floods are often used as a nutrient collector, to fertilize crops and for seasonal fishing. Further benefits are related to the availability of fresh water, in fact, floods help enrich the aquifers, rivers, lakes or wells, which are important, especially for countries that depend on a natural water source 15.

Despite the threat of floods, government systems are obliged to provide services, such as educational and health infrastructures, to the inhabitants of the areas in question, encouraged by the economic benefits that floods reserve, albeit at risk. However, this helps to alleviate political tensions in countries with socio-economic difficulties.

(15) Munsaka, E., & Mutasa, S. (2021). *Flooding and Its Impact on Education.* In E. N. Farsangi (Ed.), Natural Hazards. IntechOpen. https://doi.org/10.5772/intechopen.94368



< (Graph 9) Millions of people living in flood-prone areas Source: PBL Netherlands Environmental Assessment Agency The Hague (2019).

Rivers
Coastal Zone
Delta

Disadvantages

The extent of the impacts depends on certain factors, such as the vulnerability of the activities and the population, the frequency, extent and intensity of the floods.
Floods have disastrous impacts on the education sector. It is the trigger for interruptions in school curricula and the consequent poor quality of education, especially for schools built with low resistance to flooding. This is dictated by the fact that governments are obliged to introduce education systems in high-risk areas, promoting accessibility rather than construction quality.

Floods play an important role on social and economic issues. In fact, the most vulnerable communities are the poorest ones, who do not have sufficient means to move to less vulnerable places, indeed, as previously anticipated, sometimes they make risk an opportunity. These vulnerabilities and risks are also caused by water-related infectious diseases (such as cholera), aggravated by an overwhelmed or sometimes missing health system 15.

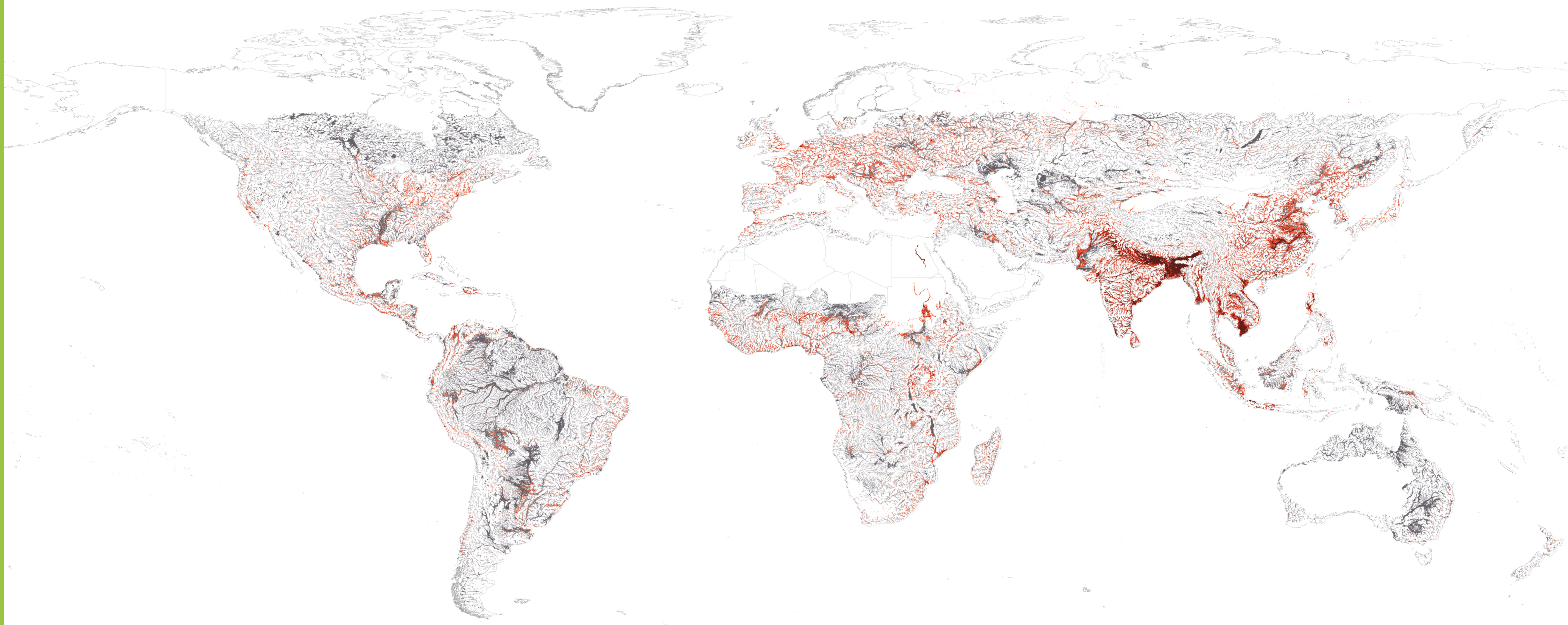
To counteract the benefits, to aggravate the social and economic deterioration of people, there is the destruction of livelihoods, caused by floods, such as agricultural land, communication infrastructures, transport, sanitation and housing.
Furthermore, floods and related events such as displacement from one's home, loss of one's means of subsistence, interruption of economic and school activities, can cause enormous psychosocial effects, with long periods of shock and stress especially for children.

These and other flood-related factors threaten school attendance. In practice, school infrastructures are recognized as reception centres for displaced persons in case of emergency, but as happened in Cambodia: in addition to the problem of school interruptions, displaced persons introducing their animals into the relatively large classrooms, that their animals destroy the entire infrastructure, thus reducing the chances of attendance, post-emergency, of the educational facility 16.

(16) Ardales, G. Y., Espaldon, M. V. O., Lasco, R. D., Quimbo, M. A. T. & Zamora, O. B. 2016. *Impacts of Floods on Public Schools in the Municipalities of Los Baños and Bay, Laguna, Philippines.* Journal of Nature Studies. 15 (1): 19-40, p. 28

Global Flood Hazard

Sources: UNEP/DEWA/GRID-Europe;
Rentschler, J., M. Salhab. 2020. People in Harm's Way: Flood Exposure and Poverty in 189 Countries. Policy Research Working Paper. No. 9447. Washington DC: The World Bank

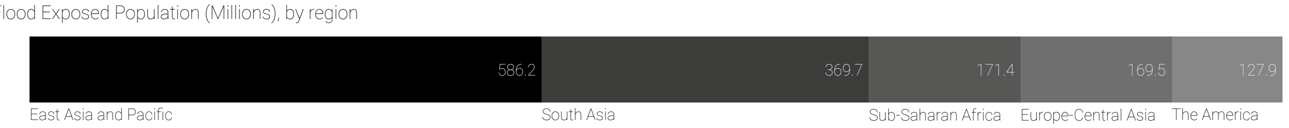


Floods Mortality Risk

Low Moderate Medium High Extreme

■ Flood Hazard (50 years)

Flood Exposed Population (Millions), by region



1.2.3. Flood-Resilient Architectures

Where there are informal settlements or that benefit from the occupation of the floodplains, careful design of the buildings can reduce their vulnerability and the risk of flooding. In the event of structural collapse, in addition to the loss of property and human life, the building may present a threat to other buildings or external people, due to the debris that could be carried by the water.
Overall, floods can have an impact on both the integrity of the building and its recovery, causing damage that could be too costly to fix and involving physical and mental health risks 13.

The construction of buildings resilient to floods cannot be based on a generic project that adapts to all study areas, but we must always stick to the context in which we are going to act, considering the local climate, material availability and construction traditions. However, a structure must have key components that can help achieve structural resilience and strength, such as:

- *Foundations* and basement (and flooring) beyond the flood level;
- The entire *superstructure* (structural frame, braces, internal and external walls, finishes, roofing system, openings);
- *Barriers* placed at the *openings* (doors and windows), to prevent the entry of water.

The latter, as well as floors, ducts and service pipes and cracks, are likely points of water entry, which must be taken into consideration during the design or recovery (and maintenance) of a building.

To ensure structural integrity, the design should take into account the characteristics of the floods. In particular, hydrodynamic (speed), hydrostatic (pressure on walls and windows could cause collapse) and debris transport can overwhelm the integrity of the building 13.
Furthermore, the erosion caused by the flood, in addition to causing landslides, can hinder the stability of the building.
Therefore, it is important to consider the characteristics of the land on which the building and its foundations rest.

Vernacular architecture as Inspires

An answer to the design of buildings resilient to floods can be found by analysing the vernacular building types, which demonstrate the efficiency and economic possibilities of which alluvial areas have always been characterized.
These houses not only prove to be efficient, but equally, the cost of construction and living are significantly lower than buildings built on dry land.

Vernacular buildings rely on the skill, craftsmanship and traditions of local builders, providing us with a key model for resilient design to weather conditions. Most of these architectures are built with indigenous and low-cost materials (e.g. bamboo, mud, straw). The climatic conditions are reflected in the shape of the building, as can be sloping roofs, to bring down the monsoon rains, lowered roofs to keep the heat or raised buildings to protect against floods17.

(17) Ham, P. (2018). *Vernacular architecture inspires flood-proof housing.*

These vernacular building typologies are, therefore, the practical example to which the new architectural and technological typologies refer.
In fact, flood-resilient structures, mostly build, can be divided into two macro-groups: structures placed on dry land that are resilient to floods and structures that allow you to live near or on the water.
The most representative aquatic structures of the respective macro-groups are divided into a wet-proofed building, a dry-proofed building, a elevated static building for the types resilient to floods and an amphibious building, a pile building and a floating building for the types that allow you to live by near or on the water. These are as follows:

Flood-resilient land structures:

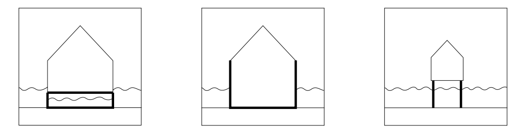
- *Wet-proofed Building:* this type of construction consists of a base consisting of an air chamber useful for allowing alluvial water to enter it, with the aim of preventing damage from possible water pressure and reducing the floating effect. This structural type is not suitable for sites that experience a rapid increase in alluvial water and at high speeds 18.

- *Dry-proofed Building:* unlike the wet-proofed structure, this type does not require drilling of the base; therefore, it requires a structure that is much more resistant to the depth, speed of floods and the impact of debris. In addition, it is important to consider a good closure of doors and windows to prevent water infiltration inside 18.

- *Elevated Static Building:* the building is elevated on the mainland, supported by a perforated structure high enough to allow the water to flow below it without causing any damage to the building 19.

(18) World Meteorological Organization, Global Water Partnership (2011), *Flood proofing: A Tool for Integrated Flood Management*, 2012.

(19) Piątek, Łukasz. (2016). *Displacing Architecture? From Floating Houses to Ocean Habitats: Expanding the Building Typology.*



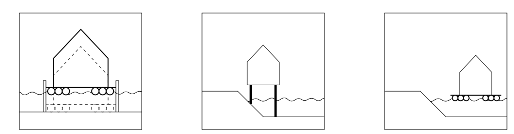
Wet-proofed Building — Dry-proofed Building — Elevated Static Building

Buildings near or on the water:

- *Amphibious Building:* they are buildings located on land, but able to float when increasing during a sudden increase in water, thanks to its low weight and the presence of floats that allow it to return to land when the water recedes. Furthermore, to allow only vertical movements, the structure is hooked to mooring elements 19.

- *Pile Building:* building located totally or partially within shallow waters (coastal areas, lakes, etc.) where it is possible to predict water levels. This structure typically rises from two to 4 meters above the water supported by a perforated structure.

- *Floating Building:* floating building located entirely in a reservoir. It can float and stay in position thanks to its low weight, the presence of floats and various mooring systems (or stop poles or anchors, etc.) 19.



Amphibious Building — Pile Building — Floating Building

(Figure 3) Edward Burtynsky, Saw Mills #1, Lagos, Nigeria 2016. photo © Edward Burtynsky, courtesy Admira Photography, Milan / Nicholas Metivier Gallery, Toronto.

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GRAPHS and DATA

Graph 1: NOAA, UNEP/GRID-Geneva, *Change in Increase of Atmospheric Carbon Dioxide Concentration.*

Graph 2: NOAA, UNEP/GRID-Geneva, *Global Surface Temperature, based on 1910-2000 average*; NOAA, UNEP/GRID-Geneva, *Global Annual Temperature Deviation.*

Graph 3: UN-Dipartment of Economi and Social Affairs, *Annual Urban Population at Mid Year (Thousands), Annual Rural Population at Mid Year (Thousands), 2018.*

Graph 4: World Resource Institute, *Global Forest Watch*, *Global primary forest loss.*

Graph 5: UN-Dipartment of Economi and Social Affairs, *population division (2019).*

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Graph 6: EMDAT (2020): OFDA/CRED International Disaster Database, Université catholique de Louvain – Brussels – Belgium, *Number of reported natural disasters (1900 – 2019).*

Graph 7: Our Wold Data on EMDAT, CRED/UCLouvain-Brussels-Belgium, *Deaths from natural disasters by type, World, 1960 to 2020.*

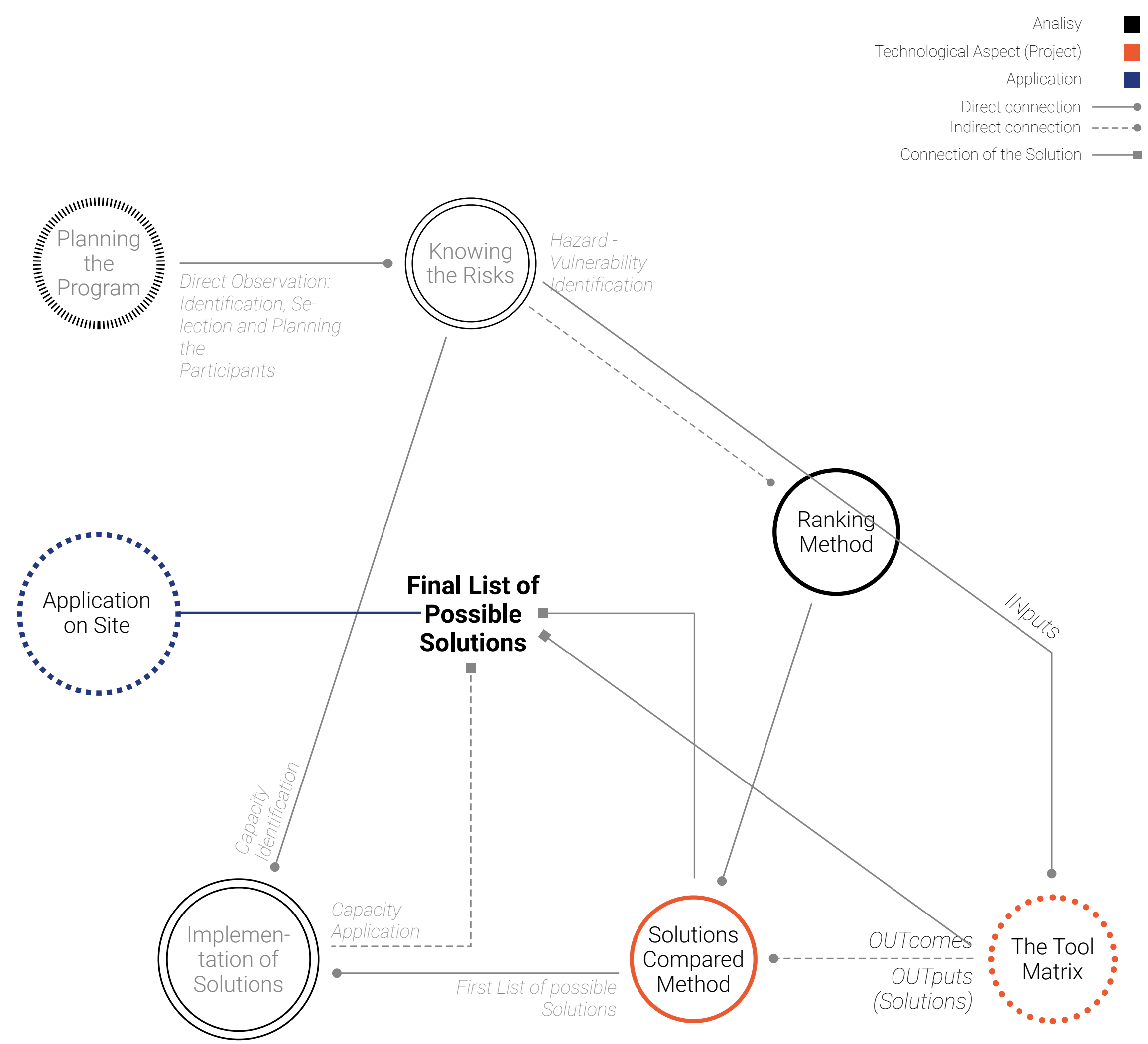
Graph 8: Interna Dispacement Monotoring Centre, Internal Dispacement in a changing climate, GRID 202, *New displacement in 2020: breakdown by conflict and disasters.*

II.

From Investigation to Action

The development of the following chapter took place through my participation and collaboration in a team of undergraduates, within which everyone has dealt of a certain hazard studied and analysed in order to create common tools and methodologies.

The chapter selects the possible existing, reformulated, and new tools and methodologies to be adopted in a structured way to collect, analyse and systematize information on the dangers and vulnerabilities to such hazards 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 individual Hazards studied by each team member (floods, storm, earthquake, disease) 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.



II.I Planning the Program

The following paragraph intends to describe, in the form of sub-paragraphs 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.

2.1.1. How to start

The CCDRR and VCA: What they are?

For multi-risk and vulnerability assessment, various investigation processes and related tools developed by Plan International and the International Federation of Red Cross and Red Crescent Societies are supported. The first developed the tool called Child Centered Disaster Risk Reduction (CCDRR) which implements "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 resilient to disasters" (Plan International, 2018) 1; while, the one developed by the International Federation of Red Cross and Red Crescent Societies is the Vulnerability and Capacity Assessment (VCA). VCA uses a series of participatory techniques to collect and analyse 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. Then build sustainable solutions that the community can develop and implement by leveraging their capabilities. With this tool, people and local communities become the fulcrum, 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.

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

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

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 a 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 in which the research will take place , including the physical characteristics of the place of study.

"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.

Step 3 - Selection Evaluation Team: it is important to determine who will be the people responsible for collecting and analysing 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.

> 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;

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.
- *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 participants 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 way information is collected, analysed 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.

> 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/

II.II 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.

(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.

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

- ***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 analysed 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.

- ***Exposure***: 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.

(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

$$\text{Disaster} = \frac{\textit{Hazard} * \textit{Exposure} * \textit{Vulnerability}}{\textit{Capacity}}$$

- *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 relationship of these elements is illustrated by a formula used by the International and Cross Federation (IFRC) (below) to evaluate the potential impact of a Hazard on a community. The greater the risk, the greater the hazards and vulnerabilities of a community, depending on their capacity.8

$$\text{Risk} = \frac{\textit{Hazard + Vulnerability}}{\textit{Capacity}}$$

- *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 exposure - Vulnerability - Capacity Identification

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 analyse 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.

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, belonging to the community, who are involved in the process *(Step 4 - Select participants 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.).
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 (Table 1) is not complete, but adapted to our purpose :

(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.

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 damage.

3. Climatic conditions (including extreme events and changes in climate)

4. Demographics of the community
• Distribution of the population (age, work, gender):
- Total adults (>20 years);
- Total youth (13 - 20 years);
- Total Children (5 - 13 years);
- Infants/young children (<5 years);

• 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. Sport facilities.

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.[1]
Very 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 neighbouring communities (what is neighbouring 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).

Location	Safe	Un-Safe	Which Hazard	Which Vulnerabilities	Who Affect	Capacities
Home			Conflict			
School			Violence			
Others: -Playground -Market						
- ...						

< (Table 2) Developed by Plan International [6] and reformulated by the author of the thesis.

Tool 4 - Seasonal Calendar (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.

Categories	Dic	Jen	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Impacts
Seasons	Winter			Spring			Summer			Autumn			
Socio-Conditions													
- Low/High Income				x									
- Immigration (migration)			**X**					x					
- ...													
Social Conditions													
- Children Out of school			x	x			**x**						
- Domestic violence													
- Conflict									**X**				
- ...													
Environment													
- Rainfall period				**x**									
- Drought period		**X**							x				
- Temperature (High/Low)		**X**		x				**X**	x		x		
- ...													
Health													
- Water-borne disease							**X**			x			
- Air-borne disease		**X**					**X**	**x**	**X**			**X**	
- Vector borne disease				**X**								**x**	
- ...													
Natural Hazard													
- Cyclon									**x**				
- Earthquake		**x**		x				**X**	x		x		
- Flood							**X**			x			
- ...													

< (Table 3) Developed by IFRC, *VCA, Toolbox*, p.98 [5] and reformulated 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 Calendar (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.

Hazard Type	Year	Impact
Floods	1992	
Cyclon	1997	
Others: - Disease	2003	
...	...	

< (Table 4) Developed by the Plan International [6] and reformulated by the author of the thesis.

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, clothing 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.

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.

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..

Hazards	Vulnerability Categories (Livelihoods)				
	Natural	Infrastructural	Financial	Human	Social
Floods					
Flash Floods					
Others: -Drought - Cyclon - ...					

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

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).

Hazards	Vulnerability Categories	Component at risk	Impact of Hazard to the element at risk	Characteristics
Floods				
Flash Floods				
Others: -Drought - Cyclon - ...				

(Table 6) Developed by the author of the thesis

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 (e.g. flooding). These strategies are what the community (or the individual or family) relies on to maintain their livelihoods during and after a disaster.

Hazards	Component at risk	Capacities	Resource used
Floods			
Flash Floods			
Others: -Drought - Cyclon - ...			

(Table 7) Developed by the author of the thesis

2.2.3. *Method 1* - The Ranking

(Community Involved / Community Not Involved)

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 studied, such as Floods, Earthquakes, Storm and Disease, to proceed with the development of the Tool Matrices.

Ranking Method

This method is useful for selecting and classifying a group of similar elements that need to be compared, namely hazards, by asking questions such as: what are the main natural hazards that threaten the community? What do they think is the most important ?.
For the identification of multiple hazards, the assessment takes place according to pre-established criteria such as the frequency (Which hazard occurs most?) Over the course of a year or a month, whether it occurs seasonally or only once in a lifetime and the effects in terms of lives and economic.

Type of Hazard	Effect/ Loss	Frequency	Rank
Floods		55	1°
Cyclon		10	2°
Earthquake		5	3°
...	...	...	...

(Table 8) Developed by the author of the thesis

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

Once the Hazards priorities have been established, the community reviews the data previously analysed to identify the impacts, in terms of vulnerability, that these have on the environment and society; and reflect on existing and desired capabilities needed to address or minimize the identified problem / risk.

II.III The Actions 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 methodologies to be applied continuously with the programs that have been supported (CCDRR and VCA).

2.3.1. *Tool 7* - The Matrix

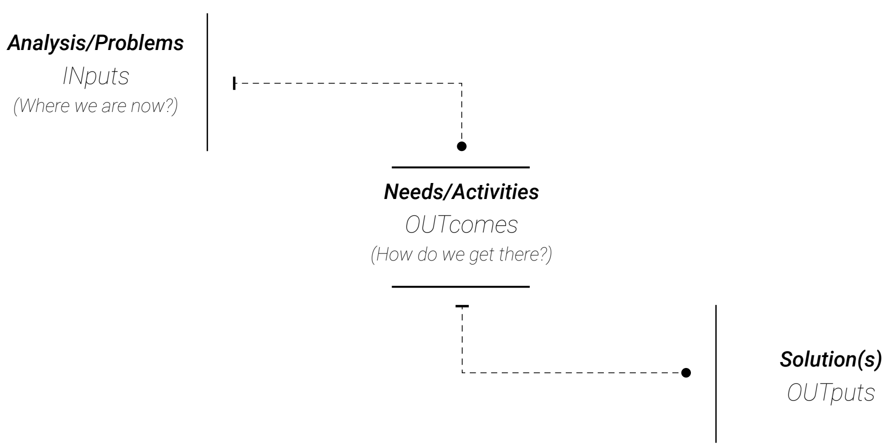
(Community Not Involved)

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 and resistant 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.

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.

Hazards	Vulnerability Factor	Causes	Needs Identification	Capacities Identification	Suggested Solutions
Hazard 1	*Vulnerability 1.1*	*Cause 1.1.1*	*Needs -a-*	*Capacity -a-*	*Solution -a-*
		Cause 1.1.2	*Needs -b-*	*Capacity -b-*	*Solution -b-*
		Cause 1.1.3	*Needs -c-*		
	Vulnerability 1.2	*Cause 1.2.1*	*Needs -a-*	*Capacity -a-*	*Solution -a-*
		Cause 1.2.2	*Needs -b-*	*Capacity -b-*	*Solution -b-*
				Capacity -c-	*Solution -c-*
Hazard 2	*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.

The ***Needs / Activities*** are directly linked to the analyses carried out and therefore require a knowledge of the place and the community that requires them.
In our specific case, the possibility of a direct confrontation with the community is unlikely, therefore 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.

- *Needs of the Educational context:* On the humanitarian level, we consider three manuals: *Humanitaria Character and Minimum Humanitarian Standards in Humanitarian Response* (Sphere, 2018), which provide practical, albeit rather general, guidance for planning, managing or implementing an adequate humanitarian response. The characteristics of an educational structure reflect the importance of primarily meeting physiological and safety needs in the first place, and to lay the foundations for the satisfaction of the needs of belonging, esteem and self-fulfilment. 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: *Safe Learning facilities (in terms of protection and well-being and appropriate facilities and services); Physical Protection (in and around the school); Educational program (in terms of flexible and accessible space); School type (in terms of division or union of the students); Accessibility for Social Minorities; Accessibility for all level; and Dimension of schools for accessibility*.
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.

- *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.

- *Needs of the Risk scenario:* In order to cope with natural or man-made disasters or the problems and characteristics concerning the design site, risk prevention and mitigation measures play an important role, which are reflected in the needs of the risk scenario through the possible compositions , positions and architectural structures.
  For example, the needs or activities of the risk scenario identified for the development of the Floods Matrix, is limited to listing the possible and *already existing buildings resilient to high or low floods* (defined in the previous chapter), suggesting the best typology depending on the site where you are and the alluvial characteristics.

- *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.

In the last phase, various usable ***solutions*** are defined which should not be understood as unique or irrevocable solutions but on the contrary as strategic, cognitive and expandable tools by guides, manuals or by the skills of the community involved, for the subsequent development of the project.
For each need or activity involved, different solutions are developed, in turn divided into macro-groups to which they belong, in order to face problems and dangers, through planning and design applicable at different scales, which allow to reduce the vulnerabilities of people and of the same building to potential material and economic damage

- *Solutions of the Educational context:* these solutions resume the study of the 3 manuals cited for the respective category of need, through which two macro-groups of solutions are identified: *Quality in Education; Accessibility and Equity in Education.*
  The first group refers to possible solutions to have protection (in and around the school), well-being, adequate services and an adequate and flexible school environment for contextual needs. While the latter refer to a school environment that has an appropriate size for the number of students who apply for access and that is a more inclusive environment, in terms of location, origin, gender, race, language religion, etc.

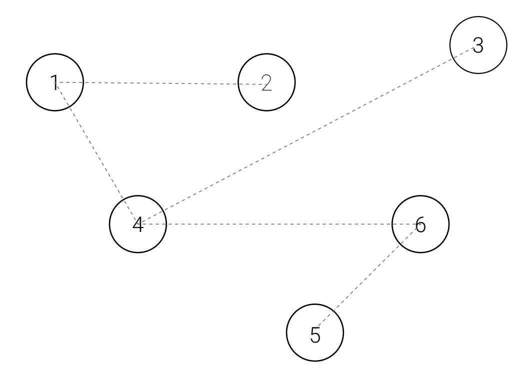
- *Solutions of the Climatic context and Risk scenario:* for each action or need considered (in both climatic and risk categories) risk prevention solutions are applied, including strategies regarding *location, materials and construction techniques*, mainly given by the study of the various Disaster Risk Reduction tools.
  These solutions are divided into groups of architectural design characteristics, such as, for example, the types of foundation, the shape and structure of the roof, the openings (windows and doors) or the structural reinforcement systems.

- *Compatibility and Material Durability Solutions:* these solutions do not want to be strategies to be adopted but, rather, information about the selected and compatible materials, defining whether or not the characteristics of the materials can affect the resilience and durability of the building, if they have a high environmental impact or on the long-term cost.

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 that is the matrix



(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.*

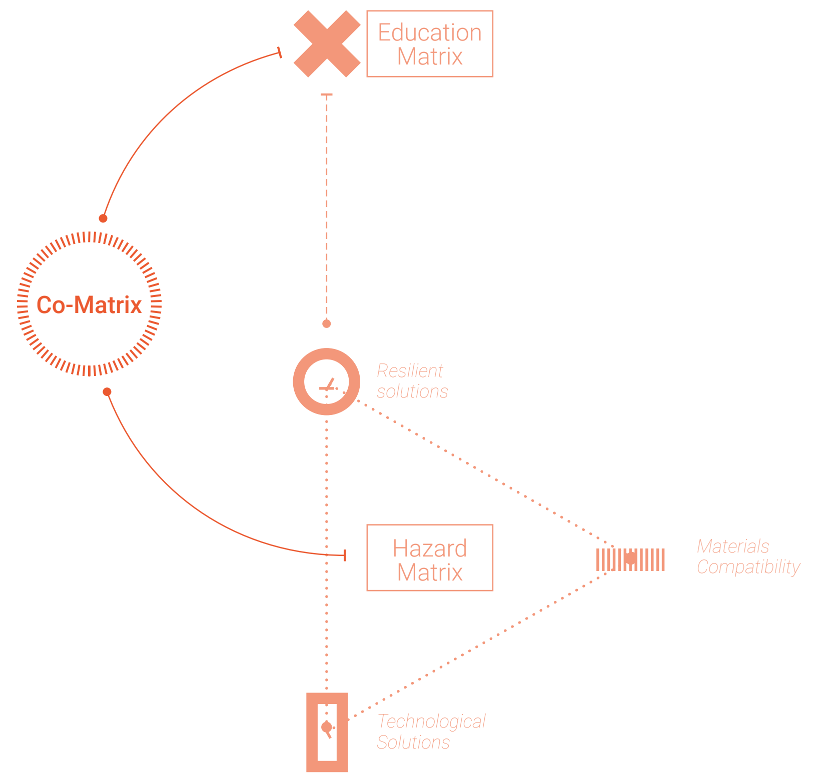
that identifies the final structure of the instrument. The matrix is defined by rows and columns and their intersection is given by the nodes of the graph, therefore near the connection point between two or more graph nodes the matrix is filled with a graphic sign.

The matrices on subsequent pages are read from left to right. The first connection points occur between the rows and the columns, respectively problems (inputs) and needs (outcomes), after having found the needs the connections with the outputs rows define the solutions.

Furthermore, each <u>*outcomes*</u> is defined by a ***symbol***, while the <u>*outputs*</u> by a color that is applied to the symbol of the outcomes, as outcomes and outputs have value only if communicating. In addition, ***symbols*** and *colors* are used to communicate and simplify the identification and collection of items in the second method (Solutions Compared) defined in the following pages.

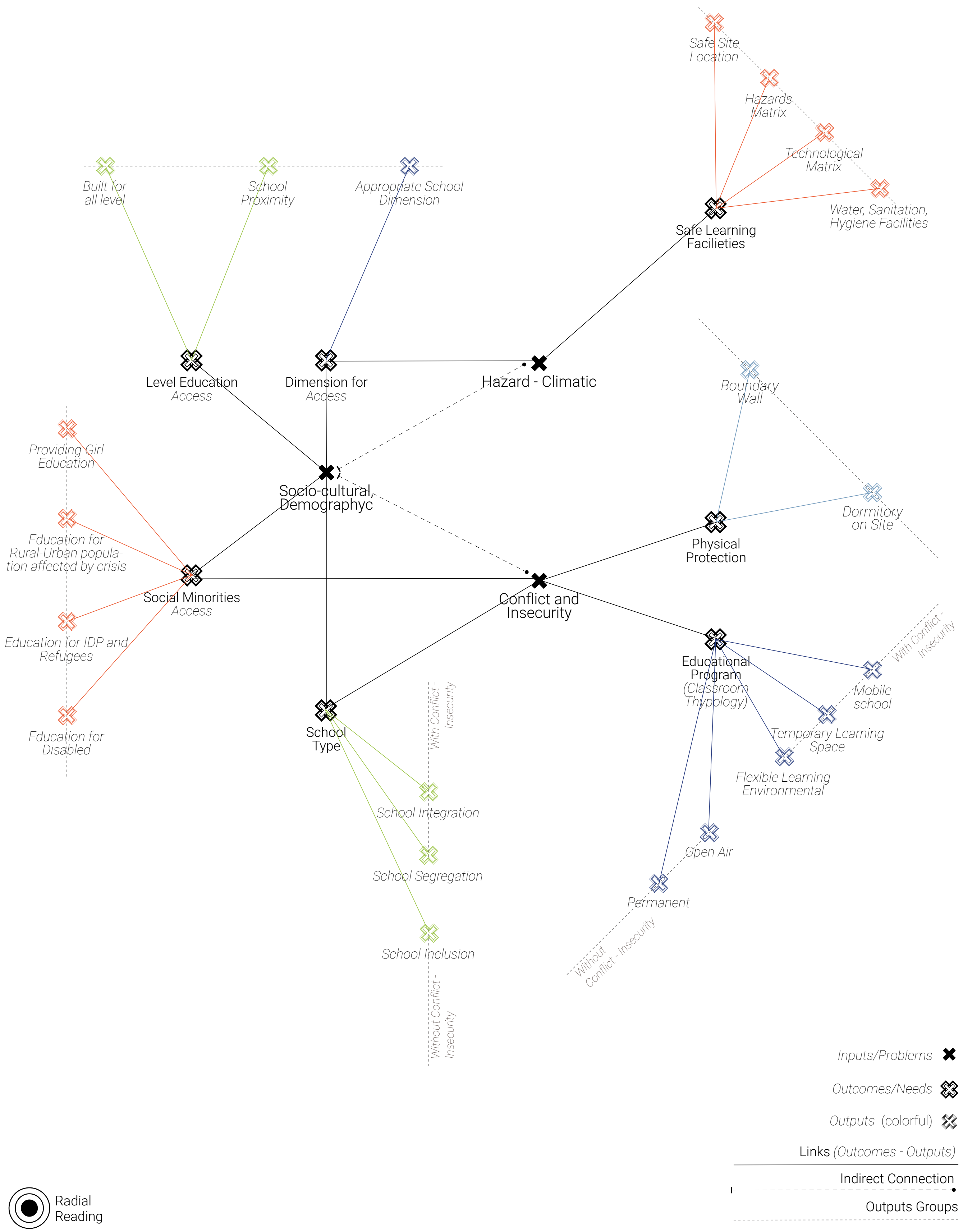
The Tool MATRIX

The following pages show the matrices, starting from those concerning the issues of the Education System and Floods that contain the study and the work I did, while the subsequent matrices (Storm, Earthquake and Disease) were developed by: Andrea Matevska, Jana Tosheva, Juan Pablo Benavides.



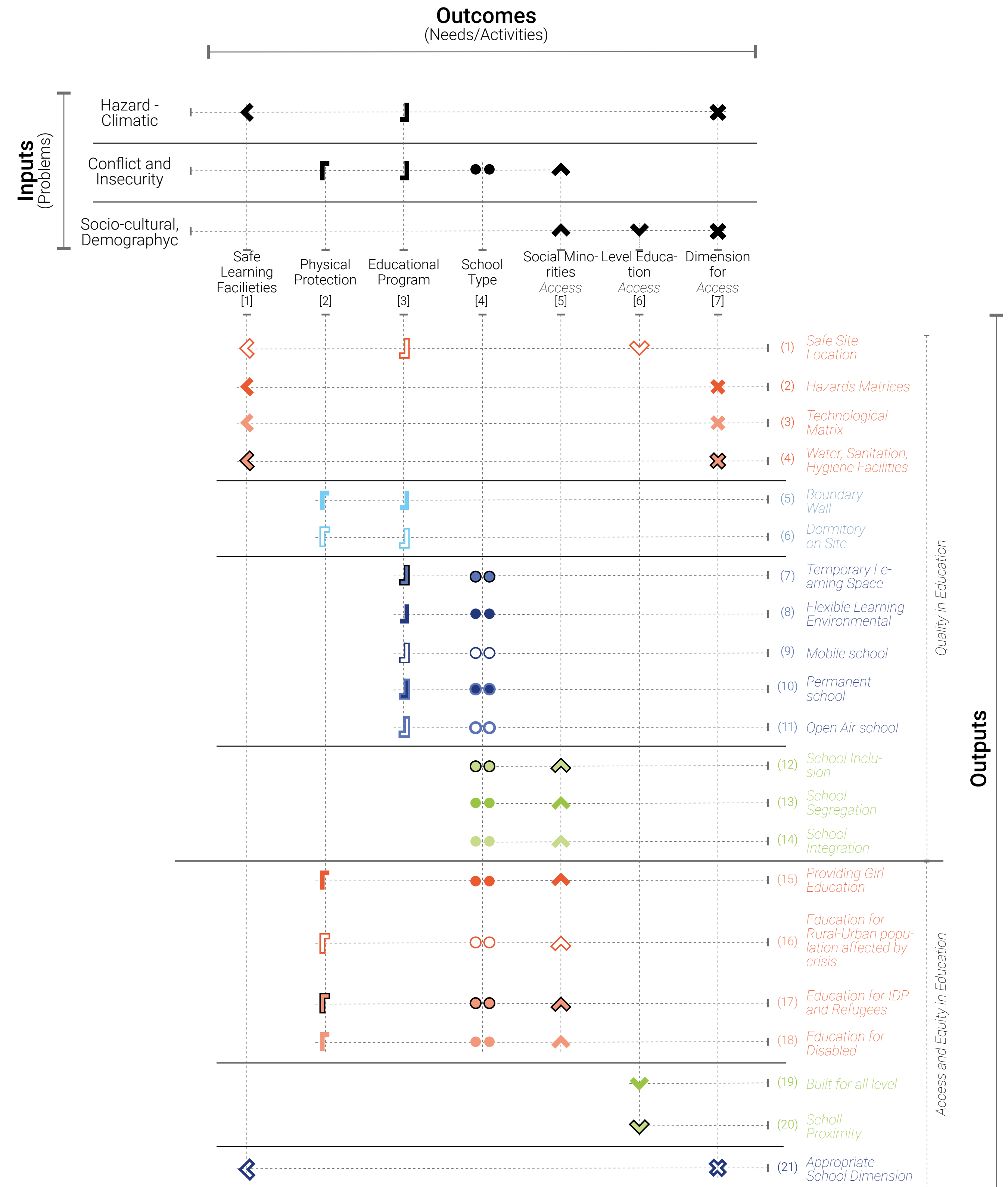
Education

Grafo



From a Grafo *To a* **Matrix**

***Education* Matrix**



EDUCATION MATRIX

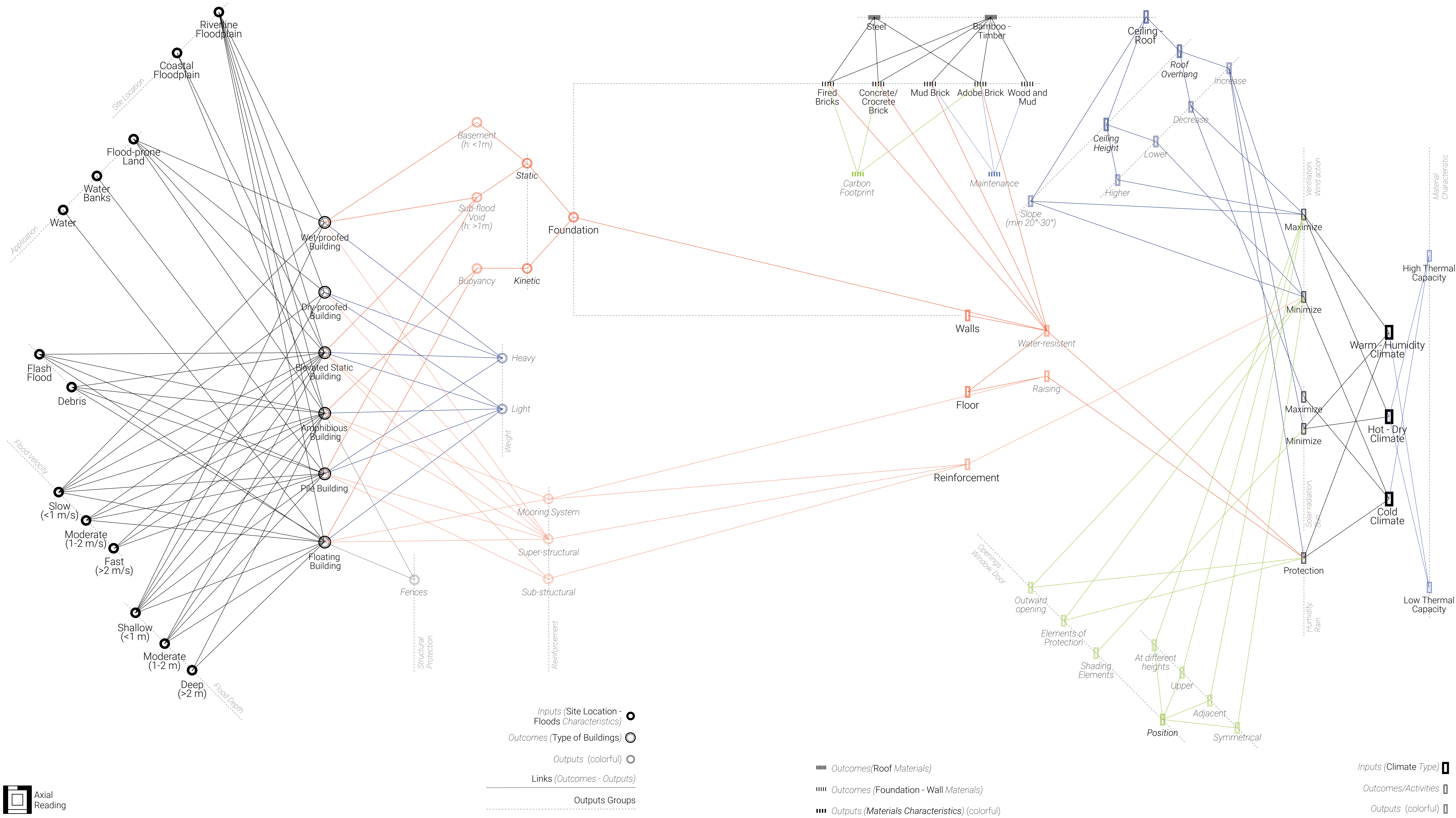
Radial Reading

Grafo

Flood Proofing *(Resilient Solutions)*

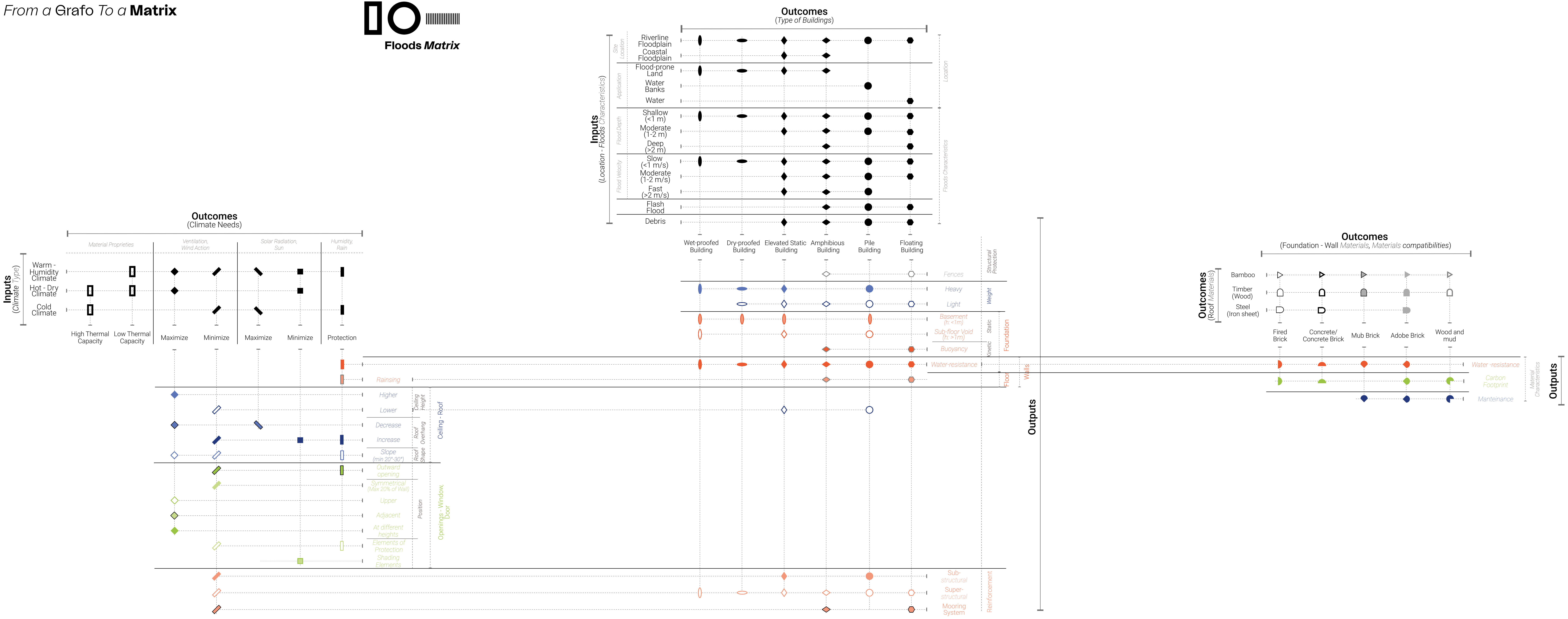
Materials Compatibility

Technological *Solutions*



From a Grafo *To a* **Matrix**

Floods ***Matrix***



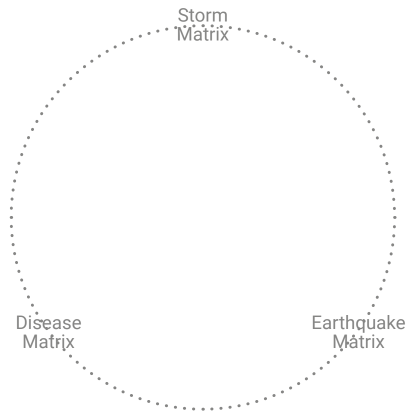
HAZARD MATRIX

Technological *Solutions*

Flood Proofing *(Resilient Solutions)*

Materials Compatibility

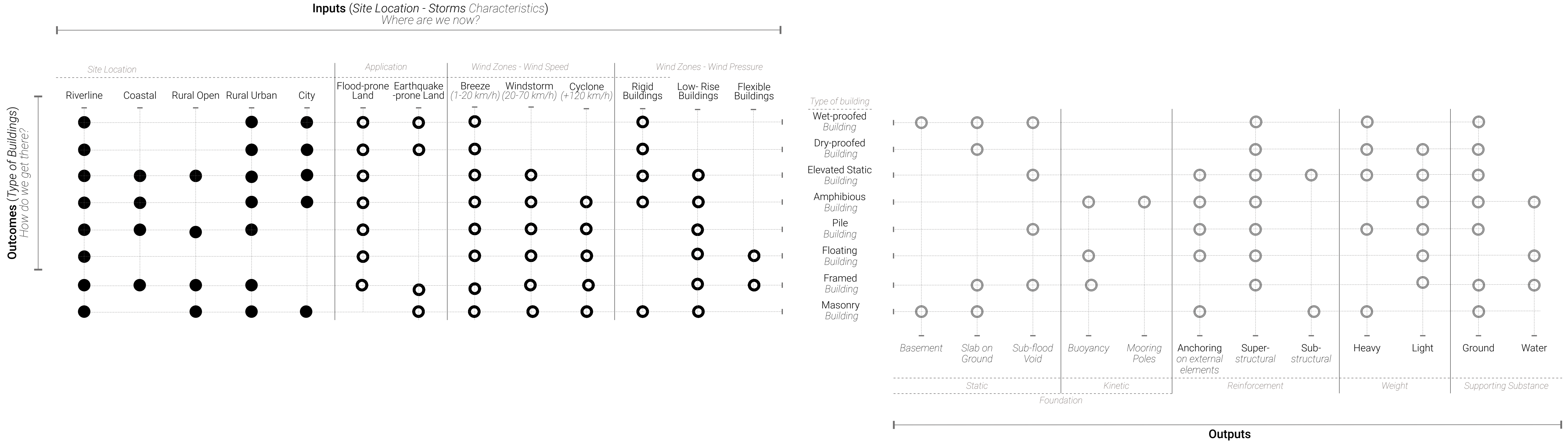
The other MATRICES



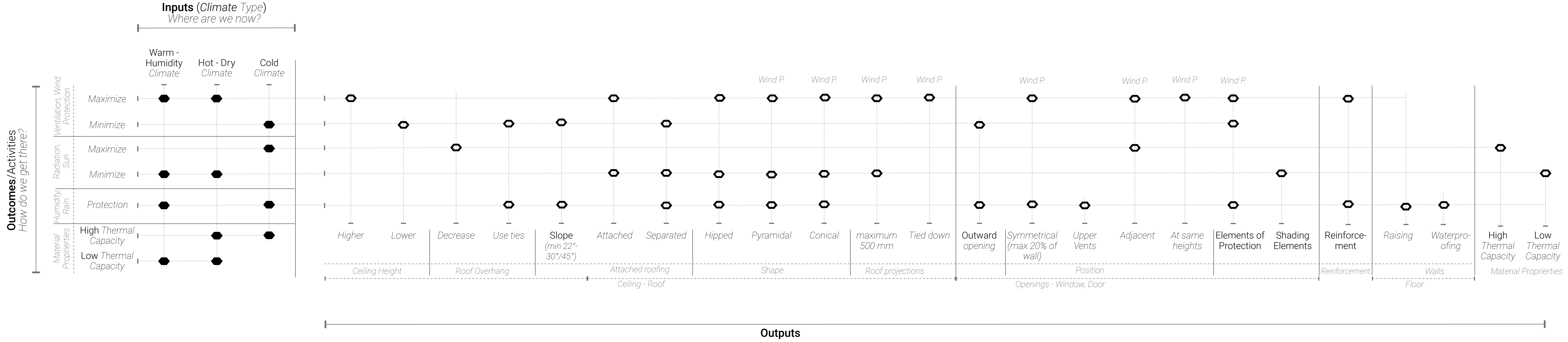
HAZARD MATRIX

Storm *Matrix*

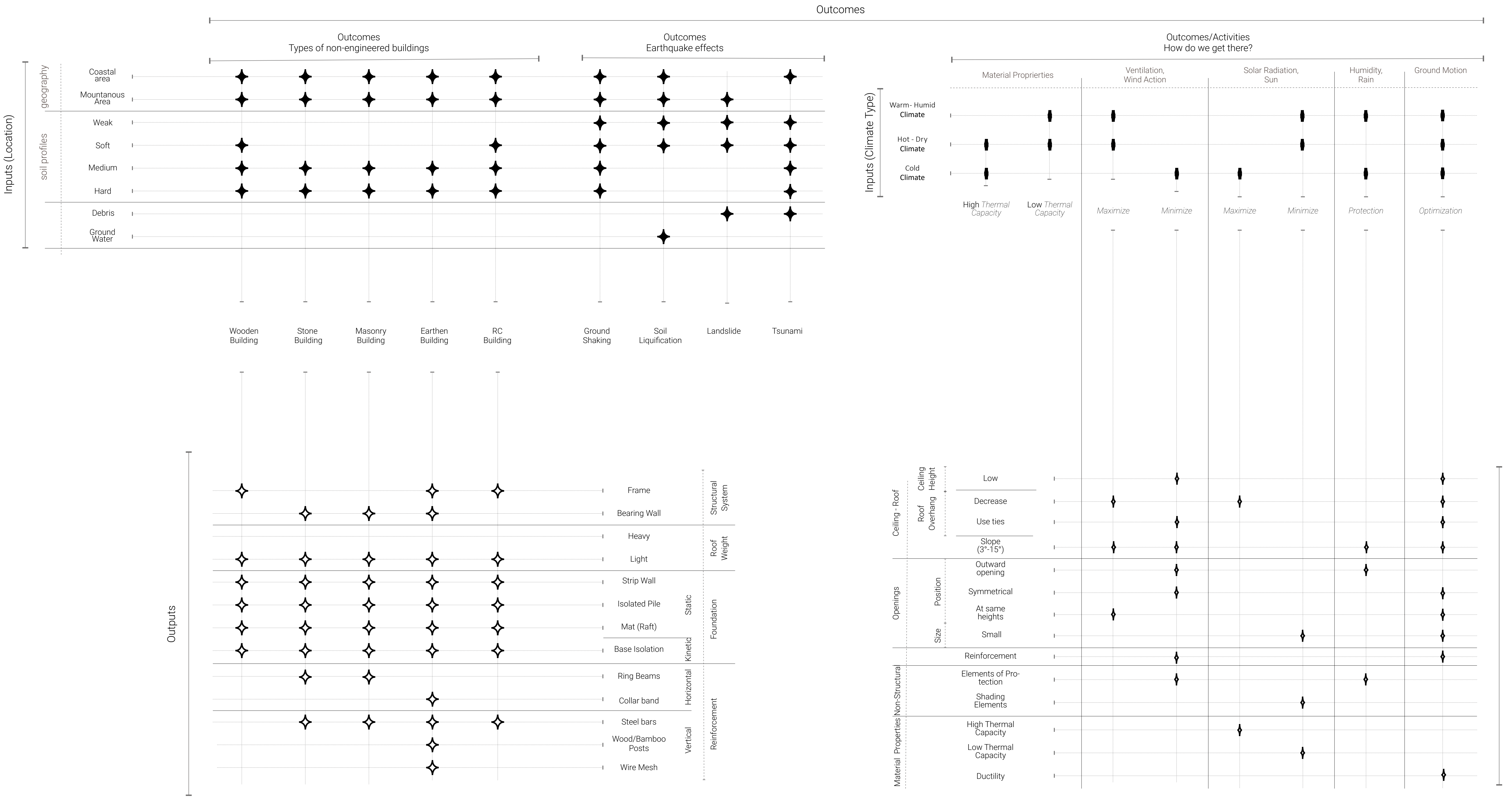
Storm - *Resilient Solutions*



Technological *Solutions*



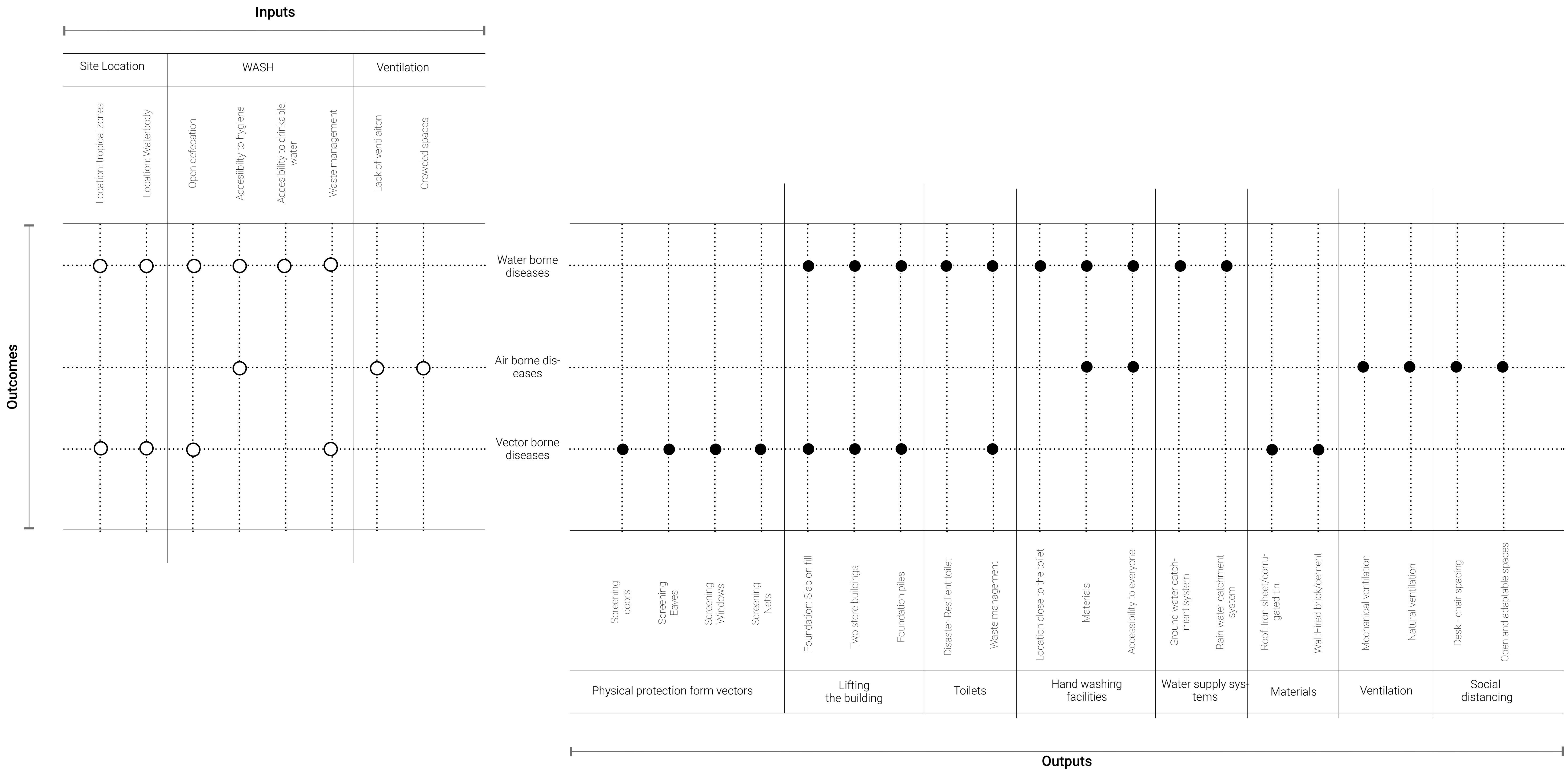
Earthquake *Matrix*



Earthquake - *Resilient Solutions*

Technological *Solutions*

Disease *Matrix*



HAZARD MATRIX

SOLUTIONS COMPARED
Method

2.3.2. *Method 2* - Solutions Compared

(Community Not Involved)

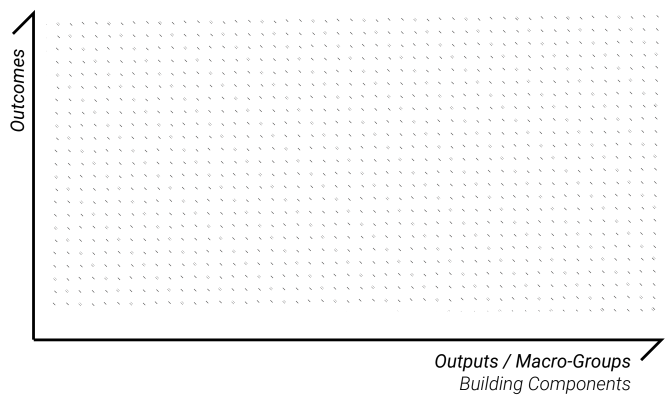
Description

The methodology that will be described below has the purpose of comparing the different solutions of the individual ***Hazards Matrices*** previously identified and classified by priority through the Ranking Method, therefore only in the case in which the studied and analyzed site is affected by more Hazards, excluding hence the Education matrix from this methodology.

For the graphic development we only use the ***OUTcome*** and the ***OUTputs*** (of each hazard-matrix developed),the latter divided into ***architectural elements*** (***macro-groups***, in turn divided into ***groups*** of ***architectural characteristics***) equally present in each Hazard Matrix. The final purpose is, therefore, to obtain a first list of compared solutions (***1st List of possible solutions***), 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 event this will be involved.

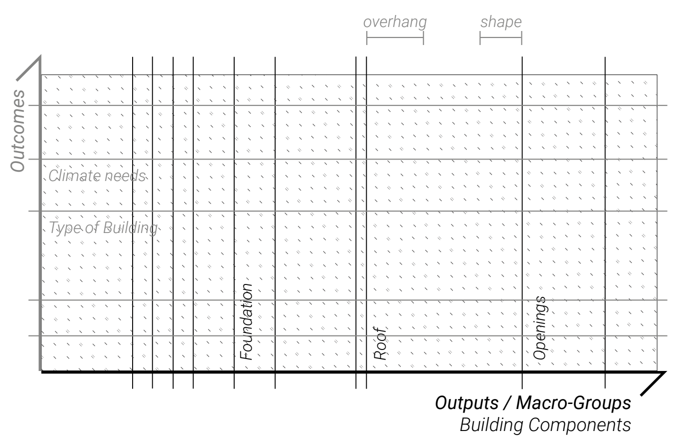
Graphic translation

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 analyses posed previously. To carry out this methodology, each hazards matrices is inserted in a 2d plan, defined by 2 axes (outcomes and outputs) on which there are all the items contained in each hazards matrices.



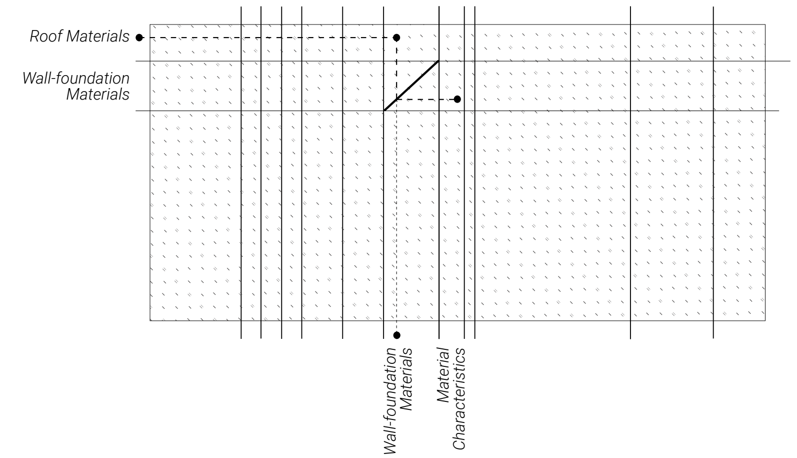
_The axis

*The plan is defined by the two axes corresponding to **Outcomes** and **Outputs** of each developed hazard matrix;*



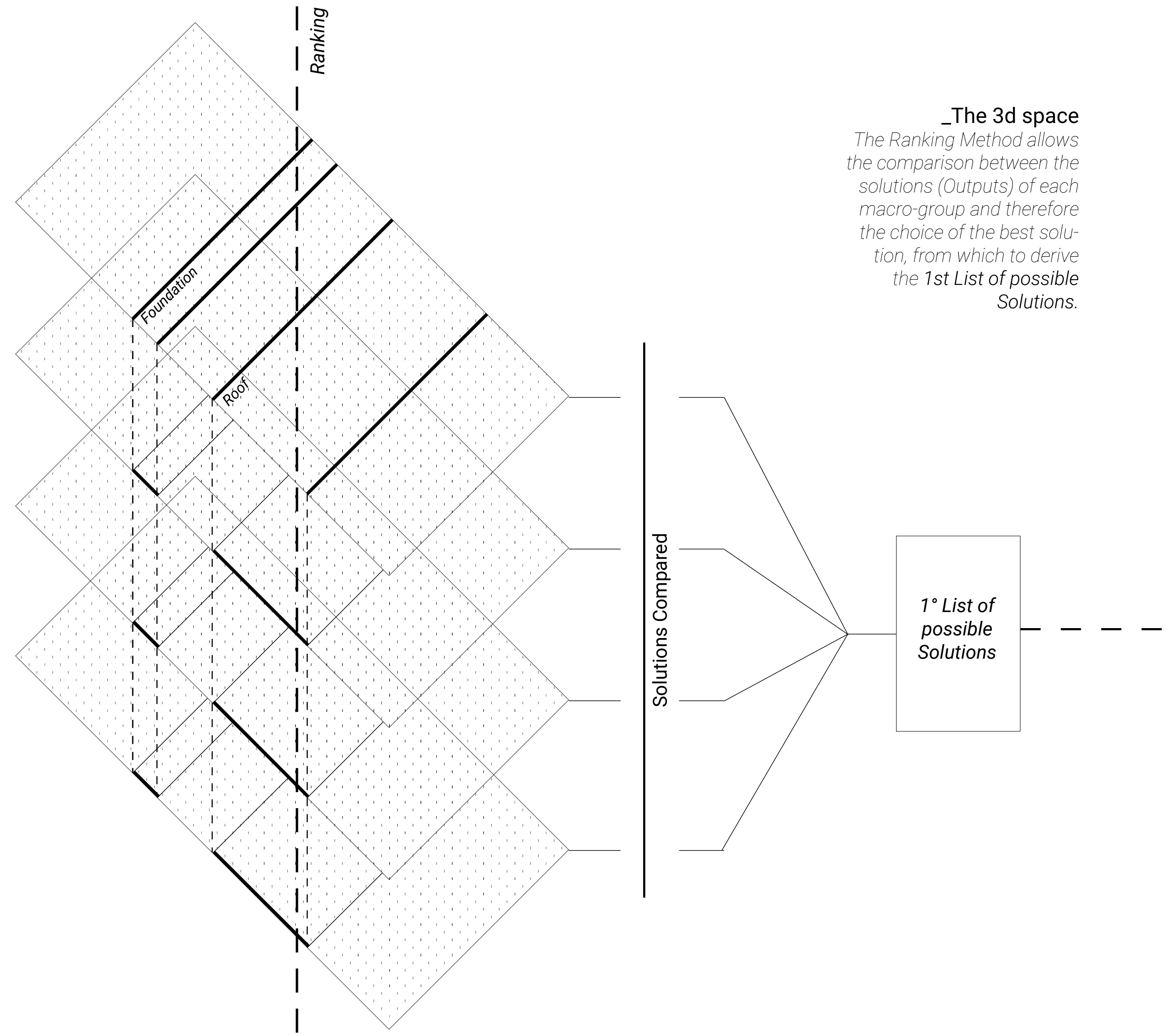
_The 2d space division

*Each matrix is divided into **macro-groups** of architectural elements and in turn the macro-groups are divided into groups **of architectural features** to facilitate overlapping. The **Outputs** axis is divided into 14 macro-groups of features or architectural elements that can be adopted as a possible solution; while the Outcomes axis is divided into 6 groups of needs or actions.*



_The diagonal material line

*The line identifies the compatibility between the combination with **Roof Materials and wall-foundation materials.** The second objective is to redirect the search for material compatibility with the **characteristics of the materials.***



_The 3d 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 List of possible Solutions.***

Legend *(Outcomes - Outputs)*

Outcomes (simbols)

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

Earthquake 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] Fired Brick
- [23] Concrete/ Concrete Brick
- [24] Mud Brick
- [25] Adobe Brick
- [26] Wood and Mud

Roof Materials
- [27] Steel (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 catchment System*
- (9) *Rain Water catchment system*

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

Weight
- (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) *Buoyancy*

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 Weight
- (44) *Light*
- (45) *Heavy*

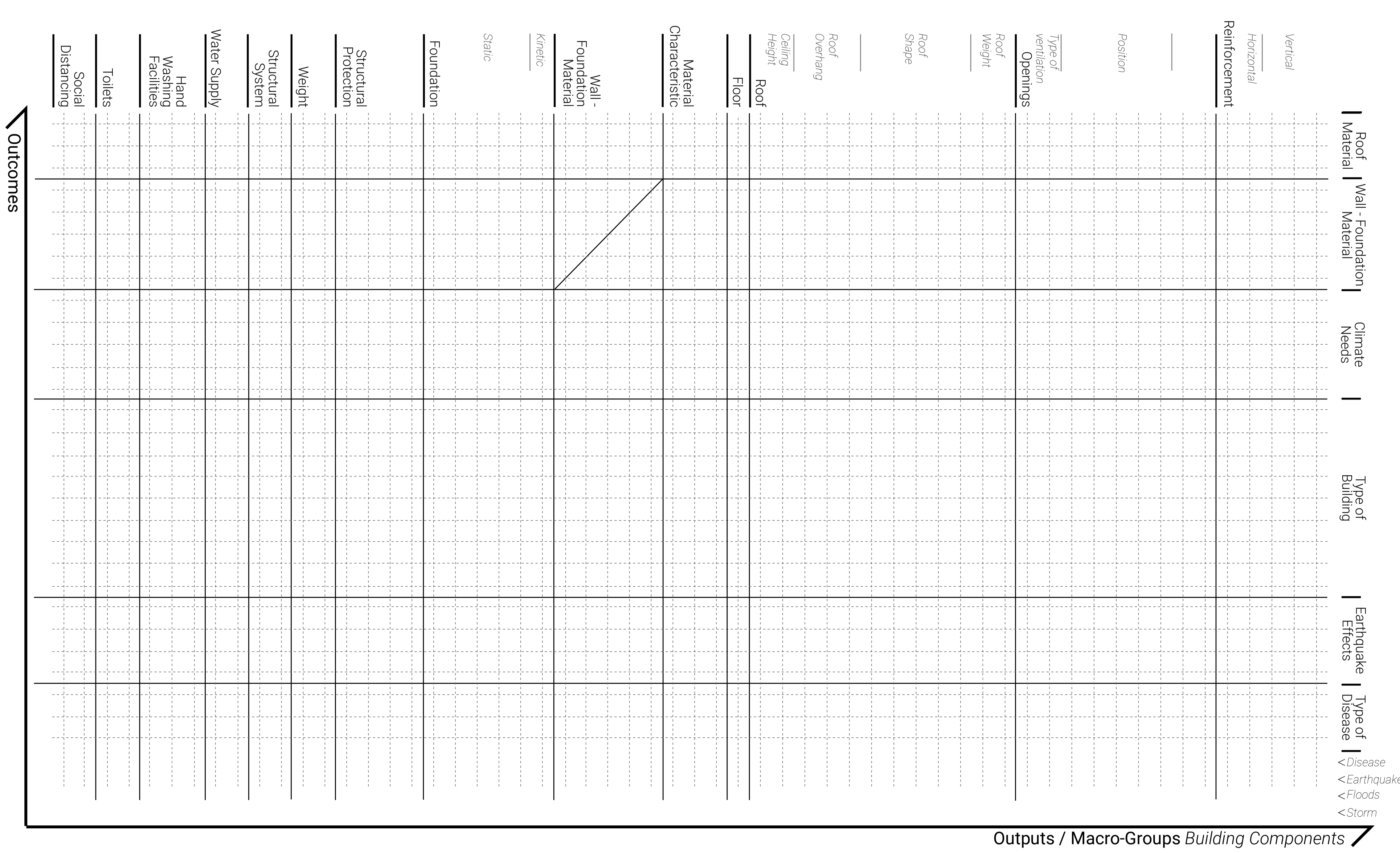
Openings
Type of ventilation
- (46) *Mechanical ventilation*
- (47) *Natural Ven-tilation*

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*

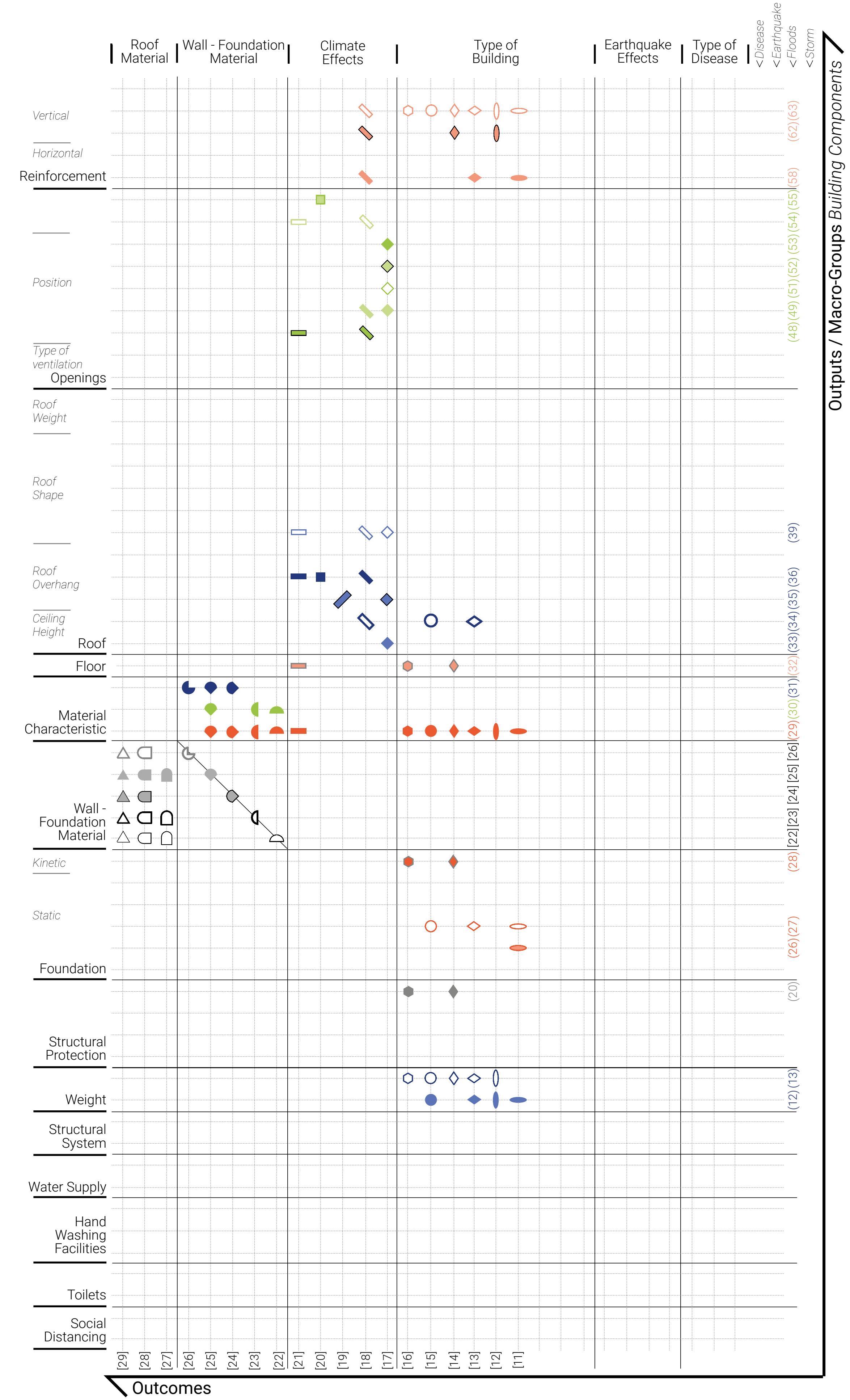
Reinforcement
Horizontal
- (56) *Ring beams*
- (57) *Collar bands*
- (58) *Mooring system*

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

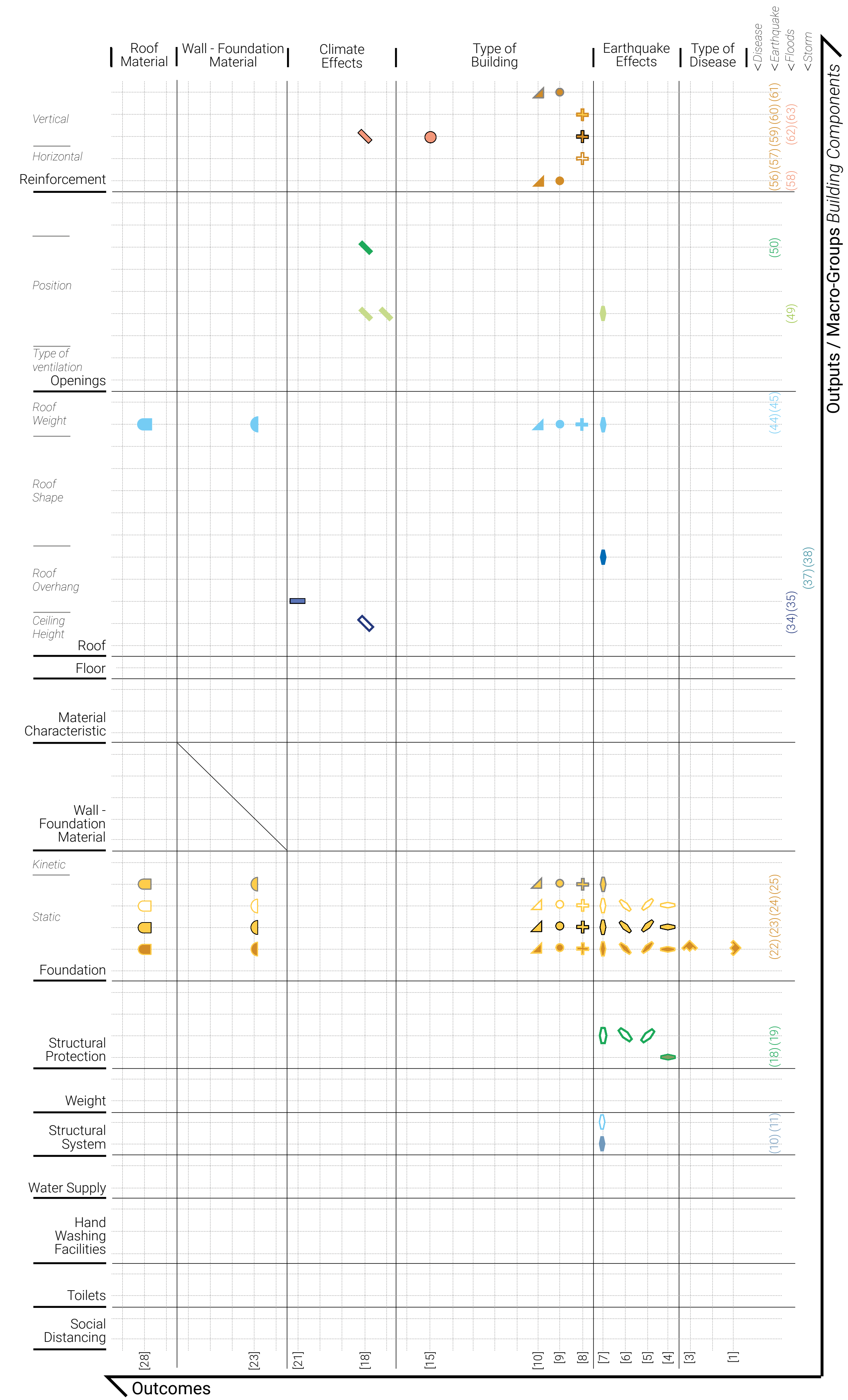
Axis and 2d Space



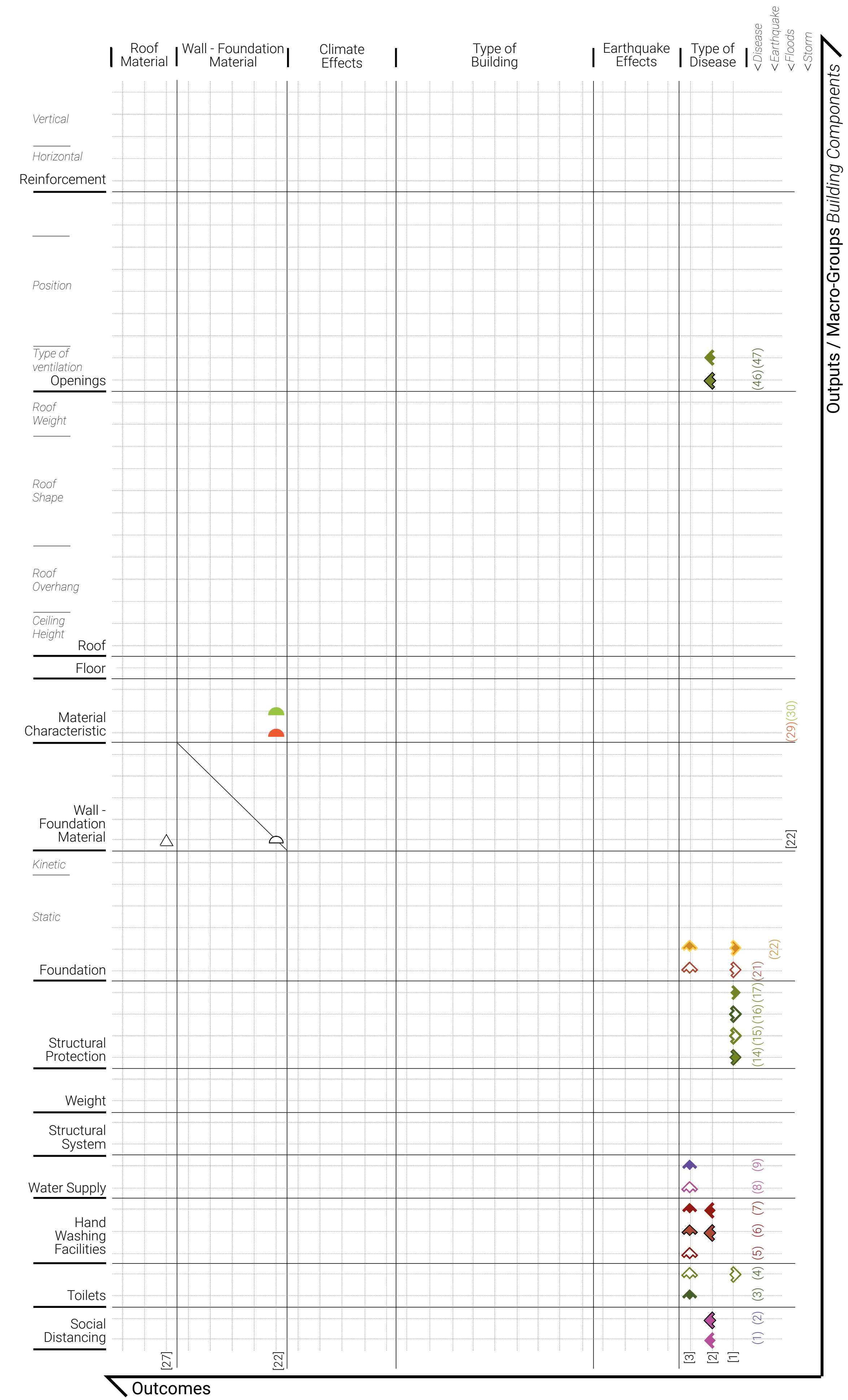
2d space: Flood



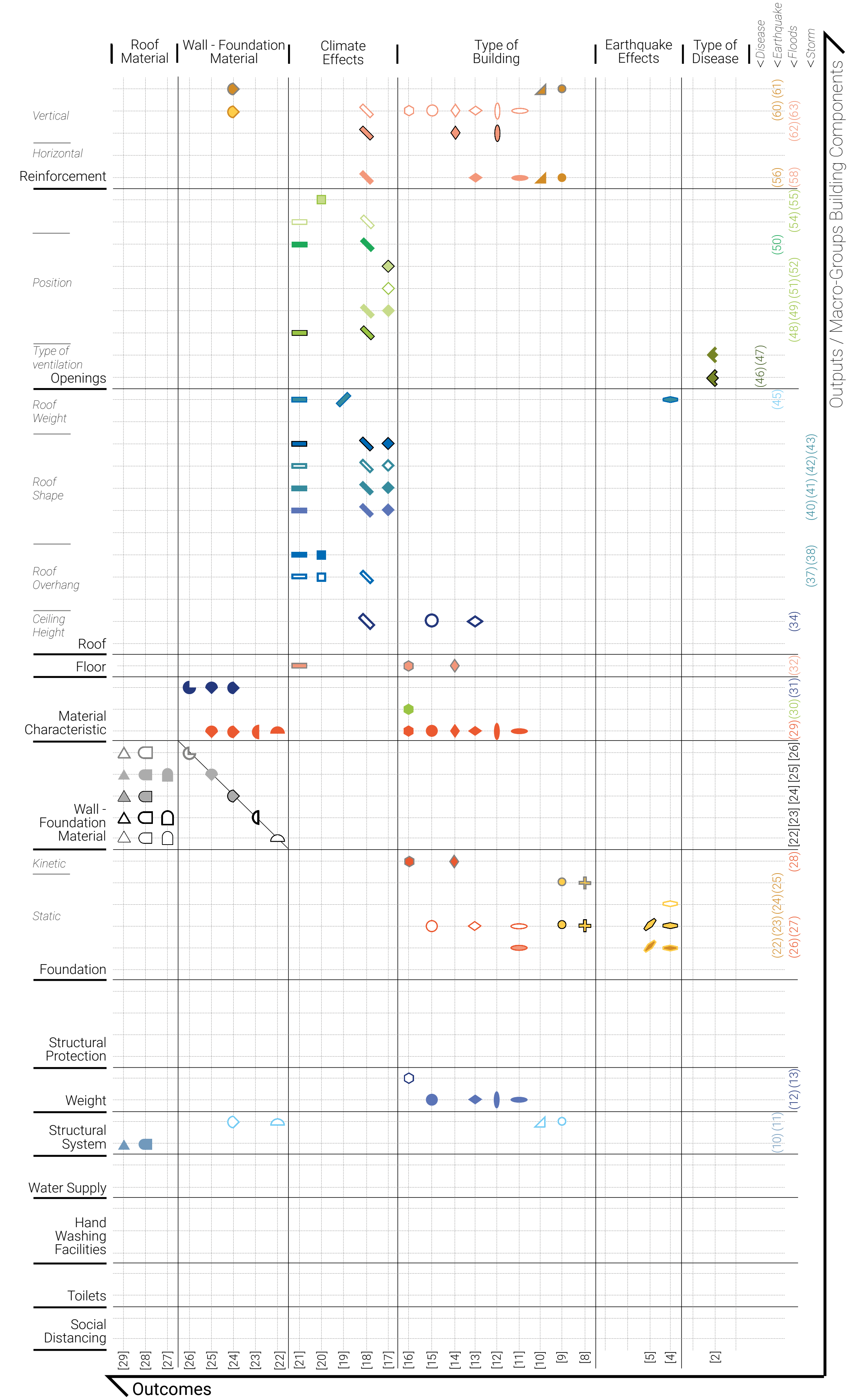
2d space: Earthquake



2d space: Disease



2d space: Storm

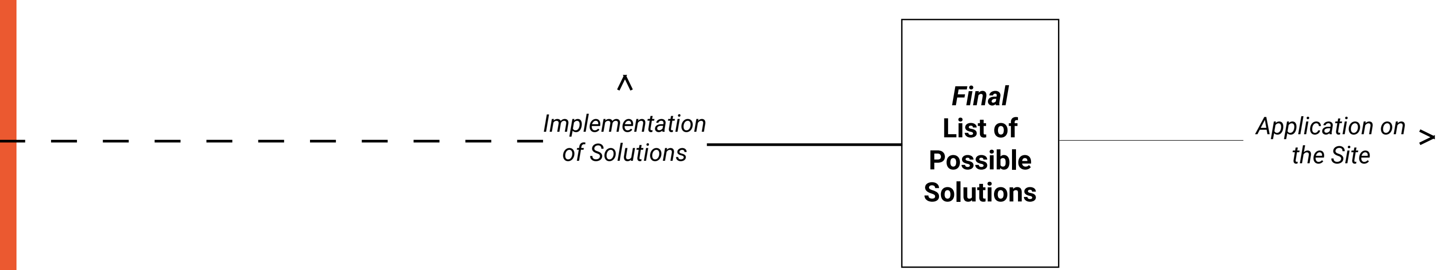


Implementation of the Solutions

(Community Involved)

The next step of the process consists in evaluating in detail how realistic each solution obtained from the ***Solutions Compared Method*** 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 List of Possible Solutions.***

> 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?



2.3.3. Ensure that the project will be done

(Community Involved)

Determine the realistic solutions, the community 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.

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

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

< (Table 10) Developed by the IFRCI, *How to do a VCA, A practical step-by-step guide for Red Cross Red Crescent staff and volunteers*, pag.71 13 and reformulated by the author of the thesis.

> 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?

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.

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

< (Table 11) Developed by the 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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GLOSSARY
Matrices: Education - Floods

INPUTS

OUTCOMES

OUTPUTS

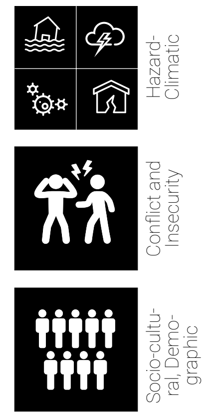
Inputs · Education Matrix

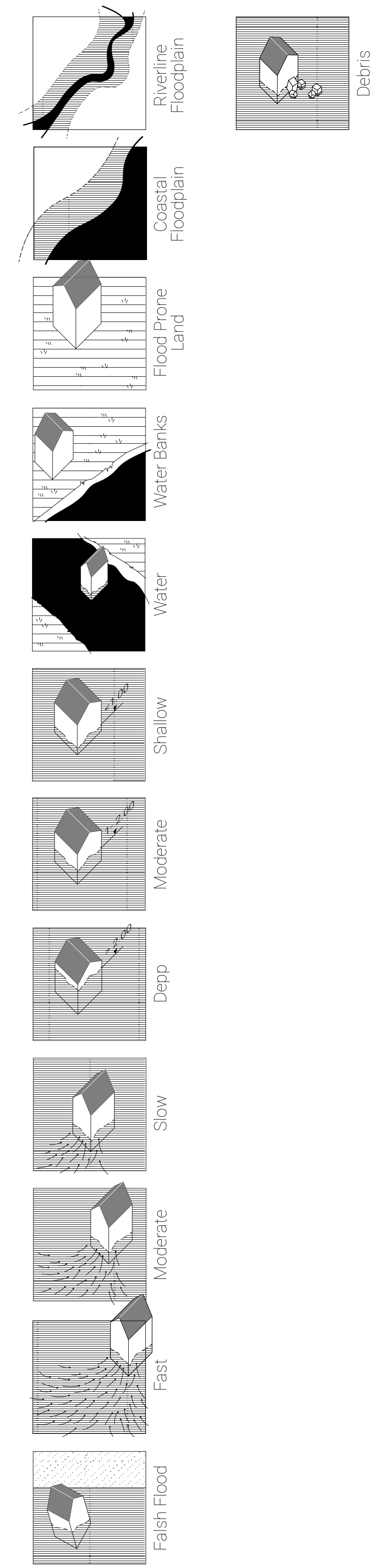
The impacts on education systems can be multiple, so it is important to identify the risks and understand how they can affect education systems. Disasters and conflicts have similar impacts on the education system, destroying or damaging infrastructure and threatening, in the long term, the physical and psychological insecurity of students and educational staff **1**.

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 drop-outs.

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. **2**





Inputs · Floods Matrix

Location and Flood Characteristics

Site Location
The floodplain defines a low-relief, dynamic landscape adjacent to rivers or coasts (marine or oceanic) that is frequently flooded when the water level of the main river or, of bodies of water in general, exceeds the height of the shore **3**. So it is the area where the water extends during periods of floods, tides or disastrous events such as storms. Two main processes involved in the development of floodplains are erosion and sedimentation. We define two alluvial areas:

- *Riverline floodplain*: defines the alluvial air adjacent to rivers. The floodplains have a high percentage of biodiversity, compared to the rivers themselves, this especially favours the growth of agricultural activities. It is important to emphasize that waterways need space to adapt to their loads and to enter into equilibrium so that they can flow into the floodplains when necessary and moderate their erosive power.
- *Coastal floodplain*: in coastal areas, apart from major storm events in which waves can invade large areas, the flood follows a largely predictable tidal cycle. The quality of the water in these areas is affected by changes in sediments, salinity, nutrients, oxygen, temperature and the addition of various pollutants that can make the materials and the building in general vulnerable. Furthermore, the violence of the sea or ocean can drag the building away.

Application Place
- *Flood prone land*: defines an area potentially subject to flooding, which is flooded once every 100 years (1% probability of flooding) **4**. It is a relatively flat or low area subject to partial or complete flooding; or it can be defined as any area subject to the unusual and rapid accumulation or runoff of surface water from any source (streams, rain, streams, etc.).
- *Water Banks*: defines the application in the land area along a mirror or stream. This area is often subject to erosion due to variations in the speed and depth of the water **5**.
- *Water*: defines the application within a water basin. The application can take place in or on the water.

Flood Depth
- *Shallow*: Defines the lowest flood depth, which is less than 1 metre.**6**
- *Moderate*: defines the average depth of flooding, namely between 1 meter and 2 meters. This depth can cause severe damage to the structure. The Wet-proofed and Dry-proofed Building are not suitable for moderate and high depths, as the pressure of the water below the building can cause the floor to break. **6**
- *Deep*: defines a high flood depth, that is greater than 2 meters. To prevent this type of flood it is right to provide architectural solutions that manage to maintain this flood depth. **6**

Flood Velocity
- *Slow*: Defines the lowest flood rate, which is less than 1 metre per second **7**.
- *Moderate*: defines the average flood rate, that is between 1 and 2 meters per second **7**. This depth can cause severe damage to the structure. The hydrostatic force directed on the building and the scour due to the velocity can cause damage to the building **8**.
- *Fast*: defines a high flood rate, that is greater than 2 meters per second. Too high speeds can drag buildings away, especially if there is no anchoring system to external elements **8**.

Flash Flood
They are floods triggered by torrential rains that fall over a short period of time or they can be caused by a landslide, a block of ice or a sudden release of water from slopes that are no longer able to absorb water (slopes with recent fires forests are a known source of rain floods)**9**. These can occur in any urban area, even in elevated areas that lie above coastal and river floodplains. Flash floods depend on the intensity and duration of the precipitation, the surface conditions and therefore the slope of the basin and topography. Flash floods are very dangerous and destructive and are directly linked to the speed characteristics of a flood and the transport of debris that are often swept away by the flow **10**.

Debris
Flood water can carry debris at high speeds which can cause serious damage due to collision to both buildings and people. Flood water could leave a deposit of debris and sediment often including contaminants, which increases the risk of damage to the structure **8**. It is good that the building has protection requirements, such as walls or external fencing element.

Outcomes · *Education Matrix*

Climate type

Warm-Humidity climate

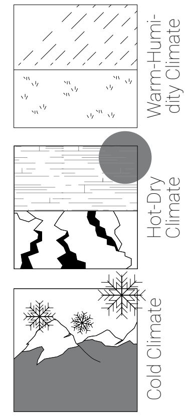
Knowed too as "Humidity Subtropical Climate". These climates are normally found on the southeast side of all continents. It is characterized by high temperatures and rainfall distributed throughout the year. During the summer, the regions that have this climate are under the influence of the flow of 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. **11**

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 **12** . The regions are very dry as rainfall is very scarce and moisture evaporates quickly from the air **13**. 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 **14**. This type of climate is found in Europe, East Asia and North America.



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. **1**

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.**1**

Educational Program

To ensure school attendance in the event of natural or man-made hazards, it is necessary to identify the educational programme 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 infrastructure 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.

Outcomes · *Floods Matrix*

Building type

Wet-proofed Building
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 not suitable for sites undergoing a rapid increase in flood water and at high speeds **15**.

Dry-proofed Building
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 the impact of debris. In addition, it is important to consider a good closing of doors and windows to not allow infiltration of water inside **15**.

Elevated Static Building
The building is elevated on dry land, away from potential flood areas, supported by a sufficiently high perforated structure to allow water to flow below it without causing any damage to the building **16**. Usually rises from two to three meters from the ground. **17**

Amphibious Building
Buildings located on the mainland, but able to float at a sudden increase in water, thanks to its low weight and the presence of floats that allow it to return to earth when the water retreats. To allow only vertical movements, the structure is hooked to mooring elements **16**. In addition, this type requires protection fences, outside the building, to avoid compromising the structure due to the accumulation of possible debris carried by water.

Pile Building
Building located totally or partially inside shallow waters (coastal areas, lakes, etc.) where it is possible to predict water levels. This structure typically rises from two to four meters above the water supported by a perforated structure.**17**

Floating Building
Floating building located entirely in a reservoir. It 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.) **16**.

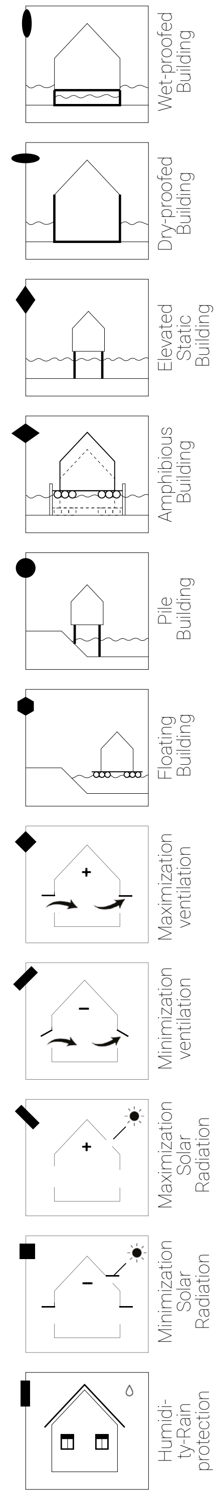
Climate Needs

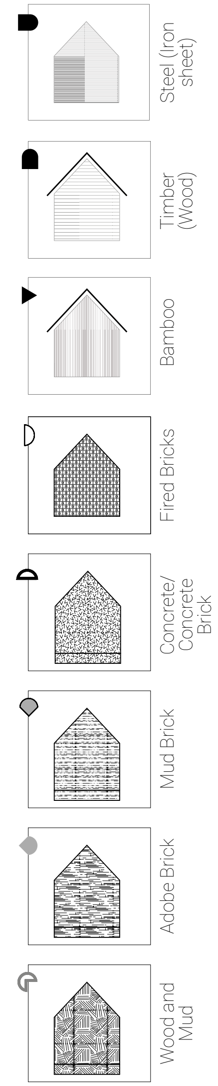
Material Properties
It is important to consider materials with different properties depending on climatic conditions. They can be materials with ***high thermal capacity*** (for example compact brick materials, such as stones or concrete) suitable for hot or cold climates, as they are able to slow the flow inwards and / or store heat; or 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 mould or disease, especially in warm-humidity 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 inside the building, therefore they do not need solar radiation protection systems. In addition, even warm-humidity climates may require solar radiation to be maximized.
- *Minimization*: Minimising 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.

Materials Compatibility

In order not to compromise the overall performance of the structure, it is important to consider the material compatibility of the building components, such as: roof, foundations and walls. Similarly, to maintain a good compatibility, it is necessary to consider the individual connecting elements, which can interfere with the resilience of the building **17**.

- *Roofs* made of *bamboo, timber or steel* are compatible with *walls* such as: *fired brick, concrete brick or adobe brick*;
- *Roof* made of *bamboo or timber* are compatible with *walls* such as: *fired brick, concrete brick, adobe brick, mud brick or wood and mud*.

Compatibility between *walls and foundations*:

- *Walls* made of *fired brick or concrete brick* are compatible with *foundations* in: *fired brick or concrete brick*;
- *Walls* made of *fired brick, adobe brick or mud brick* are compatible with *foundations* made of: *adobe brick or mud brick*;
- *Walls* made of *wood and mud* are compatible with *foundations* in *wood*.

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 Matrices:* 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 well-being 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 centres 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.

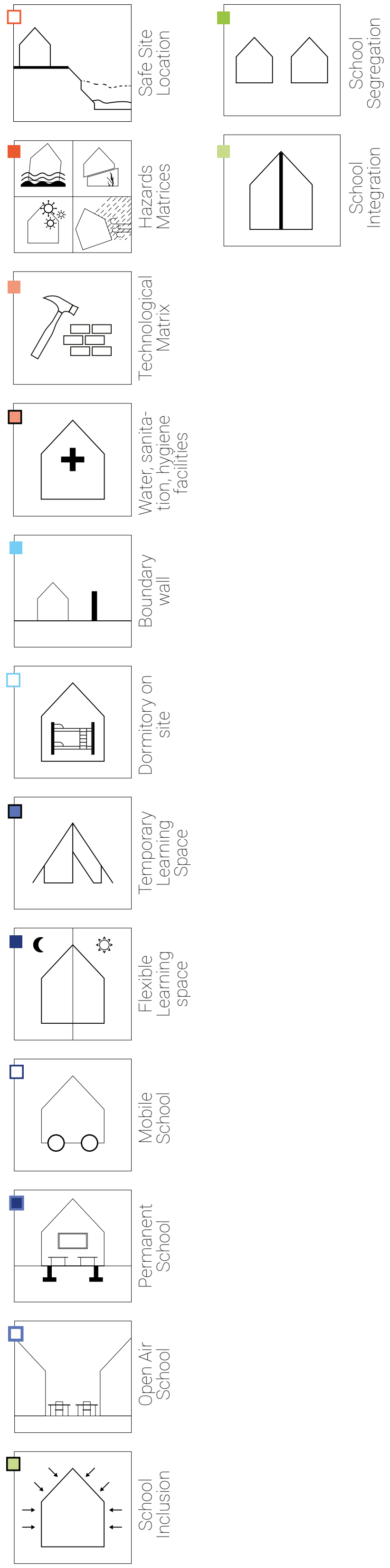
- *Permanent school:* unlike the movable one, they are often formal infrastructures; therefore, financed and built by the state or region with conventional materials and construction techniques and possibly resistant and resilient to possible natural disasters, so that the infrastructure remains for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

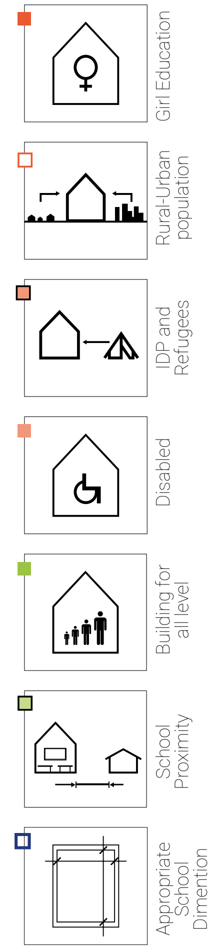
- *Open Air school:* defines a school environment in which lessons take place in the open, in the event that, as for the temporary ones, there is no possibility of accessing educational facilities, due to natural disasters or conflicts. In addition, open-air education can also be part of the school program,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

- *School Inclusion:* indicates the act of including the social whole within the school group without having to resort to separations by gender, origin, religion etc...

- *School Segregation:* unlike inclusion, school segregation indicates the exclusion of social minorities, such as race, gender, age, origin, etc. ... this does not provide for the removal of these groups from education but the division into separate buildings of the two social groups. Segregation occurs mainly in those sites where social conflicts are very relevant.

- *School Integration:* indicates the process that allows social minorities to be included within a larger group. This school typology provides for the integration of social minorities within the same structure but in different classes, as can be the separation by gender, age, religion, language, etc.





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:
- Girl;
- Urban-rural population affected by crisis;
- Internal Displaced People and refugees;
- Disabled.

- *Building for all level:* 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.

Outputs · *Floods Matrix*

Structural Protection

- *Fences:* are external elements of protection of buildings to prevent debris carried by water from reaching the structure causing possible damage. These elements are especially essential for buildings that have flotation systems, with Amphibious buildings, to prevent the accumulation of debris below them.

Weight

The weight of the building affects the required performance, so you need the right weight required for each building:

- *Heavy building*: that is, buildings made with heavy and stable materials that do not allow the building to rise and float in the event of a strong flood;
- *Light building:* buildings made of lightweight materials that allow lifting and floating in the event of a flood.

Foundation

The foundations are essential in the design of the building, as they ensure the stability and resilience of the building during a flood. 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 Foundation:

- *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.

Kinetic Foundation:

- *Buoyancy*: in the event of a flood, thanks to the floats located below the building, it 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.

Material Characteristics

- *Water resistance:* it is necessary to provide systems or techniques for waterproofing the foundations as they could be easily attacked by moisture or flood water.
- *Carbon footprint*: often, for the construction of buildings there is an uncontrolled use of natural materials due to insufficient economic availability for the purchase of conventional materials or their transport, implying a high environmental footprint. Therefore it is necessary to establish which materials, both during picking and during production, can have a greater or lesser impact on the environment and people.
- *Maintenance* Materials that do not have good water resistance performance, such as plant materials, or poor resistance to attack by insects or moulds require high maintenance and therefore a high expenditure of economic resources in the medium to long term.

In general, we can define the different characteristics and performance of water resistance for different materials:
- *Burt brick e concrete brick/concrete*: they have good performance in terms of water and structural resistance and do not require high maintenance. However, they have a high cost and carbon footprint;
- *Mud brick e adobe brick*: they have lower performances in terms of structural resistance and maintenance, even if they have a lower carbon footprint and cost;
- *Wood and mud*: it has poor structural, maintenance and durability performance (easily attacked by insects and moulds. However, it has very low costs.

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 buildings.

Ceiling-Roof 18

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.

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 that could damage the roof structure by lifting it; or it should be reduced to allow solar radiation to enter the structure.
- *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 therefore 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 °.

Openings - Window, Door

- *Outward Opening:* the opening of the windows must be external to prevent the entry of wind and flood water due to their strong pressure.
- *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. 18
- *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.

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.
- *Upper*: the openings at the top help to maximize ventilation by creating the chimney effect.
- *Adjacent*: allow cross ventilation inside the building.
- *At different heights*: as for the adjacent openings, the position of the openings at different heights also allows cross ventilation, maximizing ventilation.

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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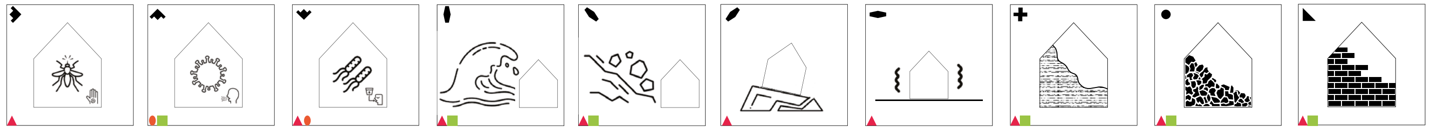
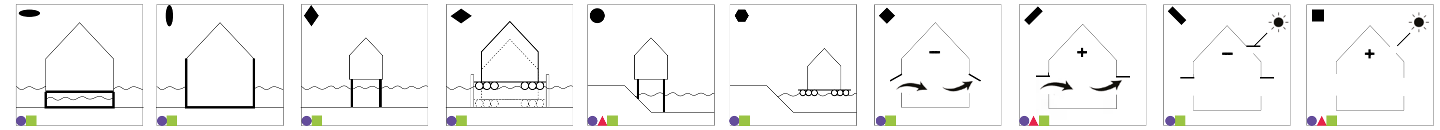
OUTCOMES - Hazards

Type of Disease · Earthquake Effect · Type of Building



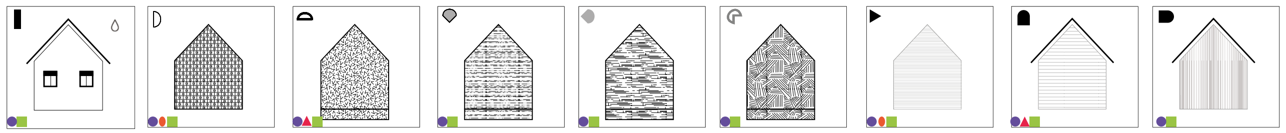
- [1] Vector Borne Disease
- [2] Air Borne
- [3] Water Borne
- [4] Tsunami
- [5] Landsline
- [6] Soil liquidification
- [7] Ground motion
- [8] Earthen Building
- [9] Stone Building
- [10] Masonry Building

Ventilation, Wind · Solar Radiation, Sun



- [11] Wet-proofed Building
- [12] Dry-proofed Building
- [13] Elevated Static Building
- [14] Amphibious Building
- [15] Pile Building
- [16] Floating Building
- [17] Maximize Ventilation
- [18] Minimize Ventilation
- [19] Maximize Solar Radiation
- [20] Minimize Solar Radiation

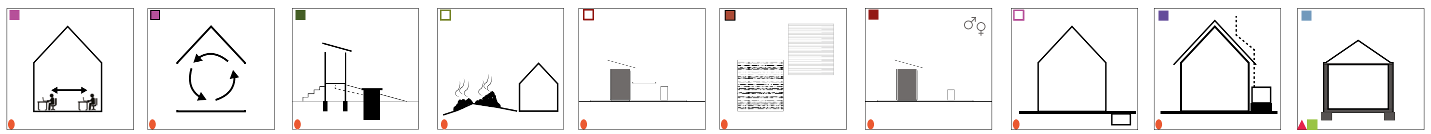
Humidity, Rain · Foundation/Wall Materials · Roof Materials



- [21] Protection
- [22] Fired Brick
- [23] Concrete/ Concrete Brick
- [24] Mud Brick
- [25] Adobe Brick
- [26] Wood and Mud
- [27] Steel (iron sheet)
- [28] Timber (Wood)
- [29] Bamboo

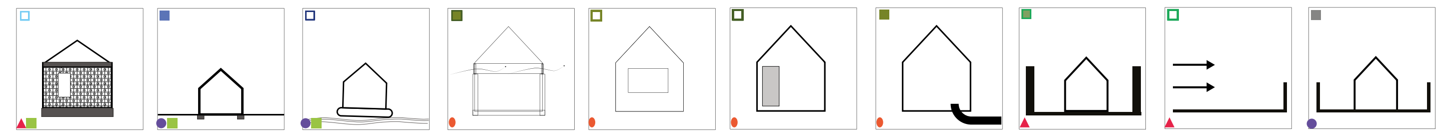
OUTPUTS - Hazards

Social Distancing · Toilet · Hand Washin Facilities · Water Supply · Structural



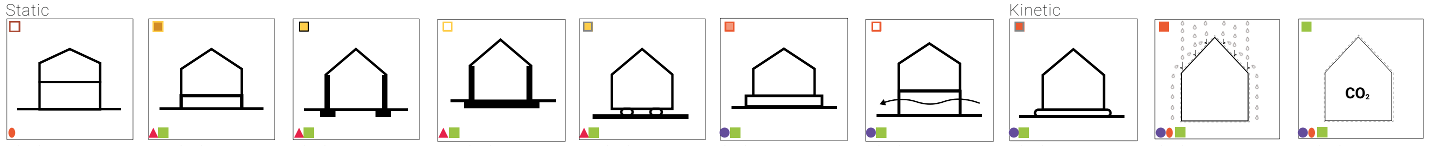
- (1) Desk-Chair spacing
- (2) Open and adapted space
- (3) Disaster-resilient toilet
- (4) Waste Management
- (5) Location close to the Toilet
- (6) Materials
- (7) Accessibility to everyone
- (8) Ground catchment System
- (9) Rain Water catchment system
- (10) Frame

System · Weight · Structural Protection



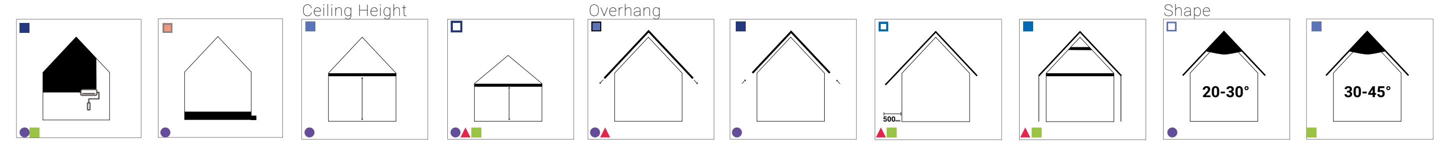
- (11) Bearing wall
- (12) Heavy
- (13) Ligth
- (14) Screening Doors
- (15) Screening eaves
- (16) Screening Window
- (17) Screening Nets
- (18) Boundary wall
- (19) Set-back
- (20) Fences

Foundation – Static · Kinetic · Material Characteristics



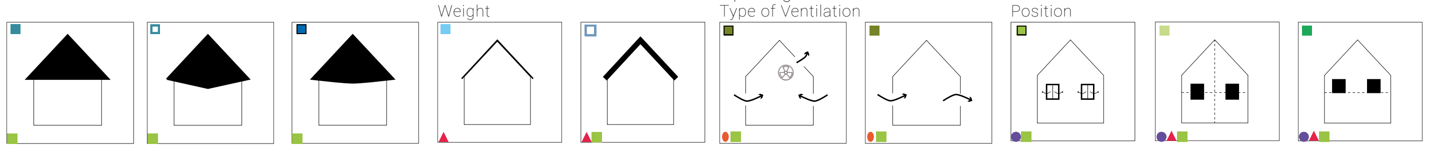
- (21) Two store building
- (22) Pile Foundation
- (23) Strip wall
- (24) Mat
- (25) Base Isolation
- (26) Basement (h>1m)
- (27) Sub-floor void (h:>1m)
- (28) Buoyancy
- (29) Water-resistance
- (30) Carbon Footprint

Floor · Roof – Ceiling Height · Overhang · Shape



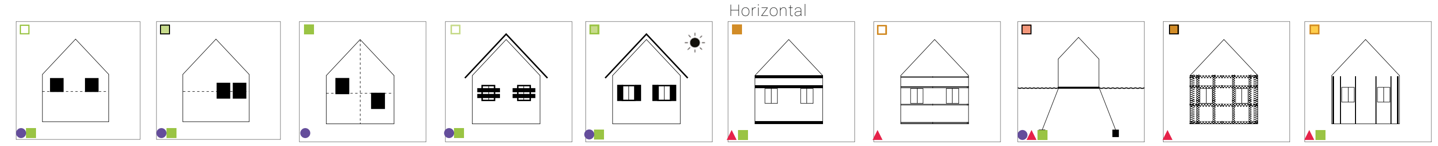
- (31) Maintenance
- (32) Raising
- (33) Higher
- (34) Lower
- (35) Decrease
- (36) Increase
- (37) max 500 mm
- (38) Use ties
- (39) Slope (min 20°-30°)
- (40) Slope (min 22-30°/45°)

Weight · Openings – Type of Ventilation · Position



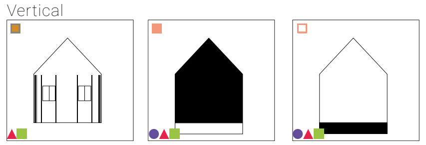
- (41) Hipped
- (42) Pyramidal
- (43) Conical
- (44) Light
- (45) Heavy
- (46) Mechanical ventilation
- (47) Natural ventilation
- (48) Outward opening
- (49) Symmetrical
- (50) At same heights

Reinforcement – Horizontal



- (51) Upper
- (52) Adjacent
- (53) At different heights
- (54) Element of protection
- (55) Shading Elements
- (56) Ring Beams
- (57) Collar bands
- (58) Mooring system
- (59) wire mesh
- (60) Wood post

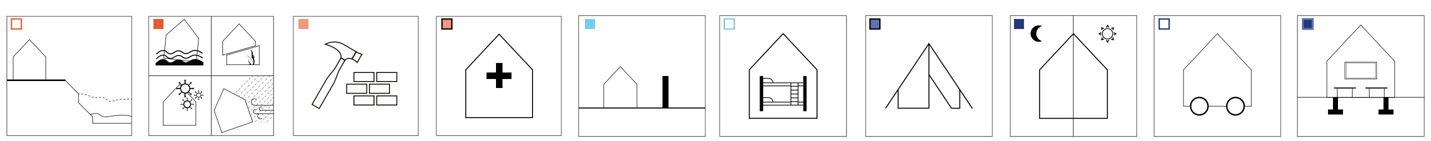
Vertical



- (61) Steel bar
- (62) Super-structure
- (63) Sub-structure

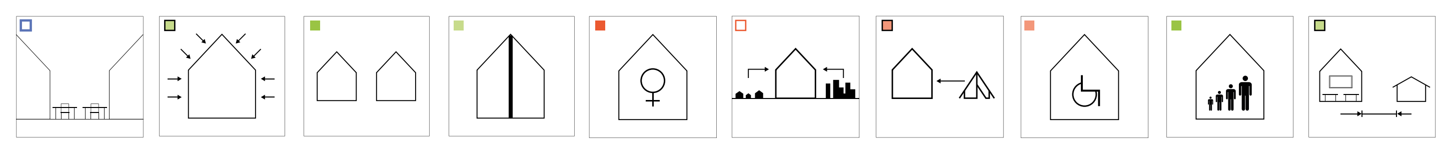
OUTPUTS - Education Matrix

Quality in Education

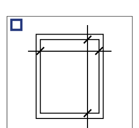


- (1) Safe Site Location
- (2) Hazards Matrix
- (3) Technological Matrix
- (4) Water, Sanitation, Hygiene Facilities
- (5) Boundary Wall
- (6) Dormitory on site
- (7) Temporary Learning Space
- (8) Flexible Learning Environment
- (9) Mobile School
- (10) Permanent School

Access and Equity in Education



- (11) Open Air School
- (12) School Inclusion
- (13) Scool Segregation
- (14) School Integration
- (15) Providing Girl Education
- (16) Education for Rural-Urban
- (17) Education for IDP and Refugees
- (18) Education for Disabled
- (19) Built for all Level
- (20) School Proximity



- (21) Appropriate School Dimension

Flood · Storm · Earthquake · Disease

III.

Mozambique: A Fragile Land

III.I Ranking the Regions Risks

This chapter is aimed at the general observation of Mozambique regarding the problems related to climatic and man-made events; socio-economic vulnerabilities and the most vulnerable groups, services and resources and; the lack of capacity in dealing with the various problems present within the country, both in terms of infrastructure and institutional. The study of these categories applied to Mozambique will support the identification of the region most at risk to which to apply the design process.

Overview

Mozambique is a state in Africa located on the south-eastern coast, bordering Tanzania, Malawi, Zambia, Zimbabwe, South Africa, Eswatini and the Indian Ocean, covering a length of the coast of approximately 2700 km. It covers an area of 799,380 km², administratively divided into 10 provinces: Cape Delgrade, Nampula, Niassa, Zambeze, Tete, Sofala, Manica, Inhambane, Gaza and the province of Maputo, with Niassa the largest region of all 1.
The Mozambican territory has a total of about 104 hydrographic basins, among these the Zambeze river divides the country into two different topographical regions: to the north, a narrow coastal strip followed by hills and plateaus; to the south, plains and highlands located in the far South 2. Mozambique is heavily dependent on these water resources, but the lack of flood control infrastructure causes high water flow which can lead to hydrological shocks such as floods or drought 1. The speed of the floods is accentuated by the difference in height from the interior of the country towards the coast, causing sudden floods. Compounding this situation are the variable patterns of torrential tropical rains that hit the whole country several times in the same year.
Furthermore, it is also a state rich in natural resources such as arable fields, energy, mineral resources, gas which, thanks also to its strategic position, make it an economic engine on which neighbouring states depend 3. Despite this, around 48% of the population lives below the poverty line 4. Mozambique is third among the African countries most exposed to meteorological risks. Poverty limits the ability of families to prepare for, respond to and recover from natural disasters, and other factors, such as lack of clean water during periods of floods and droughts, contribute to these difficulties.

(1) Maria R. L. Moitinho de Almeida, *Emergency and Disaster Reports*, 2018, pp. 2-24.

(2) *Perfil do Setor de Habitação Moçambique* 2018 - UN- Habitat Moçambique, pp.17-25, 43-53, 71-89.

(3) *The World Bank in Mozambique*. (2021, Mar 19). The World Bank.

(4) Swedish International Development Cooperation Agency, *Mozambique multidimentional poverty analysis: Stasus and trends*, 2019.

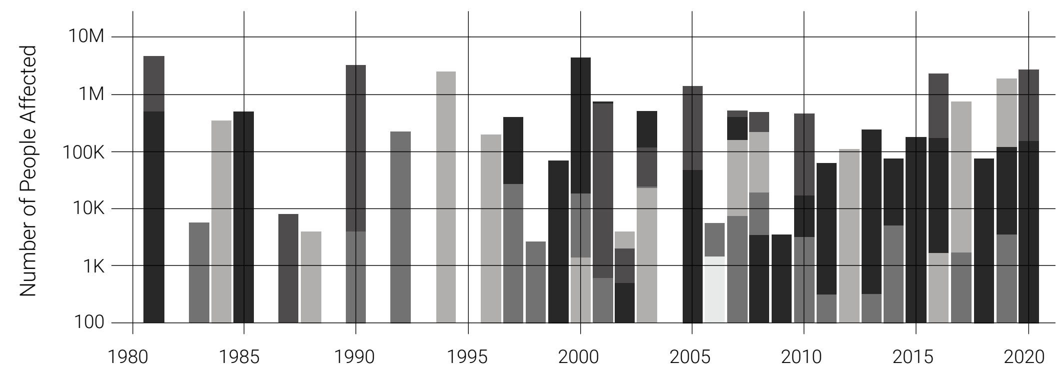
3.1.1. Hazards and Exposure

Climate context: Mozambique's climate is different from south to north, varying from subtropical to tropical. It is a territory influenced by the monsoons of the Indian Ocean and the warm current of the Mozambique Channel. The northern region is the wettest with a high amount of rainfall, while the southern regions are the driest with many months without significant rainfall. Overall, the average annual precipitation is 1200mm. An additional aggravating circumstance is the influence of the El Niño and La Niña events associated with heavy rains 1.

Natural Hazard: Mozambique is considered a country with a very high risk of disasters. In 2018, the INFORM risk index ranked Mozambique 21st out of 191 countries, within three years it ranks 9th as the most vulnerable country in the world, surpassing countries such as India and identifying it as one of the most vulnerable countries in Africa (INFORM, 2022) 5.
It is clear that Mozambique is subject to various types of risks due to its climatic and geographical situation and, due to current climate change.
The Mozambican National Institute for Disaster Management (Istituto National de Gestao de Calamidades - INGC) reports that the actual number of natural hazards and disasters has doubled in the last decade 1.
About 100 natural disasters were recorded from 1980 to 2020 6. The histogram shows the annual number of disasters (from 1980 to 2020) related to the number of people affected, over a period of 40 years (Graph 1). The surplus in the INFORM ranking is mainly due to the increase in climate impacts that limit development and the efforts applied to eliminate vulnerabilities related to socio-economic characteristics and the ability to cope with disasters.

(5) European Commission (2022), INFORM.

(6) World Bank Group (2021), *Climate Change Knowledge Portal*.



(Graph 1) Natural Hazard in Mozambique. Source: World Bank Group, Climate Change Knowledge Portal 6

Floods: Floods are the most frequent hazards in the country, with 35 events accounting for 33.33% of natural disasters (1980-2020) 6. Many of these floods occur quickly and have a short duration (Flash Flood). In Mozambique, floods have the greatest potential to occur during and after the rainy season from November to March, with peaks also in February and April, and tropical cyclones add to the situation in these periods 7. The regions most affected and most exposed to the risk of river, surface and coastal floods are Zambezia, Sofala, Tete and Gaza as (Graph 2). With thousands of people living submerged by floods and, due to extensive damage to communication routes, access to basic services and supplies is often compromised. Often the educational systems are used as shelters making them non-functional for educational purposes and causing a stop for many months 8. Furthermore, this situation is likely to increase the risk of sexual abuse and sexual exploitation.

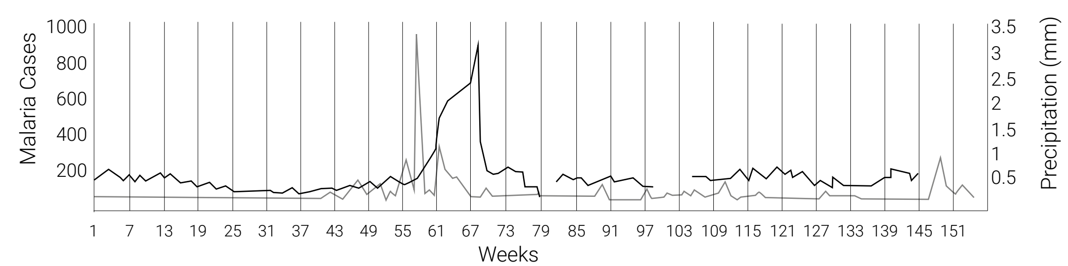
The regions of Zambezia and Sofala are affected by the flooding of the large rivers that cross them and by the flooding on the coast.

(7) The World Bank (2019), *Mozambique, disaster risk profile*, 2019.

(8) UNOCHA, *Humanitarian Response Plan*: Revised following Cyclones Idai and Kenneth, May 2019, November 2018 - June 2019, pp.2-29.

Disease (Graph 3)***:*** Epidemics rank second with 28 occurrences (26.67% from 1980 to 2020) 6, most epidemics are associated with other disasters, such as floods and droughts. Floods and periods of drought have an impact on health, causing outbreaks of communicable diseases such as malaria and cholera. In the study in the INCG Climate Change Report it is reported that malaria epidemics increase their incidence after heavy rain (Graph 4). The same study reports that in periods of drought cases of cholera and other water-related cases increase, due to the consequent decline in personal hygiene and the lack of adequate drinking water 9. Niassa, Zambezia, Cabo Delgado and Nampula are the regions most exposed to the risk of epidemics.

(9) INGC. 2009. *Main report: INGC Climate Change Report: Study on the impact of climate change on disaster risk in Mozambique*. INGC, Mozambique.



(Graph 4) Relation from Malaria cases and Precipitation in Maputo. Source: INGC Climate Change Report: Study on the impact of climate change on disaster risk in Mozambique 9

Storm (Graph 5)***:*** Long-term tropical cyclones are not common in Mozambique, although climate change could increase the frequency and severity of cyclones. In Mozambique between 1980 and 2020 there were 26 events (21.90%), mainly due to tropical cyclones 6. These are considered to be far more harmful than floods and epidemics. The risk to cyclones depends on the population exposed to the wind and storm surges. The impact of cyclones is greater in coastal regions where the cyclone maintains its intensity.
The regions most affected by cyclones, which have a negative impact on the population, are Nampula and Inhambane due to the winds and, Zambezia, Nampula and Sofala due to the strong storms 7.
In March 2019, Cyclone Idai caused numerous disasters in the provinces of Zambezia, Manica,

Zambezia is home to about 20% of schools (especially primary schools) located in areas with a high risk of flooding (i.e. close to rivers).

Sofala, Tete and Inhambane, causing 1.85 million people in need of help and around 110,000 people displaced in reception centres (such as schools and public buildings), with consequent impacts on education (around 1300 schools were damaged or destroyed), on the health and safety of boys and girls. The last tropical cyclone event (cyclone Eloise) occurred in the first month of 2021, bringing winds and rainfall to the provinces of Sofala, Manica, Zmabezia and eastern Gaza. Such areas were already experiencing significant flooding due to heavy rains and were also affected by Cyclone Chalane on 30 December 2020. Due to recurring disasters these areas have higher vulnerabilities due to slow and disrupted restoration processes 10.

(10) IFRC, *Operation Update n°1, Mozambique, Africa, Tropical Cyclone Eloise*, 2021, p. 2, 12.

Drought (Graph 6)*:* Drought is the fourth most present natural disaster in Mozambique with 13 events from 1980 to 2020 (12.38%) 6. Despite its position in fourth place, drought is the deadliest event, due to its prolongation over time. The drought occurs due to the natural atmospheric variation due for example to the conditions of El Nino. The regions most affected by drought are the southern ones.
It is strongly correlated with food availability, with a direct impact on the nutritional status and vulnerability of the population to epidemics 1. Drought has a negative impact on children and their access to education, in fact, areas affected by drought have a low concentration of classes due to the problems related to the shortage of basic necessities and the shortage of drinking water, leading to migration of families and therefore to school dropout 8.

Earthquake (Graph 7)*:* The earthquake can be placed in last place, as only one event occurred in 40 years (0.95%) 6. Although it is not a recurring danger, we must mention the presence of the East African Rift Valley that crosses Mozambique. In 2006 this caused the last earthquake, with a magnitude of 7.5 on the Richter scale, which hit the regions of Maputo, Sofala and Manica 1.

Conflict and Insecurity (Graph 8)*: **Internal conflicts in Mozambique are often driven by the lack of demilitarization and decentralization, and their protraction affects macro and micro levels.*** Among the most visible are the economic asymmetries between the country's provinces. Land conflicts, at community level, emerge as the main reasons for conflict and tensions, increasing situations of food insecurity and gender-based violence 11. Such tensions and conflicts can cause population displacements, increasing their exposure to risk. A problem to take into consideration is the possible interruption of the political system and therefore of the strategies implemented to reduce the risk of natural disasters, as all resources are reallocated to address the highest priority 1.
Gender-based violence is a major risk to the safety and health of women and girls. A year, 16% of women between the ages of 15 and 50 suffer physical or sexual violence from people close to them at least once in their life. However, many statistics reveal higher numbers across the country 4. The high levels of domestic violence may be due, in part, to early marriages. Finally, other marginalized groups that are probably at greater risk of violence are groups of people living with HIV / AIDS, LGBTQI +, disabled people and people in prostitution 4.

(11) Instituto Nacional de Estatística (2019), *IV Recenseamento Geral da População e Habitação*, 2017 Resultados Definitivos, Moçambique, 2019.

3.1.2. Vulnerabilities

Demography and Urbanization: Mozambique's population has grown significantly in recent decades, with an average annual growth of around 2.7%. Currently, according to the Mozambique National Institute of Statistics (Istituto Nacional de Estatistica, 2019) the country's population in 2019 was estimated at around 27 million 11.
More than half of the population of Mozambique lives in rural areas, but the number of the population in urban and especially coastal centres is destined to grow, since it is there that the main primary resources are found. 2 (Graph 9). The most populous and high-density provinces are located in the northern part of the country: Nampula and Zambezia which make up 39% of the national population, of which, however, 50% live in poverty 4.
Mozambique has characteristics of a widespread urban growth model, that is, growth does not occur only in one city. This model is important to dilute the pressure of urban development in a single city and therefore its density 9. Vertical development is generally not very promoted with the exception of some major cities (Beira and Chimoio) 2.
Large cities in Mozambique present themselves in different forms of urban development. Frequently they revolve around the "formal" city (called Bairro) which is often from the colonial era, from which new settlements spread that can develop in an informal or formal way

(Graph 9) Urbanization level. Source: Perfil do Setor de Habitação Moçambique 2018 - UN- Habitat Moçambique 2
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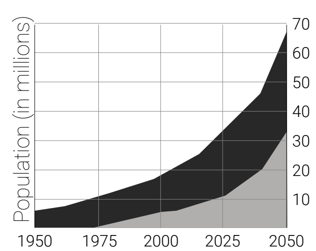

(Figure 1); Around the main development corridors (national roads), secondary or peripheral cities tend to develop. This includes an area better developed as a commercial activity, from which planned or spontaneous settlements branch off (Figure 2); Finally, the villages appear in the form of irregular or regular agglomerations. In these small settlements, housing conditions tend to be similar 2 (Figure 3).

"Out of 14 million children, nearly 10 million across the country experience poverty in one form or another." 13

Socio-economy (Graph 10)*: **Mozambique is one of the poorest countries in the world, ranked 181 out of 189 countries in the Human Development Index (HDI)*** 12, nonetheless, it is one of the countries in the world with one of the fastest growing economies, with Gross Domestic Product (GDP) growth rates between 6% and 7% since 2007 1. The country's economy is mainly based on agriculture, of which the rural population lives most, but recently new sectors have emerged such as the extractive and energy industry. Although there is this economic advance, the provision of services is below expectations: it does not target the poorest neighbourhoods of the population, so social protection covers only 20% of poor families; half of the population does not have access to drinking water, sanitation and infrastructure such as electricity and energy 4.
As already mentioned before, in Mozambique, there is a clear correlation between the annual distribution of rainfall and the occurrence of poverty. Poverty plays an important role in the vulnerability of communities, as it is found much more often in areas at greatest risk; it depends on natural and subsistence resources; and, it also plays an important role in the ability to respond to and recover from an environmental shock 1.
Many communities in Mozambique live near hydrological resources (around 60%) as a source of well-being, which makes them extremely vulnerable to natural hazards, especially as their infrastructure is often not adequate to withstand adverse weather events 1. People in rural areas and northern regions, in particular Zambezia and Napula, are most affected by environmental degradation and disasters and are equally the poorest as they do not have enough resources and opportunities for choice 4.
Child labour is an aggravating circumstance of poverty, this reaches 22% in children between the ages of 5 and 14.
The cultural and traditional context affects gender inequalities: in the past, women did not have the right to own a land, an inheritance or access to education. While this context seems to have faded over time, women are still under-represented compared to men, and do not have access to health risk education services and practices, and are therefore more prone to disease 2.

(12) United Nations Development Programme (2020), *The Next Frontier: Human Development and the Anthropocene*, 2020.

(13) UNICEF (2020), *Multidimensional Child Poverty in Mozambique*, 2020.

The Niassa, Capo Delgado, Nampula and Zambezia regions have very high levels of poverty.

Rural areas not only suffer from flooding but also from educational disparities with the majority in Cape Delgado, Nampula, Niessa, Zambezia and Sofala. The disparities emerge in primary and secondary school attendance with a high percentage of non-primary school attendants. This is mainly due to the lack of accessibility, therefore to infrastructural problems.

Education (Graph 11)*: **Mozambique has very low levels of education, with serious gender gaps and social inequalities, with consequences for socio-economic development.*** The average enrolment is low for both genders, although there are slightly more men than women enrolled. The secondary school completion rate is much lower than primary. It is clear that access to education is determined by the income gap. In poorer areas, despite the presence of school buildings, these are not used because families believe that it is necessary for children to work. In addition, the 16 national languages in the country often create significant barriers to access to education and, reading and writing in Portuguese (the official language) becomes a challenge for teachers and pupils.
A further reason for dropping out of school is teenage pregnancy and early marriages, with 14.3% of women married before the age of 15 and 48.2% of women married before the age of 18 4. Girls are much more vulnerable to sexual abuse or sexual exploitation in schools than men. About 70% of female students know of cases of teachers sexually abusing girls in exchange for grades 4.

(Graph 12) Education disparity: Deprivation rate by province. Source: UNICEF, *Multidimensional Child Poverty in Mozambique* 13
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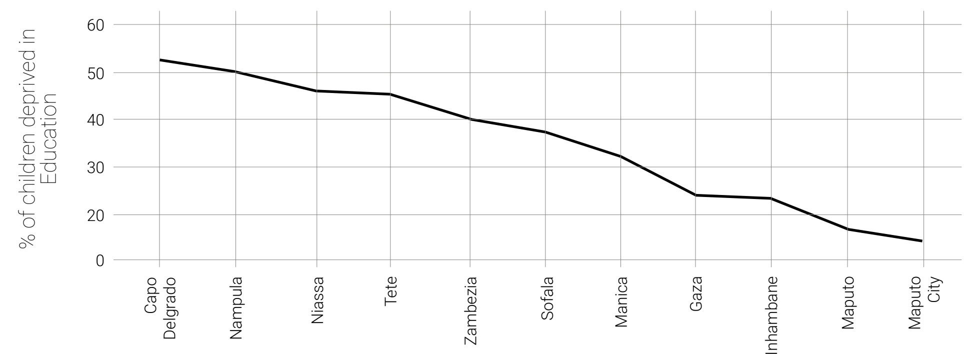


"In comparison to boys and young men, girls and young women are more exposed to sexual abuse and exploitation in schools. 70% of schoolgirls know of cases of teachers having sex with girls in exchange for grades" 4

Deforestation (Graph 11)***: An important economic contribution that generates income and employment, and on which the Mozambican population is highly dependent are forests, which are important, above all, for the development of raw materials.*** Forests are important ecosystem systems, most of the forest sources cover the main river basins of Mozambique, these play a key role in the storage of carbon and in filtering the water that enters the waterways 14 . The forest area has been rapidly diverted over the past 25 years, mainly due to unsustainable agricultural practices and the use of timber for construction and firewood. This deforestation process has a negative impact on the economic system and the conservation of biodiversity in the country. The provinces with the highest deforestation rates are Zambezia, Nampula, Cape Delgrade and Manica 4.

Inequalities are also present between girls and boys. The percentage of girls who do not finish school is very high and this implies marriages or early teens.

Due to the floods, the schools are used as shelters, interrupting the attendance of classes for months.

(14) World Bank. {2018}. *{Mozambique Mozambique Country Forest Note }*. © World Bank, pp. 4-14.

3.1.3. Lack of Capacities

Infrastructural (Graph 13)***: Catastrophic events and therefore the destruction of buildings and infrastructures are often caused by non-compliance with national planning legislation or because there is no one for areas subject to natural hazards*** (e.g. floods or tropical cyclones). Both the construction materials and the overcrowding of private homes and the low investment of the country in advanced technologies for the construction of infrastructures are factors of vulnerability 1.

By addressing the research on the spatial and morphological distribution of housing, it is evident that in large urban centres the characteristics are very similar, while in rural areas they differ according to the region: in the north, housing is mainly circular huts without partitions to divide the rooms (there is also a presence of rectangular or square lodgings, these too without a clear separation between the rooms); although in the South, rectangular and square accommodations are predominant, with different internal partitions 2.

For those who live informally, it is assumed that people are responsible for planning and building their homes (at least 80%). This is a common practice not only in rural areas with informal construction but also for formally built construction 2. Nonetheless, 27% of the population is unable to rebuild their homes due to a lack of sufficient income to cover the costs. Although at least one family member has an income, this is not enough to purchase and transport the materials.

Over three quarters of the population has access to natural materials that could be collected and used for construction. The material that can be found most commonly are wooden poles, used as vertical structural elements of a house typically found in rural areas. Furthermore, in less than two hours on foot, there are also large leaves and straw for roofing and mud for masonry 15.

In Mozambique there is a notable difference between urban and rural areas in terms of access to basic needs and services. About 56% of Mozambicans live within 30 minutes of a market, while about 35% have to walk for about an hour. These numbers are similarly reflected in access to public transport and access to water sources 2.

Added to this problem is the poor quality of the roads, generally unpaved, which often show erosion mainly due to climatic events. This problem very often limits access to homes or services and in extreme cases limits safety measures. In addition, in rural areas, safety, especially for women and children, is reduced due to the lack of lighting as well as the lack of sidewalks along the roads 2.

Institutional (Graph 13)***: In Africa, Mozambique is one of the few countries that has made progress since the adoption of plans for risk reduction (Disaster Risk Reduction - DRR) aimed at different sectors and at different scales, from national to local.*** The INGC helps institutions to apply DRR plans in ministerial planning, proposing this plan for the development of other programs, such as those outlined in the Poverty Reduction Action Plan (PARP); in the National Strategy for Climate Change Adaptation and Mitigation (ENAMMC); and in the United Nations Assistance Development Framework for Mozambique (UNDAF) 16.

The Mozambican government, to reduce the death toll and loss of assets, has implemented the community based disaster risk reduction (CBDRR), useful for mapping areas highly prone to disasters. For the application of the CBDRR, the government comes to support, they create local risk management committees, in which each person performs a key task, with responsibilities that involve him before, during and after a disaster 15.

(15) IOM's Displacement Tracking Matrix, INGC, Shelter Cluster Mozambique, *Sheleter recovery assessment in the central region of Mozambique (Manica, Sofala, Tete and Zambezia)*, April 2020.

(16) United Nations Economic Commission for Africa (2015), *Assessment report on mainstreaming and implementing disaster risk reduction in Mozambique*, 2015, pp.5-32.

"Menos de 2% dos moçambicanos vive em habitações totalmente construídas com materiais convencionais (dados de 2007). " 2

"apenas cerca de 56% dos moçambicanos vivem a uma distância de caminhada de 30 minutos de um supermercado (quase 82% em áreas urbanas e 45% em áreas rurais), enquanto que mais de 35% têm que caminhar mais de uma hora para esse fim" 2

(Figure 1)

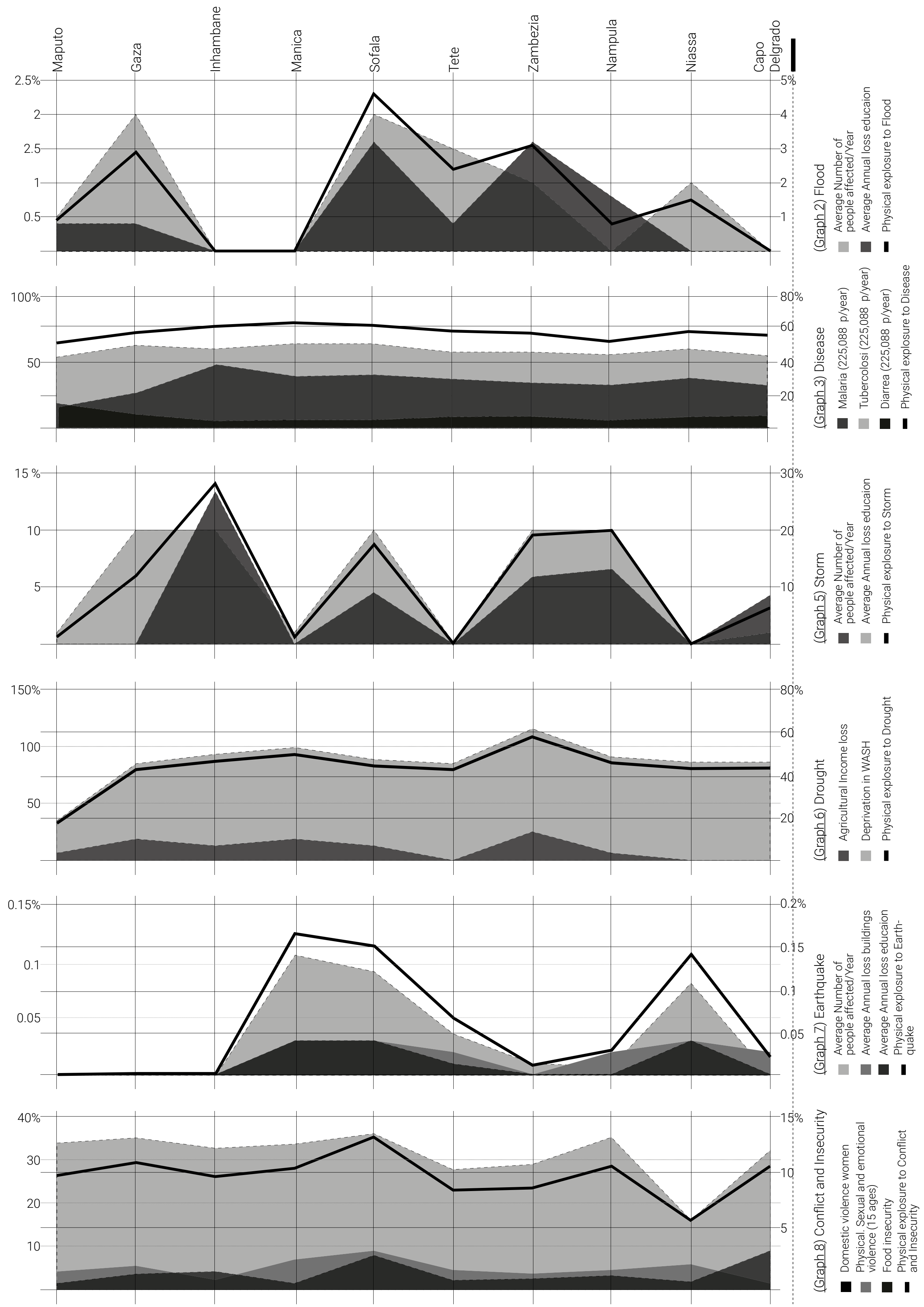
(Figure 2)

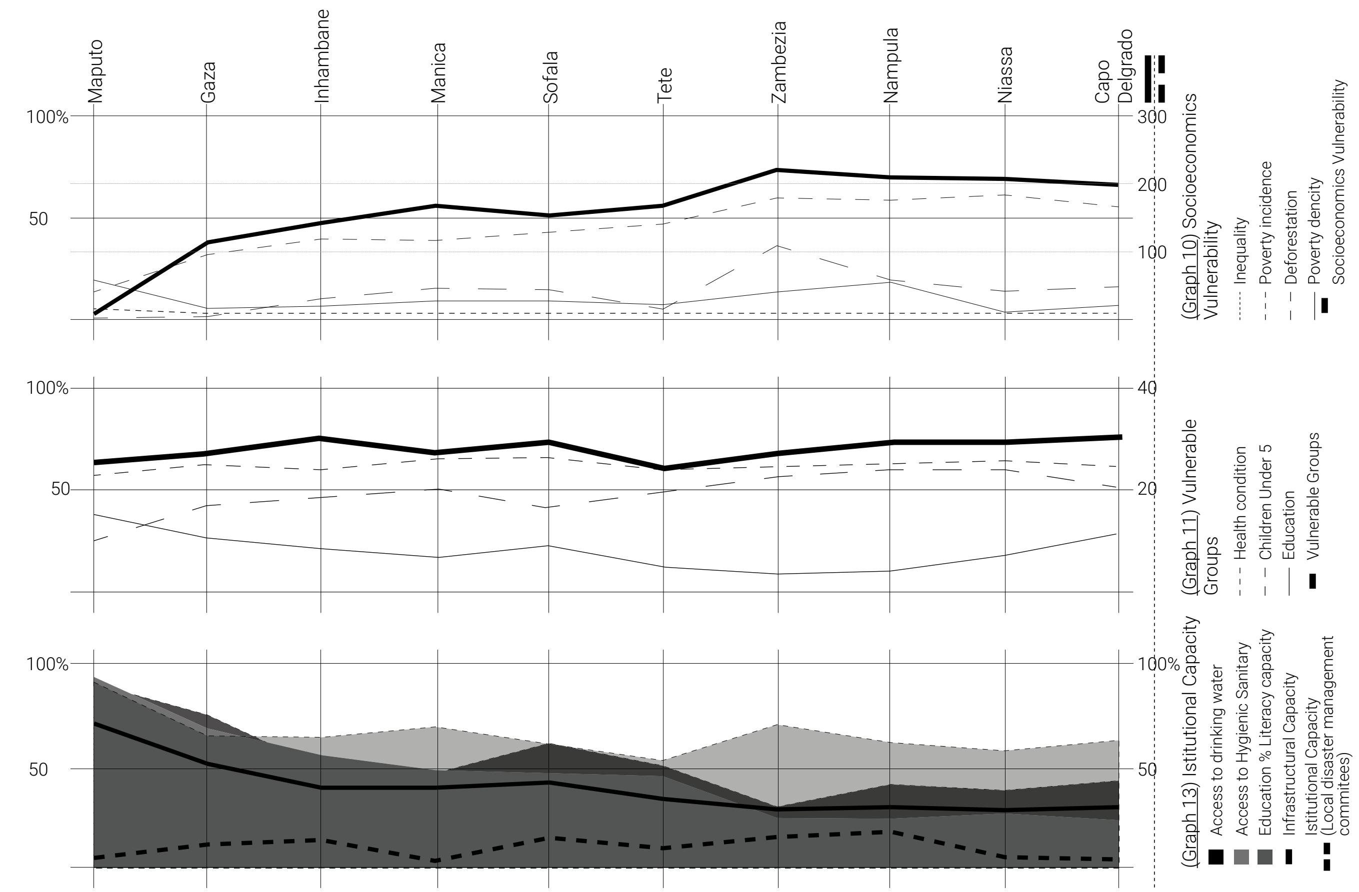
(Figure 3)

(Figure 1) Urban Center. *Maganja City, Maganja Da Costa, Zambezia.* -17.312429, 37.507842 Souce: Google Earth

(Figure 2) Secundary City. *Baixo Licungo, Nante, Zambezia* -17.443110, 37.289236 Souce: Google Earth

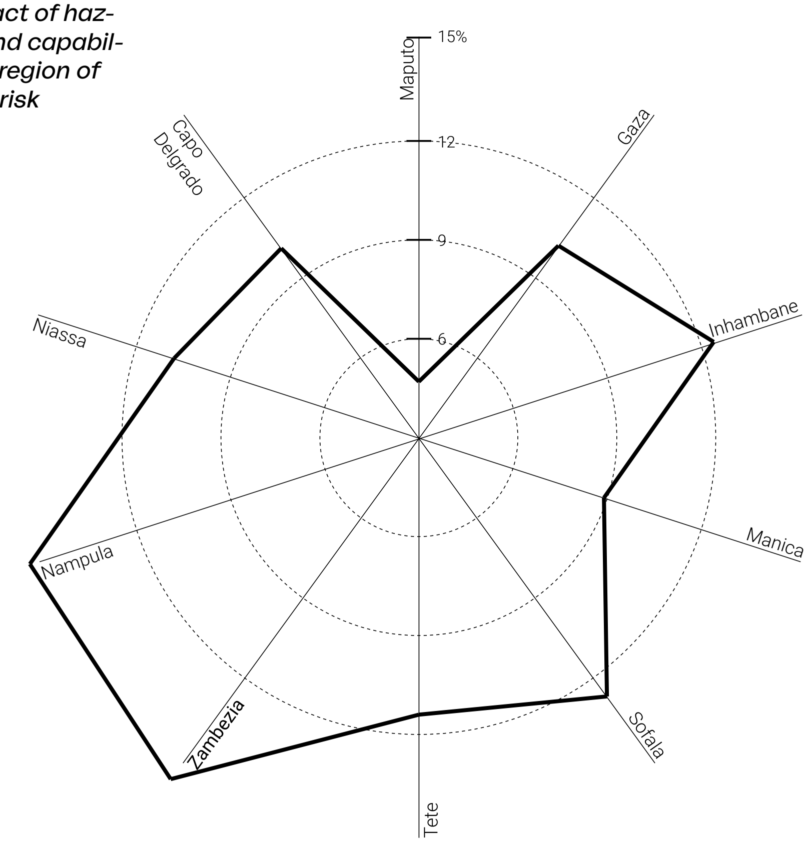
(Figure 3) Villages. *Nampilane, Nante, Zambezia* -17.410583, 37.347519 Souce: Google Earth

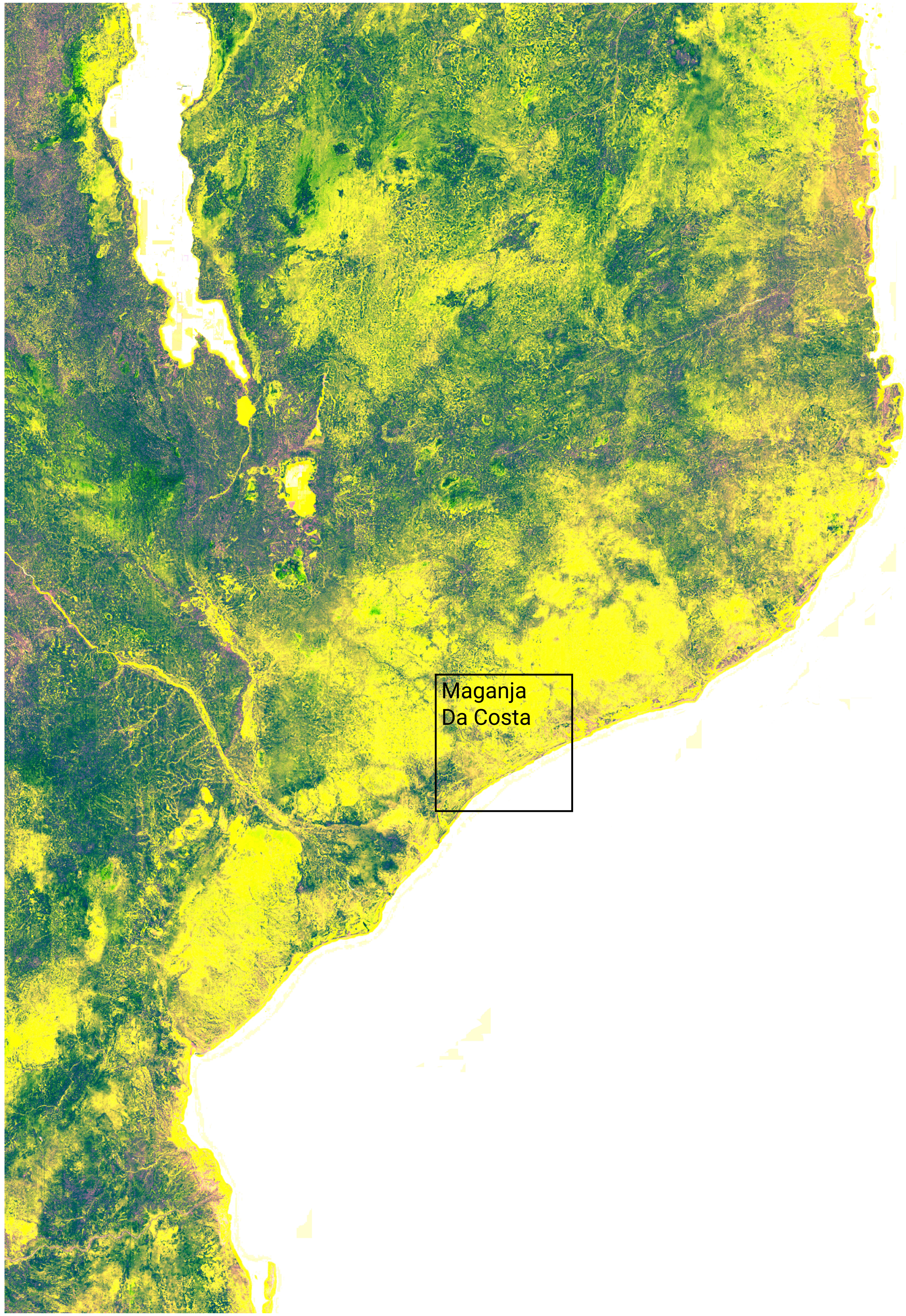




RANK RISK:

By assessing the impact of hazards, vulnerabilities and capabilities, Zambezia is the region of Mozambique most at risk





III.II Zambezia - Maganja Da Costa

For the project development we dedicate the observation to an area within the Zambezia region, chosen on the circumstances described below. The data relating to the chosen area are insufficient, so the studies do not allow for a detailed observation of the site. The studies carried out below are general and mostly refer to information from the Maganja Da Costa district (or those from the Zambezia region studied previously). Only in particular cases, when information is available, is reference made to more specific issues relating to the place of analysis, therefore, this is not an exhaustive approach, but is limited to the implementation of design tools that do not require involvement and participation of the community present on the project site (The previous chapter clarifies which tools need or do not need direct community involvement).

3.2.1. A Direct Observation

< (Tool 1) Direct Observation *(Community Not Involved)*

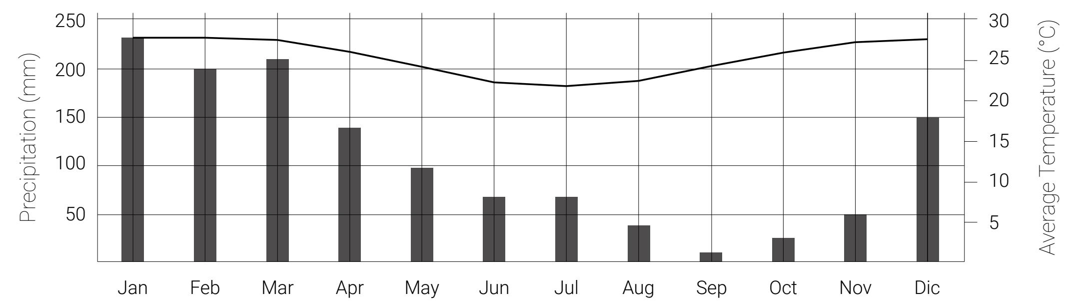
Geographic Location

The area in question, Baixo Licungo, is a rural town, in the administrative headquarters of Nante, within the coastal plain of the Maganja Da Costa district, in Zambezia. The rural village of Baixo Licungo is adjacent to several hydrological systems, such as the Tandamela and Nomuemene lakes and the Bolose River. These hydrological systems are often the cause of floods, as the area itself does not rise above 100 meters above sea level. Furthermore, Maganja Da Costa is identified as one of the districts of Zambezia most affected by erosion, one of the causes, in addition to the recurring ones floods, was the destruction of mangroves, which stabilized the slopes and banks of rivers and decreased sediment deposits 17.

(17) Distrito da Maganja da Costa , Ministério para a coodernação da accão ambiental (2012), *Avaliação Ambiental Estratégica da zona costeira de Moçambique*, 2012, pp. 1-19, 36-62.

Climate and Natural Hazards

The average monthly precipitation, in the Maganja Da Costa district, shows a significant seasonal variation, with rainy periods from November to May (85% of the total annual rainfall. 250mm) and, drier periods, with average monthly rainfall of 70mm, from June in October 17. Average annual temperature is 25.3 °C, with January being the hottest month (27.7 °C). As for the winds, these are generally calm and without a definite direction, with the exception of the months of October and November when the predominant winds come from the East17.



< (Graph 14) Precipitation and Temperature in Maganja da Costa. Source: Distrito da Maganja da Costa, Avaliação Ambiental Estratégica da zona costeira de Moçambique 17

The district of Maganja Da Costa, due to its exposure along the Indian Ocean coast, is subject to tropical storms, which pose a threat not only to the coastal area but also to the innermost areas, due to the accelerated increase of the average water level of hydrological systems, representing a greater danger, especially when combined with high tides 17. Tropical storms causing floods aggravate the phenomenon of saline formation both in groundwater and rivers. This would lead to the deterioration of the water quality of the aquifers, still used by a high percentage of the population, as the main source of water supply 17.

In the Maganja Da Costa district, malaria and cholera are the main diseases. They occur during the rainy season from October to April, and further aggravating can be torrential rains and floods. As regards tuberculosis, pneumonia and diarrhea diseases, generally associated with the precarious living conditions of the populations, there are no data referring to the epidemiological picture of the rural area of the country 17, but the information regarding Zambezia supports the analysis, ranking respectively in first, second and third place.

Demography

Within the District of Maganja da Costa, one of the most evident characteristics is the unbalanced distribution of the population. This demographic distortion is visible if we compare the northern and southern areas of the district, with the other neighbouring districts, which have higher densities.

The administrative district of Nante has a higher percentage of women (35,410) than men (28,598). Data equally common in the province of Zambezia. The population is very young, with around more than 50% of the inhabitants under the age of 10 **18**. This demographic imbalance is associated with a disproportion in terms of infrastructural distribution and accessibility, with a greater advantage for the localities in the south of the district. This question affects travel times and transport costs, monetary or not. On average, 12.5% of the inhabitants' expenses are related to transport **2**.

(18) National Institute of Statistics, *Mozambique, Regional Data of Mozambique*, 1990-2040.

Education

The illiteracy rate in Nante is very high, around 61%, being in line with the Maganja da Costa district, whose rate is around 64% **18**, and less favorable than that of Mozambique, whose illiteracy rate is estimated at around 50.3%.Although there is no data to illustrate the situation, it is estimated that, similar to the rate from the province of Zambezia, the majority of the illiterate population is represented by women **18**. Within the Maganja da Costa district, the most complete level of education is primary (EP1 and EPC), while it is reduced to only four secondary schools (ESG1), of which only one of them teaches the second cycle of secondary school (ESG2) **17** (Figure 4). The number of children attending primary school is much higher than that of secondary school, with a slow increase of 1% compared to 2011 **19**. Due to the disparate number of schools and the scarcity of infrastructure, travel times are very high, implying the loss of school attendance by pupils and an increase in the rate of child labour.

The rural village of Baixo Licungo has only 2 primary schools, one of which is full-cycle (EPC), while the other is first grade primary education (EP1) (Figure 5), these reduce travel times to about 15 minutes. A substantial problem is the high number of professors compared to the number of pupils, this has led to a reduction of the same and their training (going from 54.5% in 2008 to 33.6% in 2011). Therefore, the pupil-teacher relationship is reduced, causing a lack of interest or, in extreme cases, the renunciation of studies to favour the economic growth of the family.

> More Info:
Education is divided into two levels: first grade primary education (EP1), which teaches from 1st to 5th grade, and upper secondary education (EP2), which teaches 6th and 7th grade .

(19) Instituto Nacional de Estatística (2012), *Estatísticas Distritais (Estatísticas do Distrito de Maganja Da Costa)*, March 2012, pp. 10-22.

EP I + EP 2	ES I + ES 2	
77.524	3.880	*Number of student*
181	4	*Number of school*
35,8	27.7	*Percentage of girls enrolled*

64.5 *Illiteracy rate (population aged 15 and over who cannot read / write)*

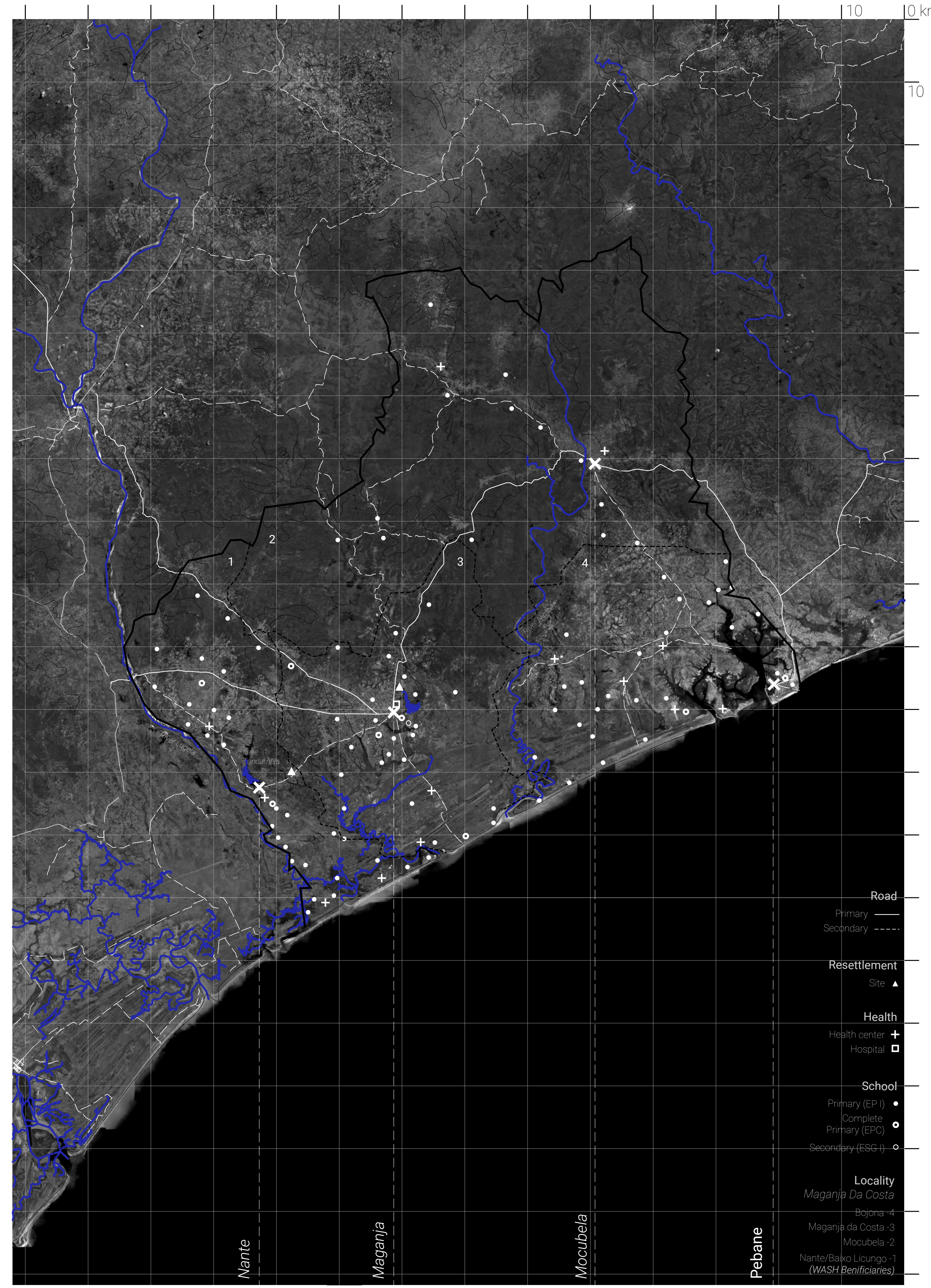
< General education indicators for the Maganja da Costa district (2012)
Souce: Distrito da Maganja da Costa, Avaliação Ambiental Estratégica da zona costeira de Moçambique **17**

Health System

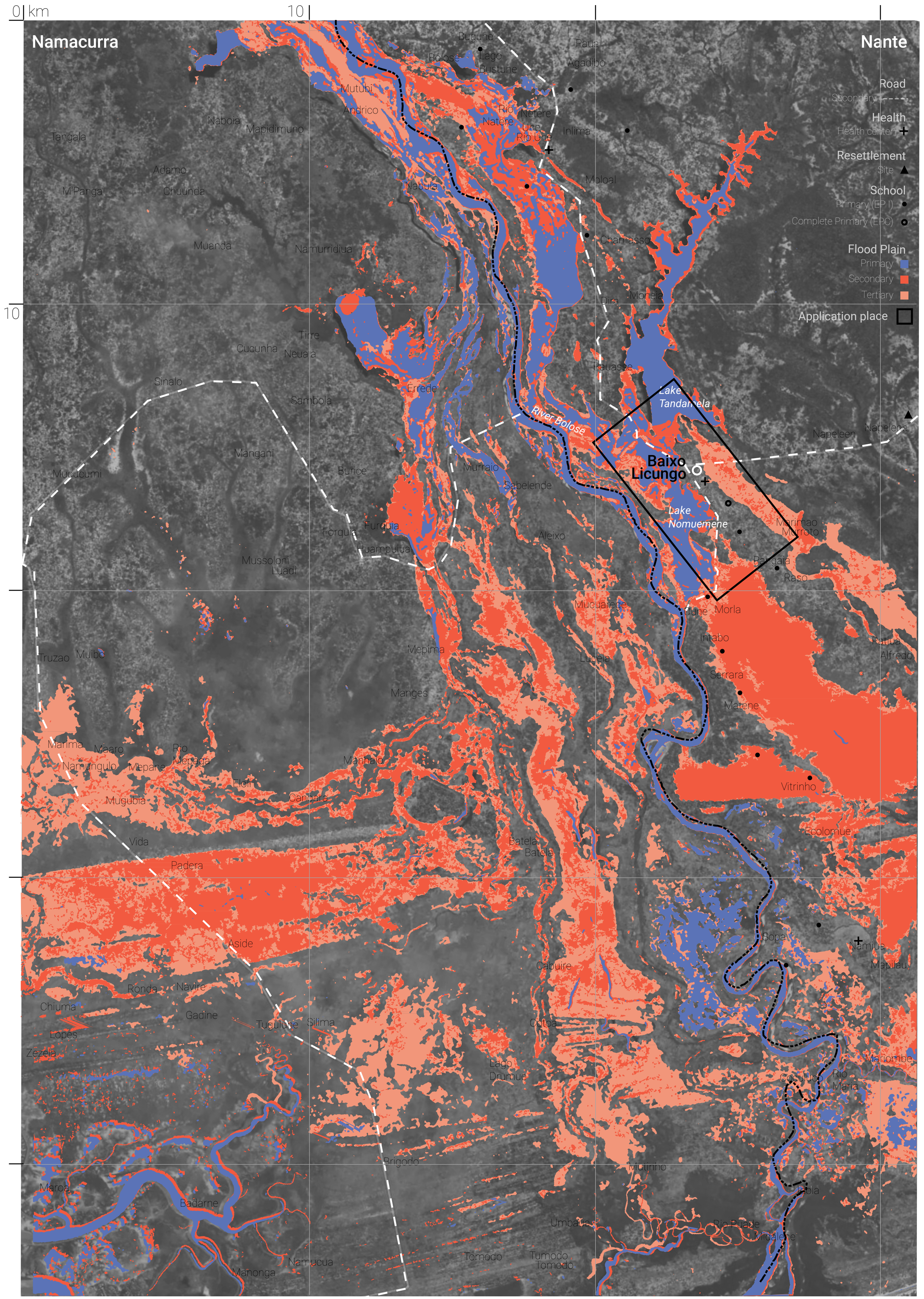
Healthcare remains an open challenge in the district. There are 18 health units within the district, spread over various administrative areas and locations **17**, among which there is Baixo Licungo, which has only one health centre. Due to the small number, at least 42% of the population resides approximately 10 km from a health facility. It should be noted that due to the lack of georeferenced data it was not possible to illustrate the remaining health centres within the district (Figure 5).

Health issues are linked to the availability of water and its supply by the population. Maganja da Costa has a drinking water coverage rate of 54%, which means that at least 46% of the population has scarce water from unsafe water sources, such as wells or natural water bodies (rivers, ponds and streams) **17**.

Finally, the use of shared bathrooms, built separately from the main house, for cultural and health reasons, is still a widespread practice. In fact, approximately 92% of families do not have a latrine and are forced to defecate outdoors. The data show that only 0.1% of families within the district have individual sanitation facilities connected to a septic tank **19**.



> (Figure 4) Maganja Da Costa District, Zambezia.
Data Source: Shelter Cluster Mozambique; Distrito da Maganja da Costa, Ministério para a coodernação da Acção Ambiental; Instituto Nacional de Estatística



Architectures and Materials

It is common practice in both rural and urban areas to plan and build their homes often with low-strength materials, a phenomenon that is reflected not necessarily on the lack of economic return, but also on the time and costs associated with mobility. This justifies the formation of formal building material supplier groups, which supply processed materials (concrete, CGI, etc.) and; informal ones that supply raw materials such as wood, straw and mud, in order to cover the high demand, especially after disastrous climatic events **20**. The collection of raw materials takes place especially in the neighbouring forest areas, causing an environmental impact. In fact, the Maganja da Costa district suffered a 2.4% loss of wet primary forest from 2002 to 2020, when in 2000 68% of the territory was covered by forests **21**, mainly made up of Mangroves, used for their resistance to water (fresh and salt) and structural stability.

Due to this easy accessibility to raw materials of mud, straw and wood and, due to extensive construction knowledge, the most widespread housing system in the district is the Palhota, a rectangular or circular house, commonly built with vernacular technologies. The walls are generally made of earth according to two main techniques: Pau-a-pique and Adobe. In some cases it is possible to find walls in wooden poles covered with capim (straw). The roof is generally formed by a wooden structure covered with capim or corrugated sheet metal (CGI) and can have two or square pitches **22**.

There is a gender separation of roles in housing construction: women work with the earth, taking care of the cladding and plastering of the houses, while men take care of the structure and roof.
As far as wall coverings are concerned, a mixture of sand and clay is generally used to guarantee the protection of the walls, which increases the durability of the walls up to two years, without the need for maintenance. Furthermore, some data suggest that the mix of dry filling, such as stones and debris, combined with isolated foundations, can make the masonry walls more resistant to humidity **20**,as in the case of the building system Pau-a-Pique.

Construction periods normally occur during the dry seasons (June - November), but very often some construction systems where it is possible to build the roof before finishing the walls are available throughout the year.
Although availability is not very low (25% for concrete and 9% for concrete blocks), concrete and concrete block structures are the least developed as they require a higher income and accessibility is equally limited. due to the low infrastructural development, requiring approximately 1-2 hours of walking **15** (data based on the Zambezia region). Very often the production of concrete or adobe blocks takes place informally and generally the quality is poor, due to the low cement / sand (or sand / clay) ratio, inadequate seasoning, or the use of undersized blocks **22**.

(20) CRAterre, Young Africa, IFRC, *Context-based assessment of local building cultures (Dondo)*, July 2019,.

(21) University of Maryland and World Resources Institute. "Global Primary Forest Loss". Accessed through Global Forest, Primary Forest Loss. Watch on 20/01/2022, from www.globalforestwatch.org.

(22) Roberta Nicchia (2011). *Planning African rural towns: The case of Caia and Sena, Mozambique* [Doctoral thesis, University of Trento]. pp. 101-129, 141-160.

Educational building typologies:

There are two types of educational structures: conventional schools and spontaneous “informal” schools. Conventional schools, built by the government, are mostly built of concrete and concrete blocks and generally do not include reinforcement systems to reduce vulnerability in the event of natural disasters **23**. Generally these are made up of one or more buildings with two or three classrooms (each of about 50 square meters and an internal height of about 3 meters), a block for sanitary facilities, an administrative block and sometimes housing for the teachers.

One of the causes that reduces the number of children enrolled is the overcrowding of the classrooms caused by an insufficient number of schools. Given this problem, in general, local communities come together to build one or more informal classrooms, often alongside conventional ones with which to share the same outdoor courtyard.

The informal educational facilities are made of poor materials and not very resistant to disasters, with wattle walls (Adobe type) or double-walled with interstice (Pau-a-pique type), while the roof is typically made of wood covered with straw. Informal buildings are generally aimed at primary education, while all secondary education infrastructures are only conventional and therefore highly insufficient **23**.

(23) DIPECHO III, *Shelter, Housing and Basic Infrastructure Resistant to Disasters in Southern Africa - Malawi, Mozambique, Madagascar*, 2015, pp. 27-32, 68-108.

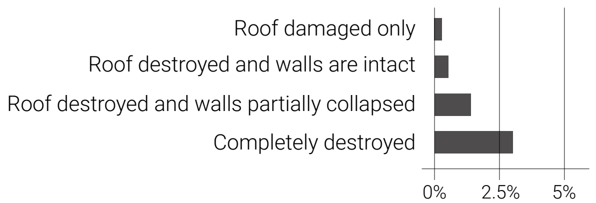
(Figure 5) Study of Nante Locality in Nante District, Maganja Da Costa.
Data Source: UNOSAT
<

Building Vulnerabilities:
The vulnerability factors, which compromise the durability and resistance of a building, are mainly divided into four categories:

- Factor linked to the place of application of the project;
- Design factor: (for example the shape of the building) buildings designed and built without taking into account the physical components of the context;
- Factor linked to the structural components of the project: the non-existence of some important structural components (for example the foundations);
- Factor linked to the techniques of application and execution of construction materials: poor execution and inadequate use of materials (and of poor quality), for important construction details.

According to some information regarding the impact on the homes of cyclones Idai and Kenneth, the destruction of homes occurs mainly after the detachment of the roof, due to heavy rain and winds 24.

(24) IOM's Displacement Tracking Matrix, INGC, Shelter Cluster Mozambique, *Sheleter recovery assessment in the central region of Mozambique (Manica, Sofala, Tete and Zambezia)*, April 2021.



< (Grafico 14) Houseing condition in Maganja Da Costa, after cyclon Idai.
Source: IOM's Displacement Tracking Matrix, INGC, Shelter Cluster Mozambique, *Shelter recovery assessment in the central region of Mozambique (Manica, Sofala, Tete and Zambezia)* 15

The substantial problems are related to the shape and slope of the ***roof***, the poor connection between the wall and the roofing structure or, between the roofing structure and the roof, the use of incompatible and poor quality materials. Generally the roofs of the houses, in Mozambique, are made with one, two, four pitches or they can be conical. The first two types are those most exposed to strong winds; therefore, they are usually made for concrete structures (Only 1% of the population in Zambezia uses concrete material for the construction of roofs 24); while the four-pitched and conical roofs are the most suitable types for construction in areas subject to strong winds 25. In addition, the pitched type (pavilion) is suitable for the use of conventional materials (CGI, etc.) and facilitates the installation of rainwater collection systems 26. Roof structures that have a slope between 30 ° - 45 ° are safer and better resist wind action (20 ° - 30 ° for areas subject only to rain).
The main materials used for the roofing are CGI, capim or plastic sheet. In Mozambique, galvanized sheet metal (CGI) is increasingly used as it is considered a more durable material than traditional materials, such as capim, at an equally affordable price. It was its introduction and influence the shape of buildings as it adapts more to more regular structures (rectangle, square) to facilitate its placement. Although they limit the entry of rainwater inside the house, due to their lightness they are very vulnerable to the action of the wind, so they can be easily raised 25.
To reinforce the roof, the custom of placing concrete blocks (or adobe) on the sheet metal is widespread, due to the lack of sufficient income for the purchase of sheets with greater thicknesses.
Within the Baixo Licungo area there are more houses that use plastic roofs, applied to capim roofs, which exclude protection from strong winds and the entry of water, due to the impossibility of connection with the roof and the lack of plastic sheets that can cover the entire house, since the union of several sheets represent a weak point of coverage.
Furthermore, in both traditional and modern buildings, external verandas connected to the main roof structure are added, generating an additional critical point of the building. This is due to its high projection, compared to the external walls, which facilitates the lifting of the entire roof in case of strong winds. It is therefore necessary to separate the veranda from the main structure 25.
Additional vulnerable points that the building may present are related to the openings and foundation systems.

(25) United Nations Human Settlements Programme, Programa de Alojamento pós-ciclone - Palpoc: *Promovendo Recuperação Resiliente de Alojamento e Infraestruturas em Comunidades afectadas pelos Ciclones*, Dondo, 31 October 2019.

(26) United Nations Human Settlements Programme, *Construir com os Ventos – Guião de Construção para Zonas de Risco de Ciclone*, Maputo, November 2007.

Doors and windows are the most likely entry points for water and wind. If not adequately protected with wooden barrier elements, they can be easily blown away by the high pressure of the wind and form cracks in the walls with consequent collapse 25.

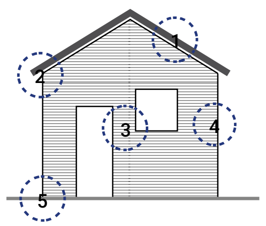
The walls are usually built without reinforcing elements or with materials that are not resistant to strong wind actions. Furthermore, if the walls are not plastered with adherent and resistant material, water can cause damage to the structure.

With the strong pressures of the wind or water, being mainly very light structures, these can be swept away if not built with the necessary attention to the combination of the different elements that make up the building. In particular, the ***foundations*** or, in its absence, the bond of the walls with the ground must be very resistant to prevent the building from being swept away. Therefore, the lighter the construction, the heavier and deeper the foundations should be 26. In addition, the hydrodynamic actions of floods very often erode the soil beneath homes, causing damage to or destruction of homes. Ultimately, homes that do not have a base that elevates them above the possible level of flooding are flooded. Generally, in fact, the houses adjacent to a catchment area or at risk of flooding have a base on which the structure can rest, avoiding the rise of water in humid periods.

Coping strategy:
Following the countless destructions due to natural disasters and the low strength of the buildings and materials used, it is essential to consider the benefits of better, stronger and faster construction to strengthen strength, so that there are fewer vulnerabilities to future shocks and, that people can return to their normal life sooner, to reduce the loss of wellness related to disasters.
Since the main goal of the construction intervention is to build safely, the knowledge is needed for a safe and resistant construction to natural actions, especially as they can make a difference to the overall performance of the building and have a considerable effect on future maintenance or rebuild costs.

The Mozambique National Institute of Disaster Management (INGC) with the help of countless international associations, has developed several manuals that should serve as a facilitating tool to improve the understanding of the production and application processes of materials and construction systems above all, to avoid situations adverse (an example: the manuals "A Arte do Bem-Costruction", the manuals "Construir Como s Ventos" and "Recostruindo melhor - Como Podemos Reconstruir Melhor?")

Architectures and Materials | **Building Vulnerabilities**



1 - ROOFING AND ROOF STRUCTURE

PROBLEMS:
- Roof built with too low slope;
- Roof built with a single pitch;
- Coating material resistant to strong winds or rain.

DAMAGES:
With the action of the wind the roof can rise and create a break in the connection between the roof covering and the roof structure and between the roof and the wall

2 - ROOF AND WALL

PROBLEMS:
- Inadequate building size;
- Insufficient connection system between roof and wall;
Roof built with poor quality materials or applied with fragile connections.

DAMAGES:
With the action of the wind the roof can rise and create a break in the connection between the roof system and the wall

3 - OPENINGS: WINDOWS - DOORS

PROBLEMS:
- Poorly designed wooden windows can cause the destruction of the structural elements of the building;
- Openings too close to each other;
- Non-insulated openings allow water to enter the building.

DAMAGES:
- Destruction of the window and all internal assets;
- Formation of cracks on the walls and subsequent collapse;
- Flooding inside the building.

4 - WALLS

PROBLEMS:
- Walls made without any structural reinforcement;
- Walls made with materials not resistant to strong winds;
- Walls made with non-water resistant materials.

DAMAGES:
- If walls are not reinforced these can collapse with the action of the wind;
- If walls are not plastered with water-resistant materials, they may collapse.

5 - FOUNDATION - BASEMENT

PROBLEMS:
- Shallow foundations;
- Foundations without adequate reinforcement;
- Foundations made of materials with little resistance or without waterproofing against moisture;
- Foundations made of materials that are too light;
- Basement made at heights below the possible level of flooding.

DAMAGES:
- By wind or hydrodynamic action of water, shallow foundations may break close to the ground;
- If foundations are built with materials that are too light, wind and water actions can lift the grease;
- The action of water can tear down walls or enter the floor and flood the building.

Architectures and Materials | **Coping Strategy**

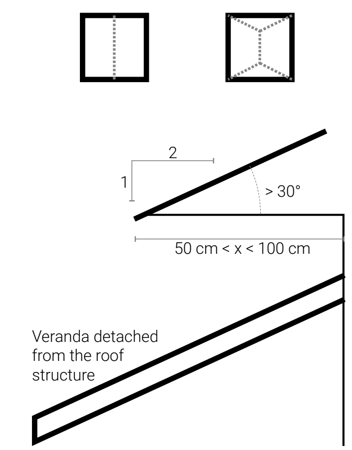
1 - ROOFING AND ROOF STRUCTURE

ROOF SHAPE:
- 1/2 pitchers exposed to the wind, recommended for constructing in concrete blocks (or reinforced concrete);
- 4 conical layers better suited to wind action and the use of conventional materials (CGI, etc...) and facilitate the installation of water collection systems;
- Gradient not less than 30 % if wind; 20 % if rain;
- The aves overhang helps protect the walls from rain.

ISOLATE AND WEIGH DOWN:
- Apply wooden boards or other material to the roof structure to give more weight to the roof and act as a defence against wind and rain;
-A mixture of earth and straw and a plastic cloth weigh down the roof and insulate it from the wind and rain;
- The thermal insulation of the roof more be obtained by applying vegetable materials (reed...).

STRUCTURAL CONNECTION:
- Secure the roof firmly with the structure;
-The structure can be reinforced by the application of metal straps;
- Apply reinforcement systems, as braces on the roof structure;
- The verandas must be detached from the main roof structure to better withstand the wind.

MATERIALS:
- Galvanized sheet more resistant than traditional materials (such as capim, etc...);
- Do not use rigid materials (such as lusanite or fibrocement) in areas at risk of cyclone as these materials can easily break with the action of wind.



2 - ROOF AND WALL

BRICKS BUILDING:
- Fastening with J-shaped iron studs or irons anchored to the top of the wall that allow the use of tactical joints to securely attach the roof structure to the wall.

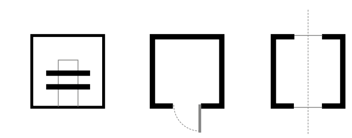
VERNACULAR BUILDING:
- The joint between the roof and the wall can be reinforced by cables, ropes or metal clamps.

IMPORTANT ACTION OF THE GUTTER:
- In addition to collecting rainwater, they effectively protect from water.

3 - OPENINGS: WINDOWS - DOORS

REINFORCEMENT AND MATERIALS:
- Provide reinforcements for windows and doors and barriers to be used in the event of wind and flooding;
- Replace glass elements with less fragile materials.

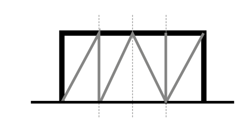
POSITION:
- Build windows or doors with openings facing the outside so as not to allow the entry of wind or water;
- Symmetrically placed windows help ventilation in case of strong wind and avoid building lifting;
- Windows placed at different heights or adjacent, help ventilation and air circulation.



4 - WALLS

CONVENTIONAL BUILDING:
- Symmetrical and aligned walls make the structure stronger.

NON-CONVENTIONAL BUILDING:
- Strengthen wall structures with diagonal elements (bracing);
- Structural elements must be anchored to the foundation element.

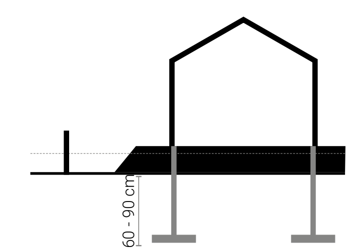


5 - FOUNDATION - BASEMENT

- Create a deep and compact base;
- Build foundations with a depth between 60 cm and 90 cm;
- Reinforce the base of the pole (if wooden) with nails and crossbars;
- If wooden foundations: waterproof with plastic sheets and treat with anti thermire products (fired engine oil, decaju walnut oil);
- Create larger and heavier foundations for lightweight structures.

CONVENTIONAL BUILDING:
- Build a raised basement beyond the possible flood level;
- Building protective walls around the building.

NON-CONVENTIONAL BUILDING:
-Raise the floor of the house with a compact plot of land.



Architectures and Materials | **Pau-a-Pique construction system**

(Figure 6)

(Figure 7)

STRUCTURE - WALL
Typically circular or rectangular shape.
The structure is formed by vertical elements (pillars) and horizontal, to form a network. The (hard) wooden pillars are inserted into the ground, excavated and filled with debris, at a depth of 50-80 cm, each at a distance of 50-60cm.
The secondary structure, horizontal, is placed at a pace of 20 cm, anchored to the primary one through nails or vegetable cord. The process can be repeated in parallel, creating a kind of sandwich.
In the interstice is placed a filling consisting of earth, rocks and debris of cement or reed (the latter is the most used filling). The type of filling is related to the type of final coating.

ROOF
The roof structure is made of wood and is installed before the start of the construction of the walls to allow protection during the rains. The roof of the structure can be in capim (straw), plastic or CGI (sheet).
The pitched are generally two, positioned against the main wind direction (East-West).

COATING - FINISHING
In case there is a filling in the interstices, the type of material used is related to the type of wall finish. For earth and reed type filling, the finishing used is a mixture of sand and clay based earth (called "saibro"). Using this dough, the durability of the walls can increase up to two years without maintenance; With a stone filling and debris, the most used finish is the type "revoco", a cement-based mixture.
The latter, when combined with isolated foundations, makes the walls more resistant, as it prevents moisture in wooden structures.
However, there is no fixed rule; In rural areas with dry seasons, dwellings may not have an external finish, consisting of a capim or reed coating ("canic").
Usually to test the quality of the clay it is used to make a ball and let it dry, to verify the presence or not of cracks. Cracks influence durability and resistance to moisture and rain.

VULNERABILITY
The destruction of the dwellings occurs mainly after the detachment of the roof, problem found particularly in the roofs in capim, as, with the introduction of a plastic layer, to avoid the infiltration of water, the structural connections between roof and roof structure are missing.

Cyclone vulnerability: Roof may risk to fly away.
Flood vulnerability: Plaster is washed away. Structure may resist to minor flooding.
Environmental vulnerability: Risk of deforestation with high number of houses to be built at the same time.

PROS
- Economic and fast construction (1-2 weeks);
- Requires local / neighbouring resources and traditional knowledge;
- Good resistance of the walls to the actions of the wind;
- Easy to repair when the finish is washed away in the part in contact with the ground;
- Easy recycling and use of materials;
- Good thermal insulation if capim roof.

CONS
- Poor durability due to the wooden structure (2 -3 years);
- Requires constant maintenance of walls and roofing (1-2 years);
- Capim roof: seasonal;
- Roof exposed to strong wind;
- Lack of structural connections between walls and roof;
- Fragile in humidity;
- The contraction of the clay during drying can lead to cracks.

(Figure 6) *bamboo sticks and mud house at the Mutua Resettlement Site.*
Photo by: Bernardo Almeida

(Figure 7) *A woman pats mud into the frame of the hut her family is building in the Mapupulu site for internally displaced people. Cabo Delgado province, Mozambique, April 2021.*
Photo by: TADEU ANDRE/MSF

Architectures and Materials | **Adobe construction system**


(Figure 8)


(Figure 9)


(Figure 10)

STRUCTURE - WALL
Typically rectangular shape.
The foundations and the basement of the Adobe manufacturing system are often made of concrete blocks (15 * 20 * 40 cm).The elevation structure is built with sun-dried blocks of earth (sand and clay) generally with dimensions 30 * 15 * 20 cm. It is a constructive system that needs materials easily available on the territory, therefore, in some cases can be considered a more economical and environmentally friendly system than the Pau-a-Pique.

ROOF
The roof structure is generally made of wood, forming two or four pitched. While, the cover can be straw (capim), plastic or sheet (CGI).

COATING - FINISHING
Also in this case the choice of the coating influence on the durability of the structure.
The use of clay-rich "saibro" soil can increase the life of walls up to two years, without maintenance.

VULNERABILITY
To reduce costs, often, the production of blocks takes place informally, under-dimensioning or gluing them irregularly, thus reducing the quality of the material and the strength of the entire structure.

Cyclone vulnerability: Roof may risk to fly away.
Flood vulnerability: House is washed away.
Environmental vulnerability: Reduced use of timber (mostly for roofing); Risk of deforestation with high number of house to be built at the same time.

PROS
- Economic and fast construction (1 - 2 week);
- Economical (about 15% less than Pau-a-pique due to the less use of poles);
- Requires local and neighbouring resources, traditional knowledge;
- Easy to recover when the ground at the bottom is washed away by rain / floods;
- Easy recycling and reuse of materials.

CONS
- Medium length construction (about 1 month) by moulding and hardening of bricks;
- The manufacture of bricks is linked to the season (not recommended during the rainy season);
- Poor durability in case of direct rain, requires constant maintenance;
- Wall and roof maintenance (every 1 - 2 years).

(Figure 8) *Palhota in adobe with a four-pitches straw roof and porches.*
Photo by: Roberta Nicchia

(Figure 9) *Detail of the porches.*
Photo by: Roberta Nicchia

(Figure 10) *A child next to his home, Mozambique.*
Photo by: Wilhan José Gomes on Pixabay

Architectures and Materials | **Cement Brick construction system**


(Figure 11)


(Figure 12)

STRUCTURE - WALL
Rectangular shape, whose foundations are made of concrete blocks (15 * 20 * 40 cm). The construction system is based on the use of concrete blocks and sand, the common dimensions of which are 40*20*20 cm, 40*20*15 cm and 40*20*10 cm.
Concrete blocks are appreciated for the durability and low maintenance required, compared to Pau-a-Pique.
Very rarely the structure is in reinforced concrete.

ROOF
Rarely the roofing structure is in reinforced concrete, while, very often a wooden structure is made to one or two pitched, which limits the attack with the wall in concrete blocks. The roof coverage is typically made of sheet metal (CGI).

VULNERABILITY
Construction systems in concrete blocks usually resist the impact of natural events (cyclones, floods, etc.) with the exception of the CGI roof. Mainly due to lack of sufficient anchorage to the roofing structure or perimeter structure of the building.
The cost for the realization is very high, therefore, in order to reduce the economic barrier, the families opt for the increase of the ratio number of blocks/cement mortar, or for the reduction of the dimensions of the blocks (also for those used for structural scopes). Lack of solid knowledge of bonding blocks and the use of cement mortar.

Cyclone vulnerability: Roof may risk to fly away.
Flood vulnerability: House is washed away.
Environmental vulnerability: Cement production has negative impact on environment.

PROS
- Construction system, resistant to cyclones and floods if properly built;
- Does not require regular maintenance;
- Fire resistant
- Reduced use of wood.

CONS
- Expensive system (if well built). Inaccessible in terms of the availability of materials and skills. Often use of insufficient materials;
- Thick concrete blocks of very poor quality due to the economic barrier;
- Poor skills for implementation;
- Long construction (1 month);
- Difficult to repair and/or rebuild;
- Poor connection between roof and structure in order to be resistant to cyclones.

(Figure 11) The Macuti street: Open space and social organization.
Photo by: Silje Erøy Sollien

(Figure 12) Concrete block house in Mutua.
Source: UNICEF

(Figure 13)

(Figure 14)


E.P.C - Macomia - Sede, aos 23.05.2019
Disciplina: Matemática
Tema: Introdução do número 5
Exercício
Cobre o tracejado

(Figure 15)

(Figure 16)

(Figure 17)

3.2.2. Tools and Methods application

Seasonal and Annual Calendar

The analyses carried out on the Maganja Da Costa district, through the Direct Observation, become a useful support for the development of Tools 4 and 5.
Respectively, the 4-seasonal calendar tool studies the current situation within the district, identifying the individual events that affect the communities, with a greater or lesser frequency (x= low; **x**= high; **X**= Heavy).
More specifically, in 2021 Maganja Da Costa encountered major problems on a socio-economic and health level due to the current pandemic and the conflicts that began in Cape Delgrade.
The current COVID-19 pandemic has resulted in increased risk to vulnerable society and displaced people, and has prompted people to migrate to South Africa or to be placed in reintegration sites that already host populations affected by the cyclone Idai occurred in 2019 [27].
In addition, about 1,200 displaced persons were reported in the province of Zambezia, fleeing the situation of insecurity in Cape Delgrade, in need of places to shelter, sources of income and access to drinking water [28].
In the same year, in October, cyclone Eloise struck the district, causing the displacement of about 270 families.
These flood events are not uncommon, often caused and intensified by tropical cyclones or torrential rains. In fact, as can be seen in the Tool 5 - annual calendar, there are many disasters related to water, including, very often, due to the vulnerable situation in which people live, diseases such as cholera or malaria arise.
These major diseases must be considered minor diseases including tuberculous and diarrhea.

Categories	Dic	Jen	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Causes
Socio-economic													
- Migration (In)						x							*COVID-19 lockdown*
- IDP	**x**	**x**	**x**	**x**						**X**	x	x	*Capo Delgrado conflict and COVID-19*
Environment													
- Rainfall period	**x**	**X**	**X**	**X**	**x**	**x**	x	x			x	x	
- Temperature	**X**	**X**	**X**	**X**	**x**	**x**	x	x	x	x	**x**	**x**	
- Wind speed	**X**	**X**	**X**	**X**	**x**	**x**	x	x	x	x	**x**	**x**	
Health													
- COVID-19	**x**	**x**	x	x	x	x	x	x	**x**	**X**	**X**	**X**	
Natural Hazard													
- Flood											**X**		*Cyclone Eloise*

< (Tool 4) Seasonal Calendar (2021)
(Community Involved/ Not Involved)

More Info:
The data found refer to the Zambezia region, obtaining among these those that most affected the Maganja Da Costa district.

(27) IOM's Displacement *Tracking Matrix Mozambique Covid-19, Preparedness assessment in the resettlement sites (In Manica, Sofala, Tete and Zambezia Provinces)*, April 2020.

(28) IOM's Displacement *Tracking Matrix Mozambique (2021), Baseline Assessment Round 12 (Capo Delgado, Nampula, Niassa, Sofala and Zambezia Provinces)*, April 2021.

(Tool 5) Annual Calendar (2020- 2021)
(Community Involved/Not Involved)

Hazard Type	Year	Impact	Causes	Source
Cyclon Eline	*2000*	*650.000 People affected*	-	I.
Flood	*2001*	*390.000 people affected, 70.000 displaced people, 41 death. A lot of school were used like shelter*	*Local Rain*	II.
Flood	*2003*	*98mila people affected, 47 death, 350 destroyed school, 3 Health center destroyed*	*Tropical depression "Delpina"*	III.
Cholera	*2003*	*12 death people*	*Flood due to Cyclon Delpina*	IV.
Cholera	*2006*	*782 cases*	-	IV.
Cyclone Flavio	*2007*	*285.000 people affected, 60.000 people displace, 29 death, 111 school destroyed 4 Health center*	*Heavy Rain*	VI.
Flood	*2008*	*81.445 displaced people, 30 death*	*Heavy Rain*	VII.
Malaria and Cholera	*2010*	*15.482 cases of Malaria and 2.683 cases of Cholera*	*Floods*	VIII.
Flood and Cyclone Dando	*2012*	*116.333 people affected, 40 death, 33 school destroyed*	*Tropical storm (Dando e Funso)*	IX.
Flood	*2014*	*575 families affected, 2844 people displaced, 2 school destroyed*	*Heavy Rain*	X.
Malaria	*2015*	*172 cases (90 children under 5)*	*Flood*	XI.
Flood	*2017*	-	-	XII.
Cyclone Idai	*2019*	*17.432 people affected, 10.512 displaced people, 10 death, 36 school destroyed, 2 Health center,*	-	XIII.
COVID -19	*2019*	-	-	XIV.
Flood	*2020*	-	*Heavy Rain*	XV.
Flood	*2021*	*270 displaced family*	*Heavy Rain due to Cyclone Eloise*	XVI.

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II. Mozambique News Agency (AIM). (2001, February 21). Mozambique: Appeal for victims of floods in central provinces. Reliefweb. www.reliefweb.int

III. UN Office for the Coordination of Humanitarian Affairs 2003. (2003, Jan 9). Mozambique: Flood isolates northern areas as food stocks run low. Reliefweb. www.reliefweb.int

IV. Thomson Reuters Foundation. (2003, Jan 27). Cholera outbreak kills 12 in flood-hit Mozambique. Reliefweb. www.reliefweb.int

V. IFRC. (2007, Jan 30). Mozambique: Floods and Cyclones: DREF Bulletin no. Reliefweb. www.reliefweb.int

VI. Thomson Reuters Foundation. (2007, Feb 9). Mozambique considers aid appeal as floods worsen. Reliefweb. www.reliefweb.int

VII. UNOSAT. (2008, Jan 18). Flood Waters over the Affected Districts of Namacurra & Maganja da Costa, Zambezia Province, Mozambique.

VIII. The New Humanitarian. (2010, Mar 15). MOZAMBIQUE: Floods could aggravate seasonal cholera. Reliefweb. www.reliefweb.int

IX. World Food Programme. (2012, Feb 1). WFP To Feed 83,000 People In Flood-Hit Mozambique. Reliefweb. www.reliefweb.int

X. AIM. (2014, Feb 24). Flooding displaces hundreds in Zambezia. Reliefweb. www.reliefweb.int

XI. UNICEF. (2015, Feb 4). Mozambique floods: Malaria major concern in displacement centres. Reliefweb. www.reliefweb.int

XII. UNOSAT. (2017, Feb 6). Satellite Detected Surface Waters Extent and Evolution around Chimuara and Caia, Zambezia province, Mozambique (Imagery analysis: 05 February 2017 | Published 6 February 2017 | Version 1.0). Reliefweb. www.reliefweb.int

XIII. OCHA. (2019, Mar 16). Mozambique: Cyclone Idai Flash Update No. 2, 16 March 2019. Reliefweb. www.reliefweb.int

XIV. IOM. (2020, Apr 24). Displacement Tracking Matrix - Mozambique COVID-19 Preparedness Assessment in the Resettlement Sites in Manica, Sofala, Tete and Zambezia Provinces (April 2020). Reliefweb. www.reliefweb.int

XV. OCHA. (2020, Jan 21). Mozambique: Heavy rains and flooding Flash Update No. 1. Reliefweb. www.reliefweb.int

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Ranking Method and Identification of Hazards Outcomes

Ranking Method

The next step outlines the use of the first methodology (Ranking Method) useful for summarizing the main problems affecting the project site, classifying them in descending order. As is clearly visible from the previous tools used, floods are the dangers that occur with greater frequency and cause a greater impact in terms of displaced people, deaths, houses destroyed. This, like the other dangers encountered (without neglecting those identified in direct observation and in the seasonal calendar) are reasons for insecurity, destruction, inaccessibility and removal from school infrastructures.
This methodology is a decision-making tool on which the subsequent design process is based, namely the choice and use of the Hazards-Matrix developed.

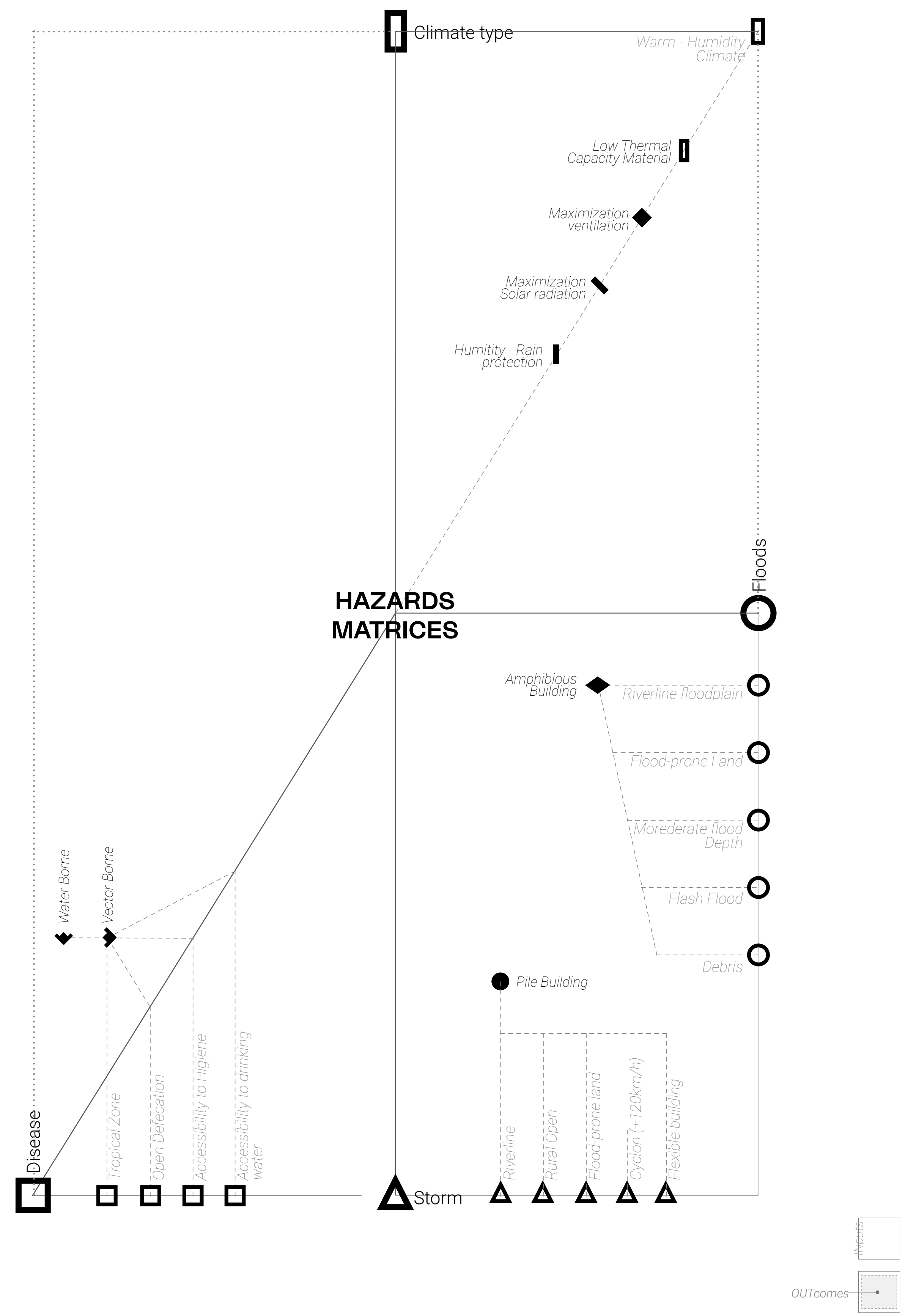
Type of Hazard	Frequency (2000 - 2021)	Rank
Flood	8	1°
Tropical Cyclon	6	2°
Disease	5	3°

< (Method 1) Ranking
(Community Involved/ Not Involved)

Outcomes Individuation of the Hazards-Matrices

The graph on the opposite page contains all the dangers present in the study site, to which the various problems (Input) obtained from the observation of the single matrices developed in the previous chapter are associated, with the ultimate aim of identifying the outcomes (architectural needs) to be taken into consideration for the subsequent project development.
The problems that limit the access, equity and quality of educational infrastructures are linked to disastrous natural events and social disparities, therefore, from the observation of the individual hazards-matrices (from which the outcomes are derived) identified through the Ranking Method , it can be said that the natural hazards that could compromise the education system are: floods, storms and disease. The first two suggest that the resilient architectural solution, which best suits quiet and flood situations, is the Amphibious building. Floods and storms define different architectural needs originating from the hot and humid climatic context; finally, in order to guarantee a safe educational structure, it is evident, both from the previous study and from the observation of the disease matrix, that the need is also to provide resilient architectural solutions to the main pathologies present in the place of study, such as water borne and vector borne disease.

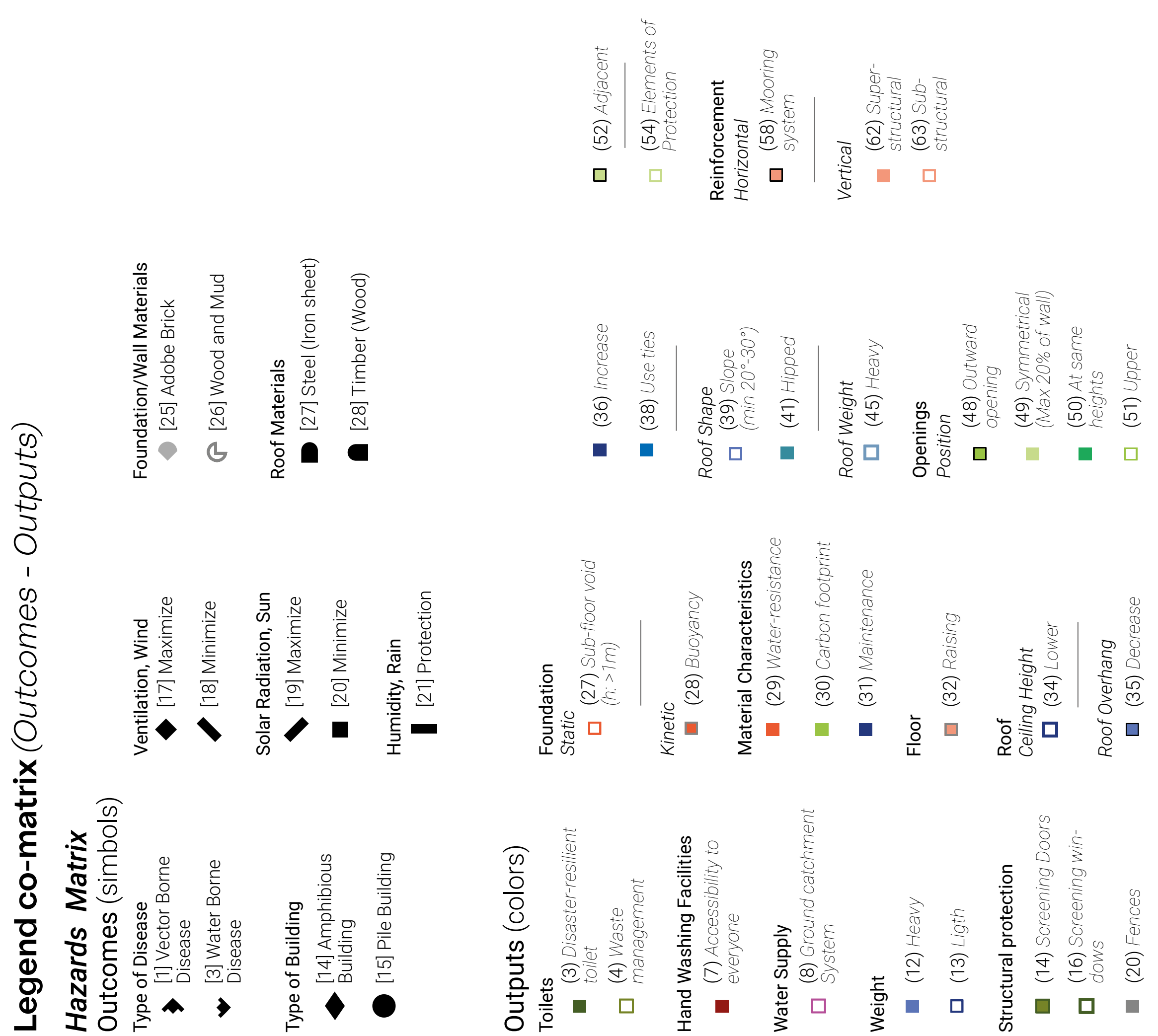
(Tool 7) The Matrix - Searching the Outcomes
(Community Not Involved)



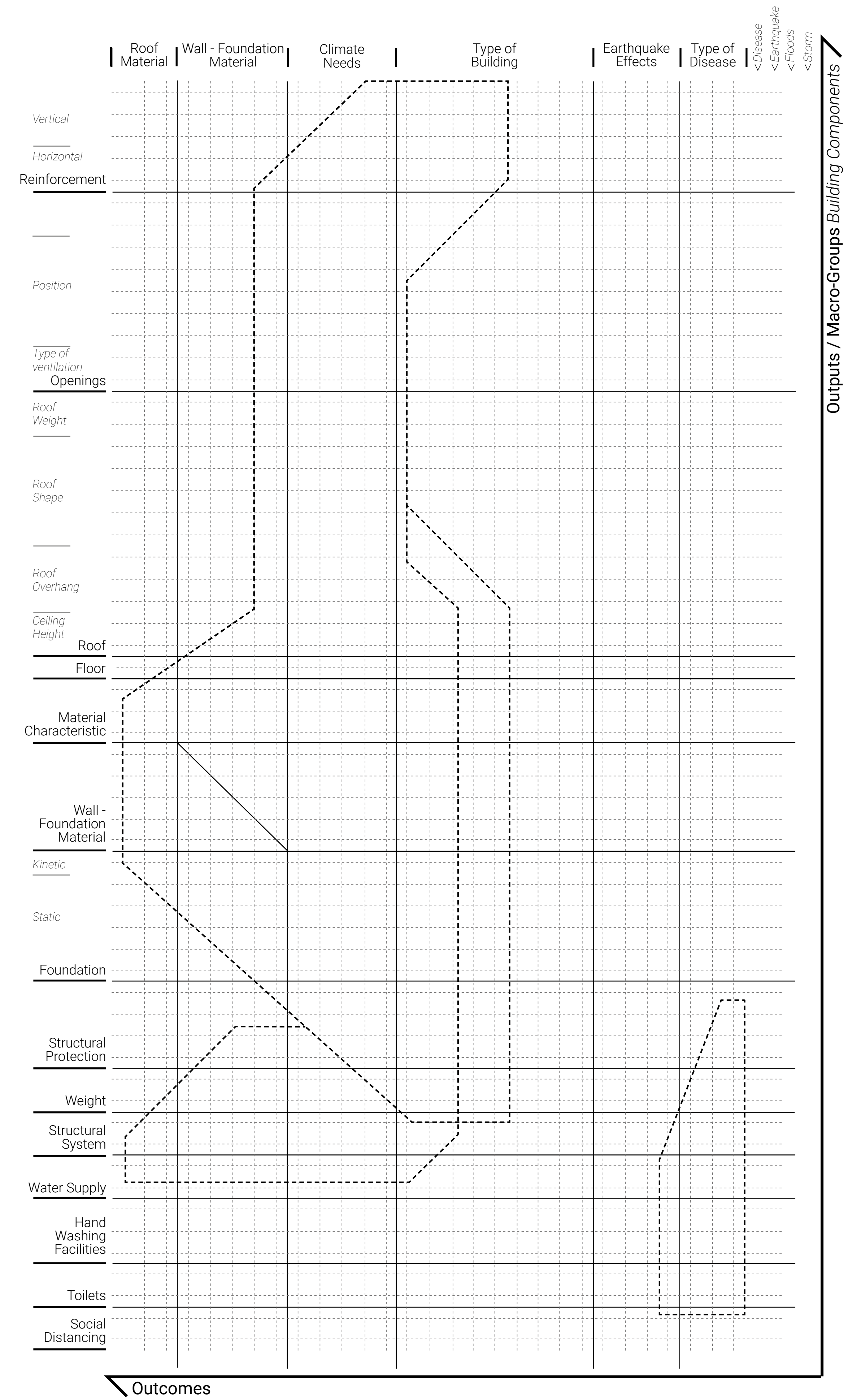
Solutions Compared Method

The identification of the most frequent danger and of the single outcomes support the development of the second method (Solutions compared) which consists in comparing the possible solutions, according to the outputs of each single selected Hazards-matrix, and to the prevalence of a matrix over the other (see explanation in the previous chapter).
In fact, as explained in the ranking method, below the overlapping of the Hazards matrix, puts floods in the foreground, whose solutions will have priority over the following ones.

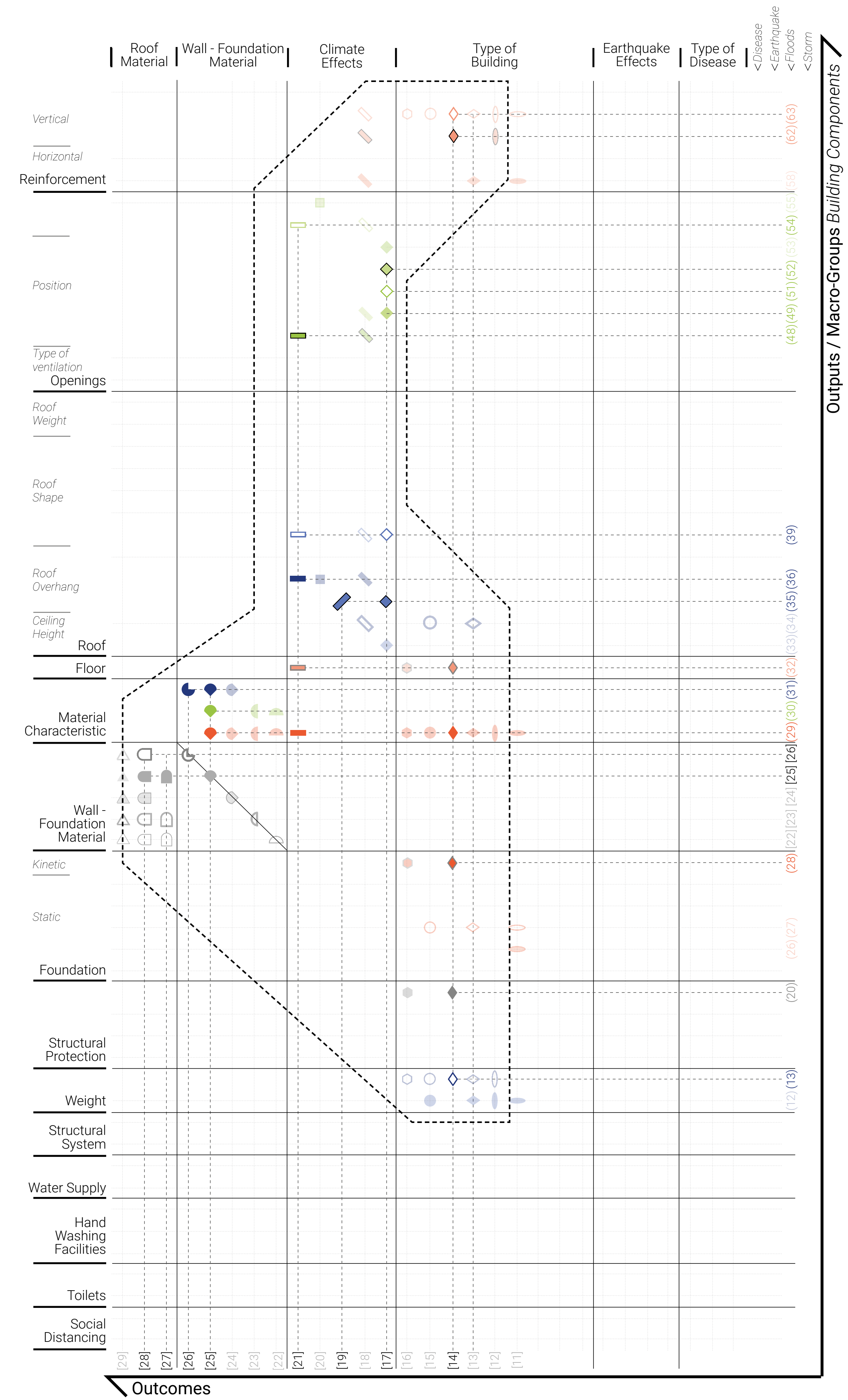
(Method 2) Solutions compared
(Community Not Involved)
>



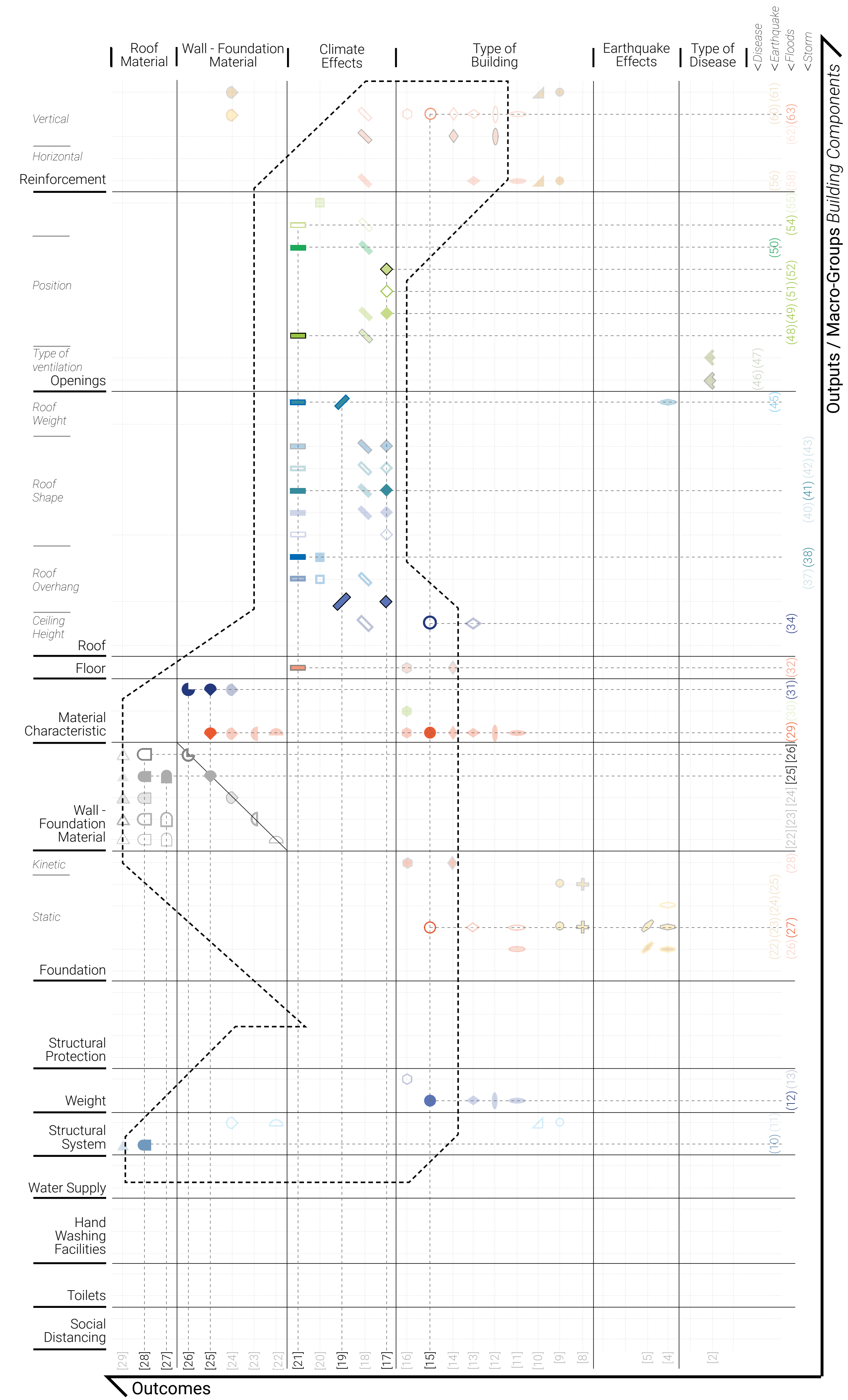
Axis and 2d Space



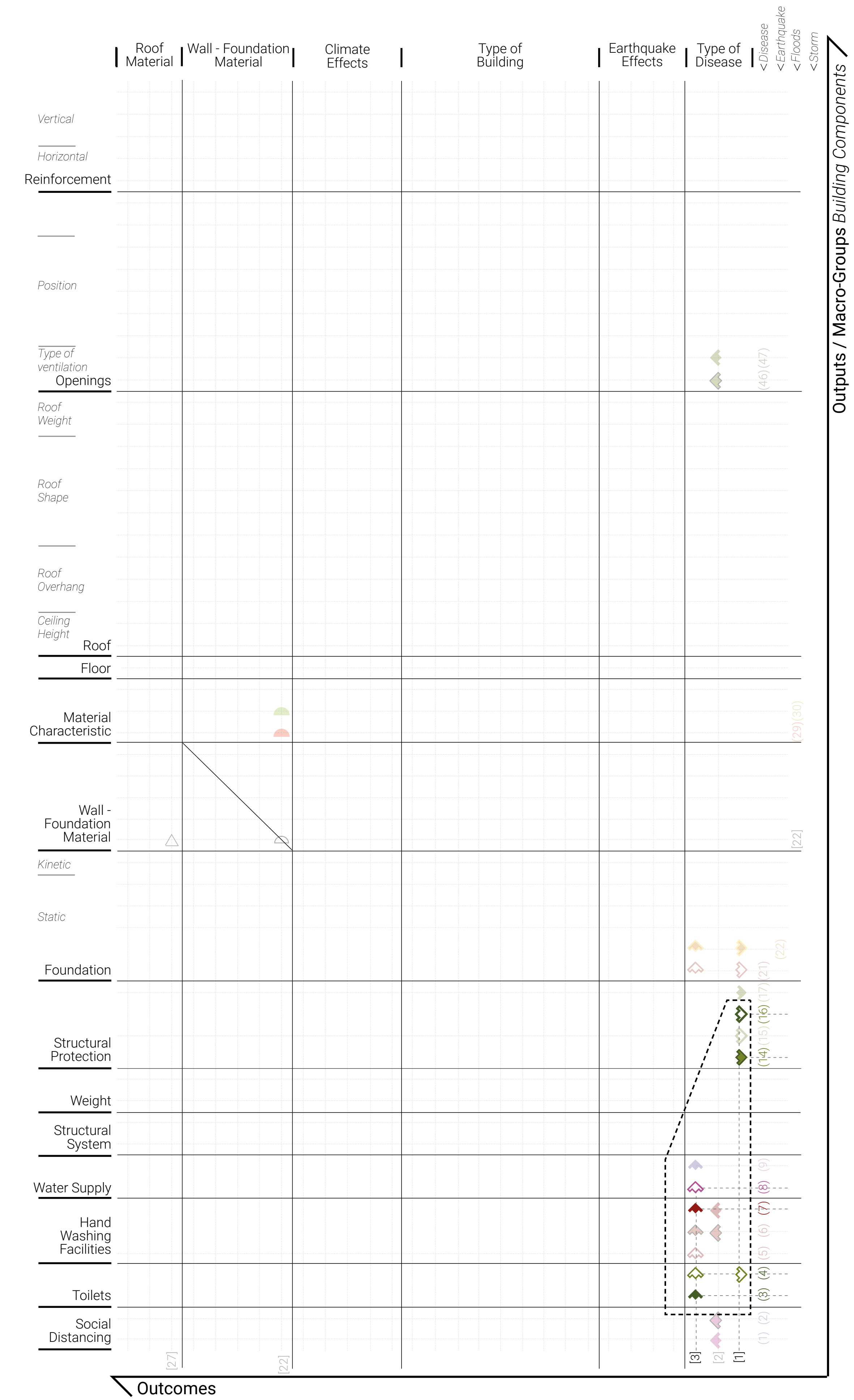
Space 2d: 1° - Floods



Space 2d: 2° -Storm

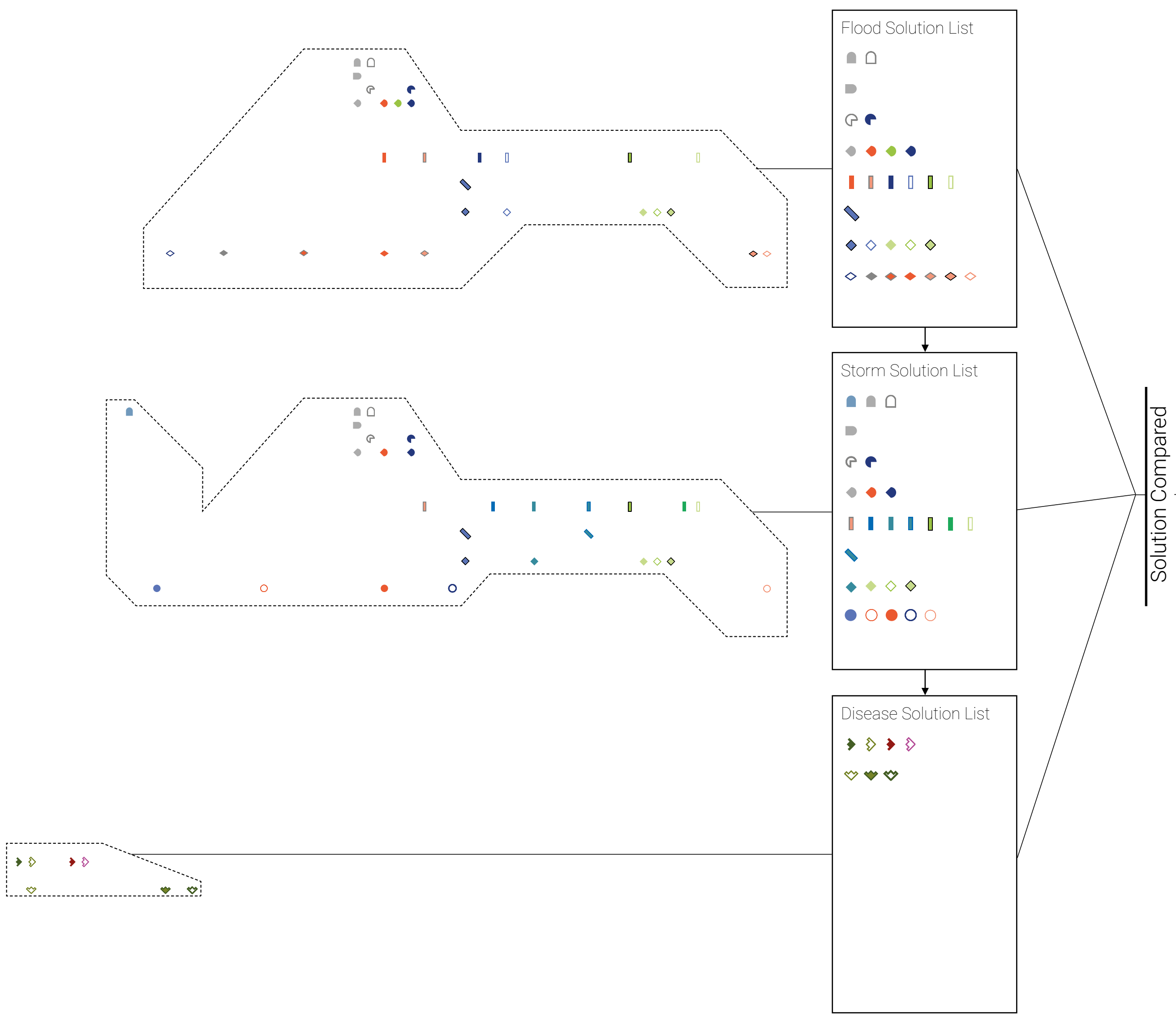


Space 2d: 3° -Disease



To simplify the understanding of the solutions compared method, a graphic example divided into steps is developed below:

- *The First step* is to work on the individual Hazards matrices, from which to derive lists of specific solutions for each problem;
- *The Second step* consists in comparing the solutions of the macro-groups of each individual Hazard Matrix, identifying the one that best suits the context, remembering the prevalence of one matrix over the other.



(Method 2) Solutions compared and List

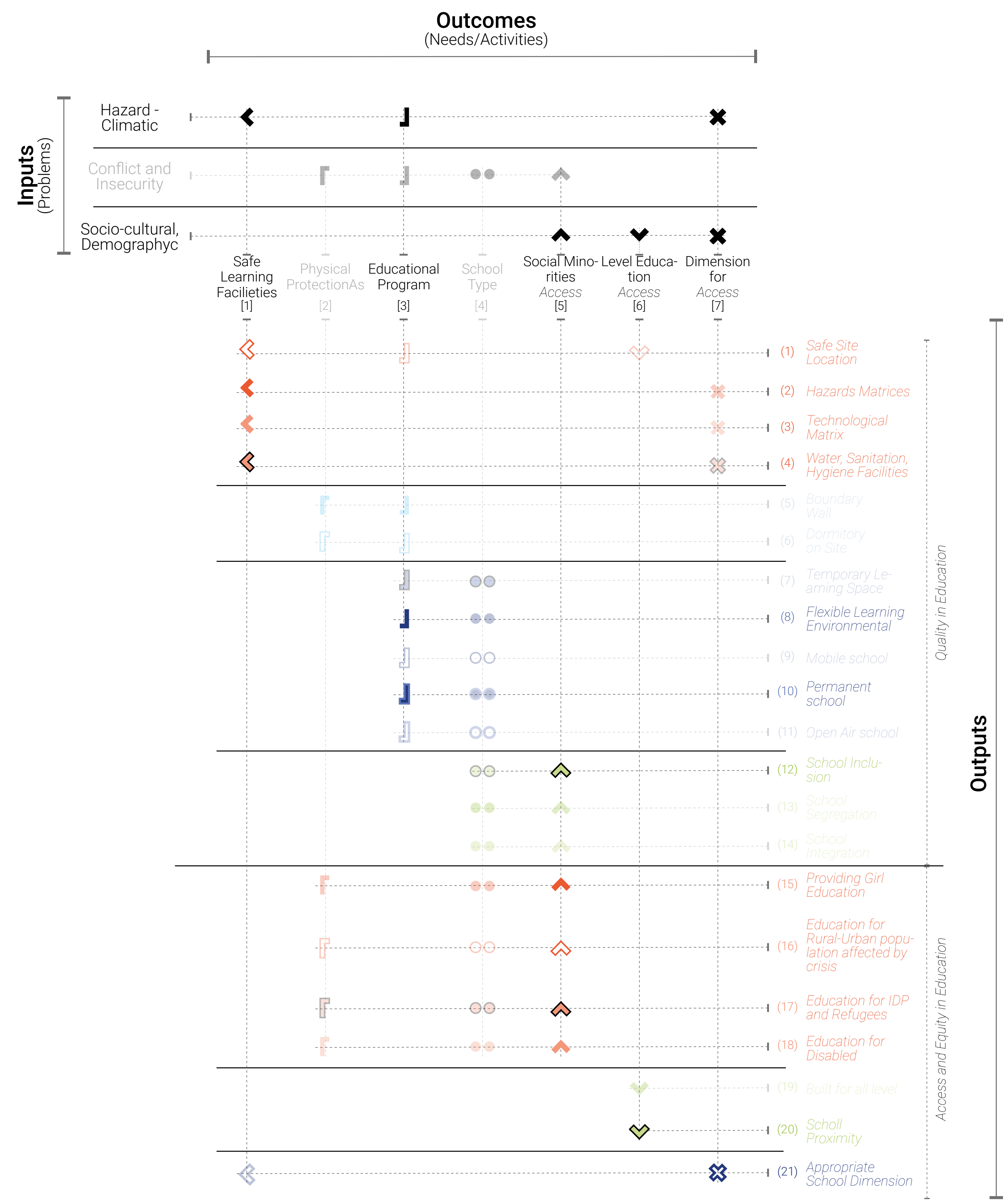
	OUTCOMES	OUTPUTS	MACRO-GROUPS
Hazards Matrix (Flood - Storm - Disease)	[1]	(4)	Toilets
	[3]	(3) (4)	
		(7)	Hand Washing Facilities
		(8)	Water Supply
	[14]	(13)	Weight
	[1]	(14) (16)	Structural protection
	[14]	(20)	
		(28)	Foundation
	[27]	[27]	Materials
	[28]	[27] [26]	
	[25]	(29) (30) (31)	Material Characteristics
	[26]	(31)	
	[14]	(32)	Floor
		(34)	Roof
	[17]	(35) (38)	
		(39) (41) (45)	
	[19]	(35) (45)	
	[21]	(39) (41)	
	[17]	(48) (49) (50)	Openings
		(52)	
	[21]	(48) (54)	
	[14]	(58) (62) (63)	Reinforcement

Outputs of Education Matrix

The issues that limit the access, equity and quality of educational infrastructures are linked both to disastrous natural events, but also to social disparities, to the practices of management, planning or implementation of educational systems. It is therefore important to fulfil physiological and safety needs, such as liveability, privacy, adequacy of spaces, thermal comfort and accessibility to sanitary facilities.
The education matrix helps us to set the key actions for the design or improvement of educational services, with the aim of increasing accessibility to safe and equitable learning opportunities and increasing resistance to natural or man-made hazards that the education sector faces.

From the observation of the education matrix we can derive the needs (outcomes) and the possible actions to be carried out (outputs) in relation to the identified problems (Hazard-Climatic and Socio-cultural, demography problems) in Baixo Licungo. The needs and actions for good planning are: provide for a safe place, far from any discrimination of gender or origin, that is easily accessible and that has the right size to accommodate the many students who, due to lack of school infrastructure, require the access to the second level.

(Tool 7) The Matrix (Education Matrix)
(Community Not Involved)



3.2.3. The Solutions of the Co-Matrix

First List of Possible Solutions

The tools and methodologies used provide us with all the possible solutions and therefore possible actions, of each design feature, to be implemented in the context of Baixo Licungo.

These solutions are included in a list, divided into macro-groups to which they belong, both to speed up reading and to simplify, at a later stage, the identification of solutions to be improved or expanded.

Legend - Education Matrix

Outcomes (simbols)

- [1] Safe Learning Facilieties
- [3] Educational Program
- [5] Social Minorities Access
- [6] Level Education Access
- [7] Dimension for Access

Outputs (colors)

Quality in Education
- (1) *Safe Site Location*
- (4) *Water, Sanitation, Hygiene Facilities*
- (5) *Boundary Wall*
- (8) *Flexible Learning Envirnmenal*
- (10) *Permanent School*
- (12) *School Inclusion*

Access and Equity in Education
- (15) *Providing Girl Education*
- (16) *Education for Rural-Urban*
- (19) *School Proximity*
- (21) *Appropriate School Dimension*

Legend - Hazards Matrix

Outcomes (simbols)

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

Type of Building
- [13] Elevated Static Building
- [14] Amphibious Building

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

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

Humidity, Rain
- [21] Protection

Foundation/Wall Materials
- [25] Adobe Brick
- [26] Wood and Mud

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

Outputs (colors)

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

Hand Washing Facilities
- (7) *Accessibility to everyone*

Water Supply
- (8) *Ground catchment System*

Weight
- (12) *Heavy*
- (13) *Ligth*

Structural protection
- (14) *Screening Doors*
- (16) *Screening windows*
- (20) *Fences*

Foundation

Kinetic
- (28) *Buouyancy*

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

Floor
- (32) *Raising*

Roof

Ceiling Height
- (34) *Lower*

Roof Overhang
- (35) *Decrease*
- (36) *Increase*
- (38) *Use ties*

Roof Shape
- (39) *Slope (min 20°-30°)*
- (41) *Hipped*

Roof Weight
- (45) *Heavy*

Openings

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

Reinforcement

Horizontal
- (58) *Mooring system*

Vertical
- (62) *Super-structural*
- (63) *Sub-structural*

1° List of Possible Solutions
(Community Not Involved)

MATRIX TYPE	OUTCOMES	OUTPUTS	MACRO-GROUPS
Education Matrix	[1]	(1) (4)	Quality in Education
	[3]	(8) (10)	
	[5]	(12)	Access and Equity in Education
		(15) (16)	
	[6]	(19)	
	[7]	(21)	
Hazards Matrix (Flood - Storm - Disease)	[1]	(4)	Toilets
	[3]	(3) (4)	
		(7)	Hand Washing Facilities
		(8)	Water Supply
	[14]	(13)	Weight
	[1]	(14) (16)	Structural protection
	[14]	(20)	
		(28)	Foundation
	[27]	[27]	Materials
	[28]	[27] [26]	
	[25]	(29) (30) (31)	Material Characteristics
	[26]	(31)	
	[14]	(32)	Floor
		(34)	Roof
	[17]	(35) (38)	
		(39) (41) (45)	
	[19]	(35) (45)	
	[21]	(39) (41)	
	[17]	(48) (49) (50)	Openings
		(52)	
	[21]	(48) (54)	
	[14]	(58) (62) (63)	Reinforcement

Community Needs and Coping Strategies

As anticipated in the previous chapter, the first solutions obtained adapt to global contexts, without going into the specific needs and capabilities of the study community. Therefore, in this last design phase, it is necessary to reorganize the information, previously identified in the first phase of analysis, on the needs, skills and economic, material and technical resources.
With respect to the first list of solutions, these observations are useful for a final critical development of the project actions, which can be really applied in the study context, for the creation of a resilient and resistant school, reducing its vulnerabilities..
Since only first-level educational infrastructures are present within the study area, or in areas adjacent to Baixo Licungo, the main need to be taken into consideration is to develop a second-level educational building, which is easily reachable on foot from the community and where the classes are inclusive in order not to create gender and age imbalances.

Due to the lack of state funds, for the construction of conventional structures, very often the communities, to compensate for this lack, realize informal educational structures, with local materials and construction techniques. We therefore use these skills to design an informal school to complement the existing primary school, to be able to share common outdoor spaces and sanitary facilities, create greater social cohesion and allow easy transition from one educational level to another.

A further need concerns the health system. In fact, within the district the percentage of people who still do not have access to water sources and quality sanitation is very high, increasing the risk of easily transmitted diseases. Therefore, disaster-resistant sanitary facilities and rainwater collection systems placed underground are envisaged.

Finally, the solutions identified in the first list, concerning the architectural characteristics, are expanded through the use of comping strategies, to make the educational structure resilient to dangers. These coping strategies concern the position and volumetric shape of the building and the construction techniques related to the materials chosen.

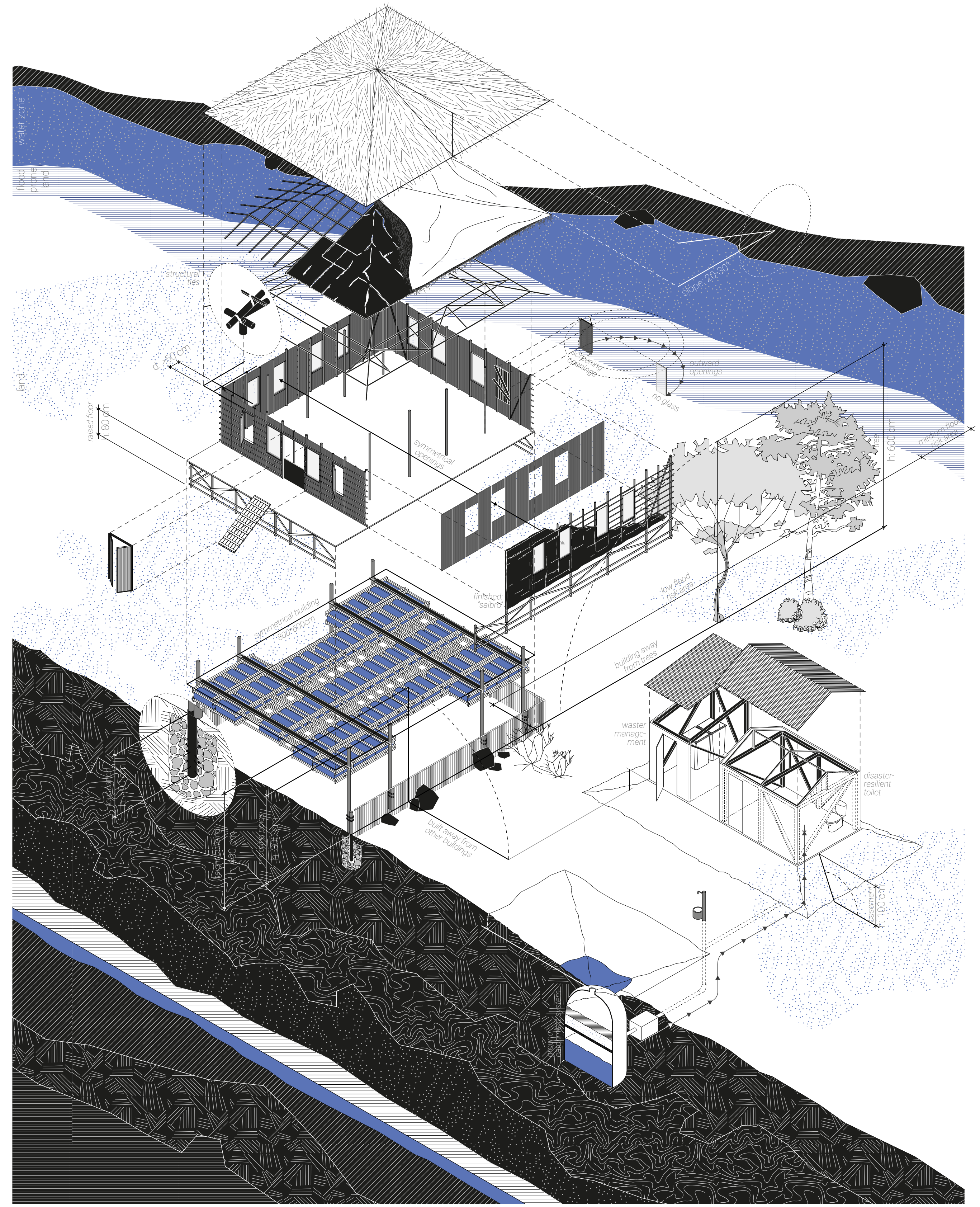
Implementation of Solutions
(Community Involved)

MACRO-GROUPS	NEEDS	COPING STRATEGIES	INFORMAL BUILT CHARACTERISTICS
Quality in Education	*Resilient school to hazards and conflict (insecurity)* *Adult school for the elimination of illiteracy*	Symmetrical Building Shape: better resistance to Wind; Build away from trees and other construction as they could fall when wind.	
Access and Equity in Education	*Equity (no age division, no gender division)* *Built for second level (ESG I)* *Reduce travel time to reach services*	Symmetrical Building Shape: better resistance to Wind (rectangular square)	Construction of an informal building next to a conventional one to have the outdoor spaces in common.
Toilets	*Waste management* *No open defecation*		
Hand Washing Facilities	*Accessibility water*		
Water Supply	*Accessibility to drinking water*		
Weight			
Foundation		Deep foundations (60-90 cm); Wooden posts reinforced with nails and waterproofed.	
Materials	*Reduce the illegal use of natural resource*	- Galvanized sheet (CGI) for roof covering; - Timber roof: Weight it with wooden planks. Mix of earth and straw with a plastic sheet to weigh it down and isolate it. Fasten the structure to the walls with straps or ropes	Architectural typology Pau-a-pique (local material); Wooden roof structure with capim cover;
Material Characteristics		Finished with clay and sand mixture ("Saibro").	
Floor			
Roof		Apply Braces Roof Shape: 2 - 4 slopes (> 30 °) Veranda detached from the roof structure Fasten the cover to the structure with nails and straps for the wall	
Openings		Position: Symmetrical openings for better resistance to wind Replace the glazed elements with less fragile materials Reinforcement element for windows and doors	
Reinforcement			

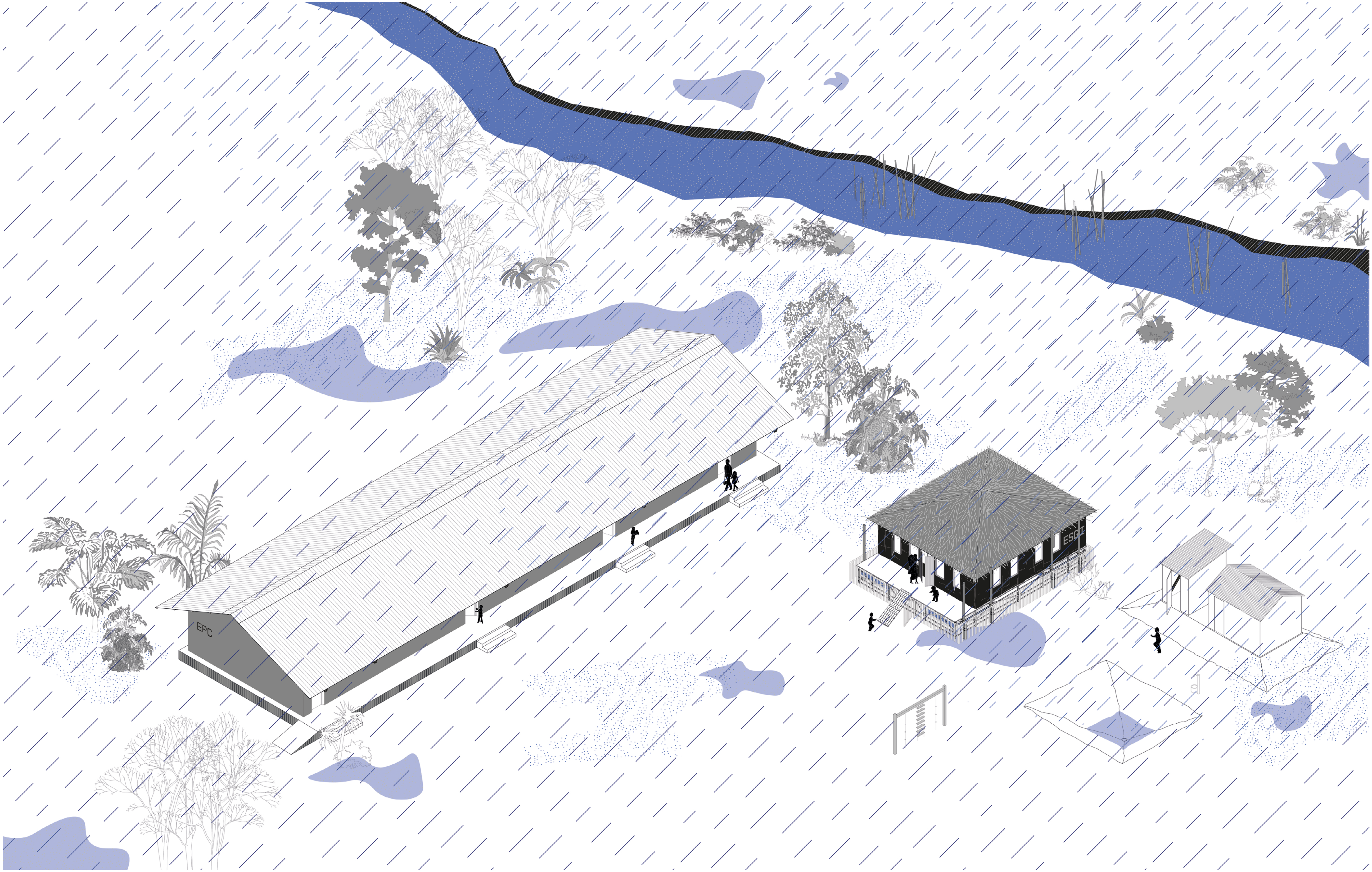
3.2.3. A Resilient-Resistant School

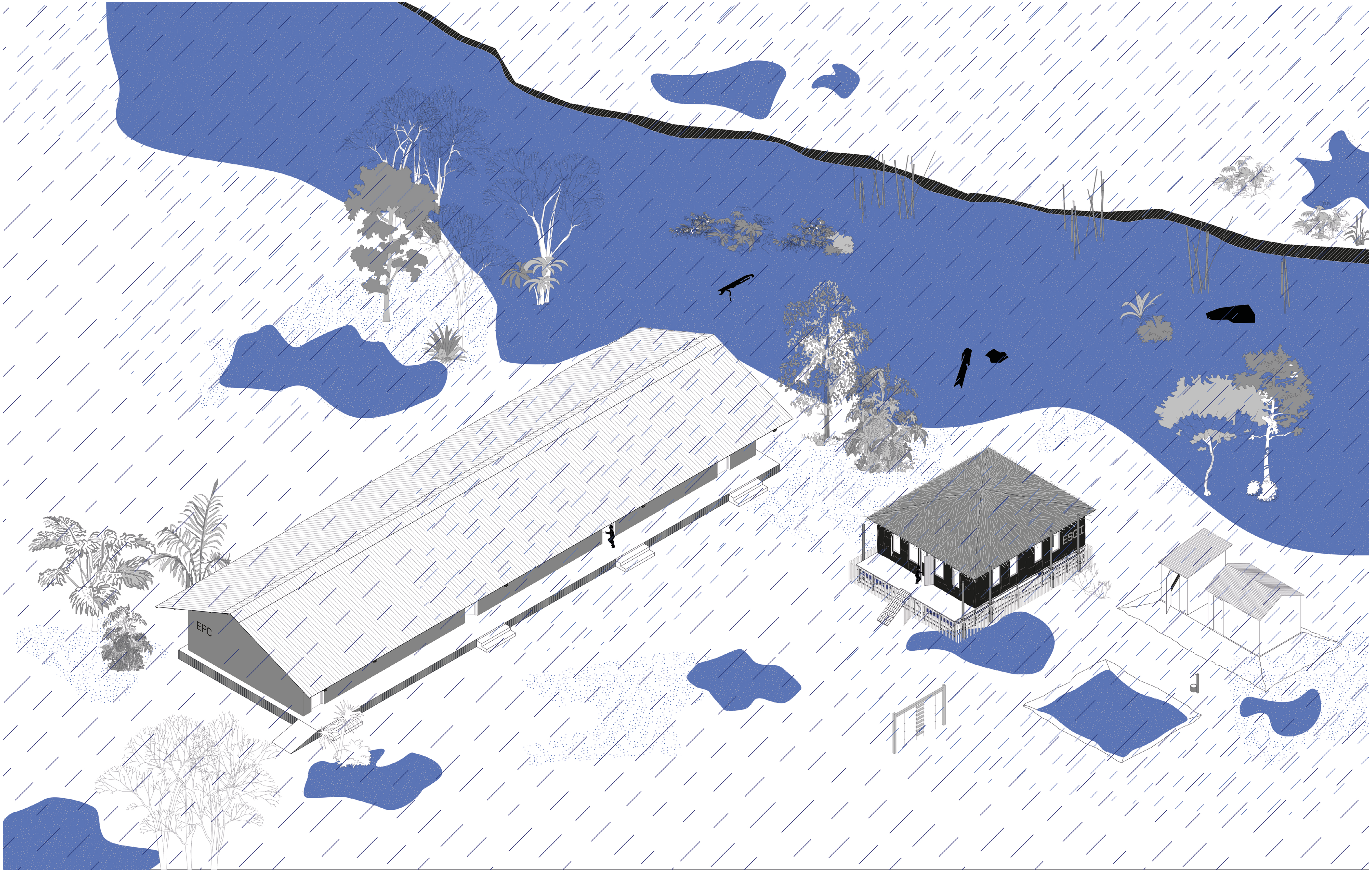
Final List of Possible Solutions
(Community Involved)

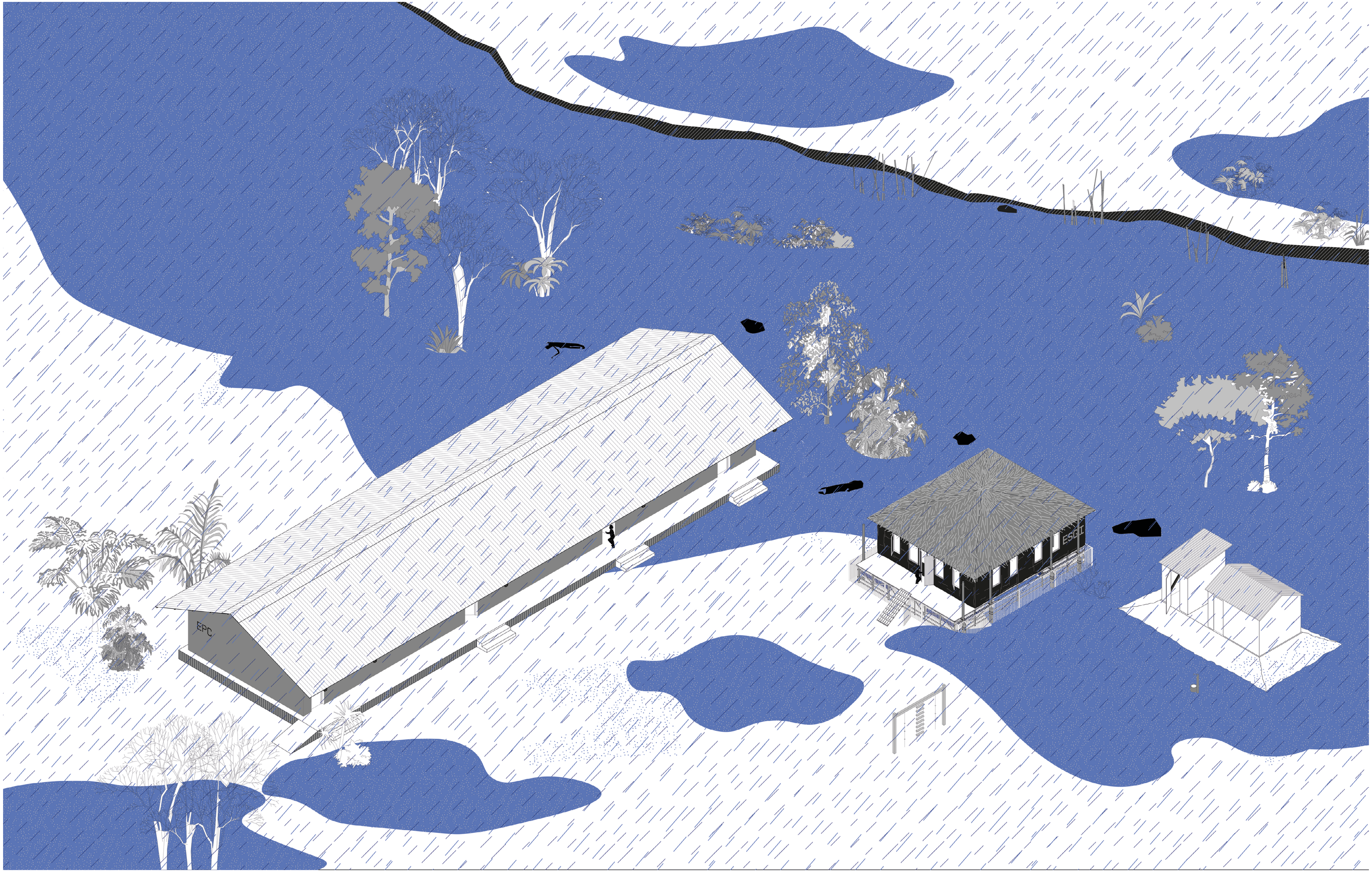
Quality in Education	*- Safe Site Location; - Water, sanitation, hygiene Facilities; - Symmetricaal building shape: better resistance to wind; - Built away from trees and others constructions as they could fall when wind; -Flexible learning environment (organize lessons to allow access at different times or days for those who need them); - Permanent school; - School inclusion (no age, gender division).*
Access and Equity in Education	*- Equity (no ages, gender, rural-urban division) - School proximity: reduce the travel time to reach services; construction of an Informal school next to a conventional one to have the outdoor spaces in common;Built for second level (ESG I) - Appropriate school dimention (7*6 m)*
Type of Building	*- Amphibious building - Pau-a-pique*
Toilets	*- Disaster-resilient toilet (no open defecation) - Waste Management*
Hand Washing Facilities	*- Accessibility to everyone*
Water Supply	*- Ground catchment system*
Weight	*- Light structure to allow lifting in case of flood*
Structural protection	*- Screening doors and window for vector borne disease - Use fences to prevent the accumulation of debris under the structure*
Foundation	*- Base structure with Buoyancy and subfloor void to avoid direct contact with the ground. - Mooring poles anchored in the ground: deep foundation (90 cm), with wooden posts reinforced with nails and plastic sheet for waterproofing*
Materials	*- Wood and mud - Wooden roof structure with capim cover*
Material Characteristics	*- Finishing with clay and sand mixture ("saibro"), for water resistant walls*
Floor	*- Raising the floor to prevent water infiltration from the floor*
Roof	*- Low ceiling height to avoid strong winds - Roof overhang lower: max 50 cm - Fasten the covering to the structure with nails and staps for the walls - Hipped roof with 4 slope (20-30°) - Heavy roof: weight it with wooden planks. Mix of earth and straw with a plastic sheet to weigh it down and isolate it.*
Openings	*- Do not use glass for windows, to avoid brittle breakage and damage to pupils - Outward openings to limit wind pressure and prevent it from entering the structure - Symmetrical, adjacent and at the same heights openings for better resistance to wind and allow good ventilation inside the structure - Use elements of protection for wind and doors to prevent the entry of wind and water inside the structure*
Reinforcement	*- Use mooring system in order not to allow the horizontal movement of the structure, given by the force of the water - structural reinforcements for super structure (roof, walls) and for sub-structure (foundation and basement)*




Conventional School
800*700cm
Informal School
700*600cm
EPC
ESGI
building away from other buildings
h: 400 cm
building away from other buildings
h: 450 cm
Space in common
water zone
flood prone land
land


EPC
ESC


EPC
ESG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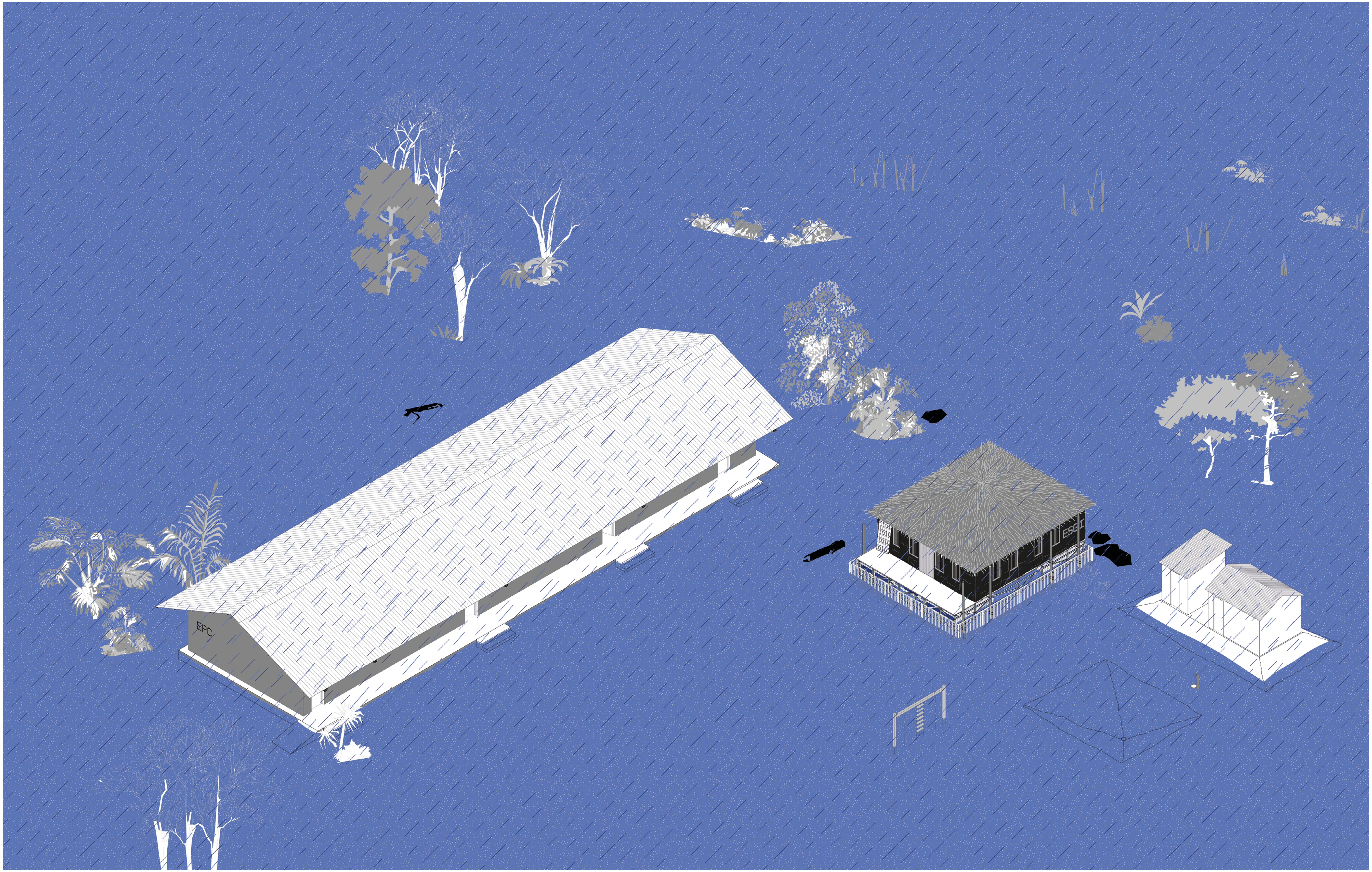
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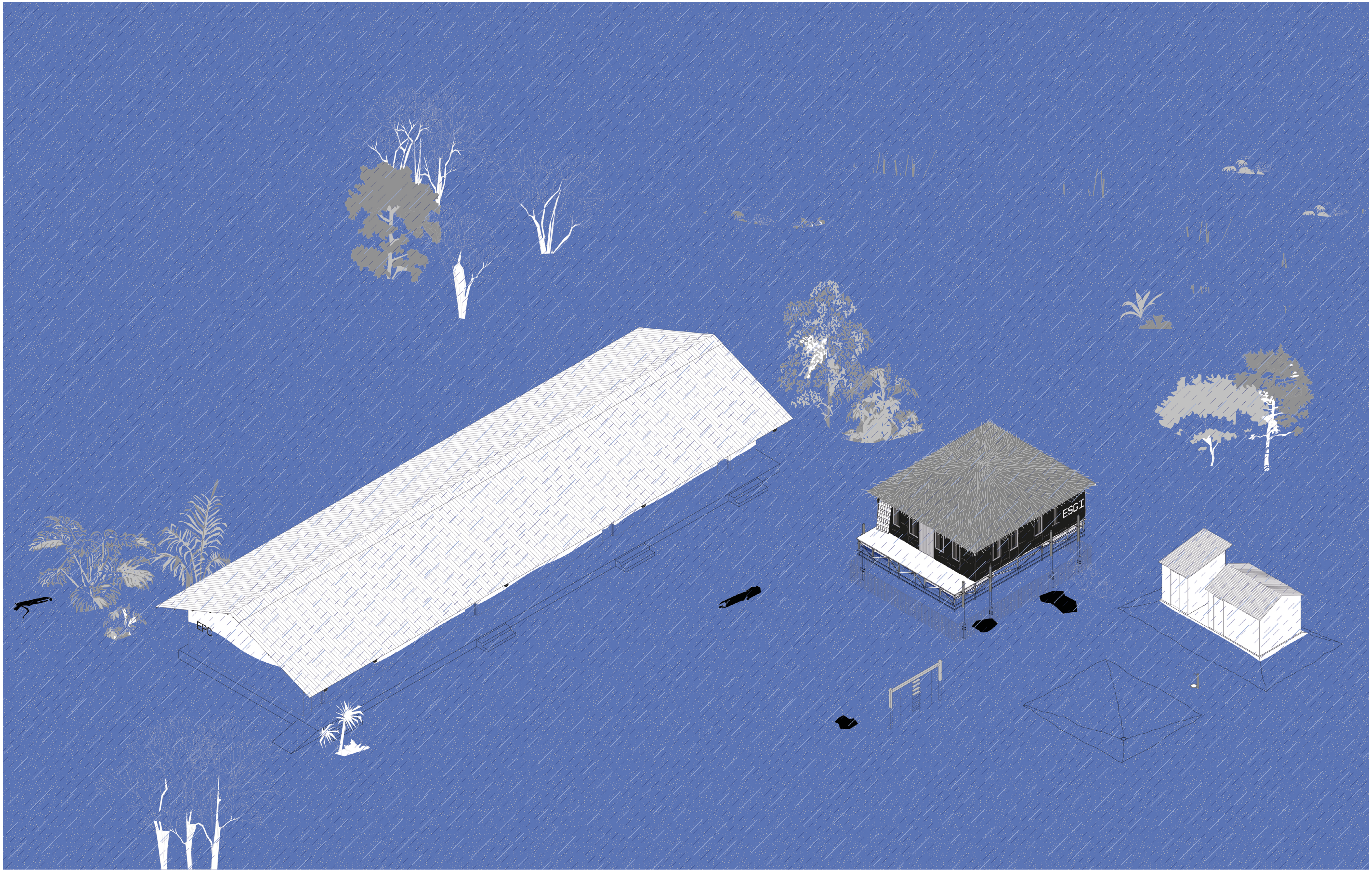
EPC
ESGI

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