

POST-DISASTER CONSTRUCTION WASTE MANAGEMENT STRATEGIES: CASE STUDY CANTERBURY EARTHQUAKE

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ABSTRACT

Natural disasters generate enormous amounts of waste, which adversely impacts on public health and the environment. The increasing number of natural disasters has made post-disaster construction and demolition (C&D) waste management a crucial component of disaster recovery. This became apparent in New Zealand after the Canterbury region suffered enormously from the 2010 and 2011 earthquakes. The East Coast City of Christchurch was severely affected, with the resulting demolition of around 1,400 commercial properties and 7,500 residential properties. It was estimated that this generated approximately 4 million tonnes of debris and probably more than a million tonnes from repairs. The government-appointed Canterbury Earthquake Recovery Authority (CERA) led and coordinated the recovery effort, including post-disaster C&D waste management. This paper reflects on the post-earthquake C&D waste management processes and their limitations, and makes recommendations to improve operations in future disasters. In-depth semi-structured interviews were conducted with government and non-government organisations involved with C&D waste management, including CERA and accredited demolition contractors.

Findings revealed that the “pick and go” strategy introduced by CERA was very effective, as it directed debris straight into the end-use market. This study identified a number of limitations in the current C&D waste management process, such as lack of pre-event planning; poor coordination between local authorities and contractors during the recovery, incomplete policies and acts, and insufficient capacity in C&D waste facilities to process waste. The findings from this research contribute to a growing body of literature on Post-disaster C&D waste management. This paper recommends the creation of a powerful organisation with a clear responsibility and goal to fully control waste management in future disasters in New Zealand.

Keywords: construction and demolition waste, post-disaster construction, waste management strategies, Canterbury earthquake

INTRODUCTION

Disaster occurs in many forms, natural and man-made including “sudden

onset” such as earthquake, fire, flood, tsunami, hurricane and volcano, or “prolonged onset”, for instance civil conflict or drought (Brown, Mike and Seville, 2011). Most disasters overwhelm the capacity of the affected regions to react to them in an appropriate way to save people, to protect property and to maintain the social and economic stability of these regions. In some cases, debris volumes from a single event are five to fifteen times greater than the waste generated by affected regions in normal situations (Reinhart & McCreanor, 1999). As urbanisation and complex infrastructure increases, the community becomes more vulnerable to such disasters (Brown, et al., 2011). Karunasena, Amaratunga, and Haigh (2012) stated that during a post-disaster situation, the types and volumes of waste generated change drastically. Hence, post-disaster C&D waste management is one of the most crucial activities during the recovery period (Karunasena, Rameezdeen and Amarathunga, 2013). The C&D waste generated by an earthquake can impede emergency services and pose an adverse public and environmental health local impact. Consequently, both short-term and long-term recovery could suffer, due to inappropriate and poor post-disaster C&D waste management.

In September 2010 and February 2011, the Canterbury region of New Zealand experienced massive earthquakes. According to government statistics, 1,400 commercial properties and at least 7,500 residential properties needed demolition. It was estimated that approximately 4 million tonnes of debris was generated by the demolition and reconstruction work and probably more than million tonnes from reparation activity (Mike, 2011). In addition to that, more than five hundred thousand tonnes of liquefaction silt needed disposing of after the earthquake (C.C.Council, 2012). The debris from many buildings (commercial and residential properties) needs special handling. Earthquakes cause significant damage and put more social, environmental and economic burdens on living conditions, recovery and waste collection processes. In recent decades, New Zealand has been more prone to natural disasters, mainly earthquakes and tornados. Therefore, effective post-disaster C&D management has become a critical issue in responding to a disaster.

This paper aims to investigate the post-earthquake C&D waste management process implemented in Christchurch, and present recommendations to improve limitations in existing practices.

POST DISASTER WASTE MANAGEMENT STRATEGIES

Suitable and sustainable waste management could minimise the generation of waste, and encourage the reuse, recycling and recovery of waste. Different authors have classified C&D waste from a disaster using different

approaches. For instance, Karunasena, Amaratunga, and Haigh (2009) categorised C&D waste according to types of material. Canterbury Earthquake Recovery Authority (CERA) came up with a broader categorisation than the above and categorised all waste into four major categories: clean-fill materials; sorted materials; hazardous materials and mixed materials.

The generation of C&D waste is not avoidable after a disaster. Normally, disaster debris management will start immediately following a disaster and last throughout, until completion of reconstruction (Pike, 2007). The majority of the published research has focused on pre-disaster activities (protecting water supply systems, developing effective evacuation plans), but less attention has been given to post disaster response activities such as debris disposal and infrastructure rebuilding (Fetter and Rakes, 2012).

However, Lorca (2015) stated that effective waste management must be initiated in two phases: pre-disaster and post-disaster. In the pre-disaster phase, protective disaster waste-management strategies should be introduced, by offering an imperative solution to reduce the risks posed by hazards and to attain speedy recovery after disaster. Post-disaster debris management mostly focuses on policy-related issues such as assigning responsibility and listing administrative procedures. Further, Fetter and Rakes (2012) mentioned two phases of disaster debris cleanup operations. The first phase begins immediately after the disaster, to clear debris from evacuation routes and other important pathways to ensure access to the disaster-affected area. Phase two is the longest period, including: organise and manage debris collection, and manage operations related to debris reduction, separation, recycling, and disposal.

Governments and other responsible authorities have initiated various waste management guidelines or debris management plans, which vary from country to country based on the situation, such as debris management guidelines by a Federal and Emergency Management Agency (FEMA), Japan's Society of Material Cycles and Waste Management manual for strategies for separation and treatment of disaster waste, and planning for disaster debris by the United States Environmental Protection Agency (USEPA) (Asari et al., 2013). The Government of Japan has initiated conventional biomass Combined Heat and Power (CHP) plants to generate energy from waste as a solution to country's energy shortage (Portugal-Pereira and Lee, 2016).

In addition, various researchers are investigating and developing numerous types of disaster waste management strategies, based on relevant case studies using both qualitative and quantitative approaches. Lorca (2015) introduced a mathematical model to use in both the pre-disaster stage, to

prepare strategic debris-management plans, and in the post-disaster stage, to determine decisions at an operational level. Onan, Ulengin, and Sennaro (2015) developed a multi-objective optimisation model for determining the locations of temporary storage facilities, and planning for the collection and transportation of disaster waste. Fetter and Rakes (2012) reported on a decision model with recycling incentives for locating temporary disposal and storage reduction facilities in support of disaster debris cleanup operations. A facility location model was proposed, to incorporate the unique assumptions, objectives, and constraints of disaster recovery in light of the FEMA policy. Hu and Sheu (2013) suggested a reverse logistics approach for post-disaster debris management, to minimise economic, risk-induced and psychological costs. Numerical results indicate that the proposed system reduces psychological costs by 54.93%.

Brown (2012) identified the six main elements of disaster waste management systems as: strategic management, funding mechanisms, operational management, environmental and human health risk management, and legislation and regulation. The author further developed key decision-making guidance and management principles for each of the elements. Considering the characteristics of building waste, some suggestions and applications on potential reuse and recycling of building waste could be applied in reconstruction work in earthquake disaster areas. Baycan (2004) provided information on collection, separation, recycling activities and disposal of disaster demolition waste following the Marmara earthquake, and offered guidelines for emergency planning for managing various waste types. Brown and Milke (2016) further demonstrated that: volume of waste, degree of mixing of waste, human and environmental health hazards, the real extent of the waste, community priorities, funding mechanisms and existing and disaster-specific regulations need to be assessed, to determine the feasibility of disaster-waste recycling programmes. The appropriateness of on or off-site waste separation depends on four factors: time constraints, resource availability, degree of mixing of waste and human and public health hazards. Accordingly, the authors mentioned that a successful recycling programme requires good management, including clear and thoroughly enforced policies (through good contracts or regulations) and pre-event planning.

Karunasena et al., (2009) concluded that the poor implementation of prevailing rules and regulations, poor standards of local expertise and capacity, inadequate funds, and a lack of communication and coordination were the main challenges to overcome in the post-disaster phase. According to Kaklauskas et al. (2009), post-disaster management has various approaches that should be reasonably compatible with disaster-level economic, social, cultural, institutional, technological, technical, cultural,

environmental, and legal/regulatory situations in the country under consideration. The strategies, issues, and challenges associated with waste management vary according to the type of disaster, magnitude, location, and country (Karunasena et al., 2009). It was obvious that effective waste management strategies should be tailor-made to the disaster conditions.

METHODOLOGY

A comprehensive literature review and qualitative approach was adopted in this study to identify post-earthquake C&D waste management processes, challenges and improvement opportunities. Data was gathered from local councils, CERA and accredited demolition contractors in Christchurch. Six local institutes responsible for managing C&D waste were selected for data collection (two from each), covering both government and non-government organisations. Interviewees were selected ranging from top management to field professionals, in both government and non-government organisations, who have been involved in the post-earthquake C&D waste management process. Apart from the above, nine interviews were conducted with CERA-accredited demolition contractors. In-depth semi-structured interviews were conducted, to obtain in-depth views and opinions of stakeholders within the research area. Content analysis was used to analyse data collected from interviews.

FINDINGS AND DISCUSSION

Christchurch earthquake C&D waste management process

Prior to the Canterbury earthquake, post-earthquake waste management was not considered in training and planning in Christchurch. Although there was a debris disposal guideline published by the Wellington Region Civil Defense, this was not adopted during the post-disaster recovery phase of the Canterbury earthquake. Initially, there was no set procedure to manage C&D waste. Hence, waste management mainly relied on coordination between demolition contractors and regional authorities, as well as the different government organisations. In order to accelerate the recovery and removal of all C&D waste as soon as possible, treating (separation of) this waste at the debris site is necessary. However, both the government and organisations involved often ignored this step, intentionally or unintentionally. In Christchurch, initially, no on-site separation was carried out post-earthquake (Brown et al., 2011).

The government established CERA under the CER Act to accelerate the recovery process. In order to manage post-earthquake debris, CERA introduced a clean method called "quick pick and go", which directed waste straight to its end-use market. In fact, a similar method had been used after

the 2004 Sri Lanka Tsunami (Karunasena et al., 2012). It was compulsory for all the demolition contractors who intended to undertake demolition work to be accredited by the project management office under the CERA, according to the CER Act. The accreditation process ensured contractors were suitably experienced for relevant projects, maintained consistent standards, raised awareness and allowed contractors to undertake more complex demolition as they developed their expertise and experience. However, at the initial stage of the disaster, there was no specific way to obtain a job. Due to the urgency of some essential demolition works, contracts were granted without following a proper tendering process.

Although CERA plays the key role, a variety of professionals and many organisations, including Civil Defence and regional councils, were given enormous help to plan and execute waste strategy, as per the CER Act. Due to the scale of the earthquake, the decision-making process involved integrated and timely decision-making across a range of organisations. CERA is the main organisation that facilitates the coordination needed to help restore the social, economic, cultural and environmental wellbeing of the greater Christchurch community, and lead or partner with local communities to return greater Christchurch to a prosperous and thriving place to work, live and play, as quickly as possible. CERA had power to determine what demolition works should be done and the corresponding waste management. A demolition team in the CERA includes professionals such as project managers, contractors and engineers.

Since most C&D waste can be recycled, a lot of post-disaster recovery and operations can utilise the waste, such as aggregates for concrete or road filling (Karunasena et al., 2012), and recycled aggregated bricks and blocks (Xiao, Xie, & Zhang, 2012). The recycling of C&D waste is routine in a disaster, as most waste can be separated, crushed and then exported. A number of authors released a hierarchy of C&D waste disposal options, which consist of six levels; reduce, reuse, recycle, compost, incinerate and landfill (Blengini, 2009; Tam and Tam, 2006). The findings clearly show that the aforesaid hierarchy was utilised in post-disaster C&D waste management in the Canterbury earthquake. The Burwood Resource Recovery Park (BRRP) was established urgently, to manage the reception and resource recovery processing of mixed demolition waste from Christchurch city. The facility delivers a series of quick, low risk solutions to address the problem of waste. It is estimated that around 4.25 million tons, mainly of mixed demolition waste from demolition of properties, was processed at this site. Within this facility, there were a manual sort line and a mechanical separator including screens, magnets and density separators. This facility plays a crucial role in the waste management process, as it enables the reuse and recycling of C&D waste that would otherwise have been sent to landfills. However,

interviewees mentioned that BRRP of Christchurch was not adequate to manage a great number of waste materials, and hazardous materials (such as asbestos) were not processed appropriately.

Landfills were considered the final step of the waste management process. Due to insufficient separation, more waste was dumped in the landfill. However, the landfill space was not sufficient for the C&D waste generated from the earthquake cleanup. For instance, the landfill site located in Kate Valley near Christchurch only had additional capacity to take 300 – 500 tons per day. If BRRP had not existed, the Kate Valley and other transfer stations could not have handled the amount of C&D waste. In order to reduce the public health risk of landfills, a surcharge was applied at the landfill for receiving asbestos in Christchurch, due to the extra operation (separation) and handling needed.

Additionally, land reclamation was used to dispose of the “clean” waste. It mainly accepted specific materials such as stone, bricks, tiles, aggregates, reinforced concrete, asphalt and glass, as ordered by the Ministry for the environment (MfE), according to CERA under the provisions of the CRE Act.

Apart from the CER Act, existing legislation applied to the post-earthquake C&D waste management process. For instance, the Resource Management Act (RMA) carefully monitors waste disposal activities to protect natural resources in New Zealand from discharges to air, water or land. The provisions in the building Act 2004 have to be followed to obtain demolition consent for buildings. In general, the Waste Minimisation Act 2008 aims to minimise the amount of waste sent to landfill, by imposing a levy on waste disposal. However, during the post-earthquake recovery period, the levy was suspended to accelerate the recovery process. The Health and Safety in Employment Act 1992 aims to provide a safe working environment when dealing with asbestos waste in the demolition process. However, CERA has strong powers beyond the regulations above. This has been a substantial legal debate, where the public was not given an opportunity to comment or made recommendations (Milke, 2011).

The Figure 1 shows a summary of the C&D waste management process used in Christchurch during the post-earthquake recovery period.

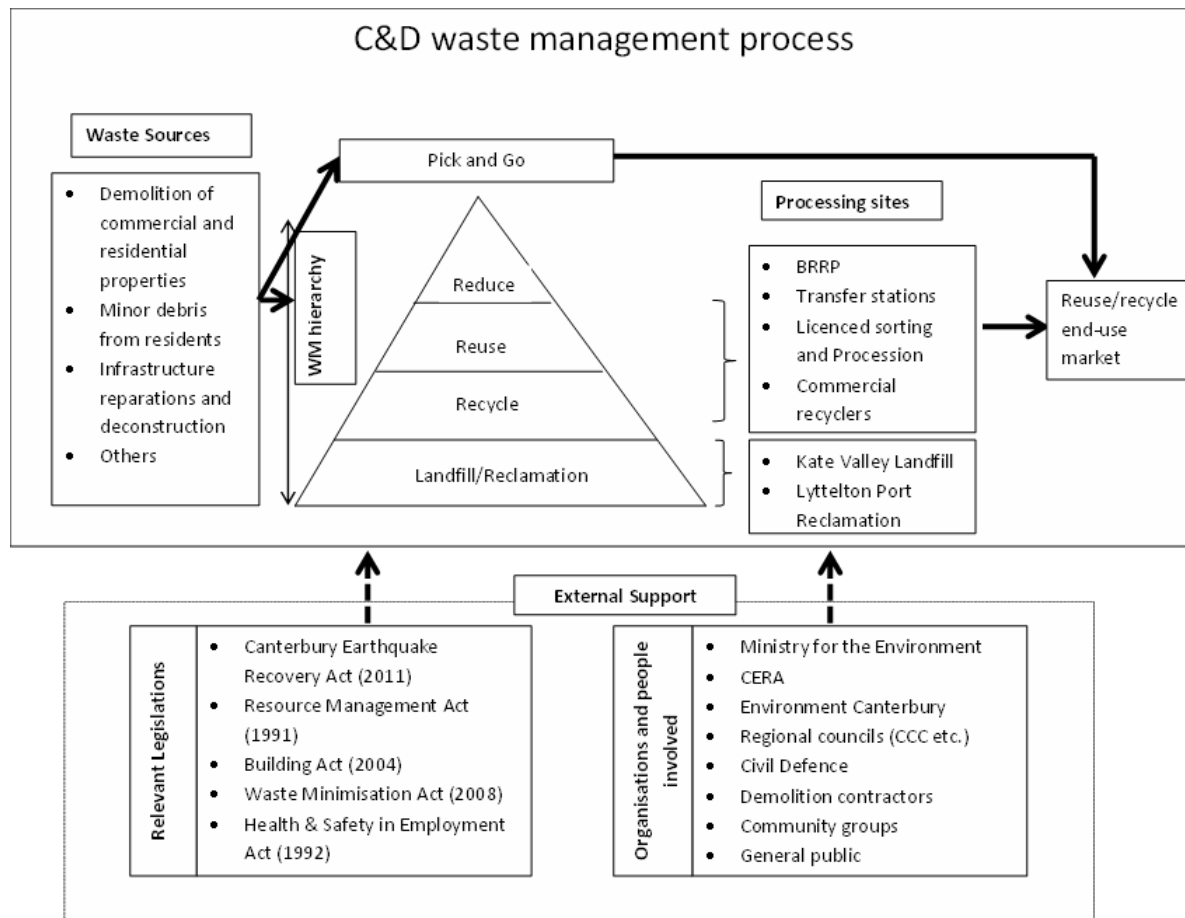


Figure 1: C&D waste management Process

Limitations and improvement measures for post-earthquake C&D waste management

During the recovery period in Christchurch, restoring the social, economic and environmental wellbeing of greater Christchurch communities was the desire of the people of Christchurch. In order to achieve this, different methods from previous experience had been implemented. During the interviews, interviewees stated a number of limitations in the Canterbury earthquake C&D waste-management process. They highlighted that even though the establishment of CERA and CER Act was reasonably quick after the first earthquake, CERA was not functional as quickly as authorities imagined. The transition period from the earthquake to the CERA Act implementation took almost three months from the earthquake. Prior to the establishment of CERA, many organisations (Ecan, CCC, Civil Defence etc.) were involved in waste management, and this resulted in overlaps in waste management. This was emphasised by a number of interviewees (12 of 21) as the main reason for delays in the whole waste management process. They strongly believe that if legislation like CERA had been established before earthquake, the waste management process would have been far

more effective. Consequently, the findings highlight that unclear roles and responsibilities confused organisations and professionals involved in the process. Although the CER Act was issued with the good intention of managing the C&D waste in an orthodox manner, accredited contractors believe the provisions designed in Act and CREA management did not meet reality. According to the interviewees, the efficiency of the waste management process was significantly affected, as CERA required monitoring and approving of all demolition plans. Most demolition contractors were not satisfied with the consent approval process, and found the great deal of paperwork to be completed every week very time consuming. Also, the coordination between contractors and CERA was poor in practice. The main conflict was about poor reactions in reality, such as the facilities, qualifications, and consent approval process. This finding is totally different from the experiences of other countries and not anticipated by CERA. Furthermore, in a previous study, Milke (2011) mentioned that there was little opportunity for public comment before establishing CERA. After analysis of the interview data, the contentions were proved justified to some extent. There were a number of limitations on the equipment and methods used by demolition contractors, according to the provisions of the CER Act. This also significantly affected the overall waste-management process. For instance, a waste airburner was prohibited from use onsite, although it complied with European and USA legislation. Additionally, the contractor's own processing facility was forced to stop. Because of the new legislation, CERA was granted strong powers to override a large number of regulations.

In addition to the above, the capacity of waste management facilities, hazardous materials management, and protection of personal contents were significant challenges during the process. Also, limited dump sites in Christchurch created a number of environmental issues, as waste often contains different kinds of hazardous material. The literature shows that seventeen dump sites were used after the Marmara earthquake in Turkey (Baycan, 2004), and seven dump sites after Hurricane Katrina (Stephenson, 2008). However, the strategy named 'pick and go' is used to deliver demolition waste to the end-use market directly, which minimises the volume of demolition waste onsite (Brown et al., 2011).

Although a number of organisations, ranging from Civil Defence to local councils, worked hard on waste management, lack of a pre-event disaster waste management plan is a significant fault in this case. Therefore, some interviewees (9 of 21) suggested that "the post-disaster C&D waste management needs to be improved in future, and a pre-event plan is crucial". Furthermore, residents and contractors strongly believe the organisations involved in C&D waste management require more authority to meet real situations in future disasters. Most interviewees (14 of 21)

highlighted that they were confused with the decision-making process needed to continue the work, and that bureaucracy has influenced people's judgement. Therefore, a majority of interviewees (15 of 21) suggested the need for a powerful organization, with a clear responsibility and goals, to take full charge of the waste management in future disasters.

CONCLUSIONS AND RECOMMENDATIONS

New Zealand has become more prone to natural disasters, mainly earthquakes and tornados. After the Canterbury earthquakes in 2011, post-disaster C&D waste management has become a critical issue in reinstating lifestyles affected by earthquake. There was no pre-established C&D waste-management plan prior to the earthquakes. This resulted in a number of initial inefficiencies and delayed the whole recovery process. The situation was reasonably managed after the establishment of CERA under the CER Act. The "pick and go" strategy introduced by CERA facilitated fast C&D waste management, as debris collected was transferred straight to the end-user market. However, a number of inefficiencies were identified in the study including: poor coordination between contractors and authorities, insufficient capacity for waste processing, conflicts in existing legislation and lack of a pre-disaster waste-management plan. The study recommends developing a robust C&D waste-management plan, covering both pre- and post-disaster stages, and a more powerful organisation than CERA to handle emergency situations more effectively and efficiently, by taking timely decisions.

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DISASTER RISK AND RESILIENCE IN INFORMAL SETTLEMENTS: THE CASE OF GUINEA-BISSAU

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ABSTRACT

Despite in 2013 the World Risk Index positioned Guinea-Bissau as one of the fifteen countries more exposed to disasters in the world, up to now little work has been done to reduce disaster risk to houses and cities. The current research is based on fieldwork conducted by the NGO Building 4Humanity (B 4H) within communities of the informal settlements of Bissau, the capital city, where the vast majority of the city's population lives in precarious conditions. Conducting in loco observation, technical reports and semi infra-structured interviews with stakeholders, in particular community-dwellers, B 4H is developing social and technical surveys with the goal of doing a detailed report on the exposure to the risk of self-help constructed family houses. The activity includes the study and implementation at urban scale of measures aimed at reducing the impact of floods and their effects on buildings made with traditional local materials such as earth and wood. The project of a new school for a local community and the reinforcement of the existing private houses will serve as a particular laboratory to essay construction techniques that might improve resilience to the effects of rains at the building and street level. First results indicate that the many works and enlargement of family houses, to accommodate more family members, ends contributing to increasing vulnerability. Work within communities, educating to risk and involving the population in the mapping of vulnerabilities and resilient practices, seem to be useful tools to raise awareness of exposure to risk as well as mitigate impacts of urban disasters.

Key words: Guinea-Bissau, community resilience, informal settlements, risk reduction, urban disaster

INTRODUCTION

The current research is based on fieldwork carried out by the NGO Building 4Humanity (B 4H) within communities of the informal settlements of Bissau, the capital city of Guinea, where the large majority of the city's population lives in precarious conditions.

Conducting in loco observation, technical reports and semi structured interviews with stakeholders, in particular community-dwellers, B 4H is developing social and technical surveys with the goal of doing a detailed report on the exposure to the risk of the family houses made in self-help construction with earth, wood, and zinc. The activity includes the study and implementation at urban scale of measures aimed at reducing the impact of floods and their effects on buildings. The project of a new school and the reinforcement of the existing private houses will serve as a particular laboratory to essay construction techniques that might improve resilience to the effects of rains at the building and street level.

The first results obtained indicate that the many works and enlargement of family houses, to accommodate more family members, ends contributing to increasing vulnerability.

Work within communities, educating to risk and involving the population in the mapping of vulnerabilities and resilient local practices, seem to be useful tools to raise awareness of exposure to risk as well as mitigate impacts of urban disasters (Hamdi, 1997, 2014; Sanderson, 2004)

CURRENT HOUSING AND OVERALL LIVING CONDITIONS IN GUINEA-BISSAU:

lack of basic services

Broadly speaking, the surveys found some tendencies among the population and characterization of the neighborhoods, which feature neither sewage nor water supply systems, and the water is still collected from traditional wells. Also, there is no public lighting except in very few main streets, and domestic electricity connection remains an exception. Several environmental problems are reported: numerous dumping areas, trash infrequently collected and consequently accumulating near houses, and, even more dangerous, shaky dry pit latrines, usually shared by several houses, becoming saturated. The Bairro Militar, the most populous of Bissau, with several tens of thousand inhabitants, has no health centre, with the result that people take between half an hour and one hour to arrive at a public hospital, and no community services are provided. Some thirty years ago it was estimated that almost 80 % of the population of Bissau lived in informal settlements known locally as "bairros", meaning popular neighborhoods (Davila,1989; Acioly 1992, 1993). These settlements grew in an informal way, without urban plans or observation of building regulations. Roads are rarely paved, and the space between the omnipresent one-storey houses is barely identifiable as a street, in spite of the frequent occurrence of local commerce. The few communal water taps in existence are insufficient to meet the actual demand for potable water.

local traditional building techniques

Dwellings are usually constructed with adobe bricks (fig. 1) according to a local building type of one-storey house with a rectangular, sometimes

square shape (10-15 meters side) surrounded by a wide balcony (around 1,80m deep) and with four to six rooms. The balcony, 'veranda', works as a place for preparing the meals, socializing and resting. These houses usually have a roof that is four-sided and covered by cheap corrugated zinc sheets (fig. 2), covering an area equal to 180 m², and sometimes even larger that includes the veranda so that the overhang protects the adobe walls from the rain. The bathroom is constructed outside, at a short distance from the home, since it is a traditional latrine, sometimes used by residents of several houses. Houses are grouped with more or less density depending on the location; for instance, on the main roads with local commerce they tend to be closer and more aligned, whereas in more residential areas they respect some distance, allowing some communal spaces in between and apparently following no clear order. These types of settlements seem to replicate the traditional rural 'tabancas' which the B 4H team visited, for instance, in the Pecixe island, in Cacheu region and nearby Quinhamel, in Biombo region (Correia Guedes et al, 2011). Remarkably, can happen that women and her children play a crucial role in the building process. As it was observed, sometimes handle the entire construction whereas men are elsewhere, supposedly doing business. (see fig. 1)

Householders pay the Municipality a yearly land occupation tax of around 7€. Land tenure is based on the customary rules ("traditional occupation"), except when the plot has been demarcated and regularized by a property title issued by the Municipality, which is the minority of cases. The population density is very high, usually above 200 inhabitants/ha and the multiple dwelling unit is often overcrowded, providing lodging for more than one family, or for extended families, with ten, sometimes up to twenty relatives. A household with up to four or five children commonly occupies two rooms of 16 m². The B4H team interviewed a retired civil servant whose home sheltered a record of forty- three people; although the women ran an informal trade selling a few vegetables and mangos, all of them depended on his retirement pension of around 90€/month and vegetable garden production. Salaries of thirty- five or forty-five euros are standard, and many teachers reported having two or more jobs. Taxi drivers and people working on the privately- operated buses, the so-called 'toca-toca', which employ several thousands of individuals, work between twelve and fourteen hours per day in twenty or thirty-year-old vehicles in the midst of dense traffic and polluted air for a monthly income of seventy to one hundred euros. These numbers and housing features confirmed that Guine-Bissau ranks amongst the poorest less developed countries in the world. (UN-Habitat, 2014).

characterization of the country regarding disaster risk

According to unofficial numbers, Guinea passed the 1,700000 inhabitants, and nearly one-quarter of the population lives in Bissau, with a high percentage of families occupying squatter houses or sharing overcrowded unities as described above. Their neighbors have, in general, one single

paved main street. In addition to several non-defined and claim roads subject to a long process of erosion, rain drainage gutters are in many cases obsolete, systematically blocked by solid waste or just inexistent. As a consequence, the rainfall forges its path and makes, what in the beginning, resembles grooves, rapidly passing to natural ditches until constituting authentic ravines, through which water flows dangerously, considering the proximity to walking paths, courtyards, and houses (see fig. 5). The houses are built without foundations and adequate care regarding flood-prone areas, thus facing rapid deterioration and collapse.

Bissau is located on the Geba River estuary and is a very flat conurbation, reaching a maximum of forty meters of altitude while the whole country never passes the three hundred meters of altitude with the vast majority of the territory situated under the sixty meters. The low altitude added to a uniform topography and a tropical climate with a pretty steady rain season lasting from June to November, and finally, to a significant level of poverty and vulnerability of peoples and houses, create conditions to disasters related to flood and storms, favoring the impact of natural hazards. This combination of factors places the country in a position of total dependence on its limited natural resources and increasingly low levels of official development assistance (Silva, 2010).

In the 2013, World Risk Index of 2013 (WRI 2013), calculated by the United Nations University for Environment and Human Security (UNU-EHS) a report that systematically considers a country's vulnerability, and its exposure to natural hazards to determine a ranking of countries around the world based on their disaster risk, positioned Guinea-Bissau as one of the fifteen countries more exposed to disasters in the world (WRI, 2013). According to the National Strategy for Management of Catastrophes' Risks (Silva, 2013) the recent crises that have affected Guinea-Bissau comprises: the military-political conflict of 1998-1999 that destroyed nearly 30% of national infrastructures; the floods, which affected 1,750 people; tropical cyclones that caused 2712 victims; epidemics, with particular incidence of cholera, affected 105 380 people causing 3032 dead. Summing up, the anthropic accidents caused 7,000 victims while the rains destroyed more than 829 homes and 25 schools nationwide. As stated in the same report, the State of Guinea-Bissau starts to recognize the integration of disaster risk reduction in the socio-economic development of the country as a prerequisite for achieving the millennium development goals (MDGs). As such, reduction of disaster risk stands as a priority in the National Strategy Document for Poverty Reduction (2011-2015) and is also part of the strategy and national policy on the Action and Adaptation of Climate Change national program (2006), as well as in the National Strategy for Protected Areas and Biodiversity (2009-2013). However, little work has been done in the past few decades in Guinea-Bissau to reduce disaster risk to houses and cities.

specific disaster risk issues, at the building and street level

At the urban scale of the neighborhood, some disaster risk measures applied by the residents were reported, for example, temporary barricades made with earthbags protecting entrances, surrounding houses or strategically aligned in crossroads (fig. 3). Other actions to protect from the rain include homemade mud plaster (fig. 4), executed in a very basic way by family members and the tying of the zinc sheets (fig.4). The reinforcement of the adobe or rammed walls with steel bars is almost unknown while the replacement of the veranda pillars and the roof frame, both made in Sibe, the traditional local wood, by reinforced concrete are increasing, although still too much expensive for the majority of the population. (Correia Guedes et al, 2011)

On one hand there are some urban and architectural endeavors to mitigate the impact of disasters; on the other hand, the enlargement of houses, to accommodate more family members and newcomers, become an issue. These extensions of the residential units are often made at the cost of the space of the verandas and somewhat would not constitute a problem since these has ample surfaces. Nevertheless, the new rooms are often built with their walls aligning with the edge of the roof and as such, these walls receive water from the gutter, are exposed to the rain and wind. When the enlargement surpasses that alignment, to gain some more space and achieve a more comfortable bedroom or kitchen, susceptible points appear, such as construction joints and leaks. These works are done without a permit and the participation of specialists, being entirely executed by members of the family, instead. As a result, rather than improving weakness, incremental housing ends contributing to increasing vulnerability (see fig 2). (Greene et al Rojas, 2008)



fig.1 traditional adobes bricks



fig.2 roof: corrugated zinc sheets



fig.3 earth bags against floods



fig.4 homemade mud plaster



fig.5 rainfall and flow water impacts



fig.6 enlargement processes



fig.7 mapping exercises



fig.8 modelling exercises

RESEARCH METHODS; FIELDWORK PRACTICES

*local surveys; inquiries; identification of local responses to risk;
exploring community-driven design through working with children*

In 2015 an ad hoc interdisciplinary team of the NGO Building Humanity (B4H) worked in Guinea-Bissau, within the community of the neighborhood of Plack 1, in the locally known as the Militar district. This area is an informal settlement without infrastructures and basic services where people live on the edge of poverty facing, on a daily basis, several challenges. With the precious the assistance of local teachers, the NGO team, a small group of architects and a psychologist, carried out a two-week program, previously discussed with the members of the school board, that comprised: three different workshops with students, including drawing, mapping, and models construction (see. fig. 7 and fig. 8); diverse meetings with teachers, parents, community representatives; interviews with key community actors; audiences with national authorities, including six state general-directors; architectural and social surveys. All activities intended to support the construction of a new school while raising awareness on urban disaster issues. Throughout the process, the teachers involved consulted with both civil and religious community leaders as well as the representatives of parents and guardians. The workshops, interviews, and inquiries registered high levels of participation. The fieldwork succeeded thanks to the involvement of some teachers who volunteered as all-purpose personal assistants and impromptu translators as despite Portuguese being the State's official language, the Guineans normally speak Creole, a common mother tongue among a population that belongs to more than twenty different ethnicities. The surveys addressed urban daily living conditions in a broad sense but mainly focused on housing and building issues, exposure to natural disasters, perception to the risk, construction skills and prevention measures to reduce the impact of rains, storms, winds, and floods.

ANALYSIS OF RESULTS AND OBSERVATIONS

identification of the local perception about the exposure to risk Poverty may explain, to some degree, why the locally called 'precarious constructions' remain for a long time, despite their fragility and lower resistance to natural agents. Householders seem to be aware of the risk that they are facing and despite the traditional African relaxed attitude they do fear that a great storm or flood would damage their homes and harm their relatives. In accordance to this concern, they corroborate the necessity of changing their situation, improve their houses, rebuild, perhaps, build a new one. Regarding their personal aspirations, it is frequently the reference to getting a better job or starting a business, namely exploring a container-shop. The lower wages, the country's long-lasting unstable political situation, the still incipient state of the economy, human rights and the rule of law, seem, however, to positively constrain peoples' ambitions, and no alternatives remain. Many of the interviewed revealed an interest in accessing the micro-credit, but so far they have not had contact with banks or other providers.

considering sustainable solutions with practical feasibility

Practical solutions to reduce the damages provoked by floods can be studied both on the urban and on the building scale.

On the urban scale, the main vulnerabilities include the lack of a drainage system and the shape of the roads, which is unsuitable to drain rainwater. The observations in the field show that people usually protect their houses placing rows of earthbags along the unpaved paths. A contribution to support this activity could come analyzing the digital maps, to get an overall idea on how the rainwater flows among the buildings. This analysis could allow for studying where to place and how to adjust the earthbags to achieve predetermined goals such as decreasing the water flow speed throughout the spaces between the buildings, preventing water from concentrating in proximity to the houses and, as a consequence, from damaging the building ground floor platform.

On the building scale, the vulnerabilities of the houses often include the inefficient connections between structural elements such as the main walls at the corners, the main walls at the top (absence of the bond beam) and the veranda pillars with the roof. They also include the nonexistence of plaster on the external walls that were moved from the original position and aligned with the roof edge, due to housing needs, such as the addition of a new room or the extension of an existing one. When it rains and in the event of floods, these walls are subjected to dangerous surface runoffs.

Moreover, it is worth to refer the current habit of replacing the old thatched roofs with bad quality corrugate zinc sheets, which are cheap and easy to obtain in the market and considered by householders as a mark of modernity. Despite its seeming usability as a protection from the rainwater, the zinc roof is an omnipresent feature of the precarious family houses that can also be considered as an indicator of vulnerability as it makes the living conditions inside the buildings substantially worse. All these are bad building practices that do not come from the local architectural culture, which on the contrary includes careful attention to details such as the incorporation of local reeds, such as bamboo, to make the walls elastic and thatched roofs connected with the main walls. These good practices produced long-lasting buildings, indeed, with good energy performances (Correia Guedes et al, 2011).

FINAL CONSIDERATIONS

Instead of imposing solutions or providing recommendations the team of the NGO Building for Humanity preferred to act as facilitators and sought to involve the community by organizing meetings with adults and practical activities with children. The workshops and informal dialogues confirmed that the latter can learn the good building practices through play and that latter can be sensitized to architectural and raise awareness of the risk issues through the eyes and handmade work of their sons and daughters. Meeting and interviewing adults was aimed at gathering

information about their skills, needs and expectations in relation to the (re) building processes. They also showed that the community is available to cooperate and how is willing to be involved at the design and building process. Sketches and drawings proved to be useful to study technical proposals within the research activity. They also demonstrated their potential for effectively communicating with the community, both with children and adults.

Cooperating with the local community in building and design process implies a mutual transfer of knowledge between the researchers and householders. In fact, on one hand the researchers might simply suggest solutions to increase resilience; on the other hand they are willing to take in consideration the feedback received by people who express their expectations. The experience on the field shows that a reasonable strategy to increase the resilience of the community is to propose strategies that people are really going to implement, according with their experience, traditions and current expectations. The challenge of the researchers doing action-research, whenever engaged in long-term humanitarian assistance, as the one pursued by low-profile NGOs is to provide suggestions about practical measures aimed at driving people to adopt the correct solutions from the technical point of view. A theoretical conception of improvement of local responses must, therefore, be grounded in local architectural culture and resources with consideration of the peoples' perception of the exposure to risk.

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