Pakistan Case Study

Use of Hydraulic Lime and Earth in Disaster Risk Management

Problem Statement

The monsoon floods that began in Pakistan in July 2010 caused a colossal disaster in the form of loss of lives, shelters and livelihood. The country has been faced with unprecedented annual flooding, having led to the collapse of over two million homes since 2010 - presenting an enormous housing challenge. Though admittedly, even in the face of severe logistical constraints and financial pressures, a major relief effort was launched by the Pakistani Government, supported by UN agencies, international NGOs, and local relief organizations, who battled to assist the population that had lost their homes. Several donor governments and millions of individuals in Pakistan and around the world acted quickly and generously to provide money and help in reconstruction.

However, we must point out the recurring problem with disaster response in Pakistan - it is unplanned, urgent and make shift. Therefore, issues related to carbon emissions or other greenhouse gas emissions have received very little consideration so far in these interventions. *Taking carbon considerations into account in risk reduction, relief and reconstruction would contribute to the potential 'greening' of the DRM industry. This is an important dimension for recognizing the benefits that a low carbon economy can bring to developing countries*[1]

There are several initiatives worldwide to assist in disaster resilient *and* low carbon reconstruction, and many manuals are available for the purpose. In Pakistan however, this is not the case. Customized construction guidelines are not widely available and instruments like the Housing Policy (2001), planning standards, and building codes that do exist are mostly outdated, not addressing the issue of low carbon construction[2]. Several efforts have been made to incorporate DRR in National Building Codes etc, as a result of the earthquake but there is no guided planning and construction regulation. The problem is worse in the rural areas, where there are no prescribed structural requirements for settlements and houses.

[1] Mitchel, Tom, Urban Frauke and Paula Silva Villanueva. *Greening Disaster Risk Management: Issues at the interface of disaster risk management and low carbon construction.* Strengthening Climate Resilience DiscussioN Paper 3. Sept 2010 <http://community.eldis.org/.59e0d267/greening-low-carbon.pdf>

[2] Taking action on climate compatible reconstruction in Punjab Pakistan. Climate Development and Knowledge Network. July 2012 <http://cdkn.org/2012/07/taking-action-on-climate-compatible-reconstruction-in-the-puniab-pakistan/>

Lime stabilized soil: Resilient and Low Carbon

Soil stabilization is the process whereby soils and related materials are made stronger and more durable by mixing with a stabilizing agent. The process enables materials to be employed in the construction of road pavements, houses, buildings etc, which without stabilization would be unsuitable or dangerous for use. The use of stabilized soils in place of natural aggregates can also have considerable environmental and economic advantages. Although other stabilizing agents can be used, this case study will focus on the use of lime by the Health and Nutrition Development Society (HANDS), an NGO working to reconstruct damaged or destroyed houses in the most affordable, resilient and energy efficient manner. It will shed light on the design process, construction techniques, quality control procedures, and problem areas faced with lime construction, and especially stress on the environmental benefits of such an alternative technology.

Lime is one of the oldest, and most vital construction material known to man. It was used by the Romans in the construction of roads and buildings, was the main material behind the Sukkur Barrage in Pakistan and till today is used in mortars and plasters in rural Pakistan. The evidence of its capacity to stand up to terrible weather and disaster has been witnessed worldwide. Furthermore, other than its strength and resilience, lime offers ecological benefits in comparison to material such as bricks or cement. Efficient small scale local production can result in lime binders having significantly less embodied energy than cement, shorter transport distances and re-absorption of carbon dioxide (CO_2) in its setting process.

This case study is aiming to show the extremely important synergy between disaster risk management and low carbon construction via the use of material such as hydraulic lime. The main focus will be on how HANDS has practically achieved a balance between disaster management and low carbon construction. What materials have they used? Why? What impact has it had? What difficulties have they faced? And what are the institutional/policy barriers that need to be eliminated for them to continue with their work?

After an unprecedented annual flooding and damage to communities, shelters and housing, DFID and HANDS were faced with what DFID shelter advisor Magnus Wolfe Murray states was a three pronged challenge: "We had to support people in flood prone areas to build disaster resistant houses at an affordable price, without causing further damage to the environment... We had to take into account the local environment that sustains us: do we want to make it worse by felling yet more trees or emitting more carbon in the production of fired bricks[3]"

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[3] Building with Lime Stabilized Soil: A reference manual and training guide for Flood Resilient Shelter Construction in Rural Pakistan. HANDS. UKAID. Foreword. iii

Their Process

Production of the Lime Putty:

HANDS constructed slaking pits that had to mix the correct amount of quick lime (CaO) and water, hydrate the quicklime, and separate the impurities and grit from resultant calcium hydroxide slurry. Quick lime, i.e. obtained from the cooking of stones, after going through this whole process is converted into lime putty that is eventually used in plasters and mortars. These slaking lime pits (a small 2 litre or quart metal container) are half filled with water (maintained at a set temperature of about 25 C), to which the quick lime lumps/powder are added and following an exothermic thermal exchange, a physical reaction takes place, changing the state from solid to hot milky slurry called calcium hydroxide, better known as slaked lime. The more water is added in the slaking process, the more efficient is the chemical reaction of oxides into hydroxides, a process that would go on slowly in time, during the long phase of seasoning. [4]

Figure 1

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Figure 1: In this method, two tanks are required, one at a higher level, whereas the second tank is made at a lower level, adjoining the first tank. Water is filled in the upper tank to about half its depth and quick lime is gradually added to it in small amounts. Water is constantly stirred during the process of addition of lime. This results in the formation of 'milk of lime', which is allowed to fall through a sieve into the lower tank. Since improper slaking results in serious defects in mortars and plasters, there are several tests in place to check the density, fineness and soundness of the lime putty produced.

[4] Building with Lime Stabilized Soil: A reference manual and training guide for Flood Resilient Shelter Construction in Rural Pakistan. HANDS. UKAID. Foreword. iii

Soil Testing

There are also field tests in place for the soils that would be mixed with the lime because the addition of lime to the right type of soil greatly improves its strength and resistance to water. It is important to check that there are appropriate proportions of sand, gravel and clay in the soil to enable stabilization with lime. HANDS conducted their earth selection by removing the top soil and selecting sub soil strata for testing, and then sieving or allowing it to pass through a screen for stones etc.[5] (Several tests referred to in HANDS DFID manual)[6] [7]

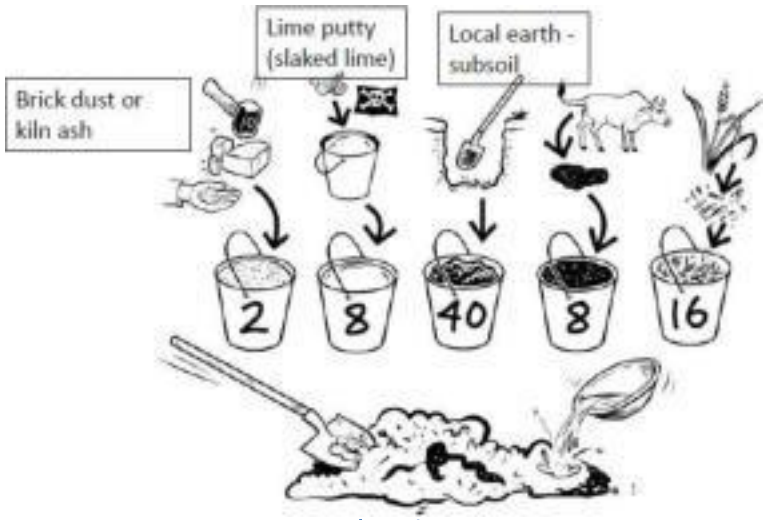

Figure 2

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Beneficiary Driven Process

HANDS used a beneficiary driven process to achieve this. They formulated Community Based Organizations in the 6 districts that they were working in, aiming to make the reconstruction process owned and led by the community. This allowed them to have a mechanism and adequate community representational to go over the existing patterns, methods of constructions, introduce people to the proposed ones and via discussion, dialogues and awareness campaigns, create a smooth transition. They also established an entrepreneurial model; making one focal person responsible for the lime pit and teaching the construction technique to others.

According to the Project Manager Ghulam Mustafa, the locals also showed familiarity with the usage of lime mortars on their houses. The way in which they were used and compositions differed from district to district, but the concept of using lime in construction was not new or alien to them - thus improving the acceptance in the community. Plus, earth with lime bases had withstood the test of the rains in September 2012, convincing the locals of the resilience and strength of the material.

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[5] Building with Lime Stabilized Soil: A reference manual and training guide for Flood Resilient Shelter Construction in Rural Pakistan. HANDS. UKAID. Pg 22-25

[6] Ibid

[7] Ibid

For the foundations a mix of soil and lime was used and put in three layers followed by proper compaction. The amount raised from the surface varies for different regions, the project manager stated that there were places in Southern Punjab where the houses were raised 8 to 10 ft, but in Sindh 1.5 to 2 ft was considered appropriate.

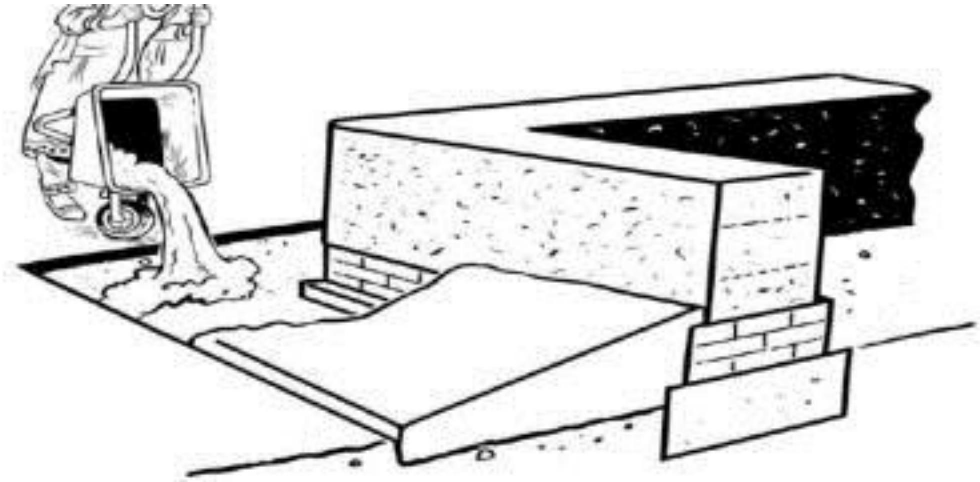

Figure 3[8]

Low Carbon Alternative

DFID shelter consultant, Magnus Wolfe Murray, combined with the team from HANDS also did an exhaustive calculation of the carbon emissions and environmental consequences resulting from conventional methods of construction in comparison with the emissions from the use of hydraulic lime.

Below are the tables that were a result of this exercise.

Table 1: Conventional construction - that would normally be carried out as part of post-flood reconstruction

Item	Required amount per house(KG)	quantity per house	CO2 (Kg) emissions per Kg / brick	CO2 (Tonnes) emissions per House	Target no Houses	Amount for 27,500 houses (CO2 Tonnes)	Comments
Fired bricks	n/a	5,500	0.53	3	27,500	80,163	The source provides emissions data per brick
Cement	750	750	0.95	0.71	27,500	19,594	
Steel	54	54	1.95	0.11	27,500	2,896	whereby 2 steel beams of 26kg each are used
Total						**102,652**	

[9]

[8] Building with Lime Stabilized Soil: A reference manual and training guide for Flood Resilient Shelter Construction in Rural Pakistan. HANDS. UKAID.

[9] Magnus Wolfe Murray, Shelter Consultant, DFID.

Table 2: Environmental Building Systems - as adopted by DFID &

Item (and items being replaced)	Required amount per house(KG)	quantity per house	CO2 (Kg) emission per Kg / brick	CO2 (Tonnes) emission per House	Target no Houses	Amount for 27,500 houses (CO2 Tonnes)	Comments
Fired bricks used for 20% of project only		5500	0.53	2.915	5500	6413	Assume that only 20% of buildings use burned bricks.
Lime - in place of Cement	50		0.234	0.0117	27500	321.75	While transport is needed for all products this is not factored into either table.
Steel: one beam instead of two procured	26		1.95	0.0507	27500	1394.25	
Total						8129	

Difference and saving in tonnes of CO2	**94,523**	25	2,363,075

Figure 4

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The source of calculation on CO2 emissions per KG of brick, cement and steel production: University of Bath, Embodied energy and carbon in Construction materials (2008). The average emissions data for lime, as stated in the Univeristy of Bath reference (above) is 0.78 kg CO2/kg. However this assumes that fossil fuels were used in the burning of lime at the outset. As lime kilns in Sindh use a local coppice woods / bushes that regrow naturally, absorbing an equal amount of CO2 during their lifetime as was emitted during their combustion, I am referring to lime as a zero-carbon product. THis follows UK Governemnt guidance on biomass energy including: Minimising greenhouse gas emissions (2009), The Environment Agency, UK Governemnt. This states that solid biomass emits up to 70% less than a gas fired power station (p.5). I have thus reduced the University of Bath's estimate by 70% and used this in the calculation table.

Difficulties faced and reasons why there isn't widespread usage of lime in construction:

DFID and HANDS had to face several obstacles in the path to low carbon disaster risk management. Firstly, there was an issue of transferring the technology and skills to the community, and the focal

[10] Magnus Wolfe Murray, Shelter Consultant, DFID.

University of Bath, *Embodied Energy and Carbon in Construction Material* (2008) - https://www.circularecology.com/nuqdiaidiaiklasah.html person who would be held accountable for the operation of the slaking lime pit. The process of forming CBO's, selection of focal individuals for the job and their training was the hardest ordeal. Since the process of creating lime putty involves very specific tests, temperatures and instructions, and is also dangerous if not done properly, the learning curve of the locals picked up very slowly, and there were several mistakes in the initial phase of the project.

Secondly, though lime was not an alien material to the locals and had been used in some form or the other, it was difficult convincing communities to adopt the earth and lime method that HANDS proposed. This was due to two reasons - firstly the proportions and method proposed seemed to be a rather unconventional practice for the locals, secondly the cost sharing factor posed as an obstacle to the project team. The organization had to go through several sessions with the community, educating them on the long term benefits of lime - stressing on its resilience and strength in the face of disasters, for them to give in to the scheme. However, the fact that 30,000 houses were reconstructed using this method in 6 districts is a standing testament to the benefits of lime.

Project Manager, Ghulam Mustafa discussed the difficulties of finding good quality lime in the market. This is the main reason that we fail to see a widespread use of the material in housing. "All the good quality lime is bought up by the sugar mills, and therefore it is next to impossible for one household to be able to access good limestone. Then there is also a monopoly of cement industries, not allowing an open discussion and promotion of alternative low cost and low carbon technology"

With regards to institutional capacity in Pakistan, they told us about the struggle they had to go through to make affiliations with universities and identifying academic experts that work on low carbon construction in Pakistan. Ghulam Mustafa stated: "There is next to no scholarship on this topic in Pakistan, which is a huge capacity gap. Until and unless there is significant research and development on this topic, the technology and practice will never permeate to the grassroots"

There was a general consensus across the board, that there is also a need for significant donor education. This is extremely important, as a demand from the donors or international agencies can help communities and national NGO's rapidly pick up the technology and implement it in rural Pakistan.

Conclusion

This case study presents before us an example of low cost, low carbon and resilient construction method/material that *is* being used in Pakistan - and has no negative consequences on the community and long term stability of the structures. Theoretically, it does away with several problems that are plaguing the construction and development sector of Pakistan, yet there is a lack of widespread acceptance and implementation. This is due to the lack of awareness, absence of research, social taboos and most importantly lack of government bodies and institutions backing the cause.

There is a desperate need for the concerned authorities to push the need for low carbon construction in housing policies, reconstruction guidelines, agendas for NGO's and international donors, as well as encourage academic research on the issue. Achieving a low carbon future, for a country like Pakistan is going to require a significant effort to enhance programmes and policies; well beyond what is happening today. Also, the construction industry's pivotal role in any carbon reduction programme makes them obligated to take up the position of leadership in such an endeavor - requiring an active engagement with the institutional and policy barriers that exist, and coming up with the means to overcome them.