Reviving people's trust in Bamboo technology: A case-study of Orlaha settlement reconstruction in Bihar, after the 2008 Kosi floods

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Abstract:

There is a growing body of literature suggesting significance of technical and social guidance during post-disaster housing reconstruction projects. Social process may include considerations of donor-driven or owner-driven approaches. Technical process may include considerations for achievinga balance between the world-views of beneficiaries and facilitators in terms of multi-hazard safe housing form, material, technology, and its cultural, environmental and financial appropriateness. Research suggests that it is the approaches to reconstruction implementation on which the long-term effectiveness of housing reconstruction projects at imparting disaster-resilience to at-risk communities, relies (Barenstein & Iyengar 2010; Jha et al. January 2010; Lizarralde et al. 2010; Lyons, Schilderman & Boano 2010; Schilderman & Lyons 2011). However, adoption of traditional technologiesamongst at-risk rural communities in India poses one of the many challenges during reconstruction. What is interesting to observe is whether the housing reconstruction process can revive people's faith in indigenous materials and technologies?

This paper focuses on the technological and social process of reviving people's faith in bamboo technology. The paper draws from empirical research of Orlaha settlement reconstruction, in Triveniganj block in Supaul district of the Indian state of Bihar post 2008 Kosi floods. The fieldwork was conducted during November-December months in 2012 and 2014. The paper investigates the process of re-introducing bamboo technology which is multi-hazard resistant and meets the housing needs and aspirations of households? What is the condition of housing, 5 years since completion of reconstruction? How satisfied are households with their housing? What are the reasons for successful uptake or failure? The paper examines whether and how a convergence was achieved between technology and social perception.

To this end, the paper's findings indicate that post-disaster context offers a small window of opportunity during which local households are open for changing their perceptions for achieving multi-hazard resistant housing.

Introduction: Mithilanchal region:

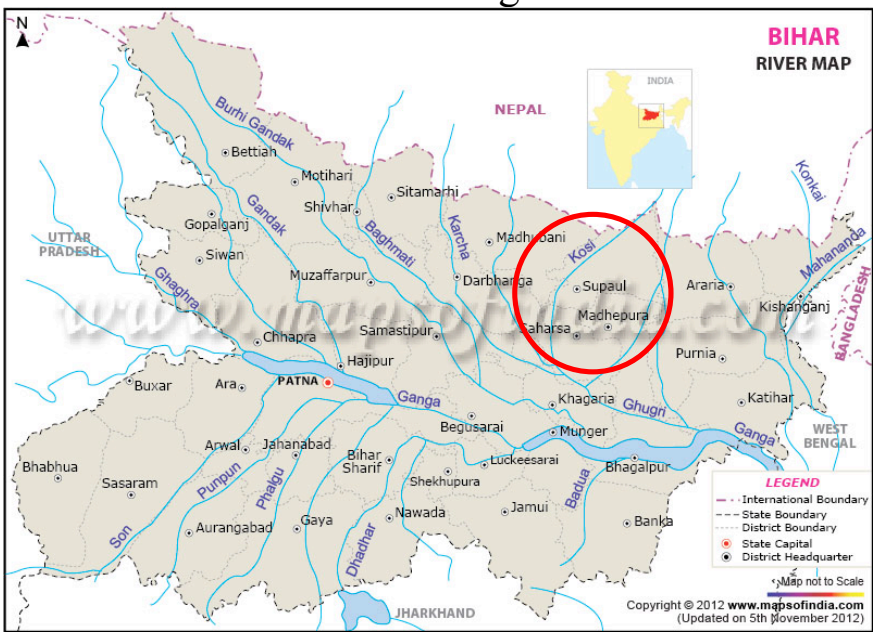


Figure 1

The Indian state of Bihar is located to its north (Figure 1). Mithilanchal region is located to the north of river Ganges in Bihar and it comprises of few districts (Figure 1). River Kosi is one of the seven rivers that flow through the plains of Mithilanchal, from Himalayan Ranges in the north to drain itself into river Ganges to its south (UNCRD 2003).River Ganga forms the main river of the state, occupying nearly 7.1 percent of total area (UNDP 2014). These rivers help rejuvenate the soil with rich alluvial deposits every year. Since Bihar is located in a tropical to sub-tropical climatic zone, it is endowed with heavy monsoonal rainfall too. Hence, the local culture is significantly influenced by the climate, hydrology and landform.

Local livelihood is mainly dependent on agriculture and mining. Due to abundant water and fertile land, the region enjoys three harvest seasons in a year – wheat, rice and *mungdaal*. Bihar is India's major production centre for key cereal crops such as Wheat and Rice. Presence of rich soil has also led to brick production.

Despite such rich natural resources, it faces immense development challenges such a poverty, flood vulnerability, health and education(UNDP 2014).

- Poverty= Nearly 54.4 percent of population lives below poverty line
- Average size of land-holdings = 0.58%
- Income = Rs. 778 (equivalent to $12.67/ person per month), as per the estimates of 2011-2012 (Government of India & Commission 2013; UNDP 2014).
- Literacy rate: 63.82 percent
- Body Mass Index of women < 18.5 = 45.1 percent
- Child<5yrs mortality rate = 84.8 percent
- Rural household's access to three basic amenities - water, toilets and electricity = 10%
- Flood vulnerability = 73 percent of geographical area
- Earthquake vulnerability = 28 out of 38 districts in earthquake zone five and four.

"Poverty in Bihar is a function of low per capita land holding, very low industrialization base and limited opportunities in the service sector. Low human endowment and poor infrastructure compound the problem" (UNDP 2014, p. 3).

2008 Kosi floods – an opportunity in disguise:

Figure 2

In August 2008, Kosi River breached its embankment at the Nepal-India border. Thought Bihar is vulnerable to multiple hazards – floods, earthquake and high wind velocity, this disaster was unprecedented (Figure 2). It had devastating effect as the Kosi River burst its embankments, changed its natural river course, inundating the so called "protected area" in Bihar that had not experienced flooding for several decades (GoB 2010; UNDP 2009). *Madhubani*and *Darbhanga*districts which are hit by floods more often have evolved means of coping with floods (GoB & ODRC 2008); however, the districts of *Supaul, Madhepura, Saharsa, Purnia, Araria* and *Katihar* in northern Bihar had been relatively flood protected with no experience in dealing with floods (FMIS & GoB 2009). About 1,000 villages of 35 blocks in these five districts were severely impacted (GoB 2010). Out of three million people that lived in this region, over 1 million people were displaced; over 3 million people were affected(PiC 2010; UNDP 2009), more than 200,000 homes were damaged and a significantly damagewas brought to cattle and crops due to protracted inundations(GoB 2010). This flood was no slow-onset disaster; it was a rapid onset disaster.

Housing and Settlement Reconstruction in Orlaha settlement

An unparalleled effort followed, to reconstruct houses and settlements and to optimise on the opportunity provided by this disaster to mitigate future disaster impacts. An Owner Driven Reconstruction initiative was adopted by the Government of Bihar (GoB) in partnership with UNDP and was implemented at pilot stage by a technical committee termed as ODR Collaborative (ODRC). ODRC was composed to technical, scientific, academics and social workers. Hence, ODRC was well-equipped with knowledge and experience to be able to devise a fine reconstruction strategy.

ODRC was in-charge of developing and demonstrating through a pilot project - the rehabilitation process and hence the policy. ODRC piloted rehabilitation process in two model settlements – *Orlaha* (Tribeniganj Block) and *Puraini* (Basantpur Block), in the District of Supaul, Bihar (GSDMA & UNDP 2005). After the completion of these model settlements, ODRC fine-tuned the ODR policy for GoB to take up the task of up-scaling reconstruction program and building 100,000

houses in the worst flood affected districts of Madhepura, Saharsa and Supaul – in Mithilanchal region.

A three-fold strategy was advocated by ODRC for reconstruction during model settlements:

1) Technical- provide technical guidelines for multi-hazard safety of houses and so that the reconstruction process is not unregulated;
2) Social - to bring faith back in people that they can built own multi-hazard safe houses;
3) Financial – provide financial and livelihood support during the process, to provide locals with an opportunity to come out of poverty (NIDM 2011),

A team of Social worker, Raj*mistry* (master mason as supervisor), *Dabiamistry* (bamboo artisan) and an engineer were appointed to implement and monitor the rehabilitation process. In the backstage, technical, financial and management team were managing the development of technical guidelines (based on scientific research); devising financial package for beneficiaries and were managing the entire process.

1) Technical: (House design, material and guidelines):

Disaster- specific risk reduction technologies in housing were of utmost importance for providing future disaster-resilience to at-risk communities in Orlaha, Bihar. Hence, vulnerability and capability assessment was taken to understand local material availability, its cost, construction practices (foundations, walls, roofs and connectivity), labour skills and quality of construction.

After considerable assessments, ODRC recommended two options for construction materials, based on i) brick work and ii) bamboo (GoB 2010). Two technical guidelines were proposed as follows:

- Part-I Reconstruction of Multi Hazard Resistant Houses: Brick Construction
- Part-II Reconstruction of Multi Hazard Resistant Houses: Bamboo Based Construction

Bamboo was advocated for in the Mithilanchal region as it was indigenous to the region - good quality bamboo along with ample artisan skills for house construction, and brick was expensive and brick may not be available in adequate quantities required during reconstruction (GoB & ODRC 2008). In Orlaha, out of 41 houses, all the houses with an exception of two houses were made out of bamboo.

Bamboo in Mithilanchal region:

Figure 3

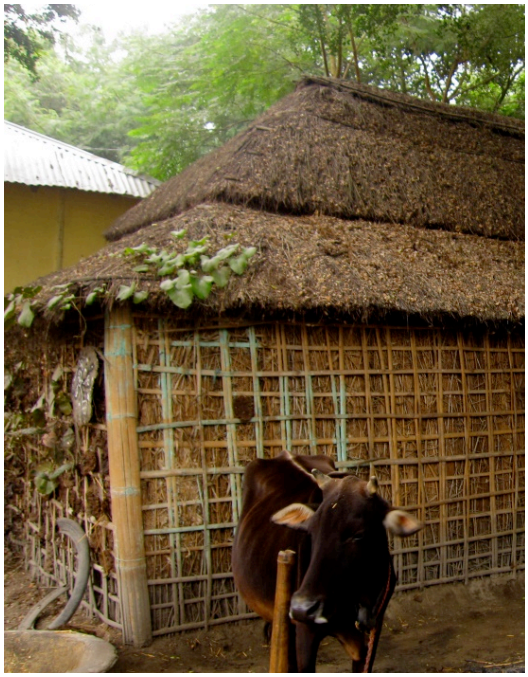


Figure 4

Bamboo is central to the life of people in Mithilanchal. People there say "from birth to death' every step in their lives is supported by the bamboo" (Rawal & Virmani 2012, p. 50). In the Kosi region,traditionally, most families grow their own bamboo groves (Figure 3). Out of many species of bamboo found in the Kosi region, three varieties of bamboo are mainly used for housing construction. *Harot (BambusaBalcoa*), thick walled, structural species is used for main structural frame of the house, the long straight *Chab (BambusaTulda)* is used for roof rafters and *Makhaur(BambusaNutans)*along with other bamboos is used for making the wovenbamboo panels for wattle and daub walls (GoB 2010). Hence various refined techniques were evident in traditional housing (Figure 4) such as, flattened bamboo, woven bamboo matts, lashing joinery systems and thatch roofs.

Bamboo houses were pre-fabricated either by a *Dabiamistry* (bamboo artisan) or by the households themselves (Figure 5). Once all panels were ready, community members helped each other in assembling them.The roofs were typically made from thatch.

Despite existence of bamboo and construction skills since time memorable, bamboo technology had to be upgraded for its sustainability over 40-50 years and so that bamboo construction is considered as *pucca*(permanent) rather than *kuchchha*(transient). To legitimise bamboo construction technology, following issues were mandated in the guidelines:

a) Harvesting and treating bamboo
b) Multi-hazard resistant design
c) Bamboo connection details (Columns lifted from foundation/ ground to keep away from moisture, wall to plinth, roof to wall

Furthermore, technical innovations had to be made to accommodate context-specific issues such as:

- Lack of electricity (no power tools for bamboo connection or for pile foundation or for bamboo treatment)
- Cost constraints (limited access to expensive metal bolts or connections or cement or steel)
- High water-table of 5feet, causing issues with deep RCC pile foundation.

Figure 5

Figure 6

a) Harvesting and treating bamboo:

The durability of bamboo relies on its time and method of harvesting and its treatment. Since bamboo contains start content, which attracts borers and fungi, it is recommended that bamboo be harvested in dry season when starch content is low (Vegesack et al. 2000). Also for structural purposes, a mature age bamboo, at least more than 3 years old bamboo pole is recommended.

Treated bamboo has a life expectancy of over 50 years. There are various methods of treating bamboo – such as lime wash, smoke treatment, chemical treatment etc. Chemical treatment is found to last longer and hence was recommended in Orlaha. The idea is to replace the starch and carbohydrate content with chemicals. Since bamboo has linear tube like fibres, movement of preservative is relatively easy. In Orlaha, an aqueous solution of boric acid, Borax and coppor sulphate was recommended (GoB 2010). The treatment was done in a temporary soaking pond, dug in agricultural fields and lined with plastic (Figure 8).

b) Multi-hazard resistance of bamboo housing:

Bihar is highly vulnerable to floods, earthquake and wind storms. However, the region of Mithilanchal had no experience or coping mechanisms against these, due to low exposure. Hence, the coping mechanisms from neighbouring regions of Madhubani were studied, as that region was more flood-prone and had coping mechanism.

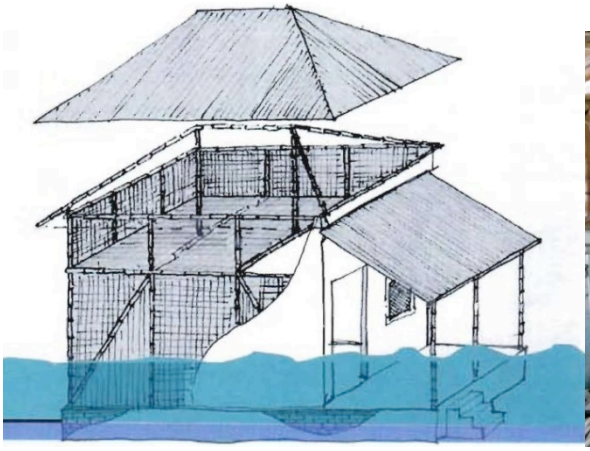


Figure 7

Figure 8

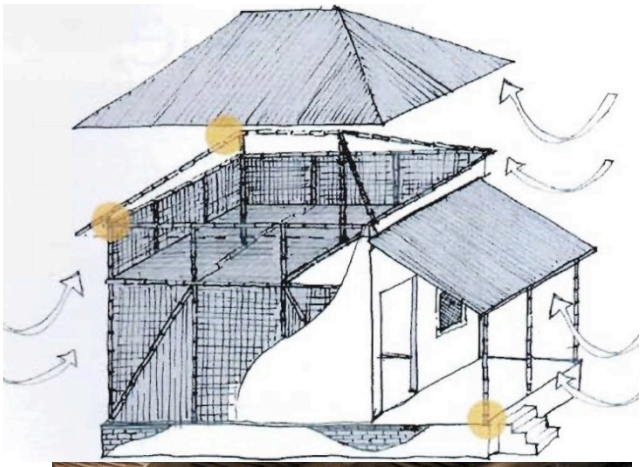
For flood protection, all houses in Madhubani region had attic space and were built on high plinths using highest flood level in extreme situation as their reference for determining the height of their plinth. Similarly, the level of flood waters in 2008 and the soil type was used for proposing house plinth level in Orlaha. Moreover, due to time constraintsand absence of flood-mapping information, ODRC recommended in-situ reconstruction. An attic space (7-8 feet above) was mandated for each house to seek refuge and save belongings in flooding (Rawal & Virmani 2012) (Figure 8).

During floods, in Madhubani region, mud plaster would wash away from wattle and daub walls leaving the bamboo woven wall-panels exposed, which being lightweight and easy to dismantle were removed, carried on boats by homeowners for relocation on higher grounds. People identify their way of living with the bamboo plant – flexible from exterior to change with the changing circumstance but very strong from its roots or in personal values. Hence, the reasons for such transient bamboo architecture were deeply rooted in the ever-changing land-form. Similar strategy was adopted in Mithilanchal, where the wattle and daub walls between the structures could give way to the pressure of water, without damaging the main structure (Figure 7).

For floods, another important consideration was building a strong, deep foundation on which the plinth beams and hence the entire house structure could sit. However, foundation proved challenging in soils which could easily liquidate during floods and where ground water level was as high as 5 feet. Working with local *mistries*, ODRC came up with innovative solution for foundation. The RCC pile foundation was pre-cast before digging the ground to install it (Figure 9). The hole in ground was dug from within a drum, so as to keep the ground-water away (Figure 10). Bamboo was not used in the foundations.

Figure 9

Figure 10



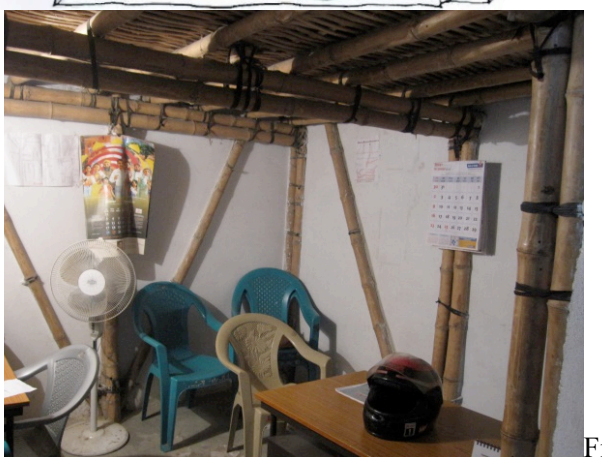


Figure 11

Figure 12

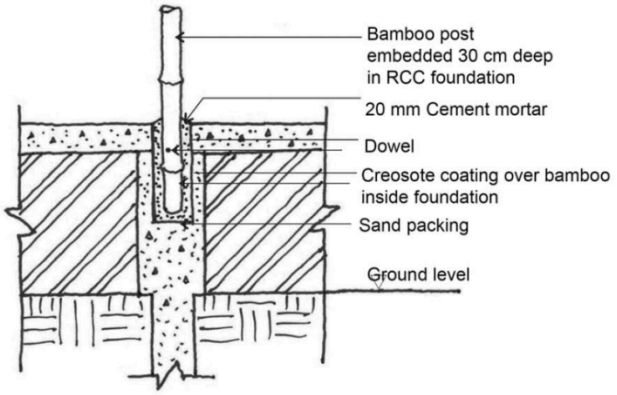


Figure 13

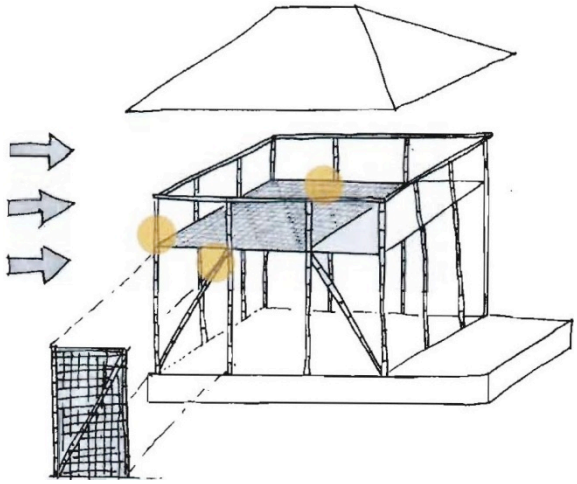


Figure 14

For earthquake resistance, the flexibility, lightness and high tensile strength of bamboo is an advantage. Diagonal bracing was mandated between posts in all corners from plinth level to attic level (Figure 11, 12). The distance between two posts was mandated to be equal to or not be more than 1.2m centre to centre (c/c) (GoB 2010). These diagonal braces provided strength to the structure to withstand lateral thrust. This structure when combined with lightweightwalls and lightweight roofing system, provided earthquake safety.For safety against high-velocity winds, the connection of bamboo post with plinth beam and the walls to roof were modified to avoid uplifting(Figure 13, 14).

c) Bamboo connections:

The local bamboo artisans in Mithilanchal region - Dabiamistry were skilled in bamboo construction. Their name was based on the knife - termed as *Dabia*, which is their main tool for working with bamboo (Figure 5). They mainly used lashing and bamboo pin connection details. Locals had innovated use of *Phita*(synthetic zipper fabric) for tying instead of natural rope, to reduce maintenance. Hence, ODRC resolved the connection details to fit in the existing skills pool rather than having to train all *mistrys*. However, wind-safety features such as tying through a hole in bamboo to avoid uplift and other minor up-gradations were introduced (Figure 15).

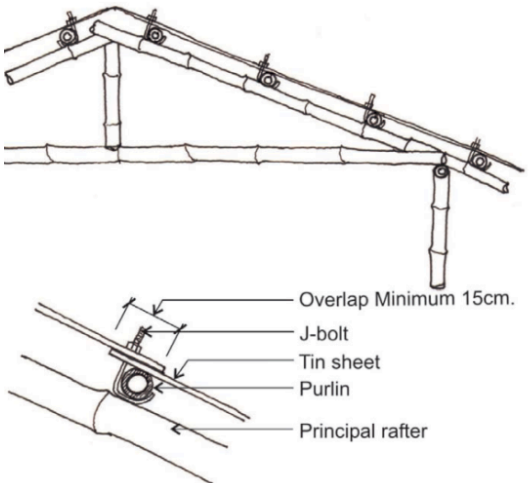


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Figure 15

Local *Dabiamistry* and *raj mistry* built the first five model houses, in government complex in Saharsa district. The reason for building the model house was to fine-tune the design, to understand associated cost per square meter and to showcase them to locals. Three main variations in these model houses were - 1) bamboo structure, bamboo wattle and daub wall with cement plaster to the outside and tin roof (Figure 16) brick structure, brick rat-trap walls and tin roof 3) RCC columns, brick walls and RCC terrace roof.

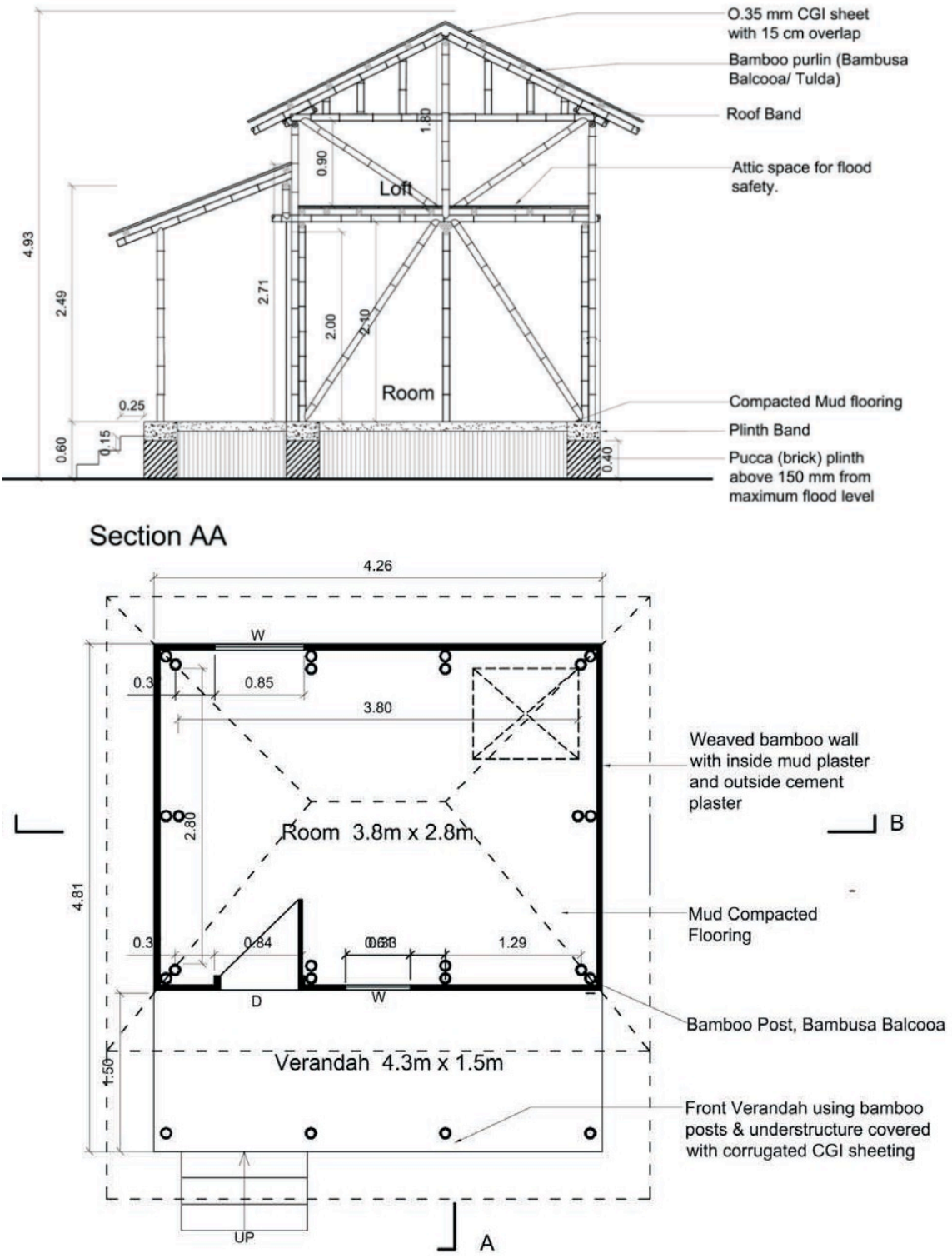

Figure 16

2) Social process:

A very strong social process accompanied the technical component. The aim was to enable people to gain faith in rebuilding a multi-hazard safe housing themselves, for them to own the process hence to retain their dignity and to reinstate people's lost trust in potentials of bamboo and to remove the stigma of it being a 'poor man's timber'. Hence an owner-driven approach was adopted.

Figure 17

To facilitate an Owner-driven approach, Kosi Setu Kendra (KSK) (literally means a bridge) was opened at Panchayat level. A number of ODRC Social Workers (SWs) were appointed to work there to directly deal with locals. The SWs managed grievances cell, resolved land-issues, raised awareness, conducted meetings with locals, helped beneficiaries open bank-account to receive their funding etc. Hence the SetuKendras acted as an information channel between the local households, ODRC and the government. However, these decisions were based on technical awareness generated by the SWs.For example, the awareness about procuring a mature age (>3yrs old) bamboo, about significance oftreating bamboo with chemicals such as boric acid, borax and copper sulphate, sun-drying of bamboo etc. was imparted by SWs and monitored by ODRC technical team. Most people in the village of Orlaha selected bamboo technology, as they could make two rooms as opposed to brick technology, in which they could only make one room, in the financial assistance provided to them.Hence, the uptake of technical guidelines and transparency in financial transactions was highly reliant on social support system.

Analysis: Orlaha settlement, 6 years after the floods:

Out of 41 houses that were built in Orlaha settlement, 39 were built using bamboo technology. Most of the houses were coloured shades of pinks, greens, whites which distinguished them. Moreover, there were minor extensions and alterations, which gave each, house its own appeal. Each and every household had built an external kitchen as they used open fire for cooking and built a *puja* room for their gods and goddess. Lot of households had built a shed for their cattle too.

Various households were identified from Orlaha settlement based on their caste, their livelihood activity, literacy, financial situation and variation in their house extensions/ modifications. Few focus groups helped identify8-10 beneficiaries for interviews and house observation as well as 2-3 non-beneficiaries from the settlement. The paper draws upon initial understanding from recently finished field-study. The outcomes should be viewed in reference to the sample size.

Multi-hazard resistance:

Almost all beneficiaries (about 80%) were confident that their reconstructed house provided hazard safety. Most of them, especially men showed awareness about safety features in their house, whereas

most women were unaware of the same. Remaining few were not sure whether the bamboo would last 40-50 years, and hence had their doubts about the safety of house.

Climate comfort:

About half of interviewed beneficiaries found reconstructed house comfortable. One of the causes of their discomfort was the use of CGI sheets for roofing – as it heats up in summer, forms condensation in winter. Though locals knew that there was some discomfort associated with the use of CGI roofing sheets, they aspired for and demanded CGI sheet roofing instead of traditional thatch roofing, during reconstruction (as per interviews with ODRC members).

It became apparent that locals were not fools. They knew why they wanted CGI sheets. This change in housing typology from sustainable/ transient to more permanent one was a direct response to a changing livelihood pattern. Traditionally people's livelihood in Mithilanchal was dependent on agricultural land, and labour work. Since the agricultural land is owned by a few with power, majority of households who work as labourers on other's land. To maximize their livelihood, men migrate to surrounding cities such as Punjab or Delhi for labour-work, in-between sowing and harvesting times. This migratory livelihood pattern imposes challenges for women who are left alone with children, to maintain house in the absence of men. Those who can afford had started replacing thatch roofs with CGI sheet roofs and from bamboo matt walls to brick walls. The more financially well to do households had started building with brick, RCC and terrace roofs. Hence, housing was already undergoing transformation, from being transient to more permanent or from high maintenance to low-maintenance. However, the rural people were using modern, so-called *pucca*building materials without understanding of proper implementation techniques. For example, concrete slabs were falling off within few years. Hence, the housing typology was more dictated more by livelihood pattern and aspirations, rather than climate-comfort.

Satisfaction with consultation and social process:

Everyone was very satisfied with the consultation process, regular meetings and how they were made aware of the processes. Overall, the satisfaction with the social process was immense.

Satisfaction with bamboo technology:

Satisfaction with bamboo technology was mere 50%, just 5 years after housing completion. Despite treatment of bamboo, majority of houses had structural members infested by *gundh (*borers). In two instances, bamboo beams were crushed. The reason for this can be either selection of immature bamboo pole and/or improper bamboo treatment. Upon discussion with a Social worker – Indukumarji in Orlaha, it was clear that those who didn't understand the significance of treating bamboo and faked treatment process were facing major issues of bamboo crushing.

Whereas some were not too worried about borers in some bamboo poles, others seemed too dissatisfied. Despite such difference in expression, almost none had extensions made out of bamboo. Almost all of those who were extending their houses or building new ones, were using brick and RCC technology. Sadly, neither *Dabiamistry* nor any households knew what chemicals were used to treat bamboo or where to procure these chemicals from.

Conclusion:

This paper focused on the technological and social process of reviving people's faith in bamboo technology, during housing reconstruction of Orlaha settlement after 2008 Kosi floods. The paper overviewed the culture of *Mithilanchal* region, the impact of Kosi floods and the process of reconstructing multi-hazard resistant bamboo houses. Based on the field-study done, 5 years since completion of reconstruction, this paper investigated housing condition, household's satisfaction with their house's multi-hazard safety, climate comfort, bamboo technology and with the social process.

The purpose of this paper was to examine whether an owner-driven reconstruction process could achieve convergence between technology and social perception.

The paper's findings indicate that post-disaster context does offer a small window of opportunity during which local households are open to changing their perceptions for achieving multi-hazard resistant housing. People of Orlaha had aside their stigma for bamboo and had given treated bamboo technology another chance to prove itself by lasting 40-50 years. However, that faith in bamboo technology is dropping, merely 5 years since house completion. On one hand, it is questionable whether it is people's growing aspirations which are the cause of dis-satisfaction with bamboo technology. For example, in recent field-study,majority of households expressed further improvement in their housing and were aspiring for a brick and RCC terraced house. On the other hand, a completely owner-driven approach is questionable – as it required every household to harvest, treat and dry bamboo to be able to use it, rather than being able to purchase a ready-to-use treated bamboo pole. Would it have been better for ODRC to pilot a local treatment facility from where households could have purchased treated bamboo poles? Such a facility would have ensured the maturity of bamboo, its treatment and drying process. Since treatment of bamboo was a crucial element in reviving people's faith and for the success or failure of bamboo technology, was it best left in hands of households?

Thus far, it is understood that despite ODRC's efforts with technical guidance for multi-hazard safety, scientific backup, owner-driven approach and social awareness process, it has barely managed to change the social perception associated with bamboo in Orlaha.

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