AN ENVIRONMENTAL AND SOCIAL IMPACT ASSESSMENT OF POST-DISASTER HOUSING RECONSTRUCTION: THE CASE OF TAMIL NADU

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Abstract

One of the most visible consequences of many disasters is the widespread devastation of houses. This explains why many humanitarian agencies are increasingly focusing their recovery assistance on housing reconstruction. Yet, the complexity and cultural sensitivity in housing and the links with sustainable development is still not fully appreciated resulting in agency-driven approaches with a narrowly technical focus (Twigg 2002; Boano, 2007). Reconstruction agencies often make technological choices without keeping into account socio-cultural, environmental and economic implications (Barakat 2004; Duyne 2006a; Boano 2008).

This paper examines housing reconstruction in Tamil Nadu after the 2004 tsunami as an example of this sustainability gap. Specifically, prejudices towards vernacular housing and building practices combined with an unprecedented availability of private funding for reconstruction led to a massive replacement of environmentally and culturally appropriate housing with reinforced concrete cement. By illustrating the social, environmental and economic advantages of vernacular housing, the article aims at sensitizing agencies involved in post-disaster recovery about the importance of recognizing and building upon local housing culture and building capacity.

The article is based on field research carried out in Tamil Nadu between March 2005 and July 2006 within the framework of two research projects funded by the Swiss Agency for Development Cooperation and the Swiss National Science Foundation. The first project focused on vernacular housing and building practices (Duyne 2006), whereas the second focused on assessing the reparability of partially damaged houses and on a comparative analysis of the costs and benefits of different building technologies in post-tsunami Tamil Nadu (Duyne and Pittet 2006).

Keywords: Vernacular Housing; Post-disaster Housing; Post-tsunami.

Introduction

On December 26th 2004 a severe earthquake hit northern Sumatra causing one of the most powerful tsunamis in recorded history. With an official human toll of over 10,000 people, and material losses and damages estimated over one billion USD, India was one of the countries most severely affected by the tsunami. Over 85% of the losses occurred in Tamil Nadu (ADB et al 2005).

The Government of Tamil Nadu estimated that the tsunami damaged around 135,000 houses and invited humanitarian agencies to participate in the effort to rebuild an equivalent number of multi hazard-resistant houses. This figure was not the result of a careful damage assessment but based on the assumptions that all affected people would need to be resettled at a safe distance from the sea. It was further assumed that already prior to the tsunami fishing communities' housing conditions were inadequate and that post-tsunami reconstruction was an opportunity to upgrade the housing of all affected communities. The call for aid was highly successful: within the framework of a public-private partnership reconstruction program coordinated by the Government of Tamil Nadu, the majority of the coastal villages affected by the tsunami were 'adopted' for full reconstruction by NGOs, charity organizations, and private sector companies.

Only a few months later it became clear that a massive resettlement of coastal communities was neither feasible nor desirable. Fishing communities, who constitute over 80% of the affected people, resisted relocation and it also turned out to be virtually impossible to find sufficient land to rebuild all coastal villages in new locations. As a consequence the government gave up its initial resettlement plan by allowing reconstruction in situ. At this stage it would have been pertinent to reconsider the number of new houses required and to assess the reparability of affected buildings by making a thorough damage assessment. This however did not occur. Most agencies involved in reconstruction had sufficient funds and hence went ahead with building new houses for all, often by demolishing undamaged pre-tsunami houses. Within the framework of our housing reparability assessment carried out in two villages in Nagapattinam district we found that among the 1500 houses an NGO planned to build, 706 houses were going to be constructed in situ by demolishing houses that were in reparable conditions or were not damaged by the tsunami at all. The owners of these houses had not been given the option to repair or upgrade their old houses as an alternative to getting a new house. Under these conditions nobody wanted to miss the opportunity of getting a house for free, though many would have preferred that option (Duyne and Pittet 2006).

Housing Culture in Coastal Tamil Nadu

Housing in coastal Tamil Nadu is a culturally sensitive and highly ritualized process with strong links to local livelihoods and social security. The construction of a new house is a social event that involves several specialized communities. A family generally initiates the construction of a new house in relation to the marriage of a son. They consult first of all an astrologer who draws the house plan. Critical issues are the orientation of the main entrance, the length of each wall, and the number of doors and windows. The astrologer decides an auspicious date and time to begin with construction. He may also be present during several rituals that are performed at different stages of construction and before occupying the new house. Women have a central role in the whole construction process. As men spend much of their time in marine fishery, the mobilization of masons or local contractors, the purchase of construction materials, and the supervision of the works are often left in their hands. The main work is done by specialized castes but adult family members may participate as unskilled laborers. The size and construction materials depend on the house owners' socio-economic status, personal preferences and comfort considerations. The first house of a newly married couple may be a small and fully thatched house. With growing age, family size, and financial resources they may decide to build a new house with brick walls and a thatched roof. A further improvement consists in replacing the thatched roof with hand-made or industrially produced tiles. Few families have the means or desire to build a flat-roofed RCC house. Those who have gone for this type of house realize after some time that it is not very comfortable under the local climactic conditions and may end up adding a thatched roof on top of it.

Fig. 1. Traditional House with Veranda and *Kolam*

Many fishers' houses consist of only 2-3 rooms: a large veranda in the front leads to the main room and a small prayer room. By far the most important room is the veranda. During the day people spend their leisure time and entertain their guests in this semi-open room. In the night the veranda is transformed in a sleeping area by rolling out straw mats on the floors. The inner room is mainly used to store the family's belongings and as a sleeping area during the monsoon season. Also the prayer room, besides containing a small shrine, is used for storage purposes. The kitchen constitutes a separate dwelling, which is invariably located in the southern-eastern corner of the homestead plot. Fishers like bright colors. Their houses' doors, walls and floors are generally painted with beautiful geometric patterns, flowers or animals.

Fishers' settlements are embedded in thick vegetation. An important function of these trees is to provide shade. In a region where temperatures most of the year exceed 40°C the importance of this natural heat protection can hardly be overemphasized.

The heterogeneity, functionality and beauty of vernacular housing disappear behind official statistics, which indicate that 87% of the houses in coastal Tamil Nadu are so-called '*kachcha'* dwellings (ADB et al. 2005). The Hindi word '*kachcha'* literally means '*row*' and generally has a negative connotation. Its opposite, '*pucca'*, means 'ripe' or '*mature*' and has positive connotation. The words *kachcha* and *pucca* are officially used by the government of India to differentiate between houses (but also roads and rural infrastructure such as dikes and irrigation canals) built with industrially produced construction materials (bricks, cement, concrete), and vernacular houses built with locally available constructions materials such as palm leaves, mud and wood. The terms *kachcha* and *pucca* are not neutral. The word *kachcha* is associated with poverty and backwardness and the word *pucca* with modernity. This perception of vernacular housing as being backward explains why immediately after the tsunami the government of Tamil Nadu announced that all damaged *kachcha* houses will be replaced by the government with *pucca* houses and why post-tsunami reconstruction was considered an opportunity to up-grade *kachcha* dwellings into *pucca* houses.

Fig. 2. Decorative elements in traditional houses

Research Methods

The objectives of the research were to assess the viability of post-disaster housing technologies in terms of socio-economic and cultural appropriateness, environmental sustainability and comfort. The research further aimed at raising awareness among agencies involved in post-disaster reconstruction about importance of recognizing local housing culture and building practices and about the advantages of indigenous building materials and technologies over imported ones. A field research has been carried out in Tamil Nadu between March 2005 and July 2006 within the framework of two research projects funded by the Swiss Agency for Development Cooperation and the Swiss National Science Foundation on vernacular housing and building practices, a comparative analysis of the costs and benefits of different building technologies in the case of Post-tsunami (Duyne and Pittet 2006).

Research Questions:

- Which building technologies currently found in coastal Tamil Nadu are most cost-effective, comfortable and have the lowest environmental impact?
- How do the building technologies promoted within the framework of post-disaster reconstruction score in terms of comfort, cost-effectiveness and environmental impact?
- What are the advantages and disadvantages of different building technologies?

Hypotheses:

- Post-disaster housing technologies overemphasize features such as multi- hazard resistance and pay to little attention to other important viability criteria such as cost-effectiveness, comfort, cultural appropriateness and environmental impact
- Post-disaster housing technologies are environmentally unsustainable, unaffordable, uncomfortable and culturally inappropriate

Research Results

With the aim of evaluating the advantages and disadvantages of different housing types that can be found in coastal Tamil Nadu we carried out a comparative analysis of a sample of five house types, with focus on comfort (in terms of internal temperature and humidity at different day and night times), the costs of construction and maintenance, and environmental impact. The following house types were considered for the study and reported in Fig. 3:

- A post-tsunami NGO built house with a RCC flat roof
- A coconut thatched roof house
- A straw thatched roof house
- A traditional tiled roof house (hand-made tiles)
- A Mangalore tiled roof house (industrially produced tiles)

Fig. 3. Different Housing Types Analyzed in the Research

The post-tsunami RCC house is representative for the type of houses built by NGOs involved in housing reconstruction after the tsunami. All other houses are part of the pre-tsunami built environment and are representative for the different type of houses that can be found in coastal Tamil Nadu. All houses were inhabited, had a comparable size and had in common cement floors, and cement plastered brick walls. Shade-providing trees normally surround local houses. For the purpose of this study, however, we selected a sample of houses with no trees around them as to avoid a potential bias caused by their influence on internal temperature.

Construction and Maintenance Costs

The construction and maintenance costs were calculated with reference to the prices of July 2006 for a house with a standard size of 350-400 sq. ft. This allowed us to assess the cost of each house type if it had to be built at the time of the research. For all houses we considered a mortgage interest of 8%. The overall cost calculation in terms of capital investment, maintenance costs, interests and repayment was made over a period of 20 years. As indicated in Fig. 4 our findings indicate that the RCC house in terms of capital investment is the most costly option, but in case of good construction quality requires relatively little maintenance. This may explain why many people, considering the fact that NGO houses are distributed for free, appreciate this technology, in spite of the lower level of comfort associated with it. Good construction quality, however, while common for owner-built houses, was rarely found in post-tsunami housing projects (Duyne and Pittet 2006).

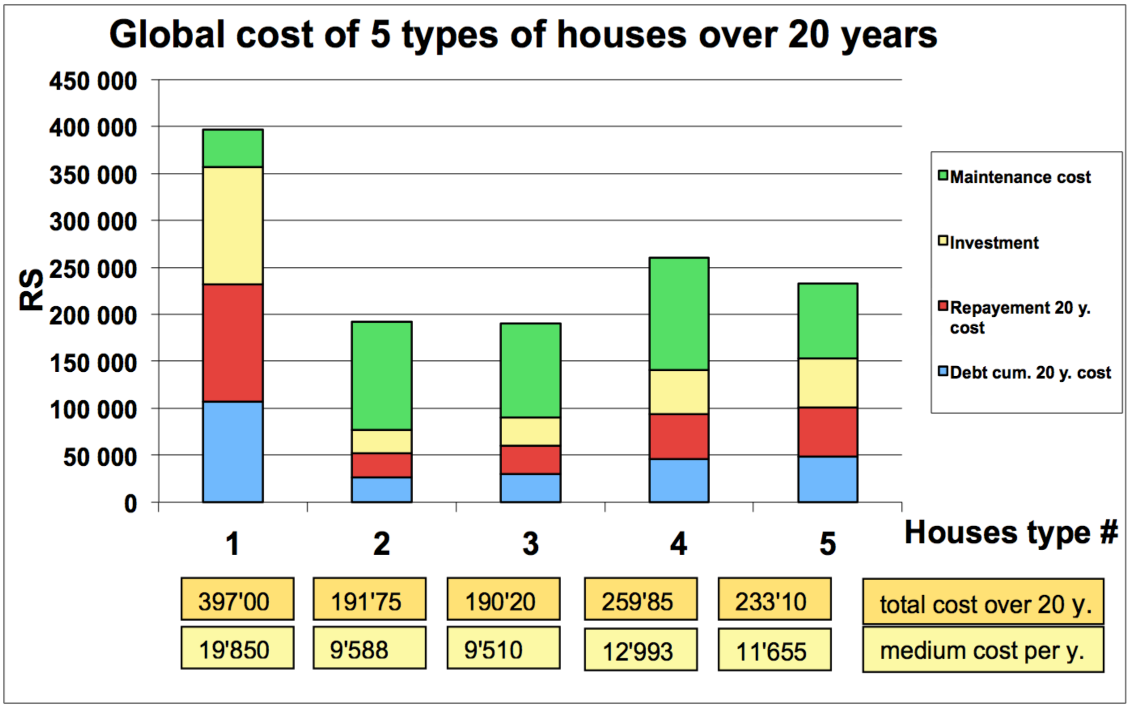

Fig. 4. Costs of Construction and Maintenance of Five House Types

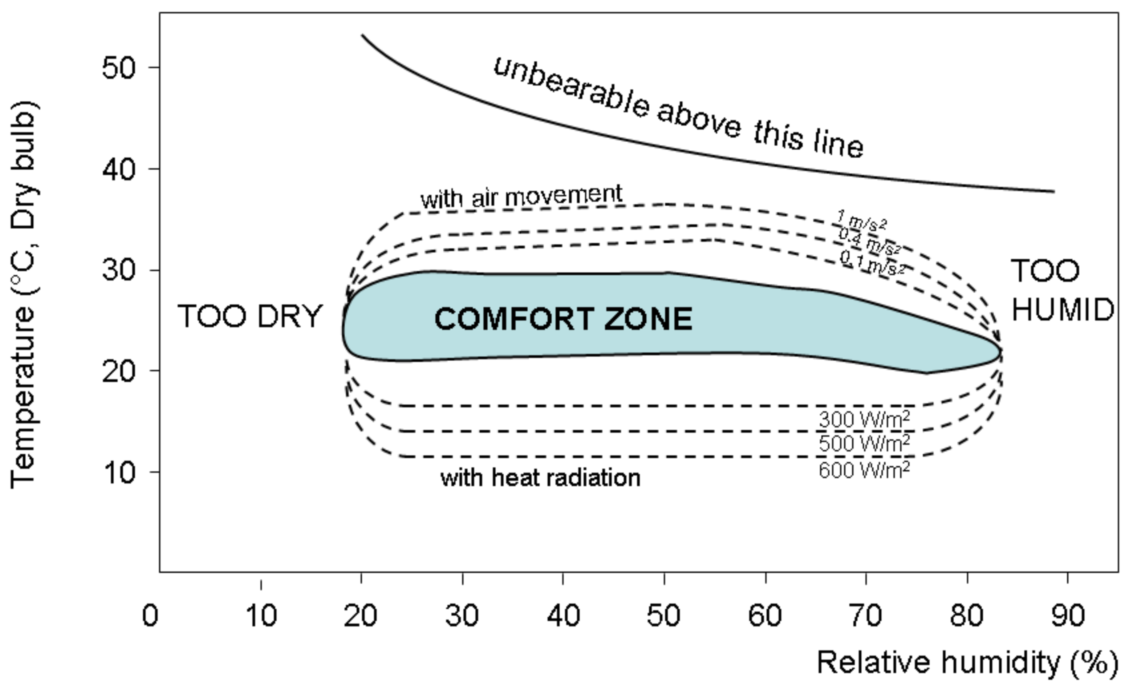

Fig. 5. Bioclimatic Chart Illustrating the Relation Between Air Temperature, Relative Humidity and Air Velocity and the Comfort Zone (Olgyay Bioclimatic Chart)

Air temperature, relative humidity, temperature of the surrounding surfaces and air velocity are the main physical factors influencing the comfort of a house. The relation between these variables, as illustrated in Fig. 5, determines the zone of comfort.

For the purpose of our study we measured the air temperature and humidity inside and outside the five houses every four hours for three days. The temperature of the surrounding surfaces and air velocity were assessed qualitatively. Our data indicate, as shown in Fig. 6 that in terms of internal temperature, the difference between the various types of houses is not very significant, though the coconut thatched house stands out for having a late morning temperature 4°C lower than the Mangalore tiled house.

Weather Fig. 7 shows however that there is a remarkable difference between the RCC house and all other type of houses with regard to relative humidity, which is significantly higher in the RCC house than in any other house type, in particular in the morning hours.

As was mentioned above the comfort basically depends on the relation between temperature and relative humidity. We therefore assessed the level of comfort by reporting the temperature and humidity measurements related to the five houses in the comfort zone graph (see figure 8).

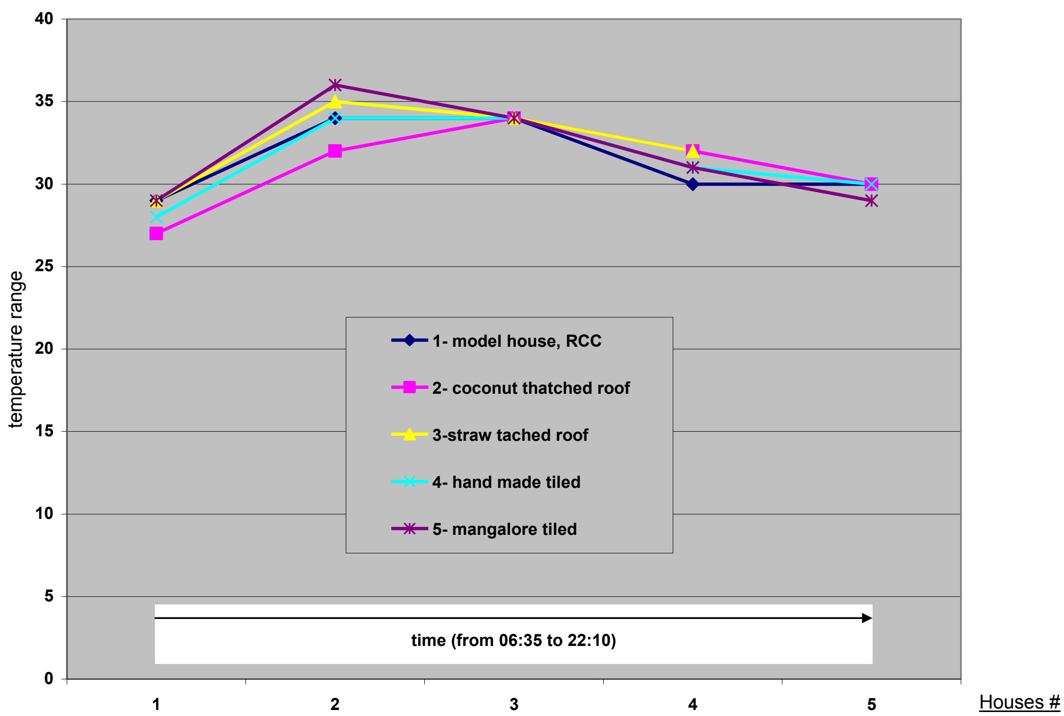

Fig.6. Internal Temperature in Five House Types (from 6:35 am to 22:10 pm)

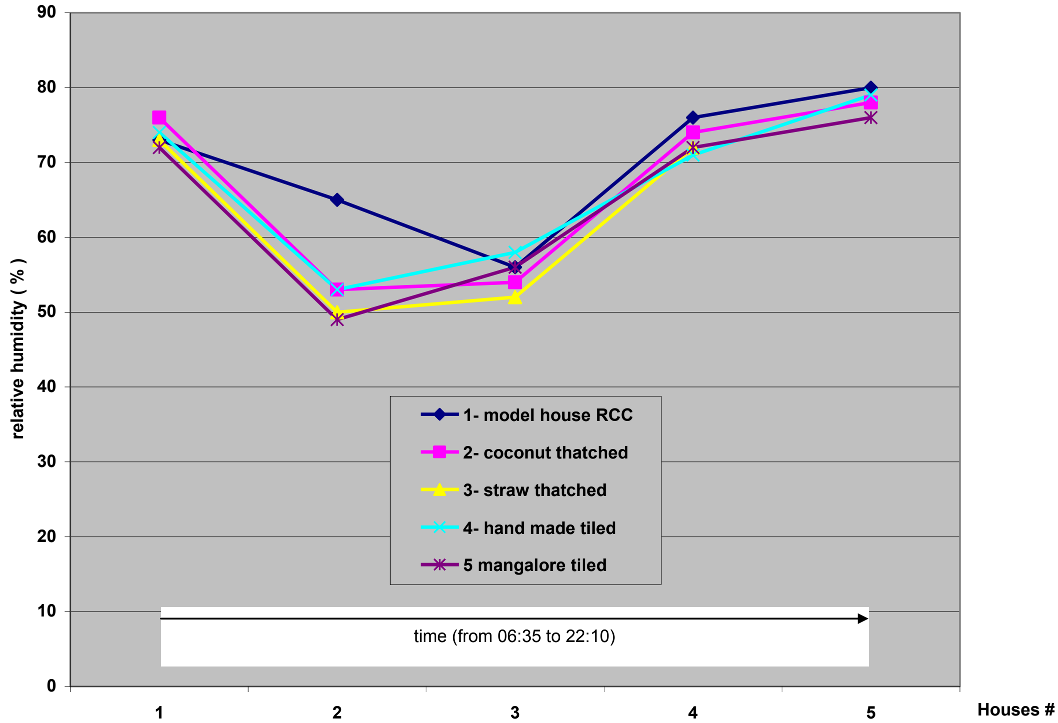

Fig. 7. Relative humidity in five house types from (6:35 am to 22:10 pm)

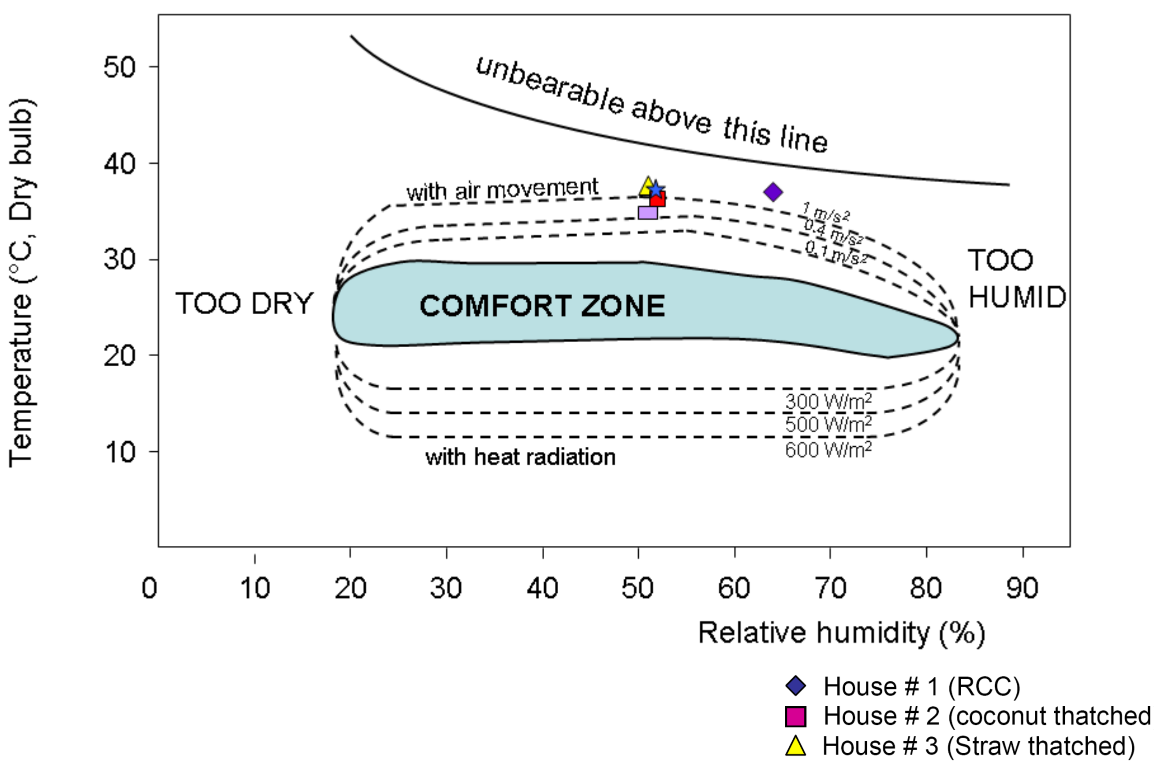

Fig. 8. Comfort of Five Houses with Reference to Comfort Zone Graph (at noon)

Fig. 8 shows that given the high temperature and humidity level prevailing in coastal Tamil Nadu, in the absence of air movement, all houses are actually beyond the comfort zone. However, whereas vernacular house types all offer comparable conditions (with the Mangalore tiled roof house being somewhat closer to the comfort zone), the typical RCC house built by NGOs is very close to being ‘unbearable’. The almost unbearable living conditions offered by RCC houses highlight the importance of the roof design of houses in a climatic zone where the sun is high in the sky and sun radiations mainly hit the roof and somewhat less the walls. Further, the material composition of the building elements exposed to sun radiations also has an important effect on internal comfort, whereby materials with high heat capacity will stock heat energy during the day and give it back through radiations during the night. This is clearly the case of RCC roofs, which accordingly, in terms of comfort provided, may not be considered a viable option in the Tamil Nadu context. The fact that all NGOs opted for flat RCC roofs indicates that local climatic conditions have not been kept into account in the choice of materials and design of new houses. Arguably people may remediate to this situation by building a thatched roof on top of the RCC roof or by using modern air-cooling devices. However, only few people can afford these solutions.

A further factor that affects comfort is the air velocity, which is substantially higher if the house design, light roofs, windows and doors allow for good ventilation. As was mentioned above, the vernacular houses all have well-ventilated verandas, where people spend most of their time. The RCC houses built by NGOs however do not have a veranda as they failed to appreciate the climatic and socio-cultural importance of this space.

Environmental Impact

In this section we aim at making a qualitative analysis of the environmental impact of the building technologies associated with the five house types considered for this study by focusing on the construction materials and their varying environmental impact based on the criteria presented in table 1. We recognize the importance of other factors such as land utilization, energy sources and consumption and all impacts related to infrastructures. However, it was beyond the scope of this study to carry out a comprehensive environmental impact assessment and accordingly we limited our analysis to considerations related to the environmental impact of the construction materials.

Table 1. Criteria for Assessing the Environmental Impact of Construction Materials

Criteria	Why	Recommendations
Local availability of raw materials	The use of locally and abundantly available materials may be considered as being more eco-friendly than the use of important or scarce materials (though even the use of abundant raw materials has to be managed rationally	Maximize the use of locally available abundant materials
Environmental impact of the materials	The environmental impact of materials may be assessed in terms of grey energy consumed for their production and related CO_2. The necessary energy for transporting the materials to the site has to be taken into consideration as well)	Keep into account grey energy consumption and CO_2 emissions in selection of construction materials
Pollutants in construction materials	Refers to the emission of pollutants indoor as well as outdoor. Air change is essential for the elimination of indoor pollutants. Although a complete elimination of pollution is unachievable, significant decrease can be achieved through careful selection of construction materials	Keep into account emission of pollutants in selection of construction materials
Impact of materials in case of demolition	Reuse and recycling potential of construction materials allows saving raw materials and energy. For recycling purposes it the original components need to be separable.	Use replaceable, separable and recyclable materials

A qualitative assessment of the environmental impact of the construction materials utilized for the five house types is given in Fig. 9.

Materials	Criteria for environmental impacts			
	Local availability	Environmental impact	Pollutants	Demolition
Stones	Low or no impact	Low or no impact	Low or no impact	Low or no impact
Local bricks	Low or no impact	Medium impact	Low or no impact	Low or no impact
Cement plaster	Important impact	Important impact	Medium impact	Important impact
Bamboo beams	Low or no impact	Low or no impact	Low or no impact	Low or no impact
Coconut leaves	Low or no impact	Low or no impact	Low or no impact	Low or no impact
Palm leaves	Low or no impact	Low or no impact	Low or no impact	Low or no impact
Straw	Low or no impact	Low or no impact	Low or no impact	Low or no impact
Wood	Medium impact	Low or no impact	Low or no impact	Low or no impact
Steel	Important impact	Important impact	Medium impact	Important impact
Concrete	Important impact	Important impact	Medium impact	Important impact
Mangalore tiles	Medium impact	Medium impact	Low or no impact	Low or no impact
Local tiles	Low or no impact	Medium impact	Low or no impact	Low or no impact
Painting	Important impact	Medium impact	Important impact	Important impact

Low or no impact — medium impact — Important impact

Fig. 9. Qualitative Assessment of the Environmental Impact of Main Construction Materials Utilized in Coastal Tamil Nadu

As summarized in Fig. 10, thatched-roofed vernacular houses have the lowest environmental impact, whereas the RCC houses proposed by external agencies in the context of post-tsunami recovery projects have the highest.

Houses types	Criteria for environmental impacts			
	Local availability	Environmental impact	Pollutants	Demolition
1- RCC	Important impact	Important impact	Medium impact	Important impact
2- Coconut thatched	Low or no impact	Low or no impact	Low or no impact	Low or no impact
3- Straw thatched	Low or no impact	Low or no impact	Low or no impact	Low or no impact
4- Hand made tiles	Low or no impact	Medium impact	Low or no impact	Low or no impact
5- Mangalore tiles	Medium impact	Medium impact	Low or no impact	Low or no impact

Fig. 10. Environmental Impacts of Different House Types by Construction Materials

Discussion and Conclusions

Our comparative analysis of different housing technologies found in coastal Tamil Nadu indicates, as shown in Fig. 11, that the coconut and straw thatched houses may be considered the best option in terms of economic viability, environmental impact, and comfort. Tiled roof houses, though offering relatively good comfort, with reference to their cost over a period of 20 years, are slightly more expensive than thatched roof houses and also have a higher environmental impact. According to local people, one of the advantages of tiled roofs over thatched roofs is the lower maintenance requirement. In fact, while a good quality tiled roof may last over 20 years, a thatched roof needs to be fully replaced every four years. Nevertheless it is not uncommon to find people who chose thatched roofs because they recognize their advantages in terms of comfort even if they could afford other types of roofing. In any case, the RCC houses built by humanitarian agencies within the framework of post-disaster recovery projects clearly represent the least viable option, are most expensive, offer the lowest level of comfort and have the highest environmental impact.

Houses types	ISSUES		
	Economy	Environment	Comfort
1- RCC	Low	Low	Average
2- Coconut thatched	Good	Good	Good
3- Straw thatched	Good	Good	Good
4- Hand made tiles	Average	Average	Good
5- Mangalore tiles	Average	Average	Good

Level of performance:

Good Average Low

Fig. 11. Economic Viability, Environment Impact and Level of Comfort by Housing Technology

Our research in Tamil Nadu shows that the tsunami did not damage the housing stock of coastal communities as extensively as was claimed by official figures. Many vernacular houses that are being demolished and replaced with presumably multi hazard-resistant houses are of good quality, environmentally sustainable, affordable, beautiful and more comfortable than the houses built by external agencies. Given the poor quality of construction that we have observed in many sites, the new houses may also be significantly less safe than traditional houses, in particular considering people's limited financial and technical capacity to repair and maintain RCC houses.

In Tamil Nadu, neither the government with its technocratic biased reconstruction policy framework, or the NGOs, paid any attention to the socio-cultural and environmental context of their housing reconstruction programs. These programs aspire to the importance of preserving the pre-disaster built environment and to the potentially severe social and environmental impact of their mass housing projects.

As shown by our comparative analysis of different housing technologies, the reasons to preserve the pre-disaster built environment are several. Human settlements reflect peoples' history and cultural identity. From an environmental point of view, demolishing reparable houses is unacceptable, in particular when linked to the introduction of locally unaffordable building materials and technologies. From an economic perspective, replacing reparable houses is the least cost-effective strategy to solve the housing problem and may detract valuable resources to meet other requirements of disaster-affected people.

Further, the demolition of pre-disaster settlements also involves massive cutting of trees as most construction companies only start building when the ground is completely cleared. The living conditions in these new settlements may thus be further exacerbated by lack of shade-providing trees that also used to be important livelihood resources, which may be compounded by processes of social disarticulation related to resettlement or by the layout and spatial organization of the new settlement.

There is no doubt that a significant number of houses have been fully demolished by the tsunami. Agencies involved in housing reconstruction, however, should have made an informed and contextually appropriate technological choice and pay more attention to preserve the design, materials and construction practices related to local housing. Indeed, our comparative analysis of the comfort, cost and environmental impact of different housing types indicated that from a comfort and sustainability perspective vernacular houses are significantly more appropriate than so-called multi-hazard resistant houses built by agencies involved in post-tsunami reconstruction. The replacement of old houses with entirely new settlements also had a considerable impact on the natural environment as it involved massive cutting of trees and land filling.

Finally it needs to be emphasized that strengthening local housing culture and building capacity by empowering people through financial and technical assistance to manage themselves the reconstruction of their own houses, as was done by the Government of Gujarat after the 2001 earthquake (Duyne 2006a), besides leading to a more sustainable built environment, also represents an effective economic, livelihood and psychological recovery strategy.

Key Lessons Learned:

- Actors involved in reconstruction should pay attention to the socio-cultural and environmental context of their housing reconstruction programs, to the importance of preserving the pre-disaster built environment and to the potentially severe social and environmental impact of mass housing projects.
- Actors involved in reconstruction should made informed and contextually appropriate technological choice and pay more attention to preserve the design, materials and construction practices related to local housing.
- Effective economic, livelihood and psychological recovery strategy should be based on local housing culture and building capacity by empowering people through financial and technical assistance to manage themselves the reconstruction of their own houses.

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Author's Biography

Jennifer Duyne Barenstein has a PhD in social anthropology from the University of Zurich. She worked and did research for over 20 years in Bangladesh, India, Sri Lanka, Indonesia, Switzerland, Italy and Mexico. Her key areas of interest are socio-economic, cultural gender and institutional dimensions of post-disaster reconstruction and livelihoods restoration, housing, rural infrastructure development and water resource management. From 1989 to 2007 she was a senior lecturer at the Department of Social Anthropology of the University of Zurich. Before joining ISAAC-WHRC and the University of Zurich she was a consultant for SDC, DGIS, UNICEF, the World Bank, DFID, IFAD, IWMI, and Swiss Solidarity.

Daniel Pittet is a civil engineer, and has MAS-EPFL in architecture and sustainable development. His key areas of interest are applied research on sustainable architecture, the architectural integration of photovoltaic, on the sustainability of public building stock management and on the sustainability of post disaster reconstruction projects in India. He has worked for several years in Nepal in the field of national road network maintenance management for SDC and Nepal Department of Roads as well as a consultant fort he NGO Kam For Sud in the field of sustainable buildings projects (ongoing activity). In Switzerland, he was active as an infrastructure site manager for seven years and then as a consultant fort the national program Swiss Energy in the field of sustainable energy management policies for Municipalities (ongoing activity).