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Half-Baked: Developing a Hybrid Between Traditional and Modern Building Typologies in the Indian Village of Bahuarwa

Daniel Haselsberger and Isha Dhingra

Abstract

Climate change, dwindling resources, and decreasing biodiversity are but a few of the most urgent challenges we are facing in the twenty-first century. All of them are influenced by a growing building sector, which in 2020 was accountable for more than 35% of the global CO_2 emissions and energy demands (UN 2021). These numbers are even more alarming, considering that big parts of the world are only at the beginning of a shift from traditional building methods with a low environmental impact to "modern" ones being responsible for an increasing environmental degradation and often not suitable for the changing climatic conditions. This transformation lies at the centre of this chapter and is analysed in the context of Bahuarwa, a rural village in the Indian state of Bihar. Interviews with inhabitants and craftspeople, analyses of buildings and observations of the daily-life patterns aim to provide a better understanding, why people transform the so-called kutcha (derived from Hindi "kaccā" for "raw, uncooked, unripe, immature") house made of the natural and locally available materials mud, bamboo, and thatch into the pukka (derived from Hindi "pakkā" for "cooked, ripe, mature") house constructed of fired bricks, cement, and steel. Based on this understanding, a hybrid typology will be proposed that aims to combine the advantages of the more environmental-friendly and climate-adapted kutcha house with those of the socially more accepted pukka house. This chapter summarizes the initial analysis of an ongoing dissertation, which is accompanied by a participatory planning and construction process of a school building for underprivileged children of a scheduled caste in Bahuarwa.

Keywords

Climate adaptation · Tradition · Hybrid · Sustainability conflicts

8.1 Introduction

In the Paris Agreement, 196 countries agreed to pursue measures to limit global warming to well below 2 °C, preferably 1.5 °C compared to preindustrial levels (UN 2015). Buildings and the construction sector play a major role to achieve this goal. In 2020, they accounted for 36% of the global energy demand and 37% of energy-related

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CO_2 emissions (UN 2021). To reach the goals of the Paris Agreement, buildings as well as building activities must be almost decarbonized by 2050. At the same time, the building sector will be confronted with an estimated doubling of global energy consumption in buildings and more than a doubling of floor area consumption, mainly due to a growing demand in developing countries as a consequence of population growth as well as industrial and infrastructural progress (UN 2021). Even though the building sector is the second most mentioned policy in the Nationally Determined Contributions to the Paris Agreement, the footprint of construction materials is often under-addressed (UN 2021).

With the adoption of the Universal Declaration of Human Rights (UN 1948, Art. 25), the right for adequate housing has been acknowledged as an integral aspect of an adequate standard of living. Nevertheless, currently every seventh person in the world is estimated to live in inhumane conditions, such as slums, favelas, and informal settlements, and every fourth person is expected to live in such conditions by 2030 (Habitat for Humanity). This does not only pose the question whether this human right can be guaranteed to every person in a world with a growing population and growing demands, but also how it can be fulfilled without exceeding the planetary boundaries (Klinker 2009). This work is a search for ways how architects cannot only promote more sustainable ways of building but direct their focus on parts of the world which will play a relevant role in the above-mentioned predictions and yet are often neglected in the work of architects.

The focus lies on the promotion of locally available and natural building materials through a recollection and advancement of vernacular building traditions in a participatory process with inhabitants and craft experts. In the context of Bahuarwa, a village in the Indian state of Bihar, two contrasting building types representing the "traditional" and the "modern" way of building, will be examined and combined to a "new vernacular" that will be tested through the construction of a school building in a later phase. Although the focus of this chapter is primarily aimed at SDG 13—Climate Action—this work also considers the promotion of regionally anchored innovation (SDG 9) and value creation (SDG 8), the creation of educational opportunities (SDG 4) for disadvantaged children and thus the reduction of inequalities (SDG 10). Thereby, environmental, social, and economic aspects of sustainability should be equally considered and brought into balance.

Conducting research in a rural Indian village comes along with communicative barriers and requires a cultural understanding that cannot be easily acquired by a researcher from Switzerland. Whilst some perceive such an endeavour as a valuable social commitment, others see it as an attempt to impose romantic Western notions of using natural building materials or as a desperate clinging to bygone traditions. We agree with these concerns, and we are aware that building materials and methods, especially when they lack social acceptance, cannot be easily (re)introduced and developed further in a context that strives after Western standards. We would not see ourselves in a position to make a sustainable contribution to improving the living conditions of the local community if we did not have a strong personal connection to the research context through Isha Dhingra's Indian origin. Without her, this research would not only lack closeness to the local community and miss connections to relevant stakeholders, but it would not take place at all. Together, however, we can create a bridge between our different cultural backgrounds which provides a strong base for a research and a development cooperation that benefits the target group.

This paper is organized in five chapters. The first is a reasoning to consider and actualize vernacular building traditions based on the example of India. The second chapter is an analysis of the vernacular building traditions in Bahuarwa. Considering environmental, social, and economic aspects, the sustainability potential of the traditional kutcha house in Bahuarwa will be analysed. Even though this building typology comes along with a great potential from an environmental point of view, it is increasingly replaced by the pukka house, which consists of fired bricks, cement, and steel. In the third chapter, the sustainability potential of the pukka house, as an anti-thesis to the kutcha house, will be analysed and compared with the kutcha house. This should not only show the complexity of the often conflicting environmental, social, and economic aspects of sustainability but also underline the different meanings of sustainability in the global north and south, which are outlined in chapter four. The comparison of the two building typologies will lead to the fifth chapter, wherein a synthesis will be proposed, which aims to combine the advantages of both typologies.

The findings presented in this paper are the result of a fieldtrip to Bahuarwa in April 2022, where we have visited around 15 families in their homes. Ethnographic research (Flick 2018), including informal talks with the inhabitants and observations made during our village explorations, has served as methodological framework for this initial research phase. The visited families were carefully selected by our local partner for the implementation and operation of the planned school, who is socially committed to improve the living conditions of underprivileged inhabitants through his work in the Bahuarwa Foundation. In a next stage, the here proposed design measures will be developed further in focus groups with the local community and through hands-on experiments with craftspeople. This should provide a base for the design and construction of a school which will be implemented in a participatory process with the local community at a later stage of this ongoing research by design.

8.2 A Need to "(Un)Bake"

Population growth, urbanization, and economic development have major consequences on the resource and energy demand in the construction and residential sector of India. The International Energy Agency (IEA 2021) expects the total residential floor area of India to increase from less than 20 billion square meters in 2020 to more than 50 billion in 2040, which comes along with an estimated doubling of the demand for cement and almost a tripling of the demand for steel. In addition to the construction, the operation of the building stock will lead to a further increase of the energy demand and the CO_2 emissions. The IEA (2021) underlines three trends that influence the energy demand of buildings in India: The construction activities due to an increasing urbanization, the shift from traditional materials to modern materials, and the increasing usage of appliances, mainly air conditioners.

The so-called modern building materials do not only contain a multiple of embodied energy and CO_2 emissions compared to natural, low-processed materials (Shubham and Kolhatkar 2020), they also lead to a multiple of the energy demand required to ensure thermal comfort (Nugent 2022). According to forecasts, this will lead to a growth of air conditioner stock from 30 million in 2018 to 670 million in 2040 (IEA 2021), as the changed construction materials and typologies usually do not manage to provide a pleasant interior climate without additional cooling appliances. Thereby climate change on a macro-level and the urban heat island effect on a micro-level are intensified, leading to a vicious cycle, wherein the treatment of the symptoms is intensifying the cause of an increasing problem.

The belief in bricks and cement as means of progress is also represented in the country's public housing programs. Following the goal of "housing for all" by 2022, the "Pradhan Mantri Awas Yojana" project (Ministry of Housing & Urban Affairs 2015) aims to provide a house constructed with modern building materials to everyone who is still living in a dwelling made of natural building materials (IEA 2021). Such programs contribute to the increasing abandonment of traditional building materials. Whereas in 1990, only 30% of the rural and 75% of the urban buildings were made of modern building materials, these shares increased to 80% and 97% in 2018 (IEA 2021). With the aim to replace natural building materials with fired bricks, cement, and concrete, the public housing programme entails the next programme, the "Indian Cooling Action Plan" (Ministry of Environment, Forest & Climate Change 2019) which started in 2019. "Housing for all" by 2022 is complemented by the promise of "thermal comfort for all" by 2040.

The increasing energy demands and CO_2 emissions related to changing construction processes, the following dependence on air conditioners to ensure a pleasant interior climate, combined with the consequences of a growing population and the impacts of global warming require a different building approach that is more climate-friendly on the one hand and better suited to dealing with the consequences of climate change on the other. The approach, presented in this paper, is closely related to the choice of natural and locally available building materials and the advancement of traditional building knowledge. In the following chapters two contrasting building types will be analysed: The kutcha house made of mud, bamboo, and thatch and its modern replacement the pukka house, constructed of fired bricks, cement, and steel.

8.3 Unbaked: The Environmental-Friendly Kutcha House

The term kutcha house is commonly used all over India for buildings that are characterized by a "form follows climate" logics. The kutcha houses are made of natural and locally available materials (Fig. 8.1). They are a product of traditional building methods that involve a high degree of manual labour but hardly any machines. The kutcha houses are adapted to the climatic conditions of their locations, ensuring thermal comfort to their inhabitants through design solutions instead of technological means. However, the term "kutcha" stands for "weak, temporary, or unbaked, uncooked" (dictionary.com 2022a). This literal translation also provides insight into the disadvantages of these buildings: little processing makes the kutcha houses less durable and involves a higher maintenance effort compared to houses built with "baked" bricks, cement, and steel.

> Our house stays cool in the hot summer months, but we need to repair it every year after the monsoon and the thatch roof needs to be replaced every five years. Therefore, we will transform our kutcha house into a pukka house as soon as we have enough money.
> Inhabitant of a kutcha house in Bahuarwa

The sustainability potential of the kutcha house is high considering the energy demand and greenhouse gas emissions involved in the construction, operation, and recycling of the buildings. However, the maintenance-intensity, the lacking durability, the dusty or muddy floors, insect infestation, and insufficient protection against crime are perceived as disadvantages by most inhabitants (Fig. 8.2). The positive aspects mentioned by the users mostly refer to the pleasant interior climate. Since the environmental aspects do not play a role for the evaluation through the inhabitants and the pleasant interior climate cannot outweigh the numerous disadvantages, all the asked inhabitants wish to live in a pukka house, which is more durable and represents a higher social status.

8.4 Baked: The Socially Accepted Pukka House

The term "pukka" is Hindi and means "strong, durable, baked, or cooked" (dictionary.com 2022b). Relating to construction, it stands for houses made of solid materials, such as fired bricks, reinforced concrete, or stones (Bera 2019). In contrast to the kutcha house, the pukka house usually involves a higher degree of processing, for example through the firing process of bricks or cement. In addition, the pukka house is usually made of materials and building parts that involve longer transport distances as they cannot be sourced and processed locally. Regarding the construction methods, the pukka house is based on a globally spread technique, wherein a reinforced concrete skeleton is combined with fired brick fillings. Unlike the kutcha house, which is

Fig. 8.1 Typical kutcha houses in Bahuarwa, made of mud, bamboo, and thatch (left), and gradual transformation into a pukka house (right) (Authors 2022)

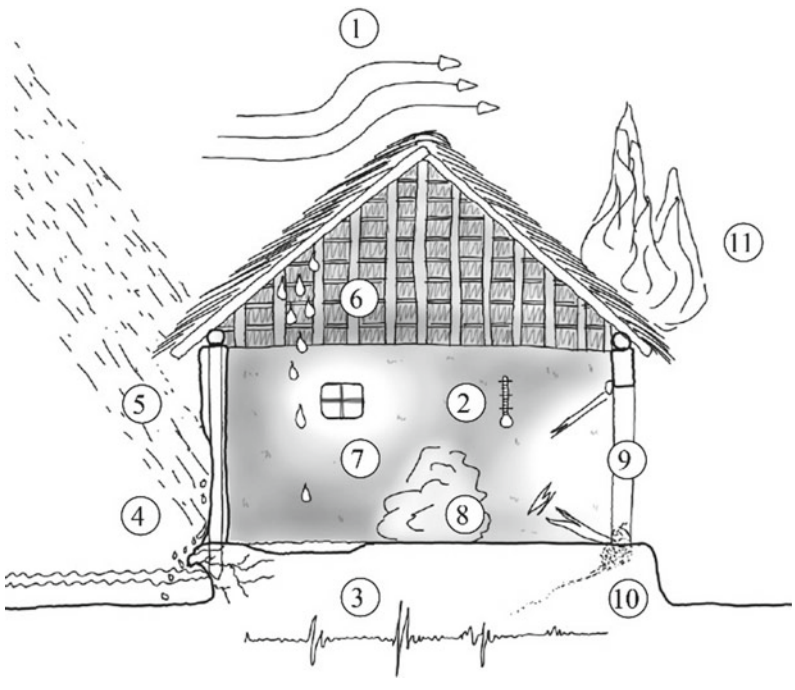

Fig. 8.2 Evaluation of the kutcha house through the local community. Pros: relatively wind-proof through hipped roof and buffering thatch (1), relatively pleasant interior temperature through insulating and breathable roof and walls (2), earthquake-resistant due to low and compact shape, lightweight roof, and flexible bamboo structure (3). Cons: erosion of mud foundation (4), erosion of mud walls (5), leaking thatch roof (6), dark interior (7), dusty floors (8), limited safety (9), insect infestation of bamboo & mud (10), fire-prone thatch roof (11) (Authors 2022)

primarily a result of the specific climatic conditions of its location, the pukka house shows little relation to its natural environment. Figure 8.3 shows the observed gradual transformation of a kutcha house into a pukka house depending on the financial means of the inhabitants.

Looking at the pukka house, the evaluation turns out to be almost the opposite from the one of the kutcha houses. The greenhouse gas emissions and the energy demand for the construction, operation, and recycling of the building are much higher. The greenhouse gas emissions of one kilogram of fired

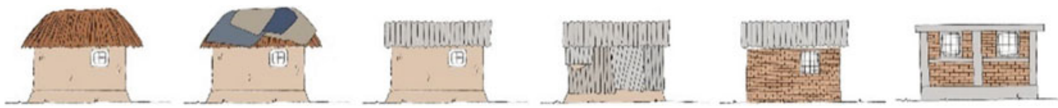

Fig. 8.3 Gradual transformation from a kutcha house on the left to a pukka house on the right: the focus shifts from an initial transformation of the roof to the walls to the foundation, whilst the materials change from mud, bamboo, and thatch to plastic sheets, corrugated metal sheets, fired bricks, and reinforced concrete (Authors 2022)

brick (0.267 kg CO_2 eq) are more than 14 times higher than those of, for instance, one kilogram of rammed earth (0.019 kg CO_2 eq) and those of cement plaster (0.261 kg CO_2 eq) almost eight times higher than the ones of clay plaster (0.033 kg CO_2 eq) (KBOB et al. 2022). According to the Indian researchers, Shubham and Kolhatkar (2020), the total embodied energy of typical vernacular building materials used in India ranges from 0.11 to 18 MJ/kg, whereas the one of modern building materials reaches from 2.6 to 360 MJ/kg. The recycling of the latter is often not fully possible. Furthermore, the inhabitants become dependent on imported, highly processed materials, which are more expensive and deteriorate the interior climate.

Even though the informal pukka house is not as environmental-friendly as its vernacular counterpart, it offers many advantages in terms of social and economic sustainability. The high durability, the waterproof construction, the minimized risk of infestation through termites, the effective protection against human intruders, and the reduced maintenance efforts outweigh the disadvantages (Fig. 8.4), which are either not taken into consideration or compensated through technological solutions.

> "Living in a pukka house is not just about less maintenance efforts, but about a higher reputation in the village". Inhabitant of a pukka house in Bahuarwa

The analysis of the two prevailing building types in the rural context of Bihar leads to the question whether and how it is possible to develop the kutcha house further to overcome its disadvantages and make it as accepted as the pukka house. This will be the topic of the next chapter, wherein sustainability conflicts of environmental, social, and economic aspects are explained based on the comparison of these two building types. In a further step, a synthesis is proposed, aiming for a balance of the different sustainability aspects.

8.5 Sustainability Conflicts

The comparison of the more environmental-friendly kutcha house and the socially better accepted pukka house is also a comparison of different sustainability aspects. Relating sustainability to its three pillars, economic viability, social equity, and environmental protection, results in conflicts that affect planning and building practices: A resource conflict as a consequence of a growing economy and the limited planetary carrying capacity, a development conflict between the growing needs of developing countries and the urgency to limit resource consumption and greenhouse gas emissions, and a property conflict between a liberal market and a fair distribution of global resources (Campbell 1996). The kutcha houses in Bahuarwa exemplify green building practices but they also mirror the social inequality, as only those still live in them which cannot afford to do otherwise. The pukka houses in turn represent a higher socioeconomic status that depends on a bigger environmental impact and an exploitation of human labour in brick kilns.

Looking at the lifecycle of a building, the conflicts become apparent from a temporal point of view: "The ideal building would be inexpensive to build, last forever with modest maintenance, but return completely to the earth when abandoned" (Bainbridge 2009). The required cheap construction is often based on short-term planning regardless of higher operational and recycling costs, which usually overcompensate the initial savings. An ever-lasting durability and a low

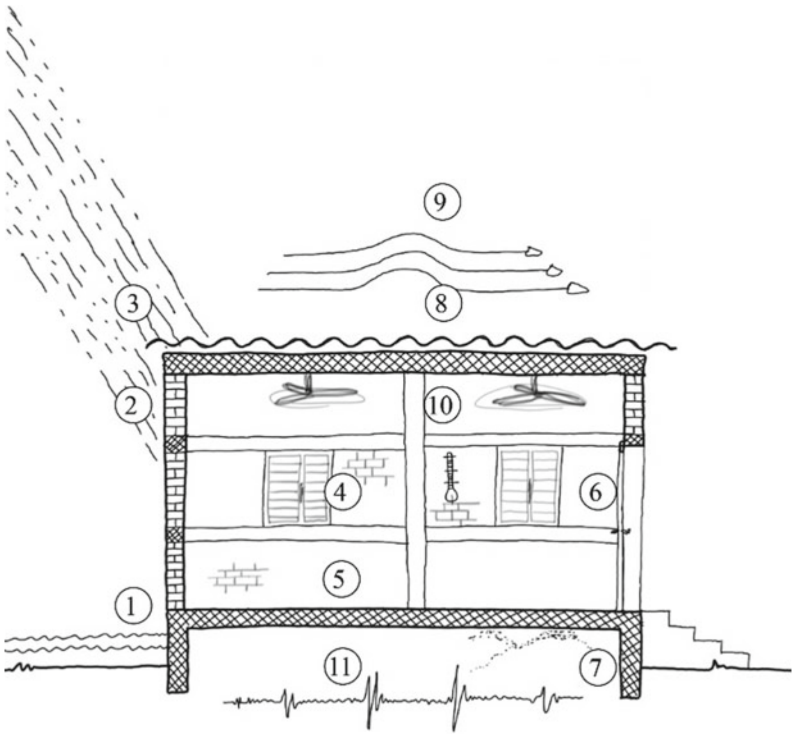

Fig. 8.4 Evaluation of the pukka house through the local community. Pros: erosion-proof foundation (1), erosion-proof walls (2), waterproof roof (3), bright interior (4), maintenance-friendly floor (5), safe doors and window grilles (6), protection from insect infestation (7), fire-proof roof (8), wind-proof structure (9). Cons: dependence on air conditioners and fans for pleasant interior climate (10), conditional earthquake-resistance depending on interlocking of bricks and concrete structure (11) (Authors 2022)

maintenance do not only require higher construction costs but stand in conflict with the recyclability of the building. A high durability usually depends on high temperatures in the processing of building materials, which results in irreversible chemical and physical transformations of its properties. Thus, the materials cannot be returned to their original condition in nature.

Comparing the before-mentioned characteristics of an ideal building with the analysed kutcha house, it turns out that the kutcha house is inexpensive to build and returns completely to the earth when abandoned but does not last for a long time without a high maintenance. The mud walls, especially the foundation, need to be repaired after every monsoon season. The same accounts for the thatch roof, which in addition needs to be replaced completely after every five years. Thus, the durability and low maintenance stand in contrast with the required recyclability and the inexpensive construction. Looking at the pukka house, the construction is more expensive, lasts longer with little maintenance, but cannot be returned to its original condition in nature. The characteristics of the kutcha- and the pukka house almost oppose each other. Whereas the kutcha house must become more durable and require less maintenance to become socially more accepted, the pukka house must involve less processing of the materials and use mechanic joints to become more environmental-friendly.

Besides the conflicts amongst environmental, social, and economic aspects of sustainability along the lifecycle of a building, there is another conflict in the perception of progress through an opposition of the traditional and the modern, as well as the locally rooted and the globally accepted. Whereas some perceive the traditional as backward and limiting, others see in it a key to (environmental) sustainability. The modern in turn is either perceived as a path to (economic) prosperity or as the reason for environmental degradation. Focusing only on the environmental sustainability of the traditional, one forgets that past generations were sustainable out of necessity (Campbell 1996). Believing, on the other hand, that economic growth necessarily leads to social justice, is doubtful and does not consider the limited capacity of our planet. Campbell (1996) suggests that such “a dichotomous, black-and-white view of sustainability” should be avoided. Instead, a “hybrid of both sorts of practices” should be developed in an “evolutionary progression”, wherein local conditions are considered to reach a global sustainability (Campbell 1996). Therefore, Frampton (2002) proposes a critical regionalism that takes an “arriere-garde” position “[…] which distances itself equally from the Enlightenment myth of progress and from a reactionary, unrealistic impulse to return to the architectonic forms of the preindustrial past”.

The aim of this work is not to play off the traditional and the modern against each other but to understand the reasons for their dynamics based on the perspective of the users, considering environmental, social, and economic aspects in order to find sustainable synergies. Instead of abandoning the locally rooted building practices of the kutcha house and replacing them by the globally spread construction method of the pukka house, a hybrid should be developed that considers local conditions and integrates technological advancements.

8.6 Half-Baked: Developing a Hybrid

The goal of this analysis is to develop a building typology that is climate-friendly as well as climate-resistant. Wherever possible, this goal should be reached through design measures instead of changes in the materials. If a problem cannot be solved through design measures, a partial replacement of a building part with other materials should be favoured against its complete replacement. In addition, a replacement through other natural or little processed materials is preferred against highly processed materials. Figure 8.5 presents the most important measures.

The measures aim to:

Allow a safe, affordable, and participatory planning and construction process:

- Ensure affordability.
- Allow adaptation to individual room layouts.
- Allow a safe construction process.
- Allow a high degree of self-construction.

Improve durability and resistance:

- Guarantee resistance against the heavy rainfalls of the monsoon season.
- Guarantee resistance in case of floodings.
- Guarantee resistance against termites and other insects.
- Guarantee resistance in case of earthquakes.

Ensure a safe and comfortable use:

- Ensure thermal comfort through low tech measures.
- Ensure a brighter and less dusty interior.
- Ensure protection from intruders.
- Require little maintenance.

Promote the regional economy and leave a small environmental footprint:

- Use natural, little processed materials.
- Use locally sourced and manufactured materials.
- Integrate local craftsmanship and knowledge.
- Use mechanical joints instead of glues, cement, and other binding materials.

8.6.1 Foundation

The foundation presents a crucial building part to make the kutcha house more durable. It raises the building from a ground that is flooded during the rainy season from July until September. During this time, the water erodes the base of the building. Whilst a wide roof overhang can protect the walls from the rain, it cannot prevent water from pooling on the flat terrain and damaging the foundation. A higher or wider foundation can only postpone but not avoid the damage either. The easily erodible mud foundation cannot become more durable and require less maintenance through constructive measures only. At least its outer layer must be replaced by

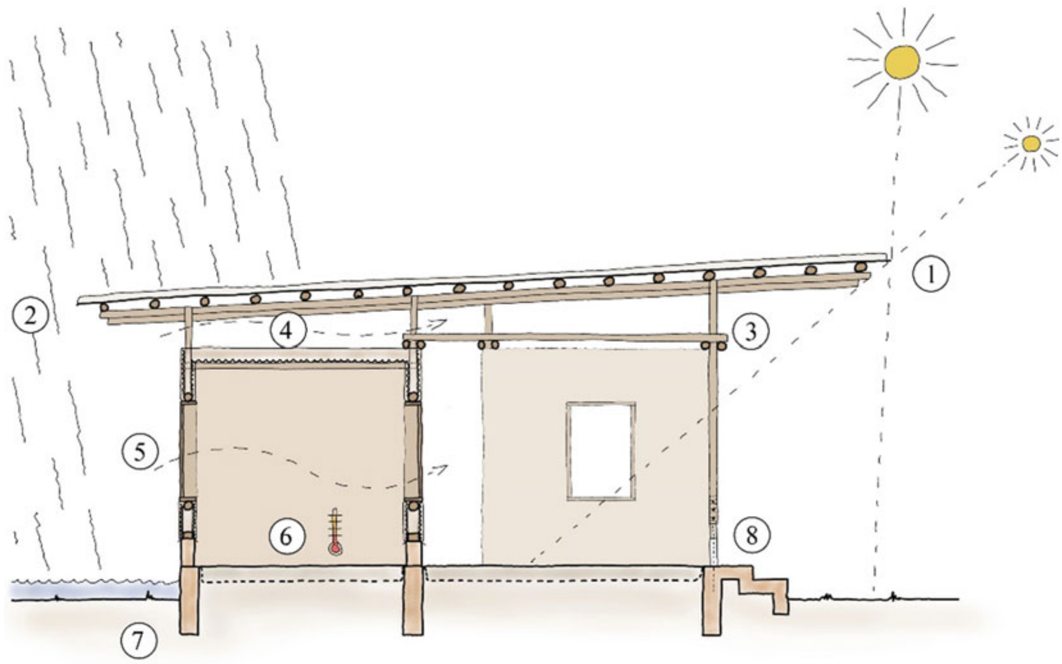

Fig. 8.5 Characteristics of the proposed hybrid construction: canopy to protect from the sun, especially during the summer months (1), canopy to protect against rain (2), low building height, light roof, and bamboo construction for earthquake protection (3), lifted roof to promote ventilation and reduce radiation (4), perforated walls and openings to promote permanent cross ventilation (5), compressed mud floor as thermal storage (6), plastered brick foundation and plinth to protect from flooding and splash water (7), freestanding bamboo pillars lifted from ground to be protected from splash water (8) (Authors 2022)

a more durable material. Stones would offer a durable option, but since there is no natural occurrence of stones in the closer surrounding of Bahuarwa and no tradition of stone crafts, stones do not present a reasonable alternative. In addition, they are heavy to transport. Thus, the options used for pukka houses must be taken into consideration. However, there is still a wide span between a complete reinforced concrete slab and strip foundations made of bricks or stabilized mud blocks (Roswag 2010) underneath load-bearing building parts. Whereas a layer of bricks covered with cement or an unreinforced concrete slab could provide a sitting ground that is more maintenance-friendly and provides an effective protection from termites (Kaminski et al. 2016a), a reduction of the foundation to the structural parts would reduce the material demand and thereby the environmental impact. Both options will be proposed to the local community. A decision will be made based on their preferences, financial means, and the suggestions of local craftspeople.

8.6.2 Walls

Like a mud foundation, walls made of mud and bamboo are perceived as weak building parts, too. In other words, an evaluation of the design principles from the perspective of the users is usually based on the choice of materials rather than the construction details of the individual building parts. Thus, whatever is built with mud or other natural materials is generally perceived as weak independently of its specific purpose. Since the walls also collapse when they have lost their base, it is reasonable to come to this conclusion. However, given that there is a durable foundation and a waterproof roof, the walls are protected from the intense rainfalls of the monsoon. The traditional wattle and daub construction of the kutcha house could be improved through a firm connection of the bamboo posts and the foundation. Bamboo posts must be raised from the ground, for instance through cement-filled PE-pipes (Heringer 2020) or a bricked plinth of around 40 cm height (Kaminski et al. 2016b) to guarantee an effective protection from splashing water. To avoid water or humidity to be soaked up by the walls, the walls can be raised through a plinth of fired bricks or separated from the foundation through a vapour barrier (Kaminski et al. 2016b; Roswag 2010). The gaps between the pillars should be around 100 cm (Kaminski et al. 2016b), which allows openings to be placed in between whilst ensuring structural stability. The wall infill can consist of only one layer of plastered bamboo slits on the outside or of two layers (Kaminski et al. 2016b). In the case of two layers, the space in between can be filled with a mud-straw-mix (Barrett 2020; Kaminski et al. 2016b; Roswag 2013), which improves the thermal properties and creates a protective layer for the bamboo posts. Through the mix with straw, the mud gets a natural reinforcement as well as erosion brakes. Mud or lime plaster should be preferred against the use of cement plaster, which should be limited to washrooms. However, since the materials also act as status symbols, there might be a need to discuss the use of cement plaster on the outside to make the building look modern. To prevent the plaster from spalling, a chicken mesh could be integrated (Kaminski et al. 2016a). This can be easily separated and reused at the end of the building's life cycle. Independently of the material, the plaster should fully cover the bamboo wattle underneath and have a thickness of around 2 cm (Kaminski et al. 2016b). Besides the humidity, termites pose the biggest risk for the durability of the bamboo structure. Therefore, all bamboo parts should be treated with boron, which is effective against insects but not very toxic for mammalians (Kaminski et al. 2016a). Except of the bamboo treatment, an eventual use of a chicken mesh and a cement plaster on the outside, the walls should be mostly improved through advanced construction measures. In addition, this construction method is very earthquake-resistant, which is relevant considering the frequent epicentres in neighbouring Nepal (Ministry of Housing & Urban Affairs).

8.6.3 Roof

The roof is the building part most exposed to the environmental conditions. It needs to fulfill several purposes that sometimes require opposing measures. The traditional use of thatch offers a good insulation from the heat, but it is often insufficient in protecting the inhabitants from the intense rainfalls and spreads fire from the open fireplaces quickly (Bihar State Disaster Management Authority). To ensure waterproofness, the roof angle must be 40 degrees or steeper and the thatch must consist of several layers. Nevertheless, the roof needs to be repaired yearly and replaced every five years. Some inhabitants have installed plastic sheets on the thatch roof to improve the waterproofness (Fig. 8.4). However, this also reduces the breathability of the thatched roof and condensation occurs more frequently. A change in the choice of materials seems inevitable, given the maintenance should be reduced and the durability prolonged. In the case of the roof, too, natural stones, such as slate, would offer a durable alternative, but the fact that those are not part of the regional building traditions already reveals that there is no natural occurrence either. Therefore, another look at the pukka house is necessary to see in how far its solutions for the roof could be adapted for the new hybrid. Corrugated metal sheets and fired roof tiles are the most common materials to cover the roofs of the pukka houses in Bahuarwa. The load bearing structure is either made of bamboo or reinforced concrete slabs. Whereas bamboo is the preferred material for the roof structure, the choice of the roofing material is less obvious. The use of corrugated metal sheets allows low roof inclinations, whereas the use of roof tiles requires steeper angles. The thin and light metal sheets are also more earthquake-resistant than the heavier brick tiles (Prion). Regarding the thermal properties in turn, the roof tiles offer a better protection from the heat and condensation is less likely to occur. Furthermore, the roof tiles have a lower environmental impact than the corrugated metal sheets (KBOB et al. 2022). The more environmental-friendly fibre cement sheeting might be an alternative to the metal sheets. A gap between the roof and the walls or an eventual ceiling, as well as covered openings on top of tent roofs should allow a permanent ventilation that carries away the hot air and humidity underneath the roof.

8.6.4 Openings

The number of openings in the kutcha houses of Bahuarwa is limited. Usually, the entrance from the veranda to the adjacent room is the only big opening. This is due to safety reasons but also to protect the interior from direct sunlight and to ensure privacy. However, the inhabitants often complain about the dark and dusty atmosphere and wish to have a brighter and cleaner interior. Therefore, the traditional perforated elements (jaalis) could serve as an ideal solution that can be easily combined with the wattle and daub construction of the walls. In certain parts, the bamboo wattle could stay uncovered to let indirect sunlight enter the rooms and to allow a permanent cross ventilation whilst providing protection against unwanted insights. Depending on the financial situation of the inhabitants, the jaalis could be complemented with windows on the inside to improve the acoustic protection.

8.7 Conclusion

This paper summarizes the initial step of an ongoing dissertation and research by design project in Bahuarwa, a rural village in the Indian state of Bihar. After a general reasoning why traditional building typologies should be considered to develop more climate-friendly as well as more climate-resistant ways of building, the traditional kutcha house of Bahuarwa, made of mud, bamboo, and thatch, is compared with the modern pukka house made of fired bricks, cement, and steel, considering environmental, social, and economic aspects of sustainability. This comparison shows the complexity and contradictoriness of different sustainability aspects. Thereby, clinging on to building methods of the past and focusing only on environmental aspects would be as romantic and naïve as blindly trusting in technological innovation and following foreign building methods. Instead, sustainability is understood as a search of balance between environmental, social, and economic factors, but also between traditional knowledge and modern tools, “unbaked” and “baked” materials. Hence, a middle way is proposed in this paper which will guide the further research by design, wherein the here presented building measures will be developed further in a participatory planning process with the inhabitants and craftspeople. Together with them, a school for underprivileged children and teenagers of a scheduled caste in Bahuarwa will be designed and built.

Appendix

Daniel Haselsberger is a Swiss researcher and PhD candidate at the Liechtenstein School of Architecture. His research includes the exploration of the potential of natural materials and traditional knowledge to develop more climate-friendly as well as more climate-resistant building methods in the Indian state of Bihar. His academic activities go hand in hand with development cooperation projects in India.

Isha Dhingra is an Indian architect based in Switzerland. She is a founding member of the welfare association “Arch Aid”. Being aware of her roots, she tries to strengthen local potentials in development cooperation projects in India, be it the use of natural resources or traditional building knowledge. Currently, she is working on the implementation of a school for underprivileged children in the Indian state of Bihar.

References

Bainbridge DA (2009) Sustainable building as appropriate technology. In: Kennedy J (ed) Building without borders: sustainable construction for the global village. New Society Publishers, Gabriola Island, pp 55–67

Barrett S (2020) Lehrer*innen Wohnungen: Rudrapur, Bangladesh. https://www.zrs.berlin/de/project/lehrerinnen-wohnungen-rudrapur-bangladesch/. Accessed 8 Nov 2022

Bera T (2019) An overview of Vernacular architecture in India. Think India J

Bihar State Disaster Management Authority Bihar Hazard Profile. http://bsdma.org/Welcome_note.aspx. Accessed 3 Nov 2022

Campbell S (1996) Green cities, growing cities, just cities?: Urban planning and the contradictions of sustainable development. J Am Plann Assoc 296–312

dictionary.com (2022a) kutcha. https://www.dictionary.com/browse/kutcha. Accessed 4 Nov 2022a

dictionary.com (2022b) pukka. https://www.dictionary.com/browse/pukka. Accessed 4 Nov 2022b

Flick U (2018) An introduction to qualitative research, 6th edn. Sage, Los Angeles, London, New Delhi, Singapore, Washington, DC, Melbourne

Frampton K (2002) Towards a critical regionalism: six points for an architecture of resistance. In: Foster H (ed) The anti-aesthetic: essays on postmodern culture. New Press, New York, pp 16–30

Habitat for humanity what is a slum?: Definition of a global housing crisis. https://www.habitatforhumanity.org.uk/what-we-do/slum-rehabilitation/what-is-a-slum/. Accessed 12 Oct 2022

Heringer A (2020) Anandaloy: centre for people with disabilities + Dipdii textiles studio. https://www.anna-heringer.com/projects/anandaloy/. Accessed 8 Nov 2022

IEA (2021) India energy outlook 2021. OECD Publishing, Paris

Kaminski S, Lawrence A, Coates K, Foulkes L (2016a) A low-cost vernacular improved housing design. Proc Inst Civil Eng—Civil Eng 169:25–31. https://doi.org/10.1680/jcien.15.00041

Kaminski S, Lawrence A, Trujillo D (2016b) Design guide for engineered Bahareque housing. Technical Report, vol 38

Klinker S (2009) Shelter and sustainable development. In: Kennedy J (ed) Building without borders: sustainable construction for the global village. New Society Publishers, Gabriola Island, pp 5–15

Ministry of Environment, Forest & Climate Change (2019) India cooling action plan

Ministry of housing and urban affairs hazard maps of India: disaster mitigation and management. https://bmtpc.org/topics.aspx?mid=56&Mid1=178. Accessed 3 Nov 2022

Ministry of Housing and Urban Affairs (2015) Pradhan Mantri Aawas Yojna. https://pmaymis.gov.in/. Accessed 5 Nov 2022

Nugent C (2022) Western architecture is making India's heatwaves worse. Time

Prion H Erdbebensicherheit von Holzbauten. https://www.forum-holzbau.com/pdf/prion_00.pdf. Accessed 8 Nov 2022

Roswag E (2010) Habitat initiative cabo Delgado: Mozambik. https://www.zrs.berlin/de/project/habitat-initiative-cabo-delgado-2/. Accessed 7 Nov 2022

Roswag E (2013) Lehmschule Tipu Sultan Merkez: Jar Maulwi, Pakistan. https://www.zrs.berlin/de/project/lehmschule-tipu-sultan-merkez/. Accessed 8 Nov 2022

Shubham SS, Kolhatkar SL (2020) Carbon footprint comparison between vernacular building and (modern) contemporary building. Int J Architect 6:21–42

UN (1948) Universal declaration of human rights

UN (2015) Paris agreement. https://unfccc.int/files/essential_background/convention/application/pdf/english_paris_agreement.pdf. Accessed 29 Nov 2022

UN (2021) 2021 global status report for buildings and construction: towards a zero-emissions, efficient and resilient buildings and construction sector. https://www.unep.org/resources/report/2021-global-status-report-buildings-and-construction. Accessed 12 May 2022