



7th International Conference on Building Resilience; Using scientific knowledge to inform policy and practice in disaster risk reduction, ICBR2017, 27 – 29 November 2017, Bangkok, Thailand

## Changing built form and implications on urban resilience: loss of climate responsive and socially interactive spaces

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### Abstract

A resilient city is a sustainable network of physical systems, constructed urban form, and human communities. Traditional or vernacular built form evolves to achieve higher human comfort by using locally available building materials and construction technology and is more responsive to the geographic conditions. In contrast to the highly bureaucratized building process in modern built form, vernacular architecture is more climate responsive. A typical traditional building of earth emits fewer greenhouse gases, consumes less energy, and maintains a high level of internal thermal comfort. Resilient urban systems must also have resilient communities. Traditional built form results in the creation of social spaces, promotes adherence to socio-cultural value systems and imbibes a feeling of social cohesion. Modern construction techniques, greater energy consumption and the loss of diversity of architectural forms would have significant implications on urban resilience. The paper aims to trace the changing built form in a small settlement of West Bengal and the resultant loss of climate responsive and socially interactive spaces. Based on primary data sources and field observations, the paper also looks into the implications of the loss of such spaces on urban resilience and assesses the perception of the locals who prefer modernization of built form.

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Peer-review under responsibility of the scientific committee of the 7th International Conference on Building Resilience.

*Keywords:* vernacular; resilience; sustainable; built-form, implications

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## 1.1 Introduction to changing built form and urban resilience

Resilience has emerged as an attractive perspective with respect to cities, often theorized as highly complex, adaptive systems [1]. Unprecedented urbanization has transformed the planet from 10 percent urban in 1990 to more than 50 percent urban in just two decades [2]. Although urban areas cover less than 3 percent of the Earth's surface, they are responsible for an estimated 71 percent of global energy-related carbon emissions [3]. As cities continue to grow and grapple with uncertainties and challenges like climate change, urban resilience has become an increasingly favoured concept [4]. A resilient city is a sustainable network of physical systems, comprising of the natural environment, the constructed urban form/ built form, and the human communities.

The spectrum of built form, constituting buildings and the human made spaces between buildings, ranges from vernacular or traditional at one end of the continuum to the organizational management of design at the other. Vernacular built form emerges from a slow evolution of form based on available technology, economy and social patterns of the very people whose hands shape the physical environment in which they dwell [5]. The production is often a natural fit between form and occupancy and is conceived as a preindustrial condition. Traditional or vernacular built form evolves to achieve higher human comfort by using locally available building materials and construction technology which are more responsive to their geographic conditions [6]. In contrast to the highly bureaucratized building process in modern built form, vernacular architecture is more climate responsive. A typical traditional building of earth emits fewer greenhouse gases, consumes less energy, and maintains a high level of internal thermal comfort, regardless of the solar radiation outside.

Traditional architecture also forms the backbone of the socio-cultural set up of a place [6]. It results in the creation of socially responsive spaces and the development of traditional customs that continue to sustain the socio-cultural value system and a feeling of social cohesion. It is often conceived as a continuing dialogue between generations. Environmental and cultural sustainability and resilience is thus inherent in vernacular built form. Adherence to traditional urban form, however, is interpreted as stagnation, incapable of meeting the needs of an increasingly heterogeneous population.

At the other end of the continuum of building production, opposite to the vernacular tradition, is a type that might be called 'organizational management of design' [5]. Here the production of built form involves not the occupants but a cast of bureaucrats, committees, and entrepreneurs, who 'place a product on the market' [5]. The marketplace drives the production of the built environment, in the complex context of private interests, public agencies, and regulations. The highly bureaucratized modern construction techniques with artificial air conditioning, greater energy consumption, loss of diversity of architectural forms and socially interactive spaces, would have significant implications on urban resilience. Climate induced higher temperatures would increase energy consumption even in low income countries under the impact of rising income and increased urbanization. Typically, 'organizational management' is associated with postindustrial economy, the rise of the service sector, mass production and specialization.

## 1.2 Objectives of the Study

- To evaluate the traditional or vernacular built form with respect to climate responsive and socially interactive spaces in a small settlement in West Bengal.
- To understand the implications of changing built form on urban resilience
- To review the perception of the local residents towards changing built form

## 2. The Study Area

The area under study is the 200 year old settlement of Malancha in C.D. Block Kharagpur II, at a distance of 140km from Kolkata, the capital city of West Bengal, India (Fig. 1). Located 5km from Kharagpur Railway Station and 12km from the district headquarter of Medinipur, the old settlement has been witnessing changes in urban built form while trying to adhere to traditions and the heritage resources. A smaller area was delineated for a micro level study to comprehend the changes in built form and the obvious implications on urban resilience.

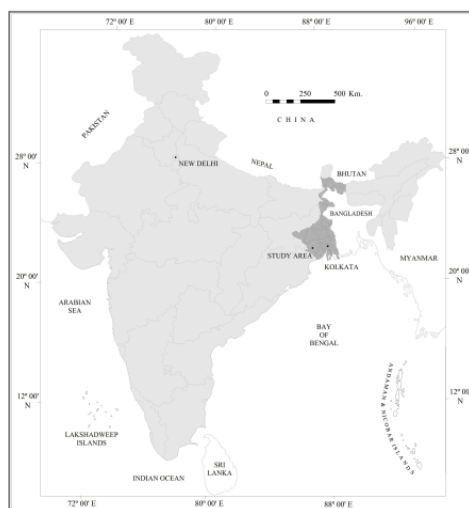


Fig. 1. Study area

### 3. Methodology applied

The work is based mostly on primary data and literature review.

- Literature review: relevant literature was consulted with an aim to understand the importance of vernacular architecture to climate resilience and its adherence to socio-cultural value system. Evolved over time, resilience is inherent in traditional built form. A change in built form is thus expected to have immense implications on urban resilience. Such implications of a changing built form were also examined through the study of relevant literature.
- Field Observation: Field visits to the study area located along Malancha Road were also undertaken. Based on detailed field observations, the traditional built form was analysed with special reference to climate responsive and socially interactive spaces inherent in such built form. The increasing number of houses with modern architectural designs, the loss of passive cooling elements and spaces of social interaction along with the increased use of artificial climate control devices were also observed.
- Primary data collection: survey was conducted through properly structured questionnaires in 200 households in the study area. Stratified random sampling was done to ensure the inclusion of both traditional houses and the newly constructed modern houses. The questionnaire was intended to find out the nature of changes witnessed in built form, the reasons cited by the local community promoting such changes or for adhering to traditional built form and to assess the perception of the local community towards the changing built form.

### 4. Vernacular architecture resulting in the creation of climate responsive and socially interactive spaces

Traditional houses in the study area are best described as grouping of isolated rectangular huts around a courtyard (Fig. 2). The central courtyard, used for festivals and social functions, plays a vital role in maintaining family bonding. The house is demarcated into the outer or formal zone comprising the main living room or 'Baithak Ghar' for guests and the inner informal zone with sleeping spaces, toilets and kitchen. The informal zone is sometimes approached directly but more often through the outer Baithak. All the rooms, except the Baithak Ghar or outer house, have shaded verandahs oriented towards the courtyard. The Baithak has a shaded outer verandah and the main entrance.

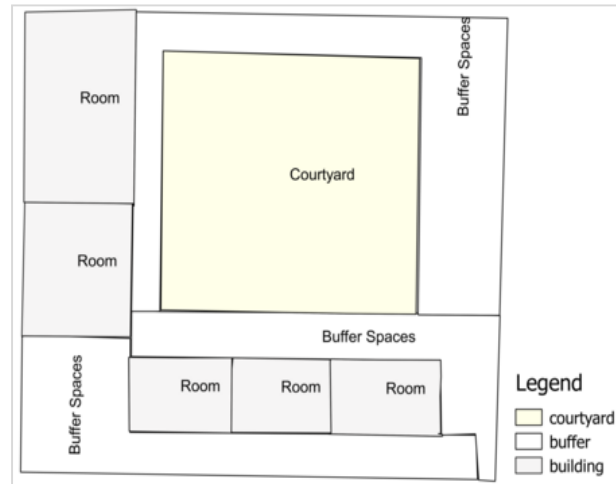


Fig. 2. Traditional houses with buffer spaces

The huts are constructed as single rooms, often double storied, and are mostly built of mud or sun dried earthen blocks, brick and lime mortar. Good thermal storage capacity of the thick mud walls provide a stable temperature inside the building. The roofing materials vary from thatches and bamboo poles to tiles and C.I. sheets. It is to be noted that mud, brick, bamboo and asbestos are bad conductors of heat and help in making the houses warmer in winter and cooler in summer. Additional bamboo poles beneath the roof provide excellent insulation. The sloping roofs extend sufficiently to protect the walls from heavy rain.

The central courtyard is an important element in traditional built form. Apart from enhancing family bonding it is ideal for the hot and humid tropics as it draws in cool air which gets circulated within the interiors to replace foul, hot air. The courtyard functions as a convective thermostat and gives protection from extremes of weather. Courtyards moderate the extreme effects of the hot summers and cold winters, and average out the large diurnal temperature differences in the study area. They minimize the surface exposed to sunlight and provide maximum shade and ventilation while acting as a source of sunlight inside the rooms and restricting the use of electrical lamps. The mud plinths contribute in keeping the indoor temperature cool and comfortable. Balconies act as buffer spaces (Fig. 2) and moderates outside extremes of temperature. The built in storage spaces inside the thick mud walls increase open space within rooms, allows greater wind circulation and releases stored heat. It thus helps in maintaining a high level of internal thermal comfort.

In order to reduce the sunlight absorption and hence the indoor temperature, openings are retreated into the facade to make more shade. The covered entrance facing south or east is more common to absorb less solar radiation during the summer and more solar radiation during the winter. Windows are small and few in number, faced mostly towards the courtyards and cover less than 10 percent area in the exterior walls. The high sill level and small opening of the windows, particularly on the exterior walls reduces heat absorption. They restrict the dry hot winds in summer by compressing air at the entry level. The air suddenly expands inside the building thereby providing cooler air by the principle of venturi effect [7]. Additional shading elements are also introduced to reduce the heat inside buildings. These shading elements also protect the mud walls from excessive monsoon rain. Using bright colours to cover the buildings, especially the roofs, which are the most exposed to sunlight, increases the albedo (high reflection coefficient), reflects more of the sun rays and prevents heat absorption. Passive cooling with the help of more water elements like ponds and wells for drinking water supply and large number of open spaces are an integral part of a traditional settlement. Plants in the courtyards and in the neighbourhood provide shade and increase the air cooling potential. By increasing air moisture through the vapour transmission process, plants make the air flow cool before reaching the building. It thus further helps in maintaining a more comfortable temperature within and around the built environment.

Vernacular built form thus results in the creation of climate responsive spaces. The basic idea is to provide

comfort in close interaction with the dynamic conditions of the environment [6]. Climate responsive designs can improve human comfort and substantially reduce the economic and environmental costs of buildings.

Resilient urban systems must also have resilient communities. Traditional built form results in the creation of social spaces and the development of traditions that sustain the socio-cultural value system and maintain a feeling of social cohesion. Houses cannot be seen in isolation, but most of them should be viewed as part of a total social and spatial system, which relates the houses, way of life, settlement, and even landscape [8]. Spaces of social interaction are inherent in vernacular built form. The extended shaded balcony creates spaces for social interaction. There is a strict and continued adherence to traditional customs and value system like the earthen pots beneath the additional shading element of the roof that serve as homes for pigeons. The traditional belief is that housing pigeons increases prosperity and happiness within the family. Such adherence to age old customs and traditions imbibes a strong sense of social bonding, thereby ensuring stronger community resilience.

Resilient cities or neighbourhoods focus energy and resources on conserving and creating strong vibrant places which soon become a significant component of the local structure and creates a strong sense of cultural identity. The area under study has also preserved traditional public places and heritage sites like the 200 year old temple sites. Surrounding the temples are open public spaces where fair is held twice a year, once in March and once in October that attracts large number of tourists from far and near. These heritage sites thus make the area vibrant and help in preserving the cultural identity. The open green areas are useful in reducing the urban heat island impact and enhance the thermal comfort of urban space.

## **5. Changing built form and implications on urban resilience**

Adherence to vernacular built form, however, is interpreted as a no-growth movement. It intensifies the level of dissatisfaction about the traditional built environment being rarely flexible enough or diverse enough to meet the needs of an increasingly heterogeneous population. Thus evolved the organizational management of design where built form is merely a commodity to be sold at the market. Industrialization of construction techniques and extensive use of artificial air conditioning systems have destroyed the diversity of architectural forms and made them similar all over the world [9].

The study area is also witnessing bureaucratization of building design and construction techniques. Mud houses are getting continuously replaced by concrete structures as is evident from the reduction in the number of traditional mud houses in the study area. In 1996, 71.43 percent of the houses in the study area were traditional mud houses. The percentage has decreased to 42.86 percent in 2016. The plinths of the houses are now built with cement-mortar and brick, ensuring easy movement within the house all year round. The number of stories has also increased. Because of the demand for more built space the central courtyards are now replaced by new construction resulting in the creation of compact urban form. The passive cooling elements like additional shading, plants and water elements are gradually disappearing. The ponds that once supplied drinking water to the households, has been converted into garbage disposal sites as municipal water supply replaces pond water for drinking and bathing.

The changing built form and concrete structures have their own advantages. The mud plinth in earlier construction increased the dampness inside buildings while the mud floor and mud walls are difficult to maintain because of the monsoon climate. The compact urban built form and higher buildings are casting more shadows between buildings and has reduced the number of surfaces exposed to solar radiation, minimizing heat absorption in summer and reducing indoor heat loss in winter. The narrow streets act like a yard at the urban scale and allow high-speed cool air to flow through. Compared to the earlier low density residential neighbourhood, the high density urban land use has made the neighbourhood vibrant while optimizing the utilization of space. The use of the ground floor for commercial activities has further increased the commercial dynamism of the place.

However, the modern built form is less climate responsive and hence likely to have greater adverse impacts on the environment. The use of concrete has increased the amount of heat absorption. The reduction in open spaces inside and around the buildings has reduced the flow of air and increased heat storage within buildings. The availability and increased use of modern technology like refrigerators and air conditioners has increased energy consumption with adverse impacts on the environment. The use of artificial cooling elements has increased significantly in the study area. In 1996 none of the houses had artificial air conditioning. However, in 2016 air conditioners are being used by

12percent of the respondent households, which amount to 21.05percent of the modern concrete structures. Modern built form has also resulted in the loss of spaces of social interaction. The balconies extending into the courtyards or into the streets from the Baithak Ghar have disappeared along with the central courtyards where festivals and ceremonies were traditionally held. This has weakened the social bonding. Changing built form has in fact resulted in the creation of spaces of social isolation and disregard for social traditions.

Changes in built form thus results in the loss of climate responsive and socially interactive spaces. Contemporary designs are heavily dependent on energy consumption because of their association with mechanical devices to control the micro-climate inside the buildings. The adverse environmental impacts of modern technology and artificial cooling on the one hand and the disappearance of passive cooling elements on the other also makes the modern built form less resilient. Unsynchronised development and increase of vehicular traffic within the narrow lanes further reduces its environmental viability. The adverse impacts of the loss of social values and traditions, community feeling and the changing built form from vernacular to modern, makes the system culturally less sustainable and hence weakens community resilience. It is thus necessary to continue the use of passive and indigenous technologies with modern adaptations to make the built environment environmentally and culturally sustainable.

## 6. Changing built form and local perception

Primary survey was conducted in 200 households located along the Malancha Road. Stratified random sampling was undertaken to ensure adequate representation of the traditional as well as the modern houses. Since traditional houses account for 42percent of the total houses in the study area, 50percent of the sample households continue to reside in traditional houses. The respondents chosen for the survey are all adults and aged 20 years and above. Majority of the respondents belonged to the middle ages ranging between 30 years to 40 years. Together they accounted for 46.3percent of the respondents. The level of education is found to be quite high. 25percent of the respondents have completed education up to the higher secondary level while another 25percent are graduates. Another 21.43percent have studied up to the post graduation level. In fact 53.57percent of the respondents have completed education up to the graduation level. Because of its proximity to Kharagpur town, the area under study has a high level of education. The monthly household income varies between Rs 20, 000 to Rs 40,000 in majority of the surveyed households. In the occupational structure, majority of the respondents are employed in the service sector amounting to 32percent of the respondent population. Another 30 percent are either self employed or engaged in business.

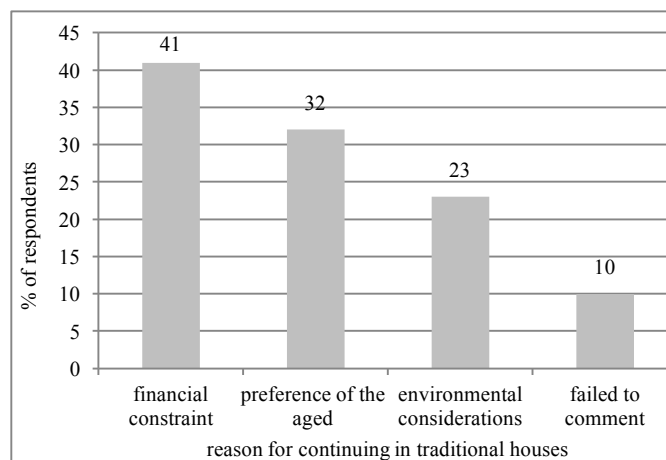


Fig. 3. Reason for continuing to reside in the traditional houses

Most of the respondents were found to be in favour of modernization of architectural form and lifestyle. For them, modernization and technological innovations are inevitable. Traditional houses account for 50percent of the

surveyed households. 41percent of the surveyed households continue to reside in the traditional houses under financial constraint. For another 32percent it is the very strong preference of the aged members of the family to continue residing in their traditional houses. They have resisted modernization of any form. 23percent households are sceptical about the impact of modernization and fears undesirable social and environmental consequences and hence prefer the traditional mud houses. Another 10percent failed to comment on their preference for modification and modernization of their traditional houses (Fig. 3).

74percent respondents prefer modern architectural elements and built form, including those who continue to stay in their traditional houses. For 32percent of the respondents preferring modern built form, the greater convenience in modern houses lured them towards modern houses and urban form, modern amenities and household gadgets .For another 27percent the house is not merely a shelter, it is an appreciating asset. They thus prefer a more durable brick and mortar home. For 21percent it is the preference of the younger generation for modern household gadgets and comfort. They are afraid that the younger generation might otherwise refuse to stay back in their ancestral home. The improved standard of living, higher levels of education and the attraction of modern amenities is responsible for the preference of modern concrete houses and modern household gadgets to ensure comfort and safety. The respective percentages of respondents are 7percent, 5percent and 8percent (Fig. 4). 62percent of the respondents are satisfied with improved amenities in the study area like piped water supply and improved road conditions. 90percent respondents have accepted the loss of water bodies as they are no longer used for the purposes of drinking and cooking. 43percent have, however, complained of increased frequency of water logging after heavy showers, not known in earlier times.

## 7. Findings and Discussion

It is thus evident that there is a gradual transformation of built form from vernacular and traditional to modern with obvious implications on resilience. There has been a significant reduction in the number of traditional mud houses with a corresponding increase in the use of refrigerators and air conditioners to control the micro-climate inside concrete buildings. There is thus an increase in the emission of green house gases, one of the major causes of climate variability. Unsynchronised development and increase of vehicular traffic further reduces its environmental viability. The increased built-up area and reduced number of water bodies not only raises the temperature but often is responsible for environmental problems like water logging in the rainy season.

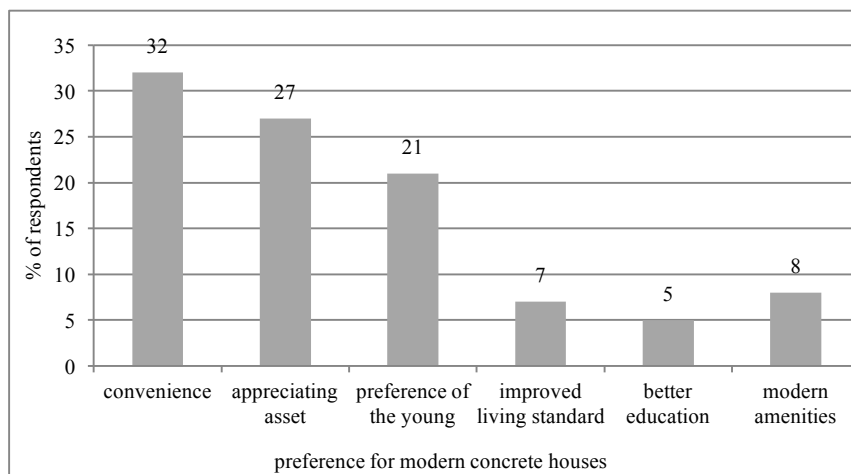


Fig. 4. Reasons for preferring modern concrete houses

Changing built form is thus responsible for increased energy consumption, increased climatic variability and inadequate infrastructural provisioning, making the urban area environmentally less sustainable. Loss of spaces

for social interaction and the reduced number of courtyards within the houses have weakened social bonding and have created spaces of social isolation. Along with the loss of architectural diversity, such changes would be accompanied by reduced community resilience. In spite of the adverse impact on both natural and social environment, the residents are in favour of modern built form because of the greater comfort associated with it.

## 8. Conclusion

It is thus important to strike a balance between traditional and modern built form. Traditional buildings made of mud have their own problems, the worst being their vulnerability to water. There is thus a need for better adaptation. The exterior face of the existing mud blocks could be given a veneer of stone or cement to make it less susceptible to damages by water without compromising with the advantages of mud. Use of traditional building materials needs to be encouraged by modern day builders and architects to help improve the aesthetic appeal of the settlement. While designing modern concrete houses, architects and house owners can continue with the traditional design of the inside central courtyards, to ensure greater wind circulation and the cooling effect seen in the traditional houses. It would also help in reviving and maintaining strong social bonding by bringing the family members and the neighbours together for social functions and festivals. Maintenance of the ponds and pisci-culture can be thought of, to regulate the micro climate and make the maintenance of ponds economically viable.

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