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ASSESSMENT OF PHYSICAL STANDARDS OF HOUSING FOR HEALTHY LIVING IN URBAN INFORMAL SETTLEMENT: A CASE OF RUPSHA SLUM IN KHULNA

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ABSTRACT

Overcrowding, poor structural quality of housing, and a lack of basic services and infrastructure differentiate informal settlement as a distinct type of community. Poor housing quality is directly connected to a greater risk of disease and illness in informal settlements. This research is being carried out to provide a comprehensive picture of the existing physical conditions of housing and aims to measure the deviation of housing quality between existing and standard healthy housing parameters in informal settlements. A substantial amount of fieldwork has been conducted to map the existing physical structure of the settlement and a list of preventable diseases suffered from poor housing is made through conducting a focus group discussion and interviews of 50 households in a distinct informal settlement situated in Bangladesh's third-largest city, namely Khulna. To assess the housing quality a framework of standard housing is made by reviewing the book "Park's textbook of preventive and social medicine" by K. Park. Results indicate that - 70% of the total household does not satisfy the minimum housing standard; in most cases, 4 or 5 persons must share a single room of 102 to 150 sqft area; a single toilet serves 180 people; the queuing time for drinking water from a tube well exceeds 45 minutes. The study also reveals the settler's complex mechanism of compact living through space sharing dynamics.

Keywords: *Housing standard; Health and housing; Housing up-gradation; Informal settlement; Rupsha slum.*

1. INTRODUCTION

Informal settlements, commonly referred to as "slums," are characterized by poor housing that does not correspond with building or planning standards, a lack of essential services, insufficient healthcare, and other public facilities, and housing (Egondi et al., 2012). The following are some of the conditions that slum inhabitants have to struggle with: access to drinkable water, access to sanitation services, and an acceptable living condition (Egondi, et al., 2012). Due to inadequate sanitation and housing structure, these conditions impose risks to the health of the city's low-income population and contribute to the spread of disease (Ambert et al., 2007; Bartlett, 2008; Benetti, 2007; Golubchikov & Badyina, 2012; WHO, 2010; WHO, 2016). Rapid urban growth and the corresponding authority's inability to address the housing demands of residents in urban areas have resulted in the growth of informal settlements (Tanni et al., 2014). Furthermore, residents in informal settlements experience socio-cultural and spatial marginalization, posing an increased risk to their mental and physical well-being (Egondi et al., 2012). Even though there is a nationwide emphasis on upgrading substandard living conditions to improve health, it is not clear how subnational and local-level built-environment initiatives directly affect health outcomes over time (Weimann & Oni, 2019). The physical configuration of housing, the psychological, social, and cultural climate within the family unit, the neighborhood environment's physical characteristics, and the social context and services within the community are considered four intersecting and interconnected housing components which have a significant influence on health and well-being (Shortt & Hammett, 2013; WHO, 2011). Only in the context of informal settlements, examples of probable traits within each domain include dilapidated or substandard housing with poor ventilation and higher concentrations of indoor pollutants (house) (Egondi et al., 2012; Sverdlik, 2011).

From the built-environment perspective, "housing" is generally defined as shelter or dwelling and its surrounding physical environment provided for people. The World Health Organization (WHO) has issued a series of guidelines emphasizing how overcrowding inside living spaces, indoor air temperature, the provision of safety of the house, and its accessibility all have a significant impact on health and wellness (WHO, 2018). Shaw (2004) outlines how the qualities of one's living environment are either directly or indirectly related to one's health. The physical aspects of the immediate housing conditions, such as the home structure, have a direct

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impact on people's health (Weimann et al., 2020). As an example, unsecured electric lines and a scarcity of cooking space can lead to child burns and fatalities in informal settlements (Parbhoo et al., 2010). Noise and feelings of insecurity can enhance the risk of injury, and depression and anxiety levels (Smit et al., 2016a). Insufficient social networks and community cohesiveness are likely to have an impact on mental health by raising emotions of alienation, helplessness, or neglect (Shortt & Hammett, 2013). UN-Habitat promotes healthy urban development planning, which fosters social cohesion and inclusion (UN-Habitat, 2018; UN-Habitat, 2015). Substandard housing affects multiple dimensions of health. Substandard housing conditions, such as a lack of safe drinking water, scarcity of hot water for washing, poor waste disposal, disease vector infiltration (e.g., insects and rodents), and insufficient food storage, have long been recognized as contributing to the spread of infectious diseases. (Mood, 1993; Marsh, 1982; Howard, 1993). Crowding has been linked to the spread of tuberculosis (Stein, 1950) and respiratory infections (Fonseca, 1996; Denny, 1995; Murtagh et al., 1993; Graham, 1990). Epidemiological research in recent years has connected inadequate housing to an increased risk of chronic disease (Krieger & Higgins, 2002). Asthma and other chronic respiratory illnesses are associated to damp, cold, and moldy housing (Bornehag et al., 2001). Water infiltration is a significant contributor to moisture and dampness, which play an important role in respiratory disorders (Eggleston & Arruda, 2001). Interior moisture is also increased by overcrowding and poor ventilation. Recurrent headaches, fever, nausea, vomiting, and throat irritation are caused by damp and moldy housing (Krieger & Higgins, 2002). Deviation from a relatively small range in indoor temperature has been linked to an increased risk of coronary heart disease (Weimann & Oni, 2019). Dwelling in cold housing has been linked to poorer physical health and higher usage of health care services (Evans et al., 2000). The above health issues have aided in the development of thermal comfort standards (ASHRAE, 2005). Smoke exposure may be increased by inadequate ventilation. The danger of injuries from fires is influenced by building design and materials. Increased noise (particularly in poorly insulated housing units) has indeed been linked to sleeplessness, which causes mental stress (Krieger & Higgins, 2002). Irritability and social intolerance have been associated with high indoor temperatures. Crowding was linked to psychological discomfort among 25-45-year-old women. Children's behavioral disorders have been associated with living in substandard, temporary housing (Zima et al., 1994). Poor living conditions may lead to social isolation because tenants become hesitant to invite their guests into their houses.

1.1 Housing Standards in Bangladesh

Housing is one of the most contextual continuous processes, following the local housing code is the meaningfully sustainable way of housing. Housing and construction bureaus are responsible for formulating and enforcing most housing codes. Our department of health develops and enforces housing standards that address a specific set of challenges (e.g., occupancy, sanitation, plumbing). Bangladesh's National Building Code sets minimum criteria for the new construction of houses, safety and fire, plumbing, and electro-mechanical components (BNBC, 2020). Moreover, these codes consider only a subset of the factors that influence housing quality. Health issues are not clearly addressed in our housing codes. For the most part, these codes do not address the maintenance or renovation of substandard conditions in existing structures. Substandard housing conditions are rarely subjected to such codes. The difficulty in adopting codes in informal settlements is a major limitation to their usefulness. Our National Housing Authority did not provide clear instructions about healthy house-making in their policy guidelines either in the formal or informal settlements (NHA, 2016). For assessing the housing quality from a health perspective, we made a framework of parameters by reviewing the housing sections from the book "Park's Textbook of Preventive and Social Medicine" by author K. Park (Park, 2021). In his book, he briefly discussed which minimum characteristics a house form should have to satisfy healthy environments. In this section, we will discuss about the healthy housing guidelines followed by K. Park. The minimum standards of housing are still applied and monitored by building regulations, the goal is to enhance housing and environmental circumstances for the vast majority of households within the limitations imposed by existing resources and objectives.

1.2 Healthy Housing Parameters

The definition of housing standards has been changed as the concept of housing has broadened. According to Park (Park, 2015), the requirements are no longer limited to restrictive health factors such as floor area and space per capita. In evaluating housing standards, economic and social parameters such as family size and composition, family income, the standard of living, lifestyle, education, life stage, and cultural aspects need to be taken into account.

According to Park's (Park, 2015) housing standards- (a) the housing development site should be elevated above its immediate surroundings in order to avoid flooding during heavy rains, (b) there should be a separate entry to the housing complex on a sufficiently wide street, (c) should be located distant from areas where mosquitoes or flying insects breed, (d) it ought to be distant from nuisances like dust, smoking, odor, extreme traffic and noise,

(e) the surrounding environment should be pleasant, (f) for the foundation to be safe, the soil must be dry and well-drained before the structure is built. In the construction industry, "made-soil," or ground level that has been levelled by the dumping of garbage, is considered extremely unsatisfactory for a minimum of 10 - 20 years. The depth of the subsoil water should be less than 10 feet (3 metres) (Park, 2015).

An open space should surround the house for proper lighting and ventilation; this is referred to as a "setback." In rural areas, the built-up area must not exceed one-third of the plot area; however, in metropolitan areas, where land is expensive, the built-up area can be as much as two-thirds of the plot size. The setback must be sufficient to ensure that lighting and ventilation are not obstructed. The following are the recommended ventilation standards for a healthy home- i) every living room must have at least two windows if mechanical ventilation and artificial lighting are not available, ii) one of them needs to be able to open up to an open space at least iii) in living rooms, windows should not be more than 3 feet (1 meter) above the floor level, iv) the window area should be equal to one-fifth of the total floor area, v) the combined area of the doors and windows should be 2/5th of the total floor area (Park, 2015).

According to the housing standard (Park, 2015), ideally, the floor must be pucca (permanent) and meet the following requirements: (a) it should be impermeable so that it can be readily washed, dried, and maintained in a clean and dry condition; it should be non-slippery. Due to the tendency to crumble, mud flooring should be avoided, (b) insects and dust can breed in gaps and crevices if the floor isn't smooth and free from cracks, (c) it is necessary to have damp-proofed flooring, (d) the plinth's height should be between 2 and 3 feet (0.6 to 1 metre). It is recommended that the walls should remain (i) moderately strong, (b) The material used should have a low thermal conductivity and a low thermal capacity, (c) weather-resistant, (d) unfavorable for the retention of rodents and other insects, (e) not vulnerable to damage and (f) smooth. These requirements can be met by a 9-inch brick wall that has been smoothed plastered and painted white or cream. In the absence of air conditioning for comfort, the height of the roof should not be less than 10 feet (3 metres). The heat transmission coefficient of the roof should be as low as possible (Park, 2015).

According to Park’s housing standards (Park, 2015), Living rooms should be at least two in number, with at least one of them being capable of being closed for security reasons. If one side of the other is a private courtyard, the other side may be open on one side as well. In order to provide the appropriate amount of floor space per person, it is advised that the number and size of rooms be increased in proportion to the size of the family. In order to accommodate more than one person, a living room should have a floor space of at least 120 square feet (12 square meters), while for one person, the minimum floor area should be 10 square meters. There should be at least 50 sq ft of floor area for each person in a living room; the ideal is 100 sq ft.; the height of rooms should be sufficient to allow at least 500 cubic feet of air space per human, and preferably 1,000 c. ft. Overcrowding means a condition where too many people are living in a single housing than there is room for, resulting in restricted movement, sequestered privacy, impossible sanitation, and difficult rest and sleep. In human habitation, overcrowding is a health hazard. The best way to indicate the degree of overcrowding is to multiply the number of people in a room by the number of people in a household, which is divided by the number of rooms in the dwelling. The accepted standards of measuring overcrowding are shown in table 1. A baby that is less than 12 months old is not counted in measuring overcrowding. When two people over the age of nine, not married, of opposing sexes, are compelled to share a room for sleeping, it is considered overcrowding. (Park, 2015).

Table 1: Measuring overcrowding according to persons per room and floor area

According to person per room		According to floor space	
No. of rooms	No. of persons	Floor area	No. of persons
1 room	2 persons	110 sq. ft. (11 sq. m.) or more	2 persons
2 rooms	3 persons	90-100 sq. ft. (9-10 sq. m.)	1.5 persons
3 rooms	5 persons	70-90 sq. ft. (7-9 sq. m.)	1 person
4 rooms	7 persons	50-70 sq. ft.	.5 person
5 rooms	10 persons (additional 2 for each further room)	Under 50 sq. ft. (5 sq. m.)	nil
		* Children aged 1 to 10 counted as half of one unit.	

(Source: Park, 2015)

A safe and sufficient supply of water should be available at any time in the housing. 500 meters is the maximum distance that a household can be from the nearest water source (USAID, 2009). The average waiting time at a source of water is no more than 15 minutes per person (USAID, 2009). It takes no more than three minutes to fill a 20-liter bucket with water. Based on a flow rate of 16 liters of water per minute, every 500 persons should have a hand pump. Water sources and systems are managed to keep in an appropriate working order so that sufficient amounts of water are provided on a continuous or normal basis. An exclusive and easily accessible sanitary latrine is a requirement in every house and that should be installed in the first place (Park, 2015). The dwelling units must be equipped with water carriage systems for the maintenance of the privy. Toilet usage should be organized by the household or separated by gender. Toilets should be no more than 50 meters away from houses and each toilet can only hold a maximum of 20 people. All intended users must have access to shared toilets, which are maintained and cleaned in a manner that allows them to do so. It is imperative that toilets are used in the most hygienic ways and that children's excrement is removed as quickly and cleanly as possible. The residence should have its own private bathing and laundry facilities so that residents can bathe and wash in private (Park, 2015). Waste should be collected from the houses daily and dumped in approved waste pits or sealed containers for safekeeping (Park, 2015). Every home must have a waste disposal container or be within 100 meters of a common refuse pit if one does not exist (Ponnuraj, 2006). Where residential garbage is not buried on-site, at least one 100-liter rubbish container should be supplied for every ten families.

Therefore, the focus of this research is to illustrate living conditions and housing deprivation in informal settlements by adopting a transdisciplinary mixed-method approach to measure the disparity of quality housing that exists in informal settlements in terms of health perspectives. A combination of these two approaches is significant to understand the relationship between health hazards and housing deprivation in informal settlements. The acquired information from this research can then be used by policymakers in decision-making in terms of resource allocation and policy formation in informal settlements. The government can also use the research findings to ensure context-specific health services in informal settlements through health workers. It will help the researchers to come up with a healthy housing solution in informal settlement upgrading projects.

2. CONTEXT AND STUDY AREA

2.1 Introducing Khulna

To under the housing process in a specific context, we focus on a large informal settlement in Khulna, the third-largest metropolitan city in Bangladesh. Khulna has a high population density of 19,000 persons per square kilometer and is located in one of the most vulnerable climate zones (the south-western coastal belt) of Bangladesh (Roy, S. & Sowgat, T., 2020). As a deltaic plan, Khulna is flat and poorly drained, whilst the whole metropolitan area is only 2.5 meters above mean sea level (KDA, 2002). Khulna's topography is characterized by a tidal bottom plain with little relief (KDA, 2012). The city also experiences frequent waterlogging during the rainy season. Key climate change studies at the national level and a recent study on Khulna suggest several forms of rapid and slow onset impacts for Khulna, such as flooding and waterlogging, and increased salinity in both surface and groundwater (IWM, 2010). In Khulna, there are around 520 informal settlements concentrated in three different parts of the city (KDA, 2002; Angeles et al., 2009). Health threats are predicted to have relatively severe impacts on these settlements, due to their geographical locations, poor socio-economic, and built-environmental conditions (Afroza et al., 2016). Urban informal settlements in Khulna are also distinguished by overcrowding, overreaching population growth trends, rapid urbanization with the urbanization of poverty, and intensification of economic activities. The following characteristics are occasionally missing from the housing: 1) environmentally sustainable housing which will be resilient to extreme climate conditions; 2) a sufficient living area with no more than three persons in the same room; 3) Immediate access to safe water at an affordable price in sufficient quantity; 4) Ensuring the availability of sanitation, shared by a considerable number of individuals in the form of private and public sanitation; 5) Tenure security that prohibits evictions from being forcibly imposed (UN-Habitat, 2006). The analysis and observations of the case study site meet the definition of a slum, with hazardous and overcrowded dwellings, inadequate ventilation, unhealthy climate (heat and rain) safety, and poor drainage and sanitation. The housing-related health hazards are coupled with the existing urban problem in informal settlements, such as Rupsha.

2.2 Study Area

Rupsha is situated in the administrative division of Ward no. 22 of Khulna City Corporation (KCC), about 2.5 kilometers southeast of the central business district (*Dakbangla)*. There are 3,700 households in the settlement, who have been faced with inadequate basic services such as poor sanitation, inadequate drainage, irregular electricity, and water supply. About half of the residents are illiterate and unable to write their names. Most of the settlement dwellers are day laborers, the majority of them work in fish processing industries and others in shipyard, building constructions, sawmill industry, and self-employment. Most of the female members are involved in income-generating activities, particularly fish processing works. The settlement is located at the bank of Rpsha river in a commercially important area with a better linking road connected to the CBD area (figure 1). Development of the Rupsha settlement started in the 1930s when economic hardship led people to migrate from the hinterland to the city in search of livelihood opportunities. During the early year, the western bank of Rupsha river was a low-lying char land (river bank), which was regularly inundated due to the active tidal flow of the Rupsha-Bhairab-Posur river system (figure 2). The initial settlers spontaneously built silted houses on higher land along the river channel. Khulna city corporation constructed a road on the reclaimed land in the late 1980s to protect the city from drainage congestion and waterlogging caused by widespread river flooding, an embankment was constructed during 1985-90 by the Bangladesh Water Development Authority. Soon after completion, the Water and Power Development Authority (WAPDA) constructed Rupsha Stand Road on the embankment. It attracted more poor people from hazard-prone rural areas to safer areas that offered both diversified job opportunities and residential spaces.

Figure 1: Satellite map of the study area.

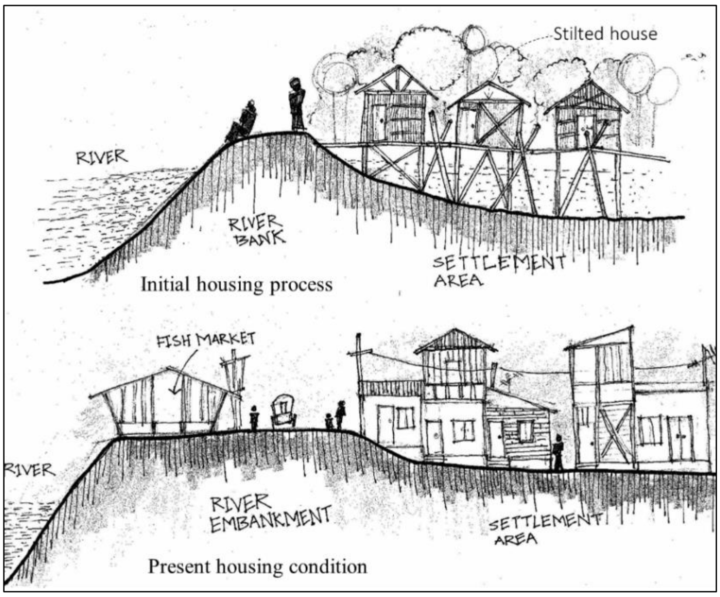


Figure 2: Sections of land development and housing growth pattern in the study area.

The informal settlement is the place where a large number of homeless people become bound to take shelter due to climate change impact and various aspects of socio-economic deprivation. In this kind of situation, measuring the house form in an informal settlement with formal housing standards is irrational. We will only try to understand how measurable their way of living is and to find out the scope of improvement in terms of health and housing perspectives. We believe that this initiative will have an impact on the lives of these people and many others in similar contexts.

3. RESEARCH METHODOLOGY

To collect and evaluate information on housing conditions, a transdisciplinary mixed-method approach was developed. This relied on methodologies and disciplines from health, built environment, social science studies, and development studies. A broad assessment framework of housing standards was developed by reviewing the literature "K. Park's textbook of preventive and social medicine" to analyze and evaluate the physical conditions of the house forms. A health professional (doctor) was involved in this research of making the assessment framework and house form evaluation. Formal housing standards are comprised of different formal provisions which are irrelevant to evaluate informal housing. K. Park's textbook is a literature on medical science which is taught in "Community medicine" courses in the medical colleges in Bangladesh (source: Khulna Medical College of Bangladesh, 2020). The "Housing standards" section of this book describes which minimum standards a house form should have to satisfy healthy living. So, describing the house form according to K. Park's housing standards is more relevant to get a better scenario of housing-related health hazards in an informal settlement. Dwelling unit surveys gathered information about housing conditions, tenant questionnaires gathered information about perceived comfort and activities, and indoor environmental observation gathered information about indoor exposure levels. This adaptive approach is similar to qualitative and quantitative methods used concurrently to explore the research topic, as well as the utilization of a range of data sources. To achieve the objectives, the study relies on available information and concepts, as well as systematic triangulation of data. The investigation involves dwelling surveys, occupant surveys, field monitoring, focus group discussions, and interviews.

The housing units of this settlement are organized alongside the internal lanes (*Goli*) connected with the embankment (figure 5). Every internal lane is almost similar to the others in its physical infrastructure and socio-cultural characteristics. For capturing the broader picture, we surveyed and monitored from three different lanes of the settlement- i) Muslim *Goli* (a wider path with the better living condition); ii) Sat-Bhai Goli (a narrow path with poor living conditions); and iii) Christian Goli (located at low elevation along the east side of the central pond; moderate living conditions). For in-depth analysis, we selected a particular internal lane (Muslim Goli) which consists of 50 households and shares the common features of other lanes. We tried to explore every type of dwelling unit from different streets and zones in the settlement: from worst-case to better condition. To understand the physical condition of housing in greater detail, dwelling units have been explored into three aspects: i) house form (built form); ii) space planning; iii) construction materials and techniques. To understand the existing housing quality from health perspective, the housing units have been described into a structured way of thirteen housing standards: i) site ii) setback and ventilation, iii) floor, ii) wall, iv) roof, v) floor area vi) kitchen vii) density and overcrowding, viii) sanitation, water supply, and waste management. Focus group discussions and structured interviews have been conducted to collect information about the housing-related health risk they suffered from in the settlement. Semi-structured interviews with the settlers in different professions helped us to know how they get construction materials from different resources. Following that, focus group discussions were conducted to examine the findings and reach a consensus on the key issues. Following the focus groups, transect walking was conducted to identify the root cause of the priority health issues. A comparative analysis of the housing quality between the existing scenario and K. park's assessment framework has been presented in this report so that we can get a better perception of the disparity of quality housing in terms of healthy living exists in the settlement.

4. STUDY FINDINGS AND DISCUSSIONS

Before assessing the housing standard, we need to have a clear perception of the complex living mechanism in the informal settlement. Like formal housing, their construction techniques, building material selection, space organization, and neighborhood cannot be defined separately. From the survey, we observed all the living components and housing elements in this settlement are closely integrated which follows a complex interdependent mechanism. In this section we will try to describe the existing housing condition, the way of house making and their uses, their housing-related health problems, and regarding the healthy living standard how satisfactory their house form is. At the same time for measuring the housing quality, we have shown a comparative analysis between standard and existing house forms.

4.1 Existing House Forms

The settlers built their houses in their own way in spontaneous work labor. The households use wide variety of construction materials for building houses depending on –the availability of materials; affordability of the family; climatic hazards; and climatic comfort. The dwellers' self-assisted houses were lightweight temporary huts which are called *"kacha ghar"* made of organic materials such as mud, wood, bamboo, thatch, plastic sheet, and sacks with simple construction techniques (figure 2). Houses were accessed by a stilted bamboo bridge locally called "shako" when inundated with seasonal flooding. Rupsha is formed of row houses, with some clustered houses at the end of the lanes. The built form of dwelling units in Rupsha settlement are composed of three types: i) single-storey, ii) double-storey, and iii) stilted. The built forms sit mostly on the street level with a very low plinth. The spatial morphology is very distinctive with almost uniformly distributed single-storey and double-storey row houses along narrow circulation spines generated from the main communication line (Rupsha stand road). Besides pedestrian movement, these circulation spaces are used for cooking, bathing, washing, child-rearing and playing, and community interaction (figure 3). The households use a variety of construction materials for building houses, depending on the availability of materials, affordability, climatic hazards, and comfort. Most of the house forms are temporary construction (*kacha ghar*). Some units are semi-permanent, built with a combination of permanent materials such as brick, cement, fire brick *tali* and organic materials. Few dwellings are of permanent construction with brick and concrete. Households chose durable materials in anticipation of hazardous consequences and affordability such as brick to withstand flood and waterlogging. For being geographically situated beside a river the settlers get some of the building construction materials without paying except a few transportation costs because char land is a great source of natural sand and mud. Generally, they made the plinth and wall of the house with a combination of mud and natural sand and a cement coating. During the house construction phase, they hire a local builder, and the family members work as his assistants. For saving construction costs they use locally available and recycled materials.

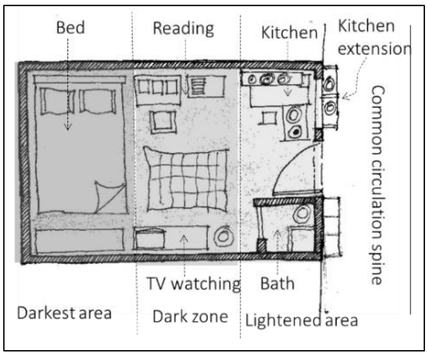


Figure 3: Plan of single-storey house.

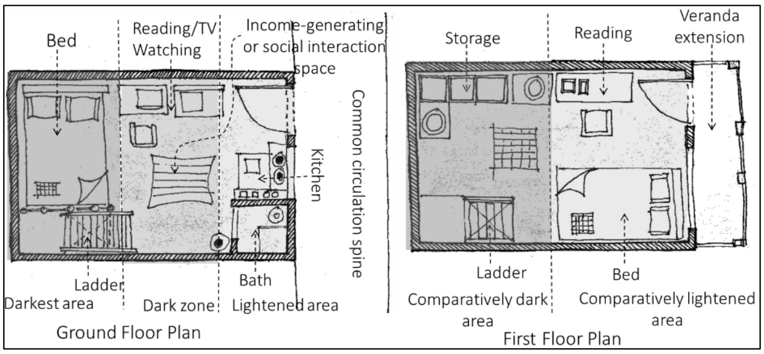


Figure 4: Floor plan of double storey house.

They have invented diversified ways to accommodate different household activities within a single indoor space (figure 3,4). Due to having the scarcity of land and space, they have to perform all of their daily household activities within a single space. They use low heightened or perforated temporary walls for space partition according to their necessity. With regard to the house entry points, four configurations are common in the dwelling units. In single-storey houses, the service space is found mostly in the front part of the house (figure 1). In some cases, the kitchen is found outside the house in the open air by the side of the lane. Keeping the kitchen outside the house at the entry point allows the female members to cook and clean on their doorstep. Services are located on the lowest level of double-story housing units, while the top levels are comprised of bed and storage facilities, as well as a small semi-outdoor (veranda) space (figure 4). In some cases, services are also found on the upper floor with beds and storage. For saving space they install a ladder instated of a regular stair to reach the upper floor as vertical circulation. The house form is not only a place of living but also a source of income-generating space.

4.2 Assessing Housing Standards

Housing standards must differ from context to context and region to region due to cultural variety and other considerations such as climate and social customs. In a brief, there can be no rigorous, universal standards. The goal is to enhance the environmental and housing conditions for the vast majority of households while remaining within the limitations imposed by existing available resources and objectives. These are the following:

4.2.1 Site and surroundings

Development of Rupsha settlement was a consequence of a long process of physical adaptation to widespread river flooding, linked to the high riverbed and filling of channels from increased sedimentation. For analyzing waterlogging, the topography of the settlement area can be divided into three major elevations- i) Upper elevation ii) Middle lower elevation iii) Lower elevation (figure 3). The river embankment is the only protection of the settlement from waterlogging caused by widespread river flooding. Being located in comparatively low land, the houses in the lower and middle lower elevation of the settlement still goes underwater due to reverse side water flow from the city area and overflow from the river during the rainy season. A little rain causes serious waterlogging for hours in the lower elevation of the settlement. The settlement is almost covered with built forms except for two large ponds at the rear middle part. The ponds act as natural reservoirs and help to reduce waterlogging. In other seasons these ponds become the dumping ground of household waste, as the site doesn't have any defined waste dumping space. It's a good sign that the site has a drainage system to reduce waterlogging though which is open to the sky. During the rainy season, these drainage systems cause flooding and pollute the environment, particularly the wetlands, causing many diseases transmitted through water, such as dysentery and cholera. These open drains and ponds are harmful for healthy living as- (i) It serves as a breeding place for mosquitoes, black flies, and a variety of disease-causing viruses and bacteria, (ii) It pollutes the air with their foul odor. The settlement area is connected to the street (the river embankment) through some narrow spinal roads or lanes. Rupsha is formed of rows of houses, with some clustered houses at the end of the lanes. Both the row and cluster organization of dwelling units are built on internal lanes and bi-lanes. There is a diverse mix of land use around Rupsha, including commercial and industrial establishments, such as shellfish processing houses and cold storage facilities, sawmills, and retail stores, among many other things on a comparatively higher elevation (figure 5). The river embankment (strand road) is crowded with heavy vehicles such as trucks and lorries to support these industrial and commercial establishments. From analyzing the land use pattern, we can easily understand the settlement area is surrounded by noisy, dusty, smokey industrial areas and heavy traffic congestion. Fumes containing carbon monoxide are created when fuel is burned in automobiles or small engines, trucks, stoves, fireplaces, lantern, furnaces, and gas appliances are all examples of items that fall into this category. Poisoning from carbon monoxide could occur if there is insufficient indoor ventilation. Carbon monoxide poisoning is distinguished by headache, nausea, weakness, vomiting, pain in the chest, and disorientation, and is similar to flu symptoms (CDCP, 2015).

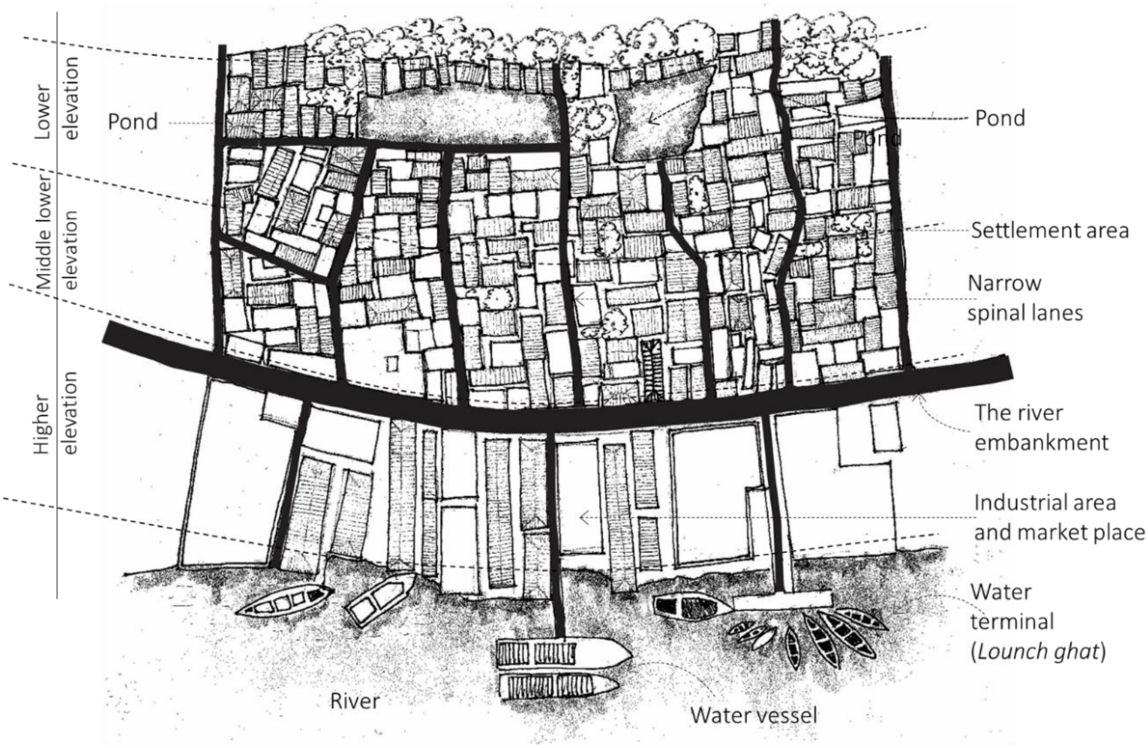
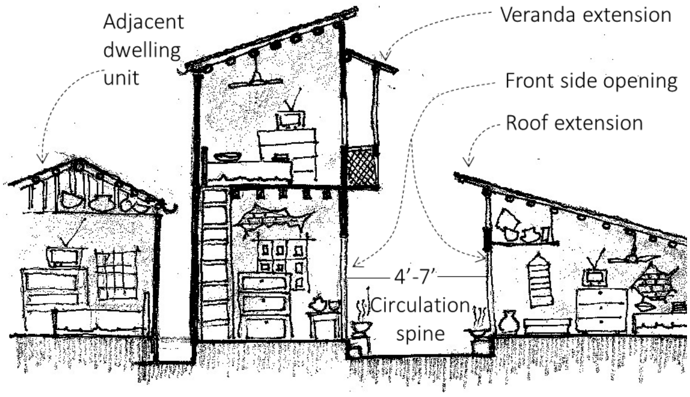


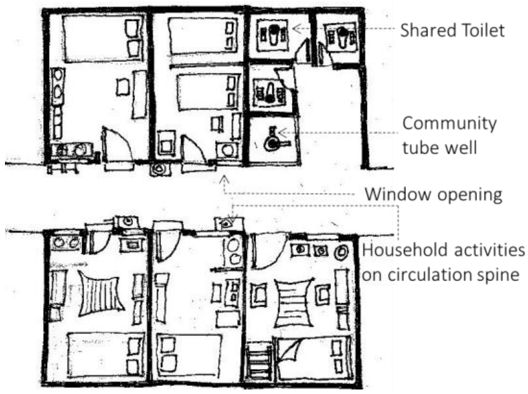
Figure 5: Settlement topography with existing land use zones

4.2.2 Setback and Ventilations

The housing units are organized on the internal lanes without maintaining any setback from the common pedestrian circulation or the non-motorized vehicular (goods carrying van or rickshaw) lane. They are also blocked from three other sides by adjoined dwelling units. Only the corner housing units beside the two cross-over lanes have two open faces which are beneficiaries of natural lighting and ventilation. Being organized in narrow lanes, there is no scope to consider climatic considerations. Thus, most of the houses facing west get very hot during summer. Due to density and space scarcity, the settlers become bound to build the housing units without maintaining any setback. Almost every house form is blocked from three sides, only the front face is open to the narrow lane. In an extreme emergency situation, the fire service vehicle or the ambulance cannot reach the densified settlement area because of the narrow lanes. The width of the lanes varies from 4 feet to 7 feet (figure 6a) whereas the minimum width of the fire truck and the regular size ambulance is 8 feet. These lanes act as the light and air ventilation spine all over the settlement. In row houses, this circulation spine is used as an extension of the house where residents perform semi-private activities and interact socially with neighbors. The dwellers extend the roof of the single storey house or the first floor of the double-storey house into the adjacent lane (figure 4a). It's the most common practice in the settlement is to extend the upper floor beam over the bi-lane (figure 6a). This cantilever portion of the built form creates shadows on the lane which protects them from heat stress in the summertime. But in wintertime, the condition becomes miserable, while the sunlight can barely enter the settlement area. As the moisture content of the soil surface cannot be dried out, the indoor and semi-outdoor spaces of the house become damp and moldy. Inadequate ventilation also increases indoor moisture. The inhabitants reported that the adult family members frequently suffered from fever, headache, and vomiting. About 40 percent of the surveyed households reported that their children have been suffered from long-term chronic diseases like cold pneumonia and asthma. Asthma and other severe respiratory diseases are accompanied by housing that is damp, cold, and contaminated with mold (Krieger & Higgins, 2002).



(a) Section of row housing units



(b) Plan of space organization in housing unit

Figure 6: Organization of Housing units in row formation

From analyzing the floor plan (figure 3,4) we can easily understand that the house form has an insufficient number of windows or openings in comparison to the floor area. There is no scope to put windows or openings on wall surfaces because of the three sides blocked façade. Only the front façade contains small openings which is not satisfactory either in number or in size. In most cases, it has one small window with an entrance door (figure 6b). In the early stage of the vertical extension of the house form, residents get opportunities to install windows on the other three walls. But these windows become inactive with the vertical extension of adjacent house blocks. In table 2 the opening size, number, and floor area of the dwelling unit have been briefly described.

Table 2: Opening sizes compared to floor area.

House types	Categories	Amount in number	Maximum size			Minimum size			Average size in sqft
			Length	Width	Area	Length	Width	Area	
Single storey	Window	1	5'	5'	25 sqft	4'	3'	12 sqft	20 sqft
	Door	1	7'	3'4"	23.5 sqft	6'	3'	18 sqft	20 sqft
	Floor area (indoor)	1	18'	12'	180 sqft	12'	8'6''	102 sqft	150 sqft
Double storey	Windows	2	5'	5'	50 sqft	4'	4'	32 sqft	45 sqft
	Door	2	7'	3'4"	47 sqft	6'	2'6"	30 sqft	39 sqft
	Floor area (indoor)	2	18'	12'	360 sqft	12'	8'6''	204 sqft	300 sqft

In this settlement, only 30 percent of houses are double storey whereas 70 percent of houses are single storey. Among the single storey houses, the maximum size of floor area is dominating in number which is 60 percent, 30 percent of houses are average size in floor area and only 10 percent houses have minimum floor area. Among double-storey houses, the average size floor area is 50 percent, the maximum size floor area is 20 percent and the minimum size floor is 30 percent. In comparison to ventilation standards, both the single-storey and double-storey houses are not satisfactory. In average cases for single-storey houses, the window area is 1/7.5th of the floor area and in combined doors and windows, it is 2/7.5th of the floor area. For double storey houses, window area is 1/6.6th of the floor area and in combined doors and windows is 2/7.14th of the floor area. For ensuring natural light and air ventilation in indoor spaces these opening numbers and sizes are not sufficient. Another problem is the position of the openings in respect to the space area though the position of windows considering the wall surface is satisfactory which is placed at a height of not more than 3 feet from the floor ground level. From indoor space analysis of household activities for single storey house, we found that the rear space (private zone: bed or sleeping area) of the house is the darkest zone where natural air can barely flow away (figure 3). The absence of ventilation increases indoor temperature; the inhabitants generally have no other alternatives but depend on mechanical equipment. On hot summer days the situation becomes the worst, the inhabitants often suffer from disturbed sleep due to the increased indoor temperature. The middle portion (reading area) is also absent of natural light and air ventilation, where artificial light and mechanical ventilation is the only source of task light and ventilation. The circulation lane adjacent front portion (kitchen or household income-generating area; swinging; tailoring) is moderately lightened and air ventilated. Considering heat stress and smoke disposal from the kitchen burner, having the kitchen near the door or outside the entry point was found to be effective. For double storey houses, the upper floor is comparatively lightened and air ventilated than the ground floor (figure 4). Residents also try to adapt to increasing heat stress by designing large openings without shutters, perforated walls, openings in the roof and ceiling, keeping the door open until midnight, rooftop planting, and designing semi-outdoor spaces at the upper level. They build perforated walls and ceiling canopies to ensure maximum natural air ventilation and cool indoor areas during heat waves.

4.2.3 Floor, Wall and Roof

The house forms sit mostly on the street level with very low plinth (floor) height. The plinth height varies from only six inches to a foot. During the rainy season, most of the houses in the lower elevation are inundated. In this circumstance, the stilted houses (figure 2) are more effective to cope with waterlogging. the residents of the single storey houses place their valuable goods such as cooker, food, and poultry on the raised beds. The inhabitants made the plinth with permanent materials such as brick, sand, and cement for their house because of frequent waterlogging, though the height of the plinth is inadequate. Net finishing cement is used to smooth out the upper surface of the floor. Except considering the standard plinth height, this kind of floor is well maintained and free from crevices to prevent the breeding of insects. Only 15 percent of houses have "kacha" plinth made with mud which is regularly washed away during heavy rainfall. In the hot dry season, the inhabitants suffer from dampness, dust, and insect-borne diseases and in the rainy season, the scenario becomes the worst. For double-story houses, the intermediate floor is made of wood or reinforced cement concrete (RCC) which is free from dampness and crevices. The intermediate wooden floor is supported by bamboo or wooden joists. Despite the fact that the house forms have satisfactory plinth condition, the wall condition lags far behind the standard level. In wall construction, mostly made of wood; however, increasing inclination to brick wall for households who can afford it. For *pucca* houses, the wall is made up of brick which is reasonably strong, but the thickness is not more than five inches. Plaster is used to smooth out the surface which is effective for protecting the harborage of rats and vermin. Semi-pucca houses have five inches-thick brick walls without plaster. Cracks and crevices are more common in this type of wall than the pucca houses. For being located in the coastal belt of Khulna, salt corrosion is quickly happening on the exposed brick wall. These kinds of walls not only make indoor space mould but also dusty. In "kacha" houses, the wall is made up of very thin temporary materials such as corrugated metal sheets and wood or bamboo fence with a permanent or *pucca* plinth. The average wall thickness varies from one inch to three inches whereas, for corrugated metal sheets, the thickness is only a few millimeters. This kind of wall has a high level of heat capacity which can easily transfer heat from outdoor to indoor. The corrugated metal sheet is one of the highest-level thermal conductors. During the summer season, the indoor environment becomes extremely hot and in the winter season, becomes extremely cold. In winter, the cold wind easily enters the indoor space through the perforated fence wall and makes thermal discomfort. Inadequate insulation, thermal bridges (metal sheets), and unplanned air paths cause surface temperatures to fall below the dew point of the air, resulting in dampness. The brick wall is a reasonably stronger and thermal insulator than the corrugated metal sheet wall. The only advantage of this kind of wall is unsuitable for the harborage of rats and vermin. Only the plastered brick wall surfaces are color coated which is insignificant in number. Fungal decay occurs when timber becomes wet for a longer length of time and is generated by an attack by one of several wood-destroying fungi. White mold grows on interior brick walls where there is a high moisture content due to seepage caused by heavy monsoon rains. Due to being located in a low-laying riverbank formed in the process of siltation, the wall, floor, and plinth are affected by salt corrosion. Moisture levels in the wall surface above a certain threshold tend to make the environment humid, and molds thrive in humid environments. From the household survey, we found that the indoor air also contains a moldy smell. To ensure adequate ventilation, the residents made perforated windows (locally called "jali") and free façade. Indoor low height partition wall is constructed with temporary materials such as wood or bamboo fence. The roof height for single storey houses varies from seven feet to ten feet. For a pitched roof house, the average roof height is below eight feet. The pitched roof is found effective in disposing of rainwater and keeping indoor space dry. Because of the increased construction cost, the lowest floor height is kept in double-storey houses which varies from seven feet six inches to eight feet. In order to minimize damage and loss of life during storm they use lightweight materials particularly for overhead construction. About seventy-five percent of house roofs both *pucca* and *kacha* are made up of corrugated metal sheets, ten percent of houses have thatched roofs, and only five percent of houses have a permanent concrete roof. Because of the lower roof height, the indoor air cannot be properly ventilated, causing the indoor environment to heat up. For using the corrugated metal sheet as a roofing material, the indoor environment becomes extremely hot on summer days and extremely cold in the winter season. The thatched roof houses provide better heat insulation than the corrugated roof houses. From the interview survey, we found that a significant number of adults and children in mold houses suffer from wheezing, tightness in the chest, irritation in the throat, coughing, and nasal congestion.

4.2.4 Floor Area, Cubic Space, and Overcrowding

The settlement is highly overcrowded with more than 600 households per acre, approximately 2600 people per acre. From the analysis of the floor plan (figure 3), we already have figured out that each household has one single house with a single room. The maximum number of family members in a single household is found 10 whereas the minimum number is 3. The average family member in a single household differs from 4 to 6 people. The settlement has about 70 percent of nuclear family having 4 or 5 members (husband, wife, and children), 30 percent joint families having 6 to 8 members (father-mother, husband-wife, and children; or husband-wife, uncle-aunt, and children). Due to the obvious scarcity of space, it is challenging for the occupants to set up separate rooms for family members. We will seek to comprehend the overcrowding by comparing the number of people with the space area. For a single-story house, each household has only one single room having an average of 4 family members. Despite having limited space, individual households have created varied spatial arrangements for different indoor space use. The floor area of the room differs from 102 to 150 square feet. In making privacy they use curtains or thin wooden fences for space separation in a single storey house. Each of the separated spaces is not more than 45 square feet in area. In most cases, the families having four or five members have to sleep in a single room in different layers where their movement and resting time are highly restricted. They use old clothes and blankets as a temporary bed on the empty floor area inside the room. The minimum standard of privacy and hygiene is not maintained, causes suffering from sleep deprivation. Family members cannot sleep before or after the fixed schedule for them to do so. In double-storey house for a nuclear family, the minimum standard of privacy is maintained by extending one single room on the upper storey. If we consider each family has 4 members- each of them is an adult, they will need at least two living rooms with 220 square feet of area. If two of them are children between one to ten years, they will need two living rooms though the floor area requirement will be considered less but not less than 170 square feet. If one of them is children under twelve months and another one is between one to ten years old, they will need two living rooms with at least 150 square feet. If among four, two of them are husband-wife and two of them are adults from opposite sexes, they will need three living rooms with at least 250 square feet. These are the most potential combination of members in a single-family found in the study area. For a nuclear family with five members (husband-wife and three children), the space demand will be increased according to the family size. The nuclear family of 4 members including two children needs 1500 to 2500 cubic feet of space regarding the standard air replacement without using mechanical equipment. If we consider 5 members including 3 adult children, the standard space requirement will be increased up to 3300 cubic feet. On the contrary, the existing single-storey housing unit has only 1050 to 1350 cubic feet of space. The low ceiling height of the house also decreases the total amount of cubic feet of space. If we consider the joint family of 6 members the floor area requirement will be 330 to 450 square feet with 3 or 4 living rooms. For standard air replacement, the space requirement will be 3300 to 4500 cubic feet. From analysing the floor area, cubic space and persons it is clear that the existing single-storey housing unit is not even satisfactory for the nuclear family in terms of overcrowding. In that case, only the double storey houses of two living rooms can be suitable for families having 4 or 5 members including 2 or 3 children. Both the single-story and the double-story houses of two living rooms are insufficient to accommodate a joint family of 6 or 8 people. However, the housing unit is used to not being overcrowded throughout the day. It becomes overcrowded at a certain time period when the male family members return home from the workplace in the evening. The home remains less crowded throughout the day, from 8 a.m. to 6 p.m when male members go to their workplace and children go to school. A large number of female members also work at the nearby fish processing market during this time period. Not only the individual household but also the overall settlement area remains less crowded at this specific period of time. In the summer season, the inhabitants suffer from heat stress and sleep disturbance, which also affects their mental health. From the household interview we found that close-contact infectious diseases, diarrheal diseases are very common in this settlement. In covid situation, the worst-case scenario of overcrowding is that it is not possible to isolate the infected family member in a separate room. The houses are not equipped with enough room and health equipment, therefore the inhabitants face increasing potential health risks. Overcrowding has a significant impact on children's growth and education. About 20 children from different households living in overcrowded houses are reported to have respiratory problems. Living in overcrowded living conditions also has an impact on a child's cognitive development, that can have long-term repercussions for a child's potential of achieving success in adulthood. School-age children claimed that they cannot concentrate on their academics at home and regularly fail to prepare their daily school assignments. They are compelled to perform multiple tasks in a single indoor space, such as studying, watching television, cooking, sleeping, eating, and so on. Overcrowding and housing conditions have also been related to mental health disorders such as anxiety and depression.

4.2.5 Water Supply, Sanitation, and Waste Management

In the settlement, access to services such as drainage, water supply, sanitation, and garbage collection is severely limited. The settlement does not have any supply water from the municipality. They are entirely reliant on groundwater both for drinking and household activities obtained by tube well. The private tube wells are not available in the study area, the inhabitants rely on a limited number of shared community deep tube wells. They installed deep tube wells with the help of Khulna City Corporation (KCC) and NGOs to have access to groundwater with low levels of salinity. Every common circulation spine of the settlement consists of more than fifty households of around 550 people, where the total number of tube wells is only one. The tube well is located within 500 meters of the most remote household and the water flow rate is comparatively satisfactory. We measured the water flow rate of the tube well and determined that it is above 16 liters per minute. Every family, on average, uses two numbers of 10-liter jars to store drinking water, and they are used to refill the jar on a daily basis. A few buckets of tube well water are used for cooking and other everyday household activities. Unfortunately, because of the fall in groundwater level, the water flow rate of the tube well remains lower during the summer season. The situation becomes miserable when the water flow rate falls throughout the entire day. At the peak hour in the morning period, the queuing time exceeds more than 45 minutes. Aside from that, they have 24-hour access to the tube well, although many of them use pond water for domestic chores and bathing. The existing two ponds could be an excellent source of water for household activities; however, the water is contaminated due to garbage dumped into the pond. The inhabitants reported that the tube well fails frequently due to excessive pressure. If the tube well goes out of service due to mechanical problems or any other issues, at that time period the inhabitants do not have any other way but to depend on the other tube well located on the nearby lane. This leads to domestic squabbles among the neighbors. Among 50 households, we found only two households have private toilets inside their housing units containing a little water closet (WC) and a bathing space. Besides this, for ensuring the privacy of the women, most of the households have a private bathing space inside their dwelling units (figure 3,4). For cleaning and maintaining the privy and the bathing space, they installed a portable water tank which is refilled by carrying water from the nearby community tube well. Generally, male adults and children use the tube well or house adjacent circulation spine for bathing. Almost every household in the settlement has to depend on the community toilets provided by Urban Partnership for Poverty Reduction (UPPR). The UPPR provided sanitary toilets are clustered in format made with brick and plaster (*pucca*) (figure 6b). Though the common toilet is located within 50 meters away from the most remote house of the settlement, it is not sufficient in numbers. For 540 people, each clustered community toilet has only three water closets without having any defined urinals. If we compare the number of toilets with the users, we will find that for every 180 people it has only one toilet which is too far behind the standard. The toilet is not separated by gender, it is used by both men and women. For every common asset, there must have an underlying issue "tragedy of common" and this community's common asset is not above this problem. The question is who is maintaining the common toilet? In spite of having a large number of users, the toilets are not well maintained, or they cannot get any chance to clean because of the excessive pressure on the common toilets. It makes the toilet environment extremely unhygienic which is not suitable for any user group, especially for women and children. Young children defecated within the settlement area, mainly on drains, exacerbating the area's sanitary issues. The common toilet is located just beside the tube well which also affects the hygiene of the tube well (figure 6b). The city corporation does not provide any waste management services in this settlement such as household waste-collecting van. Within the settlement, it does not have any dustbin or defined waste dumping ground. Aside from this, with the help of Community Development Committees (CDC), the inhabitants developed an integrated waste management system by themselves. Under the UPPR projects, CDC is formed by community groups at the neighborhood level to improve water, sanitation, and drainage. The CDC appointed two people from the community for collecting daily household garbage from door to door within the settlement area. In addition, the CDC is also responsible for managing the waste-collecting pedestal van. These two people collect household waste every day and throw it away at the nearby municipality's defined garbage dumping area. Every household has to pay 50 takas monthly to the CDC for the service. The whole process not only helps to keep the settlement clean but also ensures some people's on-site employment opportunities. On the other side, we noticed that many of the households dispose of domestic wastes into the house's neighboring drains or into the pond. As a result, this waste disposal has an adverse effect on the physical environment and pollutes the pond water, which people use for a wide range of purposes. The widespread use of dirty water, as well as the unhygienic environments that prevailed from lack of a proper toilet and drainage system, are the primary causes of most of the common diseases suffered by slum inhabitants. During the field survey, in an interview, a community health worker cited worms in the stomach, diarrhea, dysentery, typhoid, malaria, and TB (tuberculosis) as the most common health concerns in this settlement. It is becoming increasingly common for human habitation to infiltrate natural drainage systems as a result of rapid urbanization and increasing human settlement areas. In this settlement the drains are not only inadequate but also incorrectly placed with defective slopes, causing them to become clogged with unclean water and waste. Inadequate drain systems, lack of outlets, Drainage outlets that are not determined, failure to properly maintain the current system for removing waste, and the discharge of solid wastes into drains or drainage channels all of these factors lead to the massive surplus of drainage and waterlogging issues. The annual tidal action and low terrain of the region also contribute to drainage and waterlogging problems in the settlement area. Approximately 44 percent of the total households have direct access to the site's existing drainage system though it is high in number compared to the other informal settlements in Khulna.

4.3 Comparative housing scenario and development guidelines

From studying the housing conditions of this informal settlement, we tried to draw out a clear picture of how much the existing dwelling unit deviates from the standard parameters. In table 3, we have shown the housing areas that need to be improved by comparing existing housing components with the standard housing parameters to satisfy minimum health standards.

Table 3: Finding the housing area to be improved from a comparative analysis of housing components.

Housing components	Standard Housing Parameters	Existing Housing Scenario	Housing associated diseases in the study area	Housing areas to be improved
Site and surroundings	• Street access should be independent of the house. • Should be away from dust, smoke, noise and traffic • The soil should be dry • The soil should be well-drained	• 35% of household does not have independent access to the street. • Open drains are the breeding ground of insects. • Foul smell, air, and noise pollution are caused by open drains and industries • The lower elevation remains wet and damp even in summer season • The low land creates flooding in lower and middle-lower elevation areas	• Headache, • Nausea, • Weakness, • Vomiting, • Pain in the chest	• A covered drainage system can prevent the insects' breeding and foul smell • The ground soil level needs to be raised up to 2.5 feet to prevent flooding
	• The built-up area should be two-thirds of the plot area	• The plot area is almost covered with built-up area	• Cold pneumonia • Asthma	• Large window openings and vertical

Housing components	Standard Housing Parameters	Existing Housing Scenario	Housing associated diseases in the study area	Housing areas to be improved
Setback and ventilation	• An unobstructed flow of light and air • Every room should have at least one window facing the outdoors. • The openings should be 2/5th of the floor area	• Three sides of the house are blocked with neighboring dwelling units • Only a few numbers of space have windows • The average opening is 2/7th of the floor area.		extensions can be an alternative way of natural ventilation • High windows (clerestory) can be provided
Floor, wall, and roof	• The floor should be permanent and impermeable • The plinth height should be 2 to 3 feet • The minimum wall thickness should be 9 inches • The wall and roof should be free from heat conductive capacity • The roof height should not be less than 10 feet	• 85% of dwelling units have permanent plinth • The plinth height varies from 6 inches to 1 foot. • The wall thickness varies from 1 to 5 inches • The metal sheet as wall roofing material has high heat conductive capacity • The roof height varies from 7.5 to 9 feet	• Nasal congestion • Wheezing, • Chest tightness, • Coughing, • Throat irritation.	• The raised plinth height can prevent waterlogging • The ceiling height needs to be raised to ensure space cooling and ventilation • The wall material needs be replaced with thick heat insulative material
Floor area, cubic space, and overcrowding	• Each household should have minimum 2 living rooms • The minimum floor area of a single household should be 200 sqft • Each person should have a minimum of 500 cubic feet space	• 70% of the households have single room and 30% of them have double rooms • The floor area differs from 120 to 150 sqft • It has only 262.5 cubic feet of space on average for per person	• Respiratory problems • Anxiety • Depression	• Vertical extension can ensure the required cubic space
Water supply, sanitation, and waste management	• The maximum distance between household and water source is 500 meters • The queuing time at a water source is no more than 15 minutes. • Each toilet should hold less than 20 people • The households should not be more than 100 meters from a communal refuse pit	• The tube well is located within 500 meters of the most remote household • The queuing time of water exceeds 45 minutes at pick hour • It has only one toilet for each 180 people • The settlement does not have any communal garbage refuse pit • Have own waste management system	• Worms in the stomach • Diarrhea • Dysentery • Typhoid • Malaria • Tuberculosis	• Need to plan some deep tube well and sanitary latrine for cluster-based families

5. CONCLUSION

In this research, we tried to quantify how much sufferings the informal settlers suffer from housing deprivation, especially sleeping deprivation due to overcrowding. The study reveals the settler's interconnected space sharing mechanism of compact living, a household of 5 family members perform their daily activities within a single room of 120 square feet area. Almost every physical component of the housing is far behind the minimum level of health standards, with a wide range of health risks present. The narrow spine road of 4 to 7 feet in width might cause an increase in the fatality rate under fire hazards due to not allowing the fire trucks to access. The current literature demonstrates that informal settlements are poor living conditions with a greater burden of disease and a serious potential for morbidity. This informal settlement needs cost-effective innovative housing design solutions and policies to improve housing environments such as overcrowding, ventilation, water and sanitation, and site surroundings with a view to preventing housing-associated diseases. In this study, we not only have revealed the miserable housing conditions with its associated diseases but also tried to figure out which housing components need to be improved under health issues. While the relationship between health and factors associated with housing in the informal settlement is complex, available research suggests that attempts to overcome crowding, water and sanitation, indoor light and air ventilation problems. Also, upgraded housing typologies are expected to have a positive effect on health and well-being. However, while upgrading, all interconnected dimensions of housing, including the house, the home, the neighbourhood, and the community, must be addressed. For example, we emphasize the physical components of housing that may affect health patterns, as well as the findings that need to be included in informal settlement upgrading strategies. Finally, there is a need for more stratified integrated transdisciplinary data spanning health and other areas that impact health, such as housing. This information will be useful in prioritizing upgrading strategies for optimizing health improvements, as well as in assisting future research aimed at measuring and evaluating the impact of informal settlement upgradation.

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