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Transforming Slum Dwellings into Better Livable Units: An Approach through Minimum Intervention

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Abstract: Dhaka, the capital of Bangladesh and the 9th largest city in terms of population, is like an urban melting pot bubbling over with population and a city which is forever changing and never finished for it's over population. When Cities are out of control of population density problems, informal urban development is perceived as a consequence of uneven urban growth. The crisis of Dhaka city disables the conventional planning faculty and requests the formulation of alternatives that will integrate architecture of informality into the whole urban structure. This paper tried to figure out the poor living conditions at Duaripara slum which is in the north-western part of Mirpur Thana at Dhaka North City Corporation. Through research and hands-on inclusive solutions, the paper proposed options for their better living condition. Analyzing the present condition of light, ventilation and temperature inside the houses, this research shows how quality of life might be improved through nurturing the opening condition and insulation system of the existing house, which is very much affordable for the slum dwellers, but unfortunately, they are unaware of it. The innovative solutions and increase in skills of informal builders can uplift the permanent up-gradation to informal settlements. Literature study and field survey have helped to develop module design for the improved living conditions that can be retrofitted in existing built forms with minimum intervention. As we are now living in the cutting edge of technology, this small but inclusive initiative may open up big opportunities to upgrade the living conditions of the settlement of slums in Bangladesh and elsewhere with similar existing context.

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1. INTRODUCTION

The capital of Bangladesh, Dhaka has a unique phenomenon and pattern in its own lifestyle and culture. Phenomenon on rapid mass urbanization and its social consequences create new form of urban poverty and also new form of local solutions. These are the non-permanent structure in the city which we pass by and disregard. These non-permanent structures include from very big slum to a smallest tea stall. Impact of these structures in the city is so significant that we cannot discard it from our daily urban life, though it is sometimes illegal and unauthorized. It has been assorted with our urban culture and social mobility. Slum dwellers, unable to get a decent living condition, have no other way, but accept their sufferings caused by extreme heat and cold or adverse weather. Lack of experience means and understanding about proper ventilation approaches and thermal insulation is another reason for their sufferings during summer and winter months. High density of houses, clustered forms, shared walls, using non-insulated C.I. sheets as roof and walls and lack of openings due to privacy and odor issue are the basic reasons behind their sub-standard living condition. Infrastructure repairing, increasing utility bills due to lack of daylight and ventilation are one of the main reasons to affect their economic condition. As an observer, who exercises to create better living environment through designing, it is our moral obligation to bring innovative strategies to improve their living environmental quality. In this research the emphasis has been given to improve their quality of life through few indicators like Daylighting, natural ventilation and other environmental qualities of these houses.

According to Jasper Cepl, "*Urban development is rampant in many parts of the world. If we are to hope for solutions, we will have to consider informality—as part of the solution, not as a problem. We will have to reckon with the forces apparent in informal settlements and acknowledge that we cannot do any better if we don't take informality seriously. We will have to study informality and evaluate both its positive and negative aspects*" [1]. From the history of improving squatter settlements in different regions, it has been observed that, appropriate upgrading policies and healthy living designs have become increasingly socially cohesive, offering opportunities for security of tenure, local economic development and improvement of conditions of their lives [2].

Climate-responsive habitat generally refers to that particular type of dwelling unit, which address the climate change issues, like- heat, flooding and extreme cold, and encompasses the adaptation of sustainable retro-fittings in building the environment and housing structure. The Design Features make homes resilient to climate vulnerabilities, as such that they maintain an acceptable level of functioning and structure [3].

Dhaka's critical urban condition have led many institutions, especially architecture and urban design programs, both in Bangladesh and around the world, to take up research and design initiatives in response to the critical conditions of the city. This paper discusses about the study of the typology of the housing units, and the potentials of the interventions within existing condition and the affordability, to deal with climate induced problems mentioned above. The whole project was a joint venture approach, where the design and research were conducted by The Department of Architecture, AIUB and the implementation was carried out by the Habitat for Humanity International- Bangladesh.

2. OBJECTIVES

1. Identify the components of existing housing units and understanding socio economic condition for assessing the affordability of the slum dwellers.
2. Propose options for retrofitting, which will improve the quality of life of selected slum dwellers from the deprivation of daylight and ventilation with minimum intervention of the existing structure.

3. METHODOLOGY

The first part of the research encompasses the literature study on the relevant topics like slum development strategies and improvement of the quality of life of the slum dwellers.

The second part encompasses the field investigation, data collection and questionnaire survey to assess the existing condition of the housing units, assets & affordability of the inhabitants and quality of the life (QoL) in terms of housing, which is one of the basic indicators to assess the quality of life with a particular focus on daylight and ventilation of the housing units.

The questionnaire survey was conducted during a workshop, having the participants of all age groups of males and females (one from each family and both tenants and stakeholders were also among them), which covered 5% of total number of families. The questionnaire was not open-ended, and the questions were prepared to assess their existing living condition and the quality of the housing units. The findings from questionnaire and field investigation led to figure out the scope of work and, also the limitations and thresholds of affordability.

In the final step, the design options of the modules were developed, that can be retrofitted in existing built forms with minimum intervention. The implementation was conducted as a pilot project by Habitat for Humanity International-Bangladesh in randomly selected housing units among the households with poorest conditions identified during field investigation.

4. LITERATURE REVIEW

The term slum has varied definitions. UN-Habitat's definition of slum is the most common and widely used around the world. It defines a slum as an area that has one or more of the following five characteristics: [4]
-poor structural quality of housing
-overcrowding
-inadequate access to safe water
-inadequate access to sanitation and other infrastructure
-insecure residential status
The word slum was first used in the 1820s to denote the poorest quality of housing, featured by lack of sanitary facilities. It was supposed to be the "den" of marginalized activities, including crimes and drug dealing. Notably, even to this day, this derogatory undertone of the term remains. Nevertheless, as regards its applicability in developing countries, the term is used to denote poor quality of housing [5]. Urban poverty, especially in developing countries has been manifested through slums or informal settlements. Bangladesh is no exception as a developing country. To address the problem of slums, Islam (1997) [6] narrated three strategies, which are slum clearance, slum relocation and slum upgrading. Many think that slum upgrading is better than other two. In this argument, Panday (2020) stated that significant advantages of slum upgrading are reduced cost (as low as 10% of the cost of slum clearance or relocation), reduced disturbance to the livelihood and tranquility of the community as slum clearance and relocation is, by nature, traumatic and sometimes violent [5]. Slum upgrading has been successfully used as a slum strategy many times in Bangladesh, by the State, local government and NGOs. It has usually proven to be the best slum strategy for the reasons stated above and is to be preferred in most circumstances [7].
The narrow definition of slum upgrading refers to improvements in housing and/or basic infrastructure in slum areas. In a broader sense, upgrading also includes enhancements in the economic and social processes that can bring about such physical improvements [8]. Slum upgrading consists in an integrated approach that aims to put into motion the economic, social, institutional and community activities that are needed to turn around downward trends in an area [9], however David Satterthwaite (2012) defines "upgrading" as a term given to measures to improve the quality of housing and the provision of housing-related infrastructure and services to settlements that are considered to be (or officially designated as) 'slums' or that developed illegally (including squatter settlements) [10]. According to Cities Alliance (1999) slum upgrading interventions typically include the following [11]:
• Installation or improvement of basic infrastructure such as water reticulation, sanitation, waste collection, road networks, storm drainage and flood prevention, electricity, security lighting and public telephones.
• Regularization of security of tenure.

• Relocation of and compensation for the residents (both men and women) dislocated by the improvements.
• Housing improvement.
• Construction or rehabilitation of community facilities such as nurseries, health posts and community open spaces.
• improvement of access to health care, education and social support programs to address issues of security, violence, substance abuse, etc.
• Removal or mitigation of environmental hazards.
• Provision of incentives for community management and maintenance.
• Enhancement of income-earning opportunities through training and micro-credits.
• Building of social capital and the institutional framework to sustain improvements

This research is on slum upgrading in the field of housing improvement. Housing improvement helped to offer better quality of life (QoL) in selected slum of this research. The quality of life can be used as the most general aim of sustainable development as this aim represents the economic, social and environmental dimensions of sustainable development. In this term it is important to assess the quality of life by evaluating the economic, social and environmental indicators related to quality of life [12]. According to Singh & Sinha (2019), quality of life (QoL) is an ambiguous and multidimensional concept, and it conceptually includes every aspect of a person's life [13]. The quality of life (QoL) is categorized into two major parts—objective and subjective quality of life. It is used in a wide range of contexts, including the fields of international development, healthcare, environment and politics. Quality of life should not be mixed with the concept of standard of living, which is based primarily on income [14]. The standard indicators of the quality of life usually include not only wealth and employment, but also the built environment, physical and mental health, education, recreation and leisure time, crime rate and social belonging [15].
The dimension of quality of life (QoL) in slum is different from that of formal and legal housing as the living conditions and lifestyle of slum dwellers are quite different from that of the general people. One can define the slums on the basis of different characteristics or indicators like accessibility of water, accessibility of sanitation, housing quality, presence of more population, tenure security, etc. Such indicators directly reflect the living conditions and can be used in evaluating the level of quality of life of slum population of an urban area [13]. Housing is one of the indicators of quality of life which has three dimensions, that is, housing quality, housing environment and housing expenditures burden [12]. These dimensions are actually figured out for formal housing. Slums have much poorer housing conditions in comparison to that of non-slum dwellers. In Singh & Sinha (2019), housing conditions of slum are measured by the materials of construction, over number of residents, housing ventilation and social amenities are measured by the availability of the lighting, cooking, latrine, drinking water, sewerage and other essential facilities [13]. This research is dealing with one indicator of quality of life, that is, housing with a particular focus on light and ventilation of housing unit of slum.

Worldwide, slum development efforts face multiple, yet, common challenges. The following points reveal some common challenges, which was faced in the slum upgrading program at Soweto East village at Nairobi, Kenya, e.g. [16]

- Competing interests of various groups.
- Complexities of slum settlements with regard to tenure arrangements.
- Lack of coordination of various stakeholders.
- Resistance to the slum upgrading program especially by the slumlords.
- Lack of participation by the slum dwellers in the upgrading program.
- Residents not being aware of their roles as stakeholders in the upgrading program.
- Lack of adequate land for slum upgrading.
- Lack of goodwill and mistrust from the slum dwellers.
- Inadequate budgetary allocations from the government exchequer to the slum upgrading program.
- Politicization of the slum upgrading program.
- Environmental degradation; varied political, cultural and religious inclinations amongst the residents and their leaders.
- Various stakeholders being involved in the program leading to partnership concepts that often derail the implementation schedules of the upgrading program.
- Non-genuine NGOs.

5. FINDINGS

5.1. Housing and Socio-economic conditions

A. Locations and Site surroundings

Duaripara slum is located in the north-western part of Mirpur Thana in Dhaka North City Corporation (DNCC). This area may be demarcated as a semi fringe area of Dhaka. It is located in ward no. 6. This is one of the oldest slums of Dhaka and has been built upon the govt. owned land (Fig 02). Adjacent to this study area there are some slum settlements, which reaffirms one of the highest concentrations of such type of settlements particularly in this Thana (Fig 03) [17].

Fig 02: Aerial view of a part of Duaripara Slum

Fig 03: Location of Duaripara, Source: Climate Change In Urban Areas: Bangladesh Case Study 2018

B. *Profession of Inhabitants*

The inhabitant of Duaripara (part) is seven thousand (7000) comprising of fifteen hundred (1500) families. People here belong to different types of professions where the majorities are garment workers (600) (Chart 01). Others are nurse, teacher, midwife, religious leader, lawyer, cleaner, tailor, driver, electrician, small businessman, housemaid, hawker etc. They are less educated, and part of the population is illiterate.

Chart 01: Profession of inhabitants, Source: CARITAS, Bangladesh, (Source: Urban Risk Assessment and risk reduction work plan report, 2018)

C. *Existing Household and other infrastructures*

Being very poor, their living condition is not very well. The existing types of houses are *Pucca* house, *Half-kancha* house, *Kancha* house (Table 01). All these houses are built by some house owners and rented by tenants. Access to water supply and electricity are present but they are not always legal.

Table 01, Data of existing households (Source: Urban Risk Assessment and risk reduction work plan report, 2018)

Type of house	Number	Size of house	Number of inhabitants
Pucca house	15	14'X14'	100
Half-kancha house	800	11'X11'	4000
Kancha house	600	10'X10'	3000
Others	80	8'X8'	400

Around 5000 people use the supply water point from WASA and 2500 people use deep tube well. Access to the private toilet is scarce. Only 20 private toilets exist whereas seven thousand and four hundred (7400) inhabitants use only 400 community toilets [18].

D. *Income and Economic status*

The slum residents in Duaripara comprise both full-time and occasional workers. Their monthly income ranges from 5,200 BDT to 13,000 BDT *(In average, BDT 85=1 USD)*. The economic profile of families is as follows:

Table 02 shows income source and economic status (Source: Urban Risk Assessment and risk reduction work plan report, 2018)

Type of work	Number	Everyday income (BDT)	Monthly Income (BDT)	Yearly Income (BDT)
Daily Laborer	300	300	7800	93,600
House made	100	250	6500	78,000
Small Businessman	60	500	13000	15,600
Driver (Rickshaw, van, auto and other)	300	500	13000	1,56,000
Hawker	20	200	5200	6,2400
Garment worker	450	300	7800	93,600
Service	250	400	10400	2,70,400
Other	500	300	7800	9,3600

The inhabitants here enjoy networks and mutual support between households and communities. Moreover, NGO intervention gave rise to some social support like school, daycare center, small credit program, disaster management, child health and nutrition etc. Representatives from slum people are included in the committees of social support programs. Unfortunately, there are no clinic/medical services inside the slum, though around 15 private schools are running in both *pacca* and *kancha* structures.

In spite of all the hurdles in their life, Duaripara slum peoples' aspirations are expressed through some of their daily life efforts as they manage to grow some vegetation adjacent to their houses given the situation of very congested dwelling units. Many of them also have some livestock like chicken and duck.

E. Existing Site Plan

The built forms are composed of different building types, based on the building materials. The arrangement of the built forms shows the sign of organic development, having no specific planning. However, most of the clusters are in linear form and north-south oriented. Toilet and kitchens were placed at the end of each liner cluster, composed of multiple dwelling units. An unpaved road stretching from south to north, serves as the main access road to the site. Apart from this, there are several narrow access roads to the site, which are mostly for pedestrian accessibility (Fig 04).

High density of the dwelling units poses high risk of health hazards. Houses, built in a temporary manner, and having light construction, are also hazardous in terms of fire hazards. Narrow unpaved roads are the means of access for the dwellers. The eastern and northern part of the site faces the problems of water logging. Some house clusters were built of the Pallabi Lake at the northern part of the site, with the help of bamboo stilts.

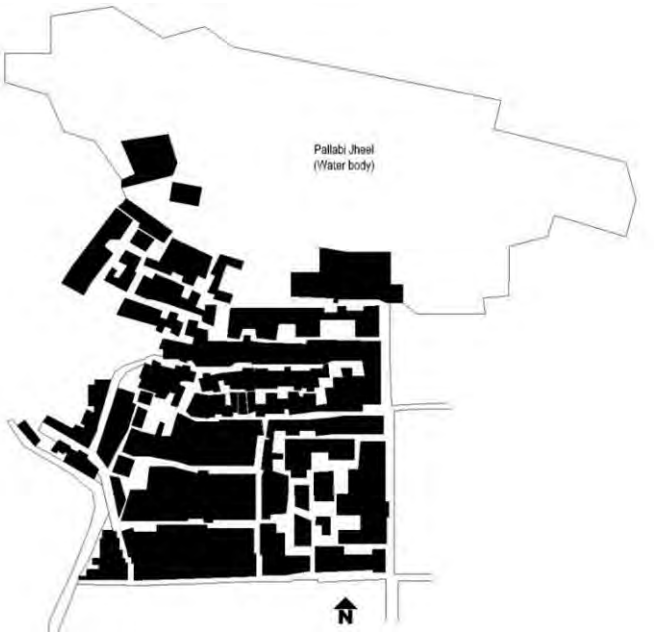

Fig 04: Figure-ground diagram of Duaripara, showing the built forms (Black), accessibility and insignificant open space (white)

F. Existing Built Forms

Dwelling units are placed to form linear cluster, and generally, 8 to 10 dueling units compose each cluster. Toilet and the cooking area are placed at the end of the cluster (Fig 05). The clusters are so closely placed, that there is barely any space to provide an opening from dwelling units (Fig 06). The access passage is also very narrow, only 3-4 feet in width. Access passage is covered by C.I. sheet in some clusters for protection from the rain. But, in most cases, the passage is open to the sky, and this is the only source of light and ventilation for the poor dwellers.

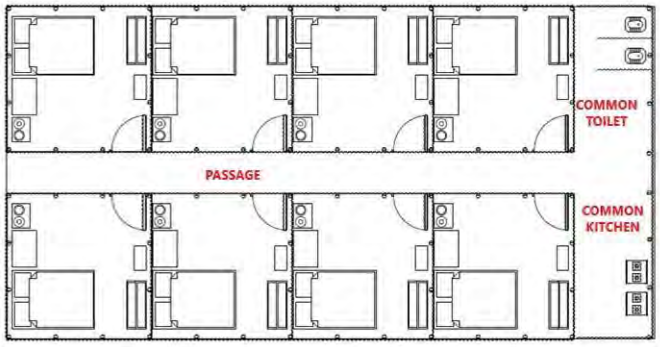

Fig 05: Schematic plan of a typical cluster

Fig 06: Dwelling units without any openings, because of narrow setback and access way

G. Problem identification and scope of work

A questionnaire survey of the inhabitants and observations during the field survey revealed some existing problems amplified by poor infrastructure.

After the analysis of the outcome from the questionnaire, the following observations were noted (Fig 07),

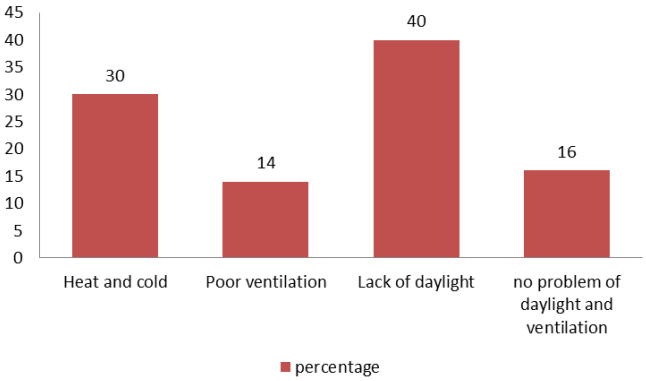

Fig 7: Percentage of the respondents suffering from thermal discomfort and deficiency of daylight & ventilation

The outcome of the questionnaire provides important feedback regarding their daily life and sufferings due to poor infra-structure and poorly built housing units. The following field visit validates the outcome of the questionnaire, through observation and analysis of the existing housing units.

The field survey conducted in the Duaripara slum also provided some insight into the dwelling units and lifestyle of the dwellers. The observations are as follows,

a) Building Materials:
Most of the dwelling units are made of C.I. sheets with bamboo frames. Only a few have brick walls with C.I. sheet roofs. Ceilings are non-insulated in almost all the houses, which makes the interior extremely hot during the daytime and cold during winter nights. Some units have vegetation on the roof. The stakeholders live in comparatively better dwelling units, where tenants are less privileged (Fig 08).
b) Floor:
Most of the units are built on the land, having 'Pacca' floor. Few dwelling clusters at the northern part were built on bamboo scaffolding on the lake (Fig 08).

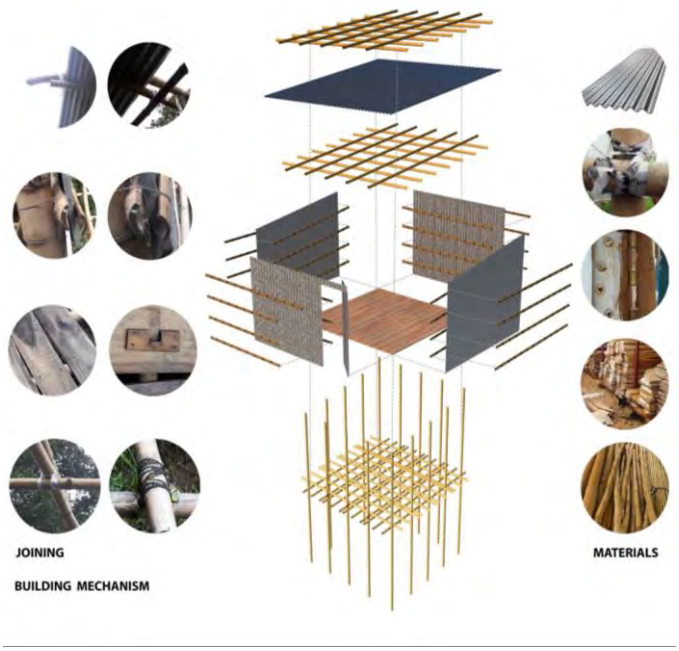

Fig 08: Building mechanism of existing typical single dwelling unit built on the bamboo stilts on the lake

c) Accessibility:
The access passage is very narrow, and in most cases, it is only 3-5 feet wide. This space also serves as the common space for social interaction among the cluster dwellers.
d) Openings:
Being composed of a linear cluster, there is no opportunity to put the opening on both sides, or even at back in most of the houses. The door opening on the access passage is the only opening in most of the dwellings, which need to be closed at night for security reasons. Lack of window-like openings creates an unbearable situation due to extreme heat.
e) Lighting and cooling:
In most of the dwelling units, electric lights and electric fans are the only modes of lighting and cooling during the day, as there is no option for windows. Electricity connection is illegal, and fees for consumption are paid to local leaders. The door is the only opening, which needs to be closed at night, and in most parts of the day, for privacy and security reasons.

Scope of work includes

a) Exploring Ventilation potentials in passage and setback areas.
b) Exploring the opportunity to incorporate daylighting in the dwelling unit.
c) Using insulators to prevent heat gain from the roof made by C.I. sheets.
d) Exploring low-cost and affordable materials for retrofitting.
e) Using adaptive technology in retrofitting with minimum possible intervention.

5.2. PROPOSED RETRO-FITTING OPTIONS

A. Design Options under Study

Earlier studies suggest that construction of houses is not considered as slum up gradation; rather, residents could opt to do this by themselves. Therefore, Low cost and adaptive recommendations were taken into account as part of development of the household unit's existing condition in this particular attempt. During the preliminary design phases following issues were kept in mind,

- Existing condition of the built forms
- Structural strength, existing building technology and Joining Details
- Scope of intervention,
- Design with minimum intervention considering the affordability of the slum dwellers to make the design recommendations adaptive

Addressing the above-mentioned issues were the key points to come up with retrofitting ideas, e.g.

a) Modular design has been considered, so that it can be easy to maintain, and easy to re-build, if necessary. Another consideration was to design it like a "Plug in" module, so that, it can be prefabricated, and can be implemented within few hours. Thus, the implementation time would be low, and it would not hamper the daily life of the inhabitants. Moreover, the strategy to design individual modules helps to select the best possible retrofit in the existing dwelling unit, considering the structural strength and scope of work.
b) Incorporating Daylight and natural ventilation in the existing dwelling units got the primary focus while designing the modules. As, from the questionnaire and field survey it was found that, the dwellers of Duaripara slum are suffering from extreme heat and cold due to the lack of openings and necessary air change.
c) Not all dwelling units were the same in a cluster, and not all have similar context. The sample dwelling unit was selected from the most vulnerable type, which are built on bamboo

scaffolding over the lake. Any module fits here, will also fit in the similar dwelling units located on the land.

Considering the above-mentioned issues, the proposed design evolved with the following qualities,

- Focus on both passive and active ventilation
- Composite module
- Introduced daylighting
- Low-cost construction
- Easy maintenance and maneuverability

The design options were as follows,

Option 01 focused on both daylight and ventilation enhancement by retrofitting modular openings. Installation of roof insulator proposed for better thermal protection (Fig 9 & 10).

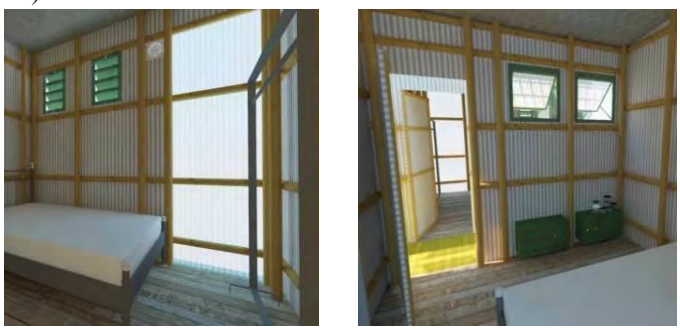

Fig 09: 3D visualization from inside, showing the room is illuminated by using semi-transparent polycarbonate sheet and well ventilated by using awning type windows along with louvered openings and exhaust fan as active ventilator.

Fig 10: Proposed ventilation and opening modules

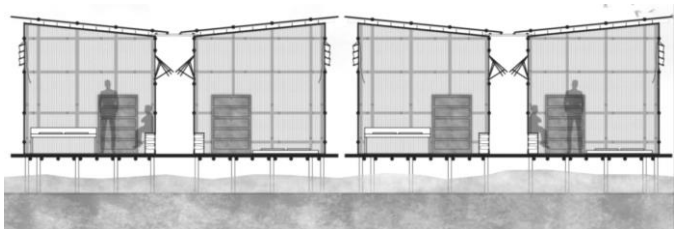

Fig 11: Proposed section of the dwelling units after retrofitting the opening modules

Option 02 focused on daylight enhancement through a composite opening module made of semi-transparent polycarbonate sheet in wooden frame, which also has a foldable opening part to allow ventilation (Fig 12 & 13).

Fig 12: Proposed dwelling unit after retrofitting the opening modules

Fig 13: Composite opening module made of semi-transparent polycarbonate sheet placed in wooden frame, having a foldable opening part to fit into spaces with minimum setback

Option 03 focused mostly on enhanced ventilation around the year, having pivot type openings at operable height, and ventilators with pivot type shutter made of bamboo below ceiling level (Fig 14 & 15).

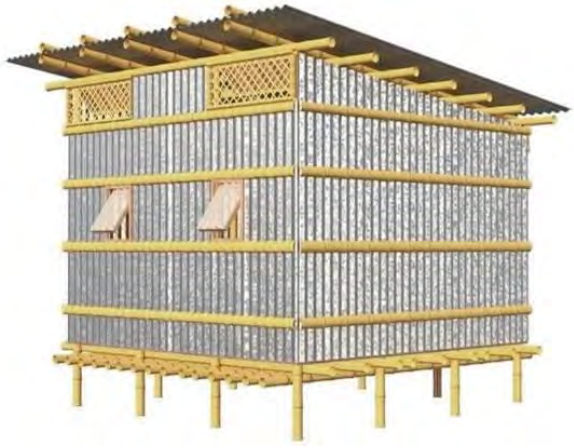

Fig 14: Proposed dwelling unit after retrofitting with pivot type openings and ventilators with pivot type shutter

Fig 15: Ventilators made of bamboo with pivot type shutter and Pivot type openings made of polycarbonate sheet in wooden frame

B. Implementation

The options were displayed in a Design Exposition and the slum dwellers came to know about the proposed features from the designers. Feedback collected from them was essential for betterment of some of the proposed solutions (Fig 16). The existing dwelling unit's form and structure were kept untouched and retained the focus on the retrofitting with minimum intervention. The prefabricated models were easy to install within a few hours which will not hinder their daily activities.

Fig 16: Student Researchers are presenting their design proposals to the Slum dwellers

Fig 17: Designed window modules with operable louvered panels and fixed mosquito net have been retrofitted in the existing façade to improve ventilation condition

The opening modules were all prefabricated and installed as 'Plug in" manner. It took very little time to add a prefabricated opening, by removing a part of the C.I. sheet wall. The process of installation did not hamper the rhythm of the daily life of inhabitants, and it took only few hours to install those prefabricated modules in each unit (Fig 17,18 and 19).

Fig 18: Designed window modules with fixed semi-transparent polycarbonate sheet in wooden frame have been retrofitted in the existing façade to improve Day light. Before this retrofitting, these units were completely dark during daytime.

Fig 19: Designed window modules with fixed semi-transparent polycarbonate sheet and louvered panels have been retrofitted in the existing façade to improve Day light and Ventilation condition. Before this retrofitting, these units were completely dark during daytime, and had no option for ventilation.

After assessment of socio-economic assets of the slum dwellers, it was found that, they can afford the expenditure of around 5000 BDT [approx. 60 USD] for the betterment of their existing living condition inside the dwelling unit. This threshold inspired the design to be low-cost, locally manufactured, and easy to maintain. Therefore, all the design modules were built by considering their daily life, social context, affordability, thermal and visual comfort and acceptability of the technology. During the material selection, the priority was given to locally available materials, local technology and local craftsmen. The design modules were adaptive in a way that they are easy to rebuild, set up, and maintain and to multiply. Initially, the modules were made and installed by Habitat for Humanity International –Bangladesh in several dwelling units. The adaptive nature and easy construction of the design modules will inspire the inhabitants to build and maintain by themselves in the future.

C. Feedback from Slum Dwellers

During the study phase, scaled model simulation projected that; implementation of some of these proposed modules could reduce the interior temperature up to 2^{o}C from the previous conditions. After implementation, when the temperature study was conducted, it was found that the temperature difference between before and after implementation was 1.5^{o}C to 2^{o}C in five different sample housing units having the combination of roof insulators, louvered openings and semi-transparent polycarbonate sheets in the walls. This post-implementation study justifies the outcome of this research through the implementation of the designed modules.

A post implementation visit to Duaripara has been done and collected the responses and feedbacks from the users. The responses were as follows,

a) Most of the dwellers were satisfied with the retro fitting works, and it improved the condition of **daylight and ventilation** inside the dwelling units.

b) Addition of louvered openings provided the opportunity for **air change**, and allows fresh air to come inside, even in a congested situation.

c) The use of insulator on the ceiling has significant impact to reduce **indoor air temperature** during daytime. The use of insulator helped to reduce 1.5^{o}C to 2^{o}C temperature difference from previous condition.

d) Using of semi-transparent polycarbonate sheet as an enclosure material was unknown to the slum dwellers. They were impressed, as it helps to **illuminate the interior** without compromising privacy and security.

e) Prefabricated module, **convenient to retro fit**, simple operation and maintenance inspired them to take it as an example for future development of the existing units.

f) Using of **local material and simple technology** was highly appreciated, as, they can now fabricate any module by using built sample as reference and by using local carpenters.

Besides those positive responses, some feedbacks were also received from slum dwellers for further development. Such as,

a) Most of the awning type opening module initially had no mosquito net, as it had to operate from inside of the house. Having no protection bars, the users had to close it down at night. Therefore, it did not work properly at night as a proper opening.

b) Some pivot type openings allowed rain water to come inside during heavy rain. On the other hand, Louver type and Awning type openings functioned well during rain.

Based on the feedback, further improvement was suggested in the Awning type window, which was implemented and preferred by the dwellers (Fig 20). The suggestion is to add a wooden framed Metal mesh, which will open in indoor side, attached with the hinges on main window frame and locked by a bolt type lock for security. It will protect the dwellers from

both theft and mosquito, and they can keep the window open at night, while closing the metal mesh frame.

Fig 20: Suggestive improvement in the Awning type opening module

6. Conclusion

The attempt of this research was to propose some retrofitting options for housing units of Duaripara slum to improve the quality of life among slum dwellers in terms of housing, which is one of the basic indicators to assess the quality of life with a particular focus on daylight, ventilation, and temperature. By exploring these research outcomes for these poor living conditions, design acts as a vehicle for directing towards future possibilities that can improve the lighting and ventilation quality for the total community. These minimum but effective interventions for the opening and façade treatment design have the ability to improve the ambient assisted living schemes that are technically and financially feasible for the slum dwellers. Some of the research conclusions have been built and applied as a pilot scheme and satisfied the occupants. The result stirred the community to replicate the research outcome which reiterates that the academic research has reached its goal.

We are now living in the cutting age of technology. This small initiative may open up big opportunities to upgrade the living conditions of the many settlements of the slums in Bangladesh. And it will enhance our better inclusive future. Further research in this field has scope of work involving the innovation of low cost, yet durable building materials and improvement of the roofing system to provide superior thermal comfort within the affordable range of the slum dwellers.

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