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Building **Inclusive** Urban Communities

CASE STUDY

MAPPING LIVABILITY OF LOWER INCOME HOUSING TYPOLOGIES IN THE CITY OF MUMBAI

Keluskar Kimaya – 2017

Funded by the Erasmus+ Programme of the European Union

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ABSTRACT

Across various housing policies governed and practiced by the state to address the issue of housing within the informal settlements, anecdotal observations talk about the serious decline in the environmental condition of the housing and its impact on the health of the occupants. This forges a need for methodological investigation about the performance of various housing typologies of the lower income communities with respect to environmental standards. The paper sets up a framework for assessment of the existing housing schemes by monitoring the three selected case-studies. It evaluates the idea of 'comfort' within the lower income groups and its importance in driving the 'livability index' which is often limited to ease of access to safe housing and good sanitation facility. The findings/observations from the field advocates the need for incorporation of sustainable measures within the lower income housing typologies, especially the housing schemes created under rehabilitation and resettlement scheme. The study examines the thermal as well as visual comfort (daylight) within the housing schemes provided by the state to ensure the well-being and resilience of poor communities within a megapolis. The paper discusses a comprehensive assessment method of deriving a livability index for each housing typology by chosing a range of parameters at neighbourhood and unit level. The derivative index strongly indicates the need for restructuring the approach, its environmental and livability standards of the lower income housing schemes. The conclusion discusses the possibilities of increasing the adaptive capacities of the poor communities and build resilience through guidelines on criterias to be followed for acquiring the land for SRA schemes and building bye-law recommendations for using passive design techniques to build livable homes and inclusive neighbourhoods. ◆

" The paper sets up a framework for assessment of the existing housing schemes by monitoring the three selected case-studies."

CONTENTS

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ABBREVIATIONS

SAS	Site and Services
PAP	People affected Projects
RNR	Resettlement and Rehabilitation Scheme
MCGM	Municipal corporation of Greater Mumbai
MMRDA	Mumbai Metropolitan Regional Development Authority
SDG	Sustainable Development Goals
SPARC	Society for the Promotion of Area Resource Centre
UN	United Nations
WHO	World Health Organisation
SRA	Slum Rehabilitation Authority
MUTP	Mumbai Urban Transport Project
BUDP	Bombay Urban Development Project
NGO	Non Government Organisation
LIG	Lower Income Group
MIG	Middle Income Group
HIG	Higher Income Group
EPS	Economically Weaker Section
RH	Relative Humidity
Clo	Unit value for clothing
DF	Daylight Factor
UHI	Urban Heat Island
ppm	Part Particulate Matter
NBC	National Building Code
PMV	Predicted Mean Vote
PPD	Percentage People Dissatisfied

PART 1
INTRODUCTION

Need for establishing livability index for lower income housing

Informal settlements are an adaptive response to the constraints and opportunities in the city with minimal resources being deployed incrementally by their residents. Often such settlements are located in unoccupied interstices and marginal lands of the city seeking a proximity to places of employment and urban infrastructure to support their livelihoods. There are different types of settlement, along a tidal drainage channel, main city water supply line or an industrial belt. Their origin for example, as an extension of a suburban village or the camp for construction labour; their history and age , the older ones are now completely surrounded by intense urban development, for instance near the airport. Proximity to sensitive areas within the city and occupying public/government or private land through encroachment often make there communities vulnerable to the threat of eviction.

The current governmental policy under the Slum Rehabilitation Authority (SRA) envisages, a re-housing of existing residents of informal settlements into multistory tenements by private real estate developers, subsidized through the profits gained by commercial exploitation of the land. It does not favor incremental in-situ improvement or community based redevelopment. Several SRA projects have been executed. The assumption is that the multistory tenement is an environmentally sound alternative to 'slums'.

Most of these SRA housing colonies are located at the periphery of the city and on grey field sites where the land value shall never increase owing to its proximity to city's dumping ground or heavy chemical based industries which continuously emit toxic gaseous content. These colonies are concentration camps to perpetuate health risks with no access to daylight and ventilation. High densification to accommodate more and more families within a vertical box and lack of advocacy has eventually converted these colonies into vertical slums. Loss of access to livelihood, education facilities, medical centers, recreational facilities expose them to more mental and physical stress. Thus, questioning the livability quotient within these proliferating housing colonies in the city of Mumbai.

Livability, within lower income housing is practiced as a commodity than a necessity or a basic requirement of a human being. The vulnerable risks are so high and over powering that it is believed; tenureship, ease of access to secure housing, clean water and good sanitation facility ensures good livable conditions. However livability is about suitable place for inhabitation, ensuring good environmental conditions which ensures community well-being and growth. The environmental performance of the dwelling units, accountability for good connectivity to the neighbourhood and the city directly impact the livability quotient.

Every individual is entitled to have access to basic needs to support their livelihood and deserves a habitable dwelling unit within the urban fabric of the city. The urban poor of informal settlements, evidently adapt to their stresses and constraints.

The first research question is:
What is the disparity between the national/urban standards and norms for environmental sufficiency and the conditions of the informal settlements? Does their difference suggest an indicator of human adaptability?

Most informal settlements grow and densify, in terms of both population and built up space to a point of saturation, accompanied by a progressive increase in environmental degradation and stress. This environmental degradation and stress occurs despite rise in incomes of the residents.

The second research question is:
Are there limits to density of population and built up space that would be environmentally sustainable, given the typologies of building that are economically affordable? How do different typologies of housing of the urban poor compare in terms of livability and how do residents perceive their own environmental conditions?

Such informal settlements are most vulnerable to the anticipated effects of eviction, where loss of livelihood, access to basic amenties like access to good quality potable water, medical and educational facilities.

Research questions:
What are the imperatives of relocation and protection to safeguard communities well-being and growth by access to basic amenties and livelihood?

In the dense city fabric, the living conditions within informal settlements, housing provided for informal settlements under rehabilitation schemes needs investigation to understand building performances with respect to inhabitants and their impact on their surrounding. Nutrition and health would also play an important role to achieve an adaptive model for sustenance. So the study of built form along with its immediate environment and inhabitants would offer a degree of certainty to derive liability index for slum dwellers and lower income people in the city of Mumbai. However, the focus of this research is the environmental conditions of different housing types by adopting the framework 'livability index'. The methodology, empirical data through field monitoring and analytical tools explored in the paper shall offer a way of assessment of various housing typologies to derive their respective livability index. Thus, reasoning the many concerns and a significant percentage of unwillingness of beneficiaries to occupy them.

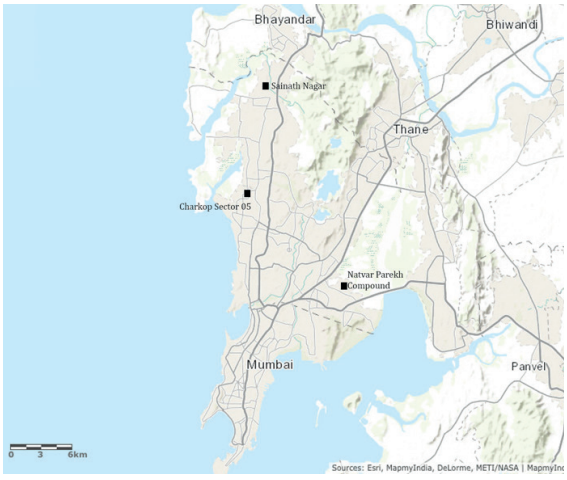
There are two broad objectives of this research: First - to objectively and quantitatively measure and describe the environmental conditions of typical low income settlements in Mumbai – indoor and outdoor thermal conditions, energy consumption, cycles of water and waste, extreme events, heat stress and health status and risks. Second - to obtain a subjective view and perception of local residents about their environmental conditions, heat stress, health and Climate Change risks.

The research objects are critically chosen to get an overview of livability index for

- Slum rehabilitation and redevelopment scheme
- Site and services Scheme
- Informal settlement ◆

Figure 1

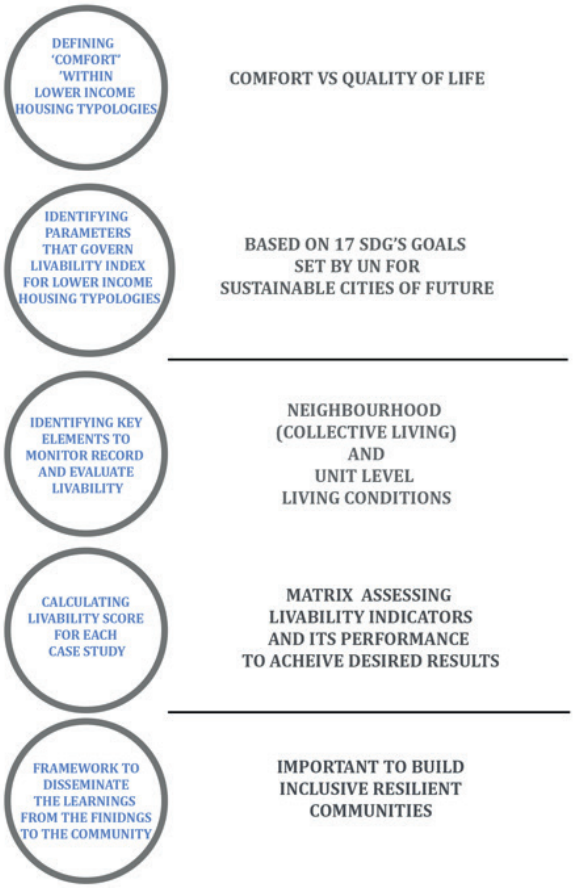
Showing location of Three case studies in the city of Mumbai



PART 2
METHODOLOGY

Figure 2

Showing the key drivers and framework methodology adopted to carry out the research



Source: Author

- Identify parameters that govern 'livability' within informal settlements. Livability index provides an understanding of requirements, tools to create healthy living conditions, establish cohesive relationship with the environment and neighborhood communities.
- Develop techniques of surveying and mapping various parameters of environmental condition in these settlements as objective data measured with instruments.
- Develop methods for recording subjective perceptions of residents - of their comfort, stress and state of health.
- Develop framework for comparative analysis of empirical data from case studies for qualitative and quantitative evaluation different typologies.
- Use of scientific measurement tools; Spot measurement of thermal comfort parameters – temperatures of ambient air, radiant temp, surface temp, air movement, and humidity combined with geo positioning. Thermal imaging, data logging using data loggers, Outdoors Mapping at city, neighborhood scales, Indoor mapping
- Heat mapping within dwelling units in each typology to assess the building construction and material performance with respect to climate.
- Daylight assessment within buildings and habitable spaces
- Analysis of electrical consumption for artificial lighting and comfort co-relating consumption with building performance.
- Analyzing the performances of building materials with respect to the operational cost in relation to household income.
- Mapping water and waste systems within informal settlements.
- Developing communication techniques for informing resident communities about indoor comfort conditions and its impact on their health and efficiency.
- Deriving livability index for each case study assessing various parameters associated with improving living conditions for population of informal settlement. ◆

PART 3
FRAMING THE PARAMETERS THAT GOVERN LIVABILITY WITHIN LOWER INCOME HOUSING

Figure 3

Sustainable Development Goals, United Nations Development Program

Source:
http://www.un.org/sustainabledevelopment/development-agenda/

The sustainable development goals came in effect in January 2016 and would continue to guide UNDP policy and funding. In September 2015 the world leaders as part of an historic UN summit adopted 2030 agenda for sustainable development officially came into force. The SDG's were the key drivers to fullfill 2030 agenda. As per the UN report; the SDG's are not legally binding however the governments are expected to take ownership and establish national frameworks for the achievement of the 17 goals. The highlighted SDG's goals form the broader framework to derive parameters to assess livability within lower income housing communities in the city of Mumbai.

Goals 1, 3, 4, 6 , 7 and 8 are key drivers to achieve goal 11. Goal 17 would institute to self sustain strategies introduced to attain goal 11. ◆

PART 4
PILOT CASES

4.1 Natvar Parekh compound- Indian Oil SRA

Overview of the Project

The site is located in M-East ward of Mumbai and is amongst one of the first public housing colony developed by Natvar Parekh group under Transfer of Development Rights (TDR) scheme. In 1990, the world bank's new position on no clearing of project site without resettlement and rehabilitation component had a direct impact on Mumbai Urban Transport Project (MUTP). The government of Maharshtra was asked to formulate rehabilitation and resettlement policy. The elected task force received help from various central state agencies, NGO's and people's organization to execute the program. The policy was driven by clear objectives laid down by the task force in order to safeguard shelter through active community participation and conserving community's existing networks. Yet the said objectives got diluted over a period of time with newer complex challenges, elaborate bureaucratic processes and getting various actors to agree upon a common interest. (Source: Sundar Burra, Vol 17 No1, 2005; Sheela Patel et.al, Vol 14 No1, April 2002) . This resulted in uncalled evictions and displacement of communities. The project affected people (PAP) were forced to occupy the rehabilitation schemes provided by the state. Natvar Parekh Compound is one such example . The housing scheme has a total of 60 buildings which were handed over to Mumbai Metropolitan Region Development Authority (MMRDA), out of these 29 are leased to Municipal corporation of Greater Mumbai (MCGM). 09 buildings are still vacant and not been occupied since construction. Each building has 96 units and the total occupancy of this housing colony is approximately 25,000 including illegal squatters. On site 7 buildings are occupied by people from Sewri, 4 buildings by people from Ray road and 3 buildings from Nagpada and Byculla sites. For study we have acquired access to blocks 11C. All buildings are 7 (ground +6) floors high and are provided with lift facility. The buildings were occupied overnight and had no municipal water connection on the time of relocation. The alliance's constant negotiation helped them to get Municipal water supply after one month of occupancy, till then private water tankers were provided for daily water needs at the occuanst cost. Being vacant for few years post construction; the drainage lines, toilet fixtures, door and window frames were damaged; this added more grief to the displaced communities.

Timeline Evolution of Rehabilitation and Resettlement Scheme under provision of 3.11 scheme also known as PAP (Project affected People)

Figure 4

Showing yearwise evolution of rehabilitation and redevelopment project using TDR.

Year 2002

Private Land ownership. Used as Ship container yard

Greyfield[1] site made available for slum rehabilitation scheme. Close Proximity to Deonar dumping ground and thus low Land value compared to other sites within the city extents

Year 2003

Land developed by Natvar Parekh under provisions of 3.11 scheme also called PAP scheme[2].
Design of the units and site highly compromised[3].

Year 2005

Project constructed and ready for allotment. Municipal water supply and sanitation facility not provided.
Project was not occupied till 2008. Hence the building services system were worn out owing to lack of usage and spaces within the schemes faced vandalism from the neighboring informal settlements.

Year 2009

Construction of all units were completed. However, 10 buildings were kept vacant till date and are not occupied. Access to Potable Municipal water started in 2010. Till then the tenants filled water from common water source. Eye Health Dispensary started in 2017

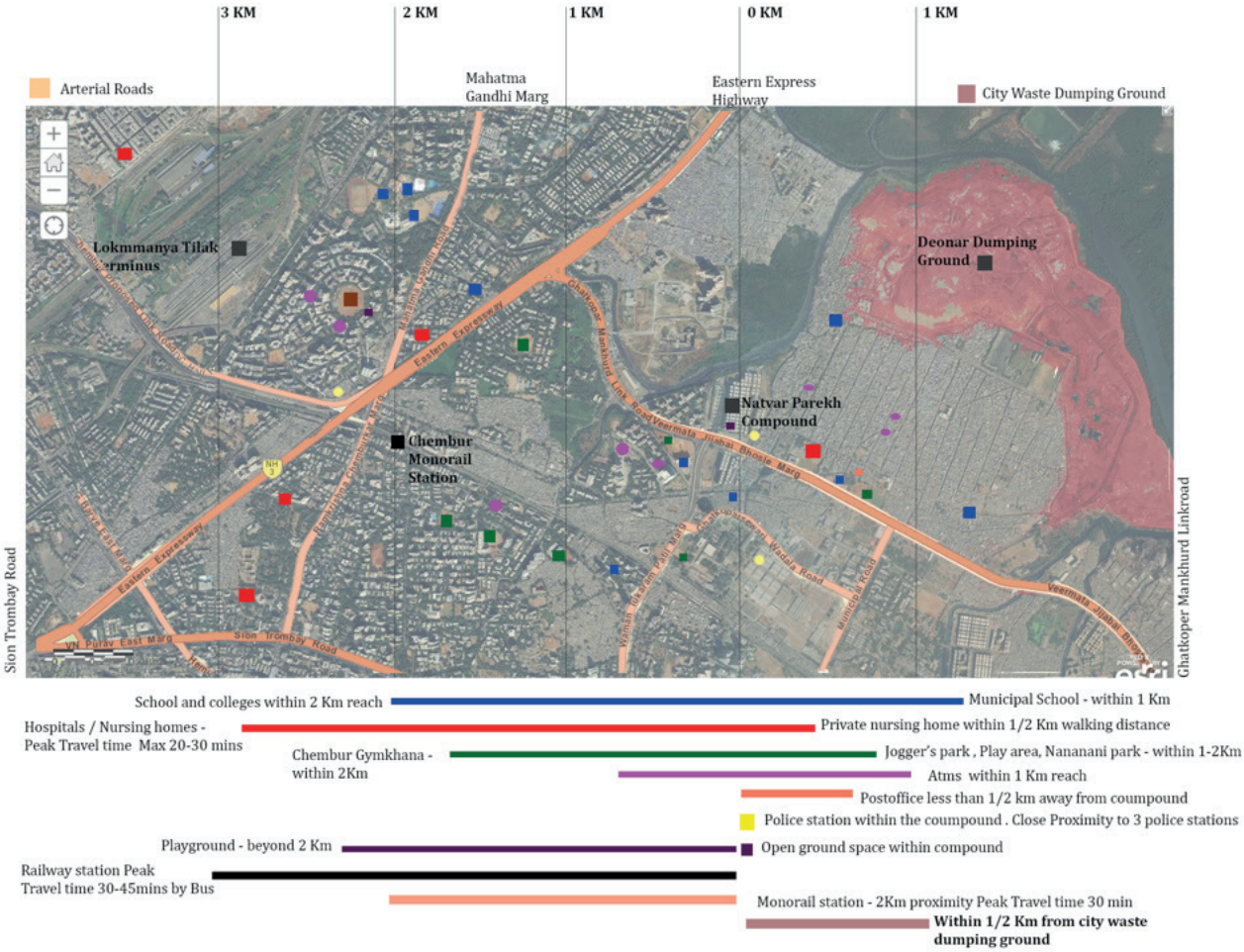
Source: Author

1 Greyfield site is economically obsolescent, outdated, failing, moribund or underused real estate assets or land.
2 PAP is Project affected People rehabilitation scheme on private land by private developer; for which he is compensated by TDR on land and construction
3 As per DCR 33(10) and 33 (14) Minimum density of 500 tenements per net hectare. Special considerations in relaxation in open space requirement and unit size

Mapping Neighbourhood Liveability for Natvar Parekh Compound (PAP), Govandi

Figure 5

Showing regional connectivity to various livability parameter and distance of travel from site



'Livability' relates directly to quality of life and well-being in a particular location (Gerradbrown, 2006). In a residential colony livability depends on the immediate physical built environment around an individual and the neighbouhood where one walks along the streets to reach to the nearest bustop or rail station (Gerradbrown, 2006). Brooke Lyndhurst talks about different interpretation of livability depening on different continents. However he agrees that globally the idea of liavbility culminates into quality of Life, well-being and life satisfaction (Brook Lyndhurst, 2004). However, some of the factors compared to developed countries become essential parameter to assess livability as part of their basic living condition. Access to minimum 5 basic ammenties needed for day to day living like grocery store, fresh vegetable/meat market, bank, etc within 500m radius. (CII, 2010). The accessibility and affordability criteria found in green building certification systems are appropriate for the middle income group (MIG) and above where 90% of the people are comfortable with the proximity to various amenities and infrastructure for day to day living.

Source: Author

The equation changes for lower income communities within the same neighbourhood as access to these are restricted only to the gated communities and the private sector schools, medical facilities within the locality are unaffordable. Hence where even 30% of these population are not comfortable then the MCGM authority's, neighborhood, city planning department objectives of re-housing poor slum communities within the city collapses. The aim of succeeding them within the city to help them grow and free themselves from the 'poverty trap' is not achieved. The Natvar Parekh compound works as a 'city within a city' where the daily grocery and housing needs are catered within the colony. Figure 05 explains the distances at which each of the amenities and infrastructure needed by the community are located. The site is within 1 Km reach from Deonar dumping ground and is highly vulnerable to hazards related to dumping ground.

4.2 Assessemnt of Residential Built Environment Performance

Thermal Behaviour of Existing Fabric

Natvar Parekh compound: Slum Rehabilitation Scheme Govandi. Dated: 2017 (Dry spell amidst monsoon)

Figure 6

Aerial view of the open ground amidst buildings. The ambient temperature in the latemorning is approximately 40°C; resultant of absence of vegetation on site and high deposit of hard paving non permeable material. This would add to the urban heat island effect. The open space is occupied by illegal car parking, construction waste thus depriving children and inhabitants from using the place for recreational and play related activities.

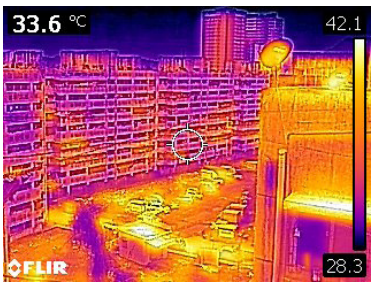


Figure 7 & 8

At 11.00am in the morning the surface temperatures have reached 36.9°C; windows on the right façade show high heat ingress owing to exposure to direct solar radiation. The alcove design allows single-sided ventilation only, this intensify the heat absorbed by the façade throughout the day creating un-comfortable indoor condition.

Figure 9 (left)

The corner housing unit at 4th floor; clearly depicts the water leakage within the structural system resulting into dampness. Absence of air circulation indoors, result in high relative humidity levels and mould formation; affecting the health of the occupants. The children suffer from asthama, frequent cough and cold. The electric fans are running continuously to achieve comfortable indoor conditions.

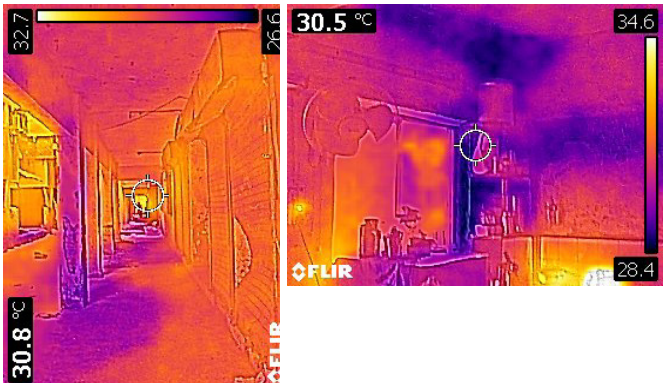


Figure 10 (right)

The ground floor corridor fringed along the internal court shows traces of water leakages and resultant dampness within the plinth level and beams.

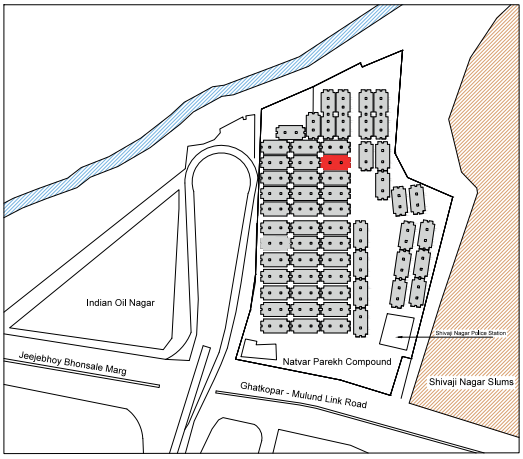
Source: Author

Figure 11

The distance between the buildings is highly compromised resulting into zero daylight penetration and low ventilation rate inside the houses. The 2m wide corridor further reduces the possibility of daylight penetration to reach the dwelling units.

Figure 12

Showing Position of Building studied for Environmental Condition assessment



Source: Author

Floor Plan Layout Showing Alcove Design of Individual housing unit of 11C

Figure 13

Typical Floor Layout

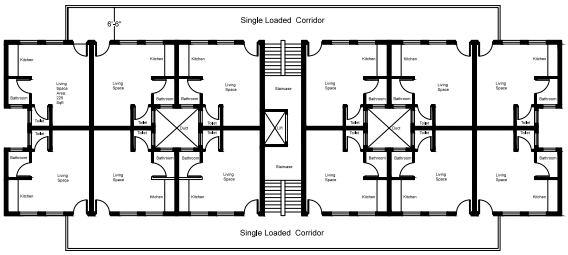
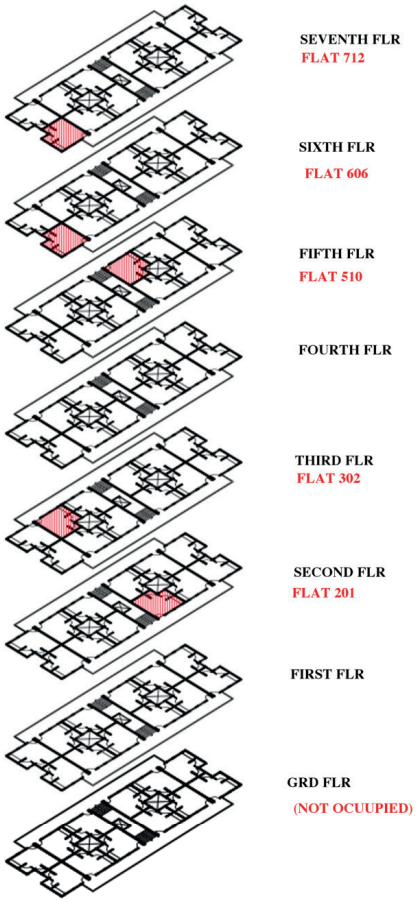


Figure 14

Showing position of Dataloggers Installed on site (Building 11C) to map Thermal comfort within units at different levels.



Mapping Thermal Comfort within the housing units at selected locations in building 11C at Natvar Parekh Compound:

Figure 15

Temperature recordings of housing units monitored in 11C

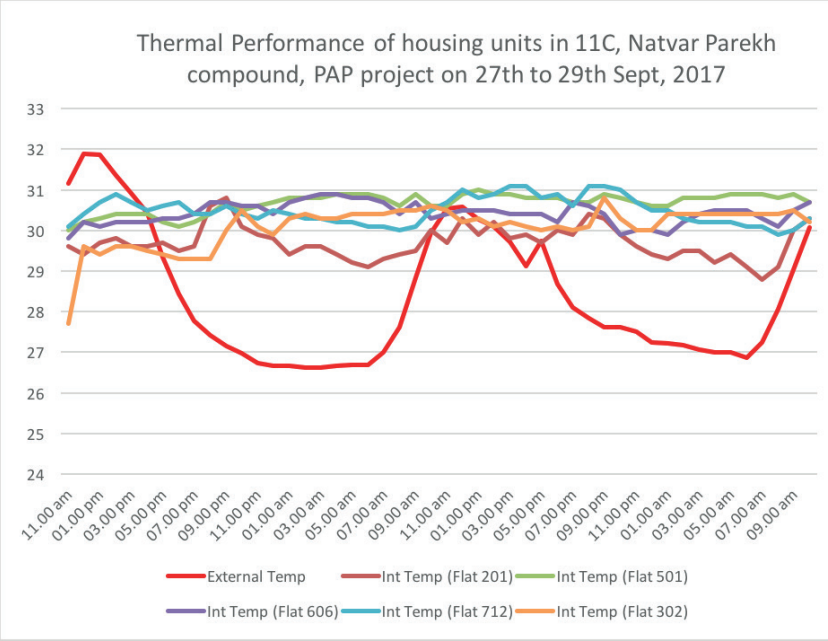
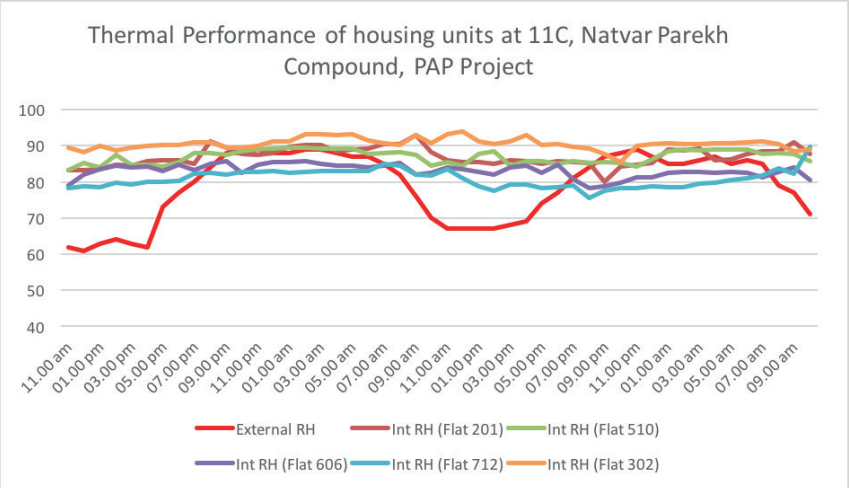


Figure 16

Humididty recordings of housing units monitored in 11C



Source: Author

Observation and related projections:
The design of the housing colony at NPC is highly compromised. The scientific data derived using instruments display some evident facts; the flats placed at the corner are performing slightly better owing to access to outdoor air and ventilation compared to the ones placed in the middle which are totally devoid of daylight and ventilation. The relative humidity in middle units is high resulting into dampness and mould formation on the walls. The flat 501 despite of being middle unit experiences high temperatures throughout the monitored time than the topmost flat 701. This clearly shows absence of ventilation and constant increase in indoor temperatures due to high number of occupants, equipment load and pollutants. The inhabitants at 5th, 3rd and 1st floor are suffering from tuberculosis. As mentioned by Claude-Alain Roulet in chapter on 'Role of Ventilation'; states that the purpose of ventilation is to eliminate airborne contaminants, these are either generated by the occupants and the activities performed within the building. The absence of ventilation is very evident in middle housing units as their interiors smell of bad odour; one experiences the fowl smell on entering these rooms. Readings shows higher levels of CO_2 concentration leading to lethargic indoor environments and experiencing high indoor temperatures indoors even when the outdoor temperatures are low.The topmost floor experience higher temperature but lower relative humidity. This occurs with the excess heat transferred from the terrace and lower RH is resultant of unobstructed induced ventilation being on the higher elevation. These observations and inferences explain that the design requires to be relooked to address basic environmental standards of thermal and visual performance.

In summers the occupants are the main source of contaminants; water vapour and odour. The airflow rate should be 22cubic meters per hour (m3/h) per person, this would limit the CO_2 concentration to 1000ppm (parts per million) and 55m3/h per person to limit the CO_2 concentration to 400ppm above the outdoor concentration. This ensures that less than 10% of people entering the room will be dissatisfied by bad odour *(prEN13779, 2004)*. In the case of PAP the airflow rate should be much higher, the risk of mould growth and water vapour condensation is high. In the old housing typologies the door and window design had ventilators on the top which is currently not seen in practice. These ventilators were medium of nightime ventilation especially in naturally ventilated buildings to achieve comfortable indoor conditions and dissipate the excess heat acquired during the daytime without compromising on privacy and security of the inhabitants.

The compact allignment of buildings at NPC have possibilities to develop urban street canyon4 effect. Urban street canyon phenomena have adverse effects on air flow rate and dispersion of exhaust pollutants within environment. Several research has been conducted to study the assessment of air quality in street canyon (Afiq Witri Muhammad Yazid et.al, 2014). Thus, affecting the indoor ventilation of the built units flanked on either sides of the street where the ventilation rate depends upon wind velocity and buyoancy5 effect. Adverse effect of un-noticed impact of street canyon phenonmena is harmful to ones health and quality fo life. Thus, it is necessary to study the possibility of street canyon effect in Natvar Parekh compound to trace the condition of air quality within the scheme and indoor units.

Urban canyons are characterised by three parameters: H (mean height of the building in the canyon), L (length of the canyon), W (width of the canyon).

4 Street Canyon is a phenomenon occurring in Urban environment. Created when a street is flanked by tall buildings on both sides resulting into canyon –like appearance. Street canyon affects indoor ventilation rates within buildings.
5 Buyoancy – Force that causes object to float

Aspect Ratio of Canyon:
H/W = 21.9 m / 4.87 m = 4.49

Aspect Ratio of Building:
L/H = 100.58 m / 4.87 m = 20.65

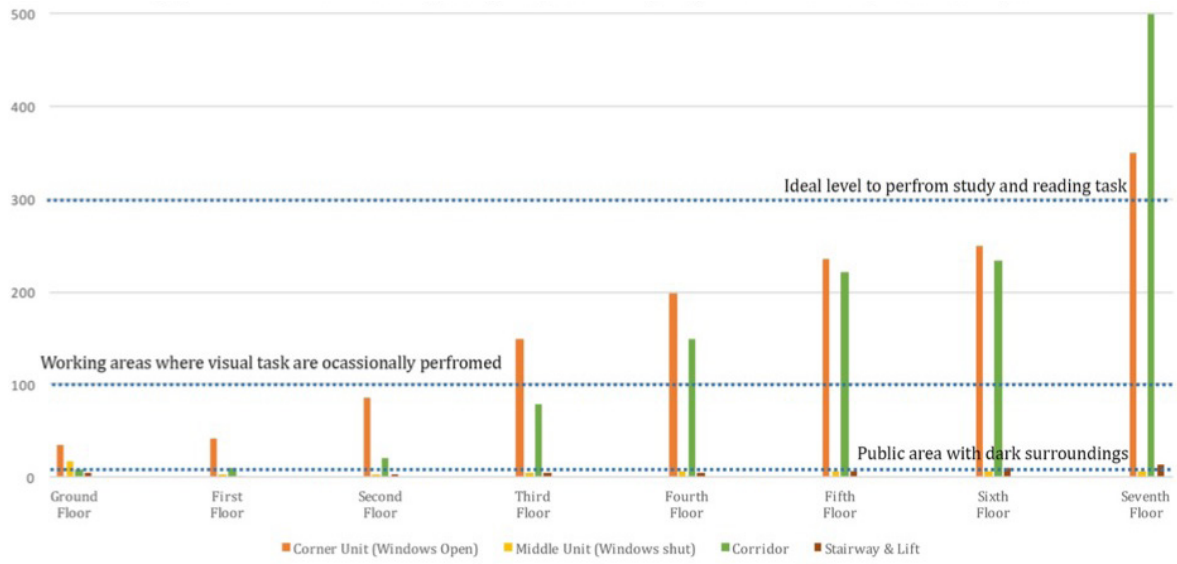
Building Density J = Ar (roof area of an average building)/A1 (unit ground area occupied by the building) = 390.38 m/390.38 m = 1

If the Aspect ratio is H/W > 0.7 , in this case the aspect ratio is 4.49 and is greater than 0.7 this means that there is canyon situation, or else the space between the buildings is not a canyon. The next step is to check the wind circulation in the canyon by deriving Aspect ratio L/W, in this case its 100.58m / 4.87m= 20.6 value greater than 20 signifies existence of wind circulation in the canyon; the wind velocity depends on the wind speed outside canyon. (source: final report of the URBVENT project, F.Allard, June 2004). The above calculations prove the existence of canyon and marginal wind circulation within the canyon. Depending on the existence of canyon, the wind direction and wind speed will vary at different positions of the canyon and eventually affect the ventilation system. In the absence of wind the concentration of air pollutants will intensify and result in the decline of the indoor air quality and consequential spread of respiratory disorders within the inhabitants, reasoning the prsenec of tuberculosis within 11C. The CO2 concentration monitored on site always exceeds 1000ppm indoors. These readings are alarming and requires immediate attention. The average monthly medical expense of a household in NPC is 800Rs to 1000Rs, this is higher compared to a middle income housing colony.

Mapping Visual Comfort in common areas and selected housholds within 11C at Natvar Parekh Compound:

Figure 17

Graph showing daylight readings on site recorded on July 2017 @ 2.00pm IST



Source: Author

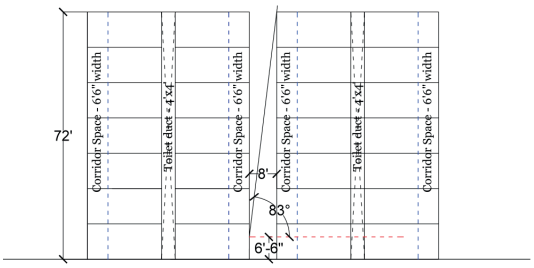
Daylight is an essential component of indoor environment, to ensure good visual comfort and indoor air quality. The standard lux[6] vary as per space specification and activity to be performed. The graph highlights the incompetent behaviour of spaces with respect to the standards directed by National Building Code(NBC). Common stairway and lift block display poor lux levels and are dependent on artificial light throught out the day. Lux levels in the corridor increase as one acends to higher floors. From the fourth floor the corridor transforms into a comfortable spaces to perform ocassional visual tasks like drying of spices, studies etc. However the daylight level doesn't change for middle unit even at higher floors. Corner unit performs better due to high exposure to the outdoor illumination. Daylight monitoring exercise clearly displays the failure of building design to ensure good daylight penetration within households and common spaces. More than 80% of the household depends on artificial light to perform their daily household ativities exerting high operational and maintenance cost. On an average the middle unit electricity bill accounts to Rs1300 (two tubelight and fan) to Rs 800 (one fan and tubelight) per month reaching 2000Rs in summers. The price excalates with increase in the occupant and quipment laod. The average electricity bill of 450Sqft area in summers accounts to maximum 2500/- Rs considering the air condition operational hours to be 5 to 6 and 1 to 2 hours of gyeser for hot water requirement every day. Each unit in NPC is 225Sqft. The dense housing model shows daylight traces from fourth to seventh floor indictaing the obstacle created by clear distance followed between buildings for daylight penetration. This creates a need to study the obstruction angle its impact on daylight penetration.

6 Lux is the SI unit of light of illumination
7 Obstruction angle is used to establish principles for the design of housing layouts.

Calculating Critical Obstruction Angle[1] for Daylighting assessment

Figure 18

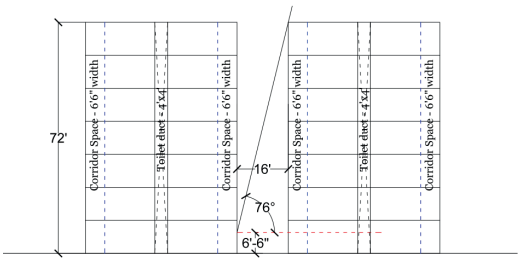
Existing Arrangement of buildings on site



Existing Scenario 01 - Distance between Two Buildings with internal courtyard space (8' W)
Latitude - 19 degree N

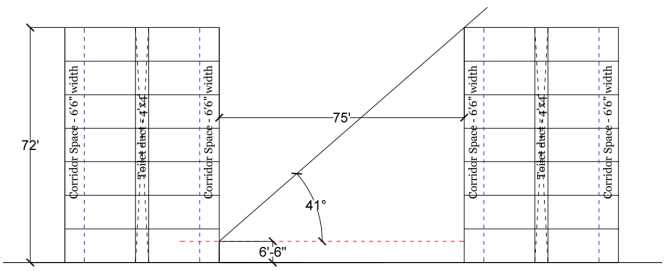
Figure 19

Existing placement of building with vehicular road in between



Existing Scenario 02 - Distance between Two Buildings abutting a road (16' W)
Latitude - 19 degree N

Figure 20



Ideal Scenario - Distance between buildings to ensure Daylight at ground level housing units
Latitude - 19 degree N

Source: Author

To ensure good daylighting it is important to calculate the angle of obstruction. Critical obstruction angle H should be less than 40° for lattitudes upto 40°. Above figures depict the calculated obstruction angle on site (latitude -19°N) and shows the ideal scenario to ensure good daylighting on site. (Source TOA vol 02, daylight design)

DF = Ei/Eo * 100%
Ei = Illumination indoors at the point of observation (Lux)
Eo = Illumination outdoors from an unobstructed Sky (Lux)
Site Condition with recorded Lux Level (refer table 02)

Table 1

Daylight Factor (DF) Calculation for PAP housig units:
Sky illuminance for warm and humid climate is 9000 lux

Dwelling	Daylight Factor (DF)
Kitchen	2.5
Living room	0.625
Study	1.9
Circulation	0.313

Source: Handbook of functional requirements of buildings (other than industrial bldg) 1987 (SP41) part 04, table 02 and IS:2440 - 1975

Table 2

Showing daylight factor (DF) in PAP housing in reference with DF as per standards

Unit placement	Corner Unit (Windows Open)	Daylight Factor (DF)	Middle Unit (Windows shut)	Daylight Factor (DF)	Corridor	Daylight Factor (DF)	Stairway & Lift	Daylight Factor (DF)
DF as per standards		2.5		2.5		0.313		0.313
Ground Floor	35	0.39	18	0.2	8	0.09	5	0.06
First Floor	42	0.47	3	0.03	10	0.11	0.6	0.01
Second Floor	85	0.94	3	0.03	20	0.22	2.3	0.03
Third Floor	150	1.67	4	0.04	79	0.88	5	0.06
Fourth Floor	198	2.20	6	0.07	150	1.67	5.5	0.06
Fifth Floor	235	2.61	8	0.09	221	2.46	7	0.08
Sixth Floor	250	2.78	9	0.10	233	2.59	10	0.11
Seventh Floor	350	3.89	11	0.12	500	5.56	13	0.14

Source: Author. Blue blocks shows compliance with standards and red block shows non – compliance with standards.

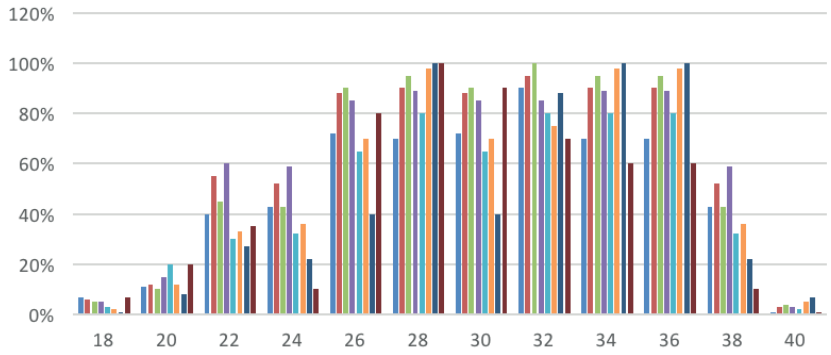
The windows in the middle units are shut for more than 90% of the daytime owing to security and privacy. Residents have complains about the thefts through window grills if the window shutters are kept open especially during the afternoon. Thus resulting into negative impact on the daylighting. The occupants are compiled to rely on artificial lighting to meet their basic requirement throughout the day. Being a studio apartment style all the activities like studying, cooking, reading are performed within the common designed unit space. As per GRIHA or IGBC rating system practiced in India 25% of the living space should be compliant with the given DF% under mandatory clause. The above data shows that the designed living space is totally devoid of daylight due to certain design constrains and occupant practices.

While one assess the daylight and ventilation within the indoor enviorments it is important to record and monitor the adaptive methods used by the community to sustain extreme conditions. Adaptive comfort model helps to qualitatively measure the comfort levels of the occupants.

Tracing adaptable comfortable temperatures within the community Natwar Parakh Compound, developed under TDR scheme

Figure 21

Showing the amount of people comfortable within 11C building and the temperature range that lies under comfort zone as per the inhabitants' vs the Ashrae comfort zone.



Source: Author. Mean Indoor Comfortable Temperature Range in Degree Celcius (NBC 2005 - 24°C to 30°C)

As per the NBC 2005 comfortable mean indoor temperatures ranges from 25°C to 30°C for naturally ventilated buildings in India. The Slum dwellers inhabitate in extreme conditions, devoid of daylight, ventilation and sanitation. The slum huts are assembled using tin roof sheet and partitions, using plastic sheet during monsoon to control water leakages. Relocating within multi storey tenement upgrades their standard of living and offers a sense of security which is often mis read as comfort. Hence the vote on comfortability of such inhabitants is generally under rated owing to their extended adaptive capacities. The idea of the house is looked as 'possession' to stack one's belonging, shelter for their dear ones and not seen as inhabitable space with good environmental living conditions to propagate well-being and growth. Similarly, MIG and HIG inhabitants vote on comfort is over rated indicating lower adaptive capacities and reliance owing to its dependency on technology to achieve comfort. This clearly points out why passive design features and comfort are not integral to the upcoming housing colonies within the city. Such oversight has direct impact on the health and quality of life of its inhabitants.

The occupants have suffered non access to portable drinking water throughout their stay. MMRDA in 2018 has executed some water tanks on site which should resolve the access to portable good quality water. However the execution of these tanks have worsen the situation inviting insect infestation and severe health conditions amongst occupants. It has created more extreme situations for physically challenged and old residents for access.

Figure 22

Showing newly built water tanks on site

Source: Author

Livability Matrix for Natvar Parekh Compound, a rehabilitation and redevelopment scheme developed under TDR

Table 3

Livability matrix for Natvar Parekh Compound

Natvar Parekh Compound, Govandi, PAP (Project affected people)							
Stakeholders	**Planning (Policy Makers)**		**Building Bye-Laws**	**Social and Institutional Level (Idea of Collective Life)**		**Performance Rating**	**Total Score**
Parameters	**Environmental Systems (Consideration while planning and dependency on natural resources)**	**Access to Life, work and Play**	**Micro-Climate (working on the principle of Ecosystem Services)**	**Embeddedness and Integration (Thriving community living and building resilience within communities)**	**Advocacy (Strategies to govern collective growth)**	**Opportunities for inclusion w.r.t site potential**	
Weightages and Points Allocation	**3**	**5**	**5**	**5**	**5**	**2**	**25**
Neighbourhood	**1**	**3**	**1**	**2**	**1**	**0**	**8**
Remarks	No vegetation cover or soft scape area on site. Accelerating the effect of urban heat island effect	No dedicated play area planned for children. No recreational space planned for people of all ages. Walking distance to schools, balwadi, grocery shopping etc. within the cluster. Outdoor recreational activities are non accessible owing to gated communities. Strong cultural and economic barrier within the other neighbourhoods	Owing to Lack of sunlight the women were unable to dry their periodic cycle clothes. Mahila Milan started making sanitary pads and women genital infections reduced drastically. Medical expense are higher than average middle class medical expenditure per month	Requires more cohesive living between individual building. Lack of awareness observed during site study	Women from 3 buildings have managed to clean the in-between court area by conducting society meeting. Limited access to Fire Engine. Water tanks have animals dead in them and of poor construction quality	The site has high potential in terms of resources. Inadequate planning have overlooked the possibilities and overlooked opportunities on site	
Stakeholders	**Planning (Policy Makers)**		**Building Bye-Laws**		**Social and Institutional Level (Idea of Collective Life)**	**Performance Rating**	**Total Score**
Parameters	**Access to Affordable housing**	**Safety and security of inhabitants**	**Access to clean air and water. Health and Well-being**		**Civic engagement and social involvement**	**Efficacy (Measuring level of comfort and self sustenance)**	
Weightages and Points Allocation	**5**	**5**	**5**		**5**	**5**	**25**
Housing	**1**	**2**	**3**		**0**	**0**	**6**
Remarks	Housing units are provided free of cost by the government under rehabilitation scheme. Each housing unit is of same size and same layout	Well connected Neighbourhood, enhancing public transport. Bus service works from 4.00am to 2.00am. Proximity to eastern Express highway. Inside cluster access during emergency situation is limited	Deonar dumping ground has saturated its capacity way long ago. It is city's waste dumping area. Ground water is contaminated. Water tanks are badly maintained	SPARC (NGO) initiated Mahila Milan (Women saving fund scheme) governed by women, workshops on health awareness. Initiated clinic facilities for heavily subsidised medical treatment	SPARC facilitates organizing festivals (Muslim dominated community) and gatherings	Housing units are exponentially below liveable state. No access to daylight and cross ventilation	
Livability Score							**14**

Source: Author

The matrix helps to position the housing typology on the livability indicator where the scheme is tested at two levels first being the neighborhood and the second is the housing unit itself (Physical condition). The attributes attached to assess livability are derived from global idea of livability, however the definitions are slightly altered to accommodate the goals of SDG's for lower income housing typologies. Weighted average of each marker is necessary as one cannot apply the rules used for MIG and HIG in the Indian context directly; the trade-offs being are way beyond comparision. Wellness/Well-being and Efficacy are weighted higher as Well-being is directly impacted by the physical living condition; directly proportional to their health and efficacy talks about the access of each basic necessary attributes to achieve a holistic livability score. The matrix also has an initial column tiltled stakeholders under which each attribute and parameter is categorized to understand the actors involved under each category and the kind of change needed to convert these exclusive lower income communities into inclusive communities. It marks the trade off and linkages to map the shortcomings of these multistory tenement housing and reduction in mitigation capacity due to negligible consideration to environmental conditions. Secondly, it shows increased adaptive capacities of residents to extreme conditions. The governmental bodies need to address the situation differently and understand the need to test their house typologies provided in the name of 'free' or 'subsidized' housing to allow people to flourish in livable conditions and also address the issue of 'density' simultaneously.

4.3 Site and Services Scheme, Sector 05, 30 Sqm Cluster (Type III) Charkop

Overview of the Project

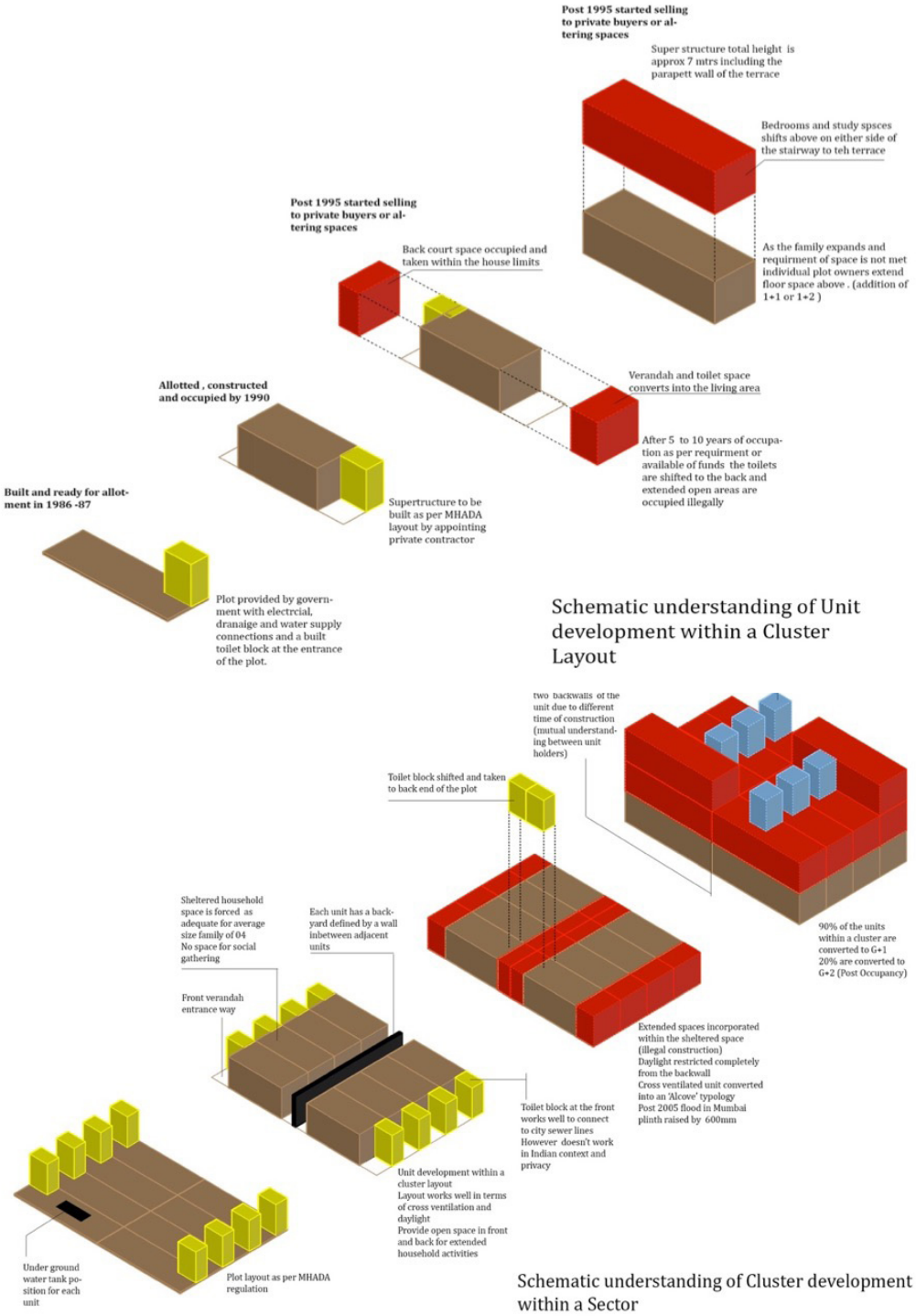
The Charkop Site and Services scheme (SAS) was build under Bombay Urban development Project (BUDP) with a vision to reduce the housing shortage in Mumbai Metropolitan Region (MMR) for Economically Weaker Section (EWS) and Lower Income Group (LIG). The project was funded by world bank and approved in the year 1984. Located on the fringes of the city, suburban extent the land was reclaimed and made available for world bank project. The plots were allotted under Mhada lottery system; where the winner is allotted a plot equipped with electrical line, drainage and water supply pipeline. A built toilet block, called the 'Utility wall' was provided with every plot. The government facilitates the winner to avail a bank loan through Maharashtra Co operative bank for the tenure of 10 years to construct the super structure on site. Each plot varies from 30 Sqmts to 100 Sqmts. The allotment is done as per the income group. Bungalow plots of 100 Sqmts for Higher Income Group (HIG) were also incorporated in the master plan. The entire scheme is divided into 09 sectors with 12m wide arterial roads and 6m wide sub lanes. Each sector consists of 64 societies and each society have 35 to 48 houses in each cluster. The co-operatives are made by the members of each cluster. Necessary income proof has to be submitted to Mhada to avail the lottery system. The plotting and provision of utility wall were completed by 1986 and people started construction of the cluster 259, Sector 5 in 1990. The layout of the house was provided by MHADA, however the process of construction was by appointing private contractor and execute as per individual's capacity and requirement. Over a period of 5 years people started re-selling the houses, altering the layout by incorporating the back yard and front verandah within the main house. Extension of floors above ground are also observed on site. Currently in 2017, all the housing is altered and people have converted ground floor structure to one or two floor units. The construction quality is moderate. Every household unit is internally finished with vitrified tiles and 3m high dado wall.

During 2005 Mumbai floods the area closure to the creek faced lesser damage compared to interior sectors which were adjoining the nallah across the R/S Ward. Post flood the storm water drains were widened and the plinth height has subsequently increased by 1.5 ft. Each household has an approximately 800 to 1000 litres capacity underground tank to meet the water requirements. The unit has direct municipal water connection and receives water every day between 11.30pm – 1.30pm. Each household pumps water using motor to PVC overhead tank at the terrace level. The underground tank is cleaned thrice in a year. The housing units pay approximately 2.25 Rs to 7.25 Rs per 100 litre of water depending upon the year of construction and sector number. Each cluster had a common garbage bin provided by the Municipality; however, owing to rat infestation the cluster stopped the practice, every morning the garbage is individually handed over to the municipal cart between 8.00am to 10.00am. Each housing society collectively pays property tax, water bills and outdoor cluster lighting bills. Each cluster has 'D' type housing which measures 40Sqmtrs. The maintenance for 30 Sqmtrs is 400Rs while for 40 Sqmtrs is 600Rs. Each cluster is planned along a courtyard space or common community space. Some clusters have 2 such spaces. A school till grade 10th and municipal clinic facility is located in each sector as per planned by MHADA housing authority. The courtyard space is tiled and maintained by each cluster and is used as play area by kids and community space for women. Each clusters had reservation plots for people from backward classes to promote equality and cohesive living between people of different backgrounds and religions. However, the area is predominantly Marathi origin and 90% of the inhabitants are from service class. Being closed to the creek the area faced severe mosquito infestation which has drastically reduced over the period of 5 years. Some housing units are converted in G+1 for commercial practices especially the ones facing the internal streets. In 1990 the land and construction cost of the ground structure came approximately to 45,000 Rs. Currently the house price has escalated anywhere between 50 to 65 Lakhs depending upon the location within the cluster and built-up area. The owner has to acquire MHADA NOC (no objection certificate) before selling out the flat to other individuals. There is no provision of 2 wheeler parking per household in each cluster. Four wheelers are parked along the roadside outside each cluster. The area is well connected by BEST bus services till 2am in the morning and privately run auto rickshaws. Both Borivali and Kandivali railway station are approximately 20 mins (travel time) away by Bus. The area is well secured and threats of robbery have declined over the last few years.

Diagramatic evolution of Site and Services Scheme Sector 05, Charkop

Figure 23

Unit and cluster development post allotment by state under site and services schemes



Source: Author

30 Sqm Cluster Map (Type III) and Layout Designs provided by MHADA for Site and Services Scheme Sector 05, Charkop

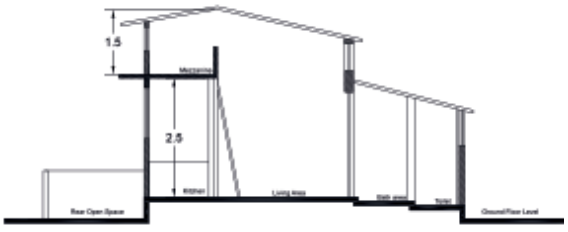
Existing unit drawings provided by MHADA to owners for construction purpose:

Figure 24

Housing unit Layout

Figure 25

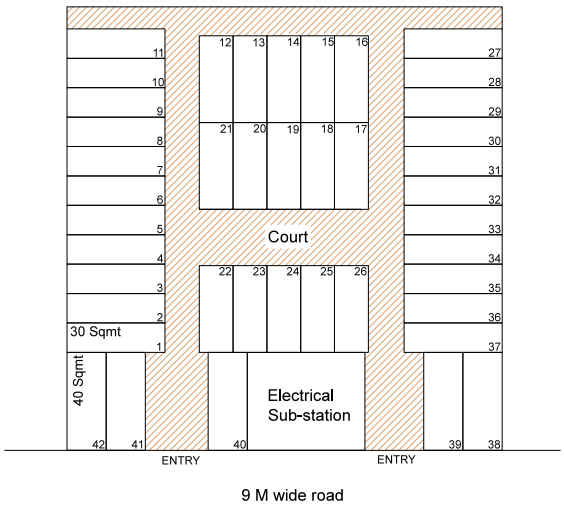
Cross-Section of the housing unit



Source: Author

Figure 26

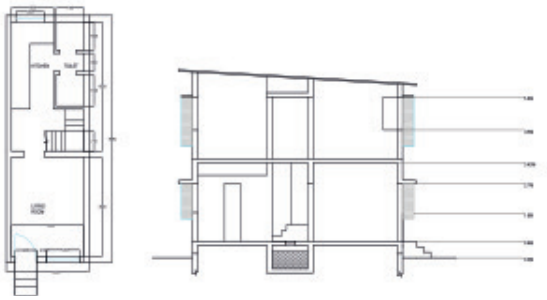
Individual Cluster Layout



Altered end unit drawing post possession:

Figure 27

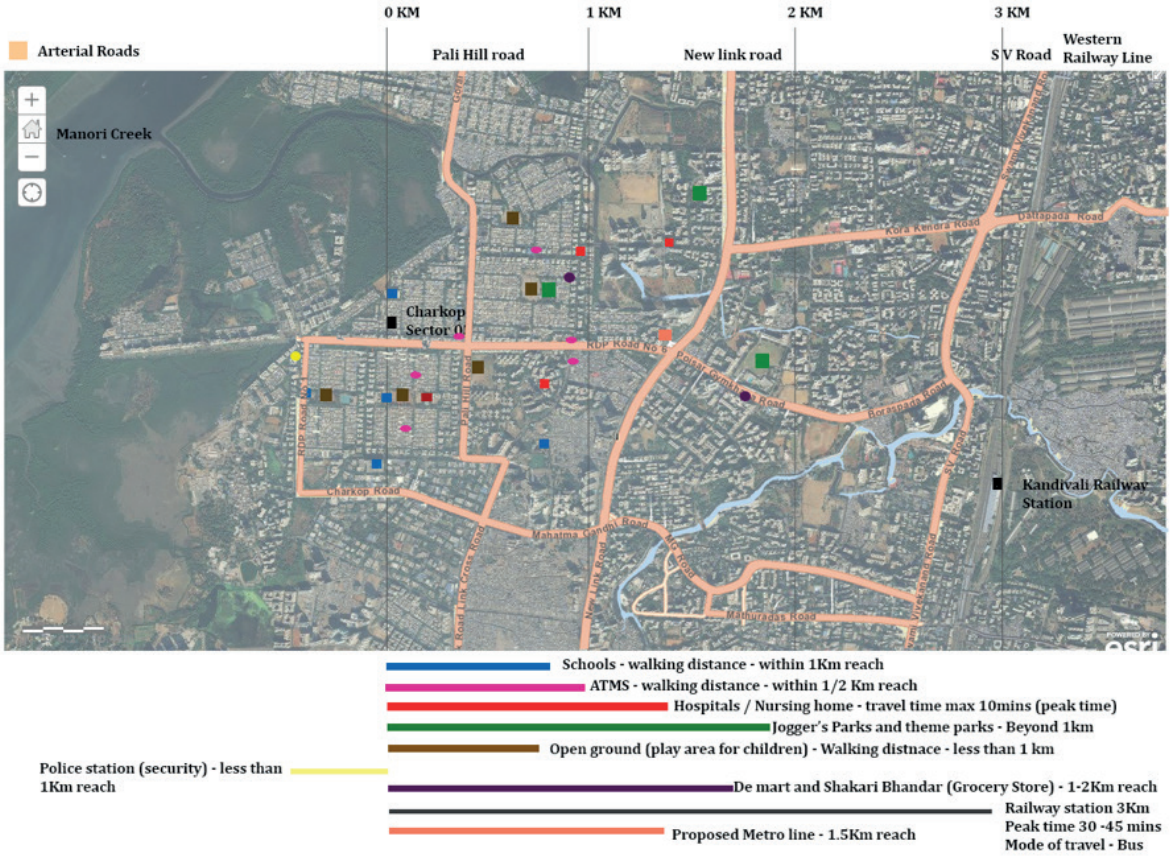
Showing the altered G+1 corner unit. In comparison with the drawings given by MHADA authority, its been noticed that in the process of incorporating more land to suit the space requirement of a family the occupants unknowingly compromise the enviornmnetal performance of the unit by blocking daylight and ventilation.



Mapping Neighbouhood Liveability for Scheme Sector 05 (SAS), Charkop

Figure 28

Showing regional connectivity to various livability parameter and distance to travle from site



Observation and Projections:

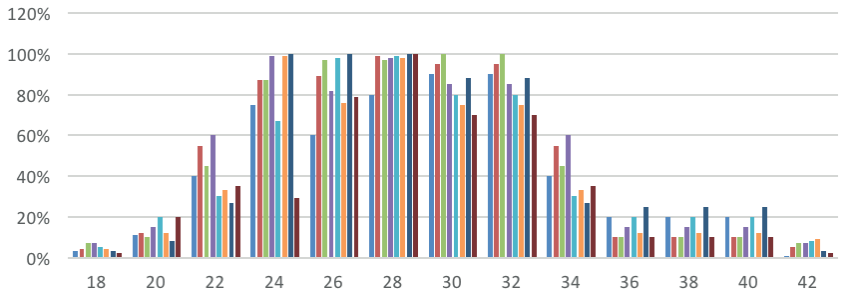
The SAS housing is very well connected and offers a choice to the dweller of varied size plots. The collective living objective enables to create a livable mix used neighborhood by providing all the day to day amenities within 1 Km reach. Inspite of being on the fringes of the city SAS is very well connected to the various parts of the city. Municipal health care, education facility and dedicated recreational spaces are integral to the planning of the SAS scheme. This ensures community well-being and growth. SAS assumes people to build 3 storey high to achieve the density over the period of 20 years. However whether the process is legitimate is still questionable. The cost incurred for distribution of infrastructure per unit is quiet high. The construction activity is totally unsupervised and resulting into compromised structures and safety within these dwellings. Recent development in charkop SAS schemes are all high-rise buildings, might be a response to heavy need of housing within the city.

Source: Author

Tracing adaptable comfortable temperatures within community of cluster 05 type 111 of Sector 05, Charkop developed under site and services scheme

Figure 29

Mean Indoor Temperature in Degree Celcius (NBC 2005 - 24°C to 30°C), showing the adaptive comfort model for site and Services Scheme, Cluster 05.



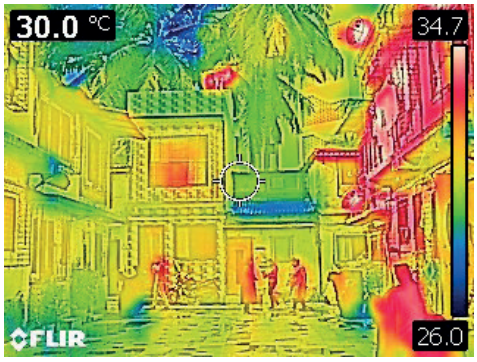
The comfort temperatures for inhabitants of cluster 05 ranges from 24°C to 32°C which is 2°C more than the comfort levels stated by NBC 2005. The survey points out about one of the adaptive measures considered by the inhabitants is by mitigating clo value. Moreover, the presence of water tank below the ground level help in mainataing cooler indoor emperatures. Majority of the tenements have air conditioner or air cooler installed to meet the comfort conditions indoor especially during during peak summertime.

Thermal behaviour of existing fabric

Cluster 05: Site and Services Scheme: Charkop; Dated: 17th August, 2017 (Intermediate wet spells)

Figure 30 & 31

Internal courts are devoid of plantation and are completely hard paved. Early morning; the ambient temperature of the court is 30°C when the outdoor temperatures are 25.9°C. A difference of approximately 4°C is observed adding to the overall Urban Heat Island effect of the place.

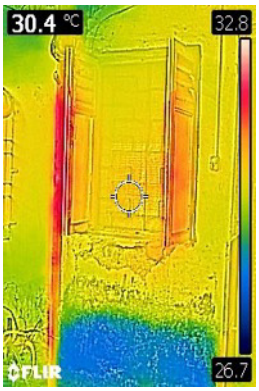


Source: Author

Figure 32, 33, 34 & 35

The cluster consists of different roofing systems and mode of adaptive strategies to combat the weathering conditions. The above figure depicts the thermal behavioural change in materials and its impact on indoor environments. The plastic sheet helps in keeping the water away however results in overheating of rooms below. Moreover the plastic sheet continues to cover the structure throughout the year resulting in high indoor temperatures in peak summer season.

The vertical images depict the thermal behavior of external wall of Bella Aunty's house. The house is retained in its original form the way it was constructed in 1985. The thermal image clearly shows the dampness on the wall (Blue colour Patch) and moss formation. The internal humidity levels are around 90%. The occupants are suffering from respiratory illness and are on constant medication. The house is also closed most of the daytime hours to ensure privacy and security, limiting the daylight penetration and ventilation.



Source: Author

Mapping Thermal Comfort within the housing units at selected locations in 30 Sqm Cluster (Type III) at Sector 05, Charkop:

Figure 36

Temperature recordings of housing units monitored.

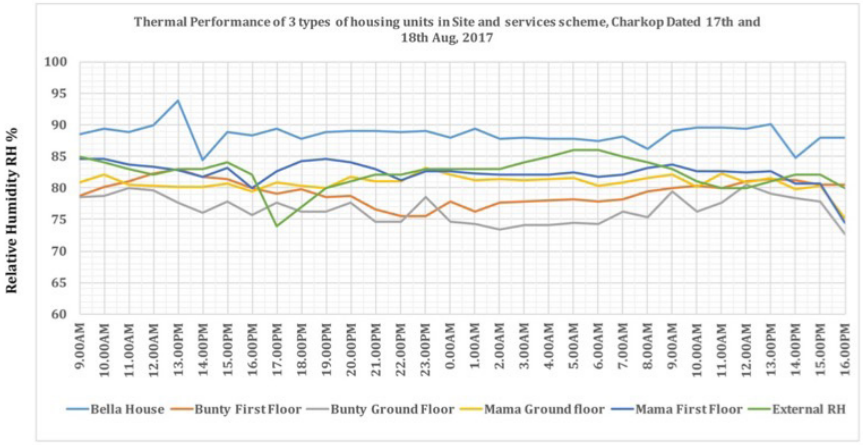
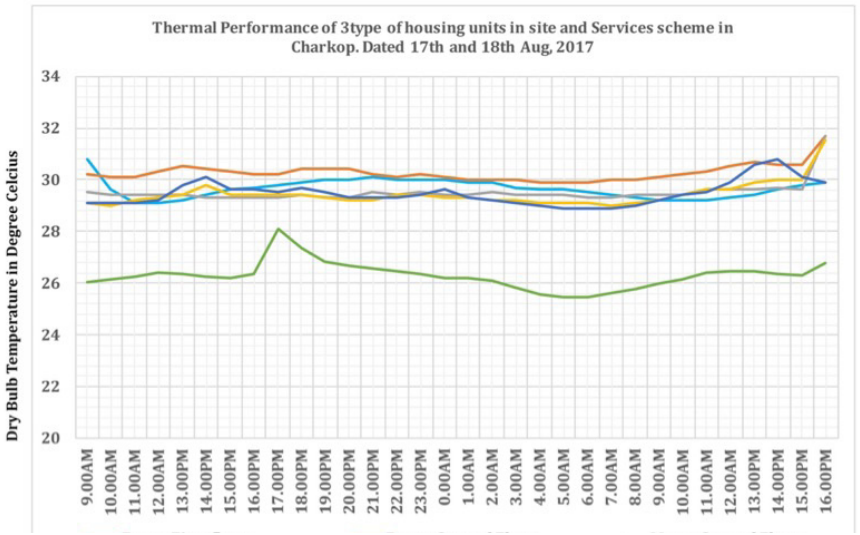


Figure 37

Humididty Recordings of housing units monitored.



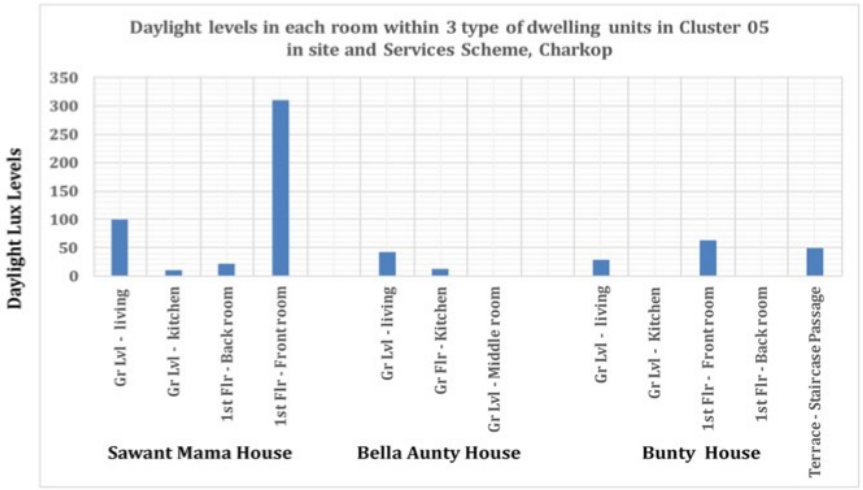
Above figures clearly demonstrate higher indoor temperatures by approximately 4°C maintained throughout the day in various locations. The heat within the indoor environments is not able to radiate out to reduce indoor temperature. The RH is high for more than 90% of the day exposing the occupants to uncomfortable indoors (feeling suffocating and sticky); direct impact on their health. Negligible levels of ventilation and air change rate results in mould generation because of continuous dampness within the walls of the houses. The tiling resolves the problem visually but does not stop the dampness in spreading. Condenstaion on dado tiles is observed during monsoon. Resulting into 24 hours of operating the mechanical equipment to attain comfort indoor conditions, more than 80% of households depends on artificial lighting and fan.

Source: Author

Mapping Visual Comfort in common areas and selected housholds within 30 Sqm Cluster (Type III) at Sector 05, Charkop:

Figure 38

Daylight recordings within housing units monitored for environmental condition.



Daylight performance is very poor in all households except first floor rooms which have larger window openings. The deep narrow plan restricts the daylight to enter after a certain distance. Only the peripheral houses in each cluster has a liberty to place a functional window on the other side to practice cross ventilation.

Daylight Analysis using Emperical data recorded at site:

Table 4

Blue blocks shows compliance with standards and red blockshows non – compliance with standards.

Tenant Name	Typology	House position within a cluster	House No	Lux reading	Daylight Factor (DF) Living room	Lux Reading	Daylight Factor (DF) Kitchen	Lux Reading	Daylight Factor (DF) Bedroom
DF as per standards					0.625 - 1.9		2.5		0.625 - 1.9
Bella Stephan	G	Peripheral	28	68	0.76	18	0.20	75	0.83
Ganesh Pawar	G+1	Inbetween Alcove	26	100	1.11	35	0.39	89	0.99
Swati Chavan	G+1	Inbetween Alcove	C2	110	1.22	42	0.47	99	1.10
Krishnadan Mahakar	G+1	Inbetween Alcove	C8	85	0.94	50	0.56	32	0.36
Sudandha Gadkar	G+1	Inbetween Alcove	10	78	0.87	28	0.31	44	0.49
Sayali Kamble	G+1	Inbetween Alcove	19	90	1.00	32	0.36	65	0.72
Maruti Mahadev	G+1	Inbetween Alcove	32	89	0.99	65	0.72	76	0.84
Prabhakar Sonu	G+1	Inbetween Alcove	37	113	1.26	60	0.67	80	0.89
Krishnakutti	G	Inbetween Alcove	C9	123	1.37	31	0.34	55	0.61
Kantila	G+1	Inbetween Alcove	C3	108	1.20	45	0.50	59	0.66
Mr Sawant	G+1	Peripheral	36	132	1.47	70	0.78	60	0.67
					Living room acts as Study area too				Bedroom act as Study area too

The design of the housing units recommended by Mhada clearly shows the daylight and ventilation strategy incorporated to achieve good enviornmnetal conditions indoor. However there is no advocacy or governance model practised during the time of plot allotment and house execution, to ensure unobstructed thermal and visual performance of the units . The deep liners plan restricts the daylight ingress and is bale to lit some portion of the living area only. Housing spaces are often used for multiple functions like studying, reading, cooking etc. Hence the daylight factor for living and bedroom is considered from a scale of 0.625 to 1.9 to achieve weighted result.

Source: Author

Livability Matrix for Sector 05 (SAS), Charkop

Table 5

Livability index for Cluster 05 in site and services Scheme in Charkop

Cluster 05 - Site and Services Scheme, Charkop							
Stakeholders	**Planning (Policy Makers)**		**Building Bye-Laws**	**Social and Instituitional Level (Idea of Collective Life)**		**Performance Rating**	**Total Score**
Parameters	**Environmental Systems (Consideration while planning and dependency on natural resources)**	**Access to Life, work and Play**	**Micro-Climate (working on the principle of Ecosystem Services)**	**Embeddedness and Integration (Thriving community living and building resillience within communities)**	**Advocacy (Strategies to govern collective growth)**	**Opportunities for inclusion w.r.t site potential**	
Weightages and Points Allocation	**3**	**5**	**5**	**5**	**5**	**2**	**25**
Neighbourhood	**1**	**5**	**2**	**2**	**2**	**2**	**14**
Remarks	Project is constructed on reclaimed land. Green field project	Each cluster has an open ground, school building and housing unit is interspaced with commercial units on site. Internal courts within clusters and playground allocation within sector are provided and planned. Well connected Neighbourhood, enhancing public transport. Bus service works from 4.00am to 2.00am. Railway station communicating distance is less than 2 Kms	Tree plantation is not integral to planning process	Each cluster works within their silos. Social integration is missing in-between clusters	Monitoring needed especially in initial phase and for future alterations at unit level. Awareness and advisory committee will help to avoid adverse effects of non informed actions taken	Considerations were made while planning procedure however owing to inadequate monitoring policies and ownership fails to convert and sustain the opportunities	
Stakeholders	**Planning (Policy Makers)**		**Building Bye-Laws**		**Social and Institutional Level (Idea of Collective Life)**	**Performance Rating**	**Total Score**
Parameters	**Access to Affordable housing**	**Safety and Security of Inhabitants**	**Access to clean air and water. Health and Well-being**		**Civic engagement and social involvement**	**Efficacy (Measuring level of comfort and self sustenance)**	
Weightages and Points Allocation	**5**	**5**	**5**		**5**	**5**	**25**
Housing	**5**	**5**	**5**		**3**	**3**	**21**
Remarks	Plots are allocated on the basis of lottery system and fund for construction is provided through bank loan. The plot size varies from 30Sqmts to 100 Sqmts. The cluster is combination of different kinds of units. work/stay typology. Cluster has balwadi, health clinics grocery stores, ATMs etc. located within walking distance from housing units	Structures are ground +1 . Clusters have adequate exits and common open space during disaster situation. Individual houses to be fire compliant	Municipal water supply, Electricity connection is provided to individual plots. Water tanks are located within plinth of each housing unit. Mosquito infestation owing to proximity to the creek. Clusters are well maintained and internal courts are clean		Cluster management is carried out within each cluster creating gated communities. In-between cluster development is not explored. Conducts GBM for betterment of cluster. Participatory workshops are limited to the cluster. Ganapati, Gokulashtami, Navratri celebrated (Hindu dominated community)	Housing units are altered over the period of time without any kind of monitoring or guidance, which unknowingly hampers the functional value of the unit w.r.t daylight and ventilation.	
Livability Score							**35**

Source: Author

The livability index for SAS is relatively higher than the other case studies undertaken. The neighbourhood is planned well with all the necessary infrastructure and amenities located within walking distance from the user. The clusters are well planned with open courtyard space within to encourage social networking and community gatherings. Access to clean water and sanitation is made available with storm water drainage plan for common spaces. The scheme fails in acquiring good construction quality and advocacy model for future alterations in designs. Through qualitative surveys conducted on site, community participation and networking with adjoining clusters is completely missing. Good governance consultation can be initiated to uplift the idea of collective living and its benefits in building resilient communities.

4.4 Sainath Nagar Informal Settlements, Dahisar West

Overview of the Project:

The Sainath nagar slum was established in 1992 on the banks of Dahisar River and has grown to accommodate more than 150 households till date. The settlement developed along the river edge and is linear in form with household units banked on each side of the internal aisle, multiplied in 2 numbers of rows. The sanitation facility connected to the Municipal drain was built in 1997; till then the slum dwellers practiced open defecation to meet their daily requirements. Historically, the Dahisar gaothan (village) is located on the river edge and has series of wells along the community edge to meet the fresh water requirement. Sainath Nagar community too relied on well water for their potable needs however over time the well water got contaminated and hence people stopped using the water for drinking purposes. The well water is now being used for women and children. A bridge built to get across the river is being used as a social space by the community during evening and night time. During summer conditions the bridge is the only alternative during night to beat the heat before sleeping. Municipal water supply connect was provided in 1995. The municipal water comes during night for around 1 hour. The water bill is shared between 10 families and they have a common tap provided along the passageway between the units. 98% of the population is Hindu in origin. 50% of the livelihood is earned by self-employment running auto rickshaws and the rest 50% do jobs and travel daily from anywhere between Churchgate to Virar for their workplace. Each household invest approx. 60 to 70 Rs into welfare fund, this fund is used to maintain common lights and sanitation facility within the community. The electricity bill of each household sums up to approx. 600rs. Health issues have reduced drastically over a period; however during monsoon community does face illness like malaria, typhoid etc. A dhobi ghat is also located at the banks which provide service to Bhagwati Civic Hospital located adjoining the settlements. Garbage collecting van comes every day at around 9.30am to 10.00am in the morning. The community children go to near by Municipal as well as private schools to attain education. The settlements is exposed to high vulnerable risk and has suffered a setback during 2006 and 2016 floods, houses within the river bed got washed away.

The units are of three different modules 16’ x 12’, 12’ x 12’ and 15’ x 12’ approximately. To meet the family requirement units are further divided into 8’ x 12’. The load bearing structure is made of brick walls. With I sections to support the first floor; built in later years using ladi coba ladi. The outer brick surface is exposed and not plastered. Most of the houses are ground structure with asbestos/ cement sheet roofing; currently covered with plastic to meet the; leakage problems during monsoon. Door and a small window adjoining the door is the only source of ventilation and daylight. Kitchens are located right at the entrance on ground floor.

Summertime overheating of ground structure occurs owing to heat getting trapped during the day-time as there is no trace of ventilation to reduce the indoor temperatures. Another hindrance is stacked up furniture which acts as thermal mass and stores heat adding up to indoor temperatures. Thermal mass strategy fails in hot and humid climate where natural ventilation is the best passive technique to beat high temperatures and high humidity levels in air. Upper storey structure is relatively comfortable as it allows cross ventilation across the unit. Woman amongst the community suffer summertime over-heating ; they prefer cooking meals and doing other household chores early in the day to mitigate sum-mer temperatures. Women and children are more vulnerable to bad indoor conditions, relatively high amount of hour spend indoors.

Figures 39 & 40

Aerial view of Sainath Nagar Slums

Figure 41

Layout of the informal settlement

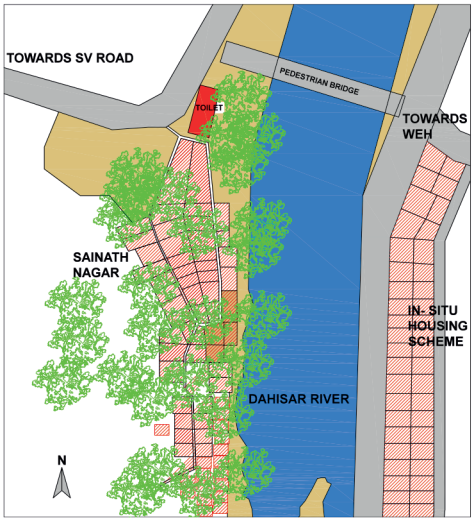
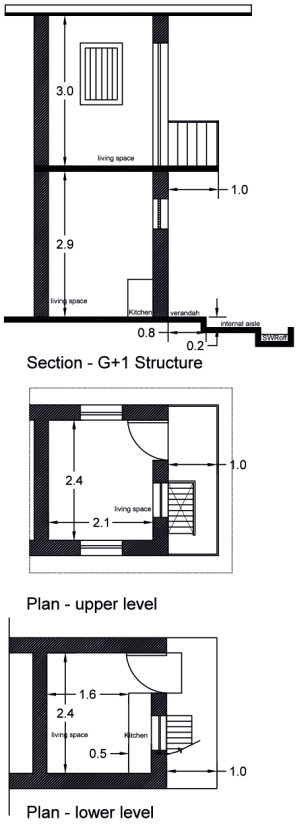


Figure 42

Typical layout of the unit built on site

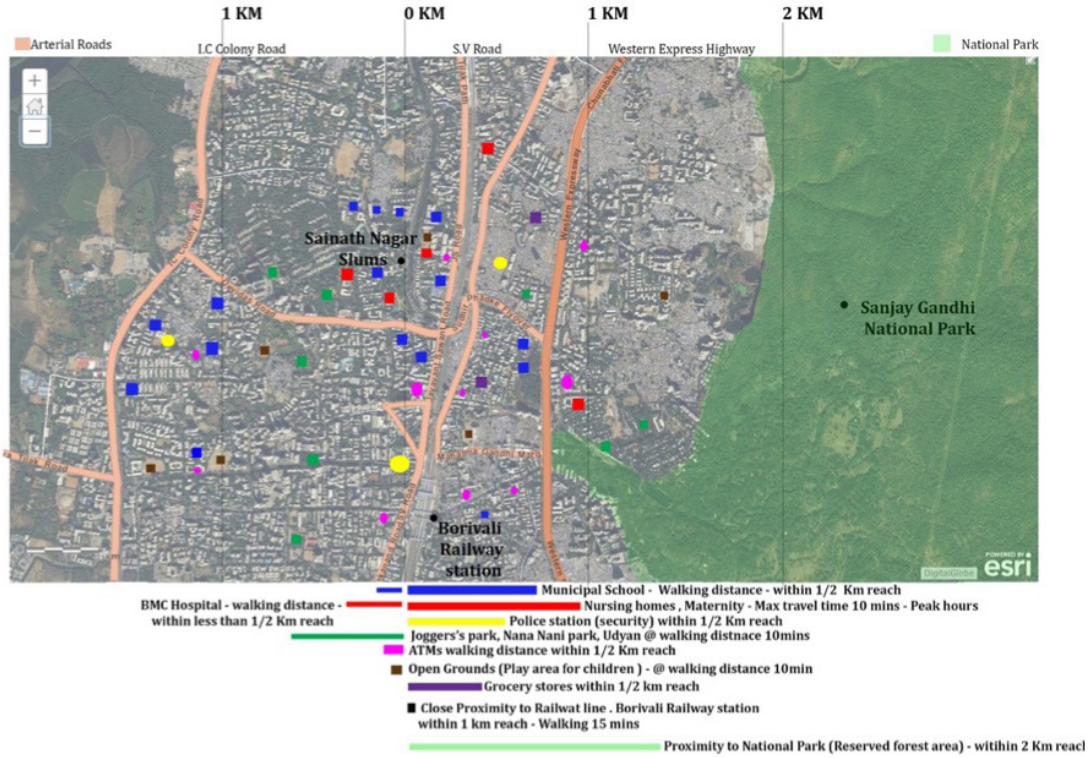


Source: Author

Mapping Neighbouhood Liveability for Sainath Nagar, Dahisar West

Figure 43

Showing regional connectivity to various livability parameter and distance of travel from site.



Neighbourhood Mapping for Sainath Nagar Informal settlements , Dahisar East - Measuring Liveability

Observation and projections

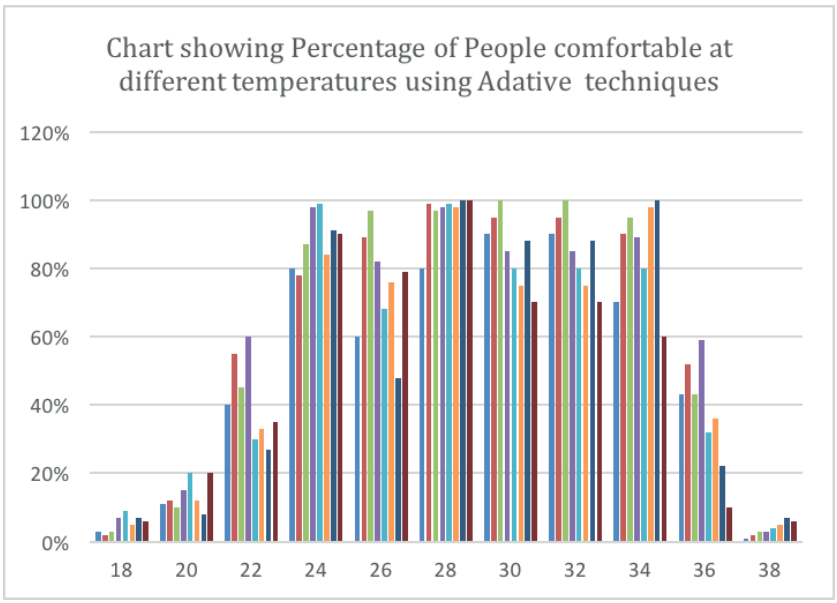
Sainath Nagar slums are located in a residential neighborhood of Dahisar West on the banks of Dahisar river. The river is not perineal and have shallow water levels throughout the year expect three months of monsoon. The settlement thrived on well water for its requirement which still exists in the neighborhood, however the well water has contaminated due to negligence. The place is well connected and accessible to full fill its day to day needs; however its close proximity to dahisar river makes it highly vulnerable to natural impacts like flooding in urban cities. These settlements shall soon face evictions if dahisar river restoration project initiates without considering the possibility of in-situ rehabilitation on site. The children and inhabitants do not have any dedicated recreational or community space. Most of them walk towards the pedestrian bridge across the river and use that as their community space. Lot of children play in the river bed. The saibaba temple at the onset of the settlement also acts as a community space. Municipal schools are available within walking distance and health facilities. The parks and grounds are gated. The children use the internal road which is desserted for activities like cricket.

Source: Author

Tracing comfortable temperatures for community using Adaptive techniques in Sainath Nagar, Dahisar West

Figure 44

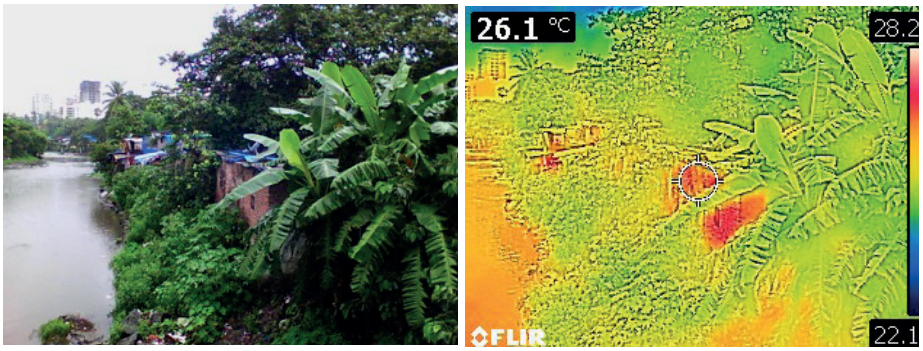
Mean Indoor Temperature in Degree Celcius (NBC 2005 - 24°C to 30°C). The adaptive measures allows the occupants to stretch their comfort levels to 36°C which is 6°C higher than the stated comfort levels. The clo value considered is 1 and metabolic rate is 1 as its sedentary position. With household work it can reduce by 2°C approximately. Woman in the house finish cooking early by 10.00am during summers to avoid excess heating post 12.00 till early evenings. From 70% to 100% people are satisfied with temperatures between 24°C to 34°C



Thermal behaviour of existing fabric and Impacts of climate risk owing to close proximity to the River Sainath Nagar Slums: On the banks of Dahisar River
Dated: 20th August, 2017 (Intermediate heavy wet spells)

Figure 45

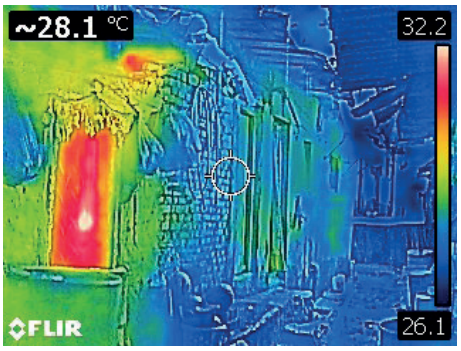
The settlement is built within the river bed. The thermal image clearly demonstrates the units radiating heat (blocks in red) within the dense vegetation.



Source: Author

Figures 46 & 47

Pictures depicting the internal aisles within the settlement. The doors are the only source of opening within the unit. Thus heat exchange takes place through doors which is clearly depicted in the thermal image above. The kitchen is located next to the door in 8ft x 12ft unit. The women within the community experiences stuffy indoor conditions with oppressively high humidity and temperature levels especially in summers.



Figures 48 & 49

Left showing the level of settlement with respect to the cross over bridge. Right: Level of water at 2.30pm on 29th august, 2017 deluge with respect to the cross over bridge. The concrete embankment is the result of Chitale Commission report presented after 26th July, 2005 deluge. The river bed was widened and embanked on both sides except the part where Sainath Nagar slums are located.

Figures 50 & 51

Close proximity to the river; the community is highly vulnerable to climate risks. The slum units situated on the edge of the river got washed away in 29th august, 2017 deluge. Most of the inner aisle units had water till 4ft height and have developed cracks within their structures. The floorings are uprooted and the settlement was without electricity for 48hrs. No access to sanitation facility for 24 hrs owing to water logging in the area.

Source: Author

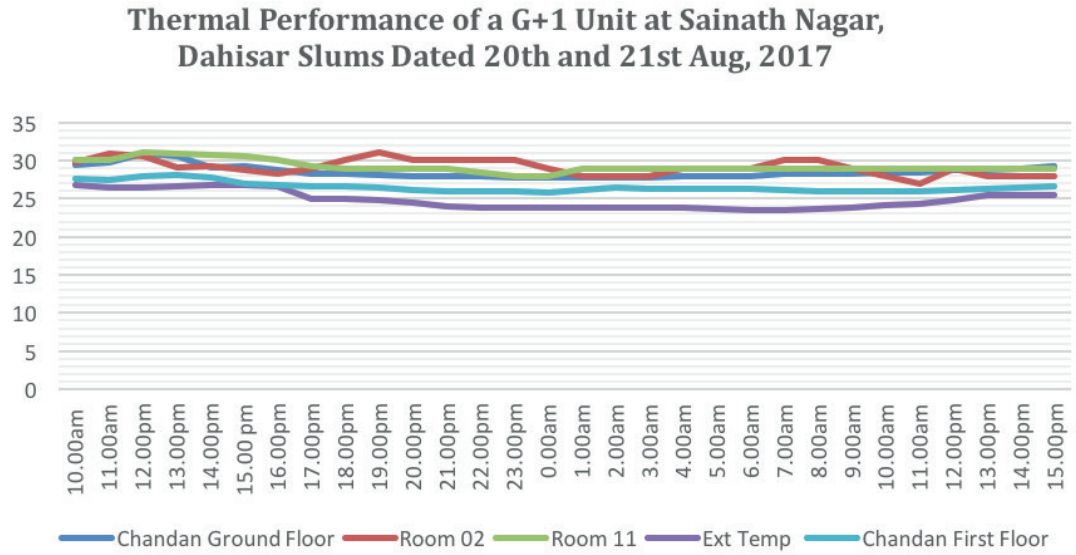
Figures 52 & 53

Structural cracks have developed within the structure post 29th August 2017 deluge. The entire floor plate has displaced and cracked. Fig 55 shows corner picture clearly demarcates the split flooring line owing to no foundation laid during construction. The underneath soil has eroded resulting into splitted floor plate.

Mapping Thermal Comfort within the housing units at selected locations in Sainath Nagar, Dahisar West

Figure 54

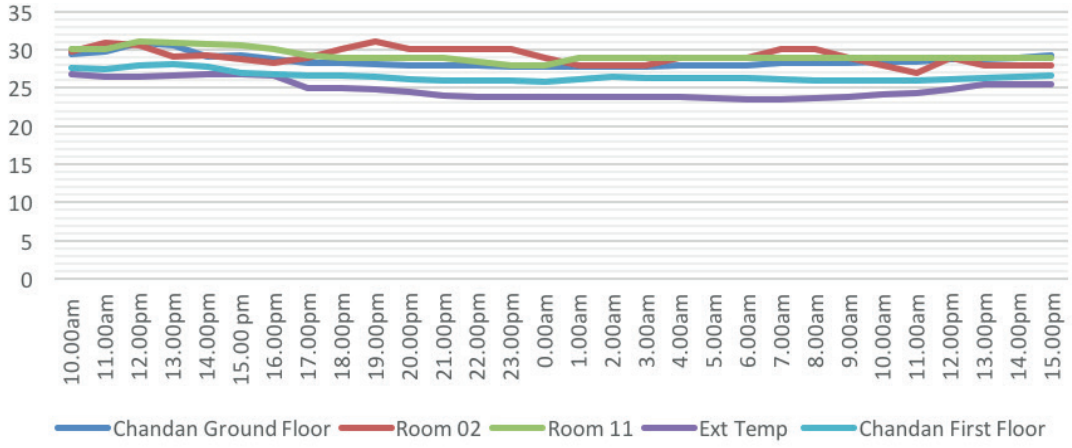
Temperature recording of the houses monitored on site for environmental condition.



Source: Author

Figure 55

Humididty recording in hosing unit monitored on site.
Thermal Performance of a G+1 Unit at Sainath Nagar, Dahishar Slums Dated 20th and 21st Aug, 2017

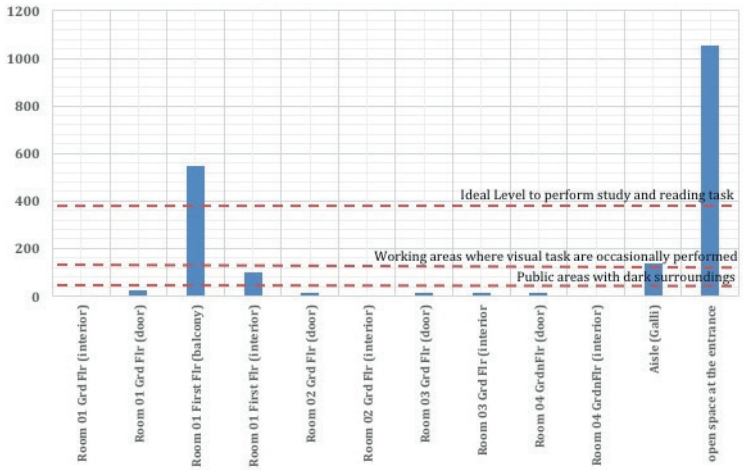


The houses are being made by the people itself using bricks and mortar. Amongst all outdoor surfaces expect the front façade, all are not plastered to withstand weathering conditions. The data shows the poor performance of the unit especially the ground floor compared to the first floor. Lack of ventilation prevents lowering of internal temperature and relative humidity. The internal temperatures are approximately 5°C higher than outdoor temperature. The RH is also high, making indoors suffocating and unbearable especially during afternoon time; hence the women in the house prefers to spend time outdoors performing household chores just outside their houses. All the houses have similar indoor conditions owing to the similar built forms and patterns of living.

Mapping Visual Comfort in common areas and selected housholds within Sainath Nagar, Dahisar West

Figure 56

Daylight levels within houses monitored on site for environmental condition.



The daylight levels are poor and thus children prefer verandahs and upper storey for studying purposes. The artificial light is constantly on during the entire day in the ground storey structure. The advantage in upper storey structure is the placement of window on two sides; facilitating cross ventilation and ample daylight ingress. However all houses are not G+1.

Source: Author

Livability Matrix for Sainath Nagar, Dahisar West

Table 6

Livability index for Sainath Nagar informal settlements

Sainath Nagar Informal Settlement on the edge of Dahisar river							
Stakeholders	**Planning (Policy Makers)**		**Building Bye-Laws**	**Social and Institutional Level (Idea of Collective Life)**		**Performance Rating**	**Total Score**
Parameters	**Environmental Systems (Consideration while planning and dependency on natural resources)**	**Access to Life, work and Play**	**Micro-Climate (working on the principle of Ecosystem Services)**	**Embeddedness and Integration (Thriving community living and building resilience within communities)**	**Advocacy (Strategies to govern collective growth)**	**Opportunities for inclusion w.r.t site potential**	
Weightages and Points Allocation	**3**	**5**	**5**	**5**	**5**	**2**	**25**
Neighbourhood	**0**	**4**	**3**	**5**	**0**	**2**	**14**
Remarks	Green Field Site. Dense vegetation and very close proximity to Dahisar River	No dedicated play area planned for children. No dedicated recreational space planned for people of all ages. Walking distance to schools, balwadi, grocery store. Neighbourhood well-connected by bus and rail station.	Thick vegetation and water body creates a micro climate however the vulnerable risk increases owing to the close proximity to river and un-informed construction of houses	Community group works on the welfare and administration of day to day maintenance of common areas. Regular cleaning of drains and spraying of pesticides	Lacks advocacy owing to its informal nature	Not applicable as the site is on high ecological sensitive land	
Stakeholders	**Planning (Policy Makers)**		**Building Bye-Laws**		**Social and Institutional Level (Idea of Collective Life)**	**Performance Rating**	**Total Score**
Parameters	**Access to Affordable housing**	**Safety and security of inhabitants**	**Access to clean air and water. Health and Well-being**		**Civic engagement and social involvement**	**Efficacy (Measuring level of comfort and self sustenance)**	
Weightages and Points Allocation	**5**	**5**	**5**		**5**	**5**	**25**
Housing	**0**	**0**	**4**		**0**	**1**	**5**
Remarks	Not applicable as housing units are build by the community itself and are ill-legal testaments on site owned by the state	No sense of security and safety regarding fire, security etc.	Municipal connection is provided. Air is polluted owing to contamination of river water. Wells along the river side are still useable for washing purposes. Public toilet was built in later years, earlier they were using open defecation system.		Lack of civic management and social involvement	Housing units are exponentially below liveable state. No access to daylight and cross ventilation	
Livability Score							**19**

The livability index is the second lowest amongst the case studies undertaken owing to high vulnerable index and lack of well- informed governance. The interesting part of the study is the constant reference between the qualitative survey and the quantitative survey. The inhabitants of Natvar Parekh compound in their qualitative survey repeatedly mention that their health conditions were much better and good when they were housed in informal settlements along the railway track than the PAP housing. The reason is the effortless constant interaction with the outdoor environments for maximum number of hours which declines to countable hours or minutes in Natvar Parekh Compound. The environmental standards of the house invariably rates secondary in informal settlement where sense of ownership is strong because of ones choice to live there and easy access to livelihood network.

Source: Author

4.5 Comparative Mapping of Adaptive Capacities within three Case studies undertaken

Indicators: Scheduling Activities and Clo Value

Table 7

Measures through which inhabitants build their adaptive capacities.

Mapping Adaptive Capacities within Lower Income Housing Units	Planning of Household Activities				Clo Value			
	Gender	Morning	Afternoon	Evening	Gender	Preffered Clothing	Summer	Winter/ Monsoon
Sainath Nagar Slums, Dahisar West	Female	Cooking is finished before 9.00am to avoid excess heat indoor	Daily chores in outdoor aisle area or Upper floor	Most of the time spent Indoors	Female	Saree or cotton Gown	0.7 - 0.9	0.9
	Male	Oudoor working hours		Upper floor or common aisle area	Male	Shorts and Jersy	0.17	0.17
	Infants / Children	School, colleges	Upper floor for study purposes owing to access to daylight	Upper floor for study purposes	Infants / Children	Boys prefer shirts and jersy. Girls prefer skirt blouse and dress	0.3 for boys 0.25 for girls	0.3 for boys 0.25 for girls
Impact on Housing unit performance with respect to Thermal and Visual Comfort		Activity chart to avoid excessive uncomfortable conditions indoor				One of the adaptive strategies to combat higher indoor temperatures		
	Gender	Morning	Afternoon	Evening	Gender	Preffered Clothing	Summer	Winter/ Monsoon
Site and Services Scheme, Charkop Sector 05	Female	Cooking finished by 10.00am	Spent indoors at ground level	Outdoor for an hour and then Indoors	Female	Saree or cotton Gown	0.7 - 0.9	0.9
	Male	Working hours		Ground and first floor	Male	Full pant and T-Shirt	0.3	0.3
	Infants / Children	School, colleges	Indoors	Upper floor for study purposes	Infants / Children	Boys prefer shirts and T-Shirt. Girls prefer dress	0.3 for boys 0.25 for girls	0.3 for boys 0.25 for girls
Impact on Housing unit performance with respect to Thermal and Visual Comfort		Kitchens have exhaust fan as one of the ways to replace hot air inside. Afternoon cooking is avoided across families. Women at home complained excessive heating of indoors and clautrophobic conditions during summer time				Inhabitants wear comfortable clothes to combat excess heat		
	Gender	Morning	Afternoon	Evening	Gender	Preffered Clothing	Summer	Winter/ Monsoon
PAP Project, Govandi	Female	Early morning cooking is done by 10.00am max	Maximum time spent outdoors in corridor space	Late evening post dinner time spent outdoors in	Female	Gowns and Dress	0.25 - 0.30	0.5
	Male	Working hours		Ground and first floor	Male	Full pant and T-Shirt	0.3	0.3
	Infants / Children	School, colleges	Indoors	Upper floor for study purposes	Infants / Children	Boys prefer Half pants and jersy. Girls prefer dress	0.3 for boys 0.25 for girls	0.3 for boys 0.25 for girls
Impact on Housing unit performance with respect to Thermal and Visual Comfort		Housing unit size is small compared to occupants and storage space hence the corridor space outside the house acts as an extended house space.				Comfortable clothes to combat excess heat		

Source: Author

Indicators: Building Elements – Design , Management and Operational Hours

Table 8

Showing performance of doors and windows w.r.t occupant behaviour and its impact on thermal and Visual comfort.

Mapping Adaptive Capacities within Lower Income Housing Units	Performance of Doors and Windows									
	Type of Floor	Window size	No of Windows	Type of Window	Type of Door	Type of ventilation within individual Unit	Operational Aperture Time Door		Operational Aperture Time Window	
							Summer time	Winter/ Momsoon time	Summer time	Winter/ Momsoon time
Sainath Nagar Slums, Dahisar West	Ground Level	350mm x350mm	1	Ventilator (concrete Jali)	Flush Plywood Door	Singleside ventilation	Daytime only	Few hours depending on the rain showers	Daytime hours only	24 hours
	First Level	600mm x 600mm	2	Casement	Plywood door with Grill door	cross-ventilation	24 hours	Few hours depending on the rain showers	24 hours	Few hours depending on rain showers
Impact on Housing unit performance with respect to Thermal and Visual Comfort		Not inadequate at ground level	Inadequate at ground level to induce pressure difference to create buyoncy effect within indoor space	Casement give optimum area in open position compared to sliding windows	No air exchange rate possible	single sided ventilation fails exponentially owing to incorrect opening size , position and room proportions	Grill door provides security and ventilation simultaneoulsy. However privacy is compromised. Some houses do have fabric curtain over the grill to seek privacy.	To avoid wet flooring by rain water the doors are shut for more that 70% of the time. Generates high moisture content within rooms resulting in dmapness and mould formation on skirting and walls.	Grill and Jali window provides security and ventilation simultaneoulsy. However privacy is compromised	To avoid wet flooring the doors are shut for more that 70% of the time. Generates high moisture content within rooms resulting in dampness and mould formation on skirting and walls.
	Type of Floor	Window size	No of Windows	Type of Window	Type of Door	Type of ventilation within individual Unit	Operational Aperture Time Door		Operational Aperture Time Window	
							Summer time	Winter/Momsoon time	Summer time	Winter/Momsoon time
Site and Services Scheme, Charkop Sector 05	Ground Level	1450mm x 1000mm	2	Sliding glass Shutters with one jali panel	Flush Plywood Door with safety grill Door	Cross ventilation	5 hours	5 hours	1/3rd window size	1/3rd window size
	First Level	2200mm x 1000mm	2	Sliding glass Shutters	Internal access to first floor	cross-ventilation	24 hours	24 hours	1/3rd window size	1/3rd window size with tarpolin sheet covering the window Grill to avoid rains
Impact on Housing unit performance with respect to Thermal and Visual Comfort		Adequate window sizes at both levels however the plan of the house is deep hence middle room is left dark and non ventilated	The deep plan creates stagnant air pocket in middle room owing to inadequate pressure difference to induce cross ventilation. Thus being windows on opposite walls does not allow cross ventilation. The scale and proportion of the room matters to induce good displacement cross ventilation to avoid stagnant zone within habitable spaces	Sliding windows given less optimum open area compared to casement windows. The air change rate gets affected	Safety grill door provides a sense of security and hence can be used as night time ventilation startegy in summers by keeping the grill door shut and flush door open. Privacy if been compromised.	Theorically Cross ventilation exist in rooms designed as placement of windows are on opposite walls however deep plan house creates stagnant air pockets in inbetween space and also pressure difference is not adequate to induce cross ventilation	Ground structure are stuffy and dark. First floor space is well ventilated in most of the cases	Ground floor is stuffy and dark all the time as the windows are shut with curtains due to privacy and security issues. First floor space is well ventilated and acts well as night-time ventilation strategy	Aperture opening is less thus, no optimum ventilation rate exists within structures. To attain privacy most of the time the curtains are pulled over window panels. The cross ventilation is not achieved to combat high temperature and relative humidity levels indoors. The occupants resort to Air conditioners for three months in summers	To avoid wet flooring the doors are shut for more that 70% of the time. Generates high moisture content within rooms resulting in dampness and mould formation on skirting and walls. The houses which are tiled from within do not have moulds expect ceiling surfaces.
	Type of Floor	Window size	No of Windows	Type of Window	Type of Door	Type of ventilation within individual Unit	Operational Aperture Time Door		Operational Aperture Time Window	
							Summer time	Winter/Momsoon time	Summer time	Winter/Momsoon time
PAP Project, Govandi	Ground Level	900mm x 1200mm	2	Sliding glass shutters	Flush door	Single sided ventilation due to alcove design type	Open during daytime and nightime	Nightime its shut and dyatime afternoon hours is shut	1/3rd window size	1/3rd window size
	First Level	NA	NA	NA	NA	NA	NA	NA	NA	NA
Impact on Housing unit performance with respect to Thermal and Visual Comfort		Adequate window sizes for the housing unit designed. However in composition with other building elements it fails terribly	The window opening size is inadequate owing to sliding window type. Position could have been addressed to achieve single side ventilation and daylight within units. Lack of ventilators and deep corridors lowers the night time ventilation strategy to acheive lower indoor internal temperatures	Sliding windows given less optimum open area compared to casement windows. The air change rate gets affected and gets worse with deep alligned corridor space.	The doors are kept open 24 hours in summers to mitigate excess heating conditions indoor	Theorically single side ventilation exists in rooms designed as placement of windows and sizes of windows are adequate. However the placement of deep corridor and space between buildings is inadequate to induce single sided ventilation system	Daylight is only achieved at 7th and 6th floor and reduced enormously as one decends down. Corridors and houses are dark all the time inspite of open windows. No provision of ventilators over doorways to facilitate night time ventilation within spaces.	Daylight is achieved at 7th and 6th floor and reduced enormously as one decends down. Corridors and houses are dark all the time inspite of open windows. No provision of ventilators over doorways to facilitate night time ventilation within spaces. Owing to poor ventilation system or running air drafts the relative humidity is high 24 hours making indoors uncomfortable.	Aperture opening is less so no optimum ventilation level within structures. The single sided ventilation is not achieved to combat high temperature and relative humidity levels indoors. The occupants resort to sleeping in corridors during summers	To avoid wet flooring the doors are shut for more that 70% of the time. Generates high moisture content within rooms resulting in dampness and mould formation on skirting and walls. The room smells of mould in monsoon resulting in poor indoor air quality

Source: Author

Indicators: Building Envelope and Mircro Climate

Table 9

Mapping impact of Building Envelope and Micro climate on adaptive capacities

Mapping Adaptive pacities within Lower ncome Housing Units	Performance of Doors and Windows														
	Type of Floor	Window size	No of Windows	Type of Window	Type of Door	Type of Ventilation within individual Unit	Operational Aperture Time Door						Operational Aperture Time Window		
							Summer time		Winter/ Monsoon time		Summer time		Winter/Monsoon time		
							Daytime only		Few hours depending on the rain showers		Daytime hours only		24 hours		
ainath Nagar Slums, Dahisar West	Ground Level	350mm x350mm	1	Ventilator (concrete jali)	Flush Plywood Door	Singleside ventilation	24 hours		Few hours depending on the rain showers		24 hours		Few hours depending on rain showers		
	First Level	600mm x 600mm	2	Casement	Plywood door with Grill door	cross-ventilation									
pact on Housing unit performance with spect to Thermal and Visual Comfort			Not inadequate at ground level	Inadequate at ground level to induce pressure difference to create buyoncy effect within indoor space	Casement give optimum area in open position compared to sliding windows	No air exchange rate possible	single sided ventilation fails exponentially owing to incorrect opening size , position and room proportions	Grill door provides security and ventilation simultaneously. However privacy is compromised. Some houses do have fabric curtain over the grill to seek privacy.	To avoid wet flooring by rain water the doors are shut for more that 70% of the time. Generates high moisture content within rooms resulting in dmapness and mould formation on skirting and walls.		Grill and Jali window provides security and ventilation simultaneously. However privacy is compromised		To avoid wet flooring the doors are shut for more that 70% of the time. Generates high moisture content within rooms resulting in dampness and mould formation on skirting and walls.		
	Type of Floor	Window size	No of Windows	Type of Window	Type of Door	Type of Ventilation within individual Unit	Operational Aperture Time Door				Operational Aperture Time Window				
							Summer time		Winter/Monsoon time		Summer time		Winter/Monsoon time		
Site and Services heme, Charkop Sector 05	Ground Level	1450mm x 1000mm	2	Sliding glass Shutters with one jali panel	Flush Plywood Door with safety grill Door	Cross ventilation	5 hours		5 hours		1/3rd window size		1/3rd window size		
	First Level	2200mm x 1000mm	2	Sliding glass Shutters	Internal access to first floor	cross-ventilation	24 hours		24 hours		1/3rd window size		1/3rd window size with tarpolin sheet covering the window Grill to avoid rains		
pact on Housing unit performance with spect to Thermal and Visual Comfort			Adequate window sizes at both levels however the plan of the house is deep hence middle room is left dark and non ventilated	The deep plan creates stagnant air pocket in middle room owing to inadequate pressure difference to induce cross ventilation. Thus being windows on opposite walls does not allow cross ventilation. The scale and proportion of the room matters to induce good displacement cross ventilation to avoid stagnant zone within habitable spaces	Sliding windows given less optimum open area compared to casement windows. The air change rate gets affected	Safety grill door provides a sense of security and hence can be used as night time ventilation startegy in summers by keeping the grill door shut and flush door open. Privacy if been compromised.	Theorically Cross ventilation exist in rooms designed as placement of windows are on opposite walls however deep plan house creates stagnant air pockets in inbetween space and also pressure difference is not adequate to induce cross ventilation	Ground structure are stuffy and dark. First floor space is well ventilated in most of the cases	Ground floor is stuffy and dark all the time as the windows are shut with curtains due to privacy and security issues. First floor space is well ventilated and acts well as night-time ventilation strategy		Aperture opening is less thus, no optimum ventilation rate exists within structures. To attain privacy most of the time the curtains are pulled over window panels. The cross ventilation is not achieved to combat high temperature and relative humidity levels indoors. The occupants resort to Air conditioners for three months in summers		To avoid wet flooring the doors are shut for more that 70% of the time. Generates high moisture content within rooms resulting in dampness and mould formation on skirting and walls. The houses which are tiled from within do not have moulds expect ceiling surfaces.		
	Type of Floor	Window size	No of Windows	Type of Window	Type of Door	Type of Ventilation within individual Unit	Operational Aperture Time Door				Operational Aperture Time Window				
							Summer time		Winter/Monsoon time		Summer time		Winter/Monsoon time		
AP Project, Govandi	Ground Level	900mm x 1200mm	2	Sliding glass shutters	Flush door	Single sided ventilation due to alcove design type	Open during daytime and nighttime		Nighttime its shut and dyatime afternoon hours is shut		1/3rd window size		1/3rd window size		
	First Level	NA	NA	NA	NA	NA	NA		NA		NA		NA		
pact on Housing unit performance with spect to Thermal and Visual Comfort			Adequate window sizes for the housing unit designed. However in composition with *other building* elements it fails terribly	The window opening size is inadequate owing to sliding window type. Position could have been addressed to achieve single side ventilation and daylight within units. Lack of ventilators and deep corridors lowers the night time ventilation strategy to achieve lower indoor internal temperatures	Sliding windows given less optimum open area compared to casement windows. The air change rate gets affected and gets worse with deep alligned corridor space.	The doors are kept open 24 hours in summers to mitigate excess heating conditions indoor	Theorically single side ventilation exists in rooms designed as placement of windows are adequate. However the placement of deep corridor and space between buildings is inadequate to induce single sided ventilation system	Daylight is only achieved at 7th and 6th floor and reduced enormously as one decends down. Corridors and houses are dark all the time inspite of open windows. No provision of ventilators over doorways to facilitate night time ventilation within spaces.		Daylight is achieved at 7th and 6th floor and reduced enormously as one decends down. Corridors and houses are dark all the time inspite of open windows. No provision of ventilators over doorways to facilitate night time ventilation within spaces. Owing to poor ventilation system or running air drafts the relative humidity is high 24 hours making indoors uncomfortable.		Aperture opening is less so no optimum ventilation level within structures. The single sided ventilation is not achieved to combat high temperature and relative humidity levels indoors. The occupants resort to skirting and walls. The room smells of mould in monsoon resulting in poor indoor air quality		To avoid wet flooring the doors are shut for more that 70% of the time. Generates high moisture content within rooms resulting in dampness and mould formation on skirting and walls. The room smells of mould in monsoon resulting in poor indoor air quality	

Source: Author

The comparative matrix clearly indicates that the buildings performance is not purely based on the design but it is also important to map how it is inhabited by occupants. The sense of privacy and security is always a prime concern within occupants. To achieve these the occupants action unknowingly impacts the environmental performance of the building. Lack of vigilance in construction process especially during future alterations and awareness further declines the buildings performance. The matrix clearly makes it evident that quality of life and environmental conditions within these built forms is overlooked by large. The study above offers a structural method of investigation and also demands a strong advocacy model to guide and explain the slum dwellers ways of living within a society in order to acheive a good livability within lower income housing. ◆

PART 5
CONCLUSION

5.1 Limitation and Way Forward

The study is based on the pilot readings, qualitative and quantitative measures conducted across a limited period. For clear and direct understanding on design parameters it is advisable to run a year long research to acquire correct sampling as per seasonal changes and its implications on design. The conducted study has clearly established the need to relook at strategic implementation planning on the basis of research findings to create resilient communities. It also clearly states that 'livability' within informal settlements should be defined differently than the HIG and MIG. The research work imparts a new methodology to access existing housing stock. Identify degrees of alterations for retrofitting and upgrading possibilities and inform newer policies, appointing guidance consultation cell and design regulations within the city of Mumbai. It is also necessary to change the way these rehabilitation schemes are envisaged within the city and address the environmental pressure it exerts on the city over the long period of time. Holistic and multi –level approach on social, economical and environmental front is required to build adaption and mitigation capacities within communities to combat climate change.

The paper displays a systematic technical method of study and derive livability using point based system. This could form a strong basis to further investigate the measured levels of mitigation using a combination of design strategies and operational efficiency. Corrected U values and iteration of simulations by monitoring the efficiency of each iteration would give diserable results in building performance. Advocacy in governance and measured design inputs shall collectively enhance livability within lower housing typologies.

5.2 Recommendations

Procurement of land for rehabilitation and re-settlement schemes

The current policy of land procurement is perpetuating slums and result in further decline of living and helath conditions of slum dwellers. Following 5 points need to be practised to ensure community well being and growth.

- The community should not be displaced beyond 5 Km from the present location to preserve the livelihood connects
- Cannot live at the greater density per hectare. Which means no of tenements per hectare needs to be re addressed
- Cannot allow any TDR or land trabsaction that does not meet teh above two criterias
- If displacement occurs then provision of child security, education and helath facility hsould be developed first. Seed money provision inetgral to the project to be incorporated for the same
- Social worker organisation should be enagaged in facilitating good communication and governance within communities

Building Bye-laws and Design imperatives

The monitoring data emphasises the need to achieve good indoor and outdoor environment for every inhabitants of buit-enviornment. The national building code of India states the building byelaws very carefully to achieve good indoor conditions. The relaxation of building bye laws to achieve density needs to be addressed.The study clearly explains the impact of relaxation on human beings and the living conditions it has created. Thus, the following design considerations should be practised for rehabilitation and affordable housing schemes across Mumbai.

- The distance maintained between buildings should ensure daylight penetration at the ground level. This means every alternate building in Natvar Parekh compound should be demolished to achieve daylight at ground level.
- Window and door designs needs consideration to facilitate night-time ventilations and single sided ventilation throughout the day and night
- The corridors should be exposed to maximum openings to allow wind and daylight penetration on all floors to all units along the corridor.
- Common passages and stairwell to be lit naturally for easy transition.
- Equation between length, height and width of streets needs to be carefully anaylsed to avoid urban street canyon
- Vegetation and micro climate should be considered in creating accessible usable open spaces within a housing scheme for healthy outdoor environment. This would encourage mental and physical wellbeing within communities of different origin.
- Building byelaws for future expansion and alterations to be stated meticulously to avoid poor construction and performance quality of passive techniques practiced during original construction.
- Guidelines on placement of water tank, future expansion posibility and considerations to avoid water contamination completely.
- The caping of tenements per hectare needs attention and revision to acheive above set goals.
- Window wall ratio, glazing type, preferred u values to acheive passive design techniques should be followed strictly by the developer and authority responsible for housing schemes in the city.
- The site planning exercise is crucial to demarcate various amenities on site, proximity to buildings, access for maintenance and usage and most importantly the surface run offs to avoid flooding or accumulation of water on site. The accumulated water thus becomes the breeding grounds for insects. All these schemes owing to high density requires phase wise planning and execution owing to the uncertanities involved in the process of execution. Possibilities of haphazard interventions should be completely ruled out. If they persists then response actions should be thought well in advance.

Building Master plan for proposed constructions and retrofitting of existing schemes:

Impact on Health and well-being

Various studies indicate five broad ways in which exposure to natural environment is beneficial for human health and well-being. Enhanced personal and social communication skills; increased physical, mental and spiritual health. The access to open space encourages an individually to practice exercise and eventually improving the liveability and quality of the existing neighbourhood area. Participation in outdoor recreational activities; build in confidence, self –esteem among people of all age groups, thus improving the quality of life Morris, (2003).

Landscape nurtures social cohesion which is essential part of informality which loses its connect when they are rehabilitated in different space, context and time. The pressure exerted on the individual capacities is immense in terms of its livelihoods, sustaining

poor indoor environments, escalated health issues, limited or no access to common spaces or outdoor environments. In such scenario young generation resort to illegal activities (e.g. Drugs and alcohol), old age group and women restrict themselves to poor indoor environments and the open ground space available is been occupied by garbage, flooding of excess waste water from storm water drain, sewer drain lines etc. On a longer term these malpractices exert pressure on natural systems; land natural water channels and ground water source. The above selected findings exhibit instance of impact on climate as well as individuals by effective planning and how a concept of ecosystem services could be evolved for the benefit of the informal sector of urban environments. Through these lens the land can be transformed as an infrastructure that retains water through rain water harvesting techniques, fulfil landscape and washing water requirements by installing waste water recycling unit. However along with these technological shifts one has to work on social behavioural change and awareness building to create building inclusive communities.

Necessity of Advocacy and Embeddedness

Occupant behaviour is crucial especially in affordable housing where the sense of security and access to basic water and sanitation facility often mistaken for the idea of comfort and quality of life. It is important to make them aware of the advantages of social cohesion and impact of simple actions on their well-being. For example keeping windows and door shut for more than 80% of the daily hours restricts the fresh air intake. Repetition of the action over long duration results in accumulation of pollutants within indoor environment impacting the inhabitants health. Daylight not only aids energy savings but it also has positive influence which improves the quality of life on human bodies. It reduces the impact of illness and results in speedy recovery (Irfan Ullah, 2014). Daylight research shows 15% of people suffer from eye strain and 78 million suffer from calcium deficiency due to insufficient vitamin D. Low levels of vitamin D increases the possibility of store and heart attacks by 60% (H.Bruan, 2008).

Counselling the inhabitants is important to control the adverse effects of occupant behaviour. Out of the case studies studied it is very evident that the people in informal settlements do have their own way of creating certain rules for community and health benefits. The sense of ownership is much stronger which declines as they get relocated in the rehabilitation housing colonies. Also there is a lot of reluctance to occupy these housing units. There is a need for strong administrative method to address the issue of displacement, maintenance and operation of these housing schemes. The occupants should be made aware of the benefits of collective living and social cohesion. A mechanism has to be established to monitor future alterations of built form to avoid performance failures. ◆

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