Toilet tragedy - Toilet treasury

On the design of sanitary amenities for the slums of Mumbai in India

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On the design of sanitary amenities for the slums of Mumbai in India

By Ruth Lanting

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Glossary

Community toilet block
Series of toilets combined in a single building that provides surrounding households with sanitation instead of having private toilets in the individual house. In the slums of Mumbai the community toilet blocks typically serve 400 to 1000 people.

Informal settlements
An area in which the general trend is the building of houses on land that has not been legally acquired by the owners of the properties[1].

MCGM
Municipal Corporation of Greater Mumbai.

NGO
Non-Governmental Organization.

Open defecation
The phenomenon of people defecating without a toilet facility, usually on open fields and junk spaces.

Piping
Water supply lines and sewerage.

Private toilet
Toilet inside or outside a house that is used by the members of the household only.

Sanitation
Any form of excreta and wastewater facility.

Secure tenure
Having property rights and therefore the insurance of permission to stay in a house of area.

Shared toilet
Toilet outside that is used by a couple of households, typically 4 to 5 in Mumbai.

Slum
An area with the following features:
- Lack of basic services;
- Sub-standard housing or illegal and inadequate building structures;
- Overcrowding and high density;
- Unhealthy living conditions and hazardous locations;
- Insecure tenure, irregular and informal settlements.[2]

SPARC India
Society for the Promotion of Area Resource Centers, NGO with sanitary department within Mumbai.

Squatter
A person that occupies a piece of land or a building without legal permission.

Sulabh International
Social services organization concentrated on sanitation with a department in Mumbai.

Urban poor
Residents of a city that life below the poverty line. For Indian standards the poverty line is set on US$10.44 per person per month[3].

Wasteland
Left over spaces that are not in use for a specific purpose. In Mumbai, these typically are lands near the sea, in the flood area of a river, around industrial buildings, around railway lines or around highways. The property can be both private and publicly owned.

1. UN-HABITAT, 2006, ch. 4.1.
2. Id.
3. Laquian, Tewari and Hanley, 2007, pp. 12.

1. Aerial view of Mumbai

Introduction

Standing in the door opening of the ladies wagon I'm staring outside. In the front trash and landfills pass by, which become a single grey mass by the speed of the train. Behind it are houses. Every house is different, I would see later on. But for now I can not see it. For now it seems an endless amount of grey as well, only alternated by the typical blue plastics used as cover in rainy season. Sometimes the sight is suddenly interrupted by a skyscraper. Or by a man defecating on the railway track.
Inside the noise is overwhelming. Women sitting on chairs bargain as lower class women pass by to sell hair pins and paper-clips. Loudly promoting their wares all the sounds merge with the rumbling of the train. The woman behind me points at the banana peel in my hand and orders me to throw it outside.

By the year of 2050, it is expected that one third of the world population will be squatter: 3.000.000.000 people[1]. A squatter is a person that occupies a piece of land or a building without legal permission. In the context of rapid urbanization the problems of squatters are increasingly difficult. More and more people come to (mega)cities for the hope of a job and a better life. Pressure on land becomes higher in the already dense cities and the newcomers can not be housed in the formal built environment. People therefore might build their own houses on marginal places like wastelands and landfills that then become slums.

As an architecture student, I did not understand how it could be that the built environment of a third of the future world population was not part of my education so far, whereas the needs are more urgent and usually more complex then any other assignment in the formal environment.
The specific location of Mumbai attracted my attention when I saw an aerial view of it, see figure 1. Although I had an idea of what a squatter area would look like, I did not expect it to be closely interwoven with the formal environment. I wondered what a place with such an aerial view would be like if it is viewed with both feet on the ground.

In the summer of 2010 I visited the city of Mumbai for the specific purpose of observing, talking about and trying toilets in the slums of Mumbai as part of my graduation project.
The aerial view of Mumbai had made me curious for the slum areas. Although the conditions of slum housing are far from the personal ideals and desires of most squatters, it is something they have managed to construct on their own efforts very well. However, houses are most often not of a standard that toilets are provided inside. Nor is it desired to do so with the present quality of the houses for hygiene reasons. A set of articles of the sanitary department of SPARC (Society for the Promotion of Area Resource Centers) showed me that sanitation is more often provided as a public facility[2]. These motivated me to make toilets the subject for my graduation, since it showed me not even 50% of India's slums are provided with toilets now and the toilets present are often inadequate or defect. More than fifty communicable diseases are associated with poor sanitation, resulting in disease and premature death for millions of people, and especially children, every year[3]. Though I did not exactly know at this point how the sanitary problem would be subject of an architectural design in the end, I prepared for the journey to get a grip on the sanitary problem and the context.

Problem description and objective
The problem considered in the graduation project is simple:
- Toilet provision in the slums of Mumbai is lacking or inadequate for most of the inhabitants, causing high health risks and humiliating situations.

The direction is towards healthy and decent sanitation that is sufficient in both number and quality for all slum dwellers. However, in search for a solution to the problem the complexity of the social and physical context displays. On the journey one will find trouble due to disadvantageous spatial circumstances in slums, complicated social relations between people in the slum and counteracting parties in making improvements.

Toilet provision in this project is approached from an architectural point of view. In architecture, the behavior related to sanitation and sanitary engineering come together. Simultaneously, working on a public facility in an environment where public or community buildings are rare, the assignment gives reason to explore extended possibilities for the facility.

The objective for the project is therefore twofold:
- Gaining deeper understanding of the sanitary problem in the social and physical context of Mumbai's slums;
- Proposing a sanitary design that suits and contributes to the slums of Mumbai.

1. Neuwirth, 2006, pp. xiii.
2. Bapat, 2003; Burra, 2003.
3. Laquian, Tewari and Hanley, 2007, pp. 261.

Methods and tools for research

The two objectives of gaining understanding of the sanitary problem and proposing a design require different methods of research. In order to gain understanding of the sanitary problem in the social and physical context, fieldwork was done in the slums of Mumbai which has later been compared with existing knowledge by literature review. In order to define principles for sanitation in the slums of Mumbai, design has been used as a tool for research. The fieldwork has been done in August 2010 in Mumbai. Literature review and research by design have taken place simultaneously over the period of September 2010 to March 2011.

1. Fieldwork

The tools that were used during fieldwork were prepared beforehand. However, slum circumstances do not allow a strict schedule for research. Sometimes new opportunities came up, sometimes prepared activities could not be accomplished. The tools that were used for field work in the end are:

Participatory research - During the one month visit in Mumbai I accompanied a woman, Bama, that set up an elementary school, a church and an employment project in the slum area Ekta Nagar close to Mankhurd station in Mumbai. As I joined her to work I could take part in the daily life of some families in the slum area. This provided for information by experiencing all day life and by informal conversations with slum dwellers. And by using local sanitation...

User interview and photo review - Five of the women in the area have been specifically spoken with about sanitation in a group interview. One young woman was interviewed separately, in the interview pictures were discussed that she made for me of her environment in order to show her vision on sanitation in the area.

Expert interviews - Two sanitary organizations of Mumbai have been visited, were expert interviews where done.

Observations - Observing of course is a 24 hour job during a research journey. Experiences vary from watching daily slum life to visiting houses to waiting for hours for maps in governmental buildings to visiting toilet blocks. Three toilet blocks have been visited for the particular reason of observation. Photographs support the observatory work.

In the text of this thesis all the result achieved in user and expert interviews are explicitly mentioned in the text. Expert interviewed are referenced as well. Insights from observations and participatory research will be used in the text without explicit announcement.

2. Literature review

To support and verify results from the field work, in the analysis of sanitation in the context literature is studied on the specific topic of sanitation and in the broader perspective of slums. The complete literature list can be found in the bibliography. Books and websites used are referred to in the text.

3. Research by design

Tools used for defining principles for the sanitary design are:

Creative session - A group of six students was gathered in the Netherlands in order to work on a specific part of the question for sanitary design principles in Mumbai's slums. The session was prepared in order to generate as many ideas as possible in a two hour time span of which a couple were worked out in some more detail.

Sketching - Sketching was done to visualize possibilities for slum sanitation in Mumbai and verify the appropriateness in the context.

Architecture analysis - Architectural types that are relevant predecessors

for a community toilet facility have been studied in order to distill aspect of interest for the sanitary design.

Urban analysis - The urban context of the sanitary amenities has been analyzed by the use of maps and written data in order to obtain useful directives on scale, density and service area of facilities.

Thesis structure

The structure of the thesis follows the two objectives. The first part of the thesis is an analysis of sanitation in the context of the slums of Mumbai based on the fieldwork and the literature review. Based on the conclusions of the analysis, principles for designing the sanitary amenity are defined in the second part using research by design.

I. Analysis of sanitation in the slums of Mumbai

2. Boy swimming between municipal piping

Bai-gan-wa-di, Bai-gan-wa-di, I repeat a couple of times in my head. Thank *God, the rickshaw driver understands me if I pronounce Baiganwadi Bus Terminal. He starts driving on a four lane road, then turns right into a slum area that seems endless. Inside we turn right and left a couple of times again. The streets now are just wide enough to pass with a rickshaw, though we have to be careful to avoid people and objects on both sides. Shouldn't a bus terminal be easy to reach? Suddenly we turn right again and enter a large open space with buses that are out of service for at least ten years. The rickshaw stops. I pay, step out. The rickshaw leaves. Around me stand a ten, twenty, thirty men staring at me in a wink. No one of them seems to be the caretaker of the toilet block I would meet here.*

On the side of the square I find a shop with soft drinks. The owner offers me a drink and turns out to speak English. I feel slightly uncomfortable since the number of men standing around has only increased. The owner tries to set me at ease: 'Don't worry, they are not staring at you, it is my cinema they are here for!'. We walk behind the counter where he opens a curtain. I'm surprised as we look into a dark space where at least a hundred young men are gathered, making abundant gestures. They stare at a tv that is large-screen by age, it displays a good old Bollywood movie.

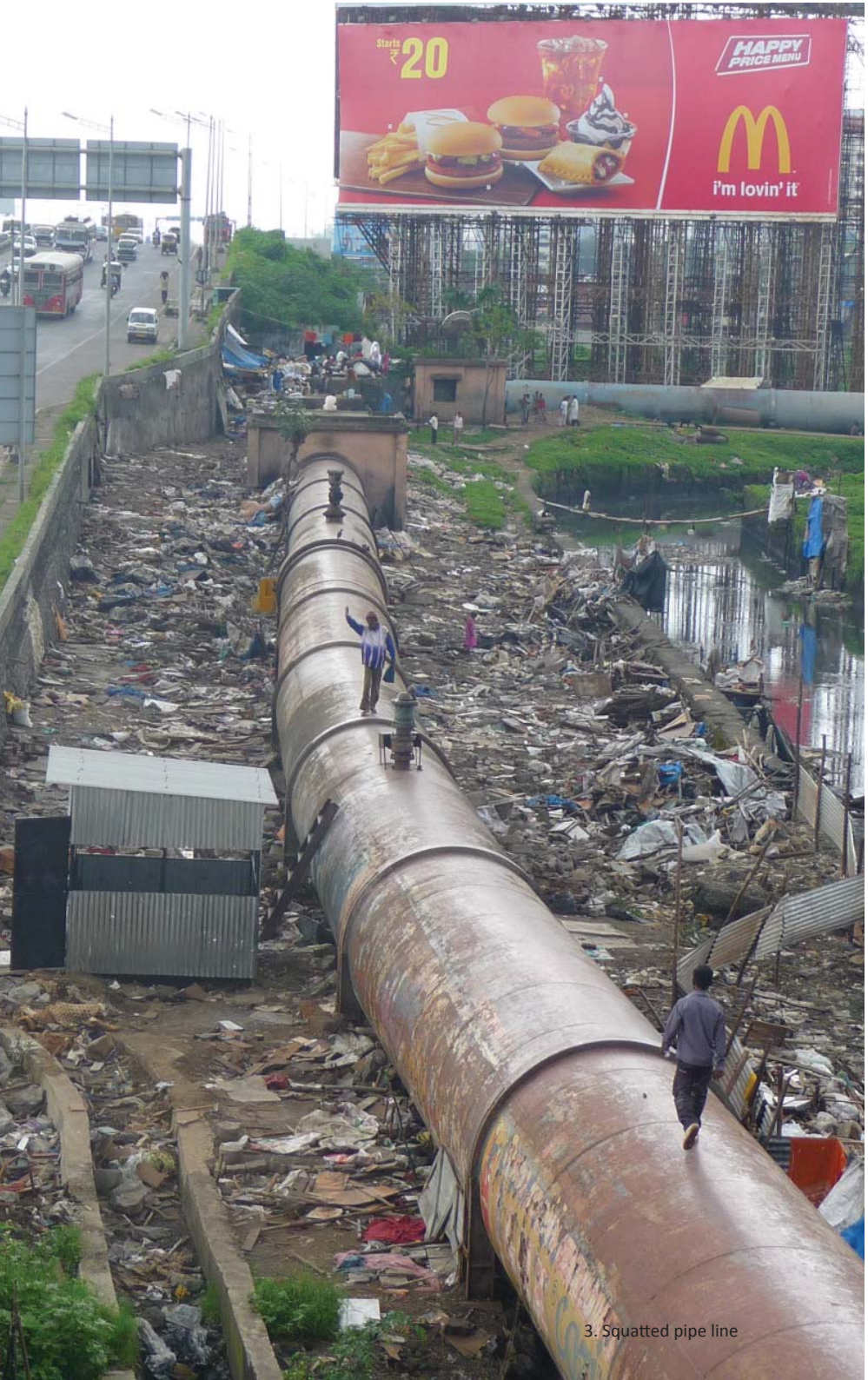
'SPARC toilet block?! Never heard of, the owner replies. He phones the caretaker for me in Hindi. The toilet block turns out to be right behind the cinema. The caretaker receives me friendly. He shows me his computer. And all the data collected on it. And pictures of himself with all people that have visited his toilet block in recent years: engineers, social workers and others from all over the world. After some time I carefully request him to show me around in the toilet block. He stares at me. 'See toilet? Why?'

Understanding more of the sanitary situation in Mumbai's slums is an adventure in itself that has guided me to remarkable places and people of the metropolis. A planner that is responsible for mapping of infrastructure, a man that takes care of a toilet block, an architect that draws toilet blocks, a boy that defecates on the pavement, a woman that uses her sink for peeing. Sanitation can be approached on many different scales that display different aspects of the sanitary problem in Mumbai. Findings in all these scales have influenced desired principles and criteria for the design of sanitary facilities. Scale is therefore the organizing principle for this analysis on sanitation in Mumbai's slums.

As explained in the general introduction, the sanitary problem in Mumbai is complicated due to its context. Solutions that seem sound from an engineering point of view might not work if user behavior is not anticipated on. Behavior can be influences by group norms as well as cultural values and therefore differs from person to person, from group to group and from country to country.
Likewise, sanitation can not be seen apart from the physical context in which it operates. This is of specific importance for sanitation since it is a service that can be seen as an extension of the homes of people.
Sanitation in the slums of Mumbai has been studied in relation to these human and spatial aspects. The questions that have directed the analysis are:

- How does sanitation operate in the slums of Mumbai?
- In what physical and social context does it operate?

For the analysis part I of this thesis is subdivided in five chapters that describe the sanitary situation from the level of the city to the level of the individual household. Each chapter starts with a paragraph 'sanitation' in which those aspects of sanitation are described that are relevant to the specific scale. The paragraphs 'built environment' and 'people' describe the physical and the social context for sanitation on the specific scale.



3. Squatted pipe line

1. Piping in the city

As I'm walking on a fly over bridge my eye falls on two little boys that are undressing next to a junction of water pipe lines. They stir each other up to jump in the gap between two pipe lines, that is filled with dirty water, see figure 2. One of the boys connects an old piece of cloth to the pipe to climb up again after taking a bath. The boys now notice me and start to do all kind of tricks. A young men relates to me on the bridge. 'This is slum swimming pool', he says, 'need a guide for tour?' At other places the main lines for water supply to this city of 21 million people go through slum areas where they are used as pathways. Or squatters use them to build their house on. Ironically, the lines cross many slum areas, but they hardly ever end there to provide half of the city population with water.

The relevance of the city level for sanitation is in the planning and distribution of water supply and drainage networks, as will be discussed under 'sanitation'. Understanding the existence of squatter areas with substandard provision opposing the formal settlements is the main theme discussed under 'built environment'. The relations between squatters, politicians and other parties as well as the general attitude towards sanitation will be discussed under 'people'.

1.1 Sanitation

Piping in the city
In Mumbai, the Municipal Corporation of Greater Mumbai (MCGM) is responsible for planning of piping, roads and electricity. The city therefore is divided in wards for which 5 year plans are produced. Piping contains both water supply and drainage. Mountain lakes north from Mumbai provide for good quality water[1]. Large provision pipes enter the city and the water is distributed by a network of main and sub pipes to all areas.
The water supply and sewer network of Mumbai has first been provided by British colonial engineers[2]. As the British troops suffered from many diseases in India leading to extremely high mortality rates in the 19th century, a survey was done by the Royal Sanitary Commission in 1859. At

1. Interview with Kini, 2010.
2. Scriver, 1994, pp. 338-353.

that moment soldiers relied on ‘dry’ privies (emptied by hand by untouchables, the lowest cast of India), and water shortage caused limited possibilities for hygiene. The survey report was the first incentive for substantial change in sanitary engineering. Around 1900 most of the Indian colonial cities were provided with a city water supply and sewer system, that mostly first served the colonial area and in a second phase also areas inhabited by natives. Though the colonials were probably not very much concerned with provision for natives, the nature of the diseases that threatened the colonials forced a full city solution: endemics do not make a difference for skin colors. The situation that can be found in India nowadays has many similarities with this earlier phenomenon.

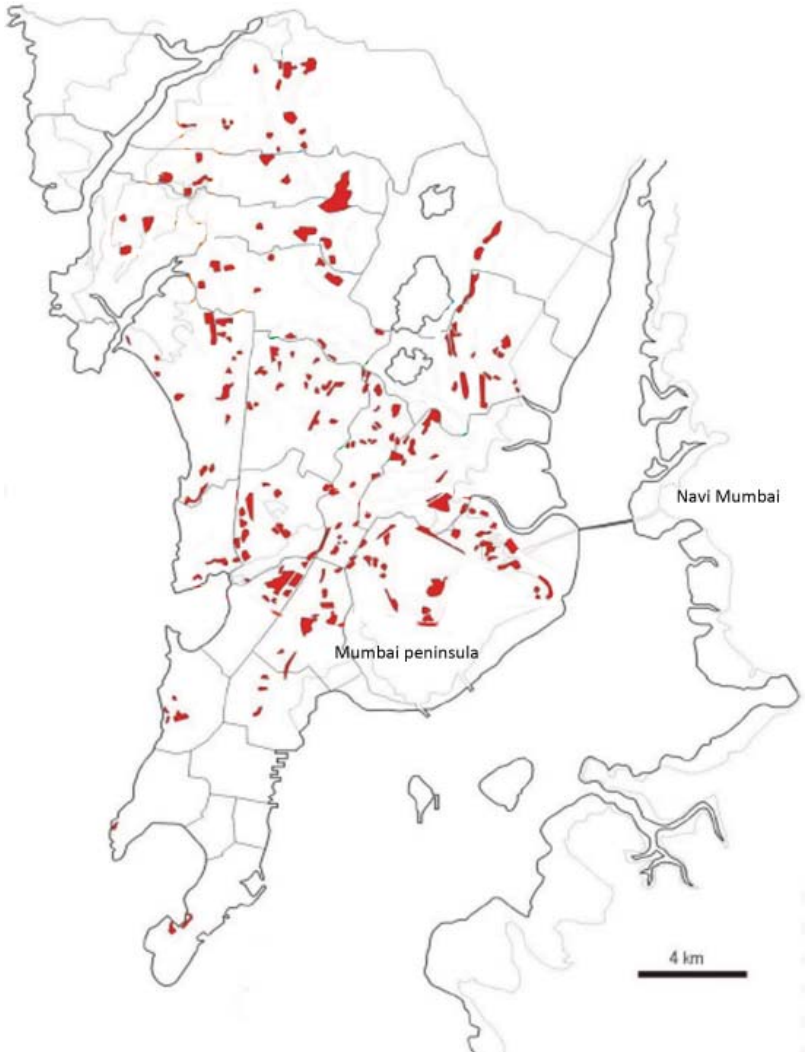
Neglecting the slums

Squatter areas of Mumbai, as opposing formal settlements, are usually not or not fully regarded in providing infrastructure. This has to do with three problems that squatters are facing: land ownership problems, building ownership problems and a lack of rights in general[1].

Squatted areas are mainly wastelands of both public and private ownership. Typical plots for example are wastelands next to railways that are owned by the railway organization and floodplains in public ownership. Piping can not be provided to privately owned land, whereas piping to squatter areas on municipal ground would undermine the five year plans of the MCGM. Without the ownership of the squatter areas, ownership rights for individual houses are diffuse as well. For this reason piping on a household level is even more unlikely.

With all the rules and regulations that are focused on banning informal settlements from Mumbai, their are still millions of people living as squatters that need water every day to survive. Common alternatives to public piping are wells, use of untreated surface water, water brought in with trucks and bottled water. Sometimes piping for slums is taken over by private organizations. Water can be illegally tapped of public piping as well[2].

In the tangible distinction between formal and informal settlements,



4. Largest slum areas on the peninsula of Mumbai

1. Laquian, Tewari and Hanley, 2007, pp. 47,66, 250-252.
2. Id., pp. 250-252.

5. Historic map of Mumbai

squatters are facing disadvantages[1]:

- Water that is brought in from far is expensive by the interference of many parties, whereas public water provision in formal settlements is relatively cheap;
- Local water sources have a high risk of contamination on wastelands;
- Water becomes more scarce in Mumbai. Cheap prices for public piped water easily lead to waste in the formal sector, whereas ground water sources in the informal sector dry up;
- Piped supply in squatter settlements is often irregular, water is only available a few hours a day.

The availability of water influences sanitation in two ways. Water based sanitation is effected by all the disadvantages as described above. But these disadvantages have also worked out an ideal to be scarce with water in sanitation or create sanitary systems that are not water based, like dry toilet systems. Read more about this in 4.1 on sanitation on neighborhood level.

1.2 Built environment

Temporal structures for permament use

The problems that Mumbai is facing in sanitation for squatter areas can not be seen apart from the generic problem of rapid urban growth. The economic climate of Mumbai attracts people from all over (rural) India. Pressure on land and basic sources are inevitable. Dealing with land pressure in Mumbai is even more complicated because the city was originally built on an Island, see figure 5. Land winning has transformed the island in a peninsula that can hardly be further expanded. Figure 4 shows both the peninsula and Navi Mumbai, the area where the latest extensions to the formal city were made. In order to deal with land pressure, the MCGM created rehabilitation programs[2]. These programs should provide an alternative to slums for the urban poor. The intention is that slums will be removed and that for every family a new house will be provided

1. Laquian, Tewari and Hanley, 2007, pp. 250-252.
2. Interview with Kini, 2010.

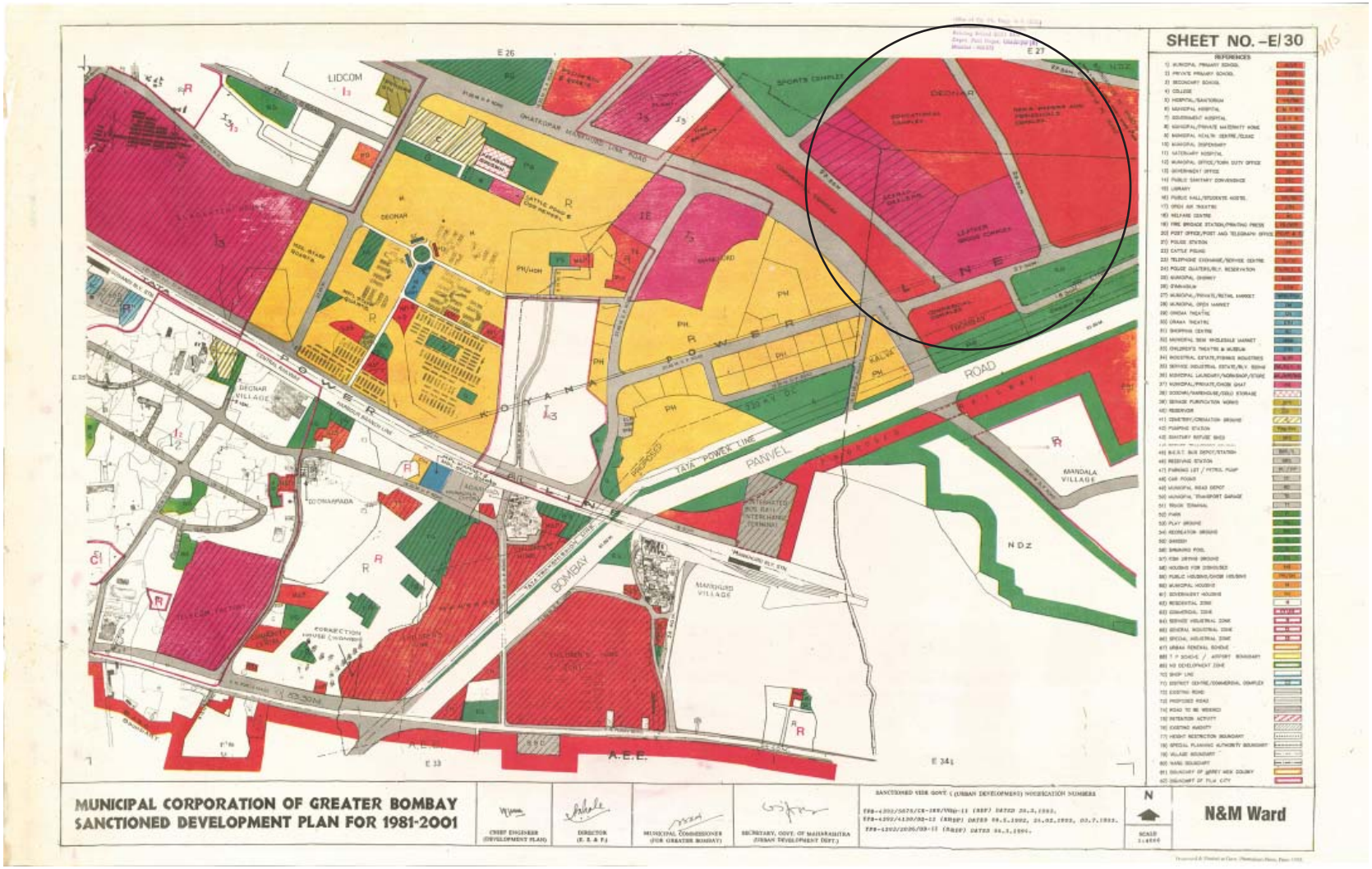
simultaneously in the formal housing sector. In conversations with slum dwellers it became clear that rehabilitation is not always appreciated. The new built areas are mostly residential areas where people can not start a business connected to the house. Relocation areas far away from the original slum can be problematic since people are depending on their feet or a cycle for transport to work. Even if these issues are not regarded, there is a wide, and widening, gap between needs and supply for rehabilitation houses. This results in squatter settlements that are equipped as temporary places to stay, where rights are lacking to fully equip the places as residential areas.

Delay in rahabilitation

The widening gap in housing provision and need can be illustrated with the map of Mankhurd area in Mumbai, figure 8. This map was obtained from the municipality and displays a development plan for twenty years, which should be revisited every five years. The area within the circle is the place where I spent most of my time with slum dwellers, Ekta Nagar slum. The map shows that the original plan for the Ekta Nagar area was to create commerce, industry and education in the period 1981-2001. However, the Ekta Nagar slum is already located in the area for more then thirty years. The year of publication of this specific map is 1995 (most recent available), meaning that the plans have not been revisited, nor implemented ever since. This means that although the Ekta Nagar slum is not taken in account in any formal planning, since it was supposed to be rehabilitated long ago, two generations of people have grown up there already. Google maps also shows that parts of the area have been demolished overtime, figure 6 and 7, with the intention to start building according to the development plans. But people started rebuilding slum housing in the area as no formal building activities were ever started.
It is also worth mentioning that in the long process of obtaining the map, one of the officers told me it might be more adequate to print from google maps instead of using any municipal map. This also became clear in the journey to five different municipal offices and nine officers that

6. Ekta Nagar slum 2006

7. Ekta Nagar slum 2010



8. Municipal map of Mankhurd area, Mumbai

were needed to find the right map in the end.

How slums relate to the formal city structure

As visitor of Mumbai, I was amazed how easily expressions of extreme poverty were taken for granted and probably not even noticed anymore. The way in which slums relate to other city structure clearly express this. In figure 9 a fly over bridge is displayed that connects a train station with an important business centre. The fly over makes it possible to reach the business centre without passing the slum in between on ground level. On the same bridge, one can see the millionaire advertisement in figure 10 in front of slum houses. It was striking to me how informal settlement spread in the formal structure, and in reaction formal structures are build to avoid the informal. As if a silent battle is going on, not visible in riots, but in a war on space.

Slums can be found all over the peninsula, both in the middle of economical and industrial hearts and on the outskirts of the city. The boundaries of slums have typical features. Often, the outlines are defined by a highways and railway lines that severely cut of the slums and hinder their accessibility. Less centrally located slums can typically be edged by the flood zone of a river or another type of wasteland. When a slum is laying next to a formal settlement, it is typically seen that the informal settlement is entering the formal area in Mumbai. In the economic hearts of the city even fully interwoven areas with formal and informal buildings can be found, meaning that the informal buildings are build in the formal structure as an extra layer. Since the sizes of slums are defined by the boundaries that they hit in the growing process, sizes show a great variety. One thing is for sure, once the boundaries are reached, the only way to expand is intensifying. For example in the slum area of Dharavi, an area of 175 acres, it is expected to house at least a million people according to slum dwellers. Note that the need for water based sanitary systems grows exponentially as a slum grows and develops[1], whereas construction of water supply becomes harder in a dense structure if not taken in account from the beginning.

9. Fly over bridging formal settlements to avoid interfering with slum

10. Millionaire advertisement in front of slum housing

1. Laquian, Tewari and Hanley, 2007, pp. 250.

1.3 People

The group not taken in account

In 2001, it was estimated that 55% of the inhabitants of Mumbai lived in slums[1]. Slum areas of Mumbai are characterized by a high percentage of immigrants, mostly from other states within India. Economic prosperity and the hope for employment have brought them to Mumbai. A variety of languages, religions and cultures therefore characterize the urban poor areas.

Since new comers in Mumbai often have left everything behind to come to Mumbai, no finance is available for housing before a job was found and some money is made. It is likely for men or entire families to start homeless, climbing to a simple shack and after to a house in an urban poor area, see 5.2 on the built environment on household level.

The fact that many of the urban poor live in areas that are squatted brings governmental bodies in a complicated position. Generally spoken any building in Mumbai will be provided with a toilet that is connected to water supply and sewerage provided by the government. But as we have seen squatters are excepted from the formal structure. What is left is a question of responsibility: Being part of the informal city, who is responsible for dignified living including sanitation for squatters?

One of the main reasons for the impasse in the situation might be the lack of trust between people. The houses of many urban poor have been bulldozed by the government without announcement or alternative in the past. Government attempt to proceed formal development on slum lands fail since people rebuild their houses after demolishing, sometimes also if an alternative is provided by the rehabilitation program. The already complicated relation becomes even worse with bribery and violence.

The main dilemma for any planner is what attitude to choose:

Should slums be considered a humiliating and substandard way of life and therefore be banned under any circumstances? Or should the local government have the focus on their inhabitants and seek for the most feasible solution for their wellbeing?

The diffuseness in policy on squatting has led to the same diffuseness in responsibility for sanitation. Some sanitary facilities in slums are constructed or paid for by the government, many are not. If facilities are provided, sometimes maintenance is also on account of the government, sometimes it stops with construction. Sometimes initiatives of the urban poor to realize sanitation on their own account are permitted, sometimes resistance is faced.

The wide gap that exists in needs and provision for sanitation has been noticed by a couple of organizations that are now active in construction, development and lobby for sanitation. This will be further explained in 3.1, where the construction of community toilet blocks is discussed.

Attitude towards sanitation

In his book 'The Bathroom' Kira mentions what the British actually learned to bath from the Hindus[2]. During my stay in Mumbai I recognized that personal cleanliness is indeed highly valued. From a western perspective, the relation between personal cleanliness and sanitation is obvious. However, in Mumbai I discovered that toilets are strongly associated with dirt in India. And in disadvantage of the slum dwellers poverty and dirt are also related in the minds of people, which Kira also acknowledges. An example of this can be found in the phenomenon of scavengers. Scavengers are people without a caste, the untouchables, that are burdened with the task of removing the human waste of higher class people from the street. Although this phenomenon is nearly eliminated, the associations are still alive.

Besides the association of toilets with dirt, I also found that the relevance of sanitation is not acknowledged by many. As I explained the purpose of my stay, to both upper class people and slum dwellers, I was often questioned why I would choose toilets if I could also research and design 'something beautiful'. However, this does not mean that people don't care about having a clean toilet, but the public toilets as an amenity are not highly valued.

1. The World bank, 2003, pp. 1.
2. Kira, 1974, pp. 10.

11. Open field in slum

2. Defecation fields in the slum

As I am on my way to Ekta Nagar slum I decide to walk form the station to see some more of the environment. I pass by a bridge that is home to at least ten families during rainy season. After the bridge I walk along the main road where I look at the some slum houses, stray dogs and children in uniform going to school. Shit, I should have looked at the ground for now I'm standing in the shit with my flip-flops. The inhabitants of Mumbai are good at avoiding the dirt without watching the ground, they have this special pace. On the other side of the main road is Ekta Nagar. As I enter a boy in his puberty squats on a set of bricks. It takes a while before I realize he is defecating there right on the place where rickshaws stop and men are doing business. It first seems to me that he did nothing to set himself apart. Then I see that he hides his face in his hand, just like smaller children hide their own eyes and think they are now hidden for others as well.

In this chapter will be described how the approach to sanitation on slum level differs from formal areas due to deviation in policy, priority and morphology. The chapter is divided in a paragraph for sanitation, built environment and people again.

2.1 Sanitation

Toilet types in the slum
Since provision of toilets on household level is exceptional in slum areas, other ways of dealing with human excrements have been developed. Basically four types of sanitation can be distinguished in slum areas:

- Open defecation
- Community toilets
- Shared toilets
- Private toilets

In absence of toilet construction, people have no choice but to defecate in the open air. Open defecation is mainly practised on junk spaces within

the slum area, usually the edges. If junk space is not easy to reach, specifically children can be seen defecating and urinating in the built environment of the slums as well. The junk spaces can be simultaneously used as playground. See figures 12,13 and 14. Specifically if these plots are wetlands as well, the plots become breeding places for diseases. At least 50 diseases worldwide are directly associated with poor sanitation. However, improvements in sanitation only positively effect health if improved sanitation is available for everyone.[1]
Open defecation is a problem due to health risks, humiliation, pollution of the environment and risks for harassment of women and children as well. Above that, women from the Ekta Nagar slum mentioned the fear of being beaten by the police if they were found defecating in the open field as the main problem of open defecation.

The most large-scale, and therefore most feasible, solution for slum sanitation in Mumbai is constructing community toilets on neighbourhood level.[2] Community toilet blocks are usually provided per 400 to 1000 persons, with a ratio of one toilet per 50 people. Community toilets can be provided publicly, initiated by slum dwellers or created with help of sanitary organizations in Mumbai. The community toilet block will be discussed in detail in 3.1 on sanitation in the neighborhood.

A second option for providing sanitation is sharing a toilet with a couple of households, typically four to five.[3] Obviously, provision of shared toilets requires more infrastructure on slum level if the toilets are water based and connected to sewers. Shared toilets will be briefly discussed in 4.1 on sanitation in streets and alleys.

As said provision of toilets on household level is exceptional, but can be found occasionally. As people are depending on open defecation, it is likely that on household level some facilities are improvised for urinating. These topics are discussed 5.1 on sanitation on household level.


12. Open defecation


13. Children playing in defecation area

1. Laquian, Tewari and Hanley, 2007, pp. 261.
2. Interview with Kini, 2010.
3. Interview with Kini, 2010.

14. School boy peeing in slum area

15. The beginning of a slum

Standing in the gap for toilets

People have noticed the problems that squatters are facing in sanitation and some have aimed to stand in the gap. Two of the largest of these organizations I want to mention in particular in this field, since I have been able to visit and see their work during the fieldwork in Mumbai:

- Sulabh International Social Service Organization was born in arch 1970 with the objective of restoring human rights and dignity to scavengers by freeing them from the inhuman practice of manually cleaning and carrying human excreta.[1] At this moment it is a leading NGO in India in the sanitary field working both nationally and internationally.
- Society for the Promotion of Area Resource Centers (SPARC) was formed in 1984 and aims to empower the urban poor in India gain access to the resources they need to upgrade and formalize their settlements.[2] Recently SPARC has provided loans for individual toilet construction. Demonstration community toilet blocks are constructed in order to display the sanitary needs of those in the slums, produce a demonstrable model for potential partnerships between cities and the poor, and establish a basis for dialogue with government to discuss scaling up the sanitation model on a citywide basis.

The approach to the sanitary problem in both organizations slightly differs, resulting in various tasks for the organizations. Sulabh is involved in both construction and design development for community toilets, including sanitary technology. The organizations works both independent and in collaboration with public agencies. SPARC focusses on the empowerment of the urban poor, educating the urban poor in designing and constructing community sanitation and lobbying at governmental bodies.

1. Sulabh International, 2010.
2. SPARC India, 2010.

2.2 Built environment

The growth of slums

Deeper understanding of slum structures is needed to understand the spatial difficulties in creating sanitation. While sizes of slums are determined by sizes of the available wastelands, the density of people can vary greatly per area. Slums housing more then 80.000 people are common. The morphology of a slum typically differs from formal settlements due to the way a slum grows:

Individual persons start living on a wasteland without previous organized preparations for the total area, see figure 15. In order to find shelter a simple hut will be created with materials available to the builder, who is usually also the inhabitant of the new structure, see figure 23. Newcomers build their houses close to each other. As the structure grows and the wasteland becomes more and more occupied, the need for pathways will grow. Sometimes this is taken in account from an early stage, sometimes it is not. The edges of the wasteland are used for garbage dump and defecation. If pressure keeps rising garbage dump, places for defecation and creating alleys can become problematic, see figure 16. Note that these issues are very serious: lack of sanitation alone can already block long term developments of an area by epidemics and poor chances for any (formal or informal) investments in the area.[1]

As the living standard of the inhabitants of the new slum rises, so does the desired size and condition for housing. Temporal structures are transformed into brick or concrete structures, small plots are merged and floors are introduced.

Circumstances can greatly vary between and within slums. For example, air-conditioned and double glazed houses exist next to huts, see figure 20. Neuwirth, who lived several years in slums all over the world including Mumbai, describes Mumbai as having a squatter class structure[2]. The welfare of a complete slum area can sometimes directly be read from the morphology of the area.

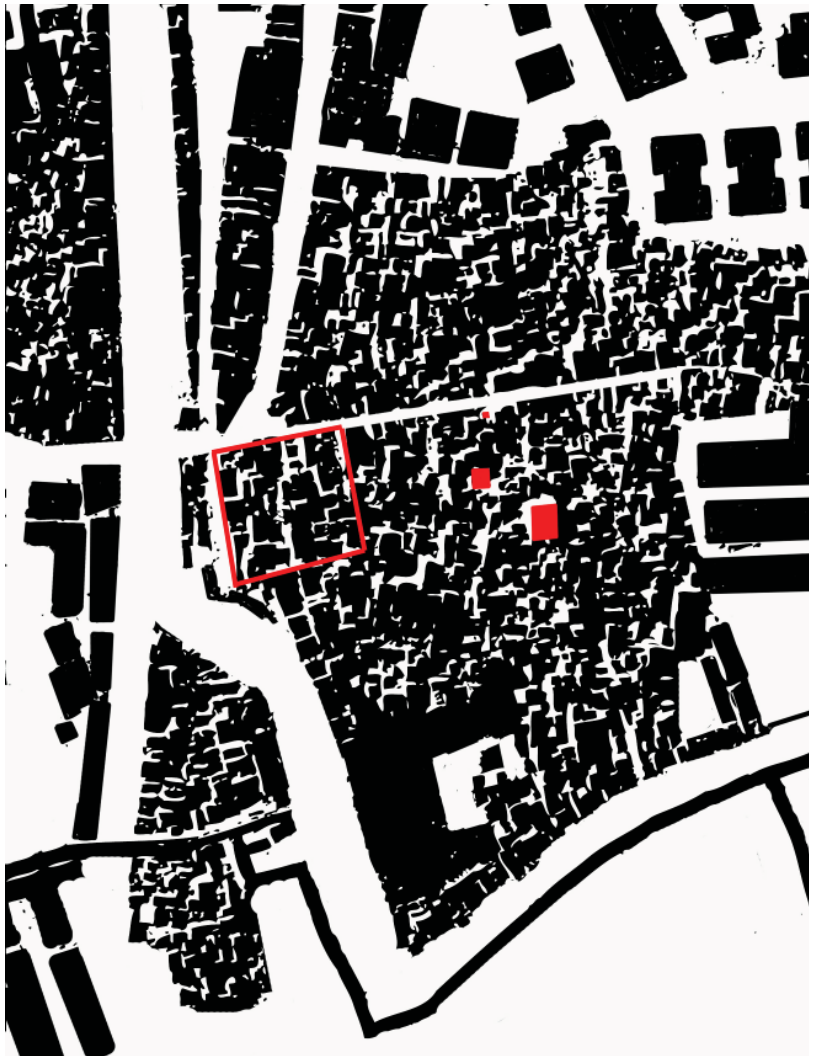
16. Narrow alleys and garbage dumb

1. Interview with Kini, 2010.
2. Neuwirth, 2006, table of contents.

Three urban poor areas
On the next page, the morphology maps of three urban poor areas are depicted. Two of the areas are slums that I have visited myself. The third area can hardly be considered a slum, since it has a predefined structure that is provided with basic services. The areas are selected based on their clear differences in morphology to explain the consequences for sanitation. The maps all have the same scale.

The first is a map of Bandra slum area, a slum that is build-in between formal building areas and main roads. Only one road enters the area, other clearly defined interruptions or structures in the dense patchwork of buildings can not be discovered. Intermediate, largest and smallest size structures are painted in red; the size differ from 6 to 120 square meters. The selected area keeps circa 100 households, what corresponds to 9 toilet seats required in terms of sanitation.
The second map Shows Ekta Nagar, a slum built on wetlands alongside a highway. Some main roads and open spaces can be read from the map, as well as a morphological structure: double rows of housing around alleys have developed perpendicular to the main road. Houses show more or less similar sizes, with an average of 24 square meters. The selected area keeps circa 500 households, what corresponds to 45 toilet seats required in terms of sanitation.
The third map depicts Malvani, an urban poor area with a predefined structure. This can be recognized in the morphology by the organization of housing: basic infrastructure is present, serving the housing blocks that contain around 80 households. Within the blocks, housing is semi organized by the introduction of alleys. Housing sizes vary from 12 to 80 square meters. Seven toilet seats are required to serve a block corresponding to the norms.

It is not hard to imagine the consequences of different morphologies for the construction of sanitation. In the planned infrastructure of Malvani water supply and sewerage was considered from the earliest stage. Con-



17. Morphology of Bandra slum area

1. Laquian, Tewari and Hanley, 2007, pp. 250.
2. Interview with Kini, 2010.

18. Morphology of Ekta Nagar

19. Morphology of Malvani

20. Air-conditioned double glazed slum house

struction of sanitary blocks does not face a lot of trouble in these circumstances.
In the situation of Mankhurd, every small alley is provided with an open gutter in the middle, providing some level of sewerage, see figure 14. Water supply chains are constructed on the main roads. The fact that infrastructure was not considered from the first stage, can be noticed in for example water supply chains that are led through open outlet channels in order to be protected from traffic riding over the pipes.
However, in Bandra both traffic and sanitation are not considered, since this area has grown due to individual initiatives. Once the structure has grown and density has increased, introduction of veins for both traffic and water is very hard to accomplish. However, as slums develop the demand for water led sanitation and water in general rises exponentially.[1]
Composition of the area does not only influence the construction of infrastructure for sanitation, but also the accessibility. Open spaces, height differences in buildings and sight axes play an important role in the ability of people to orientate. Within the monotonous and dense structure of a slum both recognizing and reaching sanitary amenities can be hard, see figure 21. Since inhabitants usually know their direct environment very well, orientation is now not considered problematic. However, as slums develop and become centres for informal economy these issues become relevant.

In the comparison of the three urban poor areas, it becomes clear that the needs for building sanitation are not uniform. Constructing sanitation is usually most urgent in areas that have least amount of planned (infra-) structure at this moment. Therefore, the research will focus on slums only, assuming that a solution for these locations might be helpful in finding sanitary solutions for further developed areas as well.

1. Laquian, Tewari and Hanley, 2007, pp. 250.

2.3 People

Slum dwellers priorities
As making a living on the country side becomes harder, growing streams of immigrants come to Mumbai. It is most often economic perspective in Mumbai that attracts people. Since the climate of Mumbai is soft, people risk being homeless as they come over. In the rainy season, bridges and arcades are common places to spend the night. Often it is the man of a family that comes to Mumbai and brings his family only after he has made some money and can afford to build a simple hut on a wasteland for his family. Sometimes it is complete families that live on the pavement, see figure 22. A scheme for development of individual houses can be found in 5.2 on individual houses in the slum.
As people have come to Mumbai, their first priority is to find a job to make money for living. As Sulabh found out, the priorities for living as a squatter in Mumbai are universal[1]:

1. making money
2. buying food
3. finding / creating shelter
4. having access to water
5. having access to electricity
6. having access to a toilet

Making money might is a remarkable priority in the sequence, since it is a condition for all of the others. Still, it should be separately mentioned, since it is typical for the approach of a slum dweller. Before anything else, even finding a suitable place to live, people will search for a job. It is an expression of the hope of making progress in life by working hard. This can also be recognized in the city of Mumbai in general by looking at a random book stall: it will be full of books that claim to have the key for becoming successful as a person or as a family and climb on the social ladder that way.


21. Alley

1. Interview with Kini, 2010.

22. Pavements dweller family

23. Slum house

Toilet provision is only on the sixth place, since open defecation takes away the urge to have proper sanitation. In the list the first three basic needs can be reached by an individual person or a family. Assuming that the family lives on a wasteland, water, electricity and toilet provision can only be reached in cooperation.
Here the slum dwellers face a problem: how to cooperate with people that you might not even share the same language with? People have come to Mumbai for employment, but they are rooted in families on the country site. Shared language, culture and religion are not common in a slum, nor is the assumption that slum dwellers live as a community true[1]. However, since provision of services for slums is rare as we have seen in chapter 1, people have to join hands to provide themselves with basic services. In doing so, opposition can be faced. Governments are not always pleased to see these initiatives coming, since in fully equipped living areas it is less likely that people are open for rehabilitation at a certain moment. However, rehabilitation might wait for years, causing children to grow up in a life threatening environment.

1. Interview with Kini, 2010.

24. Caretaker of toilet block

3. Community toilet blocks in the neighborhood

The caretaker of the Baiganwadi toilet block shows me some more documents on his computer: a series of comic strips on the sanitary situation of Mumbai. The last image he shows me is a drawing of an elementary school in which children are taught about hygiene and sanitation, while the toilet available definitely does not meet the needs for hygiene (see figure 25). *Then we go down to see the toilets. This toilet block was recommended to me because of the specific children's toilets available in the block. As we walk through the corridor the children hear us and immediately run from their toilets out of the toilet block. Unfortunately I will not be able to see the toilets in use now. But the caretaker has a solution for this; I can have a photo of the toilets in use from his computer, that he uses to promote the children's toilets...* (see figure 26).

In this chapter, the functioning of community toilet blocks in Mumbai will be discussed in the paragraph 'sanitation'. There will be attention for the way in which the blocks are build and organized as well as for the problems attributed to it and my personal experiences with the blocks. The neighborhoods in which the blocks serve are described in the paragraph 'built environment' and the social context on this scale is discussed in the paragraph 'people'.

3.1 Sanitation

The community toilet block

In Chapter 2 was described how sanitation in slums can be organized in different ways, of which community toilet blocks are most common. Community toilet blocks are buildings that keep a series of toilets with a serving area of 400 to 1000 people[1]. Community toilets are an efficient way of dealing with sanitation, since all the installations and services needed for sanitation only have to be provided once at one location. The first community toilets blocks have been provided already in slums of Mumbai in the seventies. Since that time many have been provided, and many developments on how to construct and organize community toilet

1. Interview with Kini, 2010.

blocks have taken place.
The more simple (municipal) sanitary blocks are shaped as a corridor with a series of toilet cubicles at both sides, see figure 27. The toilet pans are mostly connected to a septic tank, whereas cleansing water is taken from municipal sources (if available). Electricity might be provided. In any case, the toilet pedestal is a flat pan, not a pot in accordance with the general habit in India.
A vast amount of problems was associated with this type of community blocks. The problems could be such that people prefer open defecation over using the community facilities for the following reasons[1]: Low quality of construction, poor maintenance, inadequate water supply, lack of security. SPARC also mentions the long queues for sanitary blocks in the morning, children being disadvantaged and limited access of sanitation[2].
In my personal conversations with slum dwellers, payment of community toilets often was mentioned as a reason for not using the facility. From an environmental perspective Sulabh is also involved in finding solutions for waste (water) removal[3]. All of these problems are discussed in relation to the solutions that have been developed by Sparc and Sulabh for community toilet blocks in recent years.

Construction quality and defects of community toilet blocks
The first community toilets were constructed by the municipality in specific slums that were tolerated for their long presence in the city. Maintenance of sanitation was usually not considered in this blocks that were built under the pressure of meeting human rights requirements. Focus for construction then was to build as many facilities as possible. This operation resulted in a toilet ratio of one toilet in 1488 people, of which 80% was out of service according to a SPARC survey[4] (see also 'insufficient number of community toilet blocks').
By the interventions of, among other, Sparc and Sulabh the organization of community toilet blocks has been changed in order to guarantee continuous maintance of the toilet blocks. The main improvement in this field is the introduction of a caretaker for every community toilet block, who will

25. Comic strip on sanitation


26. Children's toilet in Baiganwadi toilet block

1. Laquian, Tewari and Hanley, 2007, pp. 48.
2. Burra and Patel, 2003, pp. 15.
3. Sulabh International, 2010
4. Burra and Patel, 2003, pp. 16.

27. Basic community toilet block in Ekta Nagar

notice defects and is responsible for reparation (figure 24). In most cases the connection between caretaker and providing organization continues after construction of the block. The idea behind introducing the caretaker is to introduce someone that takes **responsibility** for the toilet block.
In Agra, a city more to the north of India, I was able to see the consequences of lacking responsibility early in the morning when people wake up, see figure 28. The community toilet block was used for garbage dump instead of sanitation, the area around the toilets was used for open defecation by men and children. I am not sure how women would deal with sanitation in this specific situation.
A side effect of appointing a caretaker is that a salary has to be paid, which is in the case of Sulabh and other organizations resolved by introducing a 'pay and use' system for sanitation, see 'finance of community toilet blocks'.

Pollution and cleaning of community toilet blocks
In relation to (technical) maintenance, someone also has to take care of the daily cleaning of the community toilets. The caretaker was introduced for this task as well. In the general lay out of the building in relation to care taking, the caretaker is positioned behind a paying counter at the entrance (figure 24), with a view to both male and female section of the block. In the SPARC blocks, the caretaker's house is built on top of the block (figure 29).
In the Baiganwadi toilet block it could be seen that the caretaker developed into a kind of manager that operated from the house on top of the facility. The cleaning and counter work in this case was delegated to others downstairs.
Even though the responsibility is formally given to a caretaker, this is not a guarantee for clean toilets. Most of the caretakers will not continuously be cleaning the toilets, the main idea is that people will keep the toilets more clean in the presence of a supervisor. However, figure 30 shows one of the many situations that I faced where this is not the case. It can therefor be concluded that in order to keep the places clean, there is an urge

28. Community toilet block in Agra


29. Baiganwadi toilet block with caretaker's house on top

that **responsibility for the block is also felt by the users**. The serving area of the block and the way in which it relates to the users and built environment is crucial in this matter, see paragraph 3.2 and 3.3.
The availability of water is the second factor that influences cleanliness, since water is required for anal cleansing, according to the local habit, and cleaning the amenity.

Water supply, waste removal and sanitary systems for community toilets
The disadvantages that slums face in the distribution of water as described in chapter 1 also count for slum sanitation. Community toilet blocks that rely on piped water deal with irregularities in supply and low pressure. Sometimes a storage tank is placed on the roof of the building for that reason, see figure 31. Other facilities use a large tank, since they are provided by water that comes in from trucks.
In the struggle to deal with limited availability of water, the policy for many organizations is focused on reducing the water needs for the amenity. For this reason, pour flush toilets that require only 1,5 to 2 liters of water for flushing have become the standard. Also, experiments with dry toilet systems are going on. The idea behind the water reduction in flushing is that people can take water from home at moments water is not available at the amenity. People then bring a bucket or bottle of water for anal cleansing and flushing. However, problems in water provision for the toilet block or less urgently solved with this policy. And water for cleaning the amenity is not considered in the reasoning.
Figure 30 shows the consequences of bringing water from home; this girl uses a bucket for cleansing water that is shared with the family to save water. Sweeps of dirty hands can be found on the walls of most cubicles. The risk of this behavior is enormous, leading to the conclusion that the **comprehensive availability of water** is crucial. Health risks should be considered in water saving possibilities for the toilets.
For the black water streams in the toilets, septic tanks are the most common solution. Places that are facing (the flood area of) a river might also be discharged directly on the river. Sulabh has created a combined system

30. Toilet cubicle in use

for pour flush latrines connected to a double excreta tank, in which the tanks are alternated every six months. In the intermediate time, the refuge material is transformed to fertilizer in the tank. But up to now the organization has not been able to use the system in slums due to the spatial requirements in size. The **space required for discharge**, including route for transport should be considered as well as the **health and environment implications of discharge**.

Finance of community toilet blocks

The 'pay and use' toilet blocks that have been constructed for a long time charged one rupee (US$0,02) per use in order to pay for the caretaker's salary. In the last two years it was raised to two rupees. On a monthly base this used to be RS150 per family by daily use, which was a sum beyond the means of most families already before raising the charge[1]. The most common solution for this problem in Ekta Nagar slum was to send the women in the family to the toilets once a day, while the men practised open defecation. In terms of hygiene this is not a desired solution, since diseases very easily spread inside the family.

The difficulty in finance is that people tend to be more careful and responsible with an amenity that they have paid for. Another solution that was introduced is the distribution of family membership for the toilet block. The family can have the membership card for a discount price in comparison to pay and use, the benefits are that people can use the toilets as many times as they want with all family members. Therefore open defecation and other poor solutions for urinating and defecating can be prevented. Also, queues in the morning are less dramatic if people can use the toilets several times a day without extra costs. Concluding, in the finance of the toilet block two aspects should be considered: **the limited budget** of the users and the **responsibility felt for the amenity**.

Standing in line for the community toilet blocks

It is rush hour in the morning at the toilet block, before people go to work[2]. In the queues for the toilet block, children usually loose it from the

1. Burra and Patel, 2003, pp. 13.
2. Burra and Patel, 2003, pp. 15, 22.

adults, see also ‘children and community toilets’. The lines for the toilets are caused by the insufficient number of toilets in the first place, but one can also question whether toilets should be **adapted to rush times** in organization or structure.

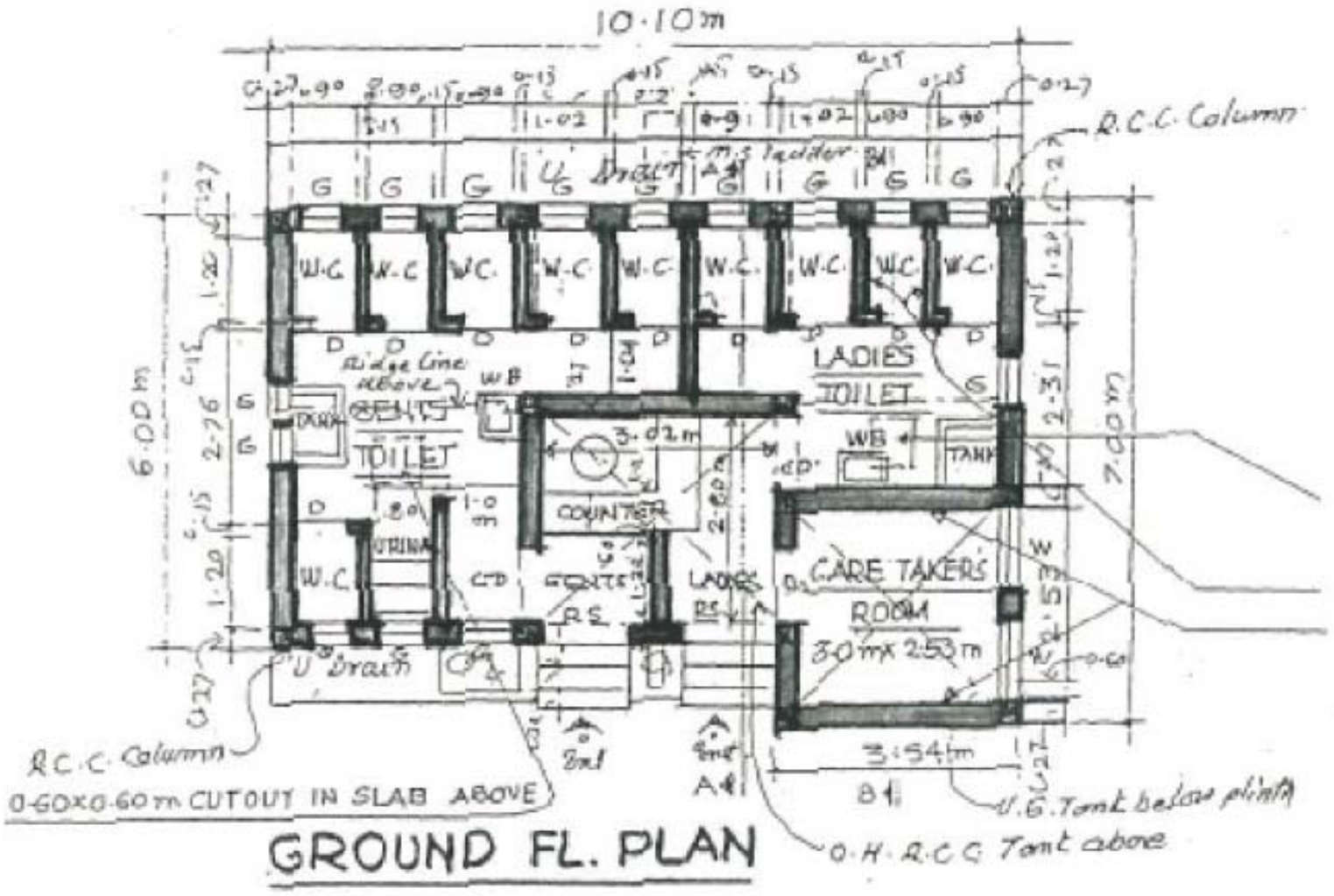
Insufficient number of community toilet blocks
The one toilet available to 1488 has become slightly better by major efforts in construction last years. Where municipal toilets used to be organized top-down without direct involvement of the users, Sulabh and SPARC toilets are constructed in close collaboration with users.
Sulabh only constructs on the request of slum dwellers, for which a minimum amount of petitioners is needed. A survey for the requirements is done in collaboration with the users as well as additional hygiene education. The designs are custom made for the location, based on Sulabh principles for caretaking, engineering, etc.
SPARC in essence is an organization for the promotion of area resource centers, meaning that empowerment of (mainly females) in the slums is their focus. Their amenities are designed and constructed by the slum dwellers, that are educated for the task by SPARC.
Based on these positive experiences, distribution of toilets should be organized in **collaboration with the users** in all stages of the process.

Children and community toilets
Children that are disadvantaged in the queues for the toilets, are likely to go for open defecation in the area. There is a second problem with the sanitary amenities for children, that is known already for all the readers that have seen the movie ‘Slumdog Millionaire’. Children might fall into slippery filthy toilets, or are afraid of falling if the span of the toilet pan is wide. If not the children themselves, then it might be the mums that learn the children to go in the fields to prevent falling[1]. **Specific solutions for children** are therefore required in community toilets.

Safety in community toilets for women


31. Entrance of toilet block in Ekta Nagar with water storage tank

1. Burra and Patel, 2003, pp. 22.



32. Plan of Sulabh toilet block

Open defecation and toilet blocks without supervision might lead to people feeling unsafe while defecating, specifically woman. The fear of harassment can be such that women only release 30% of their burden, causing chronic stomach problems that bother the daily work. The caretaker again is the answer to this problem. In the toilet blocks of Sulabh, the layout of the blocks is shaped around this theme of safety by placing the caretaker at the entrance with a view to the female area, see figure 32. The solution works well for daily use, but access to the facilities is now limited to daytime. In my experience people are trained to control their bowel movement to an extent that is unthinkable in The Netherlands. However, safety of sanitation is specifically urgent in situations of disease, including diarrhoea, which is not limited to day time. Preferably, **access and safety** should be guaranteed at any moment.

Access to community toilet blocks

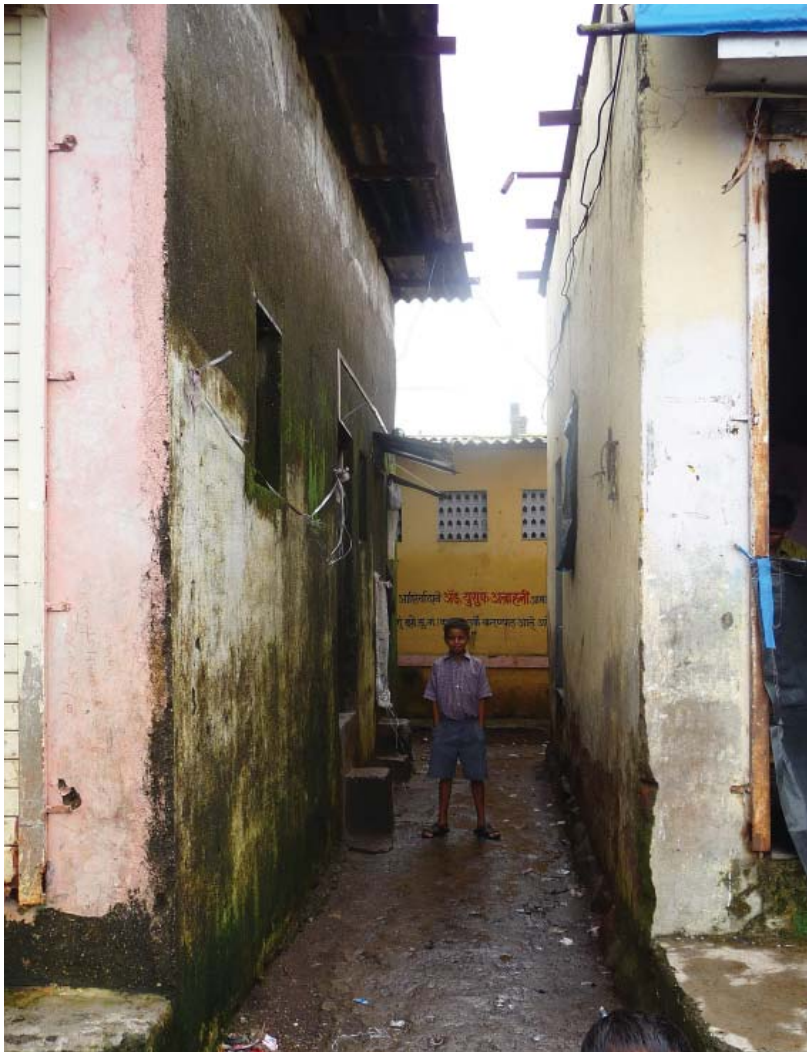
The limited opening hours and rush hours of toilet blocks can cause an accessibility problem in specific cases like disease. Physical access is another major theme. The amenities should be **accessible for users, piping and transport for supply or discharge**. Figures 33 and 34 depict how sanitary blocks are connected to the spatial context. In case of direct discharge to river or sea, the toilet blocks are typically situated on the edges of a slum. The block will then benefit from the space available to construct the block, as the density of the slum is low on the river or sea side.
In case of a septic tank the facility might also be located within the dense structure of the slum. Some of the blocks are closely surrounded by houses, causing difficult access for people and trucks for water supply or discharge, see figure 35.

Personal experiences community toilet blocks

With all the significant improvements that have been made to the community toilet blocks in recent years, I can not say using the toilets I visited during my stay in Mumbai was a pleasant experience. I remember that even the persons in the slum that helped me to do the fieldwork tried to


33. Community toilet block Ekta Nagar in spatial context


34. Community toilet block Baiganwadi in spatial context



35. Access to municipal toilet block Ekta Nagar

keep me from actually using their toilets. In figure 36, notice the woman on the right that keeps her shawl for her nose because of smells. She also holds her trouser to prevent contact with the ground. The attitude of the woman is typical for how I felt when I used the toilets: standing on my toes, trying to avoid contact with everything as much as possible. My only aim inside was to make sure that I was outside again as quickly as possible. The narrow sizes of most cubicles and corridors are not very helpful. Although many solutions for practical and social problems have been realized in the toilet blocks, the complete picture does not express that these are building of great relevance to the health of all the people in the area; the toilet blocks have a marginalized position.

3.2 Built environment

Neighborhood identification

In his book *A pattern language* Christopher Alexander states that 'people need an identifiable spatial unit to belong to'.[1] He describes the neighbourhood as the spatial area that people experience as their own. In the range of scales that are discussed in this document, it is therefore very important. What does neighbourhood mean in the slum areas of Mumbai? Alexander defines it as a distinct unit within a subculture, that has visible boundaries and is limited in inhabitants and size. As we bring into memory the way slums grow from chapter 2, we understand that slums are not naturally built with distinct neighborhoods. Planned areas often have a clear hierarchy and a subdivision in smaller structures. In the slums where people from the beginning or in a later stadium have implemented roads and other infrastructure, these structures are the subdivisions by which people can identify the place they live. However, even in these areas the neighbourhood that Alexander talks about can not clearly be found. For example, as we look at the maps of Bandra and Malvani in 2.2, the selected areas are home to about the number of inhabitants that would be appropriate for Alexander's neighborhood (500 people). In the planned area of Malvani the selected area is indeed a block defined by

1. Alexander, 1977, pp. 80.

two main roads. However, the area is much smaller then the suggested size, meaning that as we can speak of a neighborhood, it is an extremely dense one. For Bandra, the selected area has nothing to do with visible structures. Here, the density is even higher and the complete subculture can be considered as a single entity. Identification as Alexander talks about can not be spoken of in this place. Although for Ekta Nagar the density is lower, and a structure of alleys and main roads can be discovered, there is still a difference in scale: the identifiable neighborhoods count at least five times the number of inhabitants that is suggested. It can therefore be concluded that generally spoken the scale of the neighborhood is not a living entity in slums in the way that Alexander describes them.

However, the question for identification is generic. When it comes to identification with a specific spatial area, it was my experience that people do not identify with a distinct area that has clear boundaries. More likely it is that people will refer to places of interest for orientation and identification. To find a specific 'address' in a place without street names, a school, mosk or other building is used as mark. This habit is also common in the formal city. Most of the times the building that is mentioned is of greater interest then orientation only. The buildings used for identification usually have a public value, or at least a value for a reasonable group of people. Neighborhood identification is therefore closely related to identification with a group of people one belongs to.

Neighborhood in relation to sanitation
What consequences does this have for sanitation?
The name for the sanitary amenities, 'community toilet block', suggest that each block serves a distinct and comprehensive group of people. I reality, this distinction can not be found in spatial terms.
Secondly, could sanitation have the ability to play role in identification with the living environment? Where Alexander focuses on boundaries for identification, Mumbaikers tend to focus on places of common interest. However, places of common interest without exclusion can hardly be


36. Women at caretakers counter

37. Women and children gather in front of the elementary school in Ekta Nagar

found in the slums that are characterized by diversity. Sanitation might be a function that can truly be named public.

3.3 People

Relations and social interaction in slums

As we consider that what is named 'community toilet' is in reality the toilet of 400 to 1000 persons that do not share language, background, religion, and more this is a complicated request. Since it became clear in 3.1 that there is an urge to feel a personal responsibility for the common sanitary block, it is important to explain what social networks can be found in the slums.

The first entity that people will always identify with, regardless of age, is the direct family that lives together in a house. Since most people are immigrants, elderly are hardly seen in the slums. The relations with family on the country side in my experience where still tight. However, this is mostly expressed in the transfer of letters and money in daily life, since time and money for travel are scarce. If a brother, sister or cousin lives in the same slum the relations will be close as well.

Generally spoken, it is not very common to have a wide social network outside the direct personal domain: daily tasks usually keep people busy within their own domain. I spoke to many women and children that had never or hardly been outside their slum area. Men need to make long days for earning money, women alike for household tasks that are so much less convenient and more time spending under slum conditions. Women do spend a lot of time with direct neighbors during daily tasks however. It is quite common that children can go around the neighborhood unwatched from young age.

Being inside of the slums, a couple of places can observed as places where people informally meet each other. One can think of the places

1. Alexander, 1977, pp. 80.

that are also used to mark the area: public stand pipes, schools (see figure 37), shops, ‘play fields’ (wastelands), the main roads in or around an area and religious buildings. Depending on the type of place, it attracts different people. At standpipes and schools a variety of people can be found, but it will mainly be women and children. Play fields are the domain of children. At main roads, specifically those that connect the area with the city, men can be found frequently for business, waiting for transport or without distinct purpose (figure 38). Religious buildings might be open to all; children, men, women, but for a specific group only.

38. Entrance to Ekta Nagar along main road where men go for trade, chat and transport

39. Alley in the rain

4. Jars of water in the alley

Two o'clock, the narrow street is filled with people. Children run from the narrow alleys to the side of the street. They battle to be the first that may use the hand pump. Next to the gutter the hand pump is connected to the water pipelines (see figure 40)*. A bunch of women walks down the road with the typical blue plastic Jerry Cans and silver jars. A small boy walks in a small alley. He pushes a big black bicycle through the gutter that is fully packed with Jerry Cans on all sides. If I come back an hour later it is as if the whole happening never took place.*

The streets and alleys in particular are the places where slum life is exposed. Although sanitation is usually not provided on this scale, there are a couple of issues related to sanitation that are discussed in 5.1. In 5.2 and 5.3, the street life in slum is further explained in spatial and social terms.

5.1 Sanitation

Shared toilets
If people prosper and the density of the structure allows it, slum dwellers might have shared toilets, which are serving a couple of households. This will usually be a single toilet cubicle, adjacent one of the houses or as a free standing structure. This type of sanitation is rare, and if it is applied the typical problems that community toilet blocks bring along related to responsibility are less urgent. The type is not in the scope of the thesis and will therefore not be further discussed.

Street issues related to sanitation
On the scale of the street, there are a couple of issues related to sanitation that should be further explained. First of all, the guideline for provision of water sources is one per 90 persons, which means circa one per 20 households. This level is closely related to what people experience as their personal cluster of houses according to Alexander[1], especially because slum housing is dense; it is therefore likely that people consider slightly more houses as belonging to their cluster as what Alexander as-

1. Alexander, 1977, pp. 198.

sumes. Water sources can be different things, as was described in chapter 1. Most of the people in Mumbai's slums rely on piped water of private or public ownership. The taps can be shaped as public standpipes in the alleys, but more often it is loose pipes that enter the slum with limited pressure. The water should then be gained with hand pumps. If the water comes from ground sources, standpipes and the space around the tap are often slightly more appropriate. In all cases, this is an issue that is of interest for sanitation. People take the water from the standpipes to their homes. This is also the water that will be used for cleansing and flushing if water is not provided in the community toilet blocks. It is remarkable that the place around the water taps is the most vital place of the area, where many people come together during the limited hours that water is available.

A second theme that is worth mentioning at this scale is the theme of trash. A lack of good refuse collection combined with high land pressure easily leads to pollution. Though this seems to have no relation with toilet amenities, it does. As garbage on the street accumulates, defect or inadequate toilets become leftover places to dump trash (see 3.1 and figure 28). Another consequence of the trash problem is the fact that human waste that is in the built environment will not be removed. Mostly the places for open defecation are wastelands around or inside the slum, that function as trash dump simultaneously. This also means that people defecate in the middle of trash and human waste of others, with all the health risks that come along. Children might also squat directly in the alleys of the slum.

5.2 Built environment

Street profiles
The street is not only the domain where specifically women and children spend most of there time during the day in slums, it is also the scale in which interaction between human behavior and environmental design


40. Pumping water in the street

becomes most visible. Depending on the size of the street or alley, the places are used in a particular way. An overview of the possible profiles from large to small for streets is given in figure 41 to 48. See also figure 16 and 21 for the smallest alleys.

Street life

Depending on the size of the street of alley, different activities take place in there. A photography book was published last years specifically about the foothpaths of Mumbai[1]. In the scenes of this book the importance of the public street becomes clear. The foothpath is a place for business shaped by small shelters or marked by a rug on the pavement. But it is also the place where available forms of leisure take place, where people eat and drink and where daily activities take place. Sometimes people even take a nap on the street or they will come together for just a chat. Since most of the slums are residential areas in the first place and the alleys can be incredible small, the activities in the streets and alleys (apart from transport) are mainly daily activities. Only in the main roads through a slum, trade may also take place, for example on the typical push carts, see figure 49.

'Veranda'

What is more remarkable is that even the smallest alleys of slums are covered with pieces of cloth or plastic. This is the most important place for doing laundry, preparing food, chatting with the neighbors and even personal cleansing. The similarities between traditional Indian housing and the improvised slum housing becomes clear in the presence of this sheltered area between house and public area. This area can have many forms. It varies from a simple piece of plastic hanging from one side of the alley to the other, to a corrugated steel shed adjacent the house construction, a spacious shed provided with columns or a fully integrated veranda (see figure 50).

Because of the limited dimensions of alleys and streets in slums, the contact with neighbors in the use of this in between zone is absolutely

41. 'Street' profile of Bandra slum alongside railway

42. Street profile of Ekta Nagar (right) alongside main road

1. Dehejia, 2010.

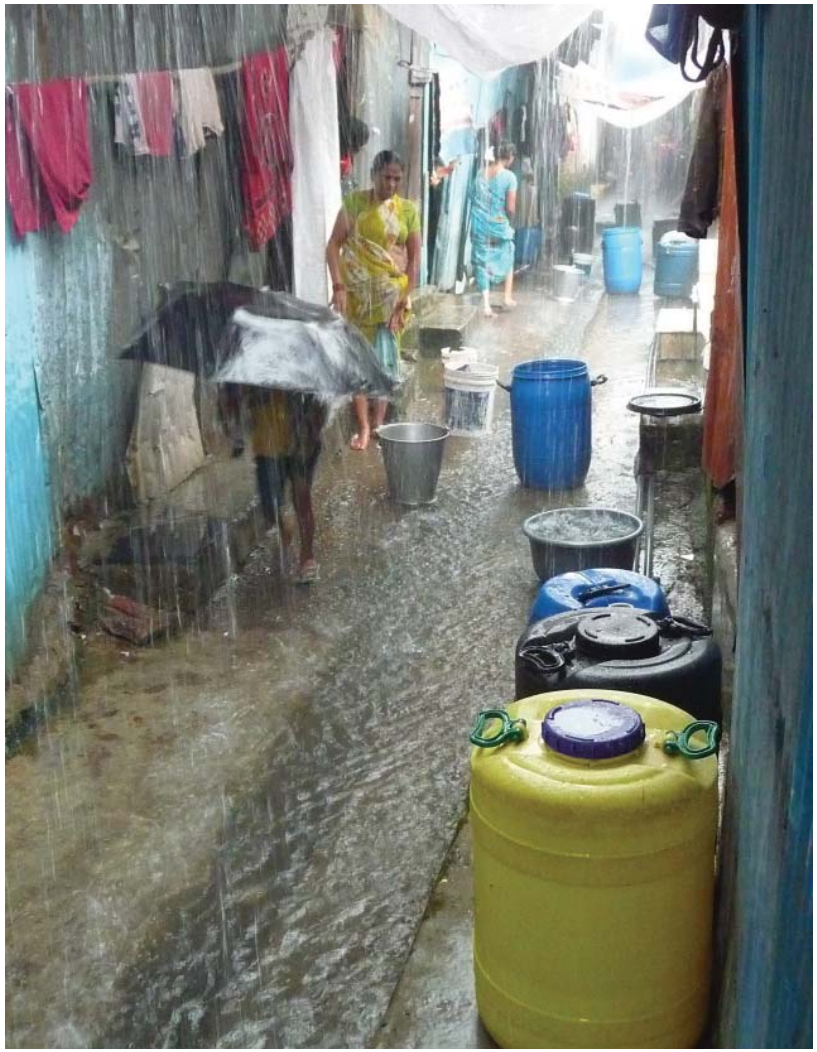
43. Street profile in Ekta Nagar

44. Street profile in Ekta Nagar

45. Profile of alley in Ekta Nagar

46. Profile of alley in Ekta Nagar

47. Profile of alley in Ekta Nagar



48. Profile of alley in Ekta Nagar

unavoidable, which in relation to water provision for sanitation means that the people sharing a single water tap will usually know each other quite well.

5.3 People

Gendered use of space

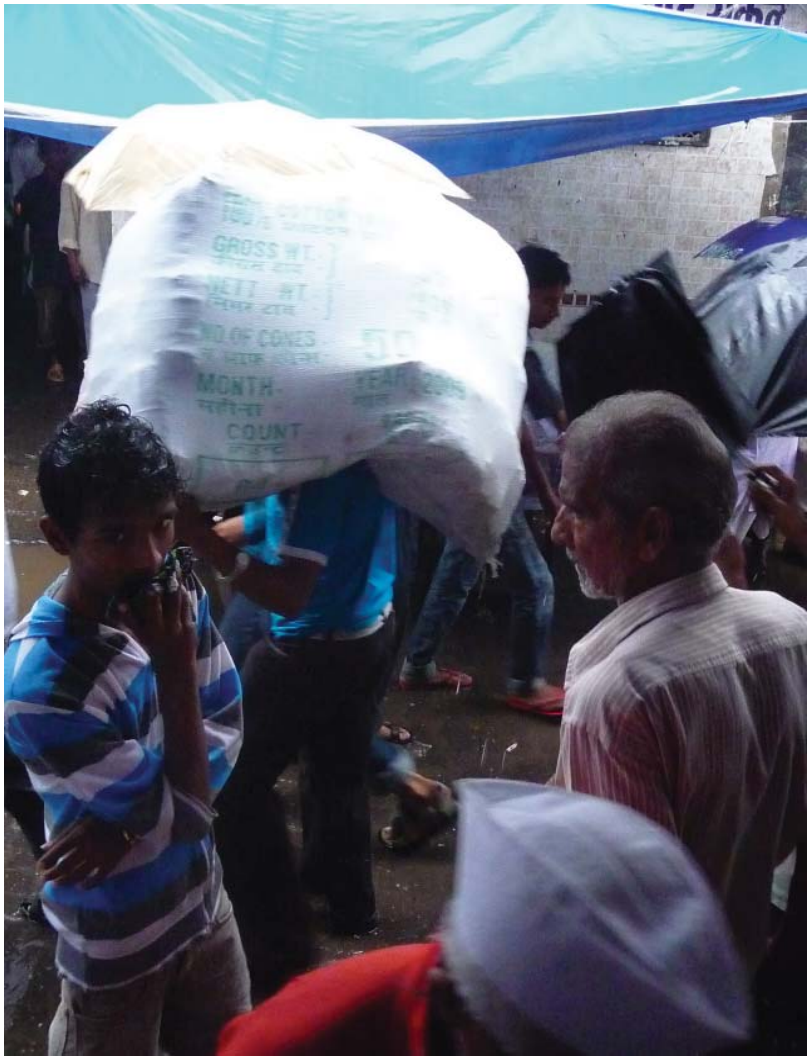
The habitat of people does not have the same dimensions for everyone. In the slum areas of Mumbai, it is quite common for women and children to have their own street/alley and maybe a couple of surrounding streets as their territory, whereas for men it is more common to work outside the slum. They will therefore be familiar with a much wider area in the city. Typical jobs can be carpenter, hand carrier of goods, seller of goods in train or on the streets, see figure 51. Due to these differences in daily activities, one can also speak of a gendered use of space in the slums. The public area in the alley around the house typically is the domain of females for their activities but also for informal meeting, whereas the main roads of a slum area seems to be more differentiated. For women it is quite unusual to be on the main roads unless it is for a direct purpose, whereas men can be seen everywhere also without direct purpose.

Movements in the area

During a stay in the slum it is remarkable how few elderly can be seen. Partly, this has to do with the fact that most people are immigrants that come to Mumbai in their younger years. However, some slums have been there for over thirty years, and still hardly any elderly will be seen there. Some of the elderly might return to the country as they age. But many of the slum dwellers are able to make progress in life, which puts the area into motion. As welfare rises a little people might rebuild their house a couple of times. Older slums will likely be multi storied areas, newer ones are relatively flat. Some might extent their house by buying the neighborhood. Other will move inside the slum, or to another slum. Eventually they might be able to afford a house in the formal sector as well.

49. Push cart selling fruits in Ekta Nagar

50. 'Veranda'



51. Carrier of goods

Relation to sanitation

The relevance of this for sanitation is mainly in the serving area of amenities and in the expected way of use. For the water taps for example, it is likely that women and children can be found there on most days. If water has a limited availability during the day, this has a large impact on the lives of women, since they are tied to the area during those hours. Whereas women in areas with continuous water supply are free to work out-of-doors. Since for women and children the house cluster feels as the safe area, it effects them if sanitation is organized on a larger scale, whereas for men this will probably not even be noticed. Organizing sanitation on a larger scale can either be positive or negative, but in any case their should be awareness of the influence of scale on the users experience. The theme of territory for creating sanitation is directly related to the theme of responsibility. In an interview with a young woman of Ekta Nagar the difficulties of common responsibilities became clear. She explained me that people that cleaning the area around the house would often mean removing the personal dirt to a place slightly further or to the gutter that could therefore be obstructed. This may sound foolish, but as public or common facilities are not provided for garbage and the first concern is to provide food for the day, dealing with these issues becomes complicated. Specifically if the hope for change is limited, taking responsibility for both personal and shared matters can easily be undermined by an attitude of indifference. The young woman used the metaphor of a hand to explain this situation as she said ‘one finger can only point, five fingers can take action’.

52. Cement wash basin

5. Secret toilets in the house

Amit Singh from Dharavi slum, Mumbai:
'I work as an assurance agent for SBI Live Insurances, so for my lifestyle I earn more then enough. In the future I want to be in business. (...) I will have a good house and live there with my family. Then we will have a bike or a car, and slowly we will have a normal life just like others'.[1]

The way in which Amit speaks is typical for slum dwellers in a sense that he assumes personal progress in live, of which the family house is an important measure. How are the house and sanitation related when houses are not provided with private toilets? This topic is discussed in 5.1. The construction and arrangement of the house is described in 5.2 and the composition of the family in 5.3.

5.1 Sanitation

Sanitation in the house
As described in chapter 2, only view households in slums have their own toilet integrated in or next to their house. A personal experience in Ekta Nagar clarifies the place of sanitation in daily life for slum dwellers:

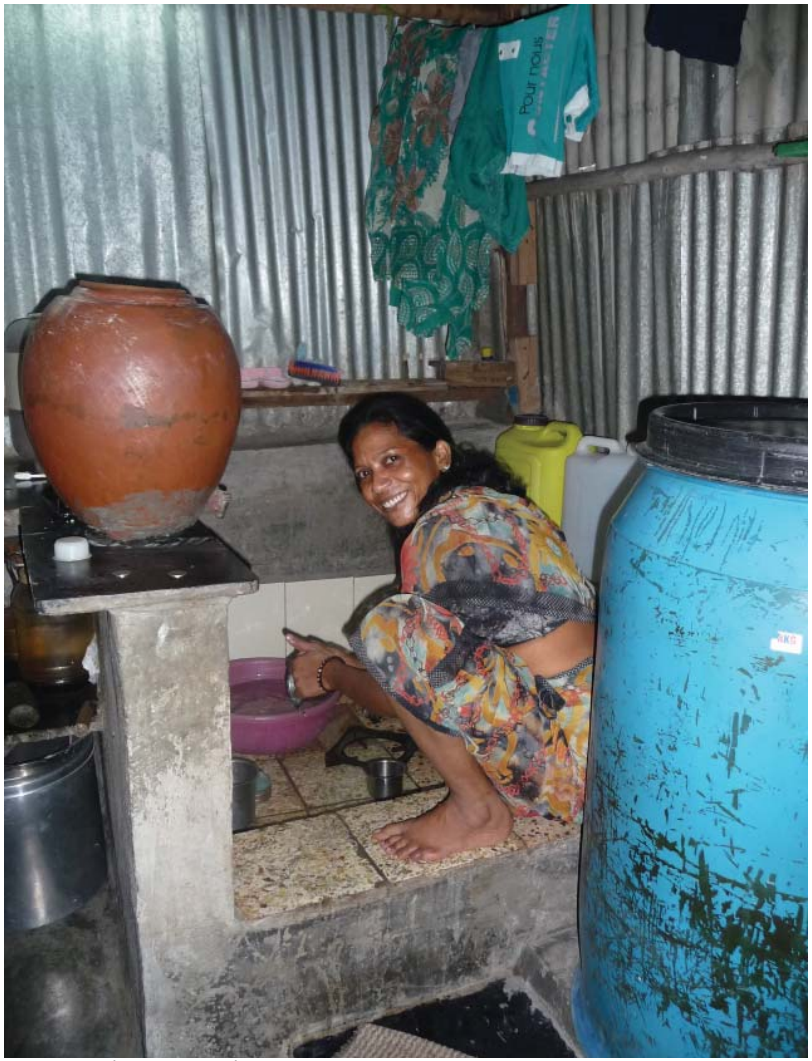
The woman in figure 53 is Sony. We have spent quite some time together. However, we were not able to communicate, except from with hands, feet and prayer. Though we had fun, I felt a bit uncomfortable after a while and decided to take a break for some time. I attempted to tell her I was going to the public toilets. She asked me 'Susu, Susu?'. I didn't understand. Again she asked me 'Susu?', now a bit edgy for I did not understand. She started pointing at the sink in her kitchen. This sink, made of cement, is used for dishes, laundry, cooking. But explicitly not as a toilet, as I learned the day before. Two girls had explained me in their house: they told me in English what they used their sink for. When I asked them carefully whether it could serve as a toilet they started giggling and denied without a doubt. But now, at Sony's place, I was asked to pee in her sink. Well... Ten minutes later she started doing the dishes there.

1. Amit in Bendiksen, 2009.

As people practise open defecation or use a community toilet, it is not very likely that people will go to the toilet block for urinating only. In almost every house there is a cement sink that looks a bit like a shower bath. This is the place for dish washing, laundry and personal hygiene, and, as the example shows, urinating.
Most houses use a corner of the home for storing different types of water for whenever municipal water will not be provided, see figure 54. An earthen pot with clay on the bottom can keep water cool for drinking (filtered or unfiltered). Several plastic tanks provide water for other activities.

5.2 Built environment
For rehabilitation schemes within the city of Mumbai, a standard of 225 square feet (21 square meters) is set for the carpet area, based on carpet area sizes of recent slum housing. However, sizes of slum housing widely vary. For the urban poor areas of chapter 2, houses of average, minimum and maximum sizes were marked in red. The sizes are most extreme for Bandra slum, where the smallest house is around 6 square meters and the largest around 120 square meters. Housing size is often related to the age of the structure and the construction type.

Slum constructing
Figure 55 depicts a sequence of housing types, which is typical for the phases that many slum dwellers are going through: from the empty handed arrival in Mumbai to the construction of a hut. The hut will be replaced by a simple corrugated steel construction, that will be provided with a foundation later on. A brick and concrete construction is the next step, which equips the house for becoming a multi storied construction.
A couple of houses in different stages of the development schemes are depicted in figure 56 to 59, see also figure 20 and 23.
For slum dwellers that construct their own property this scheme illustrates the development very well. However, now that slum dwellers have become half of the cities population, slum housing is a complete market


53. Sony at the cement sink

54. Storage of water in the house

55. Development of a family house

for the informal economy. This means that all the activities concerning housing in the formal economy do also take place in the informal economy: selling, renting, rebuilding, merging, etc. So if someone wants to change property, he can go to an estate agent or contractor in the informal economy.

Inside the house

Most of the houses are single or two room houses. The two room houses use one part for living and sleeping, and the other part for cooking and water related activities. Often there is an mezzanine floor on which part of the family sleeps. Sleeping can be done on a couch or bed, but is more likely done on the floor. In terms of hygiene there is a gap between houses that are provided with a cement foundation and those that are not. See figure 60 and 61 for interior photographs.

5.3 People

Family composition

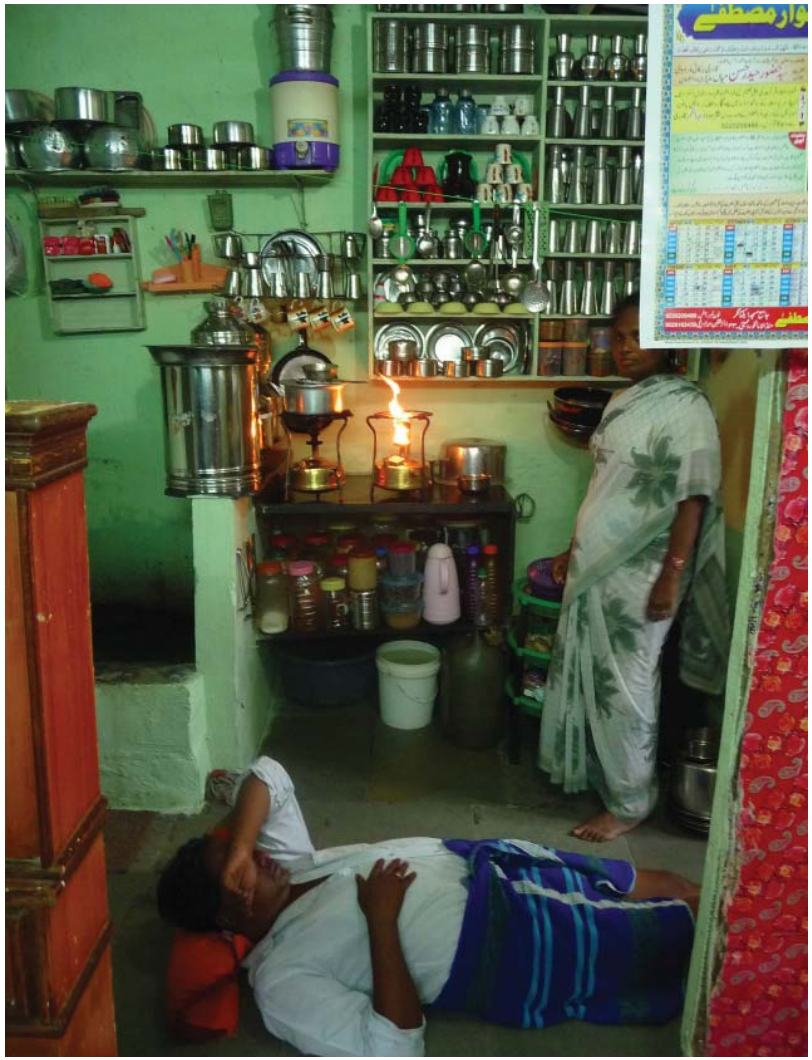
Who are the people that live in those houses? Slums are particularly the places where young men and young families start to live. It is remarkable that as speaking of dreams and desires for the future, the slum dwellers always speak for the interests of the family above personal desires. In that sense, the family really is the smallest entity that can be distinguished. Simultaneously, the roles of individual family members are distinct.
This is interesting from the perspective of sanitation. First of all, it has consequences for the way in which people use the house. Since men often go out for work, women spend a lot of time in and watching over their houses. The urgency of having good sanitation close by is therefore greater for women. Also, for men it is quite common to urinate outside, whereas this is absolutely inappropriate and also more dangerous in terms of health for women. For men, on the other side, a facility should really be user friendly in order to make the men prefer organized sanitation over going on the street.

56. Slum hut Ekta Nagar

57. Slum hut Ekta Nagar

58. Slum house Ekta Nagar

59. Slum house Bandra



60. Interior slum house Ekta Nagar

61. Interior house of Sony (Ekta Nagar)

62. Baiganwadi community toilets

6. Conclusions of analysis

The questions that have directed the analysis of sanitation in the slums of Mumbai are:

- How does sanitation operate in the slums of Mumbai?
- In what physical and social context does it operate?

In drawing conclusions from the analysis, the focus is on those aspects of sanitation in the slums of Mumbai that relate to the design of sanitary amenities. A summary of the full analysis can be found after chapter 9.

Operating of sanitation

- In the absence of sufficient and adequate sanitation, many slum dwellers practise open defecation on the edges of the slums. The consequences are easy spread of diseases, humiliation, contamination of the environment, risks for harassment for women and the possibility to be violently removed from the open defecation fields.

- In search of a solution for providing the slums of Mumbai (half of the city residents) with adequate toilets, the building of community toilet blocks that are used by 400 to 1000 people per facility turns out to be the only feasible approach to sanitation.

- In the implementation of community toilet blocks, the following problems are faced:
    - defects of the toilets
    - pollution of the toilets
    - inadequate water provision in the amenity
    - limited space for discharge / unsafe discharge of black water
    - payment for toilet use above a slum dwellers budget
    - lines in front of the toilets in rush hours
    - insufficient provision in number of seats
    - children facing dangers or disadvantages in using the toilets

- lack of safety, specifically for female users
- limited or inadequate access to the building

- In the study of community toilet blocks, the following criteria for the design of sanitary amenities can be defined based on both problems and good practises:
  - Responsibility should be clearly defined and facilitated. It is important that the responsibility is not only felt by the caretaker but also by the users.
  - There should be comprehensive availability of water.
  - In choosing a location for the sanitary amenities, access for users, piping and transport should be considered.
  - In the discharge system for black water, both health and environment should be considered.
  - Slum dwellers benefit most from sanitary amenities that are constructed in collaboration with the users.
  - In the use of sanitary amenities, specific groups require a specific approach to sanitation. For women, safety and limited distance from the house are main issues. For children size of the toilets important and for men a sanitary amenity should be created in such way that it has their preference over open defecation.

- Despite of significant improvements to sanitary amenities in recent years, the complete picture for community toilets does not express that these are building of great relevance for the health of people; the toilet blocks have a marginalized position in the slums of Mumbai.

Physical and social context

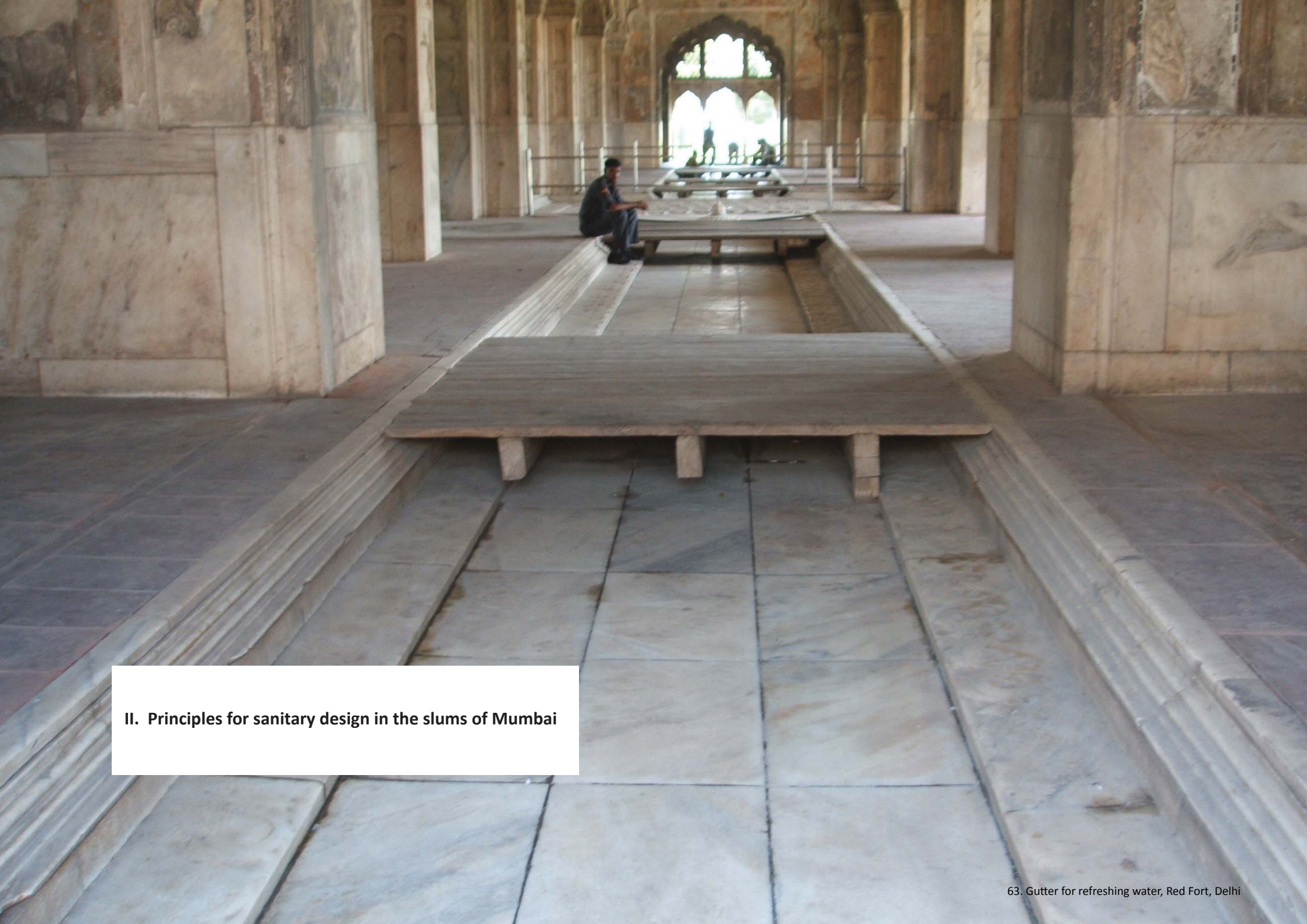
- Due to pressure on land and delay in rehabilitation schemes for slums, there is no choice but to make a living in the slums permanently for most of the urban poor. Slums are dense living areas that are mostly located on wastelands that are not owned by the slum dwellers. The areas are mainly inhabited by immigrants with a variety of social background, religions and languages.

- Slums are usually not provided with basic services from the beginning due to the informal status of the areas. In the struggles that slum dwellers face daily to make a living, constructing toilets does not have first priority, but the health risks are impressive.

- In the implementation of sanitation in the slums in a later stage, the density of the places is problematic in terms of access and availability of space. As a consequence, sanitary amenities that have been implemented do usually not strongly relate to the spatial context. By a lack of clearly defined spaces within the slum, the spatial context does not indicated a logic way of distributing and placing sanitary amenities either.

- Whereas the term ‘community toilets’ implies that the toilets are built for a coherent group, in reality the toilet blocks serve a variety of people that are not necessarily connected. Therefore, the sanitary amenities are not an integrated component in social context either.

- It can therefore be concluded that sanitation suffers from a lack of embedment in the social and physical context of the slums of Mumbai.



II. Principles for sanitary design in the slums of Mumbai

63. Gutter for refreshing water, Red Fort, Delhi

All over India, the palaces are overwhelmingly beautiful. Many of the palace complexes are an ensemble of buildings around a garden. Colonnades provide shadow with a view over the delightful gardens. One thing intrigues me in particular: the open water channels that tie all buildings together by streams of fresh water. From the spring of the water, it passes gardens, squares, colonnades and rooms for refreshment.
Traveling through some of the historic cities of India, I see large ponds in the city center where water is stored. Although many of them have fallen into decline, the splendor of the places can still be felt. Refined and highly decorated buildings surround the ponds, with stairs descending to the water.
Every time I scroll through the pictures of these places, I can not understand how the abundance of the places can exist next to the awkward shortage in the slums. I keep wondering whether something with that rich approach to architecture and water can be applied to the slums...

In order to do an architectural design proposal for sanitary amenities that suit and contribute to the slums of Mumbai, principles for design are defined in this part of the research.

Some criteria for the design of sanitary amenities were already determined in the analysis of part I of this thesis. However, two major hindrances for the functioning of sanitation in the context of the slums of Mumbai were concluded that can not be overcome by small adjustments only:

- Community toilet blocks have a marginalized position in the slums of Mumbai in relation to their relevance for health.
- Sanitation suffers from a lack of embedment in the social and physical context of the slums of Mumbai.

Concerning the first conclusion, it is my assumption that the marginality that is expressed in the toilet blocks can not be overcome by adjustments in the field of sanitation alone, because of the image of dirtiness that is indissolubly connected to sanitation in Mumbai. In search of a sanitary amenity that suits *and* contributes to the slums, the main question in chapter 7 is:

- What additional programme to community toilet blocks is able to reposition the marginalized sanitation in the slums of Mumbai?

Since the sanitary amenities are now not strongly embedded in the slums, a way should be found to firmly root sanitation in the slums of Mumbai. The leading question is chapter 8 is therefore:

- What spatial intervention in the slums of Mumbai is needed to root sanitation in the context?

Chapter 7 and 8 are separately concluded with the additional programme and a spatial intervention for the design of sanitary amenities.
In chapter 9 the results from chapter 7 and 8 are further developed in a single design concept for sanitation in slums of Mumbai.

- What are the implications of the additional programme and the spatial intervention for the design of sanitary amenities in the slums of Mumbai?

Since the last chapter can be read as the conclusion for the complete research, the thesis ends with a summary of the analysis in part I and the design principles in part II.

64. Bathing in the rain

7. Adding programme to sanitary amenities

What additional programme to community toilet blocks is able to reposition the marginalized sanitation in the slums of Mumbai?

As was concluded in the analysis of part I, slum sanitation is burdened with an image of dirtiness. In order to overcome marginalization of the sanitary function, the focus in this chapter is on finding functions that can be combined with sanitation in a relevant way. The assumption is that the sanitary function will be valued more if it is an integral part of a function that is not burdened with negative associations.
To make a successful combination with sanitation in the slums of Mumbai, the additional programme should meet two criteria:

- There should be a need for the added programme in the slum areas of Mumbai.
- The link between the sanitary programme and the additional programme must be obvious.

In the search for additional programme, three small studies have been done:

1. A creative session has been organized with six participants on the subject of adding programme to sanitation in the slums of Mumbai. Organizing a creative session is a method that is frequently used by designers in different fields to generate a large number of ideas in a short time period. Different types of brainstorming are the key to find new ideas quickly. During the session on slum sanitation, the brainstorms that took place where an oral group brainstorm, a brainstorm by drawing possibilities and a brainstorm by adding written and drawn ideas to the ideas of neighbors. The session was facilitated by Claire Visee, student in the field of industrial design. The other participants were from different disciplines to secure diversity in the ideas.
2. An analysis has been made for three Indian types of water sources. The reason for studying this specific function is twofold; during my stay in India I noticed that many of the water sources are lively places

with great relevance for the users. Besides that I discovered that these places belong to a rich architectural tradition of creating water sources in India, something that is lost in the slums of Mumbai as can be read in the chapter 4.

3. An analysis has been made of public baths in Arabic society. The function of bathing is highly valued in many Arabic areas. Opposing many countries where bathing is a highly private activity, bathing in the Arabic tradition is a public activity. Just like sanitation in the slums, it is an intimate function that is publicly organized. For this reason, the possibilities for combining with sanitation were studied.

The results of the three studies are presented in this chapter. During the studies, some aspects of the studied material turned out to be relevant as an inspiration for the project, without the direct possibility for adding programme. These inspirations are discussed in the chapter as well.
The chapter will be concluded with a motivated choice for the function to design for Mumbai's slums.

7.1 Brainstorm on additional functions

The brainstorm that was organized for idea generation on additional functions contained two parts.
During the first part, the focus was on generating quantity. By talking and drawing, a series of ideas for additional programme was produced that is summarized in the table of figure 66. One of the rules during a creative session is that ideas may not be rejected during the brainstorm, to keep the flow in the session and hitchhike on each others ideas, see figure 65. For this reason, many ideas can be find in the table that do not immediately make sense in terms of solutions.
In the second part of the session, the participants were asked to pick some of the ideas of which they thought those might have some potential for the topic. Those ideas were further worked out by sketching in cooperation: the first person draws his visualization for additional programme


65. During the creative session

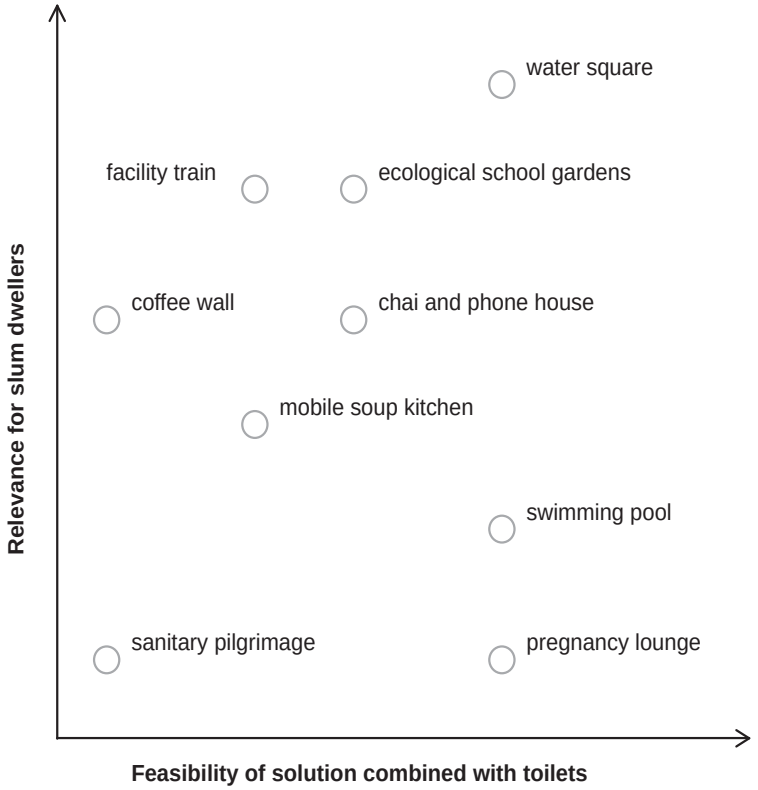
Brainstorm of additional programme to sanitation			
Transport Sanitary taxi Facility train Rent a car Bicycle reparation Drive motorcycle Rent a cart Station (bus/train) Filling station of biogas	**Education** Floating ecological school gardens Sanitary pilgrimage Pregnancy lounge Education on fornication Information centre Museum Library School Day care	**Recreation and get together (non-food)** Swimming pool Family visit Exchange actualities / gossip Social activities Going for a walk Community centre Park Dancing 'Hanging' / lounging Watching TV Resting Movies / cinema Rope carrier Pool centre Horse riding Zoo Ski dome Roller coaster Distorting mirrors	**Economy and entrepreneurship** Mobile soup kitchen Bridal fashion Employment/recruitment agency Garage / workshop Market Shopping
Eco balances and agriculture Water square 'Hanging gardens of Babylon' Vegetable garden Botanical garden Recycling and composting Urban agriculture	**Recreation and get together (food)** Coffee wall BBQ place Watertupe Café Cooking Eating Sell of chai Soup kitchen Coffee house	**Hygiene, health and personal care** Pregnancy lounge Barber Drying cloths Cleaning Mental care / psychiatry Place for laundry Beauty salon Laundry Pumping water	**Communication** Tea and phone house Call centre Internet centre Phone house **Religion and related** Sanitary pilgrimage Cemetery

66. Brainstorm of additional programme to sanitation during creative session

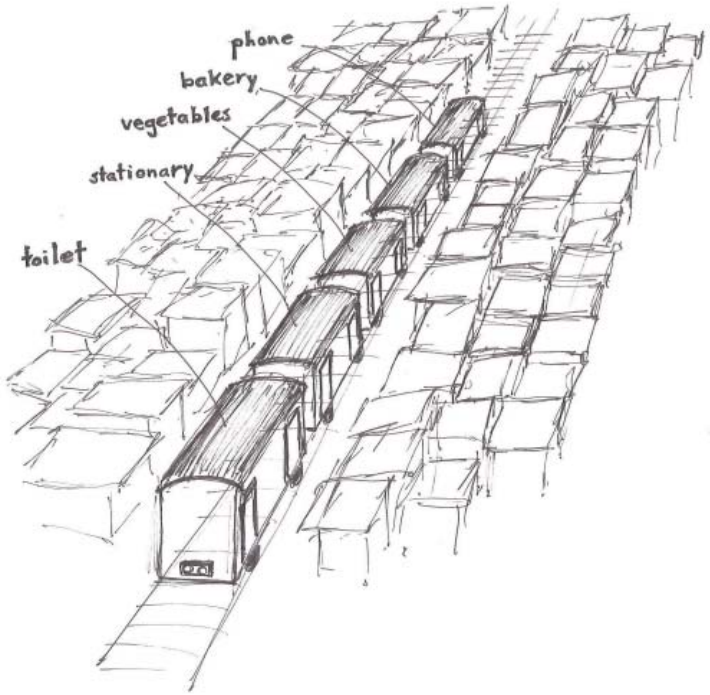
combined with sanitation, this is passed on two the next person who adds his share, and so on. The concepts that were developed in this way can be seen in figure 68 to 76.
The session was finished by making an estimation for the relevance of the generated concepts in the context of slums in Mumbai and for the relevance of the added programme in combination with sanitation, see figure 67. The solution that came out of the session as most promising was the idea for the 'water square'. The addition of places to play in slums seems significant and the presence of water is relevant to sanitation, although the feasibility of water use for recreation should be doubted in a situation of water scarcity.

To conclude, it is important to say that the results from the creative sessions should not be seen as absolute conclusions, they are an exploration of possibilities.
Some qualities for design repeatedly came back during the session and are worth mentioning for that reason. Those are:

- If it is hard to interrupt in a slum area, would it be possible to create mobile sanitation?
- If sanitation is combined with another function, can refuse materials from the toilets be serving the other function for energy or fertilizer? Or can waste water from the additional function serve the toilet function for flushing?

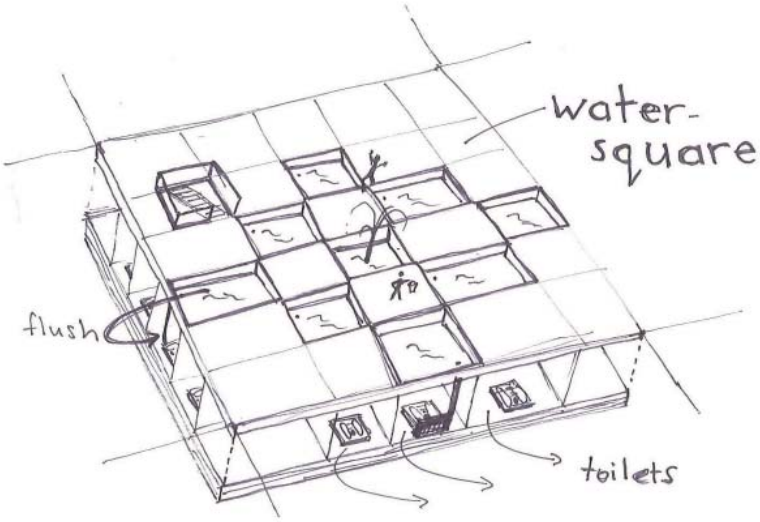


67. During the creative session



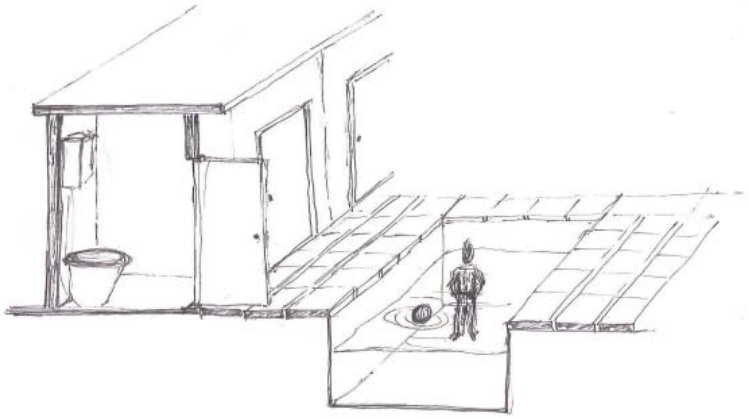
68. Facility train

Transport: Facility train
Since many of the slums are located alongside or around a railway line, the idea came up to use the possibilities of the railway line instead of intervening in the densely populated area of the slum. Instead of using the railway carriages for passengers or goods, the carriages are used as service zones. Main purpose of the train is being a mobile service centre with stops in every slum rather then transportation. Possible functions for the separate carriages are small shops for grocery and stationary, a clinic, an internet cafe and of course sanitation.



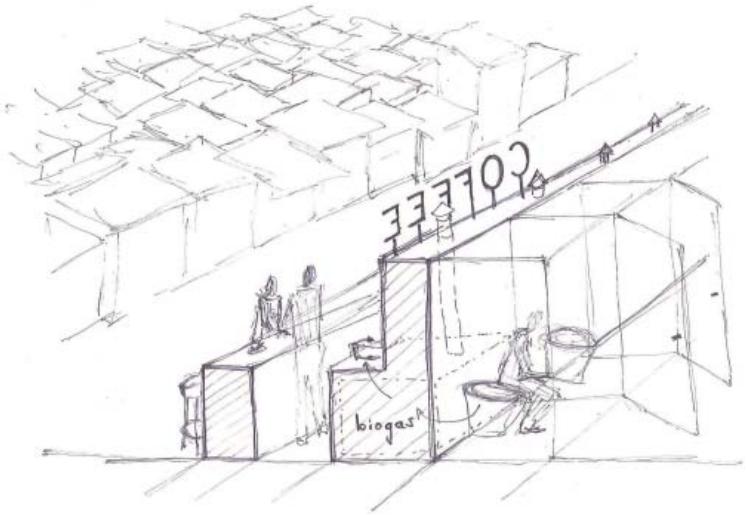
69. Facility train

Eco balances and agriculture: Water square
The water square provides open space in the slum with the possibility for water recreation. Toilets are located at a second layer underneath the playground, where the water can be used for cleaning and flushing.



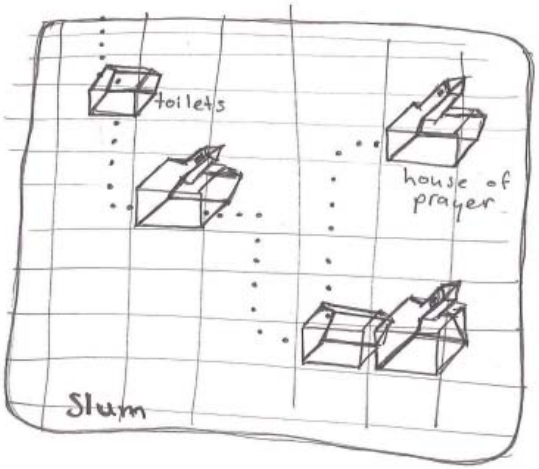
70. Facility train

Recreation and get together (non-food): Swimming pool
In the recreational sector the idea came up to combine toilets and a swimming pool. The swimming pool is a place where specifically children have a place to do sports. Adding toilets makes it a place where a variety of people comes together connected by their children. Toilets are under the responsibility of the caretaker of the swimming pool, for which cleaning and maintenance instruments can be shared.



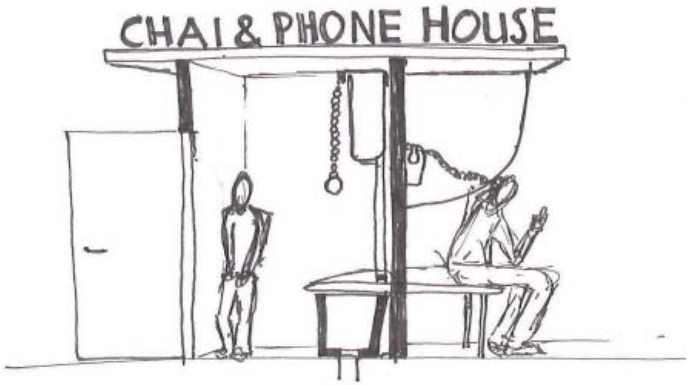
71. Coffee wall

Recreation and get together (food): Coffee wall
The coffee wall functions as a physical barrier to define space in the transition zone on the edges of a slum. The wall is equipped for toilets on one side and has a coffee counter on the other side. A biogas installation is installed inside the wall for the transformation of human waste into gas for use in the kitchen of the coffee counter.



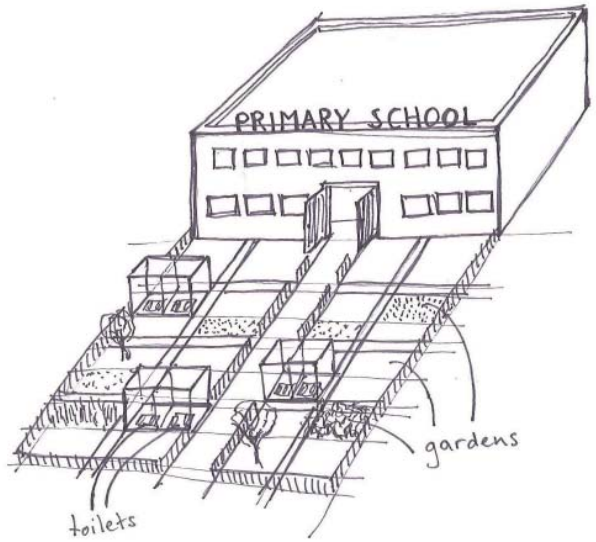
72. Sanitary pilgrimage

Religion and related: Sanitary pilgrimage
In the idea for a ‘sanitary pilgrimage’ toilets are on the main route to religious places or connected to these in order to have responsibility for the sanitary function clearly defined. In addition education on hygiene and cleanliness can be taken care of by the religious leaders in order to emphasize the importance of good sanitation for society.



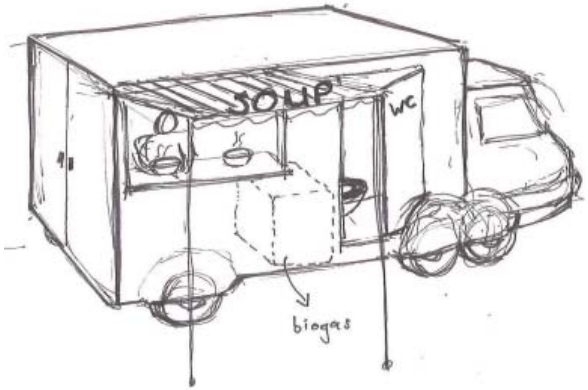
73. Tea and phone house

Communication: Tea and phone house
The tea and phone house is a small pavilion with sanitary function on the inside and adjacent canopies outside for drinking tea and making phone calls.



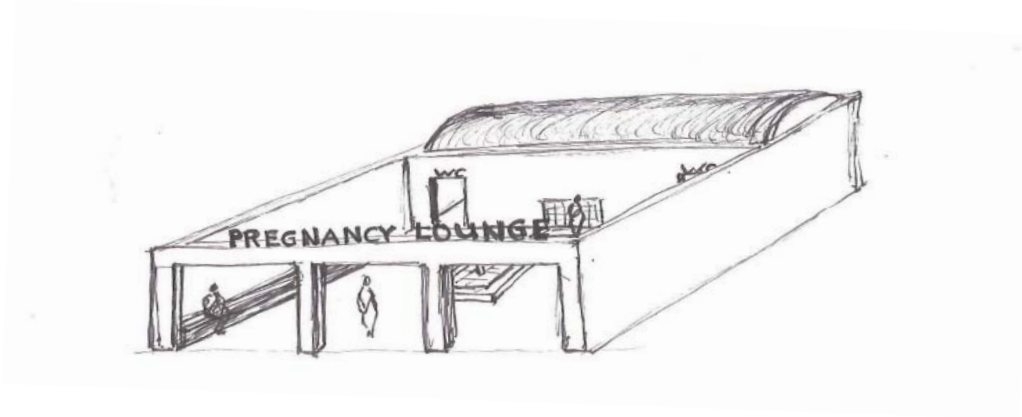
74. Ecological school gardens

Education: Ecological school gardens
The ecological school garden proposes toilets integrated in the educational environment by school gardens. The combination of toilets and garden provides opportunities for a smart ecological cycle for human waste materials. The gardens give rise to education on health and environment in the school.



75. Mobile soup kitchen

Economy and entrepreneurship: Mobile soup kitchen
The mobile soup kitchen is an interim solution for slum sanitation. It is a van specifically equipped for the combination of toilets and selling soup. The concept of street vendors with mobile carts for trading foods in now extended with sanitation and applied to a van. The commercial function helps to make sanitation financially feasible.



76. Pregnancy lounge

Hygiene, health and personal care: Pregnancy lounge
The link between health and sanitation is easily made. Physically connecting toilets and health functions is considered in this idea. One of the possibilities is to connect toilets to a health centre for pregnant women by connecting the toilets to a pregnancy lounge.

7.2 An Indian approach to water

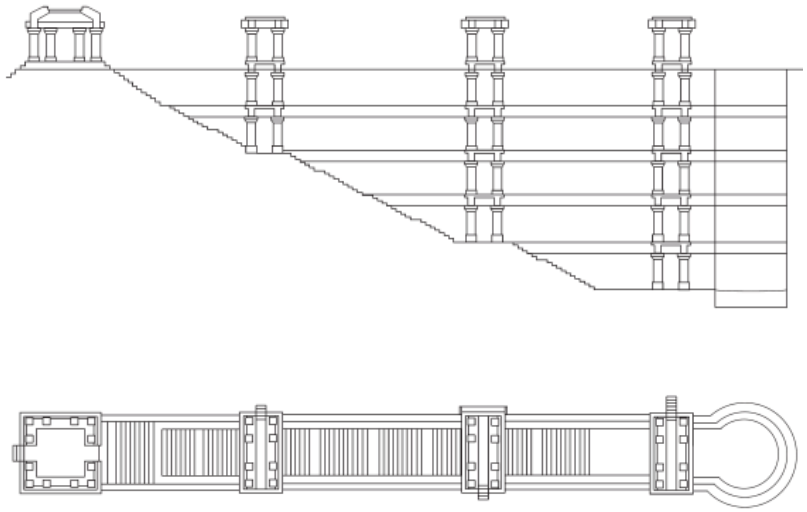
Due to the heavy rainfall during very limited period of the year, dealing with water has ever been a theme in Indian society. During my stay in India, I found different types of water sources and water storage places that are remarkable both for their design and for the lively way the sources are used by people.
The characteristics of the three main types that can be distinguished[1], the 'vav', the 'kund' and the 'ghat', are further explained is this paragraph.

Vav
Vav is the Hindi name for step well. Step wells are water sources dug deep enough to reach the ground water. Instead of pumping the water up, people descend an incredible number of steps to reach the water that reaches higher or lower depending on the season. This architectural intervention greatly influences the way of use. The stairs now function as public space, that is not only used for transit, but also for doing laundry, social interaction, drinking and more. Different phases at the stairs have different functional meaning as well. Figure 78 illustrates how this is facilitated in architecture.

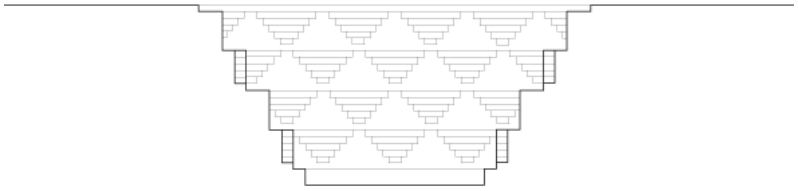
The stairs are introduced with a pavilion on ground floor level that is mainly used for social interaction and as a rest place after getting water from downstairs. On the stairs, landings are introduced where stairs and construction meet. These places are used both for activities like laundry and cleaning the body and as platforms for rest. Smaller pavilions are places at all joints of construction and horizontal traffic and are used for social interaction mainly. The platform around the source on lowest water level particularly is a lively place with men and women filling their jars, brushing teeth, washing their bodies. Children playing and even animals drinking. In some step wells horizontal traffic areas are extended with cut out spaces for more private activities like washing or even sanitation, see figure 77. Most interesting is how functional necessities for the water

1. Kulbhushan Jain, 2002, pp. 65-70 and Livingstone, 2002, chapter 1.

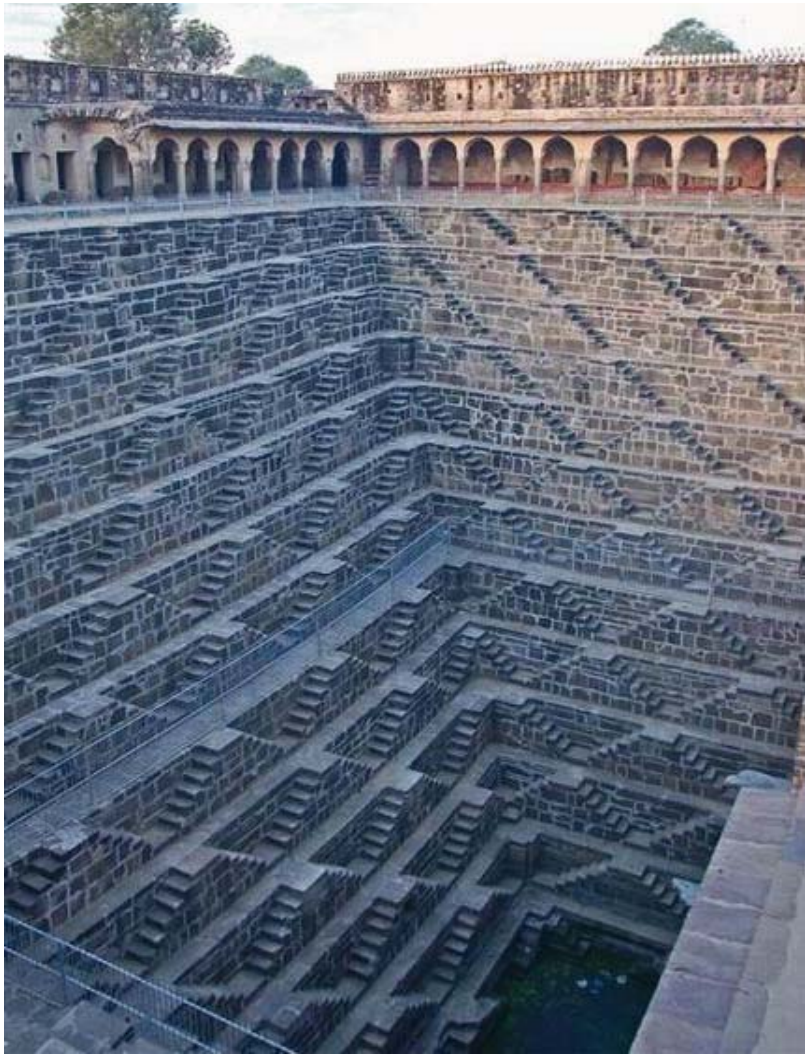
77. View in vav



78. Vav section and plan



79. Kund section



80. Kund

source are exalted to places of social importance.

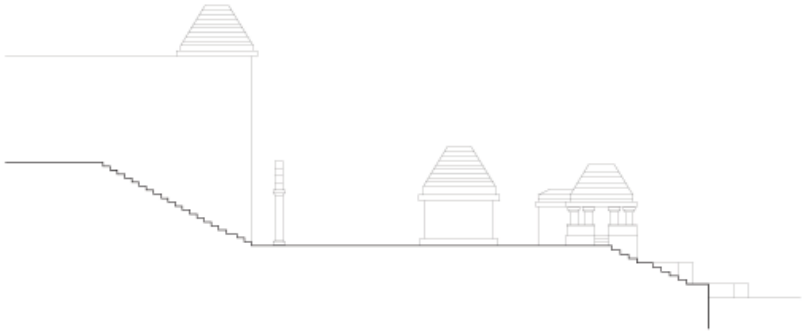
Kund

Kunds are ponds for rainwater storage. Like in the vavs, the water in the this ponds will also be reached by stairs, figure 79. The playful shape of the stairs derives from the desire to minimize the water surface to avoid losses by evaporation. The descending surface is not only appealing in expression but is in use as functional zone by users as well. The shape of the stairs facilitates a ritual way of using: one should always choose which combination of stairs to take in an almost infinite number of possibilities. It is an important value of Indian culture to never directly approach water, but always gradually. Again in this type the gradual approach facilitates places for laundry, cleansing of the body and social interaction, see figure 80. However, the approach is now less dramatic compared to the vav. This can be explained by the possibility to access the water from any direction, which also allows sunlight to enter the kund.

Ghat

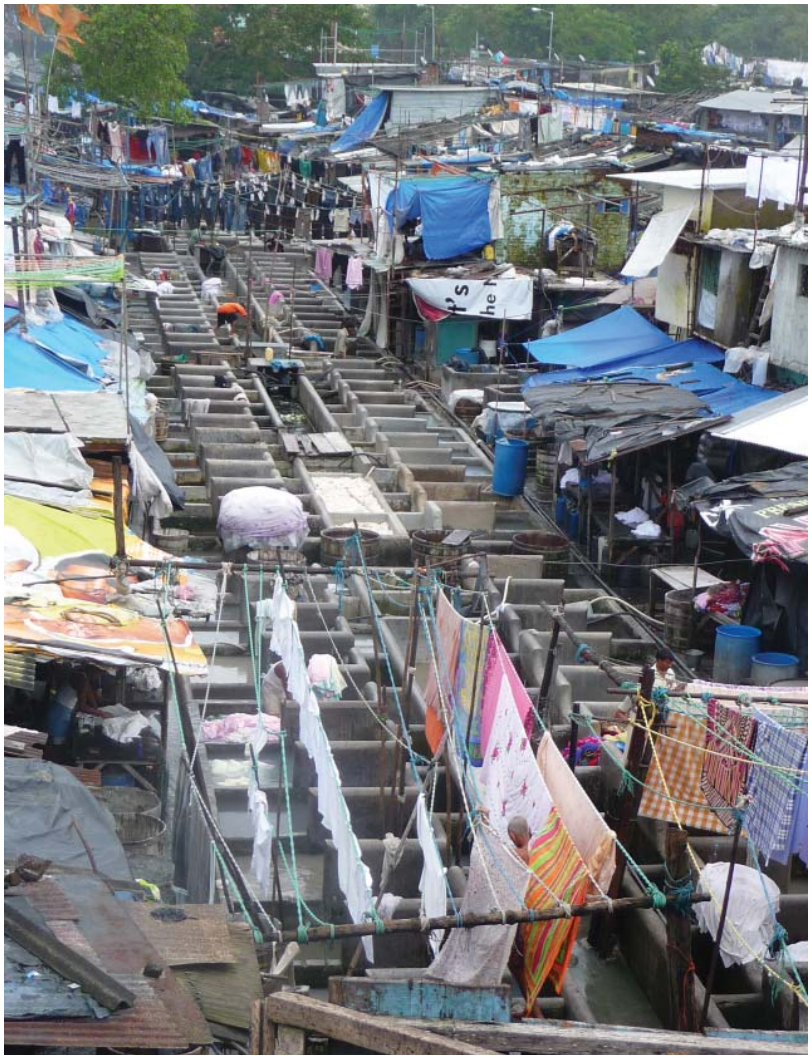
The last waterwork to be discussed is the ghat. A ghat is a wide series of steps alongside a river, sea or lake, see figure 81 and 82. The stairs shape the transition zone from open water front to water, again in a gradual way. The way of use is comparable to the kund. However, since surface water is not appropriate for drinking, the activities alongside slightly differ. Filling jars is no longer the main activity, but people can be seen fishing and it is also an important place of trade for goods transported over water.
A specific type of ghat is the dobi ghat, see figure 83. This is a place where a series of open cubicles is placed to provide space for doing laundry. Every cubicle can be filled with water, with a scrub stone in the centre. All cubicles are connected to an open gutter for outlet. The total domain is facilitated with heating installations, centrifuges and clotheslines. In some slums simplified samples of this function can be found.

To conclude, some two common qualities of the different types of water places can be summarized:



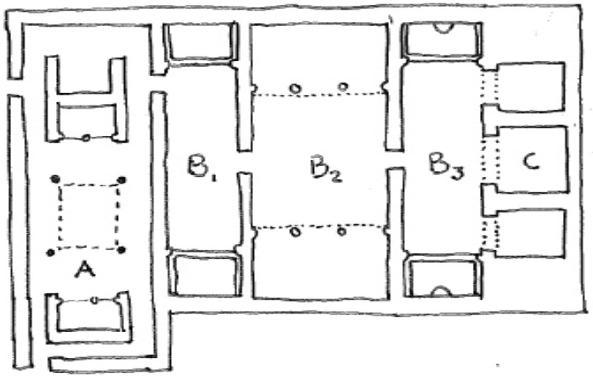
81. Ghat section

82. Ghat in use



83. Dhobi ghat Mumbai

84. Hamam e-Vakil, Fars, Iran.



85. Floorplan of baths in Alhambra Palace, Granada, Spain.

- In the waterworks the relevance of water supply for society is expressed in the liveliness of the places for more then filling water jars only. The places are intensively used for water based daily activities and they have become important places for social interaction of people. Evidently, supply of water has this ability to gather people.
- The architecture of the places maximally facilitates both practical and social function of the water sources. Functional requirements have become reason for specific moments for activity and interaction. In relation to this, the cultural value that ordains indirect approach of water has led to the strong combination of water and stairs in the waterworks.

7.3 Public baths in Arabic society

In a history thesis written on Arabic public baths, the relation between function and architecture of the baths was studied[1]. Concerning the function of the baths in Arabic society, the most remarkable finding was that public baths are not only valued as a place for cleansing the body, but four other reasons to use the public bathhouses were also found:

- The bathhouse as a place to become beautiful
- The bathhouse as a place for religious purification and contemplation
- The bathhouse as a healing place for body and mind
- The bathhouse as a place for social gatherings

The public baths are, just like sanitation in the slums of Mumbai, a public facility for an intimate function that can easily to subject to shame. However, for the public baths the place is highly valued, opposite to the marginalized sanitation in Mumbai.
In the history thesis, the different functions of the public baths were studied in relation to the architecture of the baths. In this study, three qualities in the bathhouses were found that make the bathhouses an attractive place in the eyes of the user, which will be explained in this paragraph.

1. Lanting, 2011.

The bathhouse as a place for transformation

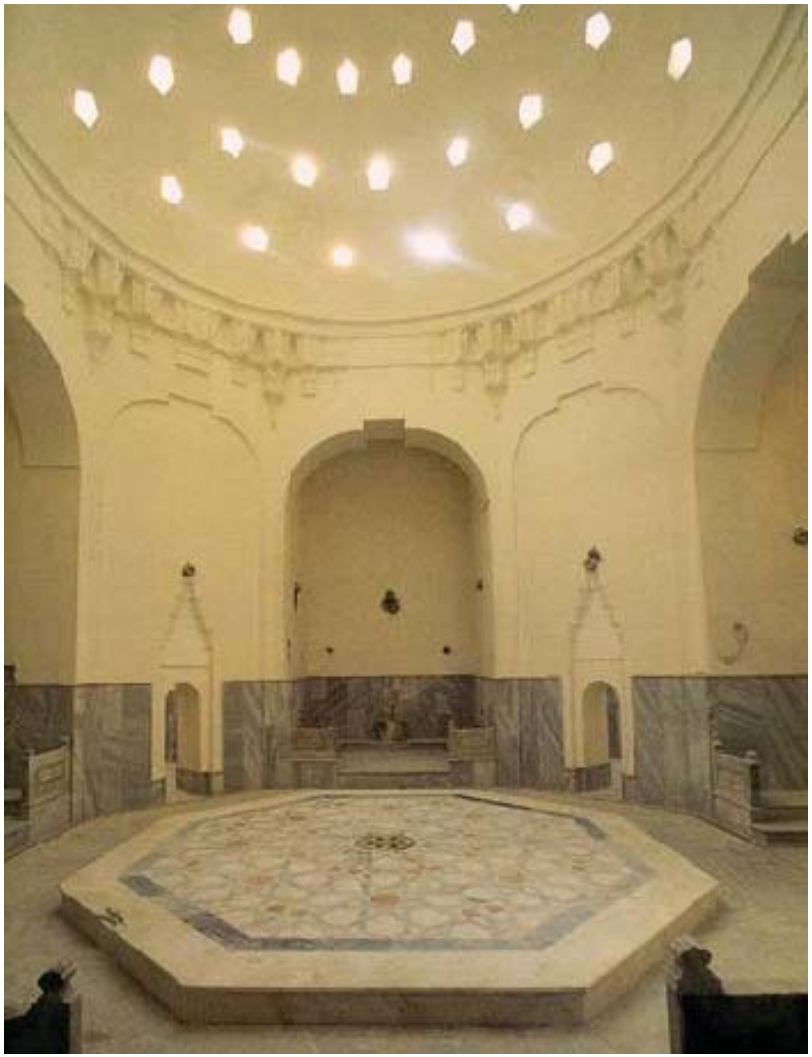
In all the reasons that users of the public baths gave to visit the place, one feature of the bathhouse was commonly mentioned regardless whether people visited the baths for cleaning, healing, ritual cleaning, becoming beautiful of having a social talk: the bathhouse is a place for transformation.

An old Moroccan saying is: 'You will leave the bathhouse different then when you came in'.[1] Poems describe the beauty that one can see in the shining skin and the fresh red color of the face of the bather. Koran interpretations focus on the transformation due to ritual cleaning in the bathhouse. Colorful nature patterns in the tiling of the bathhouse are expected to have a healing effect (see figure 84): 'Beautiful, bright and colorful scenario's refresh the soul and drive away melancholic thoughts'.[2]

In the most basic function as a place for bodily cleaning, the importance of transformation can be found in the composition of the building. In all Arabic bathhouses a sequence of spaces can be found that defines the different stages of the bathing ritual. The baths in the Alhambra palace are a good example of this, see figure 85. The first zone (A) is a rest and entrance room, secondary rooms ($B_{1,}$ B_{2}, $B_{3)}$ are the bathing spaces that are shaped differently after their function. The series of spaces ends with the heating installation room (C), meaning that people transit the spaces in opposite direction of the heat flow. The rooms for different stages of bathing also function as transition zones that have meaning in terms of hygiene. Some spaces are narrow and strictly functional, others will be used for social interaction as well.

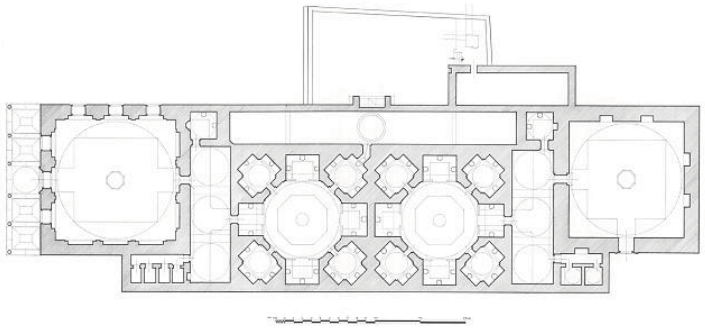
The bathhouse as a public private place for women

Marjo Buitelaar has studied the bathing habits of women in Morocco[3]. She describes the bathhouse as a complex social situation that touches many dimensions in the life of women. In this context, Buitelaar describes the value of the bathhouse for women as a 'public-private' place. She explains: 'In contrast to the domain of the house, where the intimacy of

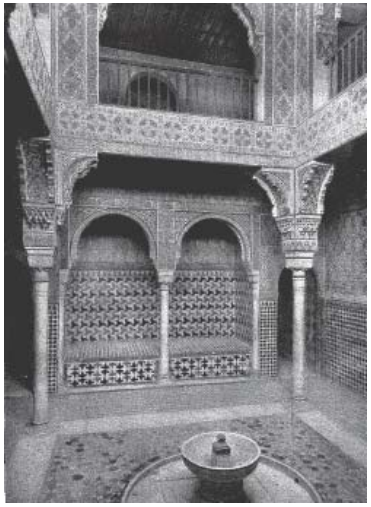


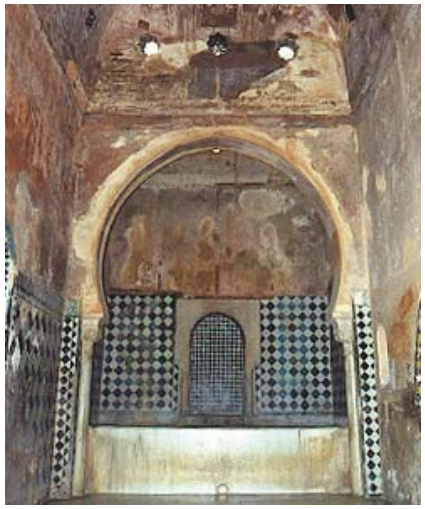
86. Main bath space in the Baths of Hasseki, Istanbul, Turkey

1. Buitelaar, 1996, pp.59.
2. Sherwani et al., 2006.
3. Buitelaar, 1996, pp. 75-94



87. Floor plan of the Baths of Hasseki, Istanbul, Turkey





88 and 89. Decorated water basins and benches in the baths of the Alhambra Palace

women can be disturbed by male family members, the women's bath-house will always be a female domain.' [1]
The bathhouse in this way is the ultimate place to be released from daily routines and social expectations for a while. Interference by male relatives is impossible, since the act of bathing should strictly be sex separated in Moroccan culture. The activities in the bathhouse take some time and do not fully occupy the mind. This concerning the privacy in the bathhouse, the second layer of it is the bathhouse as a public space for women. Buitelaar explains the popularity of the bathhouse as a consequence of the possibility for meeting women other then the direct relatives[2]. Next to possibilities for extending her social network, news and gossip will reach her here. For some women the possibility to talk confidently to a stranger without the presence of direct relatives is attractive.

The descriptions of the female habits for the bathhouse from Buitelaar can easily be imagined by studying the architecture of the baths. Although not Moroccan but Turkish, the Baths of Hasseki in Istanbul are interesting in this perspective, see figure 86. In the plan, the left wing is for male users and the right wing for female users, see figure 87.
The differences that can be found between male and female side are small but significant. The first thing to be noticed is the direction from which one enters the building. The male users enter the building in line with the longitudinal shape of the building, where a main road passes the building. The building is presented to the road by a portal resting on six columns and a doorway in the middle behind the colonnade. The female users enter in perpendicular direction from a park. Their entrance is inconspicuous and more or less hidden in a corner of the building. Once inside, the shape of the entrance hall is the same for both sides. The height of the cupola on female side is slightly lower, because the ground level on this side is slightly lower as well. The male side has a more monumental expression, for the entrance door provides a direct view in the bathing zone. This sight line divides the entrance in two symmetrical parts. From all four sides light flows in from four windows high in the room.

1. Buitelaar, 1996, pp.87.
2. Id, pp. 89.

On ground floor level, three windows provide both view and light into the building. The orderly composition of all windows is emphasized by decoration. On female side, both decoration and light entering the room are less abundant. Windows on ground floor level are absent, for which peeping in the rest room is impossible. On higher level light flows in from three windows in two directions and from only one window in the other two directions. For the perpendicular direction of the entrance door, now the bathing zone is not directly visible and the space is more sober in comparison to male side. All the small differences lead to a more private and protected composition for the female users, while not interruption the public use of the function.

Baths beyond functionality
The third quality of the Arabic baths is in the way functional necessities of the baths have been facilitated in architecture to make the baths a place of comfort. The entrance hall of the baths of the Alhambra illustrates this very well. In functional terms, this hall is an introduction to the bathing ritual. It is the place where bathers undress before bathing and redress, rest and refresh with some cold water after bathing. This functional element have been worked out in a special moment in the architecture of the Alhambra baths by placing a central fountain for refreshing water. Benches are places on the sides which are framed twice by highly decorated arches. Light from above accentuates the fountain.
In the same way framed niches are created inside the baths to highlight the basins for cleaning water. The total composition makes it appealing to take good care of oneself by cleaning the body.

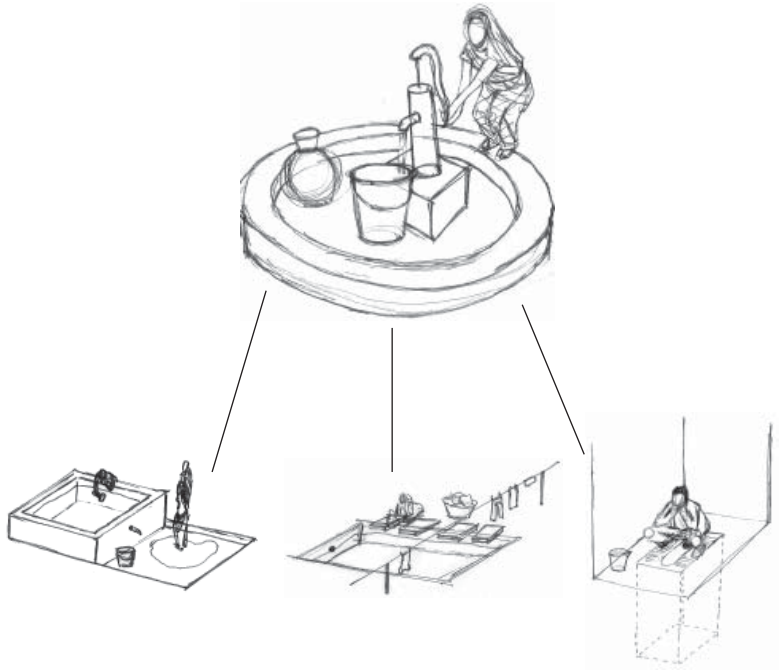
In conclusion, three qualities of the Arabic public baths make the function precious in the eye of the user:
- One will leave the bathhouse transformed.
- The bathhouse is an intimate place for social interaction away from the personal home for women.
- The bathhouse is shaped as a place of comfort for personal care.

7.4 Conclusions

In the search for a additional function to sanitation, qualities of Indian water sources, Arabic public baths and a series of other functions generated in a brainstorm have been explored. The criteria for additional programme were that there should be a need for the programme in the slums and that the link between the additional programme and sanitation is obvious.

In the study of Indian water sources it was concluded that the water sources have the ability to facilitate social gatherings for daily functions like getting water, cleaning, washing and doing laundry. This is something that was also found in the slums, as can be read in chapter 4. However, the water taps in the slums do not show any of the richness of the studied examples in design. The relevance for this function is therefore considered great in order to add quality to the place.
The fact that the facility is water based is interesting in order to link the function to the sanitary function, since comprehensive water supply is one of the core values for slum sanitation form the analysis in part I. Since sanitation is historically water related because of the habit of anal cleansing with water, the link can easily be made.

In the study of the Arabic baths, the relevance of the function in slums can not be predicted, since bathing is mostly not a public function recently in India. However, water is scarce in the slums and if a public facility for bathing is available, the link with sanitation is easily made because the functions are both intimate functions in a public setting. In this combination it should be considered that the baths are valued for the positive transformation that takes place in the bather, whereas the toilets are associated with dirt. It is a challenging combination since it might not be accepted, on the other hand it is the ultimate chance to combine sanitation with a function that is associated with cleanliness.



90. Water as a carrier for sanitary design.

In the brainstorm, water based play fields for children were preferred. The relevance of this function in the slums is great, since space to play is scarce and might be polluted by open defecation. Simultaneously, the feasibility of using water for playing should be doubted in the context of water scarcity.
In combination with sanitation, the link between playing and toilets is not very strong, but the availability of water is positive.

In conclusion, water sources could be a good carrier for the sanitary function. With water as the carrier for the design, it becomes interesting to explore the possibilities for using water sources to support other water related functions of which sanitation is one:

The design challenge for extended sanitation is to create a public amenity based on water supply, that will facilitate a combination of functions for water related daily activities: sanitation, laundry, bodily cleaning. Special attention should be paid to creating domains that are safe and comfortable for different user groups, see figure 90.

The significance of the function combination can only be assumed beforehand. The design will therefore be a test. Eventually the end product should prove the assumption for the extended sanitary function relevant in its context or not in.

91. Bandra slum

8. Spatial interventions in the slum

What spatial intervention in the slums of Mumbai is needed to root sanitation in the context?

For the construction of sanitary amenities in the slums of Mumbai, the slum should be intervened in some way. Intervening in a slum area is different from building for a formal environment due to a lack of formal regulations, but also due to the typical density and morphology as described in chapter 2. In search for a spatial intervention that can root sanitation in the area, criteria can be formulated based on the objective for defining design principles:

- The intervention should suit the slums.
- The intervention should add quality (contributes) to the slum.

In relation to the programme as formulated in chapter 7, the following criteria should be added:

- The spatial intervention should be able to facilitate sanitation and the additional water based functions.

In this chapter possibilities for intervening in the slum are explored based on the basic spatial characteristics of slums as described in chapter 1 and two.

8.1 Slum interventions

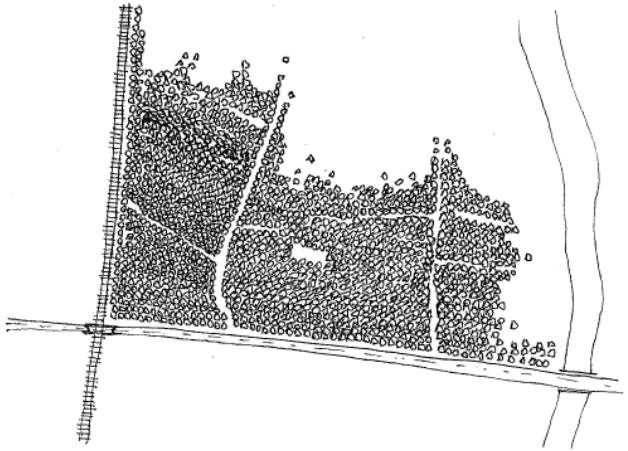
On the edges of slum

Slums are most often located on wasteland. Edges are defined for example by the flood area of a river and empty wastelands of mud or grass. Furthermore, the areas are typically cut of from the formal city by highways and railway lines. See figure 92 for an analytic drawing.

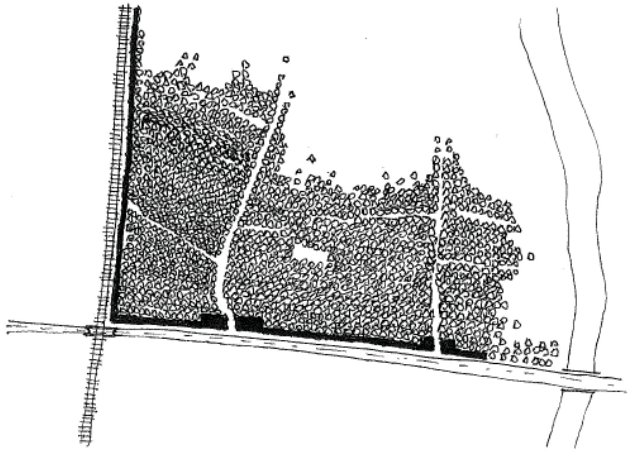
The idea to place sanitary blocks on the quiet edges of a slum is not strange, since there are no complicated interventions needed within the slum structure that is informally organized. Besides that connections for

water supply can easier reach the outsides of the slum, wastelands and rivers can also directly be used as outlet for sewerage.
Figure 93 depicts the possibility of placing sanitation on slum edges, since the organization of sanitary building here might be able to contribute to a solution on the edges of slums: dangerous zones alongside railway lines and highways specifically for kids, humiliating scenes of people defecating in the open sight of high way users, highly polluted empty zones and flood areas that spread diseases deeper inside the slums. One can imagine the benefits of creating a building as a buffer between living area and polluted wastelands, highways and railway lines.

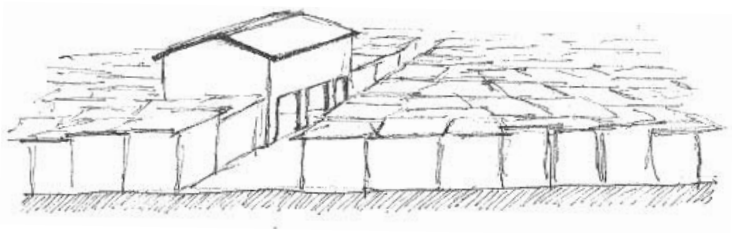
Within the dense structure of slum
In chapter 3 some attention was already paid to the inner structure of slums, in which the differences from slum to slum are typical. One thing all slums have in common: the structure is dense and the ground coverage is very high since all houses have access on 'street' level.
Interventions of different types can be imagined in this structure to create sanitary buildings, that deal in different ways with the issues of access and marginality of sanitation in the built environment: connect to main routes through the structure as much as possible, neglect the structure, built inside the rarely available open spaces, create a building to fit the dense structure, create open space instead of adding structure, building on top of existing and creating mobile sanitation, see figures 94-100.



92. Analytic sketch of slum edges

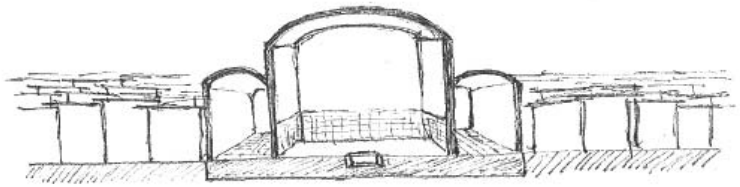


93. Interventions in the slum on the edges



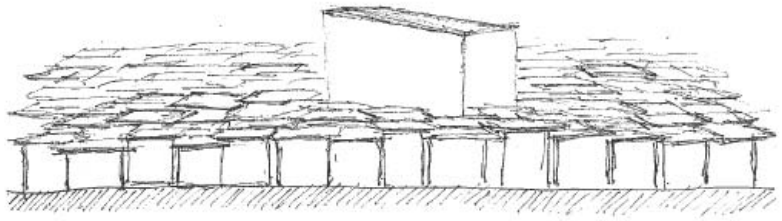
94. Connect to main routes

Connect to main routes
Some slums have a more distinct subdivision by streets and alleys then others. In those provided with some sort of main streets, the plots around the main streets are interesting for sanitation in the frame of visibility and accessibility.



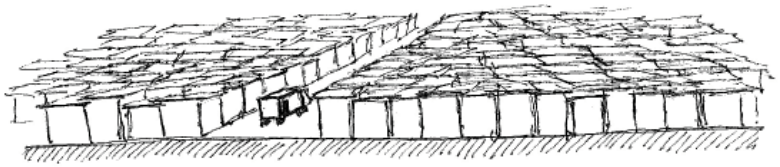
95. Fit in the dense structure

Building to fit in the dense structure
Building within the existing slum structure requires a different approach since the physical approach to the building happens in a narrow area. Just like a monumental building doesn't fit in a regular street, a regular facade doesn't fit in the alleys of slum. If something is built within the existing structure, it therefore seems logic to create something that do emphasizes the inner world more then facade.



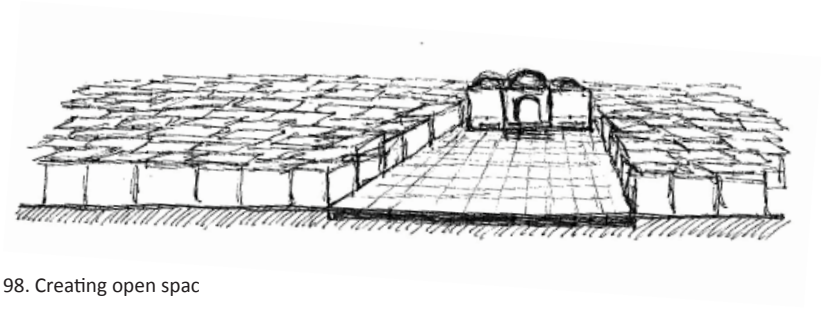
96. Neglect the existing structure

Neglect the existing structure
Coming from the desire that the new structure will add to the slum and also will trigger new building initiatives, predecessors have explored possibilities to transform slums by adding a structure that is in strong contrast with the existing. An example of this is the intervention depicted on this page of Vicciecca in South America.



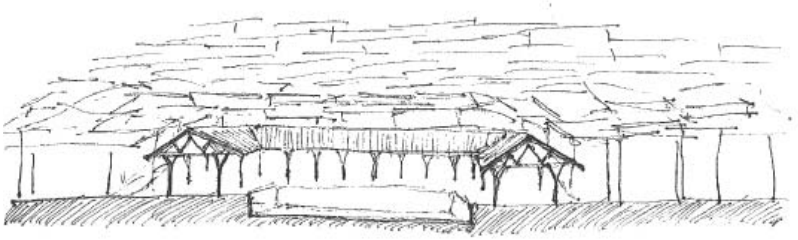
97. Mobile sanitation

Mobile sanitation
In relation to the solution of connecting sanitation to main infrastructure like streets, another approach is to let sanitation make use of the main infrastructure by creating mobile sanitation, as was also seen in the previous chapter. By drawing it also becomes clear that there is a desire to create something with a permanent character, since a mobile solution will not be able to essentially add value to the area.



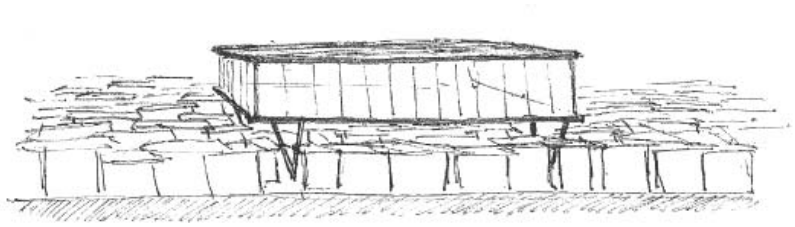
98. Creating open spac

Creating open space
In the observation of the structure the absence of open space is striking, whereas the use of (semi) public areas is very popular both in Mumbai in general and in slums. This is an incentive for creating a built facility that surrounds open space as a save, yet public open area. This is particularly interesting because of the functional program that has many outdoor elements.



99. Build inside open spaces

Build inside available open spaces
In slums where open spaces can be found, these places can be used for building in order to not have the problem of intervening in the existing houses and buildings. However, open spaces are rare and their presence is precious in the dense structure. Still, adding something small in an open space can be a motive for upgrading the open space to a valuable space, since they are now often highly polluted or spoiled.



100. Building on top of existing

Building on top of existing
Respecting the existing could result in building on top of the existing. Visibility of the sanitary amenities could be a positive result. However, there seems to be some inequity in creating a facility with a permanent character on top of privete structures with a temporal character.

8.2 Conclusions

The criteria for the spatial intervention predicted that the intervention should suit and add quality to the slum area and be able to facilitate sanitation.

Considering the solutions on the edge of the slums and within the slums, some values can be found in the study for the desired intervention:

- Constructing on edges and along main roads makes access easy.
- Creating height makes the building visible.
- Ground based buildings have a more permanent character.
- Building on the edge can create a buffer between.
- Permanent interventions in the slum might become an example for construction in the direct surrounding of the building.
- Building within the dense structure for facade expression limited, which required special attention for transition zones and interior.
- By creating open spaces in the slum, density is decreases instead of increased.

The possibility of creating open space in the slum is particularly interesting:

- Within the context of slums, adding something is always problematic since density is one of the main issues of the areas. Creating open space is therefore highly desired as an additional quality for slums. Recently, Mumbai has the lowest open space ratio in the world, there is only 0.03 acre per population of 1,000 as against 5.3 acres in New York and 4.4 acres in New Delhi[1]. In slums the availability of open space is even lower. In addition to those data, my personal experiences in the slum confirm these data by the wish of school children for a school garden or square.
- In the analysis of sanitation, access and the availability of space for discharge turned out to be important for designing sanitation. The creation of open spaces will therefore be able to facilitate sanitation very well.

In intervening the slum areas by creating open space, it should be considered that buildings that are removed can not easily be position elsewhere because of pressure on land. The main concept for the intervention is therefore to intervene by making a building of the court yard type, in which removed functions in the slum can be placed on top of the building, surrounding the court yard.

1. Mukherjee, n.d..

101. Water supply in Ekta Nagar

9. Implications for sanitary design

What are the implications of the additional programme and the spatial intervention for the design of sanitary amenities in the slums of Mumbai?

The results from previous two chapters have defined the design challenge in programmatic and spatial terms:

- Creating a public amenity based on water supply, that will facilitate a combination of functions for water related daily activities: sanitation, laundry, bodily cleaning.
- Creating open spaces in the slum by designing with court yard typology.

The principles that were defined for additional programme and spatial intervention have implications for the sanitary amenity that will be designed. In this concluding chapter the proposed programme and intervention will be further developed in a coherent concept for the slums of Mumbai, that results in a quantified programme.

In the first paragraph, the needs for sanitation and additional programme are considered in quantity and quality. In the second paragraph, the way in which the functions have to be distributed over the slums is subject of research. In the third paragraph, the possibilities for saving water are studied. Paragraph four concludes with the programme of requirements.

9.1 Needs for water supply, toilets, bath and laundry facilities

Research in urban poor areas of India has displayed both recent situation and directives for water supply capacity and toilet provision. Bathing and cloth washing is now done in the private domain inside or in front or the house, without specific facilities. However, directives for a newly introduced public function for bathing and laundry can be abstracted from data on different types of water use after proportion of consumption.

Water supply

For all India around two third of the urban poor is expected to have pri-

vate water in their houses. One third relies on standpipes or other shared sources.[1] However, my personal experience in Mumbai's slums is that shared sources were the standard, with only few exception for the 'rich' squatters of the neighbourhood. The guideline for the distribution of spot sources and standpipes in India is that one source should be available for twenty families within a distance of 100 meters from the house. People should be able to obtain a minimum of 40 liters of water per capita per day (lpcd) for this type of sources. The norms for households with private water supply is much higher, between 70 and 125 lpcd depending on presence of underground sewerage. Even though 40 lpcd in itself is insufficient, in reality the availability may be around 25 lpcd.[2]

In the scope of the design of places for water supply, two things can be noticed. First of all, as seen in many of the other services for slums, the already less endowed inhabitants without private water supply suffer from strict limitations in water provision. In this context, attention for adequate and sufficient provision of water is even more important. Secondly, the most reasonable scale of intervention is on housing cluster level, due to limitations in walking distance with heavy water jars for home use.

Apart from the capacity of standpipes and spot sources, some other features of the sources are relevant in this context. The water supply for sources based on piped water often has a limited period of supply each day or supply is irregular due to low pressure. This has many implications for the flexibility during the day for mainly women in the slums. From a design perspective, inhabitants will greatly benefit from storage that equals the availability. Also, sometimes riots are reported at the standpipe, because the prices for water rise by intermediaries that own money by pumping the low pressured water.
Another problem of the water supply is that quality of the water specifically for drinking is not guaranteed. Additional purification might be needed.

Furthermore, water waste at standpipes is a generic problem in Asian cities for three reasons[3]: with irregular supply people are eager to take as much water as possible at the moments of availability. Overflowing buckets are very common in this situation. Leakage is the second cause for waste. Both of these problems are directly related to the issue of responsibility and care taking. The third reason for waste is the illegal tapping of water for example from industrial areas, which is sold to the urban poor for daily use. Exact data on waste in Mumbai are not available, but an order of magnitude can be imagined by knowing that the percentage of non revenue water in Delhi is 50 percent[4].

Data for design: 40 lpcd required per 20 households (90 people) on housing cluster level which is a capacity of 3600 liters per day for each standpipe at housing cluster level (assuming that all of the people in one cluster rely on a standpipe and none have water supply at household level).

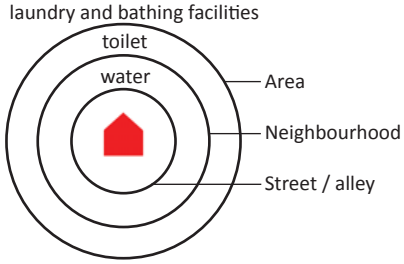
Toilet provision
Sulabh, one of the social services organizations in Mumbai, has a minimum standard for toilet provision of one toilet per 50 users[5]. In recent situation, occupation varies from 58 to 273 users per seat with an average of 81.
As was mentioned already in the first part of the report, from an economic point of few significant capacity building for toilet seats is only feasible by constructing community toilet blocks for 400 to 1000 people. As a consequence of these directives, an average toilet block will contain 8 to 20 toilet seats. Determined by serving area the amenity relates to the scale of 'neighbourhood', even though this scale can not be discerned as such in most slums of Mumbai.
Besides the specific number of seats, an estimation of water capacity required for toilets can also be made. The required capacity is dependent on three factors: use of anal cleansing water, use of flushing water and water used for cleaning the facility. Flushing water will usually be the defining factor for capacity. There are three possibilities: flush toilets, pour flush

1. Laquian, Tewari and Hanley, 2007, pp. 46.
2. Id., pp. 47.
3. Id., pp. 252 and 253.
4. Id., pp. 252 and 253.
5. Interview with Kini, 2010.

Table 7: Activity-wise Distribution of Water Consumption in Cities (% of total consumption by households / day).

Activity	All 7 cities	Delhi	Mumbai	Kolkata	Hyderabad	Kanpur	Ahmedabad	Madurai
Bathing	28.2	31.7	23.7	37.1	25.6	29.1	22.8	26.6
Washing clothes	18.6	14.2	24.3	14.0	20.9	16.3	21.4	18.9
Drinking	4.2	5.0	4.2	2.6	4.3	3.8	4.9	4.9
Cooking	3.0	3.7	1.7	2.3	3.1	3.2	3.3	4.2
Toilets	20.0	16.5	21.6	15.9	24.1	20.1	19.1	25.7
Cleaning house	7.3	7.0	6.6	11.7	3.5	5.7	12.4	1.9
Washing utensils	16.3	16.5	17.4	16.1	16.5	15.4	15.2	16.1
Others	2.4	5.6	0.5	0.3	2.0	6.3	0.9	1.7
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

102. Daily water consumption in Indian cities



103. Functions in relation to distance from home

toilets and dry toilets. Dry toilets might result in contamination due to the absence of running water as was explained in part I of the research. Flush toilets require 7 liters per use, whereas pour flush toilets require only 1,5 to 2 liters per use. Using normal flush toilets seems irresponsible in a situation of water scarcity. However, in case of pour flush the risks for contamination are higher by the lack of pressure in flushing, for which availability of running water for cleaning becomes even more important. Using anal cleansing water is the standard in India in contradiction to the European habit of using toilet paper. Presuming that pour flush toilets will be used in the design, an high estimation for total use will be 3 liters per use including anal cleansing water and cleaning water.

Data for design: amenity of 9 toilet seats for 450 users (100 households) on neighbourhood level, which requires 1800 liters of water per day assuming that people use the amenity twice a day.

Bathing and laundry

Since bathing and doing laundry are part of water use inside the house mostly in Mumbai's slums, water consumption for these activities can not easily be distinguished from water use for drinking, cooking and cleaning. Although data for Mumbai's slums are not available, data for all Mumbai's water consumption are available percentage wise, see figure 102.

In the previous, water supply capacity was based on data that include water for laundry and bathing. According to the table, 23,7% and 24,3 % of this water should be reserved for bathing and laundry. However, the distribution of water over different activities is assumed to differ in slums from other parts of Mumbai, since priorities shift in case of limited availability. It can therefore be assumed that water consumption for drinking and cooking would percentage wise be higher, whereas water for bathing and laundry would be lower. The assumption made for the design is that around 20% of the water would be used for laundry and another 20% for bathing. This means 8 lpcd for each function.

The second question is on what scale facilities for laundry and bathing would prosper. Laundry facilities are now occasionally placed in slums as shared facilities. Most people use the floor inside of outside their homes for cloth washing. However, sharing a facility can bring about water saving and the inhabitants may benefit from it in terms of strengthening relations inside the slum, in this case for women.
Bathing just like laundry in usually done in front of the house, or if the house is has something like a sink inside the house. Due to lack of privacy, the washing is usually done with cloths on. A bucket of water will be used to wash the body with the hands, often an extra jug is used to sprinkle the water over the body.
In most cases the water used for laundry and bathing is the same as used for drinking and cooking. However, quality requirements for laundry and washing are less high. From this perspective, it might be beneficial for bathing as well to create shared facilities in which water saving can be established by for example apply rainwater harvesting. At household level rainwater harvesting may be applied now as well, but only for short term purposes that do not fully exploit the possibilities. Shared facilities also create possibilities for (gender related or individual) privacy from which health could benefit.
Since a shared facility for bathing and laundry would be new, it can not be expected that everyone would switch to it. Therefore, it would be exaggerated to create a facility at a very small scale. Specifically if the functions are making use of rainwater harvesting, some space is required for collection and storage of water. It would therefore be recommended to create the experimental facility for bathing and laundry on a larger scale then sanitation, for example on the scale of living area that exceeds neighbourhood.

Conclusions for design: amenity for shared bathing and laundry facilities should be created at district level. A district is assumed to contain around four neighborhoods and therefore contains around 400 households (1800 people). Bathing facilities would count for 8 lpcd, the same is assumed for doing laundry. An estimation for the percentage of people that would make use of shared facilities for laundry and bathing is 5% (90 people). This means that a district facility would need 720 liters per day for serving laundry and another 720 for bathing without saving water in comparison to the home situation.

9.2 A network of water based functions

Water based functions and serving area
As can be concluded from the previous paragraph, scales on which different functions are needed do not match. From this perspective, the creation of a series of facilities in relation to the required serving area is more desired. The diagram in figure 103 shows the different function in relation to the distance from the house that is acceptable for users.

Water based functions as landmarks in the slums
The approach of interventions on different scale levels is interesting in a way that is directly relates to identification with neighbourhood as was discussed in the analysis of part I of this thesis. Challenge in this would be to create facilities in every scale that enable people to identify with this specific scale by values like recognizability, possibility to orientate, qualitative shared or public space that stimulates a sense of belonging.
In figure 104 - 106 the possibilities for creating sanitary functions on the level of district, neighborhood and street with which people can identify are sketched.

A city wide system for water based functions
Since the water related functions for the design invite for interventions in the slum at different scale levels, the idea of quantity production becomes reasonable. Specifically for the smallest interventions like creating a water supply place it would be cost-inefficient to make unique designs, since the requirements are more or less similar everywhere. It therefore becomes logic to create a network that spreads the three proposed types over a

slum area and in a larger scale over the city. See figure 107 for a visualization of the network in a slum, that is based on the quantity data in 9.1.

Generic approach, specific requirements
Though quantity production is reasonable from the city wide perspective, knowing the inside of slums it becomes that a slum asks for very location specific interventions. As explained in chapter 1, due to lack of land ownership rights public or common interventions are difficult to arrange. This literally means that it will be hard to empty clearly defined area of land for sanitary and water related functions. This means that specifically the larger sized functions should be designed specifically for the plot that can have irregular shape and context. In terms of cost-efficiency this fact leads to the idea that the system of building can be generic and that this system should be based on a construction method that does not depend on a specific grid size or material that has a large basic dimension. However, uniformity in materials with small dimensions and uniformity in generic sanitary element like taps and toilet pans is highly desired.

A city language for water based designing
This consideration has led to the design principle of creating a city wide language for slum sanitation that can easily be recognized on every location and in different types of facilities. In order to illustrate this principle, a reference can be made to several city wide facilities. The traditional public phones in London are a good example of a recognizable city landmark, see figure 108. Another example are the underground entrances in Paris, see figure 109. Both have become a city brand.

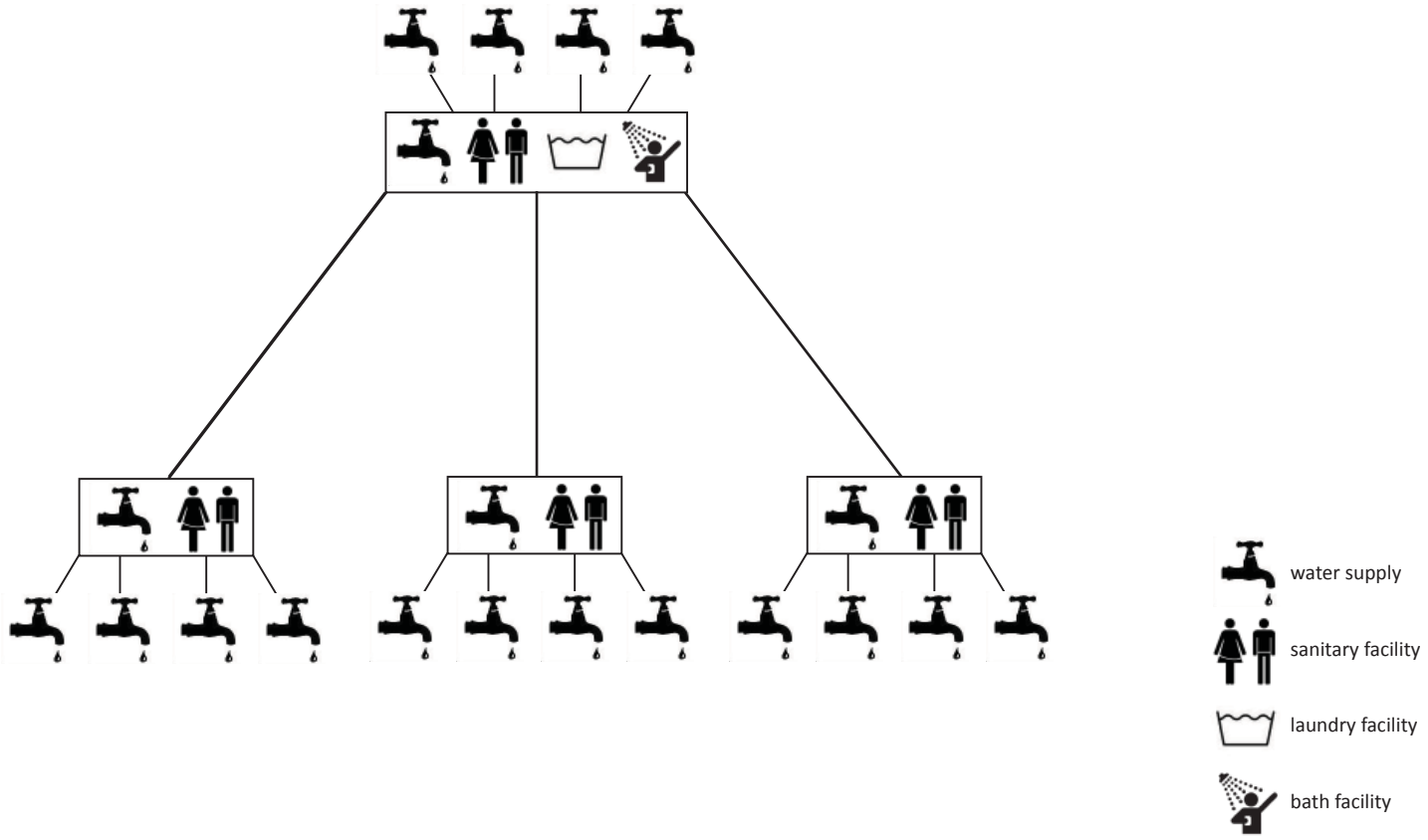
Implementing and financing water based facilities
In relation to branding, the possibilities for a commercial approach could be further explored by sanitary organizations in Mumbai. For example, the Tata group in India that comprises over 90 companies in different commercial sectors has a department for community initiatives[1]. This department is involved in community development programmes. As a commu-

104. Water supply tap at street level

1. Tata Sons, 2011.

105. Toilet facility at neighborhood level

106. Bath and laundry place in the district



107. Network of water based functions in a slum

108. London: telephones

109. Paris: access to metro station

nity development programme, water based facilities could be financed for Mumbai. The benefits of a commercial approach are threefold:

- The commercial party would take care of the cost in exchange for connecting their name to the city system.
- A commercial party like Tata also contains companies that are involved in engineering and materials by which the facilities could be constructed high quality for low-costs.
- In the implementation of sanitation at this moment, sanitary organizations have to notice the need of a specific group for sanitation. In some cases the slum dwellers request sanitation on their own initiative at a sanitary organization. In both cases, a process would be started in which needs and finance for sanitation are considered and a caretaker should be found. In a commercial approach, a franchise construction could be developed in which slum dwellers can start their own facility according to the city system, but adapted to the specific needs of the area that are well known by the slum dwellers.

9.3 Creating a water cycle

As seen in the previous paragraph, water related functions can be combined on different scales of slum areas. The function on district level for cloth washing and bathing that also contains water taps and toilets offers opportunities for saving water due to multifunctional use. In figure 110 a flow chart is made for water saving by creating a water cycle that serves all the functions of the district facility.

Basic assumption for the facility is that water comes in from municipal, private or natural sources of drinking water quality. (If not so, an extra step for purification of the water can be added in the cycle). Second assumption is that underground sewers are not available for the facility, which is mostly the case. This makes a closed cycle for water use even more important.
In the proposal, first step from supply is to create a storage tank on height. There are two reasons for this: 1) irregular supply can be transformed to continuity in supply in this way, 2) lack of pressure can be avoided. Additional energy will be needed to pump the water up initially. The second step is creating water taps for household supply. Overflowing water can be captivated and used for laundry facilities.
Other source for both laundry and washing facilities is water collected by rainwater harvesting during monsoon, that is stored in underground tanks.
Water used for laundry and bathing can still be used for flushing toilets. Cleaning the entire amenity can be done by stored rainwater as well.
The black water from the toilets is collected in a biogas installation, wher it is transformed into biogas that will be used for pumping up water in the tower. The refuse material that is also produced in the biogas installation has to be removed every half year.

Precise details for creating the cycle should be further explored in design. Although possibilities for the function of sanitation and water supply pavilion are more limited, the concept of buffering and rainwater harvesting can also be applied here.

9.4 Programme of requirements

To conclude, the programmes for the three different amenities in the network are:

Program for water based facility on district level

1. Water supply taps serving 90 people. Total capacity 3600 liters per day.
2. Laundry facilities serving 90 people. Total water capacity needed around 720 liters per day depending on saving possibilities.
3. Bathing facilities serving 90 people. Total water capacity needed around 720 liters per day depending on saving possibilities.

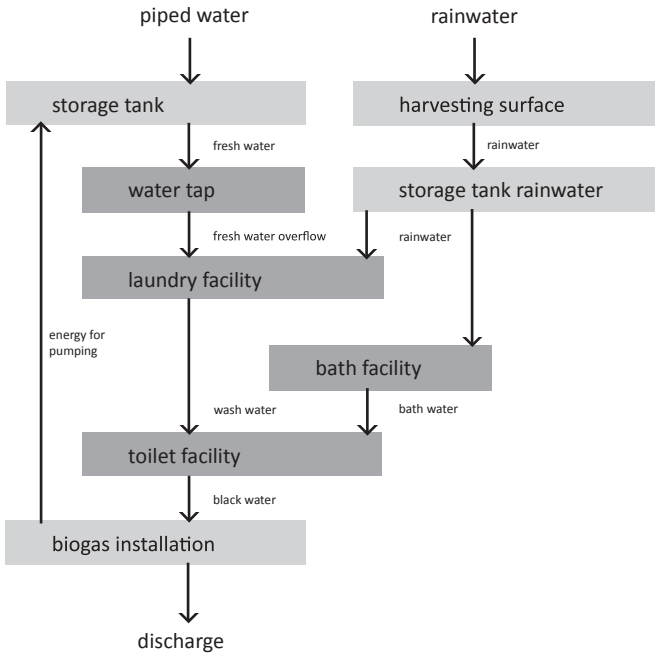
4. Nine toilets serving 450 people. Total water capacity needed for flushing 1800 liters per day.
5. Installations for toilet refuse materials treatment.
6. Maximum surface area in roofs for rainwater harvesting.
7. Underground storage tank for rainwater.
8. Water tower for storing water from initial supply.

Program for water based facility on neighbourhood level

1. Water supply taps serving 90 people. Total capacity 3600 liters per day.
2. Nine toilets serving 450 people. Total water capacity needed for flushing 1800 liters per day.
3. Installations for toilet refuse materials treatment.
4. Facilities for water storage and buffering (initial supply and/or rainwater harvesting)

Program for water based facility on street / alley level

1. Water supply taps serving 90 people. Total capacity 3600 liters per day.
2. Facilities for water buffering from initial supply.



110. Water flow chart for water based facility on district level

111. Dhobi Ghat Mumbai

Summary

Toilet provision in the slums of Mumbai is lacking or inadequate for most of the inhabitants, causing high health risks and humiliating situations.

In search of a contribution to adequate sanitation in Mumbai in the field of architecture, a research and design project is done on the subject of sanitation in the slums of Mumbai. The objective for research and design is twofold:

- Gaining deeper understanding of the sanitary problem in the social and physical context of Mumbai's slums;
- Proposing a sanitary design that suits and contributes to the slums of Mumbai.

An analysis of sanitation in the social and physical context of the slums of Mumbai was done to gain deeper understanding of the sanitary problem. In order to propose sanitary design that suits and contributes to the slums of Mumbai a research was done to determine design principles based on the analysis.

I. Analysis of sanitation in the slums of Mumbai

Two questions have directed the analysis of sanitation in the slums of Mumbai:

- How does sanitation operate in the slums of Mumbai?
- In what physical and social context does it operate?

Operating of sanitation in the slums of Mumbai

Having access to a toilet is not self-evident for people that live in the slums of Mumbai. People that do not have access to a toilet go into the fields on the edges of the slums for defecation. Since these areas are simultaneously used as play fields and garbage dump, the health risk can

not be underestimated.
A negligible percentage of the slum dwellers has a private toilet inside the house or shares a toilet with a couple of households. But the main solution for the elimination of open defecation is searched in the construction of community toilet blocks that serve between 400 and 1000 people per amenity. Considering the recent lack of toilets and pressure on toilets, building community toilets is the only solution for sanitation within the existing slums that can make a significant change in the situation.

Municipal provision of community toilets for slums is only done under strict conditions for specific areas, which are a minority of the existing slums. NGO's have raised to stand in the gap for sanitation by providing community toilet blocks. The first community toilets that were built had a very basic layout and were primarily focused on increasing the number of toilet seats for the slums. The NGO's have further developed the community toilet block ever since. Still, a series of problems is typically associated with community toilet blocks:

- defects of the toilets
- pollution of the toilets
- inadequate water provision in the amenity
- limited space for discharge / unsafe discharge of black water
- payment for toilet use above a slum dwellers budget
- lines in front of the toilets in rush hours
- insufficient provision in number of seats
- children facing dangers or disadvantages in using the toilets
- lack of safety, specifically for female users
- limited or inadequate access to the building

The most important improvement in the community toilets in recent years is the introduction of a caretaker that is responsible for maintenance, cleaning and safety of the toilet block. The layout of the block has been adapted to this transformation.

Whereas buildings in Mumbai are generally connected to water supply and sewer lines provided by the municipality, slums are not automatically taken in account for water supply and discharge because of their informal status. As a consequence, there is a lot of diffuseness in the organization of water supply and discharge provided by public or private initiative. Slum dwellers face the disadvantages in price, availability and quality of water.
Since people in India use water in the toilet not only for flushing and cleaning but also for anal cleansing, inadequate provision of water is unbearable in the community toilet blocks. The recent solution for inadequate water supply is saving water for flushing. In times the water is not provided in the block, people bring water from home. However, this policy easily leads to pollution by lacking water for cleaning the amenity. It is in particular this pollution that makes the use of the amenities so unpleasant in my personal experience.

Many of these problems are serious enough for slum dwellers to prefer open defecation over organized sanitation. For urinating men will commonly choose the streets. For women, this is considered inappropriate. However, the sink in a house might very well be used for urinating secretly...

Despite of many significant improvements that were done in recent years, the complete picture for community toilets does not express that these are building of great relevance for the health of people; the toilet blocks have a marginalized position in the slums of Mumbai.

Physical and social context of sanitation in the slums of Mumbai

Physical context
In the heavily populated city of Mumbai, pressure on land is high. People that can not afford a house in the formal city therefore live in slums. Slums are mostly located on wastelands like lands around railway tracks

and flood areas of rivers. Rehabilitation schemes of the municipality to move people from slums with substandard living conditions to housing in the formal sector are behind schedule. As a consequence, for many of the urban poor in Mumbai there is no choice but to make a living in the slums permanently.

Not every slum area is the same, there is a wide variety in size, density and morphology of the slums. Quality of the land in terms of ground conditions and location within the city also differs.
Slums grow in an organic way, in which constructing houses is the first priority for people. Planning of roads, infrastructure and services is usually not taken in account from the beginning. Implementation in a later stage is much more complicated, access to slum areas can therefore be complicated.

Within the slums, neighborhoods are usually not clearly defined: the areas are relatively monotonous. Rather then by districts, people will identify with their living environment by reference places like a school, religious building or transport station.

Typically, the street is where most of slum live takes place. Street in this context can refer to main roads in the area, but also the smallest alleys in the area are full of live. Regardless of the size of the street, people place some kind of coverage in front of their houses which provides shadow to do daily and have social interaction with neighbors.
Houses inside a single slum area can also vary widely in size, height, material and luxury. A generic scheme can be made for development of the house from a simple hut to a multi-storey brick and concrete structure. As people make progress in life in terms of money, the house is adapted in accordance.

Physical context in relation to sanitation
Due to the increasing density of slums over time in the limited space, implementing basic sanitary services is difficult, whereas the need rises with the rising density. Finding space that is suitable for community toilet blocks and accessible for piping, transport and the users is a challenge. As a consequence, sanitary amenities do not strongly relate to the spatial context. By the lack of clearly defined areas in the slum, the spatial context does not indicate a way of distributing amenities. The question rises how sanitation should relate to the way that people identify with their spatial environment.

Social context
Whereas the term ‘community toilets’ implies that slum dwellers would be a coherent group, the reality is different. Since slum dwellers are mostly immigrants that came to the city to make a better living, the profiles of people differ in language, social background, religion.

With all the struggles that slum dwellers face in daily life, it is unclear who should take responsibility for their basic needs. Because of the informal state of slums the municipality is reserved with providing basic services, whereas the slum dwellers might face opposition in organizing their own. The diversity of the people and their daily struggle to make a living also hinders people from taking common initiative.

The smallest entity that can be found in the slums is the family sharing a household. Family ties in general are close, but many people lack means to regularly meet family at the countryside. Besides family the most important social structures are relations with neighbors and relations based on common activities and beliefs. The last can for example be school, religion or work, in which the corresponding buildings are important places for interaction.

The slums of Mumbai are dynamic places, in a sense that people might move out if they prosper and can move to a better place. Elderly people therefore are a minority. In the informal economy of the slums, people

might buy, rent, build or rebuild a house.

In and around the houses, it is remarkable that behavior is gender defined. The majority of the women will spend most of their time in or close to their house, whereas for most men the area that is relevant to their lives is wider. For women the small domain in front of the house is important for social interaction, as well as the shared water taps.

Social context in relation to sanitation
In the range of basic needs of people in slums, a generic list of priorities can be made. Toilets do not have priority, even though the health implications for inadequate sanitation are impressive.
In general, toilets in India risk an association with dirt and therefore an underestimation of the value of the sanitary function.

Conclusions

- Community toilet blocks have a marginalized position in the slums of Mumbai in relation to their relevance for health.
- Sanitation suffers from a lack of embedment in the social and physical context of the slums of Mumbai.

II. Principles sanitary design in the slums of Mumbai

In order to define principles for a sanitary design that suits and contributes to the slums of Mumbai, the following questions have directed the second part of the research:

- What additional programme to community toilet blocks is able to reposition the marginalized sanitation in the slums of Mumbai?
- What spatial intervention in the slums of Mumbai is needed to root sanitation in the context?
- What are the implications of the additional programme and the spatial intervention for the design of sanitary amenities in the slums of Mumbai?

Adding programme to sanitary amenities

In search for additional programme to sanitation, the following criteria were formulated:
- There should be a need for the added programme in the slum areas of Mumbai.
- The link between the sanitary programme and the additional programme must be obvious.

Three studies were done to explore promising additional programme: a brainstorm session focused on generating a large quantity of ideas in a short time period, a study of historic Indian water sources and a study of Arabic public baths.

Brainstorm on additional programme
During the brainstorm 75 different ideas for additional programme were generated. Nine of these ideas in the categories transport, education, recreation (food), recreation (non-food), health, communication, religion, economy and ecobalances were worked out into a concept.

The idea for a ‘water square’ on which children could play with water and sanitation was provided underneath came out as most promising.

An Indian approach to water
In the Indian experience of dealing with drought during a long period of the year, three types of dealing with water in the environment can be distinquished:

The vav, a step well for groundwater in which the water is not brought up by pumping, instead the user descents a long stair to the water surface.

The kund, a pond in which water can be saved for longer period due to efficient shape to prevent evaporation, whereas approaching the water by stairs is still possible.

The ghat, a series of steps at the shore of a river, sea or lake that is used for water related activities and trade. A dhobi ghat in addition is a public laundry facility.

Common qualities of the functions dealing with water are:
- Liveliness of the places for more then filling water jars only. The places are intensively used for water based daily activities and they have become important places for social interaction of people.
- The architecture of the places maximally facilitates both practical and social function of the water sources. The cultural value that ordains indirect approach of water has led to the strong combination of water and stairs in the different types.

Public baths in Arabic society
Public baths, just like sanitation, is an intimate function that is privately facilitated and can therefore easily become subject to shame.

However, the Arabic public baths turn out to be highly valued places for the following reasons:
- One will leave the bathhouse transformed in terms of beauty, purity, health or cleanliness.
- The bathhouse is an intimate place for social interaction away from the personal home for women.
- The bathhouse is shaped as a place of comfort for personal care.

Additional programme
Because of the ability of the water supply functions to facilitate daily activities and social interaction, it could add quality to the slums in Mumbai. The link between a water based function and sanitation is easily made.

The design challenge for extended sanitation is therefore to create a public amenity based on water supply, that will facilitate a combination of functions for water related daily activities: sanitation, laundry, bodily cleaning.

Spatial interventions in the slum

In order to find a way to embed sanitation in the slums of Mumbai, the following criteria for a spatial intervention were formulated:
- The intervention should suit the slums.
- The intervention should add quality (contributes) to the slum.
- The spatial intervention should be able to facilitate sanitation and the additional water based functions.

The spatial interventions that were explored are:
- Building on the edges of the slum
- Building along the main routes through a slum
- Building interior spaces within the dense structure
- Neglecting the existing structure in building
- Create a mobile function without permanent intervention
- Building on top of the existing structure
- Building within existing open spaces
- Creating open spaces

Aspects of interest for building in slums that were found in the study are accessibility, visibility, permanent character, buffer to danger, possibility to decreasing density.

The function that came out as most promising was the creation of open spaces, what will result in a court yard type building if structures removed from the slum are replaced on top of the new structure. The reason for this choice is that open space is desired as an additional quality for slums. Sanitation will also benefit from the open space by improved access and

space for discharge.

Implications for sanitary design

The design challenges in programmatic and spatial terms that have been defined have implications for the further development of a complete design concept and programme of requirements. In the further development, the programmatic needs, the way if distributing functions over the slums and the way of distributing water in the design were determined, concluded with the programme of requirements for the functions.

Needs for water supply, toilets, bath and laundry facilities
The needs for water supply in the slums of Mumbai are:
40 liters per capita per day (lpcd) water is required per 20 households (90 people) on street level which is a capacity of 3600 liters per day for each standpipe at street level.

The needs for toilet provision in the slums of Mumbai are:
An amenity of 9 toilet seats in required for 450 users (100 households) on neighbourhood level, which requires 1800 liters of water per day assuming that people use the amenity twice a day.

The needs for laundry and bath facilities in the slums of Mumbai are:
An amenity for shared bathing and laundry facilities should be created at district level. A district is assumed to contain around four neighborhoods and therefore contains around 400 households (1800 people). Bathing facilities would count for 8 lpcd, the same is assumed for doing laundry. An estimation for the percentage of people that would make use of shared facilities for laundry and bathing is 5% (90 people). This means that a district facility would need 720 liters per day for serving laundry and another 720 for bathing.

A network of water based functions
Because the acceptable walking distance from home to visit the different water based facilities varies from function to function, their is a range of serving areas and scales on which the facilities function. Therefore, a network of functions should be created for the slums of Mumbai that distributes functions according to needs.
Three different water based facilities should be created on three scales:

- A water supply facility on street level
- A water supply and sanitary function on neighborhood level
- A water supply, laundry, bath and sanitary facility on district level

Because of the introduction of a network in which functions are repeated, a generic approach is desired. The principle of a city wide language for water based facilities has therefore been introduced: like telephones in the city of London or Metropolitain accesses in the city of Paris, a coherent design system for water based facilities will be designed for Mumbai. Such a system requires great opportunities to create a facility by which people can easily identify with their living environment on different scales.

Due to significant variety in slums, the designs can not be static, but should be adjustable to specific areas. Therefore, tools for design should be created that can still be recognized if the set up for the design is adjusted. This can best be done in materials and smaller elements.

For the financing and implementation the design, a commercial approach in collaboration with companies should be considered, in order to save money and create possibilities for franchise constructions in which slum dwellers could start their own facility.

Creating a water cycle
To save water in the slum areas of Mumbai, a cycle has been made for the water based facility with sanitation, laundry and bathing. In the cycle,

rainwater harvesting is practised. Water overflow from taps is reused, as well as wash water for flushing toilets. Black water is transformed to energy for pumping by a biogas installation.

Programme of requirements
The programme of requirements for the three different functions is:

Water based facility on district level
1. Water supply taps serving 90 people. Total capacity 3600 liters per day.
2. Laundry facilities serving 90 people. Total water capacity needed around 720 liters per day depending on saving possibilities.
3. Bathing facilities serving 90 people. Total water capacity needed around 720 liters per day depending on saving possibilities.
4. Nine toilets serving 450 people. Total water capacity needed for flushing 1800 liters per day.
5. Installations for toilet refuse materials treatment.
6. Maximum surface area in roofs for rainwater harvesting.
7. Underground storage tank for rainwater.
8. Water tower for storing water from initial supply.

Program for water based facility on neighbourhood level
1. Water supply taps serving 90 people. Total capacity 3600 liters per day.
2. Nine toilets serving 450 people. Total water capacity needed for flushing 1800 liters per day.
3. Installations for toilet refuse materials treatment.
4. Facilities for water storage and buffering (initial supply and/or rainwater harvesting)

Program for water based facility on street / alley level

1. Water supply taps serving 90 people. Total capacity 3600 liters per day.
2. Facilities for water buffering from initial supply.

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Images

All the images in the thesis that are not listen below are photographs and images made by the author.

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